

Compendium of
Emerging Construction Technologies for Housing & Infrastructure

Fourth Edition, 2023

bmtpc
Building Materials & Technology Promotion Council
Ministry of Housing & Urban Affairs
Government of India





















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The information presented in this Compendium prepared by Building Materials & Technology Promotion Council (BMTPC), Ministry of Housing & Urban Affairs (MoHUA) is supplied in good faith and is based entirely on the data furnished by the agencies for award of Performance Appraisal Certificates (PACs). The responsibility fully rests with the certificate holder and user of the technologies/products.

Preface

Pradhan Mantri Awas Yojana-Urban (PMAY-U), the world's largest housing programmes under the leadership of Hon'ble Prime Minister, is at advanced stage of implementation. Due to rapid urbanisation, massive construction activities are undergoing and planned in all the States/UTs to cater to this growing urban population. As per estimates, India needs to build 600-800 million m^2 urban space every year till 2030. Therefore, it is incumbent on part of academic, research & other organizations involved in construction to bring innovation & thus paradigm shift in the prevailing construction practices so as to fast-track delivery of housing & infrastructure without compromising structural & functional performance. With this objective in mind, BMTPC is identifying, evaluating & certifying new emerging construction systems from across the globe which can help in replacing the conventional cast-in-situ RCC framed construction. The first set of such 8 technologies were published in form of compendium in 2015 and its second & third editions with 16 and 24 new construction systems were published in April 2017 and September 2018 respectively. Since 2018, more number of technologies have knocked the door of Indian construction industry and it is heartening to mention here that with the concerted efforts put up by BMTPC, now, we have a set of 44 such new emerging technologies certified under PACS. The Ministry of HUA through GHTC-India has also shortlisted 54 innovative technologies for mass housing which can bring in speed, safety, sustainability in the construction sector. Apart from 44 innovative construction systems certified under PACS, 25 innovative technologies shortlisted under GHTC-India have also been listed in the present publication which are similar to the certified technologies through PACS.

The next biggest challenge is to mainstream these new systems in the construction sector and, therefore, there is need to create an enabling eco-system to facilitate use of these innovative materials, processes and technologies. Under PMAY(U), Ministry of Housing & Urban Affairs (MoHUA) has setup a Technology Sub-Mission which encourages the use of sustainable & safe construction practices across states with the help of IITs/NITs/SPAs and other institutes of repute. It has always been BMTPC's endeavor to handhold State Governments so as to propagate new technologies in the construction sector and with its dedicated efforts, there are around 16 lakhs houses being constructed by State Governments under PMAY(U) and other State Schemes using new construction technologies. There has always been questions regarding standards and schedule of rates of these innovative technologies and is an impediment in promotion of any new product/system. Realizing the need, CPWD and BIS was roped in by the MoHUA and as on date CPWD has published Schedule of Rates of almost all such technologies in DSR 2021. There have been circulars from CPWD & MoHUA which recommend mandatorily use of such systems and encourage turnkey approach instead of item rate contract for use of new technologies. Bureau of Indian Standards (BIS) has also included these systems in NBC-2016. Apart from this, MoHUA along with BMTPC is also constantly interacting with Defence, Railways & PSUs involved into construction such as NBCC, DDA etc. to make use of these emerging technologies in their own housing and other projects. The response has been very good. In fact, States are now coming forward to embrace these technologies for their upcoming social mass housing projects. With an aim to enhance the capability of building professionals about the new and emerging building materials, technologies and processes for construction, an online certificate course named NAVARITIH (New, Affordable, Validated, Research Innovation Technologies for Indian Housing) is being run by MoHUA in collaboration with BMTPC and SPA, Delhi on regular basis.

As of now, the only impediment in usage of these systems has been cost but given economies of scale, the cost comes comparable with conventional construction cost and there are host of additional benefits such as low maintenance, low life-cycle cost, better durability, improved thermal & acoustical performance, better hazard resistance, low wastages, less pollution & above all green & sustainable development, which are often neglected while drawing comparisons. I have been the great proponent of life-cycle cost and it is strongly recommended that whenever an innovation is being introduced in construction sector, instead of initial cost, the life-cycle cost need to be ascertained. With the tools available, the life-cycle assessment (LCA) can easily be done. The emerging technologies included in the Compendium have low life-cycle cost and thereby resource-efficient and environmentally-responsible.

The technical contributions made by BMTPC officers namely Shri S.K. Gupta, Shri C.N. Jha, Shri Pankaj Gupta and Shri Dalip Kumar in bringing this compendium are deeply appreciated and acknowledged. Through this publication, I sincerely hope that the all stakeholders involved into construction including state agencies will repose faith in the technologies and make use of the information available in right earnest and start using these innovative systems in their future housing projects so as to fulfil the dream of Govt. of India of providing housing to all without vitiating the environment & stressing the natural resources.

Date: September 12, 2023
Place: New Delhi

Dr. Shailesh Kr. Agrawal
Executive Director, BMTPC

Contents

		Page No.
BACKGROUND		1
A. PRECAST CONCRETE CONSTRUCTION SYSTEM – 3D PRECAST VOLUMETRIC		11
1	Volumetric (3D) Concrete Printing Technology (VCPT) - M/s Larsen & Toubro Limited	13
2	Concrete 3D Printing Technology (C3DP) – M/s Tvasta Manufacturing Solutions Pvt. Ltd.	21
B. PRECAST CONCRETE CONSTRUCTION SYSTEM – PRECAST COMPONENTS ASSEMBLED AT SITE		29
3	SRPL Building System (Waffle-Crete) – M/s Shaival Reality Pvt. Ltd.	31
4	Walltec Hollowcore Concrete Panel – M/s B N Precast Pvt. Ltd.	38
5	Large Hollow Wall Prefab Concrete Panels - M/s William Ling – Shortlisted under GHTC-India	
6	Precast Large Concrete Panel System – M/s Larsen & Toubro Ltd.	43
7	Industrialized 3-S system using RCC precast with or without shear walls, columns, beams, Cellular Light Weight Concrete Slabs/Semi-Precast Solid Slab – M/s B.G.Shirke Construction Technology Pvt. Ltd. – Shortlisted under GHTC-India	50
8	Robomatic Hollowcore Concrete Wall Panels – M/s Robomatic Precon Pvt. Ltd.	53
9	K-Wall Panels – M/s Pioneer Precast Solutions Pvt. Ltd.	60
10	Urbanaac Precast Construction Technology – M/s Urbanaac Infrastructures Pvt.Ltd.	68
11	Precast concrete construction system using precast walls with precast plank floor - M/s PG Setty Construction Technology Pvt Ltd. – Shortlisted under GHTC-India	
12	Pre cast components comprising of beams, columns, staircase, slab, hollow core slab etc. manufactured in plant & erected on site - M/s Teemage Builders Pvt Ltd. – Shortlisted under GHTC-India	
13	Optimal Pre-cast concrete System through structural Analysis, design & equipment support - M/s Elematic India – Shortlisted under GHTC-India	
14	Integrated Hybrid Solution – One – M/s Aap Ka Awas LLP	75
15	Kon_Crete Reinforced Autoclaved Aerated Concrete Panels –M/s UAL Industries Ltd. UAL-KON_CRETE	87
16	AAC wall and roof panel system to provide integrated solution - M/s Biltech Building Elements Ltd. – Shortlisted under GHTC-India	
17	AAC Panels for use as wall & slab - M/s SCG International India Pvt Ltd. – Shortlisted under GHTC-India	
C. LIGHT GAUGE STEEL STRUCTURAL SYSTEM & PRE-ENGINEERED STEEL STRUCTURAL SYSTEM		95
18	Factory Made Fast Track Modular Building System – M/s Synergy Thrislington	97
19	Speed Floor System – M/s Jindal Steel & Power Ltd.	100
20	Light Gauge Steel Framed Structure (LGSF) – M/s JB Fabinfra Pvt. Ltd.	104
21	LGS Framing with various walling & roofing options - M/s Mitsumi Housing Pvt. Ltd. – Shortlisted under GHTC-India	

		Page No.
22	LGS Framing with various walling & roofing options - M/s Everest Industries Ltd. – Short-listed under GHTC-India	104
23	LGS Framing with various walling & roofing options - M/s Elemente Designer Homes. – Shortlisted under GHTC-India	
24	LGS Framing with various walling & roofing options - M/s MGI Infra Pvt. Ltd. – Shortlisted under GHTC-India	
25	LGS Framing with various walling & roofing options - M/s RCM Prefab Pvt. Ltd. – Short-listed under GHTC-India	
26	LGS Framing with various walling & roofing options - M/s Nipani Infra and Industries Pvt. Ltd. – Shortlisted under GHTC-India	
27	LGS Framing with Ecopanely boards as facing material made from agricultural wastes - M/s Strawcture Eco – Shortlisted under GHTC-India	
28	Light Gauge Steel Framed Structure with Infill Concrete Panel Technology – M/s Society for Development of Composites	110
29	Continuous Sandwich (PUF) Panels With Steel Structure – M/s Kingspan Jindal Pvt. Ltd.	116
30	PUF Sandwich Panel with Pre Engineered Building Structure – M/s EPACK Polymers Pvt. Ltd.	127
31	Ferron Panel as part of Ferrobuild Design System – M/s Sanjivani Cement Products	135
D. PREFABRICATED SANDWICH PANEL SYSTEM		143
32	Advanced Building System – Emmedue – M/s BK Chemtech (I) Pvt Ltd.	145
33	QuickBuild 3D Panels – M/s Beardsell Ltd.	151
34	Reinforced EPS Core Panel System – M/s Jindal Steel & Power Ltd.	156
35	Reinforced Expanded Polystyrene sheet core with sprayed concrete as wall & slab - M/s MSN Construction – Shortlisted under GHTC-India	
36	Rapid Panels – M/s Worldhaus Construction Pvt.	162
37	Prefabricated Fibre Reinforced Sandwich Panels with or without Structural Frame – M/s HIL Ltd.	170
38	Prefabricated steel structural system with Dry wall system as AAC panels, etc. - M/s RCC Infra Ventures Ltd. – Shortlisted under GHTC-India	
39	Sandwich panels as wall & slab - M/s Project Etopia Group – Shortlisted under GHTC-India	
40	Concrewall Panel System – M/s Schnell Home	180
41	Rising EPS (Beads) Cement Panels - Rising Japan Infra Pvt. Ltd. -	186
42	PIR Dry Wall Pre-Fab Panel System – M/s Covestro (India) Pvt. Ltd.	195
43	Baupanel system – M/s Bau Panel System India Pvt. Ltd.	202
44	Flyash EPS (Beads) Cement Sandwich Panels – M/s Bhargav Infrastructure Pvt.	213
45	V-Infill Wall (Light Weight EPS Wall) – M/s Visaka Industries Ltd.	224
46	Nano Living System Technology – M/s Nano Living System Pvt. Ltd. (India)	229
47	Factory Assembled Insulated Sandwich Panels using Mineral Wool – M/s Metecno (India) Pvt. Ltd.	235
48	Factory Assembled Insulated Sandwich Panels using PUF – M/s Metecno (India) Pvt. Ltd.	244
49	Everest Rapicon Panel / Solid Wall Panel – M/s Everest Industries Ltd.	253

		Page No.
E. MONOLITHIC CONCRETE CONSTRUCTION		265
50	Monolithic Concrete Construction System – M/s Sintex Industries Ltd. – using Plastic-Aluminium Formwork – using Aluminium Formwork	267
51	Aluminium formwork system for Monolithic Concrete construction - M/s Maini Scaffold Systems Pvt. Ltd. – Shortlisted under GHTC-India	
52	Aluminium formwork system for Monolithic Concrete – construction - M/s KumkangKind India Pvt. Ltd. – Shortlisted under GHTC-India	
53	Aluminium formwork system for Monolithic Concrete construction - M/s S-form India Pvt. Ltd. – Shortlisted under GHTC-India	
54	Aluminium formwork system for Monolithic Concrete construction - M/s ATS Infrastructure Ltd. – Shortlisted under GHTC-India	
55	Monolithic Concrete construction using MIVAN technology - M/s Innovative Housing & Infrastructure Pvt. Ltd. – Shortlisted under GHTC-India	
56	Aluminium formwork system for Monolithic Concrete construction - M/s MFS formwork Systems Pvt. Ltd. – Shortlisted under GHTC-India	
57	Aluminium formwork system for Monolithic Concrete construction - M/s Knest Manufacturers LLP. – Shortlisted under GHTC-India	
58	Aluminium formwork system for Monolithic Concrete construction - M/s Brilliant Etoile – Shortlisted under GHTC-India	
59	Modular Tunnel Form – M/s Outinord Formworks Pvt. Ltd.	274
F. STAY IN PLACE FORMWORK SYSTEM		281
60	Glass Fibre Reinforced Gypsum Panel System – M/s Rashtriya Chemicals & Fertilizers Ltd. and M/s FACT-RCF Building Products Ltd.	283
61	Sismo Building Technology - M/s M K S Infosolutions Pvt. Ltd.	288
62	Insulating Concrete Forms – M/s Reliable Insupacks (P) Ltd.	295
63	Monolithic Insulated Concrete System – M/s Maiwir Ecotech Pvt. Ltd.	
64	FastBloc, Insulated Concrete Form (ICF) - M/s Fastbloc Building Systems – Shortlisted under GHTC-India	
65	Lost-in-place formwork system- Plasmolite Wall Panels – M/s FTS Buildtech Pvt. Ltd.	302
66	Lost-in-place formwork system- Plaswall Panel system – M/s FTS Buildtech Pvt. Ltd.	307
67	Structural Stay-in-place formwork system – M/s Coffor Construction Technology Pvt. Ltd.	313
68	Stay-In-Place PVC Wall Forms – M/s Novel Assembler Pvt. Ltd.	319
69	Permanent Wall Form (PVC) – M/s Kalzen Realty Pvt. Ltd.	327
APPENDICES		335

Background

The Pradhan Mantri Awas Yojana (Urban) launched on 25th day of June 2015, set the target of providing all weather houses to all eligible urban households (approximately 12 million houses sanctioned by 2022) and subsequently Pradhan Mantri Awas Yojna (Rural) launched on 1st day of April 2016 (~29 million houses sanctioned). In order to achieve this gigantic task, the natural question comes to mind whether we have sufficient quantity of such building materials which do not impact the mother earth adversely and further can our existing construction practices in vogue help fast delivery of houses in given time frame? The answer to both the question is negative as we look at the traditional building materials e.g. brick, cement, steel, aggregates, sand etc., they are either based on natural resources which are finite in nature or energy intensive or emit greenhouse gases during production. Thus, the entire proposition of using these materials as usual will not be sustainable and environment friendly. Further, the ubiquitous construction system being practiced in India, is cast-in-situ RCC framed (beam-column) construction which is primarily time consuming construction methodology and is prone to time & cost overruns. Also, these constructions are labour intensive, which further hamper fast delivery, as there is acute paucity of unskilled labour force in cities. Therefore, it is prudent to take a paradigm shift from brick & stick approach and look for alternate systems which can address these limitations. There have been proven time-tested such construction systems available elsewhere in the world which are in use since decades successfully. Nevertheless, these systems ought to be promoted and adapted in Indian conditions. BMTPC have been identifying, evaluating and certifying these systems and also in order to showcase these technologies, demonstration housing projects are being executed in different States/UTs under PMAY(U). Our endeavor has been to bring innovation, speed, safety & sustainability in the existing construction methodology without compromising structural & functional performance. Also, BMTPC has been conducting handholding programmes across India, in partnership with States, so as to educate practicing engineers & architects, students, policy makers, contractors and artisans about these technologies.

In order to give further impetus to these technologies, Ministry of Housing & Urban Affairs has assertively pursued CPWD, BIS and state departments to come out with notifications, circulars, SORs, specifications etc. which will authorize state governments to use these new construction technologies in their respective housing projects. The various OMs of the Ministry and CPWD, and DSR items are included in Appendices. CPWD has included New Technology Items in Delhi Schedule of Rates (DSR) 2021 Volume-2 namely (a) Light Gauge Steel Framed System (Item No. 26.41 to 26.45 and 26.65), (b) Expanded Polystyrene Core Panel System (Item No. 26.46 to 26.47 and 26.66), (c) Aluminum Formwork for Monolithic Construction (Item No. 26.48), (d) EPS cement sandwich light weight solid core panels (Item No.26.49), (e) Non asbestos fibre reinforced aerated cement sandwich wall/roof/floor light weight solid

core panels (Item No.26.50), (f) GFRG Panel System (Item No.s 26.51 to 26.61), (g) Speed Floor System (Item No.26.62 to 26.64), (h) Factory Made Fast Track Modular Building System (Item No.26.65 to 26.66), and (i) Prefab Technology (Item No.26.73 to 26.80) and their detailed analysis is given in Delhi Analysis of Rates (DAR) 2021 (Volume-2).

Further, in the National Building Code 2016 by BIS, provisions have been updated to ensure utilization of number of new/alternative building materials and technologies so as to provide for innovation in the field of building construction. Updated provisions on new alternate technologies for speedier construction have also been included in Part-5 BUILDING MATERIALS; Part-6 STRUCTURAL DESIGN: Section 7 Prefabrication and Systems Building and Mixed/ Composite Construction, 7A Prefabricated Concrete, 7B Systems Building and Mixed/Composite Construction; and Part-7 CONSTRUCTION MANAGEMENT, PRACTICES AND SAFETY.

The following 44 innovative construction systems, developed within the country & from aboard have been certified under Performance Appraisal Certification Scheme (PACS). These systems are recommended for use by the public and private agencies based on their technical suitability and certification.

PRECAST CONCRETE CONSTRUCTION SYSTEM – 3D PRECAST VOLUMETRIC		
1	Volumetric (3D) Concrete Printing Technology (VCPT)	1059-S/2022
2	Concrete 3D Printing Technology (C3DP)	1067-S/2023
PRECAST CONCRETE CONSTRUCTION SYSTEM – PRECAST COMPONENTS ASSEMBLED AT SITE		
3	SRPL Building System (Waffle-Crete)	1021-S/2015
4	Walltec Hollowcore Concrete Panel	1022-P/2015
5	Precast Large Concrete Panel System	1027-S/2016
6	Industrialized 3-S system using RCC precast with or without shear walls, columns, beams, Cellular Light Weight Concrete Slabs/Semi-Precast Solid Slab	-
7	Robomatic Hollowcore Concrete Wall Panels	1040-S/ 2018
8	K-Wall Panels	1043-S/2019
9	Urbanaac Precast Construction Technology	1046-S/2019
10	Integrated Hybrid Solution - One	1048-S/2020
11	Kon_Crete Reinforced Autoclaved Aerated Concrete Panels	1056-P/2021
LIGHT GAUGE STEEL STRUCTURAL SYSTEM & PRE-ENGINEERED STEEL STRUCTURAL SYSTEM		
12	Factory Made Fast Track Modular Building System	1011-S/2013
13	Speed Floor System	1013-S/2014
14	Light Gauge Steel Framed Structure (LGSF)	1014-S/2014
15	Light Gauge Steel Framed Structure with Infill Concrete Panel Technology	1028-S/2016
16	Continuous Sandwich (PUF) Panels With Steel Structure	1038-S/2018

17	PUF Sandwich Panel with Pre Engineered Building Structure	1060-S/2022
18	Ferron Panel as part of Ferrobuild Design System	1066-S/2023
PREFABRICATED SANDWICH PANEL SYSTEM		
19	Advanced Building System – Emmedue	1010-S/2014
20	QuickBuild 3D Panels	1019-S/2015
21	Reinforced EPS Core Panel System	1020-S/2015
22	Rapid Panels	1026-S/2016
23	Prefabricated Fibre Reinforced Sandwich Panels	1030-S/2017
24	Concrewall Panel System	1031-S/2017
25	Rising EPS (Beads) Cement Panels	1032-S/2017
26	PIR Dry Wall Pre-Fab Panel System	1039-S/2018
27	Baupanel system	1041-S/2018
28	Flyash EPS (Beads) Cement Sandwich Panels	1042-S/2018
29	V-Infill Wall (Light Weight EPS Wall)	1045-S/2019
30	Nano Living System Technology	1047-S/2019
31	Factory Assembled Insulated Sandwich Panels using Mineral Wool	1057-P/2021
32	Factory Assembled Insulated Sandwich Panels using PUF	1058-P/2021
33	Everest Rapicon Panel / Solid Wall Panel	1061-S/2022
MONOLITHIC CONCRETE CONSTRUCTION		
34	Monolithic Concrete Construction System	1006-A/2011
35	Modular Tunnel Form	1018-S/2015
STAY IN PLACE FORMWORK SYSTEM		
36	Glass Fibre Reinforced Gypsum Panel System	1008-S/2011
37	Sismo Building Technology	1025-S/2016
38	Insulating Concrete Forms	1029-S/2017
39	Lost-in-place formwork system- Plasmolite Wall Panels	1033-S/2018
40	Lost-in-place formwork system- Plaswall Panel system	1034-S/2018
41	Structural Stay-in-place formwork system	1035-S/2018
42	Monolithic Insulated Concrete System	1036-S/2018
43	Stay-In-Place PVC Wall Forms	1044-S/2019
44	Permanent Wall Form (PVC)	1050-S/2020

Apart from the above 44 innovative construction systems, 25 innovative technologies short-listed under GHTC-India have also been listed in this Compendium which are similar to the certified technologies through PACS.

One of the crucial components of technology transfer cycle is demonstration construction and therefore, in order to demonstrate these new systems in the field, BMTPC with the support of Ministry of Housing & Urban Affairs, Govt. of India has initiated several Demonstration housing projects as pilot projects in different states wherein around 40 houses are being constructed under PMAY(U). The land is provided by the state govt. free of cost whereas the houses are constructed along with onsite infrastructure by BMTPC as per the Operational Guidelines of

Demonstration Housing Projects issued by the Ministry of Housing & Urban Affairs in April 2018. During the construction, the professionals, students, artisans, policy makers & residents of the area are sensitized & educated about these new technologies. Seven projects at Nellore, AP (GFRG panel systems), Bhubaneshwar, Odisha (EPS Core Panel system), Bihar Sharif, Bihar (structural stay-in-place formwork system), Lucknow, UP (Double walled EPS Core Panel system), Hyderabad, Telangana (Light gauge steel structural system & structural stay-in-place formwork system), Panchula, Haryana (LGSF system with cement fibre board on both side of wall and rockwool as infill), Agartala, Tripura (Structural Stay-in-Place Formwork System), Bhopal, Madhya Pradesh (Insulating Concrete Form) and Ahmedabad, Gujarat (Integrated Hybrid Solution – ONE) have been completed. Other projects at Guwahati, Assam (LGSF with fibre cement board on both sides of wall and light weight EPS as infill), Ayodhya, UP (LGSF with cement fiber board on both side and mineral wool as in-fill), Tiruppur, Tamil Nadu (Precast Construction System), Jammu, J&K (EPS core panel system) and Dimapur, Nagaland (Flyash EPS Cement Sandwich Panels with steel structure) are in various stages of construction.

The details of the technologies evaluated and recommended, as contained in this Compendium, will help user agencies in getting informed choice of different innovative construction practices, which could be utilized for mass housing scheme.

Performance Appraisal Certification Scheme (PACS)

BMTPC operates Performance Appraisal Certification Scheme (Gazette Notification No. I-16011/5/99 H-II in the Gazette of India No. 49 dated December 4, 1999). The emerging technologies for mass housing appearing in the Compendium have been evaluated and certified through Performance Appraisal Certification Scheme (PACS) of BMTPC.

The PACS is a third party assurance system based on laboratory and field tests of the required performance criteria of the any system / building materials on which there is no Indian Standard. The broad parameters, based on which the evaluation is done inter-alia include:

- Structural performance against vertical & lateral loads
- Fire resistance
- Protection against rain & moisture.
- Thermal & accoustic behaviour
- Ease of fixing services
- Quality assurance
- Durability / Service Life

The process flow chart for PACS is given in Figure-1. Whereas PACS takes care of verifying technical suitability of the system; other parameters are required to be addressed for proper selection of technology for particular place. A multi attribute evaluation system developed by BMTPC to provide a technical framework for selection of any new technology is given in Figure-2. It may be used by agencies for selection of any technology/construction system.

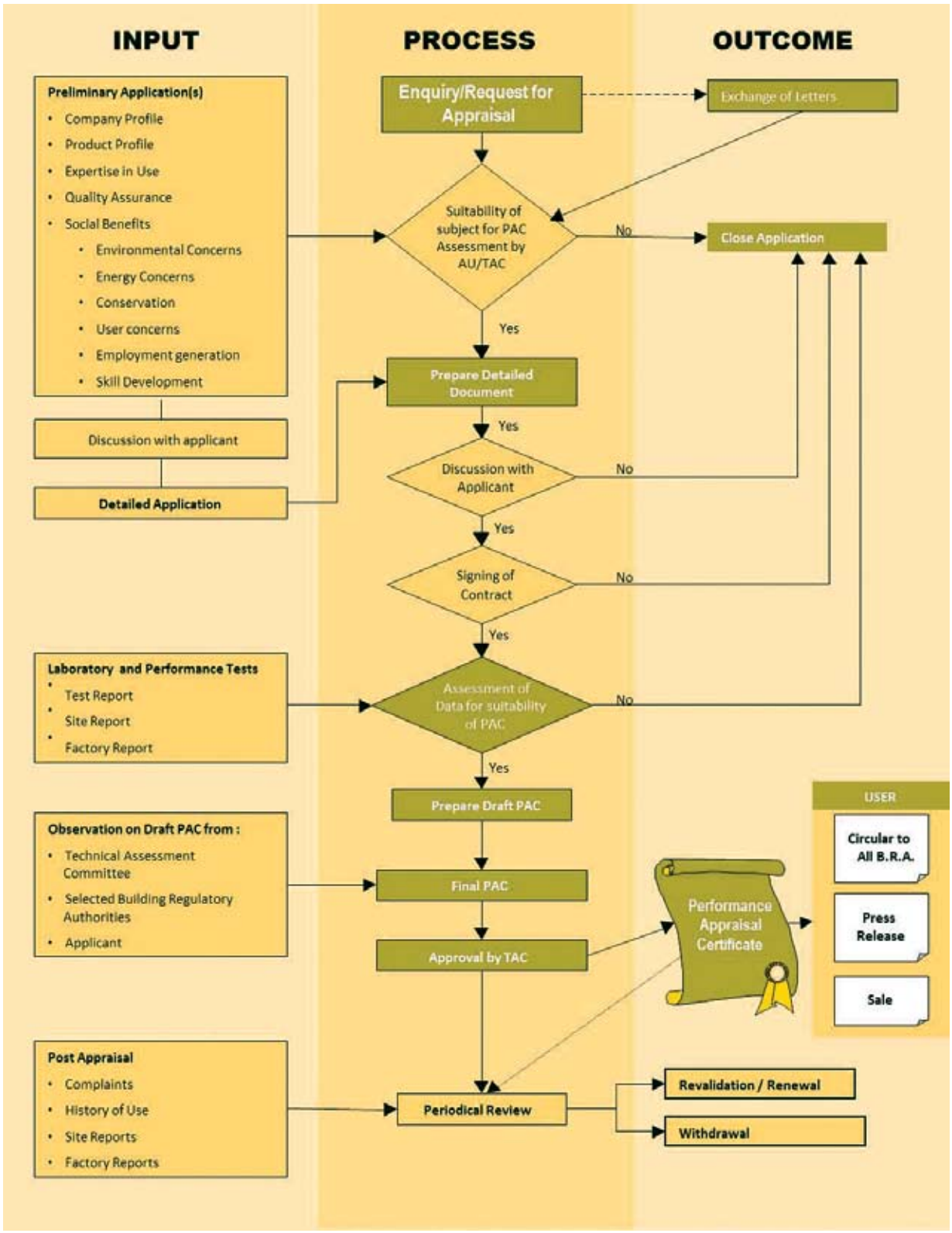


Figure-1: Performance Appraisal Certification Scheme – Process Chart

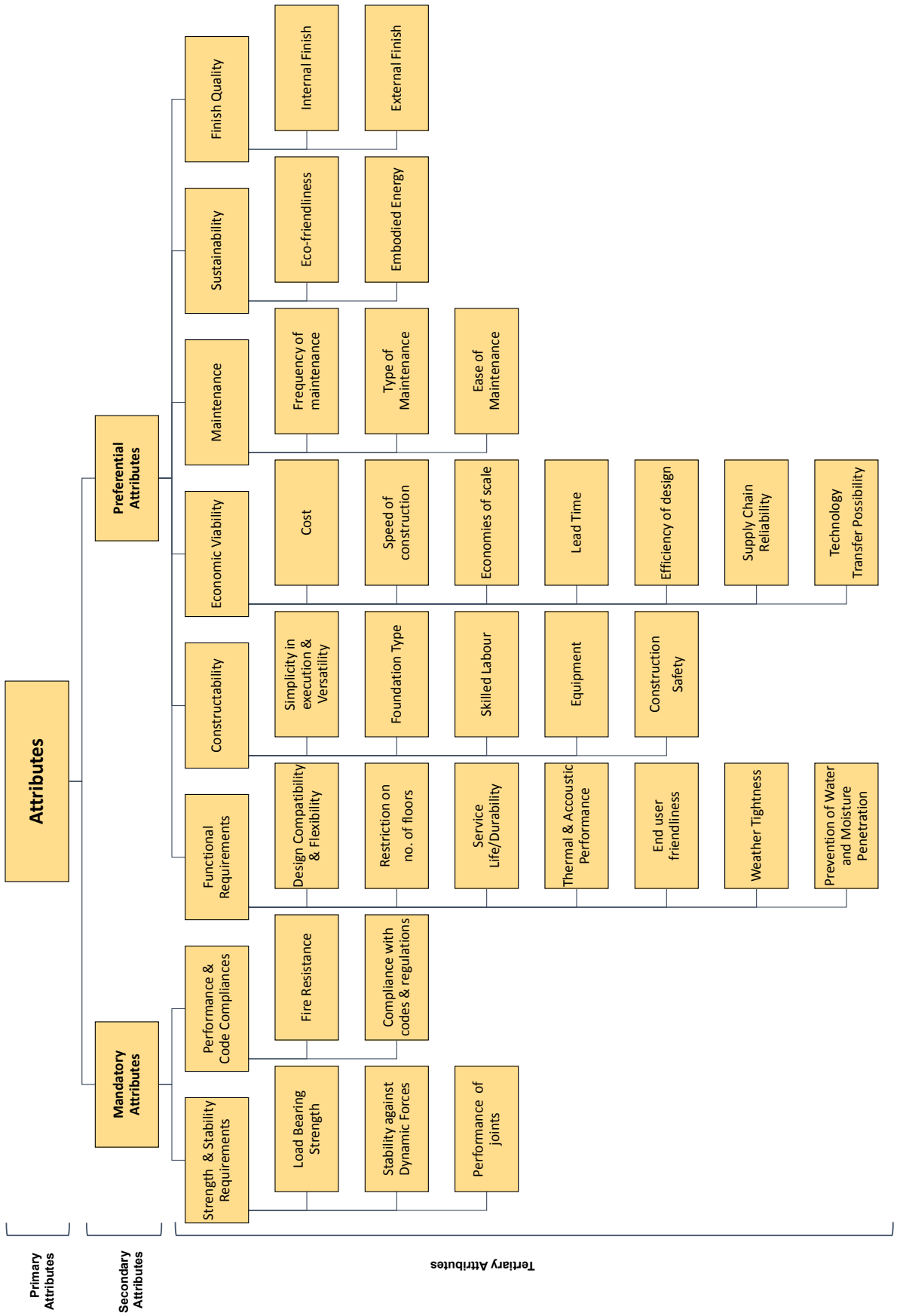


Figure-2: Multi-Attribute Evaluation System for New Technologies

Global Housing Technology Challenge - India (GHTC-India)

Further, to give impetus to use emerging construction systems in PMAY(U) and other construction projects, the Ministry of Housing & Urban Affairs initiated Global Housing Technology Challenge - India (GHTC-India) in January 2019 which aimed to identify and mainstream the globally best available proven construction technologies that are sustainable, green and disaster resilient through a challenge format. The over-arching aim is to trigger technology transition in construction practices for affordable housing. GHTC-India has three components viz. i) Construction Technology India (CTI): biennial Expo-cum-Conference, ii) Identifying Proven Demonstrable Technologies from across the globe to construct Light House Projects (LHPs),and iii) Providing Incubation and Acceleration support for promoting Potential Future Technologies (domestic) through establishment of Affordable Sustainable Housing Accelerators- India (ASHA-India).

Construction Technology India (CTI), 2019, the 1st Biennial Expo-cum-Conference was organized on 2-3 March 2019 for providing a platform for exhibition, assessment and promotion of Innovative Construction Technologies from across the globe. The CTI-2019 was inaugurated by Hon'ble Prime Minister of India. Both Indian and International Technology Providers/ Companies participated in this challenge process. In the CTI-2019 Expo-cum-Conference 54 Innovative Construction Technologies were shortlisted as per the suitability of construction in different geo-climatic regions of the country and grouped into six broad categories namely (i) Precast Concrete Construction System - 3D Precast volumetric (ii) Precast Concrete Construction System - Precast components assembled at site (iii) Light Gauge Steel Structural System & Pre-engineered Steel Structural System (iv) Prefabricated Sandwich Panel System (v) Monolithic Concrete Construction, and (vi) Stay in Place Formwork System. Out of 54 technologies identified under GHTC-India, 6 technologies have not been covered so far under PACS.

S. No.	Technology	Company	Covered under PACS (Yes or No)
A. Precast Concrete Construction System – Precast components assembled at site (8)			
1.	Precast Large Concrete Panel (PLCP) System with structural members (wall, slab etc.) cast in a factory/ casting yard and brought to the building site for erection & assembling.	M/s Larsen & Toubro	Yes
2.	Pre-cast Concrete Structural system comprising of pre-cast column, beam, precast concrete / light weight slab, AAC blocks/ infill concrete walls.	M/s B.G. Shirke Construction Technology Pvt. Ltd	Yes
3.	Optimal Pre-cast concrete System through structural Analysis, design & equipment support	M/s Elematic India	Yes
4.	Precast concrete construction system using precast walls with precast plank floor.	M/s PG Setty Construction Technology Pvt Ltd	Yes
5.	Pre cast components comprising of beams, columns, staircase, slab, hollow core slab etc. manufactured in plant & erected on site	M/s Teemage Builders Pvt Ltd	Yes

S. No.	Technology	Company	Covered under PACS (Yes or No)
6.	Pre-cast sandwich panel system & Light weight Pre cast concrete slab	M/s Nordicflex House	No
7.	Prefabricated Interlocking Technology (without mortar) with Roofing as Mechnized Precast R.C. Plank & Joist system	M/s Aap Ka Awas Adlakha Associates Pvt. Ltd	Yes
8.	Large Hollow wall prefab concrete Panel (lightweight, interlocking, concrete panel) using factory produced large standard hollow interlocking concrete block.	M/s William Ling	Yes
B. Precast Concrete Construction System - 3D Precast volumetric (4)			
9.	Pre-cast concrete system with columns, beams, walls, slabs, hollow core slabs & also 3D Volumetric components	M/s Katerra India Private Limited	No
10.	Vertical structural modules cast in Plant/Casting yard are assembled together through casting of floor panel. The unit is transported & installed at site.	M/s Moducast Pvt. Ltd	No
11.	3D Modular casting using steel mould and high performance concrete of building modules in factory. These pods are transported to the construction site & assembled.	M/s Magicrete Building Solutions	No
12.	Modules with 3D Volumetric Precast concrete unit, various units make on house	M/s Ultratech Cement Ltd	No
C. Light Gauge Steel Structural System & Pre-engineered Steel Structural System (16)			
13.	LGS Framing with various walling & roofing options	M/s Mitsumi Housing Pvt. Ltd	Yes
14.	LGS Framing with various walling & roofing options	M/s Everest Industries Ltd	Yes
15.	LGS Framing with various walling & roofing options	M/s JSW Steel Ltd.	Yes
16.	LGS Framing with various In-situ light weight concrete walling & in-situ concrete slab	M/s Society for Development of Composites	Yes
17.	LGS Framing with various walling & roofing options	M/s Elemente Designer Homes	Yes
18.	LGS Framing with various walling & roofing options	M/s MGI Infra Pvt. Ltd.	Yes
19.	LGS Framing with various walling & roofing options	M/s RCM Prefab Pvt. Ltd	Yes
20.	LGS Framing with various walling & roofing options	M/s Nipani Infra and Industries Pvt. Ltd.	Yes
21.	LGS Framing with Ecopanely boards as facing material made from agricultural wastes	M/s Strawcture Eco	Yes
22.	LGS Framing with walling as Lightweight concrete (Cement, sand, EPS & proprietary additive) mixed with water & poured between V Premium boards (Autoclaved Cement fibre boards) as facing sheet & various roofings	M/s Visakha Industries Ltd.	Yes
23.	Prefabricated steel structural system with Dry wall system as AAC panels, Puf panels etc	M/s RCC Infra Ventures Ltd.	Yes

S. No.	Technology	Company	Covered under PACS (Yes or No)
24.	Hot rolled steel frame with speed floor	M/s Jindal Steel & Power Ltd.	Yes
25.	Hot rolled steel section with AAC Panels as floor & slab	M/s HIL Ltd.	Yes
26.	AAC wall and roof panel system to provide integrated solution. AAC products are reinforced and used in both load and non-load bearing applications.	M/s Biltech Building Elements Ltd	Yes
27.	AAC Panels are Wire mesh/ steel reinforced for use as wall & slab. Appears to be non load bearing panels to be used with structural framing.	M/s SCG International India Pvt Ltd	Yes
28.	Precast Light Weight Hollow-core wall Panel is a non-structural construction material with framed structures.	M/s Pioneer Precast Solutions Private Limited	Yes
D. Prefabricated Sandwich Panel System (9)			
29.	Reinforced Expanded Polystyrene sheet core with sprayed concrete as wall & slab	M/s Worldhaus	Yes
30.	EPS Cement sandwich Panel): wall & slab with EPS Cement sandwich Panel to be used with RCC or Steel structural frame.	M/s Bhargav Infrastructure Pvt.Ltd	Yes
31.	EPS Cement sandwich Panel): wall & slab with EPS Cement sandwich Panel to be used with RCC or Steel structural frame. Load bearing upto G+1 storey	M/s Rising Japan Infra Private Limited	Yes
32.	Reinforced Expanded Polystyrene sheet core with sprayed concrete as wall & slab	M/s Bau Panel Systems India Pvt Ltd,	Yes
33.	Reinforced Expanded Polystyrene sheet core with sprayed concrete as wall & slab	M/s BK Chemtech Engineering	Yes
34.	Reinforced Expanded Polystyrene sheet core with sprayed concrete as wall & slab	M/s MSN Construction	Yes
35.	Reinforced Expanded Polystyrene sheet core with sprayed concrete as wall & slab	M/s Beardshell Ltd.	Yes
36.	Pre-fab PIR (Poly-isocyanurate) based Dry Wall Panel System" as non-load bearing wall.	M/s Covestro India Pvt. Ltd.	Yes
37.	Sandwich panels as wall & slab	M/s Project Etopia Group	Yes
E. Monolithic Concrete Construction (9)			
38.	Aluminium form work system for Monolithic Concrete construction	M/s Maini Scaffold Systems Pvt. Ltd.	Yes
39.	Aluminium form work system for Monolithic Concrete construction	M/s KumkangKind India Pvt. Ltd	Yes
40.	Aluminium form work system for Monolithic Concrete construction	M/s S-form India Pvt. Ltd.	Yes
41.	Aluminium form work system for Monolithic Concrete construction	M/s ATS Infrastructure Ltd.	Yes
42.	Monolithic Concrete construction using MIVAN technology	M/s Innovative housing & Infrastructure Pvt. Ltd	Yes
43.	Aluminium form work system for Monolithic Concrete construction	M/s MFS formwork Systems Pvt. Ltd.	Yes

S. No.	Technology	Company	Covered under PACS (Yes or No)
44.	Aluminium form work system for Monolithic Concrete construction	M/s Knest Manufacturers LLP.	Yes
45.	'Tunnel form' construction technology, an cast in situ RCC system, based on the use of high-precision, re-usable, room-sized, steel forms or moulds for monolithic concrete construction	M/s Outinord Formworks Pvt. Ltd.	Yes
46.	Aluminium form work system for Monolithic Concrete construction	M/s Brilliant Etoile	Yes
F. Stay In Place Formwork System (8)			
47.	Expanded-Steel Panel reinforced with all-galvanised Steel Wire-Struts serving both as the load-bearing steel structure and as the stay-in-place steel formwork filled with EPS-alleviated concrete.	M/s JK Structure	No
48.	Factory made prefab Glass fibre reinforced Gypsum cage panels suitable for wall & slab with reinforcement & concrete as infill as per the requirement.	M/s FACT RCF Building Products Limited,	Yes
49.	Structural Stay In Place Galvanized Steel formwork system for walling with the same bottom single layer formwork for slabs/ in-situ slab	M/s Coffor Construction Technology Pvt. Ltd	Yes
50.	Factory produced PVC Stay in place formwork with concrete & reinforcement in walling units with cast in-situ RCC Slab.	M/s Joseph Jebastin (Novel Assembler Private Limited),	Yes
51.	Fully load bearing walls with 150 mm monolithic concrete core sandwiched inside two layers of EPS as walling.	M/s Reliable Insupack Building Solutions	Yes
52.	Ready to use Stay in place polymer formwork, light weight, with flooring slab (combination of ferro cement and natural stone) placed on RCC precast joists)	M/s Kalzen Realty Pvt. Ltd	Yes
53.	FastBloc, Insulated Concrete Form (ICF), acts as formwork for concrete and rebar, Coloumn/post and beam construction, creating an strong skeleton in the walls.	M/s Fastbloc Building Systems	Yes
54.	Formwork system "Plaswall" with Two fibre cement boards (FCB) & HIMI (High Impact Molded Inserts) bonded between two sheets of FCB in situ and erected to produce a straight-to-finish wall with in-situ concrete.	M/s FTS Buildtech Pvt. Ltd	Yes

The construction systems presented in the Compendium can help construction fraternity/users to choose a technology out of the basket of enlisted technologies (44 technologies certified under PACS & 54 technologies shortlisted under GHTC-India) which are resource-efficient, climate-responsive, energy-efficient, eco-friendly & disaster resilient ensuring faster delivery of sustainable housing and infrastructure with improved structural and functional performance than the cast-in-place conventional RCC framed construction.






Precast Concrete Construction System – 3D Precast Volumetric

Volumetric (3D) Concrete Printing Technology (VCPT)

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE SYSTEM

3D Printing, also known as additive manufacturing, is an automated process that produces complex shaped geometries from a 3D Model (Computer-aided design (CAD) model) on a layer-by-layer basis. It is used in various manufacturing industries such as automobile, aerospace, medical etc.

3D Concrete printing technology (3DCP) constructs concrete structures by selectively placing a special quick-setting concrete mix using a numerically controlled robotic printer layer by layer as per a 3D CAD model. The operation can be performed with minimal human intervention/support and eliminating the need for formwork to construct walls. It is either executed on the site (Like cast In-situ) or Offsite in a centralised set-up (Like precast). In offsite 3DCP, the units or components are printed in the factory and then transported to the assembly site. In onsite 3DCP, the units are constructed at the site directly.

BASIC RAW MATERIAL REQUIREMENTS

1	Cement – OPC 53 Gr	IS 269
2	Fly ash	IS 3812 Part1
3	Micro silica	IS 15388
4	Crushed sand (5mm down)	IS 383
5	Chemical admixture-PCE based	IS 9103
6	Chemical admixture- VMA	ASTM C494
7	Chemical admixture- shrinkage reducer	ASTM C 494
8	PP Fiber (Micro 6 to 12mm)	
9	Water	IS 456

Specifications of Raw Materials

3D concrete mix design requires paradoxical combination of concrete properties to achieve successful printing. An appropriate proportion of aggregate, cement, mineral admixtures and reinforcing fibres enables a wider particle size distribution, making it possible for the fresh mixture to achieve good mix.

The material must maintain its shape and sustain subsequent layers after extrusion. Due to difference between conventional construction methods and 3D-printing process, it is important to consider both fresh and hardened properties of materials.

SPECIAL FEATURES OF THE SYSTEM

- Eliminates the use of formwork
- Automated construction ensures excellent build quality and safety
- Rapid construction with significant improvement in productivity
- Cost optimisation possibilities that are constrained in conventional formwork & execution methods
- Innovative design possibilities to elevate aesthetics and convenience to end users
- Optimum usage of skilled workmen
- Highly digitised 3DCP workflow offers good predictability of the execution results
- 3D printers are lightweight systems that can be easily shifted, erected, and commissioned at job sites

USES OF THE SYSTEM

VCPT is a digitized version for replacing conventional concreting process at locations having facilities for mechanization and automation. The end product from this process is similar to regular concrete products and can be used with appropriate engineering at all suitable locations requiring concrete construction.

Special Aspects of Use /Limitations:

- Basic performance and analysis behaviour shall be similar to regular concrete buildings.
- Skilled manpower with appropriate engineering and implementation techniques is required.
- Climatic conditions as required for regular concrete production will suffice. Efficiency and quality of product is further enhanced if factory like controlled environment is provided.

Maintenance is required for:

- External surface having primer with external grade paint finish
- Internal surfaces having primer with Internal grade paint finish
- Wet areas having suitable water proofing with protective plastering

MANUFACTURING PROCESS

VCPT System manufacturing details

3D Concrete printing technology (3DCP) constructs concrete structures by selectively placing a special quick-setting concrete mix using a numerically controlled robotic printer layer by layer as per a 3D CAD model. The operation can be performed with minimal human intervention/support and eliminating the need for formwork to construct walls.

3DCP requires comprehensive knowledge and control of 3Ms (Material, Machines and Methods) to successfully operate in a large scale and speed demanded by construction industry. The interaction between 3Ms need to be seamlessly integrated within the system to get the perfect results.

Manufacturing Machinery

It primarily comprises of the following three subsystems,

- Pumping system
- Positioning system (Typically, a part of 3D Concrete Printer)
- Extrusion system (Typically, a part of 3D Concrete Printer)

The agency has used a Cartesian printer with active extrusion system for its printing works.

Pumping system:

Due to the nature of thixotropic material consistency required for 3DCP, special type of concrete pumping system is needed. Segregation of mixture ingredients, change in mixture properties are few undesirable effects that can be resulted with a wrong pumping system. The pump must also be able to keep the mixture in continuous agitation to prevent flocculation of the mixture. Based on various research trials, piston type pumps have finally been zeroed down, which are best suited for 3DCP application and able to overcome the above cited issues.

Positioning system:

Based on market research, there are two types of the positioning systems used for 3D concrete printing.

Cartesian Printers

Cartesian Printers are characterised by mechanisms that are configured to act like mutually perpendicular axis of 3D coordinate system. The positioning of the end effector is achieved by the relative motion of machine parts along one of its axis rails. The workspace of these robots is enclosed within in dimensions of the robot or conversely Cartesian robots occupies space outside its build volume. As the dimension of such robots are limited only by the length of rails along each axis, these kinds of robots can provide large workspaces for printing. The following figures showcase the variation of 3D printers in this kind of system.

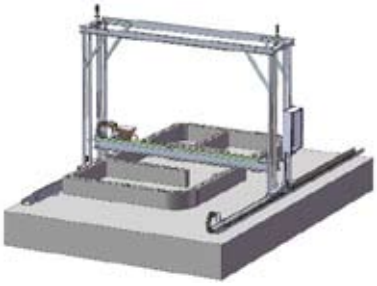


Figure 1 Cartesian Printers 1



Figure 2 Cartesian printers 2

Radial Printers

Radial Printers are located at the centre of their build volume and they build structures around them or away from them. Industrial 6 axis robots and crane like cylindrical robots belong to radial mechanism. Their primary advantage is that they come as a single unit and does not require assembly and installation like Cartesian systems at site. This enables them to be mounted on mobile platforms to act like mobile 3d printers. But unlike Cartesian systems their build volume is limited and is constrained by the reach of its mechanical arm. The following figures showcases the variation of 3D printers in this kind of system.



Figure 3 Radial printers 1



Figure 4 Radial printers 2

Extrusion system

It refers to the mechanical assembly at the end of printer head that controls how the material is extruded from the tip. The extrusion systems have control on the following variables of 3D printing.

a) Addition of admixtures for property modification at the tip
b) Control on rate of extrusion
c) Compensation for minor change in material properties in permissible ranges
d) Creating a desirable extrusion profile while depositing the material on the print
e) Forming of the deposited material for tighter dimension control of the final print.

Extrusion system can be classified as passive extrusion systems and active extrusion systems. Active extrusion will have mechanical actuators that will actively control the material flow at the tip. Passive extrusion does not have any dedicated systems for controlling material at the tip and directly depends on the pump for achieving the desired flow rate. Active extrusion system is most preferred to have better control on the printing process and concrete flow.

CONSTRUCTION PROCESS

Volumetric (3D) Concrete Printing Technology (VCPT) based G+1 building (mock-up) was built in the engineering workshop at the company's Kanchipuram facility, Tamil Nadu. The building was built as a part of a study to use this technology to improve speed and scale, especially for mass housing projects. The total built up area of the building is 700 square feet. The actual photograph of the building is given below.



Figure 5 Actual photograph of prototype project constructed by L&T to demonstrate the 3D printing technology

Based on the design validation established vide this proposal and successful demonstration by printing India's first G+1 3D printed building, L&T Construction recommends the implementation of Volumetric (3D) Concrete Printing Technology (VCPT) for construction applications.

Structural System

G+1 building consists of structural wall in superstructure and strip foundation. The member size and geometry were selected to suit 3D printer capabilities. The concrete layer dimensions that can be printed depend upon the printer nozzle size. The printer (COBOD) is set to print concrete layer up to 45 mm wide and 15-20 mm thick according to the requirements. There are no limitations on member geometry since the printer nozzle would follow the geometry from 3D digital model.

Foundation

The Strip footing constructed using conventional method. The strip footing used as a substructure with 720 mm wide with thickness of 200mm.The reinforcement provided in the strip footing is 8@150mm c/c in both the directions.

Walls

Walls of the G+1 building are printed by 3D printer. Walls are intended to resist both gravity loads and lateral loads. The wall's total thickness is 120 mm, in which there are two outer layer 45 mm thick and inside grout of 30 mm is filled with the same material. Hence 45+45+30 = 120 mm. Minimum reinforcement (8 @250 mm c/c) is provided in both horizontal and vertical direction to take care of any shrinkage and cracks. Hence, the end product wall is like a regular RC wall, only with the casting process difference. Each wall is divided into 3 segments. The height of each segment is 1m.

Printing Process

1. There are 4 stages of printing to finish a floor.
    a. Printing with start rebars in place (Max possible height of 400mm)
    b. Continuous normal printing for a height of 2850mm
    c. Printing of Lintel level layers as an exception that spans from 2100 mm to 2200 mm.
    d. Printing of the top layer from 2850 mm to 3000mm
2. Printing of initial 400mm is done with a specially designed nozzle to ensure that the machine parts does not interfere with the protruding starter rebars at the bottom. This must be done with great care and vigil



Figure 6 Wall printing photos

as there is high risk of machine running into a rebar if the rebar has strayed away from its initial position due to some human errors.

3. Normal printing can commence once the print has built-up above the starter rebar levels. It is advisable to use a different nozzle at this stage without offsets to reduce the risk of errors. This is a system dependant attribute.
4. The dimensional conformance of the built wall must be always monitored. This can be automated with profile sensors or camera mounted on top of the print head.
5. Any deviation in material behaviour can be corrected during live operation if the behaviour is in the permissible range of printability.
6. If the material property is found to deviate beyond the permissible range of printability, printing shall be stopped, and material shall be retuned back to its original state.
7. In the event of temporary pause of printing the system shall ensure that wetness of top layer is always maintained until printing is resumed. This can be done by sprinkling of water or with mist spraying.
8. In the last stage of printing a floor (ie. from 2850mm to 3000mm) only the exterior skin of the outer wall of the building is printed. These layers behave as the external formwork while slab activities are carried out later.



Figure 7 Reinforcement Strategy

Reinforcement

1. During G+1 building printing, 100mm wide weld meshes with 30mm pitch is used as horizontal distributors.
2. Horizontal distributors are placed at an interval of 250mm vertically, as per the approved design. Dedicated team members in-charge of reinforcement places the pre-cut weldmesh sheet on top the printed layers such that the sheets rest evenly on the inner and outer skin of the printed wall.
3. The weld meshes are overlapped at corners, wall intersection and wherever the continuity of reinforcement must be ensured.
4. Special care is taken to while placing the weldmesh sheets at starter bars so as to ensure that the starter bars does not deviate from their position while the weld meshes are inserted through them.
5. Weld mesh sheets of this dimension look like an array with three rows where one row rest on inner skin of the wall and the last row rest on the other skin of the wall. The centre row thus takes care of aligning the vertical rebars that are placed at a later point in the printing.
6. Vertical rebar 8mm dia are inserted from the top of the wall through the centre gap once the printing of

the whole wall height is complete.

7. The insertion is done at an interval of 250mm along the length of the wall, as per the approved design.
8. The weld meshes placed at appropriate interval routes the vertical rebars to its exact location so that lapping with the starter bars at the foot is ensured.

Grouting Works

1. After completion of walls 3D Printing to the required floor height, the concrete grout (Liquid form 3D print concrete mix) is uniformly filled across the gap between 3D Printed walls.
2. During the testing, it was found that a homogenous bonding behaviour between 3D printed wall and grouted portion.

Lintel Works

1. At the lintel level, printing is performed normally with few additional considerations.
2. Once the lintel height is reached temporary formworks in the shape of plates are placed in the window or door area. These plates are supported by props that transfer load to the windowsill or floor.
3. Alternatively, compliant window and door frames can be directly placed at this stage to serve as the formwork for printing further on top of it.

Slab

Due to the layer-by-layer vertical formation method of construction, horizontal members like slabs cannot be 3D printed in a job site. Alternately, Slab works can be executed either one of the following methods. Live loads and finishes load along with self-weight are present on the slab, and these are then transferred to walls.

a. Pre-cast Slab members: The off-site precast slab members can be directly erected on top of 3D printed concrete walls, as per the prevailing approved construction design and methods.
b. Cast In Situ Slab: The slab can be casted in-situ using formwork system, as per the prevailing approved construction design and methods.

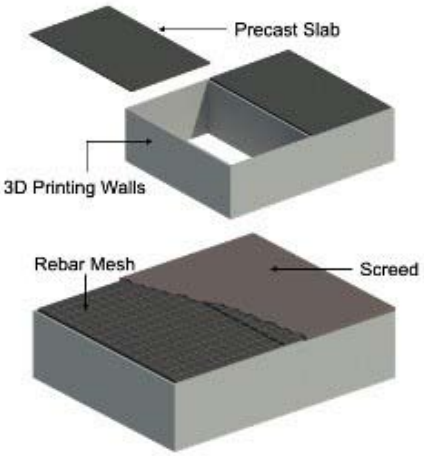


Figure 8



Figure 9

MAJOR WORKS UNDERTAKEN

1. Prototype building (G+1) of 700 sqft. built up area at Kanchipuram, Tamil Nadu (G+1)
2. 32 houses of 300 sqft. each (G+3) at IIT Madras campus, Chennai - proposed.

CERTIFICATION

Performance Appraisal Certificate No. 1059-S/2022 has been issued to M/s Larsen & Toubro Ltd., Chennai.

STANDARDS/REFERENCES

IS-875 (Part 1) – 1987	Code of Practice for Design Loads (other than earthquake) for buildings and structures – Unit weights of buildings materials and stored materials
IS-875 (Part 2) – 1987	Code of Practice for Design Loads (other than earthquake) for buildings and structures – Imposed loads
IS-875 (Part 3)- 2015	Code of Practice for Design Loads (other than earthquake) for buildings and structures – Wind loads
IS-875 (Part 5) – 1987	Code of Practice for Design Loads (other than earthquake) for buildings and structures – Special loads and load combinations
IS: 456 – 2000	Code of Practice for Plain and Reinforced Concrete
IS: 1893 (Part 1) – 2016	Criteria for Earthquake resistant design of structures
IS 13920- 2016	Code of Practice for Ductile Design and Detailing of RC Structure subjected to Seismic Forces
IS 516-1959 (RA 2018)	Methods of tests for strength of concrete
IS 383 : 2016	Coarse and Fine Aggregate for Concrete - Specification (Third Revision)
IS 269 - 2015	Ordinary Portland cement - Specification (Sixth Revision)
IS 3812 (Part 1)-2013	Pulverized fuel ash - Specification: Part 1 For use as pozzolana in cement, cement mortar and concrete
IS 9103-1999 (RA 2018)	Specification for Concrete Admixtures (First Revision)
IS 15916 : 2010	Building Design and Erection using Prefabricated Concrete — Code of Practice
IS15917 : 2010	Building Design and Erection using Mixed/ Composite Construction — Code of Practice
IS 11447 : 1985 (Reaffirmed 2003)	Code of Practice for Construction with Large Panel Prefabricates





Concrete 3D Printing Technology (C3DP)

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE SYSTEM

Concrete 3D printing is the technology in which concrete layers are laid one over the other using an automated robotic system. The system consists of a pump and extruder along with a print head. The entire printing process is streamlined with the help of software integrating the machine & material parameters.

Special features of the system include the following;

i. Design Freedom – A wide range of designs can be constructed which are structurally stable.
ii. Construction Efficiency – Construction time can be reduced due to the inclusion of automation during construction. Also, the manpower requirement can be reduced significantly.
iii. Automation – The process of construction is performed using robotic systems, also bringing accuracy.
iv. Labour safety – The safety of the workers can be enhanced by the use of this technology.
v. No Requirement of Formwork- The printing operation of the vertical elements does not require formwork.

BASIC RAW MATERIAL REQUIREMENTS

1.	OPC – 53 Grade	IS 12269-2013
2.	PPC	IS 1489 (Part 1) – 1991 (Reaffirmed. 2020)
3.	Fly ash	IS 3812 (Part 1)-2003
4.	Water	IS 456 – 2000
5.	Sand	IS 383 – 2016
6.	Accelerating admixture	IS 9103 – 1999 (Reaffirmed. 2018)
7.	PCE based superplasticizer	IS 9103 – 1999 (Reaffirmed. 2018)
8.	Viscosity modifying admixture	ASTM C494/C494M
9.	Non-structural fiber (6 to 18 mm)	

Specifications of Raw Materials

3D concrete mix design requires paradoxical combination of concrete properties to achieve successful printing. An appropriate proportion of aggregate, cement, mineral admixtures and reinforcing fibres enables a wider particle size distribution, making it possible for the fresh mixture to achieve good mix.

The material must maintain its shape and sustain subsequent layers after extrusion. Due to difference between conventional construction methods and 3D-printing process, it is important to consider both fresh and hardened properties of materials.

SPECIAL FEATURES OF THE SYSTEM

- Eliminates the use of formwork
- Automated construction ensures excellent build quality and safety
- Rapid construction with significant improvement in productivity
- Cost optimisation possibilities that are constrained in conventional formwork & execution methods
- Innovative design possibilities to elevate aesthetics and convenience to end users
- Optimum usage of skilled workmen
- 3D printers are lightweight systems that can be easily shifted, erected, and commissioned at job sites.

USES OF THE SYSTEM

The main uses of the system are;

i. Faster construction of concrete structure using high-efficiency appliances, low material wastage & without the requirement of formwork for vertical members.

ii. Construction of customized & air-gap insulated building walls/elements, reducing heat gain through walls, as per the requirement.

MANUFACTURING PROCESS

Concrete 3D Printing Process

The machine consists of a pump, extruder along with a print head, and an accelerator mixing setup at the nozzle, as shown in Fig.1. The printable mix needs to satisfy the three material requirements of pumpability (ability to be pumped), extrudability (ability to be extruded), and buildability (ability to build).

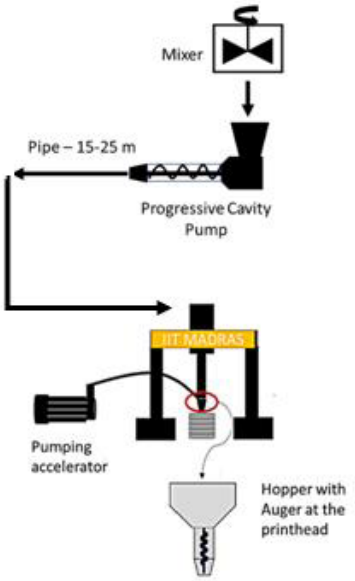


Fig. 1 Machine for 3D Printing

Printer

The printers used by Tvasta for executing construction projects have been designed and developed in-house to achieve optimal resource utilization and unconventional architecture. The printers have numerous subsystems that ensure its operations. These are integrated using our proprietary software to streamline the printing process.

The printers have been designed to follow two methods of machine movement, namely, *Gantry and Robotic Arm*.

Gantry-based Concrete 3D Printers

These printers consist of Tvasta printheads mounted on a gantry system. The printheads print the proprietary material through *screw-based extrusion*. The range of printers includes;

- ***R&D scale Concrete 3D Printer***

  Research 3D Printer aiding 3D Printing with a variety of materials has been developed by the Agency, as shown below in Fig. 2, which is compatible with various materials and designs, easy and user-friendly in machine operation.



Fig. 2 Printing setup Gantry based – R&D

- ***Off-site Concrete 3D Printer***

  This printer (Fig. 3) can be used to print large-scale concrete parts that can be used individually or assembled to form a bigger structure. It implements a novel multi-pallet printing mechanism, allowing fast printing.



Fig. 3 Printing setup Gantry based – Off-site

- ***On-site Concrete 3D Printer***

The on-Site Printer developed by the Agency is a system intended to print large-scale concrete structures such as residential buildings as shown below in Fig. 4. This printer can be assembled on-site and can be made ready to print (24/7) in a short duration of 2 days. A unique truss framework allows ease of transport and assembly. It has a real-time feedback system with sensors for precise printing of layers and an automated material supply system for dust-free operations.



Fig. 4 Printing setup Gantry based – On-site

Robotic-Arm based Concrete 3D Printers

These printers consist of printheads developed by the Agency mounted on a robotic arm. The printheads print the proprietary material through screw-based extrusion. The range of printers include;

- ***Stationary Robotic Arm-based Concrete 3D printer***

It is 6-axis robotic arm with 3 m reach (Fig.5), equipped with a unique extrusion system that allows ease of printing and movement for both large and small-scale production. This also provides greater design flexibility, faster production times and seamless deposition of layers through advanced nozzle and smart sensor systems. The streamlined arm enables access to tight spots without potentially interfering with printing.



Fig. 5 Printing setup Robotic arm – Stationary

- ***Mobile Robotic Arm-based Concrete 3D Printer***

This printer utilizes a distinct 7th axis motion system in addition to 6 axes of a robotic arm (Fig. 6). The motion system consists of a crawler that enables printing large and small-scale structures. The printer has larger reach than a fixed robot and can be used ideally in a factory-setup for production.



Fig. 6 Printing setup Robotic arm – Mobile

Mixer

A batch-type mixer (Pan type planetary mixer or Drum mixer) is preferred. However, an inline continuous mixer can also be used to prepare the concrete. The dosage of admixtures needs to be optimized to reduce the probability of segregation or bleeding depending on the mixing system and parameters such as speed etc.

Pumps

Any commercially available screw-based positive displacement pump (Fig. 7) (with maximum particle size of 8 mm) or piston-based pump with the provision of zero dead volume can be used to pump 3D printable mix. Both pumps are used for different projects. No special modification to the available commercial pumps is required for this process.



Fig. 7 Pumping system

The accelerator/chemical admixture is pumped using a commercially available centrifugal pump to the nozzle head/ extruder.

CONSTRUCTION PROCESS

C3DP System manufacturing details

The manufacture of the concrete 3D-printed building is schematically described in Fig. 8. In the first step, the concrete needs to be designed and prepared using specified raw materials. The quality check and control of the raw materials are performed as per quality assurance plan. After batching of the concrete, the quality is checked again, and the concrete is transferred to the pump for pumping. Simultaneously, the software file for the robot to function is processed. The 3D module in the form of .stl file is further sliced to form the G-code. The G-code is needed for the control of the print path. The robotic movement needs to be ensured before the initiation of the real print. The printing of the modules is controlled by both machine and material parameters.

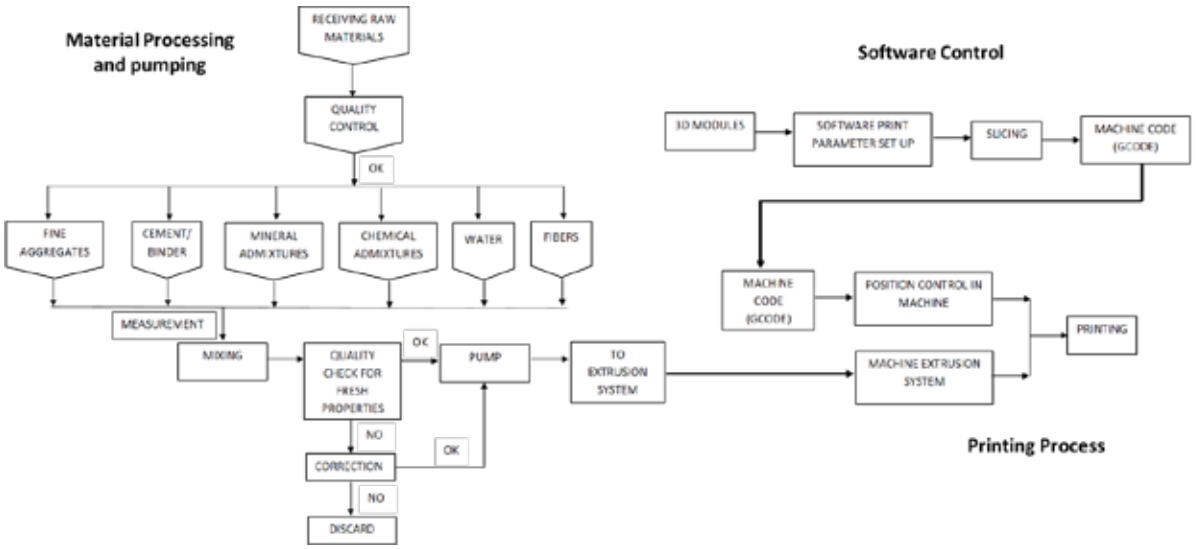


Fig. 8 Schematic diagram –Concrete 3D-printing of building

Construction of 3D Printed building - Structural system

Fig. 9 describes the construction process at different elemental levels of the 3D printed building. The construction is divided into six steps starting from foundation to upper storey slab/roof. The foundation can be either cast-in-situ or precast. The outer boundary of the footing can be of 3D printed elements, however, lateral support is needed during the concreting of the foundation. The foundations are designed and constructed as per the guidelines of IS

Conventional/ Precast foundation	With 3D printed outer boundary and lateral support or conventional formwork	Rebar needs to be conventionally placed for the foundation	Foundation casting shall be done as per the cast-in-situ method mentioned in relevant IS codes. For precast foundation, single footing foundations is only accepted.	Reinforcement as per IS 456 and IS 15916. Connections between grouted RC frame sections should follow IS 456, IS 15916, and IS 15917. Min reinforcement provision need to be satisfied for plain wall panels also. *Provision of tie beam and tie column is necessary for load bearing wall systems *Reinforcement placement shall be as per the suggestion of structural engineer.
		Starter rods for column/ wall		
Conventional / 3D Printed plinth beam	Precast 3D printed plinth beam can be used	Damp proof course on top of the plinth	3D Printed beams as precast beams can be used for plinth beam or the cast in-situ beam with conventional formwork can also be done.	
Ground floor slab/ Plinth level slab	Conventional slab casting	Sand filling before casting the slab		
Walls	Printed as wall modules. It can be both load bearing (part of RC frame) or non-load bearing	Modules are transported to the site and assembled as large panels	Printer is hosted at a covered place where modules are printed. Modules can be grouted at the factory also before transportation or grouted at site	
		Modules are printed on the plinth beam at site	Printer transported and installed at the site for printing modules. Foundation provision need to be provided for the printer installation.	
Columns and beams	Columns and beams	3D printed as columns and beams to be a part of RC frame. Encapsulated by 3D printed walls	Columns and beams are cast within the wall modules with help of external supports and props. The columns and beams can be grouted at factory or site with provision of connections for monolithic behaviour.	
Slab/ roof	Conventional or precast roof	3D printed as precast roof and connected at site or 3D printed and supported by shuttering and props as cast roof on-site		

Fig. 9 Construction steps for a 3D printed building

456 and NBC. The plinth beam can be cast on-site or precast plinth beam can also be used. 3D printed beams as precast plinth beams can be used following the requirements of relevant IS codes for footings (such as IS 456, IS 15916 etc.). The ground level/ plinth level floor is constructed using the cast-in-situ method.

The wall modules can be constructed in two ways - (a) The modules are printed away from the site and transported to the site, and assembled on the plinth beam and on subsequent beams of the building at different floors, and (b) The printer is installed at the site, and the modules are printed directly on the plinth beam and on subsequent beams at different floors. The construction of the first floor commences only after the full construction of the ground floor (excluding MEP and finishing), including the infill or encapsulating walls. If the walls are load-bearing, the modules constructed by either method 'a' or 'b' are joined together using tie beams and tie columns at-site while grouting the modules following cast-in-situ method. If the modules are printed as per method 'a', the panels need to be erected using manpower or machines depending upon the size of the modules. Partial grouting of the modules at the factory is possible while allowing provisions to be connected at-site. However, for both cases, the provision for connecting the modules at-site is provided and shown in Fig. 10. If the modules are printed at-site, the printer nozzle can be positioned over the last printed modules/ tie beam/ beam and printing of subsequent modules can be continued. The grouting of load-bearing components with reinforcement is done at site using cast-in-situ method. If the RC frame consists of beams and columns instead of load bearing walls, required provisions as per the dimension requirement are provided as shown in Fig. 11. These provisions can be grouted after inserting reinforcements either in the form of cages or through manual lapping of bars at-site. Cast-in-situ method is used for grouting the columns and beams at-site. Fig. 12 shows an example of the process of joining a plinth beam/ foundation wall with the column cage and provision of lateral support during column grouting. While a panel printed away from the site is shown in the picture, a similar strategy will be used for the panel printed at site over the plinth beam/ foundation wall. In the end, a cast-in-situ slab or precast slab can be used for the upper floor slab or roof. Shuttering will be required for cast-in-situ, whereas props will be required for precast until connections gain the required strength. The complete flowchart of the process flow is shown in Fig. 13.

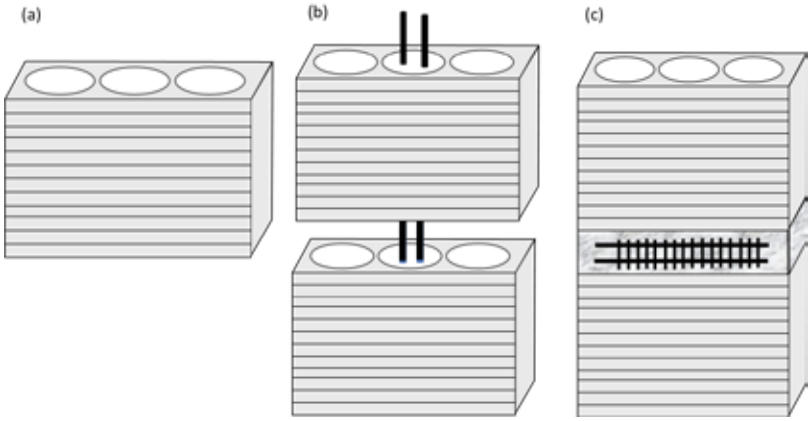


Fig. 10: (a) A single wall panel with cavities/ provisions, (b) vertically joining with rebars, (c) Tie beams to connect the horizontal modules. The vertical reinforcement and the tie beams/ beams will be joining all the modules together

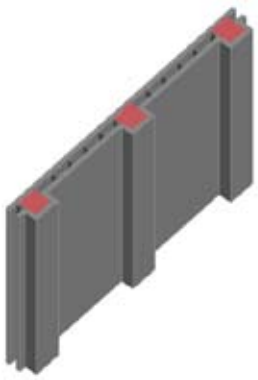


Fig.11 Provision of column and beam in the printed encapsulating wall



Provision of Join panels with footing wall/ plinth beam

Column reinforcements at different wall provisions

Lateral support during grouting of column/ beam

Fig. 12: Joining column with footing/ plinth beam (left), column reinforcement at selected positions (center), Lateral support while concreting column (right)

Curing protocol

The curing protocol needs to follow IS 456. Curing shall initiate just after the starting of printing or near the initial set of the material to avoid plastic shrinkage cracks. 21 days of curing is prescribed to avoid drying shrinkage cracks for 3D printed wall panels.

MAJOR WORKS UNDERTAKEN

- India's First 3D Printed House at IIT Madras, Chennai
- 3 Number of Doffing Unit at various locations in Tamil Nadu
- Sanitary Block for Air Force Station Jaisalmer, Rajasthan
- Guest House for Air Force at Chiloda, Gujarat
- Modular Site Office at GRSE, Kolkata
- Bus Stand at Mumbai
- BPCL Boundary Wall at Krishnapattam, Andhra Pradesh
- Anant Siras Statue at Chennai
- M.A.Chidambaram Stadium Boundary wall at Chennai

CERTIFICATION

Performance Appraisal Certificate No. 1068-S/2023 has been issued to M/s Tvasta Manufacturing Solutions Private Limited, Chennai.

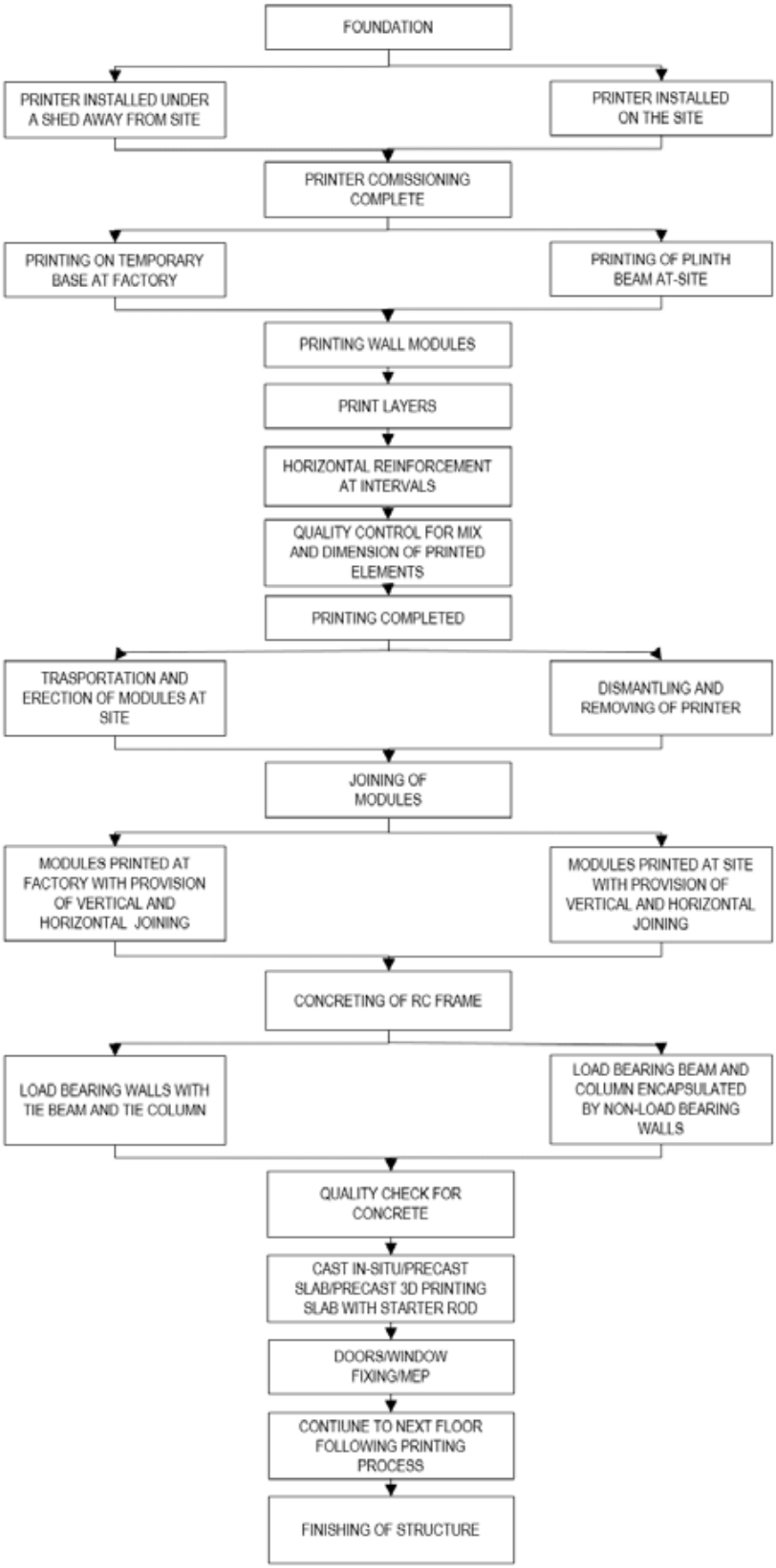


Fig. 13 Construction steps followed for the 3D printed building

STANDARDS/REFERENCES

Loads and Structural Design	
IS:456-2000	Plain and reinforced concrete- Code of practice
IS:875-1987 (Reaffirmed 018/2020)	Code of practice for design loads (other than earthquake) for Buildings and structure (Part 1 to Part 3)
IS:1904-2021	General requirements for design and construction of foundations in soils — Code of practice
IS:1893 (Part-1)-2016	Criteria for earthquake-resistant design of structures (Part 1: General provisions and building)
SP:34-1987	Handbook of concrete reinforcement and detailing
Materials and Mix design	
IS:269-2015	Ordinary Portland cement - Specification
IS:1489 (Part 1) -2015	Portland pozzolana cement - Specification, Part 1: Fly Ash based
IS:3812 (Part 1)-2013	Pulverized fuel ash - specification (Part 1 for use as pozzolana in cement, cement mortar and concrete)
IS:383-2016	Coarse and fine aggregate for concrete – Specification
IS 9103-1999 (Reaffirmed 2018)	Concrete admixtures – Specification
IS:10262-2019	Concrete mix proportioning - Guidelines
ASTM C494/ C494M-19	Standard specification for chemical admixture for concrete
Fresh and Hardened properties of Concrete	
IS:1199- 2018 (Part 1 to 9)	Fresh concrete-Methods of sampling, testing and analysis
ASTM C1437-07	Standard test method for flow of hydraulic cement mortar
ASTM C1741-18	Standard test method for bleed stability of cementitious post-tensioning tendon grout
IS 10086-2021	Moulds for use in tests of cement, concrete, and pozzolana- Specification
IS 2720 (Part 10)-1991 (Reaffirmed 2020)	Methods of test for soils (Part 10 determination of unconfined compressive strength)
ASTM C109/109M-21	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50 mm] Cube Specimens)
IS: 4031 (Part 7)-1988 (Reaffirmed 2019)	Method of physical test for hydraulic cement (Part 7 Determination of compressive strength of masonry cement)
ASTM C348-21	Standard test method for flexural strength of hydraulic-cement mortars
IS:516 (Part 1/Sec 1)-2021	Hardened concrete - methods of test: part 1 testing of strength of hardened concrete: section 1 compressive, flexural and split tensile strength
Durability	
ASTM C1202-22	Standard test method for electrical induction of concrete's ability to resist the chloride ion penetration
Reinforcements	
IS:800-2007	General construction in steel - Code of practice
IS:1786-2008	High-strength deformed bars and wires for concrete reinforcement - Specification
IS:1566-1982 (Reaffirmed 2020)	Specification for hard-drawn steel wire fabric for concrete reinforcement
IS:432 (Part 2)-1982 (Reaffirmed 2020)	Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement (Part 2 Hard-drawn steel wire)
Modules testing	
IS 1237-2012	Cement concrete flooring tiles – Specifications
IS 1905-1987: 2002	Code of practice for structural use of unreinforced masonry
ASTM C1314-22	Standard test method for compressive strength of masonry prisms
Precast code	
IS 15916-2020	Building design and erection using prefabricated concrete -Code of practice
IS 15917-2020	Building design and erection using mixed/ composite construction-Code of practice
IS 11447-1985 (Reaffirmed 2018)	Code of practice for construction with large panel prefabricates
IS 3414-1968: 2000	Code of practice for design and installation of joints in buildings
IS 10297-1982: 2008	Practice for design and construction of floors and roofs using precast reinforced/ prestressed concrete ribbed or cored slab units



Precast Concrete Construction Systems -Precast Components Assembled at Site

SRPL Building System (Waffle Crete)

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE TECHNOLOGY



Waffle-Crete Building System consists of large, structural, ribbed panels of reinforced precast concrete, bolted together and the joints between the panels are caulked to form the walls, floor and pitched or flat roofs of buildings.

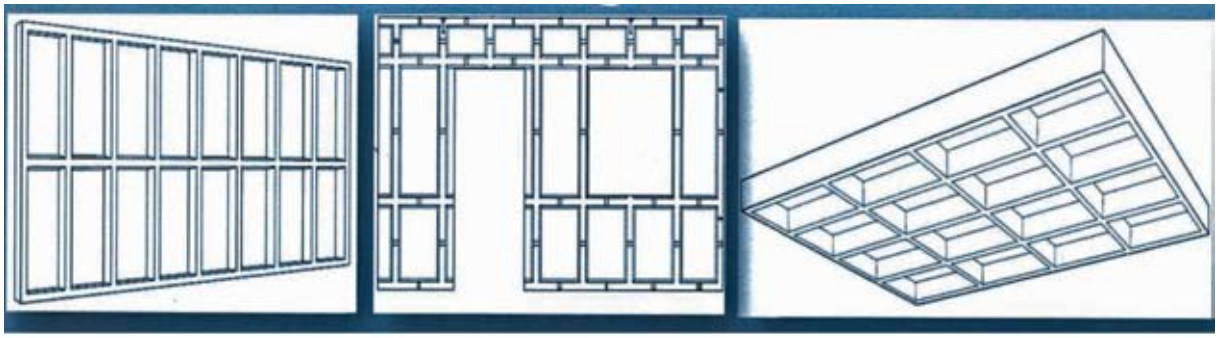
The surface of each panel consists of 51 mm thick slab or skin, stiffened with the ribs around the perimeter and across the panel, giving an overall panel thickness of 152 mm or 203 mm.

In single storey buildings, floors are constructed using precast reinforced concrete floor panels supported on precast concrete grade beams on well- compacted earth. The walls are constructed of 152 mm thick wall panels of precast reinforced dense concrete.

For buildings of more than one storey, the walls are supported on foundations designed as per the soil condition. A concrete apron are laid around the perimeter of buildings where there is a danger of water or wind erosion of the ground adjacent to the building. Metal or timber window and door frames are incorporated into the wall panels during casting or fitted after erection into openings that are formed in the panels during casting.

Internal walls consist of either reinforced precast concrete ribbed panels, conventional masonry walls or concrete walls. Where precast concrete panel or masonry internal walls are used in single storey buildings, these are normally be erected on a concrete surface bed or on concrete strip footings and not on *suspended floor*.

Services like water supply and electricity shall be normally accommodated in preformed slots in the ribs of panels, before the walls are lined. The casting can be done in casting yard while foundation is done, which reduces the construction time. Curing time is reduced by trapping the moisture generated from the concrete. The building after construction can be shifted from one place to another as the structure is joined using bolt connections.



Standard wall panel | Harmonized wall panel | Ceiling/floor panel

The Waffle-Crete system consists of the following core elements:

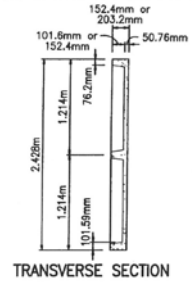
- Lightweight insulated precast insulated molds
- Insulated curing covers that are used in conjunction with Waffle-Crete molds
- Specialized equipment are designed for use with Waffle-Crete molds and covers
- A construction methodology for casting and erecting concrete panels with molds and equipment.

Concrete panels cast in molds and then covered with a curing cover are removed from the mold and erected. Modular panels and bolted connections speed up the erection process. The system can be utilized for a variety of structural applications.

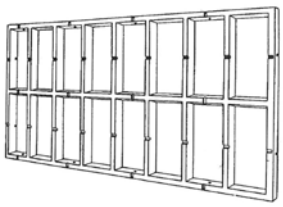
TYPE OF PRECAST CONCRETE PANELS & WALLS

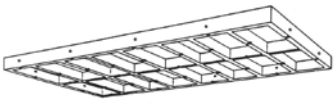
1. Standard reinforced precast concrete wall, floor and roof panels are 2.43 m wide and are manufactured in lengths of 3.65 m, 4.26 m, 4.87 m, 5.48 m, 6.09 m & 7.31 m. The surface of each panel shall consist of a 51mm thick slab, stiffened with tapered ribs around the perimeter and across the panel. The ribs shall be at approx. 1214 mm centres in one direction and 610 mm in the other and give an overall panel thickness of 152 mm or 203 mm, as required.

2. Harmonized reinforced precast concrete wall panels are 2.58 m high and are manufactured in lengths of 3.65 m, 4.26 m, 4.87 m, 5.48 m, 6.09 m & 7.31 m. All harmonized panels shall be 152 mm or 203 mm thickness. The surface of these panels shall consist of a 51 mm thick slab, stiffened with ribs around the perimeter and across the panel. The ribs shall be at approx. 610 mm centers,with two horizontal ribs along its length, one approx. 836 mm from the bottom and the other 418 mm from the top. These panels are used for window/door and window cut-outs.

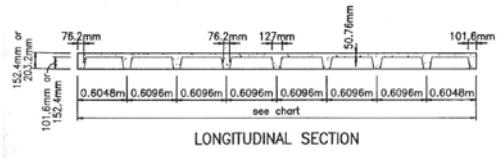


TRANSVERSE SECTION


WALL PANEL – 2.438m height


FLOOR SLAB – 2.438m span

Standard Panel Sizes	
W-12	3.6481m
W-14	4.2576m
W-16	4.8673m
W-18	5.4769m
W-20	6.0865m
W-24	7.3057m
special sizes available	



LONGITUDINAL SECTION

3 Accessory Panels

a) Eave panels are used as decorative building trim and also cover waffle voids that may be exposed on the edges of cut roof panels.

b) Grade beams are used to cast a first floor foundation. Grade beam panel are keyed to fit floor panel ribs.

c) Stair panels are included an adjustable blockout to cast concrete stairs of variable width up to 2.44 m. Stair molds are available in 3.66 m & 6.10 m lengths with 164 mm risers.

4 Waffle-crete Floor Slabs

Thickness of concrete of topping may vary for different requirement of fire ratings. Floor slabs with a 60 minute fire-resistance rating shall require a minimum of 38 mm concrete topping and floor slabs with a 120 minute fire-resistance rating shall require a minimum concrete topping of 75 mm or cladding to the underside.

The joints between the plasterboard shall be sealed according to the manufacturer's recommendations. Floor slabs with a 30 minute fire-resistance rating shall not require a concrete topping. Thickness of concrete topping may vary for different requirement of fire-ratings.

5 Type of Walls

5.1 There are six types of internal and external walls which are used in conjunction with brick or concrete masonry walls etc. The wall panels are 152 mm or 203 mm thick overall.

i. **Type 1** 152 mm or 203 mm panels, unlined.
ii. **Type 2** Wall panels lined on one side with 12.5 mm thick gypsum plasterboard on 38 mm x 38 mm timber studs at 600 mm centers fixed to the panel ribs with screws into nailer blocks cast into concrete at 600 mm centers.
iii. **Type 3** Wall panels lined on one side with 12.5 mm thick gypsum plasterboard of 63.5 mm x 35 mm x 0.71 mm thick on galvanized steel studs spaced at maximum 450 mm centres fixed to the ribs of the panels with 18 gauze steel galvanized wire wound around threaded 6 mm dia. galvanized steel fasteners hand-driven into a previously drilled hole in the rib of the floor panel.
iv. **Type 4** Wall panels lined on one side with two layers of 12.5 mm thick gypsum plasterboard on galvanized steel studs with staggered joints similar to those used in Type 3 wall fixed to the panel ribs in the same manner as wall Type 3.
v. **Type 5** Wall panels lined on one side with 12.5 mm thick gypsum plasterboard on top hat section galvanized steel channels fixed to the panel ribs as for wall Type 3 and insulated with 150 mm thick glass fibre.
vi. **Type 6** Wall panels lined on one side with 12.5 mm thick gypsum plasterboard on timber studs fixed to the panel in the same manner as for wall Type 2 and insulated with 50 mm thick glass fibre.

MATERIAL REQUIREMENTS

Rebar Fe 415/485 are in accordance with IS1786:2008 and of dia. 12 mm, 16 mm & 20 mm.

Wire mesh is made of 6 mm dia. bar as per IS1786:2008 @ 300 mm c/c.

Connection bolts M 16 x160 mm, M 16 x 380 mm & M 16x310 mm conforming to ASTM A 307 Gr A/IS 1363 (Part1-3):2002.

Anchor bolts HIT V M16 & HY 200R chemical conforming to ASTM A 307 Gr A/ IS 1363 (Part 1- 3):2002.
Concreting to be of M 30 grade concrete in accordance with IS 456:2000, without fly ash and coarse aggregate shall be not more than of 20mm size. Water-cement ratio to be 0.40. Mix design with admixtures conforming to IS 9103:1994 shall have compressive strength of 19 N/mm^2 in 18-24 h.

Swift lift Anchor have two anchors in each wall panel and four anchors in each floor panel. Spacing of anchors to be according to cut-outs provision in respective panel.

Gypsum board conforming to IS 2095 (Part 1):2011.

MANUFACTURING PROCESS

Process of manufacturing of the panels is as follows:

i) Waffle-Crete components shall either be cast on site or in casting yard. An inverted panel or a concrete surface bed shall be used as a base on which the components shall be casted.
ii) The heavy quality insulated plastics and aluminium molds shall be blocked off at any point if a particular non-standard sized panel is required.
iii) Holes for bolted connections between components shall be usually formed during the casting of the components.
iv) Metal, RCC or timber window and door frames shall be fitted in the block-outs left for the purpose.
v) Steel rod and mesh reinforcement shall be placed in the mold as specified by the professional engineer responsible for design of the building. Spacer blocks shall be used to correctly locate the reinforcement to ensure that the specified concrete cover is achieved.
vi) Concrete of minimum grade of M 35 MPa shall be poured into the molds from ready mix trucks / dumpers or other suitable means.
vii) Specially designed vibrator shall be used to strike off and compact the concrete in one operation.

viii) The insulated plastics and aluminium cover to the molds keep the heat and moisture during curing of the panels.

ix) The concrete components shall be lifted using specially designed lifting beam, or with cable slings and embedded lifting anchors at appropriate positions.

x) The panels shall be stacked horizontally on top of each other, supported on timber spacers and stored in the casting yard until required at site.



xi) Panels shall be de-molded after checking the results by rebound hammer

xii) Molds shall be stacked in the casting yard and curing of panels shall be done

xiii) The panels shall be transported to the erection location by trailer

xiv) The panels shall be lifted using crane and fixed on the location by connection bolts

xv) After connection bolts are fixed, panels shall be covered with high strength chemicals



xvi) Thereafter, finishing items like flooring, door & window fixing and painting etc. shall be done.

ERECTION PROCEDURE



(i) The properties of the soil on site shall be established by a professional engineer and the foundations and floors designed accordingly.

(ii) The conventional cast-in-situ concrete foundations and surface beds with thickened edge beams or footings, shall be constructed on site in accordance with IS 1904:1986. The surface beds shall be laid on well compacted earth.

(iii) When suspended floor panels and foundations are used, the grade beams shall be located under the longitudinal external walls of the building. They shall be placed in position on the surface of the ground on well compacted and levelled earth, laid end-to-end with butt joints.

(iv) Where the span between the grade beams on either side of the building is such that it is necessary to use two or more floor panels across the width of the building, the ends of the panels at the joints where they meet shall be supported by additional grade beams, laid parallel to the external grade beams.

(v) A continuous damp-proof membrane of a suitable plastic material, at least 0.25 mm thick, shall be provided under conventional concrete foundations and surface beds.

(vi) The wall panels shall be hoisted and set in a vertical position, onto hardwood shims on the panel floor, concrete footing or surface bed, to create a space of uniform thickness under the bottom ribs of the wall panels, for the grouted joint.

(vii) After levelling and aligning the wall panels on the shims, these shall be bolted to the floor panels and grade beams, or to the cast-in-situ concrete surface bed or foundations.

(viii) Where threaded galvanized steel or stainless steel rods are used instead of anchor bolts, the ends of the rods

shall be embedded in epoxy grout in holes drilled into the concrete, in strict accordance with the manufacturer's instructions.

(ix) Sand-cement grout having a compressive strength of 35MPa at 28 days shall be used in all horizontal joints between precast concrete components, unless otherwise specified by the engineer. A vibrator rod shall be used to ensure that the grout completely fills the joints.

(x) Intermediate floors shall always consist of panels which are bolted together. There are three types of floor to wall connections. In the first case the floor panel shall be supported on top of an external wall, in the second case two floor panels shall be supported on an internal wall and in the third case a floor panel shall be supported on a ledger beam.

(xi) Staircases which are of precast concrete shall be deigned in the normal manner and bolted to the supporting structure. At the beginning of a rise, the staircase shall be bolted with a 19 mm dia. vertical expansion anchor through a 76 mm x 76 mm 38 mm recess in the first step to the supporting structure. At the upper end of the rise, the staircase shall be fixed with a minimum of three 19 mm dia. x 254 mm long expansion anchors through the floor.

(xii) On the outside of the building, the grout shall be partially raked out of the horizontal joint all round between the bottom of the external walls and the floor, concrete surface bed or footing to allow for the insertion of butyl rubber rope, followed by a bitumen impregnated foam plastics backer rod or bond breaker and caulked with one component polyurethane sealant.

(xiii) The adjoining vertical ribs of the external panels shall be bolted together with 12.7 mm dia. galvanized steel or stainless steel bolts at 1.2 m centres through preformed or drilled holes for 152 mm thick panels or 20 mm dia. bolts at 1.2 m centres for 203 mm thick panels.

(xiv) The vertical joints between external wall panels shall be caulked on the outside of the building with one component polyurethane sealant a bitumen impregnated foam plastics backer rod or bond breaker.

Roof Construction and Gable Wall

(i) Triangular wall in-fill panels shall be hoisted into position on hardwood shims on top of the end walls of the building and bolted together through the adjoining outer horizontal ribs with 12.7 mm dia. galvanized steel or stainless steel bolts at 1.2 m centres.

(ii) Precast concrete roof panels which span between the gable ends shall be hoisted into position on the sloping tops of the gable wall panels and bedded in 6 mm thick 4:1 sand: cement mortar, to form a pitched roof. The pitch shall generally be 30º.



(iii) Galvanized steel plates, 60 mm long x 100 mm wide x 10 mm thick, at 2.4 m centres and cast into the ribs on the underside of the roof panels on either side of the ridge, shall be connected at the apex by welding a steel rod at the joint between each pair of plates.

(iv) Depending on the structural design of the building and span of roof, the roof shall be supported at its apex by a ridge beam spanning between the gable wall infill panels at each end.

(v) The adjoining roof panels shall be bolted together with 12.7 mm dia. galvanized steel or stainless steel bolts at 1.2 m centres, through preformed or drilled holes in the ribs of the panels. Before fully tightening the bolts, butyl rubber rope shall be inserted into the joint between the panels, followed by a bitumen impregnated foam plastics backer rod or bond breaker and the joint shall be caulked externally with one compound polyurethane sealant or equivalent.

(vi) Flat roof shall consist of 152 mm or 203 mm thick precast reinforced ribbed wall panels bolted together and covered with a conventional waterproofing system on screed. Precast roof copings shall be bolted to the roof panels with 12 mm dia. bolts at 1219 mm centers.

(vii) Internal walls on suspended floors shall usually be constructed of timber with 12.5 mm thick gypsum plasterboard cladding on both sides. Conventional burnt clay or concrete masonry internal walls shall usually be erected on conventional concrete surface beds and foundations.

(viii) Internal walls shall also be plugged and screwed by means of steel brackets and bolts to the adjacent vertical ribs of the external walls at T-junctions and bolted or plugged and screwed to concrete surface beds or precast floors.

Windows, Doors, Services and Attachment of Fittings

Timber or steel window and door frames shall be fitted into preformed openings in the wall panels and sealed all round with silicone sealant, unless they have been cast in during manufacture of the panels.

Electrical and plumbing services shall be installed in the preformed notches on inside of the wall panels, or through sleeves cast into the ribs.

Sanitary fittings, cupboards, shelving, and other heavy fittings shall be attached to the walls with galvanized steel bolts taken through holes drilled in the backing skin of the wall panels, or with expansion bolts fixed to the panel ribs.

Protection against corrosion and finishes

Steel bolts, anchor bolts, nuts, washers, threaded rods, brackets and cleats used at connections and joints in external walls, roofs, floors and foundations are hot-dip galvanized in accordance with IS 4759:1996 and coated with a metal primer, a good quality bituminous paint or epoxy painting or they are of stainless steel.

The exterior surface of roofs and external walls shall be painted with two coats of suitable exterior grade acrylic emulsion paint. Painting of reminder of the building shall be carried out in accordance with the manufacturer's requirements.

APPLICATIONS

The system is used for low rise to mediurm rise mass housing projects, commercial buildings, manufacturing facilities, retaining walls etc.

SPECIAL FEATURES

Structural Stability

The strength of connections between components and with recessed bolts shall be determined by test before use. In addition to conventional structural design aspects, the design of the building shall address the following:

- Stability of gable walls
- Bracing of façade walls against wind loads
- Structural integrity and resistance to progressive collapse due to accidental damage to local elements.

Durability

The structural design shall comply with all the relevant Indian Standards, including IS 456:2000, IS 875 (Part 1, 2 & 3):1987, IS 4326:2013, IS 1893 (Part 1):2016, IS 13920:2016 & National Building Code of India 2016. Reference shall also be made to the design recommendations given in Waffle-Crete's design manual and specifications.

Behavior in earthquake and wind

All precast concrete floor, wall and roof panels and grade beams shall also be designed for loading conditions during de-molding, transportation and erection.

Fire Safety

Floor slabs with a 60 minute fire-resistance rating shall require a minimum of 38 mm concrete topping and floor slabs with a 120 minute fire-resistance rating shall require a minimum concrete topping of 75 mm or cladding to the underside

MAJOR COMPLETED PROJECTS

- 464 Dwelling units under IHSDP for slums of Anand Nagarpalika (Gujarat)
- 480 Dwelling units of Dahod Nagarpalika (Gujarat)
- 512 Dwelling units Housing (G+3) at Bharuch Nagarpalika, Bharuch (Gujarat)

CERTIFICATION

Performance Appraisal Certificate No. 1021-S/2015 issued to M/s Shaival Reality Pvt. Ltd., Ahmedabad.

STANDARDS/REFERENCES

No. 97/260	South Africa Agreement Certificate No. 97/260 for Waffle-Crete Agreement System of Waffle-Crete International Inc
IS 158:1981	Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali and heat resisting
IS 456:2000	Code of Practice for Plain and Reinforced Concrete (Reaffirmed 2016)
IS 875 (Parts 1&2):1987 IS 875 (Parts 3):2015	Code of Practice for Design Load of Buildings and Structures (Reaffirmed 2013)
IS 1363:2002	Hexagon Head Bolts, Nuts and Screws of Product
IS 1367:2002	Technical Supply Conditions for Threaded Steel Fasteners
IS 1786:2008	High strength deformed steel bars and wires for concrete reinforcement - specification (Reaffirmed 2013)
IS 1893 (Part 1):2016	Criteria for Earthquake Resistant Design of Structures (Part 1). General Provisions and Buildings.
IS 1904:1986	Code of practice for design and construction of foundations in soils – general requirements (Reaffirmed 2015)
IS 2095 (Part 1):2011	Specifications for gypsum plasterboards –Plain gypsum plaster boards (Reaffirmed 2016)
IS 4326:2013	Code of Practice for Earthquake Resistant Design and Construction of Buildings
IS 4759:1996	Hot Dip Zinc Coating on Structural Steel Products
IS 7215:1974	Tolerances for Fabrication of Steel Structures (Reaffirmed 2016)
IS 9103:1999	Concrete admixtures - Specification (Reaffirmed 2013)
IS 10505:1983	Code of practice for construction of floors and roofs using precast concrete waffle units (Reaffirmed 2013)
IS 13920: 2016	Code of practice for ductile detailing of Reinforced Concrete Structures subjected to seismic forces.

Walltec Hollowcore Concrete Wall

(Suitable for Non Load Bearing Structures)

ABOUT THE TECHNOLOGY

These are extruded non-load bearing concrete hollowcore wall panels manufactured in fully automated machines. Walltec wall panels are factory produced using light weight concrete made of river sand, crushed stone aggregate, light weight aggregate and Ordinary Portland cement. The concrete are extruded and cut while still wet to the requisite length. Curing and sealing are followed for 24 to 48 hours by stacking and palletizing after which the walls are watered and cured for a further period of 7 to 8 days. After 15 days the panels are ready for transportation to site.

Walls have cylindrical hollow cores incorporated with 7 No. 53 mm dia voids in the 92mm thickness and 6 No. 74 mm dia. voids for the 120 mm thickness panels. The corresponding nominal weight shall be 140 kg/m^2 and 170 kg/m^2 for 92 mm and 120 mm thick panels respectively. Hollows are incorporated in Walltec walls to reduce weight, facilitate mechanical, electrical and plumbing services through hollows, thereby increasing sound and thermal insulative properties. The sides of all panels are tongued and grooved to facilitate positive jointing.

Walltec walls do not require stone or wood sills/frames to level surfaces for windows and openings. Lintels need not be cast as panels may be placed horizontally as lintels wherever required. Wash basins, cup-boards, mirrors, paintings etc. may be hanged with regular plug screws. Details of the wall panels showing hollow cores is given in Fig.1

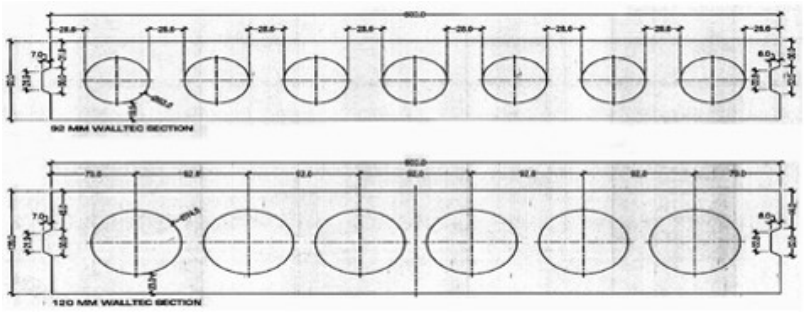


Fig.1

TYPE AND SIZE

Walltec walls are produced in standard widths & thicknesses and in lengths to suit room height as per the details given below and shown in Figs. 2 & 3:

Wall width	: 600 mm
Wall thickness	: 92 mm & 120 mm
Wall Height	: 2.40 m, 2.60 m, 2.85 m, 3.00 m, and 3.30 m
Weight	: 92 mm : 140 kg/m^2, 120 mm :170 kg/m^2

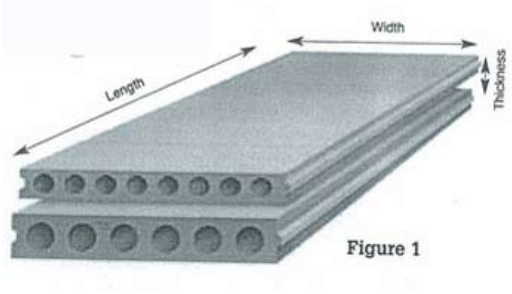


Fig.2

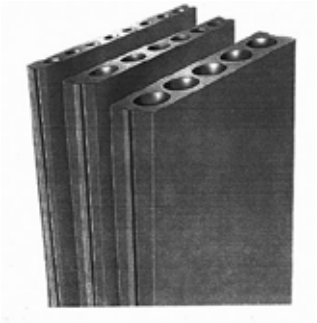


Fig.3

Walltec walls use regular concrete of density 2350 kg/m^3 and Walltec Lite uses light weight concrete of density 1550 kg/m^3.

TOLERANCES

The panels shall be produced in accordance with the following tolerances:

Length	: ±10 mm,
Width	: ±3 mm,
Thickness	: ±3 mm,
Squareness of end	: ±6 mm
Differential bowing between adjacent panels of the same Length	: =15 mm

RAW MATERIALS

i) OPC 53 grade cement shall conform to IS 12269:2013
ii) River sand and coarse aggregate 2-6 mm shall conform to IS 383:2016
iii) Flyash shall conform to IS 3812 (Part 1):2013
iv) Crushed Autoclaved Aerated Concrete (AAC) Waste

MANUFACTURING PROCESS

The manufacturing process of Walltec wall panels is as follows:

Raw Material
Sieved River Sand, 6mm Stone Aggregate, AAC Waste shall be supplied to the plant by supplier where it shall be weighed and sieve analysis & silt content checked as per the quality assurance norms. Cement shall be supplied in closed bulkers directly from the manufacturers' plant and fed into cement silo directly using blower. AAC Waste shall be crushed and sieved in using crusher & sieve combo machine which also has a dust collector shall collect superfine particles and the crushed AAC aggregate (8mm and lower fineness) shall be fed directly into the LWA (light weight aggregate) aggregate bin which shall be equipped with a moisture probe.

Concrete Mixing
Concrete required shall be batched and mixed at an automatic batching and mixing plant with Planetary Pan Mixer and Moisture probes. The relatively dry aggregates shall be automatically weighed & batched into the mixer from Aggregate Bins. Two of the Aggregate bins shall be equipped with moisture probes to ascertain accurate weighing and water content calculation later in the final concrete mix. Afterwards cement and water shall be added into the mixture. A low water-cement ratio of about 0.3 ensures that concrete is zero-slump and gains about 70% of its design strength within 12-24 hours of casting. Moisture content of the mixed concrete shall also be automatically controlled and adjusted by the software thus ensuring consistent concrete mix at all times. The software auto adjusts for water content based on readings of the moisture probes. After mixing, the concrete batch shall be fed to the conveying system, which brings fresh concrete to the hopper of the Acotec Wall – line where Walltec-Walls shall be cast, cut, trimmed, stacked, pre-cured, restacked and strapped into bundles.

Extrusion
The Walltec-Wall elements shall be formed in a continuously operating extruder. The concrete shall be compacted onto thin base moulds, which support the products during the pre-curing time. Base moulds shall be automatically fed to the extruder as a continuous ribbon. The base mould length shall determine standard length of the products. There can simultaneously be maximum five plate lengths in the system. The extruder shall compact the concrete with extrusion screws against the packing bar and side walls. Top surface of the product shall be vibrated by a vibrating plate.

Cutting
After extruding, the products shall be cut according to the base mould length. A circular saw shall cut the fresh concrete on each base mould seam. Then the cut product together with the supporting plate shall be pulled to the stacker.

Trimming

When necessary, the fresh product shall be stopped at a specified point, where the manually adjusted circular saw cuts off the wanted trimming piece. Trimming length shall be max. 20 cm. The trimmed off concrete shall be recycled back to the extruder.

Stacking

Cut, fresh products shall be stacked into pre-curing stacks. Depending on the product thickness and weight each stack shall contain 4 to 10 products and base moulds. Stacks shall be supported by steel pallets, which are automatically fed underneath each stack.

Pre-curing

The stacks shall stay 12 to 24 hours in the pre-curing indoor storage area where natural pre-curing occurs for each stack which is covered with tarpaulin to stop any evaporation and moisture loss. The storage shall be an area where natural curing occurs. Product stacks shall be moved into and out from the stock area by a forklift.

Restacking

After pre-curing the products are strong enough to stand automatic handling. Products shall be separated from the base molds. Base molds shall be returned back to circulation trough a cleaning and oiling unit. The products shall be restacked to form delivery stacks with 4 - 10 products on top of each other. The stack shall be pushed against a wooden delivery pallet and turned on its side. Delivery stacks shall be strapped before transportation to delivery storage. Stacks must stay in the delivery storage where they shall be kept moist by external manual water sprinkling for at least 7 days before transporting to a construction site after 15 days on a Truck or Flat-bed Trailer. Loading of trucks shall be done with Forklift or Hydraulic Cranes.

PERFORMANCE CRITERIA

Walltec wall panels shall meet the following performance criteria:

S.No	Properties	Test Method	Requirements as per relevant Standards	
			92mm	120mm
1.	Dry density (kg/m^2)	IS 516:1959	140 min.	170 min.
2.	Flexural strength N/mm^2	IS 516:1959	2.4 max.	3.5 max.
3.	Compressive strength N/mm^2	IS 516:1959	15 min.	25 min.
4.	Moisture content (%)	IS 516:1959	4.8 max.	4.8 max.
5.	Impact strength (Falling weight) (N)	ISO 179 2: 1997	>5	--
6.	Drying shrinkage (%)	IS 2185 (Part 1):1979	0.04 min.	0.04 min.
7.	Thermal conductivity (m^2.k/W)	IS 3346:1980	0.4 min.	> 0.4
8.	Sound transmission Class (dB)	IS 9901:1981	42 max.	44 max

INSTALLATION PROCEDURE

i) Only two stacks shall be put on top of each other during stocking and transportation.
ii) Panel stacks shall always be lifted from under wooden pallet with a lifting fork or belt.
iii) The panel stacks shall be moved by forklift or trolley to construction site. Individual panel may easily be moved by a simple wheel. Panels can also be moved manually by inserting a short tube (500mm) into the second hollow as handle. These shall always be transported sideways.
iv) Gluing agents (cement based adhesives) as per IS 9103:1999 shall be mixed as per the manufacturer's instructions.
v) The line of wall shall be marked on the floor and ceiling before start of installation.

vi) Guiding boards shall be fixed on the floor and ceiling. The guiding support will automatically align the wall when lifting the panels straight into upright position.
vii) The gluing agent shall be spread on the side of the already installed panel.
viii) Before the panel shall be lifted to upright position, it should be moved so that the panel bottom is as close as possible to its correct position. After that the panel shall be lifted to upright position.
ix) This panel shall be pushed against the previous panel (and move up and down) so that tongue and groove are carefully positioned against each other and gluing agent is squeezed out. Correct thickness of joint between two panels shall be 1 to 2 mm.
x) The panel shall be positioned to correct level by using wooden wedges at the bottom and top of the panel erected earlier. The height of the panel should be about 10 to 50 mm shorter than free-room height.
xi) The top joint shall be filled with polyurethane foam. Correct thickness of joint shall be 5 to 10 mm.
xii) Alternatively, when same gluing agent as in sides is used for top joint, the panel shall be pushed against ceiling so that gluing agent is squeezed out. Correct thickness of joint shall be 1 to 2 mm. The surplus gluing agent shall be removed from joints after installation.
xiii) Bottom joint of the panel shall be filled with mortar or concrete. Correct thickness of joint shall be 10 to 40 mm.
xiv) 'Shoulders' shall be sawed or flat steel bar for door top portion fixed to the panels next to the door. The door top piece shall be glued by using polyurethane foam or gluing agents. The joints should be as thin as possible.
xv) All corners shall be strengthened with nail plugs (3 per corner).
xvi) Paper or fibre tape shall be glued on to the corner joints and to the joints at a door top portion before plastering.
xvii) Flexible joints between panels shall be built after each 5 - 6m. Polyurethane foam or mineral wool may be used as elastic joint material.
xviii) The hollow boxes may be used for the cables and electrical boxes shall be fixed at the desired points after drilling.
xix) The panels need only a very thin skin coating (1-2 mm) before surface finishing. It may be easier to do with a wide trowel.
xx) All kinds of drilling and sawing can be easily made in the panels.
xxi) The necessary tools required for installation shall be hammer, saw, screw driver, level, meter rule, trowel, drill, trolley concrete cutter, steel bar, buckets and lifting bars.

Plumbing & Electrical

Walltec panels shall have hollows of 53mm dia. in 92mm wall and 74mm dia. in 120mm wall to allow the passage of water pipes, electrical wiring, HVAC and hydraulic installations without making holes/chases. Plumbing and Electrical service fittings shall be pre-planned and shall be passed through hollow portions of the wall panels.

Painting, Tiling and Cladding

Painting shall be done directly or after applying a 2mm wall putty coat. Texture paint coat shall be directly applied to external surface for decorative effect.

All tiling and cladding shall be directly fixed using regular cement mortar or tile adhesive.

USE OF THE WALLTEC WALLS & ITS LIMITATIONS

Uses

These walls shall be used as non-load bearing walls/partition walls and compound/ boundary walls in residential/ commercial/ industrial/ institutional buildings.

Limitations of Use

For non-load bearing walls only. Not to be used as load bearing walls.

CERTIFICATION / VALIDATION OF THE SYSTEM

i) Performance Appraisal Certificate No. 1022-P/2015 on Walltec Hollowcore Concrete Panel has been issued to M/s B. N. Precast Pvt. Ltd., Gandhinagar.

OTHER SIMILAR SYSTEM SHORTLISTED UNDER GHTC-INDIA

i) Large Hollow Wall Prefab Concrete Panels of M/s William Ling, Singapore has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

STANDARDS AND REFERENCES

IS 383:2016	Specifications for coarse and fine aggregate for concrete (third revision)
IS 516:1959	Method of test for strength of concrete (Reaffirmed 2013)
IS 2386(Part 3):1963	Methods of test for aggregates for concrete - Part 3 specific gravity, density, voids, absorption and bulking (Reaffirmed 2016)
IS 3346:1980	Method of determination of thermal conductivity of thermal insulation materials
IS 3812 (Part 1):2013	Specifications for pulverized fuel ash - part 1 : for use as pozzolana in cement, cement mortar and concrete
IS 9103:1999	Specifications for concrete admixtures (Reaffirmed 2013)
IS 9142:1979	Specifications for artificial light weight aggregates for concrete masonry units (Reaffirmed 2016)
IS 9901:1981	Measurement of sound insulation in buildings and of building elements
IS 12269:2013	Specifications for 53 grade ordinary Portland cement
IS 15916:2010	Code of practice for building design and erection using prefabricated concrete (Reaffirmed 2014)
ISO 179-2:1997	Determination of charpy impact of plastics



Precast Large Concrete Panel System

(Suitable for Low Rise to High Rise Structures)

ABOUT THE TECHNOLOGY

Precast Large Construction Panel (PLCP) system consists of various precast elements such as walls, beams, slabs, columns, staircase, landing and some customized elements that are standardized and designed for stability, durability and structural integrity of the building. Precast residential building construction involves design, strategic yard planning, lifting, handling and transportation of precast elements. This technology is suitable for construction of high rise buildings resisting seismic and wind induced lateral loads along with gravity loads. The building framing is planned in such a way that maximum number of repetitions of moulds is obtained. These elements are cast in a controlled factory condition. The factory is developed at or near the site which provides an economical solution in terms of storage and transportation.

TYPES OF PRECAST ELEMENTS AND MOULDS

Two main types of precast concrete elements, namely precast reinforced concrete elements and precast pre-stressed concrete elements are used as per the details given below:

i. Precast reinforced concrete elements

These shall consist of reinforcement bars and/or welded wire meshes within the elements to provide the tensile strength and resistance against cracks such as façade walls, beams, columns, slabs, refuse chutes, staircases and parapet walls.

ii. Precast pre-stressed concrete elements

These shall consist of pre-stressing tendons within the elements to provide a predetermined force needed to resist external loadings and cracks such as hollow core slabs, beams and planks.

Typical size of precast elements is given below:

Sr. No.	Precast Components	Typical Sizes*
1	Wall Panels	5m x 2.85m
2	Slabs	3m x 5m
3	PODS	1.52m x 1.36m x 2.83m
4	Beam	0.20m x 0.40m x L
5	Staircase	As per design
6	Columns	0.90m x 0.35m x 2.85m

** Sizes of panel slabs may vary as per the architectural and construction requirement.*

iii. Moulds

Moulds for precast elements shall be of steel and concrete. For design of the moulds for various elements, special importance should be given to easy de-moulding and assembly of the various parts. At the same time rigidity and strength and water tightness of the mould are also important taking into consideration forces due to pouring of green concrete and vibration. The type of moulds used for pre-casting various elements with various methods is given below:

Sr. No.	Mould Type	Uses
1	Conventional moulds	Ribbed slab, beams, window panels, box type units and special elements

2	Battery moulds	Interior wall panels, shell elements, roof and floor slabs
3	Tilting moulds	Exterior wall panels where special finishes are required on one face or for sandwich panels
4	Long line prestressing beds	Double tees, ribbed slabs, piles and beams
5	Extrusion machine	Roof slabs and hollow core slabs



Battery Mould



Tilting Mould



POD Mould

MATERIAL REQUIREMENTS

Ordinary Portland Cement: Shall be of 43 grade as per IS 269:2015.

Fine aggregate (M Sand): Shall be as per IS 383:2016 & IS 1542:1992 and 4.7 mm.

Coarse Aggregates: Shall be as per IS 383:1970 and of 20 mm, 40 mm size

Steel reinforcement: Shall be as per IS 1786:2008

Concrete: The grade of concrete shall be M 30 and slump for walls, floors and roofs shall be as per IS 456:2000.

Brick masonry: Shall be designed as per IS 1905:1987

Solid Block work: Shall be as per IS 2185 (Part 1):1979

Aluminium: Shall be as per IS 733:1983

Glass: Shall be as per IS 2835:1987

Non-shrunk non-metallic grout: Cement based flowable grout shall have compressive strength of 65 N/mm^2, flexural strength of 9 N/mm^2 at 28 days and E-modulus of 37000 N/mm^2.

Water proofing membrane: Fibre reinforced repair mortar shall have compressive strength of 45 N/mm^2 at 28 days and density 2250 kg/m^3

Baker Rod: Closed cell polymer based product shall have compressive strength of 0.45 kg/cm^2 min. at 25% deflection, density 22 kg/m^3 min. and water absorption 0.14 gm/cm^3 max.

Corrugated sleeve: Hot dipped galvanized prime steel sheet shall be as per IS 277:2003.

APPLICATIONS

The system is used economically for mass housing projects and commercial buildings, etc.

INSTALLATION

1. Precast Installation

Proper planning and preparatory works shall be required before the actual installation of precast concrete elements in order to ensure quality installation. The following items shall be planned in advance:

i. Method of sequence of assembly and installation: Precast elements should be identified based on their location number and the tagged.

Ii. Method of providing temporary support: Elements should be supported temporarily before these get stabilized. Generally structural members with adjustable ends shall be used for securing the panels. Shims should be used to adjust the panels to ensure dimensional correctness.

iii. Installation tolerances: Installation tolerances should be based on codal provisions and design considerations should be clearly indicated.
iv. Handling and rigging requirements: Elements should be checked for handling stresses before lifting and the cranes should have sufficient capacity to handle the precast panels. At least 10% impact should be considered while calculating the lifting capacity of the crane.

At site locations, panels shall be first unloaded and stacked or directly lifted by the crane. The element shall then be installed on the site and supported by temporary jacks. The cranes shall be released for next lifting once the temporary supports are in place. Shims shall be used to carefully align the element before grouting. The panels shall be grouted after the final adjustments are done.

2. Waterproofing

External joints shall be sealed with baker rods and sealants after filling the joints with grout to avoid the leakage. Additional waterproofing treatment shall be provided at external joints and wet areas to ensure water tightness.

3. Mechanical, Electrical & Plumbing Fittings

- Mechanical, electrical & plumbing fittings shall be kept open or concealed as per the requirements. For concealed fittings, provision for grooves, blockouts shall be made in casting moulds.
- The conduits and electrical boxes shall be embedded and fixed in moulds before casting. For open fittings, these shall be fixed after erection at site.
- For firefighting systems, provision of National Building Code (NBC) and local Building Byelaws shall be adhered to.

4. Fire Rating

- Precast concrete shall be designed for fire rating of 1 to 2 h based on codal requirements.
- Minimum precast concrete wall thickness of 120 mm shall be provided for 1 h fire rating as per IS 456:2000.

5. Finishes

- Variety of shapes, colours, textures and finishes may be obtained with precast concrete.
- The surface treatments shall be done by rebating, grooving, surface coatings, cement based renders, oxide coloring etc.
- Precast concrete facades of various shapes, colours and textures may be moulded and installed.

IMPLEMENTATION OF PRECAST ELEMENTS

1. Casting Concrete

The procedure for casting concrete shall be as follows:

i. Precast concrete elements shall be produced on horizontal/vertical, flat steel surfaced tilting tables.
ii. Prior to casting, electrical conduits and other required shall be fixed in position and the mould treated with mould release agent.
iii. Steel reinforcement shall be kept in position using adequate spacers to ensure correct position and concrete cover.
iv. After that side shutter shall be fixed. The high quality concrete shall be transported from batching plant to the precast yard through transit mixer.
v. Thereafter, concrete shall be carried to mould by gantry crane with concrete bucket.
vi. During casting, table vibrators (as & when required) shall be used to achieve the best compaction. Top surface shall be finished with hand operated trowel which gives smooth finish.
vii. Care should be taken on embedded items while concreting.
viii. After casting, all exposed surfaces shall be covered with a tarpaulin (as and when required) to avoid vaporization. Casted elements shall be de-moulded once the strength meets the design requirements and the units are then shifted to the stockyard. Thereafter, curing shall be carried out for 5 days.



Wall Panels



Parapet Beams



Spandrel



Solid Slab Panels



POD Elements



Staircase

Precast Elements

2. Curing

The curing of the prefabricated elements may be done by the normal methods of curing by sprinkling water and keeping the elements moist. This can also be done in the case of smaller elements by immersing them in specially made water tanks.

3. Screed Concrete for Flooring

The surface for screed concrete shall be clean, free from dust, loose materials, lumps and foreign material.

The screed shall generally be provided over the entire slab. In this case the entire slab shall act as a continuous structural diaphragm providing optimum load transfer mechanism for lateral loads. The screed shall be treated as a part of the compression zone for gravity loads on the slab. The design shall consider composite action between the slab & screed and compressive strength of screed in slab. Further, the interface shear between the slab & screed shall be checked for verifying adequate shear transfer capacity at the interface.

i. Screed on haunches may be provided, only if the conduits are exposed, with the mutual agreement between the project authority and the technology provider. In such cases, additional water proofing treatment of a reputed company shall be provided at the precast slab and site concrete stitch.
ii. Electrical conduits or any other embedment shall be laid as per approved drawings before screed concrete flooring.
iii. The reference level from main survey pillars shall be transferred and marked on side channels.
iv. While marking level, sloping direction in flooring shall be taken care as per approved drawing.
v. Before laying the concrete, cement slurry shall be spread on the slab surface for better bonding and filling of gaps between wall and slab soffit junction.
vi. The concrete should be placed from one end and shall be compacted immediately after placing and levelled uniformly.
vii. The vibrator should be applied smoothly and concrete compacted well.
viii. The concrete shall be allowed to set so as to be in dry condition.
ix. The trowelling shall start after concrete is set and reach dry condition.
x. Curing shall be done by using bunds over the screed surface/wet hessian cloth.

4. De-moulding and Stacking

4.1 Lifting of elements from mould

i. It must be ensured that all the elements should have identification mark.
ii. It must be ensured that all side shutters are loosened so that the elements may be lifted without any damages.
iii. Before demoulding, it must be ensured that compressive strength of the cubes should meet the specified requirements.
iv. The lifting clamps/clutches shall be fixed to lifting beam at proper positions.
v. Then the elements shall be lifted carefully to the stocking area.

4.2 Stacking of elements

i. The surface of stacking area should be horizontal.
ii. The wooden runner shall be placed perpendicular to lifting points and the elements placed over runner.
iii. Number of the elements per lot should not exceed man height.
iv. In case of vertical stacking, the gap between the elements should be 150mm to 200 mm.
v. Stacking shall be done in such a way that slabs of longer span should be placed below that of shorter span.

5. Transportation of Elements

5.1 Loading of slab over trailer

i. It must be ensured that the identification mark on the slab should be the same as per dispatch list.
ii. Any damage occurred during loading should be informed to the concerned authority.
iii. The lifting clamps/clutches shall be fixed to the lifting beam at proper position.
iv. The lifting beam shall be placed over the precast elements and ensured that the clutches are locked properly before lifting.
v. Instruction regarding loading height, positioning of precast elements over the trailer should be followed as per capacity of trailer.
vi. The wooden rubber shall be placed in between the slabs at 500 mm from each end.
vii. Some of precast elements should be placed vertically and transported through “A” frame fixed vehicle.
viii. The slab shall not be overhanging from trailer.
ix. The slab shall be tied firmly to the trailer by means of belt/rope as moving the load without proper tie will cause damage.
x. While transporting elements vertically, the vehicle should be loaded equally on both sides.

5.2 Unloading of slab from trailer and placing in site yard

i. Every slab shall be inspected for dimensions/identification mark and damages etc. prior to unloading at site.
ii. The stacking area should be levelled and hard enough for stacking the elements.
iii. There should be proper access for trailer movement.

6. Erection

The process of erection and installation of panels during the construction cycle by using tower cranes shall be as follows:

i. Before starting erection a survey of the area to receive precast elements shall be done to monitor any difference in dimensions or levels exceeding the tolerances. In case of unacceptable tolerances, necessary action shall be taken for rectification.
ii. Installation shall be done by tower crane with sufficient capacity. Panels shall be shifted from the stack rack/truck from yard to the nearest point of construction site and shall be kept above the truck during the construction or inside the storage racks as per the site situation.
iii. The necessary access for the truck to reach the nearest point of the tower shall be prepared before starting erection of the panels.

iv. Once the truck reaches the tower, chain and lifting clutch with required capacity and guide rope shall be attached to the precast panels to allow the workers to control the load to its final place.



v. As the elements are lifted to its final position above the cast-in-situ slab/precast panel, vertical and horizontal alignment of the panel shall be adjusted. The gap between the element and adjusted elements shall be maintained as per the drawings within the allowable tolerances. Shims and spacers shall be used for levelling and adjustment.



vi. Temporary propping jacks shall be provided for restraining the walls laterally until grouting.

vii. After completion of fixing, alignment of the panels shall be checked again.

viii. Minor damages, if any to the precast panels shall be repaired by approved materials.

ix. After completion of installation and alignment, elements shall be handed over for inspection.

x. The joints between the precast wall panels shall be filled with joint filler material.

xi. Precast slab shall be erected above the wall panels without any scaffolding system. The electrical conduit/fitting shall be done. After electrical works are completed, screed concrete shall be laid over the precast slab.

xii. Installation of the next floor shall start only after completion of screed concrete of the previous floor.

xiii. The sequence of erection shall be as follows:

- Installation of precast wall panels above cast-in-situ slab
- Provide temporary props/jacks for restraining of the walls laterally.
- Grout the connection between the wall panels & ground floor slab and the joint between each wall panel.
- Installation of precast slab panels above the erected precast wall panels.
- Screed concrete above the slab after placing of electrical conduits / fittings
- Installation of the wall panels over the floor slab.
- Installation of the roof panels such as parapets etc.

SPECIAL FEATURES

Structural Stability

The overall behavior of a precast structure is dependent on the behavior of the connections which must provide:

- Resistance to all design forces
- Ductility in case of excessive deformation
- Resistance to volume changes and related forces
  - Adequate durability
  - Required fire resistance
  - Feasible production considerations
  - Feasible construction considerations

The overall design of the structure shall be done in accordance with IS 875 (Part 1 to 5), IS 456:2000, IS 1893(Part 1): 2016, IS 13920:2016 and IS 15916:2010, as applicable.

Large panels shall be in accordance with the provisions of IS 11447:1985.

Durability

Structural load bearing walls shall be designed as per codal provisions of IS 456:2000 and IS 13920:2016 as applicable.

Behavior in earthquake and wind

The components of the structure shall be designed for loads in accordance with IS 875 (Parts 1-5):1987 and IS 1893 (Part 1):2016. In addition members shall be designed for handling, erection and impact loads that might be expected during handling and erection.

Fire Safety

Period of fire resistance of RCC buildings is based on NBC requirements. To meet the fire rating requirement, provision specifications.

WORKS COMPLETED

1. Construction of (G+23) Pragati Towers at Mumbai in 1972 (2024 units).
2. Construction of (G+12/G+14) Provident Sunworth Project at Bangaluru in 2015 (5952 units).

CERTIFICATION

Performance Appraisal Certificate No. 1027-S/2016 issued to M/s Larsen & Toubro Ltd., Mumbai.

STANDARDS/REFERENCES

• Suitability of Precast Concrete Large Panel system for Mass Housing Projects by IIT Madras	
• Design & Construction Methodology Review for Rehab Bhiwada Precast Project, Mumbai by IIT Madras	
• Verification of Thermal Performance Reports – Evaluating RCC Wall apartments in Ahmedabad & Chennai by Indian Institute of Science, Bangalore.	
IS 456:2000	Code of Practice for Plain and Reinforced Concrete (Reaffired 2016)
IS 875 (Parts 1,2,4&5):1987 IS 875 (Part 3):2015	Code of Practice for Design loads (other than earthquake) of buildings and structures
IS 1786: 2008	High strength deformed bars and wires for concrete reinforcement (Reaffirmed 2013)
IS 1893 (Part 1):2016	Criteria for Earthquake Resistant Design of Structures (Part 1) - General Provisions and Buildings
IS 1904:1986	Code of practice for design and construction of foundations in soils – general requirements (Reaffirmed 2015)
IS 2062:1992	Hot Rolled Medium and High Tensile Structural Steel
IS 7215:1974	Tolerances for Fabrication of Steel Structures (Reaffirmed 2016)
IS 9103:1999	Specifications for Concrete admixtures (Reaffirmed 2013)
IS 11447:1985	Code of practice for construction of large panel prefabricates (Reaffirmed 2013)
IS 13920:2016	Code of practice for ductile detailing of Reinforced Concrete structures subjected to seismic forces.
IS 15916:2010	Code of practice for building design and erection using prefabricated concrete (Reaffirmed 2013)





Industrialized 3-S system using RCC precast with or without shear walls, columns, beams, Cellular Light Weight Concrete Slabs/Semi-Precast Solid Slab

(Suitable for Low Rise to High Rise Structures)

ABOUT THE TECHNOLOGY

The industrialized total prefab construction technology, being used since 1972, is based on factory mass manufactured structural prefab components conforming to provisions of relevant Indian Standards. The major precast elements are:



- RCC hollow columns with notches
- RCC solid beams (T/L/Square Shape)
- Staircase
- RCC precast slab
- AAC precast slab
- AAC precast block

In the system, precast dense concrete hollow column shell of appropriate sizes are used in combination with precast dense concrete rectangular / 'T' shape / 'L' Shape beams with light weight reinforced autoclaved cellular concrete/Precast RCC slabs for floors and roofs. The hollow columns are grouted with appropriate grade of in situ concrete. All the components and jointing of various structures are accomplished through on-site concerting along with secured embedded reinforcement of appropriate size, length and configuration to ensure monolithic continuous resilient, ductile and durable behaviour. Autoclaved Aerated Concrete (AAC) slabs can be used as floor / roof slabs. Joints are filled with reinforced screed concrete (minimum 40 mm thick) of M20 grade minimum. RCC screed is laid over entire area of slab before flooring / water proofing.

BASIC MATERIAL REQUIREMENTS



RCC hollow columns & Beam

Concrete

Shall conform to appropriate grade based on environmental and structural requirements condition as per IS 456 : 2000

Reinforcement

Shall be of Fe 415 Grade or Fe 500 Grade as per IS 1786:2008

AAC Precast Slab

Grade 1 of Density 551 – 650 Kg/m^3 of IS 6073:2006

AAC Precast Block

Density 451-550 Kg/m^3 for internal wall, 551-650 Kg/m^3 for external wall as per IS 2185 (Pt. 3) :1984

OTHER REQUIREMENTS:
EVALUATION OF STRUCTURAL REQUIREMENT OF JOINTS

Against vertical load

- Full Scale load test on assembly of precast elements by Tor Steel Research Foundation in India, Bangalore

found it safe.

- Structural Design evaluation for HIG – II Buildings at Powai by Shri H.P. Shah; Stanford University found that based on the design concept, design calculation and detailing; the structure is safe against vertical loads, seismic loads and the wind loads.
- Scrutiny of design for S+24 type buildings by IIT Mumbai found it safe.
- Scrutiny of design details for Delhi project by IIT Roorkee found jointing & connections ensuring monolithic, durable & ductile behaviour.





Against seismic and wind load

A Test was performed by CBRI on full-scale building to establish behaviour of various joints under all design loads including seismic Zone IV. The experimental results on Full Scale Building Structure demonstrated the desired performance and behaviour of the 3S system under all loading condition as envisaged.

When designed for use in Zone V, independent verification may be needed.

DURABILITY

- Anti corrosive treatment given to reinforcement used in AAC slab panels for durability, was evaluated by CBRI, Roorkee with satisfactory results.
- Concrete and cover requirement are as per durability clause of IS 456 : 2000, to ensure adequate durability.

FIRE RESISTANCE PROPERTY OF BLOCK / SLAB AS DWELLING UNIT

AAC blocks / Slabs used will have fire rating as per the NBC norms for dwelling units.

THERMAL BEHAVIOUR

Kvalue – 0.122 k cal/h/m^{o}c of AAC blocks*.

ACOUSTIC COMFORT TEST

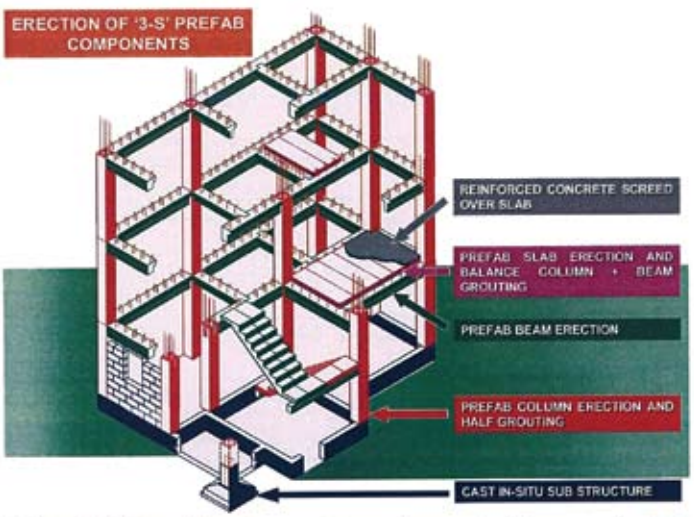
For 100 mm ACC Wall, Sound absorption is 38 – 40 db*

IMPACT RESISTANCE

Not tested*

EASE OF FIXING SERVICES (ELECTRICITY & PLUMBING)

With pre-planning, electricity & plumbing services can easily be placed.



Pictorial view showing various elements / stages of work

AVAILABILITY OF PLANTS & MACHINERY

Plants & Machineries for production of Components available in Pune, Mumbai, Bangalore and Delhi

ECONOMY OF SCALE



- For a new plant to be setup, a minimum project of 5000 dwelling units may be needed.
- In places, where plant is already set up, smaller project may also be viable.

ESSENTIAL REQUIREMENTS



- Precasting yard / factory set up is required with facilities such as Casting Yard, Computerised batching plant, Moulds, Transportation facility, Stacking yard for materials & components, Lifting and loading facility, Laboratory to test raw material & finished products, Water tank of enough holding capacity as required for 2 – 3 days, Service road, etc.
- Utmost attention is required for process engineering before taking up any field work. Close co-ordination between design crew, field staff and quality crew is essential.

LIMITATION

The project is taken as turnkey project by the agency M/s B.G.Shike & Co., Pune. No other agency is involved in this propriety system.



MAJOR CONSTRUCTION WORK DONE

1. Multistoried prefab residential buildings comprising over 400 Lacs sft built area have been completed since 1974
2. Residential EWS, LIG, MIG and HIG housing projects at Kharghar, Navi Mumbai for CIDCO.
3. Residential mass housing project of MHADA, Powai, Mumbai.
4. S+24 Multistoried Residential Building for mill workers & transit accommodation for 1000 families at Mumbai.
5. Mass Housing Projects at Delhi for DDA.
6. S+14 multi storeyed MIG & HIG type buildings at Versova, Mumbai for MAHADA.
7. Multistoried residential buildings of Transit, LIG, MIG & HIG type of 10,650 families at SION Mumbai.
8. Construction of 1152 houses under Light House Project (LHP) at Chennai, Tamil Nadu.
8. Several projects are being taken up / completed in the state of Maharastra, Karnataka, Andhra Pradesh, Tamil Nadu & Delhi.

STANDARDS/GUIDELINES REFERRED

IS 456:2000	Code of Practice for plain and reinforced concrete (Reaffirmed 2016)
IS 875 (Pt.3):2015	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Part 3 : Wind Loads
IS 1786:2008	High strength deformed steel bars and wires for concrete reinforcement - Specification (Reaffirmed 2013)
IS 1893 (Pt.1):2016	Criteria for Earthquake Resistant Design of Structures - Part 1 : General Provisions and Buildings
IS 1950:1962	Code of practice for sound insulation of non-industrial buildings (Reaffirmed 2015)
IS 2185 (Pt.3):1984	Specification for Concrete Masonry Unit - Part 3: Autoclaved Cellular (Aerated) Concrete Blocks (Reaffirmed 2015)
IS 3792:1978	Guide for heat insulation of non-industrial buildings (Reaffirmed 2013)
IS 6073:2006	Autoclave Reinforced Cellular Concrete Floor and Roof Slabs - Specification (Reaffirmed 2017)
IS 13920:2016	Ductile detailing of reinforced concrete structures subjected to seismic forces - Code of practice
NBC 2016	National Building Code, 2016

Robomatic Hollowcore Concrete Wall Panels

(Suitable for Non Load bearing Structures)

ABOUT THE TECHNOLOGY

Robomatic wall panels are extruded non-load bearing concrete hollowcore wall panels manufactured in fully automated machines. These wall panels are factory produced using light weight concrete made of manufactured sand, crushed stone aggregate and Ordinary Portland Cement. Concrete panels are extruded and cut while still wet to the requisite length. Curing and sealing are followed for 24 to 48 hours by stacking and palletizing after which the walls are watered and cured for a further period of 7 to 8 days. After 15 days the panels are ready for transportation to site.

Wall panels have cylindrical hollow cores incorporated with 8 Nos. 44 mm dia voids in the 75mm thick panels, 6 Nos. 62 mm dia. voids for the 92 mm thick panels and 6 Nos. 74 mm dia. voids for the 120 mm thick panels. Hollowcores are incorporated in the walls to reduce dead weight, facilitate mechanical, electrical and plumbing services, thereby increasing sound and thermal insulate properties. The sides of all panels are tongued and grooved to facilitate positive jointing.

These wall panels do not require stone or wood sills/frames to level surfaces for windows and openings. Lintels need not be cast as panels may be placed horizontally as lintels wherever required. Wash basins, cup-boards, mirrors, paintings etc. may be hanged with regular plug screws.

Details of the wall panels showing hollow cores are shown in Figs.1, 2 & 3.

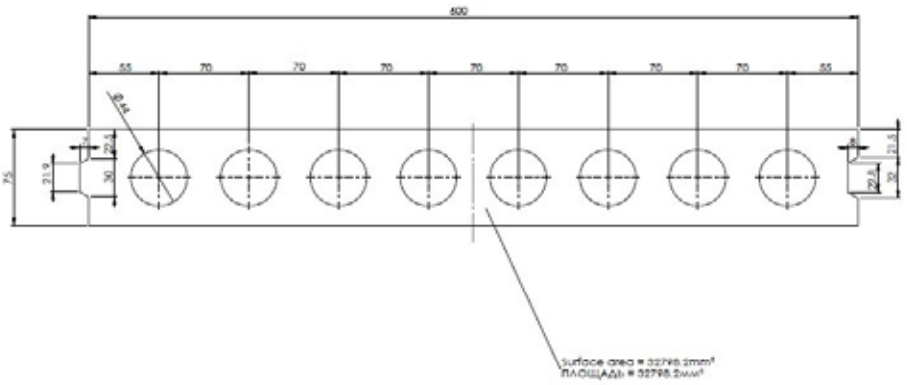


Fig. 1 75mm thick panel

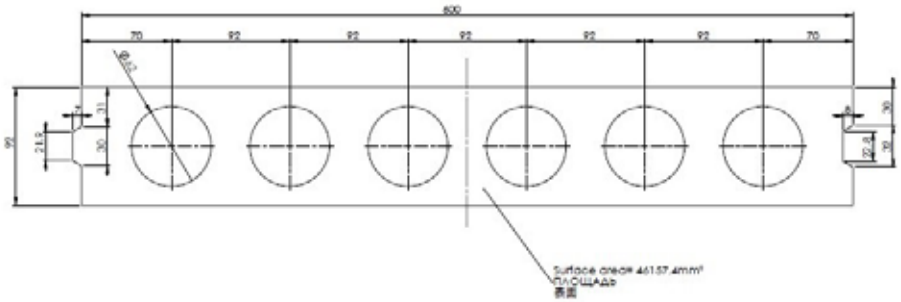


Fig. 2 92mm thick panel

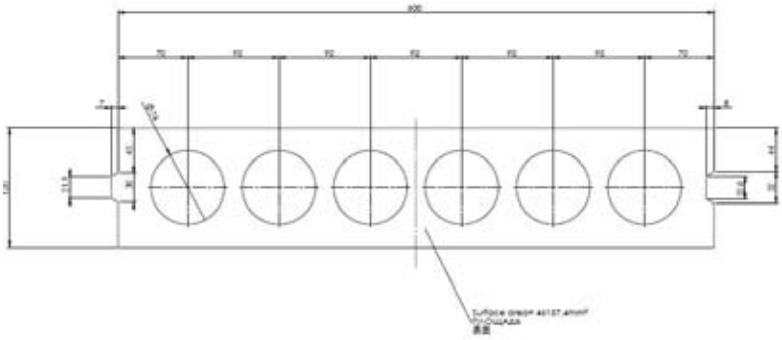


Fig. 3. 120mm thick panel

TYPE AND SIZE

Robomatic walls are produced in standard lengths, widths & thickness and to suit room height as per the details give below and as shown in Figs. 4 & 5:

Wall width	:	600 mm
Wall thickness	:	75 mm, 92 mm & 120 mm
Wall Height	:	2.40 m to 3.30 m
Weight	:	120 kg/m^2 for 75 mm, 150 kg/m^2 for 92 mm and 190 kg/m^2 for 120 mm thick panels.

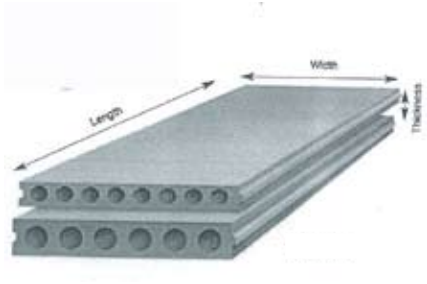


Fig. 4

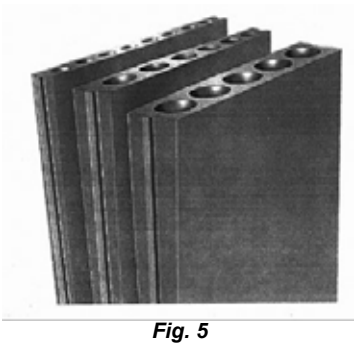


Fig. 5

Tolerances

The panels shall be produced in accordance with the following tolerances:

Length	: ±10 mm,
Width	: ±3 mm,
Thickness	: ±3 mm,
Squareness of end	: ±6 mm
Differential bowing between adjacent panels of the same length	: 15 mm

BASIC RAW MATERIAL REQUIREMENTS

i) OPC 43/53 grade cement shall conform to IS 8112:2013/IS 12269:2013.
ii) Sand 0-2mm shall conform to the manufacturers specifications.
iii) Coarse aggregate 2-6 mm shall conform to the manufacturers specifications.
(iv) Light weight aggregate shall conform to IS 9142:1979.
(v) Fly ash shall conform to IS 3812 (Part 1):2013.
vi) Water shall conform to IS 10500-2012.
vii) MS-C Channel 100x50mm x 6m shall be manufactured from pre-galvanized high tensile steel conforming to IS 277:2018.
viii) Adhesive, glue & bonding agents shall conform to the manufacturer's specifications.

MANUFACTURING PROCESS

The manufacturing process of Robomatic wall panels is as follows:

Raw Material
Sieved manufactured Sand and 2-6mm stone aggregate shall be supplied to the plant where it shall be weighed and sieve analysis done & silt content checked as per the quality assurance norms. Cement shall be supplied in closed bulkers directly from the manufacturers' plant and fed into cement silo directly using blower.

Concrete Mixing
Concrete required shall be batched and mixed at an automatic batching and mixing plant with Planetary Pan Mixer and Moisture probes. The relatively dry aggregates shall be automatically weighed & batched into the mixer from Aggregate Bins. Two of the Aggregate bins shall be equipped with moisture probes to ascertain accurate weighing and water content calculation later in the final concrete mix. Afterwards cement and water shall be added into the mixture. A low water-cement ratio of about 0.3 ensures that concrete is zero-slump and gains about 70% of its design strength within 12-24 hours of casting. Moisture content of the mixed concrete shall also be automatically controlled and adjusted by the software thus ensuring consistent concrete mix at all times. The software auto adjusts for water content based on readings of the moisture probes. After mixing, the concrete batch shall be fed to the conveying system, which brings fresh concrete to the hopper of the Robomatic Wall – line where wall panels shall be cast, cut, trimmed, stacked, pre-cured, restacked and strapped into bundles.

Extrusion
Robomatic Wall elements shall be formed in a continuously operating extruder. The concrete shall be compacted onto thin base moulds, which support the products during the pre-curing time. Base moulds shall be automatically fed to the extruder as a continuous ribbon. The base mould length shall determine standard length of the products. There can simultaneously be maximum five plate lengths in the system. The extruder shall compact the concrete with extrusion screws against the packing bar and side walls. Top surface of the product shall be vibrated by a vibrating plate.

Cutting
After extruding, the products shall be cut according to the base mould length. A circular saw shall cut the fresh concrete on each base mould seam. Then the cut product together with the supporting plate shall be pulled to the stacker.

Trimming
When necessary, the fresh product shall be stopped at a specified point, where the manually adjusted circular saw cuts off the wanted trimming piece. Trimming length shall be max. 20 cm. The trimmed off concrete shall be recycled back to the extruder.

Stacking
Cut, fresh products shall be stacked into pre-curing stacks. Depending on the product thickness and weight each stack shall contain 4 to 10 products and base moulds. Stacks shall be supported by steel pallets, which are automatically fed underneath each stack.

Pre-curing
The stacks shall stay 12 to 24 hours in the pre-curing indoor storage area where natural pre-curing occurs for each stack which is covered with tarpaulin to stop any evaporation and moisture loss. The storage shall be an area where natural curing occurs. Product stacks shall be moved into and out from the stock area by a forklift.

Restacking
After pre-curing the products are strong enough to stand automatic handling. Products shall be separated from the base molds. Base molds shall be returned back to circulation trough a cleaning and oiling unit. The products shall be restacked to form delivery stacks with 4 - 10 products on top of each other. The stack shall be pushed against a wooden delivery pallet and turned on its side. Delivery stacks shall be strapped before transportation to delivery storage. Stacks must stay in the delivery storage where they shall be kept moist by external manual water sprinkling for at least 7 days before transporting to a construction site after 15 days on a Truck or Flat-bed Trailer. Loading of

trucks shall be done with Forklift or Hydraulic Cranes.

Reusability of concrete materials

- During manufacturing of Robomatic Hollowcore Wall panels, there is possibility of wastage with concrete due to machinery tune up in the beginning of every shift. But this should be taken as wastage because, the concrete which could not be manufactured into wall panels are looped to a separate line, dismantled into concrete again and sent back to machine for casting of wall panels.
- Due to this, there is zero percentage wastage in the plant. The plant operational personnel are trained well to handle these situations and whatsoever the reason for not casting at any instance will be reused.
- The other possibility of wastage is during installation. In general, 3% of the total area of installation is allowed as wastage due to cuttings and left over small panels due to staggering installation of walls.
- Even this 3% of wall panels are transported back to the plant and is used as coarse aggregate. The well cured and formed panels left over at the site will be pulverized manually and mixed with the coarse aggregate in batches.
- While handling of panels inside the plant area there is a small percentage of breakage of panels is observed. During quality checks these panels are identified and sent to raw material dump yard and pulverized manually and mixed with the coarse aggregate of 2 – 8mm.

Durability

Durability of the walls panels is defined as the capability to resist weathering action, chemical attack and abrasion while maintaining its desired engineering properties. It normally refers to the duration or life span of trouble-free performance. The panels are manufactured using M25 mix with design mix of coarse aggregates 3-5mm, manufactured sand 0-2mm, cement and optimum mix of water as per IS 10262:2009 & IS 456: 2000.

As per the design of M25, it can withstand physical factors in general just like the regular concrete members and physical forces like percolation and permeability of water through its medium and temperature stresses. In the same way, M25 design mix concrete can withstand chemical attacks viz., sulphate and chloride attacks.

PRODUCTION PROCESS

Production

Robomatic wall panels shall be machine made from sand, coarse aggregate and 53 grade Portland cement. These shall be free from crack and nodules of free lime. These shall have smooth rectangular faces with sharp corners and shall be uniform in colour.

Precast light weight hollow core wall panels shall be manufactured in Dry casting method. The units shall be made with tongue and groove joint. Section of the tongue rebate shall be 21.9 mm (top) x 30mm (bottom) x 7mm (deep) for entire thickness of 75mm, 92mm and 120mm on one end of the panel and on other end of the panel, the size of groove rebate shall be 22.8mm (top) x 32mm (bottom) x 8mm (deep). Panels shall have cylindrical hollow core incorporated with 8 No. 44 mm dia voids in the 75mm thick panels, 6 No. 62 mm dia. voids for the 92 mm thick panels and 6 No. 74 mm dia. voids for the 120 mm thick panels. Faces of panels shall be flat, rectangular and smooth.

Adhesive

High strength and tensile adhesion non-shrink cementations grout premixed compound/void filling expanding polyurethane foam (PU) shall be used for vertical and horizontal joints of precast hollow core wall panels. Butt joints at corners shall be fixed with special frame anchors.

Plumbing & Electrical

Robomatic wall panels shall have hollowcores of 44mm dia. in 75mm wall, 62mm dia in 92mm dia. and 74mm dia. in 120mm wall to allow the passage of water pipes, electrical wiring, HVAC and hydraulic installations without making holes/chases. Plumbing and Electrical service fittings shall be pre-planned and shall be passed through hollow portions of the wall panels.

Painting, Tiling and Cladding

Painting shall be done directly or after applying a 2mm wall putty coat. Texture paint coat shall be directly applied

to external surface for decorative effect. All tiling and cladding shall be directly fixed using regular cement mortar or tile adhesive.

CONSTRUCTION PROCESS

Installation Procedure

- Only two stacks shall be put on top of each other during stocking and transportation.
- Panel stacks shall always be lifted from under wooden pallet with a lifting fork or belt.
- The panel stacks shall be moved by forklift or trolley to construction site. Individual panel may easily be moved by a simple wheel. Panels can also be moved manually by inserting a short tube (500mm) into the second hollow as handle. These shall always be transported sideways.
- Gluing agents (cement based adhesives) as per IS 9103:1999 shall be mixed as per the manufacturer's instructions.
- The line of wall shall be marked on the floor and ceiling before start of installation.
- Guiding boards shall be fixed on the floor and ceiling. The guiding support will automatically align the wall when lifting the panels straight into upright position.
- The gluing agent shall be spread on the side of the already installed panel.
- Before the panel shall be lifted to upright position, it should be moved so that the panel bottom is as close as possible to its correct position. After that the panel shall be lifted to upright position.
- This panel shall be pushed against the previous panel (and move up and down) so that tongue and groove are carefully positioned against each other and gluing agent is squeezed out. Correct thickness of joint between two panels shall be 1 to 2 mm.
- The panel shall be positioned to correct level by using wooden wedges at the bottom and top of the panel erected earlier. The height of the panel should be about 10 to 50 mm shorter than free-room height.
- The top joint shall be filled with polyurethane foam. Correct thickness of joint shall be 5 to 10 mm.
- Alternatively, when same gluing agent as in sides is used for top joint, the panel shall be pushed against ceiling so that gluing agent is squeezed out. Correct thickness of joint shall be 1 to 2 mm. The surplus gluing agent shall be removed from joints after installation.
- Bottom joint of the panel shall be filled with mortar or concrete. Correct thickness of joint shall be 10 to 40 mm.
- 'Shoulders' shall be sawed or flat steel bar for door top portion fixed to the panels next to the door. The door top piece shall be glued by using polyurethane foam or gluing agents. The joints should be as thin as possible.
- All corners shall be strengthened with nail plugs (3 per corner).
- Paper or fibre tape shall be glued on to the corner joints and to the joints at a door top portion before plastering.
- Flexible joints between panels shall be built after each 5 – 6m. Polyurethane foam or mineral wool may be used as elastic joint material.
- The hollow boxes may be used for the cables and electrical boxes shall be fixed at the desired points after drilling.
- The panels need only a very thin skin coating (1-2 mm) before surface finishing. It may be easier to do with a wide trowel.
- All kinds of drilling and sawing can be easily made in the panels.
- The necessary tools required for installation shall be hammer, saw, screw driver, level, meter rule, trowel, drill, trolley concrete cutter, steel bar, buckets and lifting bars.

Installation/Instruction/Construction details

Conditions for installation: Before installing the Robomatic Hollowcore Wall Panels, the conditions available at the site are to be studied in detail and then decide what format to be used to install the wall panels. The major issues that are to be considered are:

a. Horizontal – Vertical Support Prerequisites
b. Top – bottom Support Prerequisites
c. Maximum Height Restrictions

d. Procedure for installation when height is > 3m

Horizontal – Vertical Support Prerequisites:

- In standard installation procedure, the wall panels should be installed between column to column or column to wall or wall to wall.
- Open ended walls should be avoided. In case of open ended walls, precautions should be taken for proper anchoring both at top and bottom of the panels.
- Additional support mechanism to be implemented through C Channel placement where there is no support horizontally.
- If the length of the wall is more than 5 meters in the abovementioned scenarios, provision of expansion joints through PU foam or mineral wool to be provided with thickness of 5mm.
- Alignment of the wall panels to be checked with the existing members of the structures viz., columns and beams.
- If the vertical members viz., column or wall are not in plum the wall panels cannot be placed in perfect position and lot of filling up either through PU Foam or Concrete to be applied. To avoid that insist client to have perfect plumb and alignment of the structural members.

Top - Bottom Support Prerequisites:

- In standard installation procedure, the wall panels are to be installed between the bottom slab and top slab or bottom slab and top beam.
- If top beams or slabs are not available as in few cases, I or C section iron members are to be placed where ever the walls are placed.
- Installation of walls with plumb is the main essential component.
- Electrical, Mechanical and plumbing conduits connectivity either at bottom or top of the wall panels to be planned before installation. As per the requirement, connectivity with the hollow cores to be established.
- Bottom slab or top beams with too much undulations to be avoided and should be taken up with client for rectification before installation of the wall panels.

Maximum Height Restrictions:

- Robomatic Hollow core Wall panels can be installed as non-load bearing internal walls for maximum height of 4.5 m. It is not advised to construct above this height.
- Robomatic panels are manufactured with maximum height of 3.3m.

Procedure to install when the height is > 3 M:

- Robomatic wall panels are manufactured with a maximum height of 3.3 Meters.
- It is suggested to construct walls maximum ranging up to 4.5m.
- The walls are to be constructed in staggered mannered as shown in the below photos.
- Cutting of the panels for bottom and top placements are to be planned to avoid wastage of material.

APPLICATION

These panels shall be used in non-load bearing walls/ partition walls and compound/boundary walls in residential/ commercial/ industrial/ institutional buildings.

PHOTOS OF WALL PANEL INSTALLATION



Only two stacks be placed on top of each other



Unloading of panel



Panel are fixed to the floor & ceiling



Tongue and Groove to be carefully positioned against each other



Top joint filled with PUF



Fixing of Electrical fittings



Gluing agent spreaded on side of the panel



Fixing of Plumbing fittings



Drilling and cutting being done on Panels



Panel installed

CERTIFICATION/VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No. 1040-S/2018 has been issued to M/s Robomatic Precon Pvt. Ltd., Hyderabad.

STANDARDS/GUIDELINES TO BE REFERRED

IS 383:2016	Specifications for coarse and fine aggregates for concrete
IS 516:1959 (Reaffirmed 2013)	Method of test for strength of concrete
IS 2386 (Part 1 & 3):1963 (Reaffirmed 2016)	Method of tests for aggregates for concrete
IS 3346:1980 (Reaffirmed 2017)	Method of determination of thermal conductivity of thermal insulation materials
IS 3812 (Part 1):2013	Specifications for pulverized fly ash for use as pozzolana in cement, cement mortar and concrete
IS 9103:1999 (Reaffirmed 2013)	Specifications for concrete admixtures
IS 9901:1981 (Reaffirmed 2007)	Measurement of sound insulation in buildings and building elements
IS 9142:1979 (Reaffirmed 2011)	Specifications for light weight aggregate
IS 10500:2012	Specifications of drinking water
IS 8112:2013/12269:2013	Specifications for 43/53 grade ordinary Portland cement
IS 16700:2017	Criteria for structural safety of tall concrete buildings
IS 15916:2011	Code of practice for building design and erection using prefabricated concrete
ISO 179-2:1997	Determination of charpy impact of plastics

K-Wall Panels

(Suitable for Non-Load bearing Structures)

ABOUT THE SYSTEM

K- wall panels are factory produced hollow core wall panels using light weight concrete made of ordinary Portland cement, fly ash, perlite, foam, fevicol DDL, fiber-glass mesh, river sand and water. After manufacturing, K-Walls are watered and cured properly for a period of 7 to 8 days. After 15 days the panels are ready for transportation to site.

Panels have cylindrical hollow cores incorporated with 7 no. 60 mm dia voids in the 100mm thickness, 8 no. 50 mm dia. voids for the 80 mm thickness and 9 no. 39mm dia voids for the 65mm thick panels. The corresponding nominal weight shall be 35 kg/m^2, 61 kg/m^2 and 102 kg/m^2 for 65mm, 80mm, and 100mm thick panels respectively Hollow cores are incorporated in K – wall panels to reduce weight, facilitate mechanical, electrical and plumbing services through hollow core, thereby increasing sound and thermal insulation properties. The sides of the panels are tongued and grooved to facilitate jointing.

K-Wall panels shall be used for non-load bearing structure in residential and non-residential buildings etc. according to thickness as given below:

(i) 100 mm wall panels are Suitable for external walls and partitions.
(ii) 80 mm wall panels are suitable for internal partition walls.
(iii) 65 mm wall panels are Suitable for interal walls and washroom partition walls.

K – Wall panels do not require stone or wood sills/frames to level surfaces for windows and openings. Lintels need not be cast as panels may be placed horizontally as lintels wherever required. Wash basins, cup-boards, mirrors, paintings etc. may be hanged with regular plug screws. Details of the wall panels showing hollow cores in figs.1,

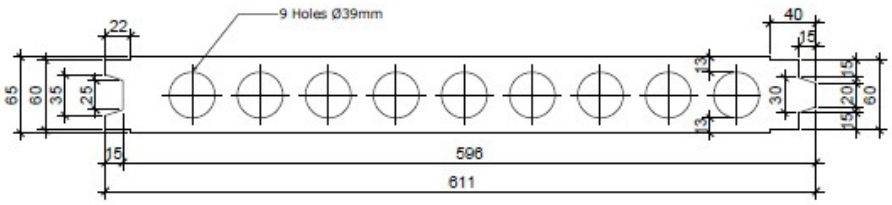


Fig.1

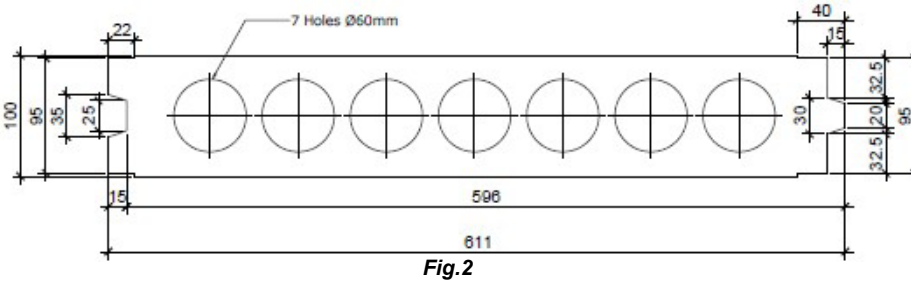


Fig.2

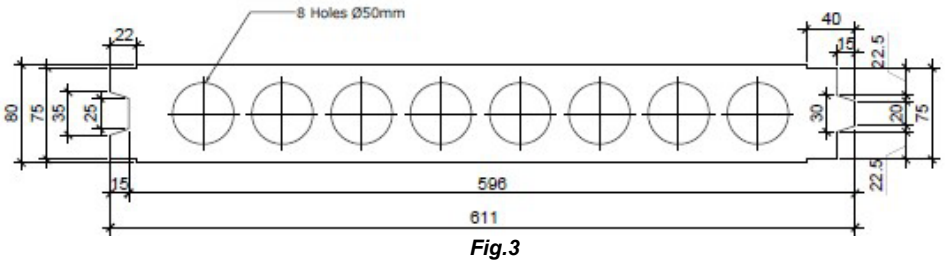


Fig.3



Fig.4

2, 3 & 4.

Type and size

K-Wall panels are produced in standard lengths, widths & thicknesses and in lengths to suit room height as per the details given below.

Wall width	:	611 mm
Wall thickness	:	65 mm, 80mm & 100 mm
Wall Height	:	2900mm
Weight	:	35 kg/$m^{2,}$ for 65mm, 61 kg/m^2 for 80mm and 102 Kg/m^2 for 100mm thick panels.

K-Wall Panel uses light weight concrete of density 675 kg/m^3 to 750 kg/m^3

Tolerances

The panels shall be produced in accordance with the following Tolerances:

Length	: ±3 mm,
Width	: ±2 mm,
Thickness	: ±1 mm,
Squareness of end	: ±3 mm

BASIC RAW MATERIAL REQUIREMENTS

- OPC 43/53 grade cement shall conform to IS 12269:1987
- River sand shall conform to IS 383:1970 IS 2386:1963
- Fly ash shall conform to IS 3812 (Part 1):2003
- Water shall conform to IS 10500:2012
- Perlite
- Fiber Glass Mesh

MANUFACTURING PROCESS

The manufacturing process of K - wall panels is as follows:

Raw Materials

River Sand shall be supplied to the plant by supplier, where it shall be weighed, sieved & Silt Content checked as per the quality assurance norms. Cement shall be supplied in bags, for which manufacturer will submit the test report along with the load. Fly Ash shall be supplied in closed bulkers directly from the thermal power plant. Cement and Fly Ash can be conveyed directly to the Mixer by using Screw Conveyor. Foaming Agent shall be supplied by the Manufacturer directly to the plant. Manufacturer will submit the test Certificate for the Foaming Agent supplied to the plant.

Preparatory Works

The Moulding machine is first made ready by placing the bottom mould of required thickness with relevant key and lock plates which move the panel plates on a guided rail operated by twin hydraulic jacks placed at the bottom of the panels.

Then Pipes of required diameter are inserted for the hollow core. The Fiber or GI mesh as per customer's requirement are placed on either side of the Pipes in each mould. Now the Mould is ready to take the light weight concrete mix.

Concrete Mixing

Concrete required shall be batched and mixed at batching and mixing plant. Water quantity required for a batch shall be loaded in the mixer chamber and then perlite shall be added.

The foaming agent shall be mixed with water to the right proportion as per manufacturer recommendation. Afterwards Fly Ash and Cement shall be added gradually into the mixture. The mixer shall run till a homogeneous mix is obtained. Required quantity of river sand shall be added at the end of the process and allowed to mix properly before pouring in to the panel mould.

Pouring of Light Weight Concrete

After mixing, the concrete mix which is in the form of slurry is poured into the special moulds and left to dry naturally.

Removing of Pipes

The pipes are then pulled out by winches from the moulds after initial setting and before hardening.

Stacking

When the lightweight hollow core panels have hardened in the moulds, they are released by moving the mould plates using jacks. The Light weight hollow core wall panels are then lifted with the help of special attachment in the hoist for stacking.

Pre - curing

The stacks shall stay 12 to 24 hours in the pre-curing indoor storage area where natural pre-curing occurs for each stock which is covered with tarpaulin to stop any evaporation and moisture loss.

Restacking

After pre-curing the products are strong enough to stand automatic handling. The products shall be restacked.

Curing

Curing is followed for 24 to 48 hours by stacking. The panels are watered and cured for a further period of 7 to 8 days. After 15 days the panels are ready for transportation to site.

CONSTRUCTION PROCESS

Installation procedure

Proper preparatory works are required before erection of K-Wall Panel to ensure quality, handling and installation.





Preparatory work items and checklists

- Check the site accessibility for the delivery of the Panel.
- Check delivery checklist for correct size and quantity of Panel.
- Check the adequacy of crane capacity and working clearance for hoisting of Panel
- Check the location and condition of lifting and hoisting of panels.
- Check the accessibility of unloading point and storage area.
- Check the storage area for its level, cleanliness and well drained dry ground
- Store the Precast panels according to the delivery schedule and erection sequence.
- Panels stacks shall always be lifted from under wooden pallet with a lifting

fork or belt.

- The Panel stacks shall be moved by forklift or trolley to construction site.
- Panels can also be moved manually. Panels should always be transported sideways.

Installation Method

1. Setting Out - Set reference line and offset line to determine the position of the K-Wall Panel to be installed. The line of wall is marked to the floor and ceiling before the start of installation.




2. Guiding boards shall be fixed on the floor and ceiling. The guiding support will automatically align the wall when lifting the panels straight into upright position.




3. The height of headroom needs to be checked for each individual panel before fixing, the same method shall be followed for all panels.
4. The floor, tongue and groove portion of panels shall be cleaned properly for firm fixing.
5. The 600mm side of panel shall be lifted & kept parallel to the floor. The groove side of panel shall be kept towards the wall or column end.
6. Cement based adhesive shall be spread on side of already installed panel.




7. Fix the G.I “U” Shaped Cleat in hollow core holes to lift the panels straight upright position using Machine or Manually.




8. Before the panel is lifted to upright position, it should be moved so that the panel bottom is as close as possible to its correct position.
9. Check the alignment before fixing of Panels. If required, adjust it to achieve the level and position of the Panel




10. The G.I “U” Cleats shall be fixed with self-expansion screws in columns.




11. Cement Based Adhesive shall be applied along entire length of tongue and groove of panels.





12. Before the Panel is lifted to upright position it should be moved to its correct position for fixing. After that panel is positioned manually or mechanically.
13. The Panels should be pushed against the previous Panel (and move up and down) so that tongue and groove is carefully positioned against each other. Correct thickness of joint between two panels is 1-2mm.
14. K-Wall Panel is positioned to correct level by using wooden wedges at the bottom and top of the Panel erected earlier. The height of the panel should be about 10 - 20mm lesser than free room height.




15. The bottom, top and side joints of panel are filled with Adhesive. The surplus Adhesive is removed from the joints, right after installation.

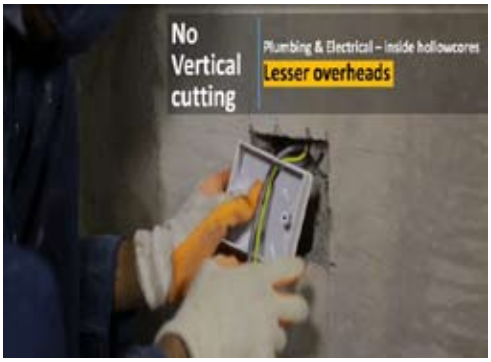



16. The partition shall be completed by joining panel by panel as per the above procedure.



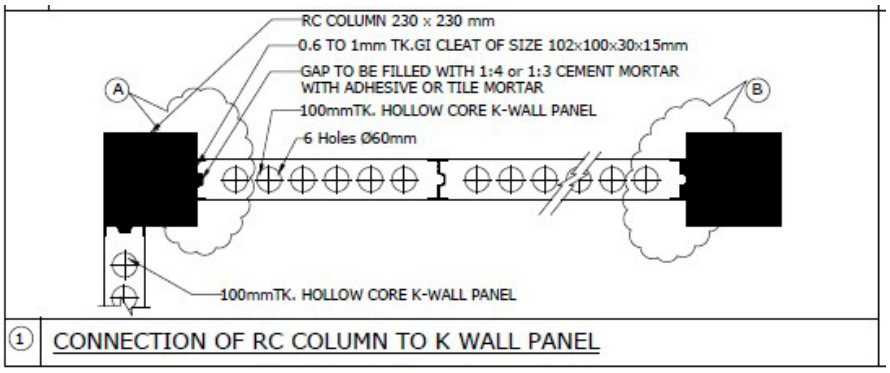


17. Keep the installed panels undisturbed for at least 8 hours.
18. After final setting of the adhesive applied in tongue and groove joints, fiber mesh of size 5mmx5mm 140 GSM shall be glued on both sides of the Panel.
19. The hollow cores may be used for access of the electrical conduits and water supply services.
20 K-Wall Panel need only a very thin coat (1-2mm) of putty for smooth finishing.
21. Necessary tools required for installation shall be hammer, saw, screw driver drilling machine, trolley, concrete cutter machine, lifting rods etc.

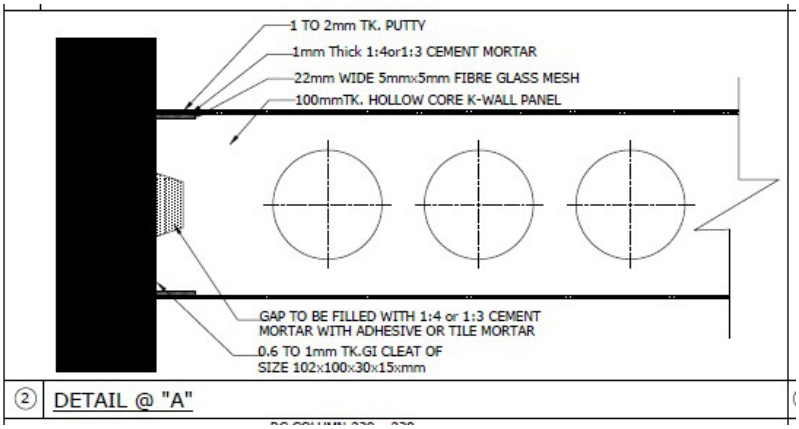




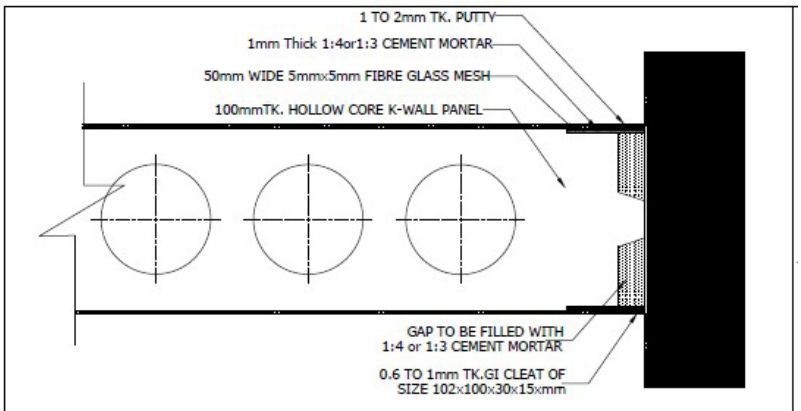
K-WALL PANEL INSTALLATION DETAILS
(100mm TK. HOLLOW CORE K- WALL PANEL)
ALL DIMENSIONS ARE IN "MM"
SHEET- A5



① CONNECTION OF RC COLUMN TO K WALL PANEL



② DETAIL @ "A"



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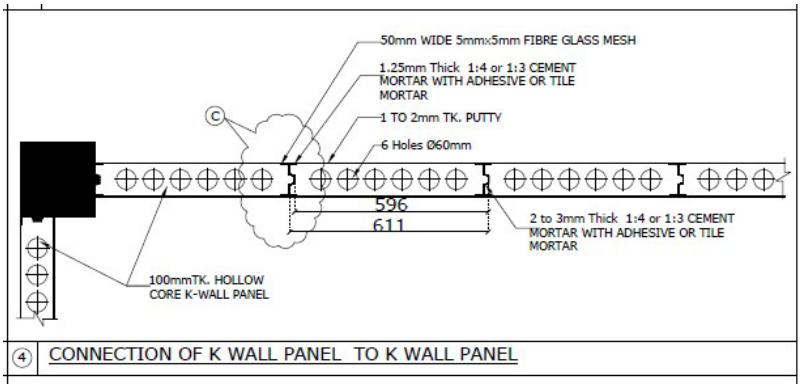
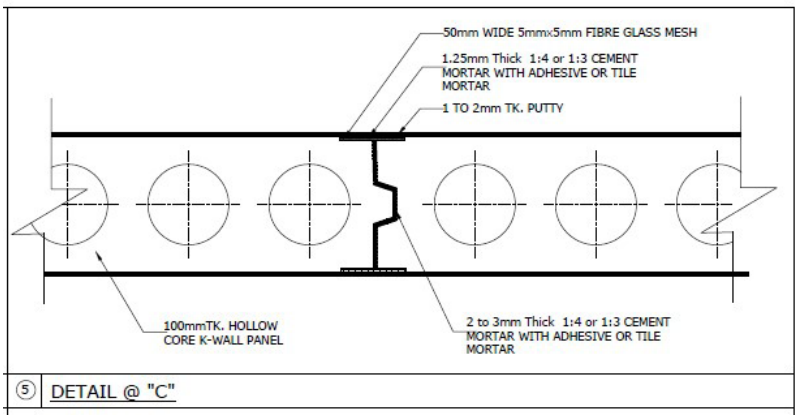


④ CONNECTION OF K WALL PANEL TO K WALL PANEL



⑤ DETAIL @ "C"

LIMITATIONS

For non-load bearing walls only. Not to be used as load bearing walls.

CERTIFICATION/VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No.: 1043-P/2019 has been issued to M/s Pioneer Precast Solutions Pvt. Ltd., Chennai.

STANDARDS/GUIDELINES TO BE REFERRED

IS 383:2016	Specifications for coarse and fine aggregates for concrete
IS 516:1959 (Reaffirmed 2013)	Method of test for strength of concrete
IS 2386(Part 1& 1963(Reaffirmed 2016)	Method of tests for aggregates for concrete
IS 3346:1980 (Reaffirmed 2017)	Method of determination of thermal conductivity of thermal insulation materials
IS 3812 (Part 1):2013	Specifications for pulverized fuel ash for use as pozzolana in cement, cement mortar and concrete
IS 9103:1999 (Reaffirmed 2013)	Specifications for concrete admixtures
IS 9142:1979 (Reaffirmed 2011)	Specifications for light weight aggregate
IS 9901:1981 (Reaffirmed 2007)	Measurement of sound insulation in buildings and building elements
IS 10500:2012	Specifications of drinking water
IS 8112:2013 / 12269:2013	Specifications for 53 grade ordinary Portland cement
IS 15916:2011	Code of practice for building design and erection using prefabricated concrete





Urbanaac Precast Construction Technology

(Suitable for Low Rise to High Rise Structures)

ABOUT THE SYSTEM

Precast Construction Technology consists of various precast elements such as walls, beams, slabs, columns, staircase, landing and some customized elements that are standardized and designed for stability, durability and structural integrity of the building. Precast residential building construction involves design, strategic yard planning, lifting, handling and transportation of precast elements. This technology is suitable for construction of high rise buildings resisting seismic and wind induced lateral loads along with gravity loads. The building framing is planned in such a way that maximum number of repetitions of moulds is obtained. These elements are cast in a controlled factory condition. The factory is developed at or near the site which provides an economical solution in terms of storage and transportation.

Types of precast elements

Two main types of precast concrete elements, namely precast reinforced concrete elements and precast pre-stressed concrete elements are used as per the details given below. Concrete components of a building are prefabricated in precast yard or site and shall be installed in the building during construction (*See Fig. 1*).

(i) Precast reinforced concrete elements:
These shall consist of reinforcement bars and/or welded wire meshes within the elements to provide the structural strength as per requirement of the component such as façade walls, beams, columns, slabs, staircases and parapet wall

(ii) Precast pre-stressed concrete elements:
These shall consist of pre-stressing tendons within the elements to provide a predetermined force needed to resist external loadings and cracks such as hollow core slabs, beams and planks.

The sizes of various components may vary as per requirement

Moulds

Moulds for precast elements shall be of steel and concrete. For design of the moulds for various elements, special importance should be given to easy de-moulding and assembly of the various parts. At the same time rigidity and strength and water tightness of the mould are also important taking into consideration forces due to pouring of green concrete and vibration. The type of moulds used for pre-casting various elements with various methods is given below *(see Fig. 2):*



Wall Panels | Parapet Beams | Staircase | Hollow core slab | Pod Element

Fig 1. Precast concrete elements

S. No.	Mould type	Uses
1.	Conventional moulds	Ribbed slabs, beams, window panels, box type units and special elements
2.	Tilting moulds	Exterior wall panels where special finishes are required on one face or for sandwich panels
3.	Long line prestressing beds	Double tees, ribbed slabs, piles and beams
4.	Prestressing bed with Extrusion machine	Hollow core slabs andhollow core non load bearing wall



Conventional Mould



Titling Mould



Extrusion Machine

Fig.2

BASIC RAW MATERIAL REQUIREMENTS

Sr. No	Raw Material /Component	Specification
1	Cement – 53 grade OPC	OPC 53 as per IS 12269:1987
2	Sand (River)	IS 383:1970 & IS 2386:1963
3	Coarse Aggregate & Light weight aggregate	IS 383:1970, IS 2386:1963 & IS 9142:1979
4	Fly ash	IS 3812(P-1):2003
5	Additives	IS 9103:1999
6	Reinforcement steel	IS 1786:2008
7	Anchors	ASTM A 307 Gr A/IS1363(P-1& P-3) :2002
8	Anchor bolt	IS 1363:2002
9	Non-shrink grout	ASTM C 109 &ASTM C 293-79)
10	PU Sealant	ASTM C 920 CLASS :25 IS 12118(P1&2):1987

INSTALLATION

Precast Installation

Proper planning and preparatory works shall be required before the actual installation of precast concrete elements in order to ensure quality installation. The following items shall be planned in advance:

i. Method of sequence of assembly and installation: Precast elements should be identified based on their location number and the tagged.

ii. Method of providing temporary support: Elements should be supported temporarily before these get stabilized. Generally structural members with adjustable ends shall be used for securing the panels. Shims should be used to adjust the panels to ensure dimensional correctness.

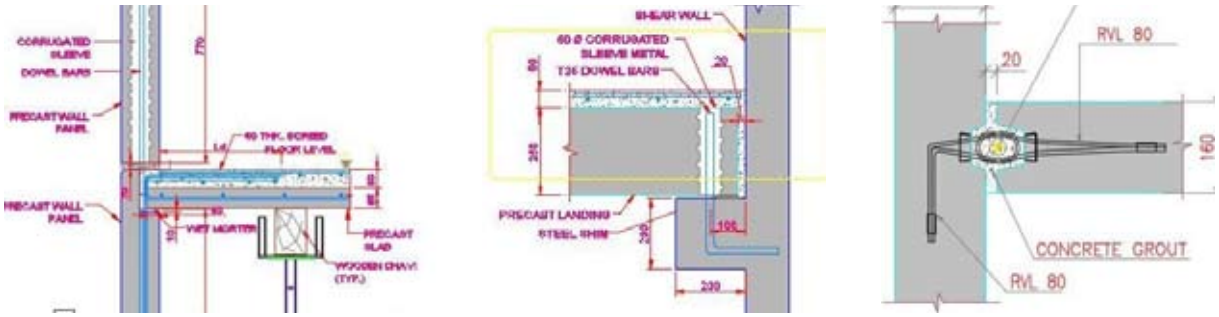
iii. Installation tolerances: Installation tolerances should be based on codal provisions and design considerations should be clearly indicated.

iv. Handling and rigging requirements: Elements should be checked for handling stresses before lifting and the cranes should have sufficient capacity to handle the precast panels. At least 10% impact should be

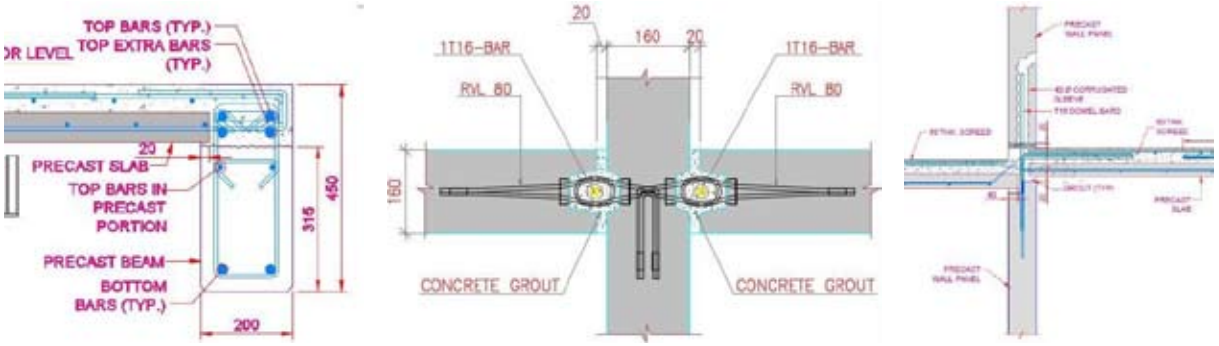
considered while calculating the lifting capacity of the crane.

At site locations, panels shall be first unloaded and stacked or directly lifted by the crane. The element shall then be installed on the site and supported by temporary jacks. The cranes shall be released for next lifting once the temporary supports are in place. Shims shall be used to carefully align the element before grouting. The panels shall be grouted after the final adjustments are done.

Connection Details:



Wall panel to wall panel and wall panel to slab | Wall panel to precast landing | Wall panel to wall panel



Slab and beam | Wall panel to wall panel | Wall panel to Slab

Fig 3. Connection Details

Waterproofing

External joints shall be sealed with baker rods and sealants after filling the joints with grout to avoid the leakage. Additional waterproofing treatment shall be provided at external joints and wet areas to ensure water tightness. (*See Fig. 4*)

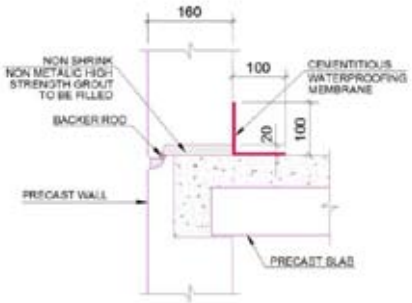


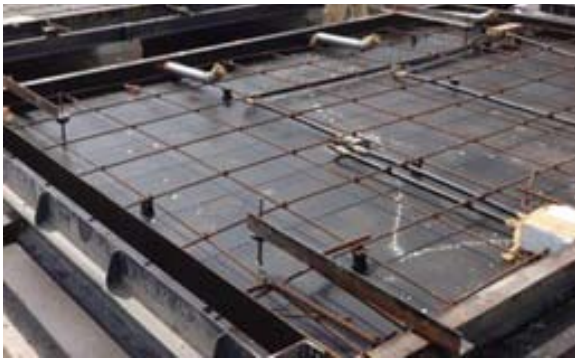
Fig 4. Cementitious waterproofing membrane

Mechanical, Electrical & Plumbing Fittings

- Mechanical, electrical & plumbing fittings shall be kept open or concealed as per the requirements. For concealed fittings, provision for grooves, blockouts shall be made in casting moulds.
- The conduits and electrical boxes shall be embedded and fixed in moulds before casting. For open fittings, these shall be fixed after erection at site. (*See Fig. 5*)
- For firefighting systems, provision of National Building Code
- (NBC) and local body law shall be adhered to.



Fixing electrical conduits



Fixing electrical boxes and conduits



Laying conduits on slab



Plumbing

Fig.5 Mechanical, Electrical & Plumbing Fittings

Fire Rating

- Precast concrete shall be designed for fire rating as per codal requirements.

Finishes

- Variety of shapes, colours, textures and finishes may be obtained with precast concrete.
- The surface treatments shall be done by rebating, grooving, surface coatings, cement based renders, oxide coloring etc.
- Precast concrete facades of various shapes, colours and textures may be moulded and installed.

CONSTRUCTION PROCESS

Casting Concrete

- The procedure for casting concrete shall be as follows:
- Precast concrete elements shall be produced on horizontal, flat steel surfaced tilting tables.
- Side shutter are fixed in position.
- Apply mould release agents to sides and bottom.
- Steel reinforcement shall be kept in position using adequate spacers to ensure correct position and concrete cover.
- Prior to casting, electrical conduits, plumbing grooves and sleeves, and other required accessories like lifting anchors, loop boxes and dowel tubes shall be fixed in position.
- The high-quality concrete shall be transported from batching plant to the precast bay moulds, through concrete distribution system of flying bucket, discharge chutes, distribution bucket and EOT cranes.
- During casting, table vibrators (as & when required) shall be used to achieve the best compaction. Top surface shall be finished with hand operated trowel which gives smooth finish.
- Care should be taken on embedded items while concreting.
- After casting, all exposed surfaces shall be covered with a tarpaulin (as and when required) to avoid vaporization. Casted elements shall be de-moulded once the strength meets the design requirements and the units are then shifted to the stockyard. Thereafter, curing shall be carried out for minimum 5 days.

Curing

The curing of the prefabricated elements may be done by the normal methods of curing by sprinkling water and keeping the elements moist.

Screed Concrete for Flooring

The procedure for screed concrete shall be as follows:

1. The surface for screed concrete shall be clean, free from dust, loose materials, lumps and foreign material.
2. The screed shall generally be provided over the entire slab. In this case the entire slab shall act as a continuous structural diaphragm providing optimum load transfer mechanism for lateral loads. The screed shall be treated as a part of the compression zone for gravity loads on the slab. The design shall consider composite action between the slab & screed and compressive strength of screed in slab. Further, the interface shear between the slab & screed shall be checked for verifying adequate shear transfer capacity at the interface.
3. Screed on haunches may be provided, only if the conduits are exposed, with the mutual agreement between the project authority and the PAC holder. In such cases, additional water proofing treatment of a reputed company shall be provided at the precast slab and site concrete stitch.
4. Electrical conduits or any other embedment shall be laid as per approved drawing before screed concrete flooring
5. The reference level from main survey pillars shall be transferred and marked on side channels
6. While marking level, sloping direction in flooring shall be taken care as per approved drawing
7. Before laying the concrete, cement slurry shall be spread on the slab surface for better bonding and filling of gaps between wall and slab soffit junction.
8. The concrete should be placed from one end and shall be compacted immediately after placing and levelled uniformly.
9. The vibrator should be applied smoothly and concrete compacted well.
10. The concrete shall be allowed to set so as to be in dry condition.
11. The trowelling shall start after concrete is set and reach dry condition.
12. Curing shall be done by using bunds over the screed surface /wet hessian cloth.

Lifting of elements from mould

1. It must be ensured that all the elements should have identification mark.
2. It must be ensured that all side shutters are loosened so that the elements may be lifted without any damages.
3. Before demoulding, it must be ensured that compressive strength of the cubes should meet the specified requirements.
4. The lifting clamps/clutches shall be fixed to lifting beam at proper positions.
5. Then the elements shall be lifted carefully to the stocking area.

Stacking of elements

1. The surface of stacking area should be horizontal.
2. The wooden runner shall be placed perpendicular to lifting points and the elements placed over runner.
3. Number of the elements per lot should not exceed man height.
4. In case of vertical stacking, the gap between the elements should be 150 mm to 200 mm.
5. Stacking shall be done in such a way that slabs of longer span should be placed below that of shorter span.

Transportation of Elements

The process of transportation of precast elements from yard to site shall be as follows:

Loading of slab over trailer

1. It must be ensured that the identification mark on the slab should be the same as per dispatch list.
2. Any damage occurred during loading should be informed to the concerned authority.
3. The lifting clamps/clutches shall be fixed to the lifting beam at proper position.
4. The lifting beam shall be placed over the precast elements and ensured that the clutches are locked properly before lifting.
5. Instruction regarding loading height, positioning of precast elements over the trailer should be followed as per

capacity of trailer.

6. The wooden rubber shall be placed in between the slabs at 500 mm from each end.
7. Some of precast elements should be placed vertically and transported through “A” frame fixed vehicle.
8. The slab shall not be overhanging from trailer.
9. The slab shall be tied firmly to the trailer by means of belt/rope as moving the load without proper tie will cause damage.
10. While transporting elements vertically, the vehicle should be loaded equally on both sides.

Unloading of slab from trailer and placing in site yard

1. Every slab shall be inspected for dimensions / identification mark and damages etc. prior to unloading at site.
2. The stacking area should be levelled and hard enough for stacking the elements.
3. There should be proper access for trailer movement.

Erection

The process of erection and installation of panels during the construction cycle by using tower cranes shall be as follows:

1. Before starting erection a survey of the area to receive precast elements shall be done to monitor any difference in dimensions or levels exceeding the tolerances. In case of unacceptable tolerances, necessary action shall be taken for rectification.
2. Installation shall be done by tower crane with sufficient capacity. Panels shall be shifted from the stack rack/ truck from yard to the nearest point of construction site and shall be kept above the truck during the construction or inside the storage racks as per the site situation.
3. The necessary access for the truck to reach the nearest point of the tower shall be prepared before starting erection of the panels.
4. Once the truck reaches the tower, chain and lifting clutch with required capacity and guide rope shall be attached to the precast panels to allow the workers to control the load to its final place.
5. As the elements are lifted to its final position above the cast-in-situ slab/precast panel, vertical and horizontal alignment of the panel shall be adjusted. The gap between the element and adjusted elements shall be maintained as per the drawings within the allowable tolerances. Shims and spacers shall be used for levelling and adjustment.
6. Temporary propping jacks shall be provided for restraining the walls laterally until grouting.
7. After completion of fixing, alignment of the panels shall be checked again.
8. Minor damages, if any to the precast panels shall be repaired by approved materials.
9. After completion of installation and alignment, elements shall be handed over for inspection.
10. The joints between the precast wall panels shall be filled with joint filler material.
11. Precast slab shall be erected above the wall panels without any scaffolding system. The electrical conduit/fitting shall be done. After electrical works are completed, screed concrete shall be laid over the precast slab.
12. Installation of the next floor shall start only after completion of screed concrete of the previous floor.
13. The sequence of erection shall be as follows:
    - Installation of precast wall panels above cast-in-situ slab
    - Provide temporary props/jacks for restraining of the walls laterally.
    - Grout the connection between the wall panels & ground floor slab and the joint between each wall panel.
    - Installation of precast slab panels above the erected precast wall panels.
    - Screed concrete above the slab after placing of electrical conduits/fittings
    - Installation of the wall panels over the floor slab.
    - Installation of the roof panels such as parapets etc.

CERTIFICATION / VALIDATION OF THE SYSTEM

i) Performance Appraisal Certificate No.: 1046-S/2019 has been issued to M/s Urbanaac Infrastructures Pvt. Ltd., Ahmedabad by BMTPC.

MAJOR COMPLETED/UNDER COMPLETION PROJECTS

- Plant Shed Precast Wall Panels- Ranesar, Bavla, Ahmedabad.
- Boundary Wall System- Ranesar, Bavla, Ahmedabad
- Staff Quarters- Ranesar, Bavla, Ahmedabad

OTHER SIMILAR SYSTEMS SHORTLISTED UNDER GHTC-INDIA

i) Precast concrete construction system using precast walls with precast plank floor of M/s PG Setty Construction Technology Pvt Ltd., Mysuru has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

ii) Precast components comprising of beams, columns, staircase, slab, hollow core slab etc. manufactured in plant & erected on site of M/s Teemage Builders Pvt Ltd., Tiruppur has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

iii) Optimal Pre-cast concrete System through structural Analysis, design & equipment support of M/s Elematic India, New Delhi has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

STANDARDS/GUIDELINES TO BE REFERRED

IS: 875 (Part-1) -1987 (Reaffirmed 2008)	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures-Unit Weights of Building Materials and Stored Materials.
IS: 875 (Part-2) -1987 (Reaffirmed 2008)	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures-Imposed loads
IS: 875 (Part-3) -1987 (Reaffirmed 2003)	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures –Wind Loads
IS: 875 (Part-5) -1987 (Reaffirmed 2003)	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Special Loads and Load Combinations
IS: 456 -2000 (Reaffirmed 2005)	Code of Practice for Plain and Reinforced Concrete
IS: 13920-1993 (Reaffirmed 2008)	Ductile Detailing of reinforced concrete structures subjected to seismic forces –code of practice.
IS 15916:2010	Code of practice for design and erection using prefabricated concrete
IS: 9103:1999 (Reaffirmed 2004)	Specification for Concrete Admixtures
IS: 2062:2011	Specification for Hot Rolled Medium and High Tensile Structural Steel
IS 11447:1985	Code of Practice for Construction with Large Panel Prefabricates
IS 10262:2009	Guidelines for Concrete Mix Proportioning





Intregated Hybrid Solution-ONE

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE SYSTEM

IHS-ONE is an Intermediate Building System (IBS) having three main components: walls, floor/roof and stairs. All 3 components are integrated to construct a building and hence named as “Integrated Hybrid Solution – ONE”. It has the integration of the following:

Walls : Hydraform Prefabricated Mortarless Interlocking Technology. The interlocking blocks are manufactured with a block making machine offsite or onsite in an open shed. The blocks can be of cement-flyash-block or cement-soil block.

Floors/Roof : Mechanized Precast R.C. Plank & Joist system : The RC planks as well as joists are partially precast either offsite or on site. After placement as floor/roof elements, the haunches are filled with in-situ concrete. A layer of ferrocement course is laid with wire mesh reinforcement. The assembly provides monolithic behavior and diaphragm action to transfer horizontal loads to supporting members.

Ferrocement Elements : Mechanized precast/prefab Ferrocement staircase, kitchen shelves, kitchen platforms, sunshades, lintel bands, water tanks, fines.

The Integrated Hybrid Solution – ONE uses the technologies, which can be bridged to erect a structure by using precast floor/roof system bridged with interlocking mortarless block wall system in a load bearing system upto G+3 structures. Both roof/floor and walling system can also be bridged with RC framed structure as well as steel structure in multistoried structure providing a complete solution for a building structure.

The system has been designed for all loads including earthquake.

TYPES OF PRECAST ELEMENTS (FOR WALLING)

The Interlocking Block

There are two major objectives of any dry-stack interlocking block system. The first objective is to be self-aligning. Features requiring for self-aligning interlocking blocks include:-

- Fitting into each other without adjustment (e.g. cutting, shaving or shining)
- Features, so that, if wrongly placed they will not fit and therefore, require either reversing or replacement for rectification.
- Modular coordination requirements.
- Tight tolerances.
- Simple shapes so as to simplify the management of production, construction & maintenance.

An Interlocking Compressed cement/ flyash / gypsum / sand or soil /Flyash / cement Block made on the Hydraform machines is referred to as a block (Fig 1)

Interlocking: The locking of a male face of one block with the female face of another or the locking of the bed of one block with the ridge of the one below it is called Interlock (Fig.2).

Bed: The recessed under surface of the block is called the Bed (Fig.3).

Ridge: The raised top surface of the block is called the Ridge. (Fig. 3)

Course: One (horizontal) layer of Hydraform blocks is called a course (Fig.4).

Height of a course = 115 mm

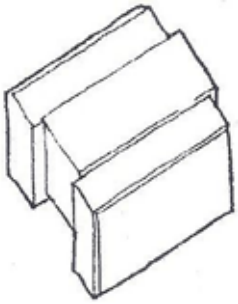


Fig. 1

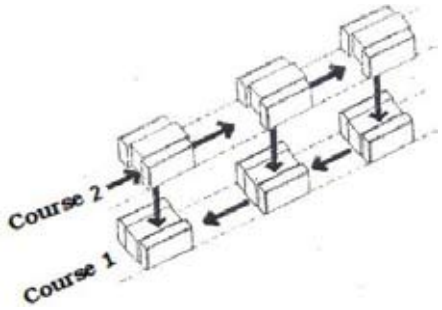


Fig. 2

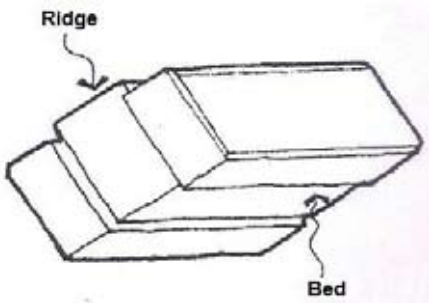
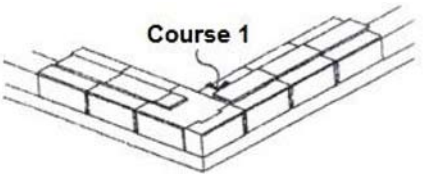


Fig. 3



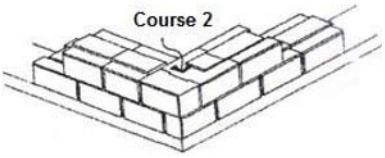


Fig. 4

Size & Dimensions of Blocks

The blocks are mainly of following size and dimension to suit standard application. However, size can be tailored for large quantity application requirements.

For external application:

for load bearing the block sizes are :

HF190 : 240mm (l) x190mm(w) x 115mm (h)

HF 220 : 240 mm (l) x 220 mm (w) x 115 mm (h)

HF 150 : 240mm (l) x 150 mm (w) x 115mm (h)



For partition walls:

HF 100:240mm(l)x100mm(w)x115mm(h) or 220mm(h)

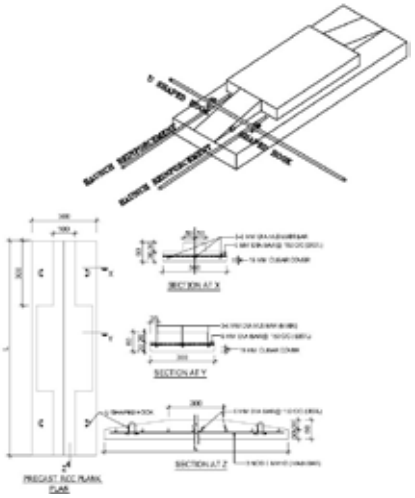
Special blocks:

For conduits and embedding of reinforcement bars.

TYPES OF PRECAST ELEMENTS (FOR FLOOR / ROOF)

Floor / Roof is a precast system named as Precast RC Planks & Joists System. The precast planks are partially precasted and when placed over wall / joists/beams, serve as form work for cast-in-place concrete. The haunches are filled in situ along with the negative reinforcement of 6 mm dia in haunches.

This system consists of precast R.C. planks 60 mm thick supported over partially precast RC joists of 150 mm width and 150 to 200 mm depth with stirrup projecting out on the top. To provide for Tee-beam effect with the joist, the plank is made partly 30 mm thick. A 100 mm wide tapered concrete fillet is provided for strengthening the haunch portion during handling and erection.



Precast Planks :

The RC Planks typically have 3 Nos. 6mm dia bars as main reinforcement and 3mm dia mild steel wire @ 150mm c/c or 6 mm dia bars up to 200mm c/c as transverse reinforcement. The in-situ concrete at every joint with 2 no. 6mm dia as negative reinforcement form the flange of the tee beam along with the joists and provide monolithic effect.

Fig. 5 ***Plan, Section & view of R.C. Plank***

Partially Precast RCC Joist

It is a rectangular shaped joist 150 mm wide and the precast portion is generally 150 mm deep. The portion above is casted while laying in-situ concrete over planks. The stirrups remain projected out of the precast joist. Thus the total depth of joist becomes 210 mm. The joist is designed as composite Tee-beam with 60 mm thick flange comprising of 30 mm precast and 30 mm in-situ concrete. This section of the joist can be adopted upto span of 4 m. For smaller spans, the depth of precast joist can be reduced. For longer spans the depth of joist can be increased. However, the self-weight of joist shall increase and lifting would require simple chain-pully block.

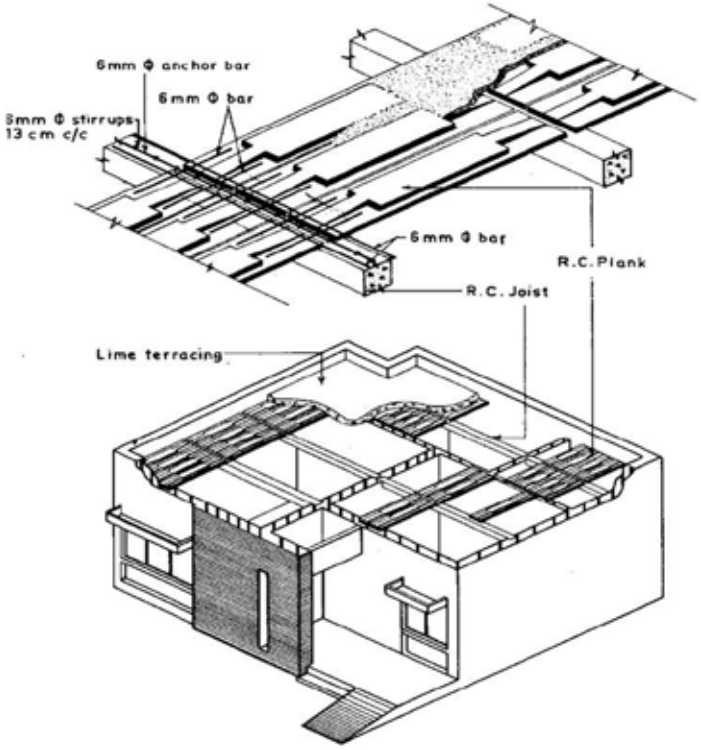


Fig. 6

Precast Ferrocment / Ferrocrete Elements

Ferrocement is a special form of reinforced concrete. It is a composite material consisting of cement sand mortar (matrix) reinforced with layers of small diameter wire meshes. It differs from conventional reinforced concrete primarily by the manner in which the reinforcement is arranged within the brittle matrix. Since its behavior is quite different from that of conventional reinforced concrete in performance, strength and potential applications, it is classed as a separate material. Usually steel bars are also used in addition to wire mesh, to form a steel skeleton, which helps in retaining the required shape of the ferrocement components once the cement mortar hardens. The wire mesh reinforcement is uniformly distributed across the thickness of the element.

Ferrocement Shelves

Conventionally, cooking platforms are provided in 50 mm thick cast-in-situ RCC slabs. Precast ferrocement cooking shelves are used which are easier to cast, easier to handle and light weight besides being economical. The cooking platform has 25mm thickness having one layer of welded mesh 25x75mm of 2 mm dia and two layers of chicken mesh 24 gauge, embedded in cement mortar.

Ferrocement Staircase Steps

Stair case is an essential part of any building as it provides access to different floors in the structure. Conventionally, staircases are constructed in Reinforced Cement Concrete, having a waist slab, treads and risers, hand rails etc.

Precast ferrocement steps (tread & riser unit) are 25 mm thick, supported on walls / beams and provide aesthetic look like a folded slab.

Ferrocement Water Tanks

There are a number of options available to store water viz. brick masonry tanks, RCC water tanks, PVC tanks etc. Ferrocement tanks of 1200 litres & 1600 litres have been provided which have a dia of about 1.5m. For these tanks, the base and the cylindrical container are casted separately. The wall thickness is 25mm. Two layers of chicken mesh along with GI wire in helical shape are provided in the walls.

BASIC RAW MATERIAL REQUIREMENTS

Interlocking Blocks

The main raw materials for production of interlocking blocks are Cement + Flyash + Sand for Flyash Blocks or cement + soil for soil blocks, which are available cheaply and in abundance. The ingredients are compressed and compacted in the block making machine.

The Mix design and proportions of the ingredients depends upon the nature of fly ash and the strength of block required.

Fly ash grade II AS PER is 3812-1981 is used for Blocks.

Sample mix design for achieving respective class strength.

	Cement	Gypsum	Lime	Sand	Fly-Ash
Class 75	6%	3%	3%	25%	63%
Class 100	7%	3%	4%	30%	56%
Class 125	8%	3%	4%	35%	50%

RC Planks & Joists

The materials used are cement, aggregates, water, reinforcement, admixtures.

Ferrocement elements

The materials used for ferrocement are cement, sand, wire mesh and steel bars.

Quality of Materials :

All the raw materials used shall be as per relevant IS Codes.

MANUFACTURING / PRODUCTION PROCESS

Interlocking block

- Blocks are produced in a special Block Making Machine of different production capacity.
- Ingredients (sand, flyash and gypsum) or soil, flyash are mixed dry in pan mixer for one minute. Then cement is added. When homogenous mixing is achieved, water is mixed.
- The moisture in the mix is checked with drop test.
- The sequence of operation of machine is :
    - Lower the main ram
    - Open the pre-compression ram
    - Fill the compression chamber with raw material mixture in the hopper.
    - Close the pre-compression ram.
    - Raise the main ram to compress the block
    - Open the pre-compression ram

- Raise the main ram fully to eject the blocks.
- Remove and stack the blocks
- Curing done for 14 days.

Flow Chart For Production of Blocks :
The Flow chart for production of Interlocking blocks is given in Fig.7.

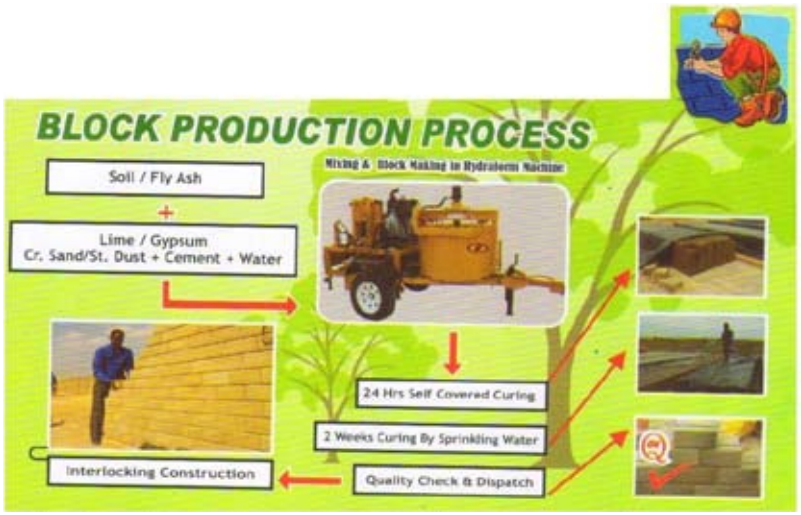


Fig. 7

RC Planks & Joists

The reinforcement cage comprising of 3 Nos., 6mm dia main reinforcement and distribution bars 6mm @ 200mm spacing is prepared. 3 Nos. of cover blocks are also binded. The cage is placed on the pallet over the Vibrating table. Two planks are casted together on one table. The twin moulds are tightened with the table. Min. M-25 strength of concrete is poured in a measured quantity. Vibration is done with a timer. No smooth finish is required on top of planks. Rather it is roughened with a steel broom.

After the casting, the mould is lifted and the plank along with pallet is lifted and placed for curing. After 48 hours the plank is demoulded from the pallet and shifted to curing yard. The process takes about 3 minutes, when self compacting concrete is used no vibration is required.

The precast joists are casted on a leveled platform using MS Channel as form work. The reinforcement cage with triangular stirrups having one bar on top and 2 or 3 bars in bottom is placed. Concrete is poured and compacted with a 25mm needle vibrator. The lower part of joists is casted up to top of the MS Channels. The edges are finished. The mould are removed after 4 hours of initial setting and reused. The joists are cured with gunny bags or under polythene cover. After 14 days they are shifted to stacking yard.

Ferrocement elements

The reinforcement cage is prepared for ferrocement items such as sunshades, platform, shelves, steps, tread riser units, covers etc., using min. two layers of chicken mesh, one layer of WWF/mesh and edge bars/middle bars for handling stresses. The cage is placed on leveled platform with steel angle moulds. A thin layer of 5mm thick cement sand mortar (1:1.5 or 1:2) is mortared. Chicken mesh is placed. Next layer mortar is laid, WWF is inserted and top layer of mortar is laid and finished. The thickness of ferrocement elements vary from 10mm to 50mm.

CONSTRUCTION PROCESS / METHODOLOGY

Wall

Preparation of blocks: Before use in stacking of blocks for walling, the blocks require preparatory work.

Cleaning: By using a piece of hacksaw blade, remove any stubborn mortar/soil lumps from top and bottom surfaces of recesses, ridges of flanges of blocks, so that laying of successive layer of blocks are laid in the 'true' line and level (Fig.8). Before using, the top and bed surfaces of the block must be cleaned using a brush.

Cutting and Shaving: You can cut your block with a block cutter or a blaster chisel and hammer. Use "used" hacksaw blades or chisel and hammer to shave blocks (Fig.9).

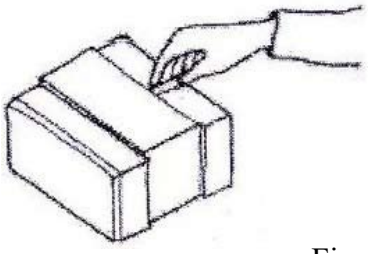
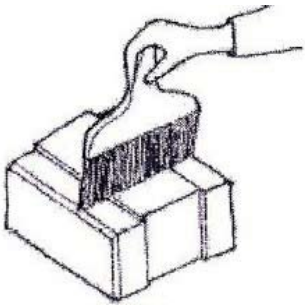


Fig. 8



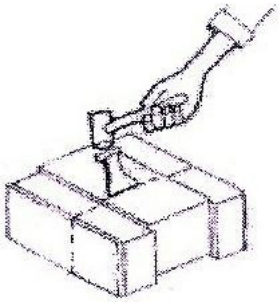


Fig. 9

Laying the First Superstructure Course: It is most important that the first course is perfectly level since superstructure courses are without mortar. Find the highest corner of the plinth beam/ DPC. Start laying the first course on a 10/12 mm bed of 1:4 /1:6 mortar at this point with a spirit level or water level for checks. Do not build on top of this first course for at least 12 hours because the weight of the blocks will squash the un-cured mortar and may spoil base level, resulting into undulations in block laying.

Corners: All corners are started with a half block. The male face or 'tongue' may be cut off, but this is not essentials. The ridges on the blocks are shaved to allow the incoming blocks to sit level. The tongues of the blocks may be shaved, but this is not essential (Fig.10).

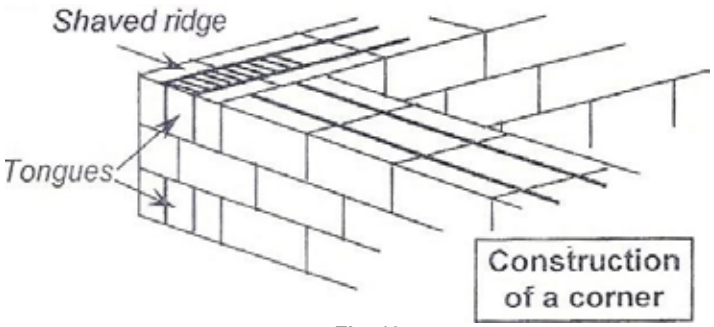


Fig. 10

Gauge rods and Line blocks: The ideal method of ensuring that walls are straight and level is to set up gauge rods at each corner of the building. A gauge rod should have two steel stays to anchor it are set on the gauge rods to hold the building line (Fig.11).

Half block direction: Note that the corner half blocks 'rotate', facing as shown in the sketch. (Fig.12)

Reversing alternate block courses: Each course of blocks is laid in the opposite direction from the course below. This compensates for differences between the upper and lower sections of the wear plates, during block production.

Laying a wall: Begin at two corners and work towards the centre of the wall, ensuring that the blocks are being laid in the same direction so that the male and female interlocks will marry when the last block is laid. When only four or

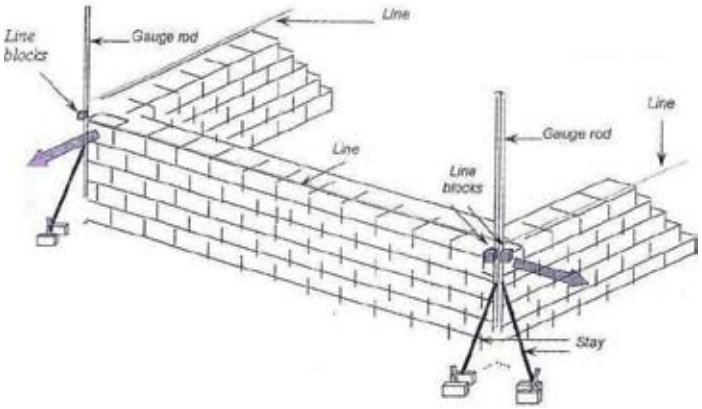


Fig. 11

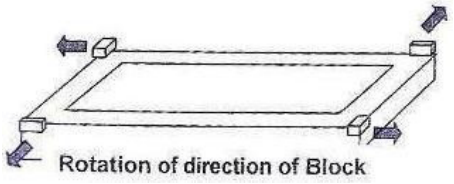


Fig. 12

five blocks remain to complete a course, measure the gap and select blocks which will fill the gap precisely.

Seating the blocks: It is vitally important that every block is seated with a rubber mallet. It is essential to have best rubber headed mallets preferably with steel or fibre handles. Wooden handles do not last.

Checking levels: Block layers should use spirit levels not less than 1,000 mm long, but 1,200 mm levels are preferable. They are also long enough to check the vertical alignment of walls.

Keying in internal walls: Every internal wall must be 'keyed' into an outside wall. Alternate courses are 'tooth bonded' into the outside wall. A half block is always used at the end of the internal wall. The ridges are shaved off as illustrated in the sketch alongside that of a 'One-Block Pier'.

EQ Bands : Earthquake resistant bands and vertical reinforcement are provided as per design requirements.

Fig.13 to 16 shows the blocks laying process for walls.

RC Planks & Joists

First the joists are lifted and carried to the site location. They are placed Mannually or by light crane over the walls with bed blocks beams and leveled. The spacing depends upon the room dimensions.

The RC planks are also lifted manually or by light crane. Planks are placed on wall to joist, joist to joist or beam to joist with a bearing of 40mm. 6mm dia negative reinforcement is provided in the haunched. Concrete is poured and compacted with hand plate vibrator. A coat of cement wash mixed with water proofing compound is laid, the next day of pour. A layer of 12mm thick ferrocement plaster with 150 x 150mm wire mesh of 2 mm dia reinforcement and



Fig.13 ***Block production in a shed***



Fig.14 ***Corner vertical reinforcement***



Fig.15 a,b,c,d *Walls under construction*



Fig.16 a,b,c,d *Walls under construction*

water proofing compound is laid over the slab within 72 hours of haunch filling, when the in-situ concrete is 2 cm. This completes the slab system. The joists are supported at mid span till the insitu concrete gains bond strength.

Fig.17 to 30 shows the construction of floor slab with planks & joists systems.



Fig.17 *Stack of reinforcement cage for different size of planks*



Fig.18 *Placing twin plank reinforcement*



Fig.19 *Placing mould over*



Fig.20 *Pouring of concrete in mould*



Fig.21 *Ready casted twin planks over pellets*



Fig.22 *Lifting casted plank with pellet*



Fig.23 ***Casted planks on pellets stacked for initial strength***



Fig.24 ***RC joists being precasted***



Fig.25 ***Precasted joists under covered shed***



Fig.26 ***Lifting of planks mechanically***



Fig.27 ***Planks & Joists being placed on walls***



Fig.28 ***reinforcement in haunches***



Fig.29 ***Filled up haunches with in-situ concrete (curing being done)***



Fig.30 ***The sunk slabs and vertical reinforcement projecting out***

Ferrocement Elements

The ferrocement elements are placed in position embedded in walls/beams like any precast RCC element using mortar for gap fill. Fig.31 to 34 shows ferrocement elements.



Fig.31 ***Precasting ferrocement shelves***



Fig.32 ***Mesh placed on mould (staircase steps)***



Fig.33 ***Laying mortarand finishing stairs step***



Fig.34 ***Precast steps placed in first flight***

Services

Electrical conduits in floor/roof can be concealed, through RC Joist, nearly at mid level (near neutral axis) and through the in- situ joints of two panels.

Finishing

The interlocking block external walls can be kept exposed with silicon water resistant paint or any other external paint, as done on the plastered surface. For the ceiling direct POP/Gypsum putty can be done. Ferrocement elements can be finished like any RCC element.

APPLICATION

The system shall be used in load bearing walls upto G+3 structures, partition walls and non-load bearing walls in high rise structures for residential/ commercial/ industrial/ institutional buildings.

CERTIFICATION/VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No.: 1048-S/2020 has been issued to M/s Aap Ka Awas LLP, New Delhi.

MAJOR COMPLETED/UNDER COMPLETION PROJECTS

Sl. No.	Name of the Client	Nature of work
1	Delhi State Industrial & Infrastructure Development Copr.Ltd. (DSIIDC) - 2003-06	3164 Housing with cost effective technologies (Industrial Workers housing at Bawana) (SFS Scheme)
2	Delhi State Industrial & Infrastructure Development Copr. Ltd. (DSIIDC) - 2007-08	1184 houses (Type-III) with cost effective technologies at Bawana Industrial Complex (Pocket-B, Extn.)
3	Delhi State Industrial & Infrastructure Development Copr. Ltd. (DSIIDC) - 2007-09	Housing for Urban poor at Narela, Delhi (BSUP / JNNURM)
4	Delhi State Industrial & Infrastructure Development Copr. Ltd. (DSIIDC) - 2008-10	Housing for Urban Poor Delhi Bhorgarh (BSUP JNNURM)
5	Delhi State Industrial & Infrastructure Development Copr. Ltd. (DSIIDC) - 2008-11	5552 EWS houses with cost effective technologies (Composite work) at Baprola, Delhi
6	The G.M. (Planning & Architecture), Greater Noida Industrial Development Authority- 2013-15	EWS Housing at Greater Noida
7	M/s. Infra Inno Private Limited - 2009-13	Innocity Geo Smart City, Oragadam, Chennai
8	M/s Welspun Projects Ltd., Welspun City - 2013-16	Bachelor/Family/Workers Accommodations for WSL at Anjar
9	M/s Welspun Projects Ltd., Welspun City - 2013-16	Bachelor/Family/Workers Accommodations for WSL at Vapi
10	BMTPC - MoHUA under PMAY(U) (under construction)	40 Demonstration houses at Ahmedabad, Gujarat

STANDARDS/GUIDELINES TO BE REFERRED

ACI 549 (1999)	“Guide for design, construction and repair of ferrocement”, ACI 549 ACI 549. IR-93.
ACI 549 R (1993	)“Guide for the Design, Construction & Repair of Ferrocement (Reapproved 2009)”, American Concrete Institute.
ASTM A820-11	“Standard Specification for Steel Fibers for Fiber-Reinforced Concrete”, ASTM International.
IS 383 : 1970	Specification for coarse and fine aggregates from natural sources for concrete (second revision)
IS 1542 : 1992	Specification for sand for plaster (second revision)
IS 2116 : 1980	Specification for sand for masonry mortars (first revision)
IS 2386 :	Methods of test for aggregates for concrete
IS 1489 :	Specification for Portland pozzolana cement :
IS 3466 : 1988	Specification for masonry cement (second revision)
IS 8112 : 1989	Specification for 43 grade ordinary Portland cement (first revision) (Part 2) : 2003 For use as admixture in cement mortar and concrete (second revision)
IS 456 : 2000	Code of practice for plain and reinforced concrete (fourth revision)

IS 4926 : 2003	Code of practice for ready mixed concrete (third revision)
IS 516 : 1959	Methods of test for strength of concrete
IS 1199 : 1959	Methods of sampling and analysis of concrete (Part I) : 1982 Mild steel and medium tensile steel bars (third revision)
IS 1786 : 1985	Specification for high strength deformed steel bars and wires for concrete reinforcement (third revision)
IS 6523 : 1983	Specification for precast reinforced concrete door and window frames (first revision)
IS 12440 : 1988	Specification for precast concrete stone masonry blocks
IS 13990 : 1994	Specification for precast reinforced concrete planks and joists for flooring and roofing
IS 875 (Part I) : 1987	Code of practice for design loads (other than earthquake) for buildings and structures Part I Dead loads – Unit weights of building materials and stored materials (second revision)
IS 8888 (Part I) : 1993	Guide for requirements of low income housing : Part I Urban area (first revision)
IS 13920 : 1993	Code of practice for ductile detailing reinforced concrete structures subjected to seismic forces
IS 4326 : 1993	Code of practice for earthquake resistant design and construction of buildings (second revision)
IS Codes	for Ferrocement under preparation (CED-2 A2-25)
IS:3812(Part1) : 2003	Flyash
IS:2542-2(1981)	Gypsum
IS :4948-2002	Galvanised wire mesh
IS :4948 -2002	Galvanised chicken mesh
IS : 9103 – 1999	Admixture
IS : 1725-1982	test for compressive strength
IS : 3495 (Part II) :	Test for water absorption
IS : 4139-1989	Drying shrinkage
IS : 1725 – 1982	Weathering
IS : 12894 – 2002	Compressive test

Kon_crete Reinforced Autoclaved Aerated Concrete Panels

(Suitable for Low Rise to Medium Rise Structures)

DESCRIPTION OF SYSTEM

KON_CRETE Reinforced AAC wall & floor/roof panels are innovative Autoclaved Aerated Concrete (AAC) products, having properties such as light weightness, high thermal resistance, acoustics & energy efficiency. It is a steam cured cementitious material manufactured from a mix of flyash, cement and other additives giving the material a unique cellular lightweight internal structure.

Type and size:

The KON-CRETE reinforced AAC panels are grouped into two basic types based on its application;

- Wall panel
- Floor / roof panel

Product specification: Walling Panel

Grade (As per IS 6072: 1971)	Class C	Class D
Mean compressive strength (Mpa)	>5.0	>3.5
Mean dry Density (Kg/ M3)	651-750	551-650
Dry thermal conductivity (W/m2.k)	<0.26	<0.21
Drying Shrinkage %	<0.09	<0.09

Product Dimension

	Partition Wall	**External wall**	**Floor/ roof**
Length	Up to 6 Meter. (Customizable)	Up to 6 Meter. (Customizable)	Up to 6 Meter. (Customizable)
Width	600 mm. fixed	600 mm. fixed	600 mm. fixed
Thickness	100mm,125 mm	150mm,200mm,250mm	According to the design criterion.
Lintel Beams	750 mm 1000 mm 1200 mm 1500 mm	600 mm	Fixing of Doors and Windows

The photo of the product (Figure-1) is as per the details below;

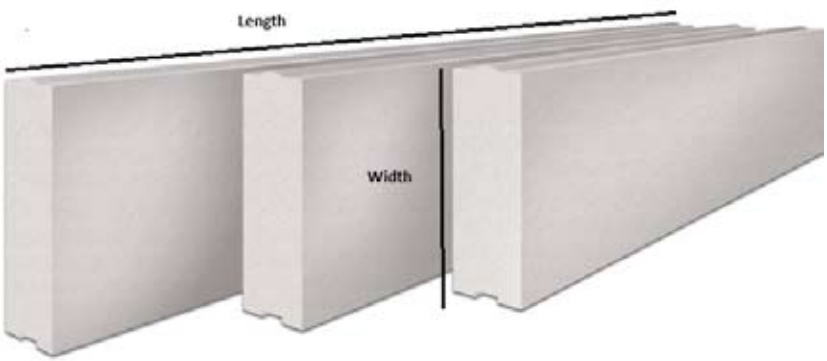


Fig. 1

Tolerances for dimensions shall be the following;

Length	*+-5 mm*
Width	*+-1.5 mm*
Thickness	*+-1.5 mm*
Diagonals (Max)	*5 mm*
Edge straightness deviation(Max)	*1.5 mm*

The panels shall be produced in accordance with BIS specification IS 6072:1971 (Wall Panels) and IS 6073:2006 (Roof / Floor Panels).

BASIC RAW MATERIAL REQUIREMENTS

i) Cement: Shall conform to IS 269-1967 or IS 455 -1967 or IS 1489-1967
ii) Lime: Shall satisfy the requirements for class C lime satisfied in IS 712-1964
iii) Fly ash: Shall conform to IS 3812 part -1966 except that the loss on ignition shall not be more than 6%
iv) Water: Shall conform to the requirements given 4.3 of IS 456-1964
v) Reinforcement:
    a) Plain mild steel bar conforming to grade I of IS 432 part I – 1966 of IS 226- 1967
    b) Plain medium tensile steel bars conforming to IS 432 part I -1966.

MANUFACTURING PROCESS:

The manufacturing process of KON_CRETE wall and roof panels is as follows:

Raw material preparation and mixing
The Flyash slurry is stored in slurry tanks and pumped into the slurry weighing hopper in the mixer tower. The binders (lime, cement and anhydrite) are stored in silos. The aluminum powder is prepared in a separate building where it is dispersed in water. All the components are accurately weighed, and are released into the mixer in a pre-defined order. Recipe and temperature control system constantly monitors this process.

Pouring and Pre-Curing
The mould consists of four fixed sides and one detachable platform. The inner mould surfaces are covered with de-moulding release oil before casting. This oil is applied either manually or automatically.

The mix is then poured into the moulds. A mould circulation system conveys the moulds to the rising area, where the cake pre-cures for 2-3 hours after which it is ready for cutting. Depending on the plan design, the moulds are handled by a mould traverser or by a tilting manipulator.

Cage manufacturing and insertion:
1. Mild steel bars (5-10 mm dia) in coils form are fed to automatic cage making machine and mats of specific sizes.
2. Two individual mats are then tied to form a single cage.
3. Cages are assembled into a holding frame assembly.
4. Whole cage assembly is dipped in an anti-corrosive paint tank by the Crane and dipped into it.
5. Cage assembly are then stored in an enclosed drying chamber to get dried up and then kept in position for insertion.
6. Immediately after the mix has been poured into the mould, the reinforcement frame assembly is inserted. Before cutting of the cake, the holding frames with needles are lifted, leaving the reinforcement in the cake.

Tilting
The tilting manipulator tilts the mould by 90°. The manipulator unlocks the mould and removes the mould body, so that the cake remains on one mould side/platform for cutting. This tilting system has proven to be the safest

method for tilting the cake into the vertical cutting position, as the cake is remaining on the platform/mould side for the cutting process.
This way of handling results in optimal efficiency in raw material consumption due to the low mechanical forces on the product in the green stage and reduces the risk of cracks and product damage.

Cutting
The cake is cut by high-precision cutting machines. Cutting is done by cutting knives and by pneumatically tensioned cutting wires.

- The pre-cutter and vertical cutter cut the block length and panel width. In this station the profiling (tongue and groove) shall be cut into the cake with profiling knives
- The horizontal cutter cuts the block and panel thickness; for special demands in surface finish and thickness accuracy beyond the traditional building standards, HESS AAC SYSTEMS provides proven alternative cutting systems with oscillating wires while maintaining the advantages of the tilt cake cutting system
- The cross cutter cuts the block height and the panel length. Optionally hand-grips can be milled in the blocks in the green stage.

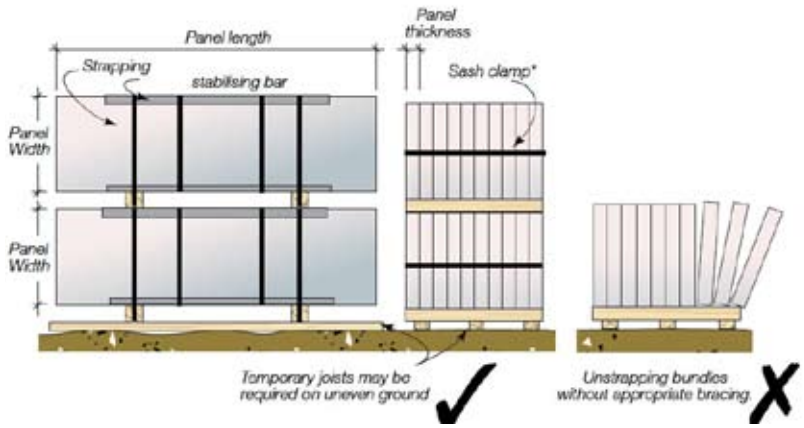
Back tilting and green separation
After the cutting is completed, the cake is tilted back by 90° onto a cooking frame. After the cake has been tilted back into the horizontal orientation, the bottom/bed waste shall be removed before autoclaving. Autoclaving the cake horizontally on the cooking frames allows efficient autoclave loading and, most importantly, will prevent most of the sticking of the layers, which is a typical disadvantage of the traditional tilt-cake systems.
In the green separator the horizontal cuts (now laying vertical) are carefully separated before autoclaving, leaving a small gap between the layers. This eliminates any sticking, which is typical for other tilt-cake systems. Further this green separation substantially improves the autoclaving process as steam can penetrate into the cake more effectively.

Autoclaving
In the autoclaves the cakes are cured for approx 10–12 hours at a temperature of 190° C with saturated steam at a pressure of 12 bar. The fully automatic autoclave control system ensures a safe and optimal autoclaving process.

Packaging
After the Autoclaving, finished products are then packed by unit sizes and transferred to stock yard by a grab forklift.

STORAGE, HANDLING AND TRANSPORTATION OF THE PANELS

Storage
After the Autoclaving process, Panels are stacked on wooden planks or other supports free from contact with the ground. Panels of different specifications are marked and kept in separate stack. Pattern of stocking the finished product is organized in such a way that material can be dispatched in FIFO system.



All material must be kept dry and preferably undercover. Care should be taken to avoid sagging or damage to ends, edges and surfaces.

Panel must be stacked on edge and properly supported off the ground on a leveled platform. Panel bundles can be stacked in two tires.



Handling

Panels are handled by pallets forks of forklift or suitable carne /hydra by using nylon straps, slings.

Excessive handling may cause damage, chipping of material. It is advised to set delivery schedule to match the erection sequence exactly.



Manual handling

It is recommended to use a trolley or other mechanical apparatus to move the panels around the work site.



Transportation

After complete curing and at the time of shipping of the panels to the site, type of the truck is decided based on the volume of the load being handled. Capacity of the truck is decided varying from 8T to 27T. Wooden logs for buffering are placed on the platforms of the trucks and bundles of panels are placed on them to avoid sudden forces generated during movement of truck in adverse conditions of the road. Only two-tier arrangement (bundle over bundle) is allowed during transportation to safe guard the bottom panels. Proper packing between the bundles with the thermocol is provided for sudden horizontal movement in any eventuality. After loading the trucks with proper layout matching to its carrying capacity and optimum utilization of area/space, the load is tied with heavy duty ribbons arresting the movement of the panels in any direction. UPVC sheets or tarpaulin sheets are used to cover the panels to avoid soaking in rain.

The photos below explain the transportation of panels from casting to shipping out of the plant to the customer sites.







INSTALLATION PROCESS

Preparation



1. Layout of wall panels should be marks on the foundation using Chalk
2. Nylon offsets lines should be used to ensure outside line of panels,
3. Aluminium straight edge should be set to line and level the inner face of the wall
4. Use Koncrete Jointing mortar (as guided by the Manufacturer) as a bed for the wall panels.
5. Verify dimensions, positions and quantity of panels according to the installation drawing
6. First the corner panel is to be installed
7. Lift the panel by a lifting hook.

Installation of wall panels



1. Place the first panel (corner panel) is position and check for plumb.
2. Wooden wedges are used for temporary support of wall panels and allow for find adjustment in alignment
3. Succeeding panels are to be installed as per part mark on each panel and following KONCRETE Installation Drawings
4. The top edges of wall panels are also aligned and steadied by temporary wall braces at every 3rd and 4th Panel
5. KONCRETE jointing mortar of 3-4 mm thickness should be applied on the two adjoining edges of the wall panel before fixing them against one another.
6. After the final alignment of the erected wall panels synthetic mesh of 75 mm – 100 mm width should be pasted using KONCRETE jointing mortar at each vertical and horizontal joint of wall panels.
7. KONCRETE Wall Panels can be used as lintels on top of windows and door openings. These lintels are supported on and connected to the wall panels adjacent to the openings.

Installation of Floor / Roof Panels



1. Place the first panels with groove side in position on the lines as already marked.
2. Succeding panels are to be installed as per part mark on each panel and following KONCRETE Installation Drawings.
3. After panel / Installation, place steel reinforcement in longitudinal joints and ring beams surrounding panels, as spcifed by the Structrual Engineer and / or Architect.
4. These longitudinal joints and ring beams are then filled with concrete
5. A smooth surface of concrete is required to match the top of panels using a mason's trowel.

CERTIFICATION / VALIDATION OF THE SYSTEM

i) Performance Appraisal Certificate No.1056-P/2021 has been issued to M/s UAL Industries Ltd., UAL-KONCRETE, Howrah, West Bengal.

MAJOR COMPLETED/UNDER COMPLETION PROJECTS

The product has been supplied to PWD, Govt. of Best Bengal and Kolkata Port Trust (Haldia Dock Complex)

OTHER SIMILAR SYSTEMS SHORTLISTED UNDER GHTC-INDIA

ii) AAC wall and roof panel system to provide integrated solution of M/s Biltech Building Elements Ltd., New Delhi has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

iii) AAC Panels for use as wall & slab of M/s SCG International India Pvt Ltd., Gurugram has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

STANDARDS/GUIDELINES TO BE REFERRED

BS 476-20:1987	Fire Tests on Building Materials and Structures-Part-20
IS 6073(2006)	Test for Deflection and Ultimate Load Test of AAC Floor and Roof Panels
IS 6072(1971)	RA-2010: Test for Deflection and Ultimate Load Test of AAC Wall Panels.
IS 2185 (P-3): 1984:	Tests of Autoclave Aerated Concrete Blocks.
IS 6441 (P-1): 1972 (RA-2012)	Tests for Block Density in Kg/cum.
IS 6441 (P-5): 1972 (RA-2012)	Tests for Compressive strengths in N/mm^2
IS 6441 (P-5): 1972 (RA-2012)	Test for Drying Shrinkage percentage in AAC.
IS 3346:	1980Test for Thermal Conductivity in Air Dry Condition in W/m








Light Gauge Steel Structural Systems & Pre-Engineered Steel Structural System

Factory Made Fast Track Modular Building System

(Suitable for Low Rise to High Rise Structures)

ABOUT THE TECHNOLOGY

Factory Made Fast Track Modular Building System comprises of prefabricated steel structure with different walling components. About 70 percent of the work is done in the factory with minimal usage of concrete, which enables system to deliver the building within a few days of work at site. The steel moduled are pre-fitted with flooring, ceiling tiles, electrical and plumbing fittings. The assembled steel modules are transported to the site for installation which is done using crane and other required machineries. Once all the components are assembled and erected at site, factory made 3–D Expanded Polystyrene (EPS) wall panels are fixed and shotcreting is done from both sides.

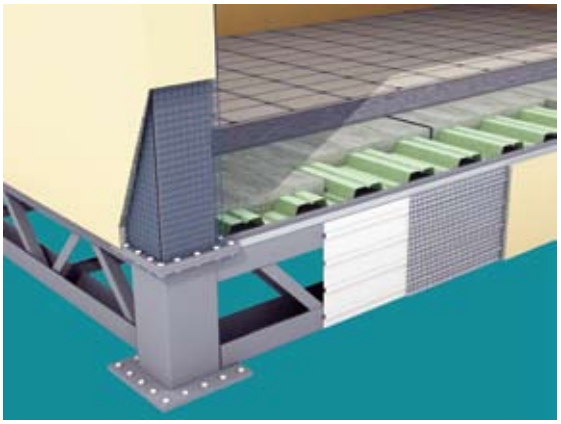


The uniqueness of system is the efficient and simultaneous activities of site preparation and building construction in factory, rather than two phased customary process.

DETAILS OF STRUCTURE

Foundation

Foundation shall be either strip or raft as per site conditions. The design and construction of foundation shall be carried out as per IS 1904:1986 and other related Indian Standards, as applicable.



Steel Structure

The structure consists of steel pillars, modules and other components designed for worst loading conditions as per IS 800:2007 and IS 801:1975. In addition, the structure shall be designed in accordance with IS 1893(Part 1) & IS 875 for seismic and wind load considerations, both individually and in combination, as applicable. Steel pillars shall be made by welding MS plate of 16mm thickness and steel tubes of size 200mm x 200mm having wall thickness varying from 3mm to 16mm depending upon the number of floors. The smaller pillar is fixed with sub-assemblies for modules. All the columns shall be checked for their safety and computations shall be done for the same for satisfying requirements of IS 800 and IS 801.



Steel Staircase

Steel staircase shall be designed and fabricated using HR steel sheet of thickness 3mm / 4mm with MIG welding process. Staircase is pretreated for surface cleaning using steel cleaning agent and painted with two coats of anti-corrosion primer and fire proof paint.

Flooring

The floor is made up of deck sheet and wire mesh of size 100mm x 100mm x 3mm thickness. The deck sheet is fixed on the modules ready after providing with utilities like plumbing and electrical etc. Flooring, roofing and ceramic tiles are fixed as per relevant specifications.

Walling

Walling is completed by using factory made EPS based wire mesh welded 3D panels. The panels are easy to install and manufactured using insulated polystyrene core covered on both sides by hot GI coated round wire square mesh, duly connected by 33 connectors per m^2.

Door and Window

The structure can accommodate any types of door and window frames and panels. Metal door frame pressed from 1.2/1.5mm thick galvanized steel sheet with mitered and welded construction may also be fixed. The doors used, however, should satisfy the performance requirements as per relevant Indian Standards. For doors not covered by any Indian Standards, third party certification may be adopted. Performance characteristics for dimensions & squareness, general flatness, impact indentation, flexure test, edge loading, shock absorption, buckling resistance, slamming and misuse as per relevant parts of IS 4020:1998 shall be required before accepting any doors for use.

Utilities

i) Once the steel structure module is ready for electrical and plumbing work as per the drawings, these utilities are planned & executed based on the services/utilities layout design and requirement of the floor area.

ii) After completion of services/utilities, the module is covered with deck sheet. Wire mesh and MS studs of required size are fixed on the deck sheet before laying of PCC flooring. After decking, PCC of M25 grade is laid for a total depth of 76mm and flooring tiles are fixed wherever required depending upon utilization of area. With all fittings the module is ready for shifting to the site.









TRANSPORT OF MODULES AND PILLARS ALONG WITH ACCESSORIES

All the handling/transportation at site for erection are done by means of mechanical equipments such as tower & mobile cranes and trucks etc. Due care should be taken to avoid any damage to these modules, pillar and other

elements. Special lifting points are provided in these modules so that handling stresses are kept to a minimum. Transportation are carried out in mainly two stages:

i) From manufacturing plant to stacking yard.
ii) From stacking yard to erection site. The transportation is carried out by using trucks of desired capacity and length. Erection are carried out by cranes of suitable capacity at site.

PERFORMANCE EVALUATION

Structure

Seismic Performance Evaluation of a G+7 CRC framed structure model for ground motion compatible to Seismic Zone V was performed at SERC, Chennai and found to be satisfactory.

Walling Component

Evaluation on the behavior of reinforced EPS Panel under flexural and Axial Compression load on 100 mm and 150 mm thick panels were satisfactory. Other performance characteristics are:

Thermal transmittance of Single Panel	0.537 w/m^{2}k
Acoustic Behavior	37 dB (noise reduction)
Water Penetration	No penetration after 3h
Resistance to impact with softbody and hardbody	Impacts of 90 & 1200 J –No crack

CERTIFICATION

Performance Appraisal Certificate No. 1011-S/2013 has been issued for the system to M/s Synergy Thrislington, Mohali.

STANDARDS/REFERENCES

• Report of Seismic Evaluation of Model of G+7 CRC framed structure for a ground motion compatible to zone V spectrum by SERC, Chennai.	
• Inspection Report of the visit for Performance Appraisal Certification.	
IS 800:2007	General Construction in Steel - Code of Practice
IS 801:1975	Code of Practice for Use of Cold Formed Light Gauge Steel Structural Members In General Building Construction
IS 875(Part 1):1987	Code of Practice For Design Loads (Other Than Earthquake) For Buildings And Structures Part 1 Dead Loads - Unit Weights of Building Material And Stored Materials (Incorporating IS 1911 : 1967)
IS 875(Part 2):1987	Code of Practice for Design Loads (Other Than Earthquake) For Buildings And Structures: Part 2 Imposed Loads
IS 1893(Part 1):2002	Criteria for Earthquake Resistant Design of Structures - Part 1 : General Provisions and Buildings
IS 4020(Part 1 to 16):1998	Door Shutters - Methods of Tests
SP 7:2016	National Building Code of India 2016.

Speed Floor System

(Suitable for Low Rise to High Rise Structures)

ABOUT THE TECHNOLOGY

The Speed Floor System is a suspended concrete flooring system using a roll formed steel joist as an integral part of the final concrete and steel composite floor. It is essentially a hybrid concrete/steel tee-beam in one direction and an integrated continuous one-way slab in other direction. The joists of different depths are manufactured from pre-galvanized high tensile steel in a one pass roll former, where it is roll formed, punched, pressed and slotted in a fully computerized machine. The joist depth and the concrete thickness are varied depending on the span, imposed loads and other functional considerations. The Speedfloor composite floor system is suitable for use in all types of construction. The Speedfloor joists are designed and custom manufactured to suit particular job conditions.







DESIGN

The design of the speed floor system is based on NZS 3404 (Part 1 &2), AS/NZS 4600 and the Australian Composite Standard AS 2327 (Part-I). The design load shall be taken as prevalent in IS 875 (Part 1 & 3). Earthquake forces shall be taken in accordance with IS 1893 (Part-1).

The section properties and design parameters are calculated from the section geometry, supplementary full scale tests and finite elements analysis.

THE JOIST

The joist is manufactured from G 350 Z 275 pre-galvanized steel conforming to AS 1397:2001. Size may be any one of the following i.e. 200mm, 250mm, 300mm, 350mm and 400mm, depending upon the design requirements. Concrete thickness may be 75mm or 90mm as required.

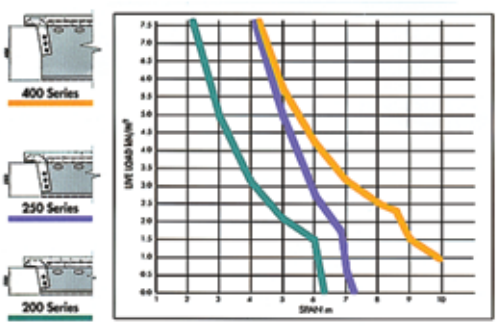
The joist weight vis-à-vis the depth are given below:







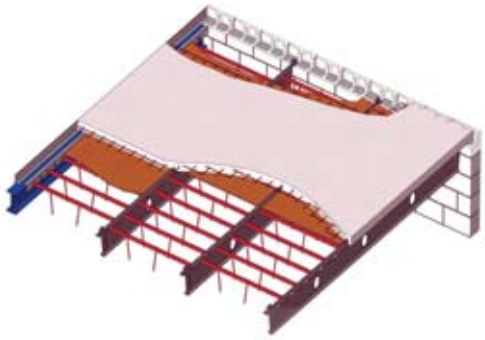
Depth (mm)	*Weight (kg/ In m)*
200	9.41
250	10.59
300	11.76
350	12.94
400	14.12



Load span graph – 75mm topping

The ***top section*** of the joist is embedded in concrete and has following functions:

- It is the compression element of the non-composite joist during construction
- It is a 'chair' for the welded mesh or the reinforcement which develops negative moment capacity in the concrete slab over the joist
- It locks in and supports the slab shuttering system (lock bar and plywood forms)
- It becomes a continuous shear connector for the composite system. The bottom section of the joist acts as a tension member both during the construction phase and when the joist is acting compositely with the slab.



The ***mid section*** or web of the joists has the flanged service hole and the lock-bar hole punched into it. The flanging of the service hole provides stability to the web and services can pass through without requiring protection from the sharp edges of the punched material.



The ***bottom triangular*** section of the joist acts as a tension member both during construction phase and when the joist is acting compositely with the slab.



THE LOCKBAR

The lockbars support the temporary plywood formwork between the joists during construction. They shall be spaced approx. 300mm apart and engage in the slotted holes punched in the top section of the joist. They also maintain the exact spacing of the joists.

The standard lockbars when installed will position the joists 1230mm, 930mm or 630mm apart. There are also special adjustable lockbars that will position the joists in increments of 50mm from 330mm to 1530mm. Other type of lockbars are provided for special situations such as cantilevers or lowered soffits.

TEMPORARY PLYWOOD FORMWORK

High density paper overlaid 12mm shuttering plywood conforming to IS 4990:2011 or equivalent is used as formwork to produce a good finish to the underside of the slab. The rigid plywood sheets are used in conjunction with the lockbars and when locked in place, provide lateral stability to the entire Speedfloor system during the construction phase.

REINFORCING MESH

Welded reinforcement mesh made of 8mm dia bar (fy 415 N/m^2) placed @ 200mm c/c in both directions, is laid and tied into place. No chairs are required as it is held off the plywood forms by the top section of the joist, which becomes embedded in the concrete.

CONCRETE

i) Minimum grade of concrete shall be M25 as per IS 456:2000. It should preferably be batched at 60mm and super plasticized to 110mm slump to provide good placement and shrinkage characteristics. A curing compound should be used and an expanding agent may be introduced in consultation with the engineer to further control shrinkage during the curing period.

(ii) The concrete should initially be placed evenly and continuously over the area to be formed. Special attention should be given to ensure the concrete is screened and finished to the specified thickness so that designed deflections are achieved in the Speedfloor joists and the supporting structures.

(iii) In structures for carparking, an expanding agent is generally used to reduce the effect of shrinkage during initial cure and a curing compound is used to help control the curing process.

ACCESSORIES

Edge angles

A standard edge form is available in two heights – 75mm & 90mm.Special heights and specially shaped edge angles may be manufactured but would require longer lead times.

Jointers

Precut sections of galvanized sheet steel may be provided to overlay joints in the ply to ensure they are flush and remain well supported while the concrete is poured.



Lockbar Hanger Angles

A galvanized steel angle with pre-punched lockbar holes is used for situations where the lockbars need support on slab edges parallel to the joists.

LIMITATIONS

The system is used as framed steel structure in all types of construction for laying RCC roof.

Maximum length of joist which can be used is 10m.



INSTALLATION PROCESS

Installation process is as follows:

(i) Lightweight bundles of joists is lifted into position and then individual joists are placed by hand.

(ii) Speedfloor joists are generally placed at 1250 mm c/c.

(iii) Joists are held in place using the lockbars which slip into slotted holes.

(iv) The lockbars is placed at 300mm apart to support plywood formwork. The propping is not required.

(v) Full sheets of 12.5mm plywood formwork is to be laid from above creating a working platform. Cam action of lockbars secures plywood.

(vi) Mesh is placed on top section of joist thereby embedded in the concrete poured thereafter.

(vii) After three days of concreting, lockbars and plywood are removed from the underside revealing a clean surface ready for services or a fire rated suspended ceiling.



MAINTENANCE REQUIREMENTS

Speedfloor is a composite floor system using both steel and concrete. The two materials must be treated and maintained separately.

Steel : If the joists are in a clean and dry environment, they may not require any maintenance. If it is exposed to aggressive environment, they shall require maintenance to ensure that the expected performance is achieved. Guidelines given below should be followed for maintenance

a) Keep surfaces clean and free from continuous contact with moisture, dust and other debris.
b) Periodically inspect the joists for any signs of corrosion. Remove any by-products of the corrosion by mechanical means and spot prime the exposed steel substrate with an appropriate steel primer. Repaint the area using an appropriate paint.

Concrete: During the service life of the Speedfloor system, if any cracks appear in the concrete floor, they should be filled using an epoxy injection grout or equivalent, to completely close the crack and prevent moisture ingress.

For detailed Installation process, manufacturer's Installation Manual shall be referred.

APPLICATIONS

The Speed floor composite flooring system is suitable for use in all types of construction including:

- Steel frames structures
- RCC frame buildings
- Poured insitu or precast concrete frames
- Light gauge steel frames
- Conventional Structural brick wall constructions etc



CERTIFICATION

Performance Appraisal Certificate No. 1013-S/2014 has been issued for the system to M/s Jindal Steel & Power Ltd., Gurgaon.

STANDARDS/REFERENCES

IS 277:1992	Specifications for Galvanized Steel Sheets (Plain & Corrugated)
IS 456:2000	Code of Practice for plain & reinforced Concrete (Fourth revision)
IS 875 (Parts1to3):1987	Code of Practice for Design Loads (other than earthquake) for buildings & structures
IS 1893 (Part-1):2002	Criteria for Earthquake Resistant Design of Structures - Part-1: General Provisions and Buildings
IS 2062:2011	Specifications for hot rolled medium & high tensile structural steel
IS 11384:1985	Code of Practice for Composite Construction in Steel and Concrete
AS/NZS 1170-2 (Parts 0 & 2) : 2002	Structural Design Actions—General principles and Wind actions
AS 2327(Part1):1996	Design of simply supported Composite structures
NZS 3101(Part1):2006	Design of Concrete Structures
NZS 3404 (Part1):1997	Design of Steel Structures
AS/NZS 4600:2005	Design of Cold Formed Steel Structures
AS/NZS 4671: 2001	Specifications for Steel reinforcing materials

Light Gauge Steel Framed Structures (LGSF)

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE TECHNOLOGY

Light Gauge Steel Framed Structures (LGSF) is based on factory made galvanized light gauge steel components, designed as per codal requirements. The system is produced by cold forming method and assembled as panels at site forming structural steel framework of a building of varying sizes of wall and floor.



The basic building elements of light gauge steel framing are cold formed sections which can be prefabricated at site using various methods of connection. The assembly is done using special types of screws and bolts.

Cold formed sections are widely used in construction including residential floors, industrial buildings, commercial buildings, hotels and are gaining greater acceptance in the residential sector. LGSF is a well established technology for residential construction in North America, Australia and Japan and is gaining ground in India.



LGSF is typically ideal for one to three storey high buildings, especially for residential and commercial buildings. Due to its flexibility, fast construction and durability, this technology has great potential for counties like India.

LGSF can be combined with composite steel / concrete deck resting on light steel framing stud walls. Apart from having potential for mass housing, modular buildings can be used for long term temporary or permanent structures such as schools and classroom, military and civil housing needs, post – disaster relief structures and industrial buildings. Advisable maximum span for LGSF buildings should be 7.5 m.



SPECIFICATIONS FOR THE SYSTEM

Structural Section

Main Section are Studs & Track Studs serve as a general all purpose framing component used in a variety of applications including external curtain walls, load bearing walls, headers floors & roof joists, soffits and frame components.

Track is used as closure to stud and joists end as well as head and sill conditions. It is also used for blocking and bridging conditions.

Load bearing steel framing members shall be cold – formed to shape from structural quality sheet steel complying with the requirements of one of the following:

i) ASTM A 653 / A 653 M -13 Grade 33, 37, 40 & 50 (Class 1 and 3) or
ii) ASTM A 792 / A 792 M -13 Grade 33, 37, 40 & 50; or
iii) ASTM A 875 / A 875 M – 13 Grade 33, 37, 40 & 50; or
iv) Sheets, that comply with ASTM A 653 except for tensile and elongation with requirements, shall be permitted, provided, the ratio of tensile strength to yield point is at least 108 and the total elongation is at least 10 percent for a 5 mm gauge length or 7 percent for a 20 mm gauge length.

Wall frame

Consists of top track (U shape configuration) with a depth compatible with that of the studs of the same nominal size. Minimum height of track flanges shall be 19 mm.



Load Bearing Walls

C section studs with depth of 90 and 200 mm and thickness between 2.7 mm and 2.0 mm shall be provided at a distance of 300 mm / 400 mm / 610 mm to ensure efficient use of cladding material. Multiple studs are used at heavily loaded application such as adjacent to openings or in braced panels. C section with 94 x 50 mm is used for noggins.

Alteration shall be required for the local details at the head & the base of the wall to ensure that loads are adequately transferred without local deformation of the joists & studs.



Non Load Bearing Walls

It is similar to that of load bearing walls except that noggins and diagonal bracing are not required to stabilize the studs.

Deflection Limit of Walls

Suggested deflection limit for external walls subject to wind loading are as follow:

Full height glazing	Height / 600
Masonry wall	Height / 500
Board / reduced finish	Height / 360
Steel cladding	Height / 250
Other flexible Cladding	Height / 360



Wall cladding

Wall cladding shall be designed to resist wind load. Sheet has to be screwed to the joist / purlin with maximum spacing of 300 mm c/c. All the joints of sheet in longitudinal direction require a minimum lap of 150 mm in order to make them leak proof.

Following materials are generally used on wall cladding:

- Gypsum board conforming to IS 2095 (Pt. 1): 2011
- Heavy duty cement bonded particle board conforming to IS 14276 : 1995 (Reaffirmed 2014)
- Fibre cement board conforming to IS 14862:2000.

Bracing



Bracing and bridging shall have configuration and steel thickness to provide secondary support for the studs in accordance with the relevant specification for the design of Cold – formed steel structure of members.

Floor frame

For speed of construction, floor joist may be pre-assembled to form floor cassettes. This works well for regular floor places but care shall be taken when the geometry of the building requires the cassettes to vary in size with location or when non – right angel corners are required. Resistant may be provided to the top flange of the joists by the flooring board. The floor should be designed for the combined effect of dead and imposed load.

The construction of a suspended floor comprising cold formed steel floor joists is similar to that for a floor using timber joists. The strength to weight ratio of light steel joist is higher than that of other material. Steel joists are stable and do not suffer, the long term problems of drying out, creep and Shrinkage. Joists are generally positioned at 300, 400 & 600 mm centres, depending on the spacing capabilities of the floor materials used.

Roof frame

Flat roof is made up of joists, where steel decking form a flat roof, a minimum fall of 1:4 should be introduced to ensure that any moisture runs off. To avoid local ponding to rain water, the pitch may need to be increased to overcome the effective reduction in roof angle caused by the deflection of long span roof purlin or decking.

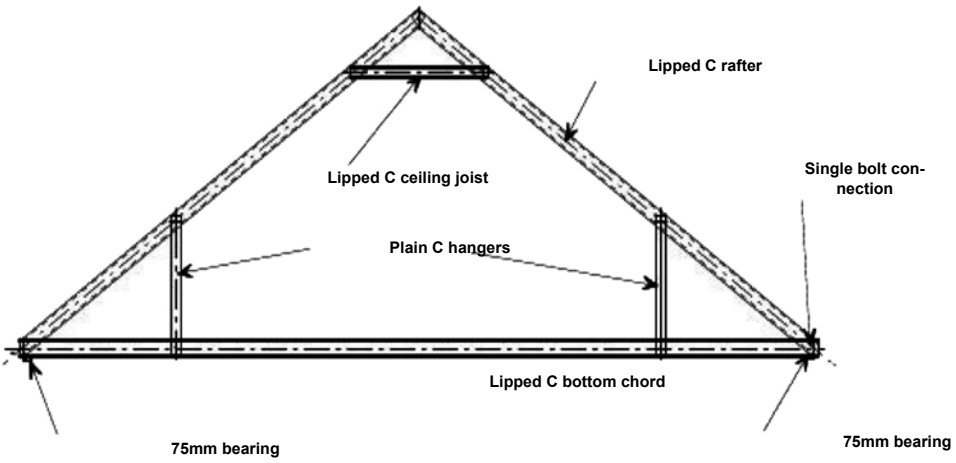
Roof truss

Use of Light Steel roof truss is economical for larger span building. In attic or open roof truss creates usable roof space, uses fewer components than Fink truss and provides an economical solution, since it utilizes the high strength of the steel members.

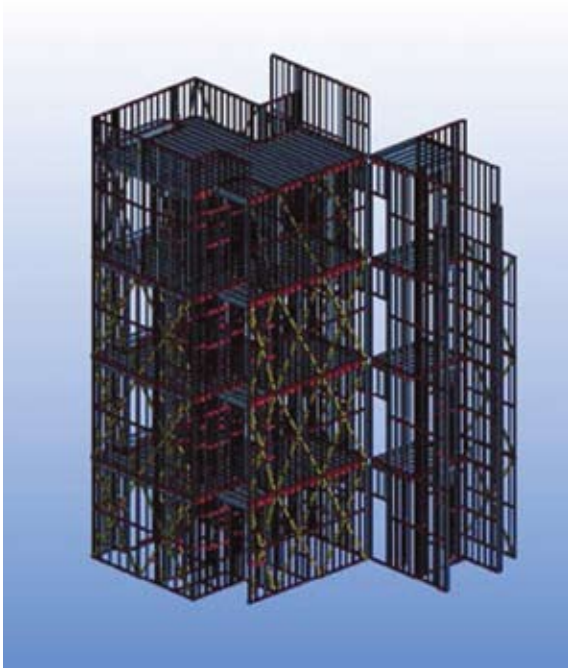
The trusses are placed at 600 mm maximum spacing and are battened and tiled in a conventional manner.

Screws

Screws as per the details given below shall be used:



- Panel Assembly – Low profile screws
- LGS-LGS Wall panel to roof cassette – 12-14x15mm
- LGS to concrete – Tapcon screw 14-12x60mm Hex head
- Wire mesh = EPS board – SDS Hex head with Ceresin without washer
- HRS-LGS – Hex heat
- CP board 6mm – WT 8 CSK Phillips
- Gypsum board – Flat heat self-driven type
- Deck sheet/Wire mesh – SDS WT, CSK, Flat head





DESIGN

The LGSS is designed based on provision of the following standards:

- Indian Standard IS 801: 1975 Code of Practices for use of cold formed and welded section and light gauge steel structural members in general building construction.
- British Standard BS 5950 (Part 5):1998 – Structural use of steel in Building Part 5 – Code of Practice for design of cold formed thin gauge structure.
- British Standard BS 5950 (Part 1): 2000 Structure use of steel work in Building Part 1 with loading requirement as per IS 875 (Part 1)
- Indian Standard IS 875 - Code of Practice for design loads
  Part 1 - Dead Loads - Unit Weights of Building Material and Stored Materials
  Part 2 - Imposed Loads
  Part 3 - Wind Loads
- IS 1893 (Part 1):2002 Criteria for Earthquake Resistant Design of Structures - Part 1 : General Provisions and Buildings

MANUFACTURING

The sections are manufactured using Centrally Numerical Control (CNC) automatic four Pinnacle Roll Forming machine having production speed of 450-900 m/hr with very high precision.

CONSTRUCTION

Foundations for light steel framing are essentially the same as for any form of construction, although dead loads applied by the light steel frame will be much lower than in the concrete or masonry construction.

Construction phases of steel buildings resembles the phases of conventional reinforced concrete buildings. The sections manufactured as per design are numbered properly. The profiles are sent to site either as profile or panellized parts, considering the distance of the construction site and transportation conditions. Profiles are assembled by trained assembly team at the construction site in line with the architectural plan. Only special studs are used during assembly, no welding is done. Once the assembly is done, the frame is filled with insulation materials (fibreglass, rockwool etc). Walls are then covered with standard boards or similar approved materials.



The sequence of construction comprises of foundation laying, fixing of tracks, fixing of wall panels with bracings as required, fixing of floor panels, fixing of roof panels, decking sheet, fixing of electrical & plumbing services and finally fixing of insulation material & walling panels.

Electrical Gas and plumbing, services are installed through pre-punched service holes in the web of the steel forms. Plastic grommets and silicon seals are used to fasten and protect wiring and pipes from corrosion and damage arising from vibrations



Electrical cables running within floor insulation layer in the separating floor construction should be protected with cartridge fuses or mini circuit breaker.

Wall panels are generally made by using heavy duty Cement Particle Board and Gypsum board. It can also be made using high density extended polystyrene core plastered from outside using wire mesh and chicken mesh. Galvolume sheet of appropriate thickness can also be used as cladding. This technology is certified by BMTPC under PACS.



ADVANTAGE

LGSF is based on established system of light gauge steel structures and designed as per codal provisions with loading requirements as per Indian Standards. The merits of the system encompasses:

High Precision

- Fully integrated computerised system with CNC machine provides very high accuracy upto 1 mm.

Structural

- High strength to weight ratio. Due to low weight, significant reduction in design earthquake forces. Chance of progressive collapse are marginal due to highly ductile and load carrying nature of closely spaced studs/joists.

Speed in Construction

- Construction speed is very high. A typical four storeyed building can be constructed within one month.

Saving in foundation

- Structure being light, does not require heavy foundation.

Mobility

- Structural element can be transported any place including hilly places to remote places easily and structure can be erected fast.
- Structure can be shifted from one location to other without wastage of materials.

Environment friendly

- Steel used can be recycled when required.

CERTIFICATION / VALIDATION OF THE SYSTEM

i) Performance Appraisal Certificate No. 1014-S/2014 has been issued for the Light Gauge Steel Framed Structures (LGSF) to M/s JB Fabinfra Pvt. Ltd., New Delhi.

OTHER SIMILAR SYSTEMS SHORTLISTED UNDER GHTC-INDIA

i) LGS Framing with various walling & roofing options of M/s Mitsumi Housing Pvt. Ltd., Ahmedabad has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

ii) LGS Framing with various walling & roofing options of M/s Everest Industries Ltd., Noida has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

iii) LGS Framing with various walling & roofing options of M/s Elemente Designer Homes, Noida has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

iv) LGS Framing with various walling & roofing options of M/s MGI Infra Pvt. Ltd., New Delhi has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

v) LGS Framing with various walling & roofing options of M/s RCM Prefab Pvt. Ltd., New Delhi has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

vi) LGS Framing with various walling & roofing options of M/s Nipani Infra and Industries Pvt. Ltd., Jabalpur has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

vii) LGS Framing with Ecopanely boards as facing material made from agricultural wastes of M/s Strawcture Eco, Gorakhpur has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

STANDARDS

IS 801: 1975	Code of practice for use of cold formed light gauge steel structural members in general building construction (Reaffirmed 2016)
IS 2095 (Part 1) : 2011	Specification for Gypsum Plaster Boards - Part 1 Plain Gypsum Plaster Boards (Reaffirmed 2016)
IS 14862 : 2000	Specification for Fibre Cement Flat Sheets (Reaffirmed 2015)
ASTM – A653/ A 653 M -13	Specification for steel sheet, zinc coated (galvanized) on zinc – iron alloy coated by hot dip process.
ASTM – A 792/792 M -13	Specification for steel sheet, 55% aluminium zinc alloy coated by hot dip process
ASTM – A 875/875 M -13	Specification for steel sheet, zinc 5% aluminium alloy coated by hot dip process.



Light Gauge Stell Framed Structure with Infill Concrete Panel (LGSFS-ICP) Technology

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE TECHNOLOGY

Light Gauge Steel Framed Structure with Infill Concrete Panels (LGSFS-ICP) Technology is an innovative emerging building and construction technology using factory made Light Gauge Steel Framed Structure (LGSFS), light weight concrete and precast panels. The LGS frame is a “C” cross-section with built in notch, dimpling, slots, service holes etc. produced by computerized roll forming machine. These frames are assembled using metal screws to form into LGSF wall and roof structures of a building. Provisions for doors, windows, ventilators and other cutouts as required are incorporated in the LGSFS.

The LGS frames are manufactured in a factory and assembled in to LGSF wall structures and then transported to

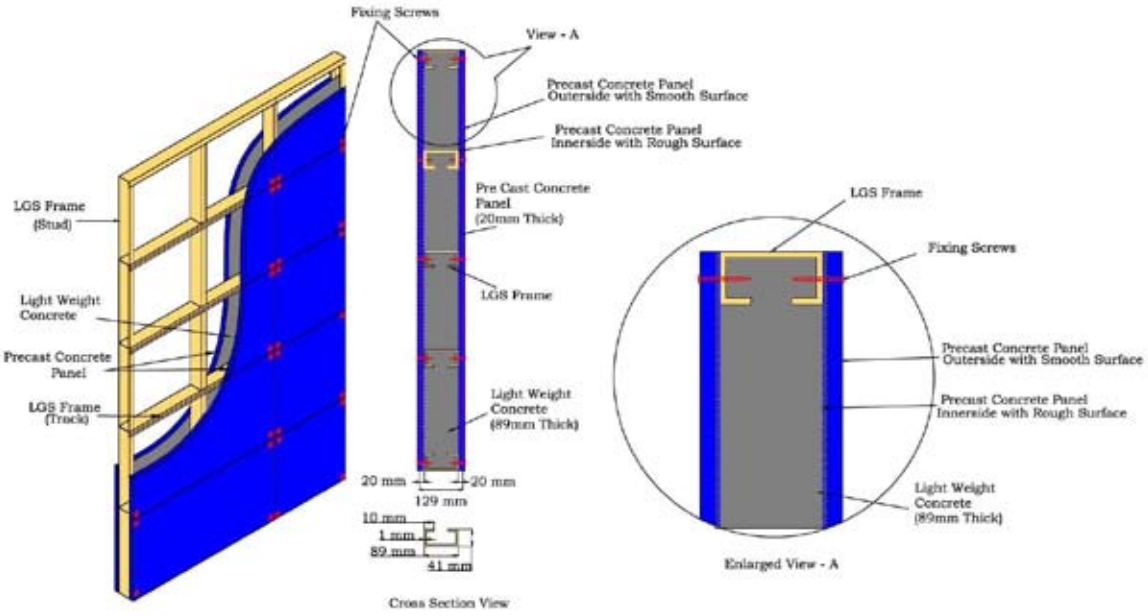


Fig.1 Structural Details of LGSFS-Infill Concrete Wall

the construction site and erected wall by wall on a pre-built concrete floor as per the floor plan of the building. Steel reinforced concrete panels of size 610 mm x 305 mm x 20 mm thick are manufactured at factory and transported to site. These panels are fixed on either side of the LGSFS wall using self-drilling/tapping screws to act as outer and inner faces of the wall leaving a gap between them. This gap is then filled with light weight concrete using a special mixing and pumping machine. Electrical and plumbing pipes/conduits are provided in the service holes of the LGSFS before concreting is done. Self-compacting concrete is mixed and pumped into the gaps between two panels. The concrete flows and fills the gap and provides adequate cover to the LGS frames and joints. The concrete shall also adhere to the concrete panels. After curing, LGSFS with in-fill concrete and panels (LGSFS-ICP) forms a monolithic sandwich composite wall structure with thermal and sound insulation properties.

The roof structure of LGSFS-ICP building is constructed using metal/plastic formwork system with steel reinforced concrete as per structural design. Standard procedures are employed to concrete the roof slab. After curing for 96

h, the formwork is de-moulded and the wall and roof are putty finished. Door and window frames are fixed to the LGS frames and shutters fixed with necessary accessories. Finishing work such as laying floor tiles, fixing electrical and sanitary fixtures and painting is carried out using standard conventional methods.

After completion of ground floor, first, second and third floors of the building is constructed using the same procedure that of the ground floor. The staircase, chajja and parapet walls of the building are also constructed using LGSFS-ICP Technology.

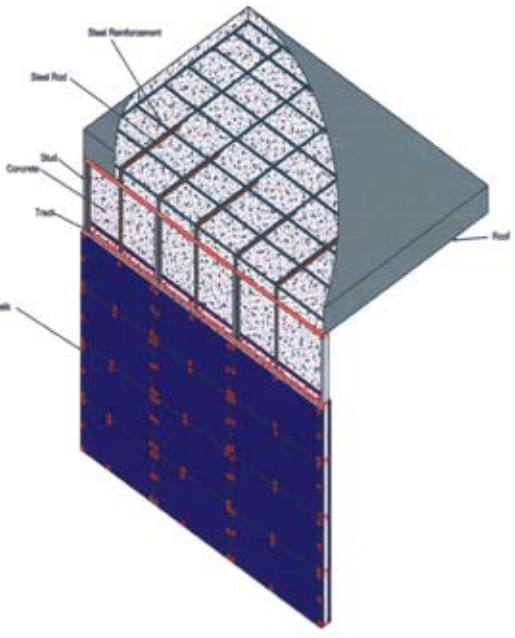
MATERIAL REQUIREMENTS

1. Raw Materials

i. LSG Coil of galvanized steel shall conform to IS 277:1992.
ii. Fasteners and Connectors
   (a) Frame assembly screws: Shall be galvanized steel screws self-drilling type of size 10 x 25 mm having Truss-head and shall be as per ASTM C 1513-10.).
   (b) Wall Erection Screws: Shall be galvanized steel screws self-drilling type of size 8 x 25 mm having Hex Washer head and shall be as per ASTM C 1513-10
   (c) Precast Concrete Panels Fixing Screws: Shall be of galvanized steel screws self-drilling type of size 8 x 50 mm having CS head and shall be as per ASTM C 1513-10.
   (d) Wall and Foundation Anchor Bolt: Shall be of high tensile galvanized steel of size 10 x 100 mm/ 10 x 150 mm and 12 x 100 mm/ 12 x 150 mm and shall be as per ASTM C 1513-10.
iii. Foaming Chemicals: Shall be made from protein foam concentrate and FC-lite foaming agent
iv. Gypsum plaster board: Shall be of size 1830 mm x 1220 mm and 12.5mm to 20 mm thick and shall conform to IS 2095 (Part 1):2011
v. Water Proofing Treatment: Shall be using integral waterproofing compound as per IS 2645:2003
vi. Putty: Shall be as per IS 63:2006
vii. Ordinary Portland cement (OPC) shall be of 43/53 grade as per IS 269:2015
viii. Sand and Aggregates shall be as per IS 383:2016
ix. Reinforced Steel: Shall be as per IS 1786:2008
x. Structural steel: Shall be as per IS 800:2007
xi. Steel fiber: Shall have length of 60 mm &dia. 0.75 mm and shall be as per EN 14889-1:2006
xii. Glass fiber: Shall be made from Fiber mesh 303 E3 and shall be as per EN 14889-2:2006

2. Light gauge steel frame/ structure

The Light gauge steel frame structure (LGSFS) comprises of “C “cross section studs (vertical members) and tracks (horizontal members) frames assembled together by means of mechanical screws. The joints between wall & roof junctions/wall to wall junctions are designed as rigid joints

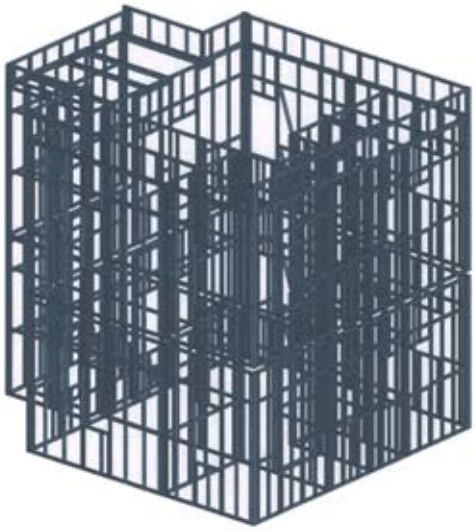


3. Precast concrete panels

Precast Concrete Panels are used as facing sheets for construction of walls. Self-compacting concrete of M20 grade is used. Metal modes, concrete mixing machine and vibration tables are used for manufacturing the panels. The panels are designed to withstand the concrete weight pumped in between the gap of the panels without failure and buckling.

The steel reinforced precast concrete panels (PCP), has one side rough surface and the other side smooth surface. The PCP’s are fixed on either side of Light Gauge Steel Frame Structures (LGSFS)–studs and tracks using mechanical fasteners. While fix-

ing, the rough side of the panels are facing inside and smooth side is facing outside. Each PCP is fixed with 6 screws. Light weight concrete is pumped in to the gap between two PCPs. The concrete bonds with the rough surface of the panels. Thus, the LGSFS and PCPs are firmly joined to make a monolithic steel–concrete structure.



4. Concrete/light weight concrete

The concrete used for infill wall is light weight and free flow. The density shall be 1500-1800 Kg/m^3 after adding/mixing foam or EPS beads as per the design mix developed by the agency. The light weight concrete shall be of grade M5 to M10, as required. The light weight concrete shall be mixed and used at site.

MANUFACTURING PROCESS

The manufacturing process of the constituents of LGSFS-ICP system is as follows:

1. Light Gauge Steel Frame Structure

Cold formed Light gauge steel frame super structure is manufactured out of min. 0.95 mm pre-treated factory finished hot dipped GI high tensile steel sheet (AZ 150 GSM Aluminium zinc alloy coated steel and having yield strength of 550MPA) which shall be as per IS 800:2007 and conforms to AISI specification and IBC 2009. The wind loads shall be as per IS 875 (Part 3):2015. The framing section is cold form “C’ type of 0.55 mm to 1.55 mm thickness in required length as per structural design requirements, duly punched with dimple slots at required locations as per approved drawings. The slots shall be along center line of the web and shall be placed at 250 mm min. away from both edges of the member. The frame is supplied in specified dimensions and fastened with metal strip of 25 mm x 25 mm x 0.50 mm to both adjoining walls.

2. Precast Concrete Panels

Precast concrete panels are manufactured using cement, sand, aggregates, glass &steel fibers, water and admixtures using a design mix and curing cycle developed by the agency. It is steel fibre reinforced precast concrete panel. It gets strength as steel reinforced concrete.

The overall dimensions of the panel are 1220 mm x 610 mm x 20 mm thick and the weight shall be around 36 kg. The panels are designed to have smooth or textured outside surface and rough inside surface. The panels are also designed to withstand green concrete load of 200 kg without failure and deflection shall be less than 1.0 mm.

The concrete used for the panels shall be of grade M20 having water absorption less than 8%.
Mix ratio of light weight aggregate for 1.0 cu.m is as follows:
Cement = 300 kg
Sand = 400 kg
Flyash = 300 kg
6mm-8mm Aggregate = 1350 kg
PPfibre + steel fibre = 4.14 kg
Water = 150 kg
Admixtures = 150 ml

3. Concrete/Light Weight Concrete

The wall or the roof is constructed using M20 grade concrete and M5 –M10 grade light weight concrete. The concrete used is light weight and free flow. The light weight concrete is mixed and used at site. The concrete/light weight concrete is pumped into the gap between the panels.

4. Assembly/Connecting Screws and Anchoring Bolts

LGS frames are assembled together to fabricate LGSF structures using self-taping screws. The LGSF structures such as wall, roof, truss and staircase are connected by using special screws which shall conform to ASTM C 1513. The anchoring boards used for connecting LGSF wall structure to the foundation shall conform to relevant Indian/ American Standards.

APPLICATIONS

The technology is used for construction of Low rise residential buildings up to G+3 storey – EWS, LIG & MIG houses, Schools, Health centers, Community centers, independent houses and rehabilitation buildings.

INSTALLATION/ CONSTRUCTION OF LGSF STRUCTURES

1. Construction of Foundation and Plinth

The foundation and plinth is constructed confirming the floor plan of the building. The foundation depth, width, steel reinforcement, grade of concrete etc. is determined by structural analysis report prepared on the basis of soil condition, height of building, number of storeys, special live load requirement, if any.

2. Assembly of LGS Frames and Construction of Wall

The LSG frames manufactured using numerically controlled roll forming machine using CAD design shall be transported to the construction site. The frames shall be assembled into wall structure. All the wall structures shall be connected together one by one as per the building plan by connecting screws. The wall position shall be marked on the floor and the wall structure placed on the marking. After completing the same, straightness, square and the levels shall be checked by magnetic spirit level. The bottom track shall then be connected with the floor using anchor bolts at every 600 mm bolts.

3. Fixing of Pre-cast Panels

The precast concrete panels shall be fixed on the LGSF wall structure on studs and tracks by using metal screws. The panels shall be fixed first on the outer side of the LGSFS wall. Electrical/plumbing pipes/conduits shall be fixed as per the electrical and plumbing layout. After completion, the panels shall be fixed inside the LGSFS walls and allocations for electrical and plumbing cutouts shall be marked on the panel.

4. Concrete Mixing and Pumping

Self-compacting concrete of required grade/light weight concrete shall be mixed using concrete mixing machine and then pumped into the gap between two panels using a special pumping unit. Care shall be taken to pump the concrete gradually and uniformly on all the walls. Concreting shall be done till the gap is completely filled up to the top of the LGSFS wall.

5. Construction of Roof Slab

The roof slab of the building shall be constructed by using metal/plastic shuttering and conventional concreting. Necessary steel reinforcement as per design shall be provided over the formwork and concreting shall be done to required thickness. Balcony and chhajja etc., wherever required shall also be constructed using formwork. After curing the slab, shuttering shall be removed and bottom of the roof slab putty finished.

6. Reinforcement

Deformed steel bars of 8mm/10mm dia. as per design shall be used.

7. Staircase and Railing

Staircase and balcony railing shall be fixed using conventional methods.

8. Fixing Electrical and Plumbing Fixtures

The panels shall be cut at the marked locations for fixing electrical and plumbing fixtures.

9. Fixing of Doors, Windows & Ventilator Frames and Shutters

The doors, windows & ventilator frames shall be fixed on the cutouts provided in the LGSFS. The frames shall be

made of WPC, uPVC and other materials, as required. Thereafter, the doors and windows shutters shall be fixed to the frames. The shutters shall be made of glass fibre/ HDF sandwich composite materials.

10. Fixing Floor Tiles

Floor tiles of desired quality and make shall be fixed to the floor, as required. Similarly, wall tiles of desired quality and make shall be fixed in the kitchen, bath and toilet using conventional methods, as required.

11. Surface Finishing and Painting

Cement based putty shall be applied on the outside and inside walls and then painted with desired colour.

SPECIAL FEATURES

Structural Stability

Due to low weight, significant reduction in design earthquake forces. Chance of progressive collapse are marginal due to highly ductile and load carrying nature of closely spaced studs/joists.

Durability

Buildings shall be designed as per codal provisions of IS 456.

Behavior in earthquake

The buildings shall be designed for loads in accordance with IS 875 (Part 1 to 5) and IS 1893 (Part 1).

Behavior in wind

The wind loads shall be as per IS 875 (Part 3).

Fire Safety

During fire performance oriented test, it was observed that there was some minor cracks on the surface of all the walls.

Rain

During the ponding on roof slab for 24 hours, no dripping or leakage of water through roof slab or drop patches were observed on underside of the roof slab.
During rain simulation of external face of the wall by jetting for 12 hours, no leakage of water, dampness or sweating were observed on inner face of the wall.

Thermal Performance

There was a reduction in temperature upto 4ºC inside the unit indicating that it has got a good thermal comfort.

Acoustic Performance

The unit has got a good acoustic comfort.

Light weight

Weight of the LGSFS-ICP building is about 20-30% lighter when compared to conventional building thereby resulting in material and energy savings.

Limitation of Use

- LGSFS-IPC Technology may be used for construction upto G+3 storey Buildings only.
- For more than G+3 storey buildings, hybrid construction methods shall be used.

Critical Details

- 10 mm thick plaster on external walls shall be provided to take care of water proofing.
- Guard bars and wooden/steel windows shall be provided. Aluminium sliding windows shall be avoided.
- Sun shades shall be provided for all windows/external doors as per design.

WORKS COMPLETED

Police Constable Quarters (G+1) building for Karnataka State Police Housing Corporation Ltd., Bangalore in 2012.

CERTIFICATION

Performance Appraisal Certificate No. 1028-S/2016 has been issued to M/s Society for Development of Composites, Bangalore.

STANDARDS/REFERENCES

• Design and Construction of "2 Police Constables Quarters (G+1) building for Karnataka State Police Housing Corporation Ltd., Bangalore" by the manufacturer	
• Technical Report on "Light Gauge Steel Frame Structure with Infill Concrete Panels for Fast Tack and Disaster proof Housing"	
• Structural Analysis Report for "G+2 storey building constructed using LGSFS-ICP Technology" by M/s Nagesh Consultants, Bangalore	
IS 277:2003	Specifications for Galvanized Steel Sheets (Plain & corrugated)
IS 383:2016	Specifications for fine and coarse aggregates for concrete
IS 456:2000	Code of practice for Plain & Reinforced concrete (Reaffirmed 2016)
IS 800:2007	Code of practice for general construction in steel (Reaffirmed 2012)
IS 801:1975	Code of practice for use of Cold Formed Light gauge Steel structural members in General building construction (First Revision) (Reaffirmed 2016)
IS 875 (Parts 1,2,4&5):1987	Code of Practice for Design Loads (other than earthquake) for buildings & structures (Reaffirmed 2013)
IS 875 (Part 3):2015	Code of Practice for Design Loads (other than earthquake) for buildings & structures - Part 3 Wind Loads
IS 1786:2008	Specifications for high strength deformed steel bars and wires for concrete reinforcement (Reaffirmed 2013)
IS 1893:2016	Criteria for Earthquake Resistant Design of Structures (Part 1) - General Provisions and Buildings
IS 1904:1986	Code of Practice for design and construction of foundations in soils: General requirements (Reaffirmed 2015)
IS 2062:2011	Specifications for hot rolled medium & high tensile structural steel
IS 2095 (Part 1):2011	Specifications for gypsum plaster boards - Part 1 plain gypsum plaster boards (Reaffirmed 2016)
IS 9012:1978	Recommended practice for shotcreting (Reaffirmed 2016)
ASTM C1513-10	Standard specification for steel taping screws - cold formed steel framing connections
EN 14889-1-2006	Fibre for concrete, steel fibres - definitions, specifications and conformity
EN 14889-2-2006	Fibre for concrete, polymer fibres - definitions, specifications and conformity

Continuous Sandwich (PUF) Panels With Steel Structure

(Suitable for Low Rise to High Rise Structures)

ABOUT THE SYSTEM

Continuous sandwich panels with steel structure is a combination of single piece, prefabricated, modular, factory made panels and pre-engineered steel framing system. The panels comprise of PUF bonded between two sheets of Pre-coated GI sheets of 0.5 mm thick to produce straight-to-finish panels. Insulation core provides effective insulation and strong bonding for better structural stability to facilitate higher loading and wider spans. These panels are available for both wall and roof.

The system can incorporate all types of architectural features like coving, boxes, cantilevers, projections, infill walls, mezzanine floors etc. This system can also incorporate all types of services viz. electrical, gas and plumbing etc. The design and engineering of the structures is executed by following the norms & guidelines stipulated in relevant Indian Standards.

Typical Isometric views of both roof and wall panels are shown in Figs. 1 & 2 respectively.

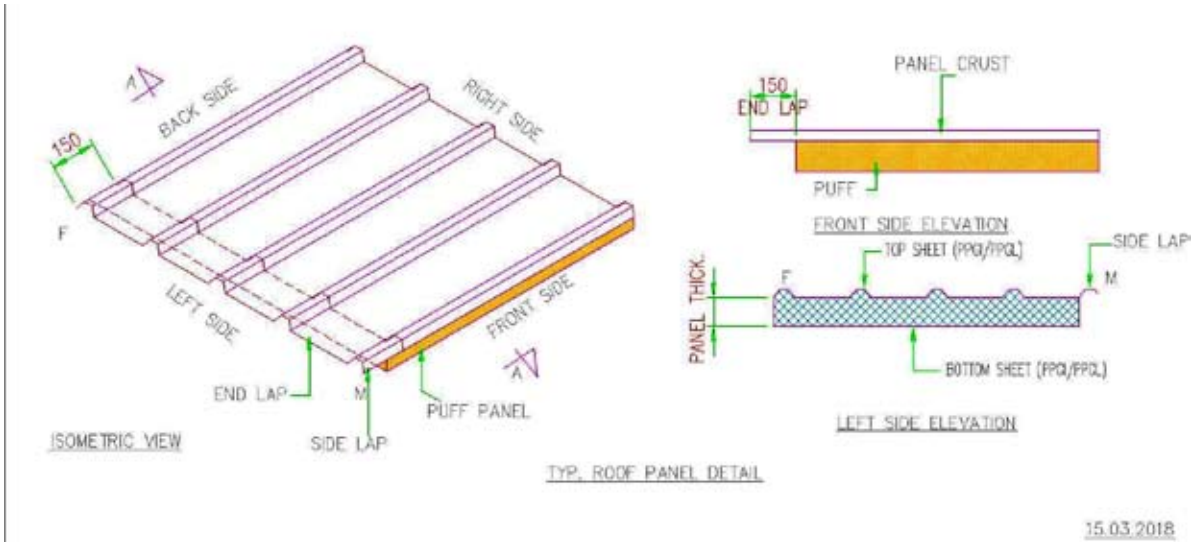


Fig. 1 Roof Panel

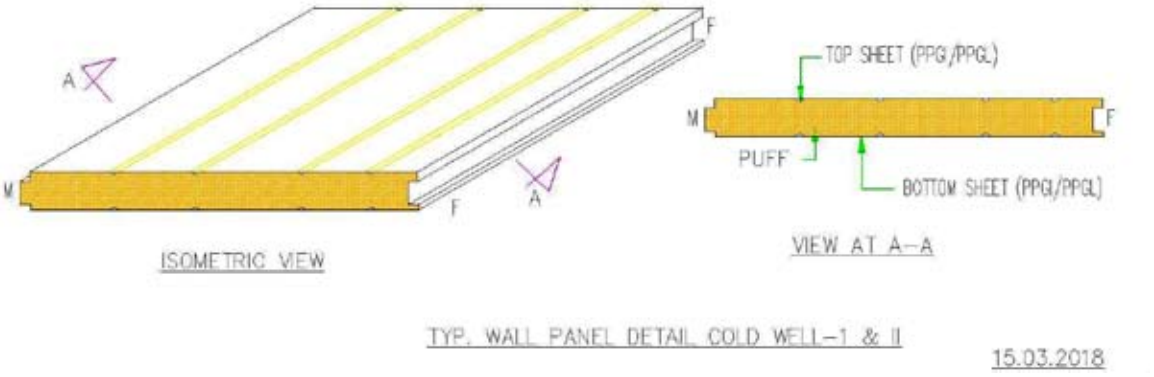


Fig. 2 Wall Panel

Size and profiles of PUF Panel

Size of panels

Panels are available in thickness from 25mm to 150mm, width 1000mm and length as per requirement.

Profiles of the Panels

Coldwell Wall panels

Coldwell wall panels are tongue-n-groove joinery for air-tight, effective panel to panel interlocking which provides an effective seal. Two types of panels – single groove and double groove systems are manufactured. While single groove panels are suitable for general purpose and application in buildings and shelters; double groove panels are suitable for cold room and cold chamber applications. Double groove ensures precise interlocking, dimensional accuracy and also eliminates the risk of air gaps and thermal bridging. Coldwell panels are in higher thicknesses are self-supporting free standing upto 6 metres. All joints are covered with flashings.

Profiles of these panels are given below:
Inner & Outer skin: 3 types of rib configuration – Micro-rib, Wave and Mini box.

Facing Options: Pre-painted galvanized steel/aluminium, stainless steel and craft paper and perforated metal sheet for inner skin.

Surface finish: Mettalic, solid colours, Polyvinylidene fluoride (PVDF) & super polyster coatings.

Coldwell-1
These panels are available in thickness of 30, 40, 50, 60, 80 & 100mm. Detail of this panel is shown in Fig. 3.

Coldwell -2
These panels are available in thickness of 80, 100, 120 & 150mm. Detail of this panel is shown in Fig. 4.

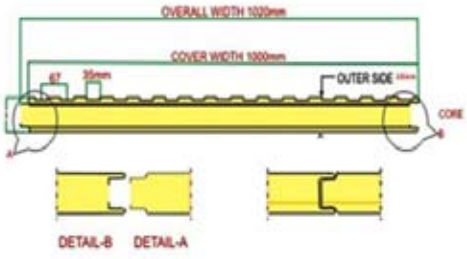


Fig. 3

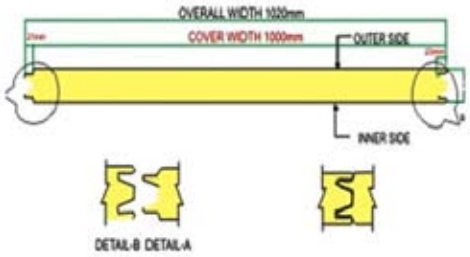


Fig. 4

Strupan Roof panel

Strupan is a structural roof panel with a trapezoidal profile on the top surface and a ribbed liner tray on the underside and a sandwiched insulation cover.

Profile of this panel is given below:
Inner skin: Ribbed liner, aluminium foil/craft paper
Outer skin: 35x250mm trapezoidal profile with 2 secondary ribs and anti-capillary flute.
This panel is available in thickness of 30, 40, 50, 60, 80 & 100mm.
Surface finish: Metallic, solid colours, Polyvinylidene fluoride (PVDF) & super polyster coatings. Detail of this panel is shown in Fig. 5.

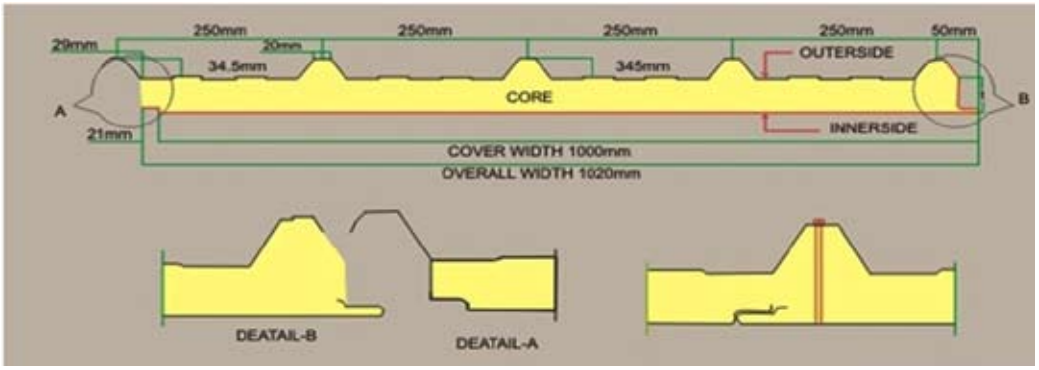


Fig. 5

Isoclad

Isoclad panels act as partition walls as well as façade cladding with permanent finishing and can be integrated well with structural glazing, curtain walls, windows and other type of fenestrations and openings.

Profile of this panel is given below:
Skins: 3 types of rib configuration – Micro-rib, Wave and Mini box
This panel is available in thickness of 40, 50, 60 & 80mm.
Facing options: Pre-painted galvanized steel/aluminium
Surface finish: Metallic, solid colours, Polyvinylidene fluoride (PVDF) & super polyster coatings. Detail of this panel is shown in Fig. 6.

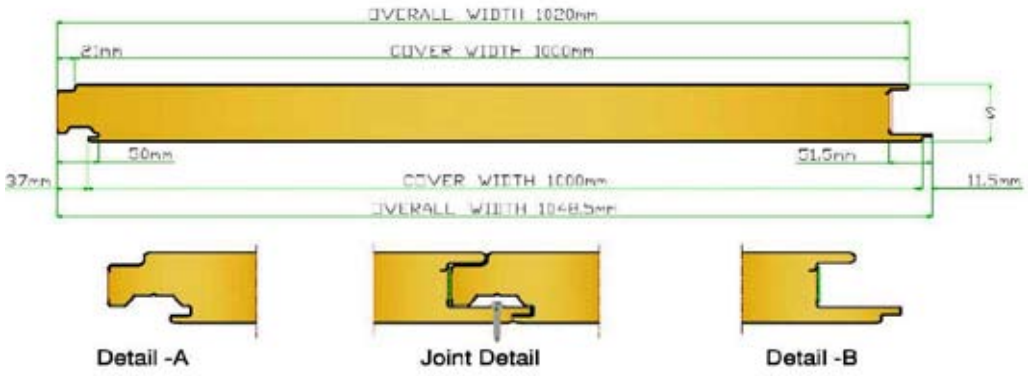


Fig. 6

BASIC RAW MATERIAL REQUIREMENTS

1. *Polyurethane Foam (PUF):* It is thermosetting material when exposed to fire, does not drip or melt; forms a strong carbonaceous char that protects the core and prevent spread of flame. It shall be Chlorofluorocarbon (CFC) free and self-extinguishing and shall conform to IS 12436: 1988.
2. *GI Pre-painted sheet (PPGI):* The pre-coated sheet shall have min. yield strength of 240 MPa conforming to IS 14246:2013 and shall have zinc coating of min. 120 gm/m^2 as per IS 277:2018. The sheet shall have 5-7 micron epoxy primer on both sides and polyester top coat of 15-18 micron. The sheet shall also have plastic protective guard film of min. 25 micron to avoid scratches during transportation.
3. *U Channel*: Made of PPGI sheet conforming to IS 14246:2013 and shall have zinc coating of min. 120 gm/m^2 as per IS 277:2018.
4. *PU Chemical:* Shall be as per the manufacturer's specifications
5. *Polyol Glue*: Shall be as per the manufacturer's specifications

MANUFACTURING PROCESS

- Raw-material & Pre-Coated sheets (PPGI) shall be procured from the market and then loaded pre-coated sheet profiled and rolled as per the drawing of manufacturing process.
- Pre-coated GI coated sheets shall be loaded as coil in lower & upper section of the machine, for profiled and rolled as per the relevant drawing.
- Polyol/isocynate shall be sprayed in between pre-coated sheets. After passing double belt conveyor, the raw material for the required thickness shall pass as per the specification of the client and cooling conveyor cools the panel.
- The panel shall be cut as per the required size with cutting machine and end surface shall be cleaned.
- Inspection & testing shall be done at each stage of manufacturing process.
- After inspection of the material by the inspection team that the product is upto the mark as per the required specification of the client, the panels pass automatically towards wrapping & packing.
- After finished product is ready, the panels shall be dispatched to the client.

CONSTRUCTION PROCESS

Installation Procedure

Panels with damaged side joints, surface dents or scratches shall be set aside. Excess foam (if any) shall be removed from panel joints to allow proper panel engagement.
The first panel shall be installed plumb/level. A spirit level or transit shall be used on each panel. Adjoining panels shall be installed with overlapping rib/inserting tongue-in to the groove toward the last erected panel. Structural members shall be drilled, if required and fasteners installed at lapped rib. A chalk line shall be used to mark the girt location and maintain a straight line of screws, thus avoiding miss-drilling and possible leakage. The preferred procedure is to complete all wall sheeting before starting the roof sheeting.

Roof Panel

Fastener installation
It must be ensured that the fasteners are installed at locations indicated on the building drawings. It is easy to misjudge the location of the structural member, resulting in a fastener off the structural member or below the sealant at the end lap. The fastener shall be driven in until it is tight and the washer is firmly seated. A slight extrusion of neoprene around the washer is a good visual tightness check.

Orientation of panels before lifting
For maximum weather-tightness, start laying panels from the end of the building that will be in the lee of the worst-anticipated or prevailing weather. It is much easier and safer to turn panels on the ground than up on the roof. Before lifting panels on to the roof, it must be checked that this is the correct way up and the overlapping side is towards the edge of the roof from which side installation will start. Bundle of panels shall be placed over or near firm supports, not at mid span of roof members.

Roof paneling sequence
It is advised that both sides of the ridge of a building be sheeted simultaneously. When lifting panels onto the roof frame for laying and fastening, care should be taken to make sure all panels are the correct way up with the overlapping side towards the edge of the roof from which installation will commence.

Installation of the first roof panel
The roof panel shall be set in place over the inside closure ensuring the major ribs of the panel rest properly with the inside closure. The panel edge shall be aligned with the edge of the end wall roof line. With the panel properly

placed, the line of panel shall be adjusted for squareness.
A nylon line projected from the eave strut by a certain distance shall be used to give correct distance and line. A chalk line shall be used to mark the location and maintain straight line of screws, thus avoiding miss-drilling and possible leakage. The panel shall be secured to the structure with appropriate fasteners. The fasteners will be installed after the overlapping is installed.

Sealing the side laps
The side lap sealant shall be applied to the weather side edge of the lower major. The sealant should only be applied to clean, dry surfaces. Press firmly along the length of the sealant to insure proper adhesion. The adjoining panel shall be installed positioning the overlapping rib with care. Required size pilot holes for the lap fasteners shall be drilled at the centre of the clearance holes in the overlapping panel. The lap shall be stitched with the self-fastening fasteners supplied with the screw line. Sealant shall not be placed inside of the screw line. (Fig. 7)

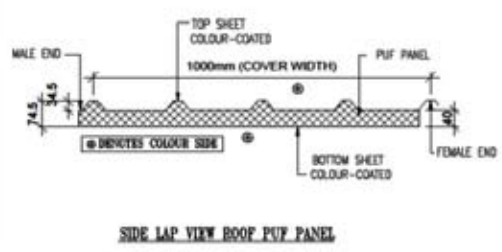


Fig.7 Roof Panel - Side Lap Detail

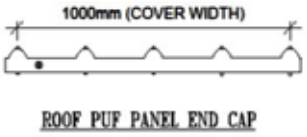


Fig. 8 Roof Panel – End Cap Detail

Installation of remaining roof panels
With the first panel run installed & secured and side lap sealant applied, the second panel run may be started. The eave shall be prepared with an inside closure and sealant. The panel shall be positioned so that the overlapping ribs will rest properly. Proper overhang and panel coverage shall be checked. The major ribs of the two panels shall be stitched together and panels attached to the purlins.

Sealing the end laps
At the panel end laps, sealant shall be placed across the full panel below the fastener line. The panel end laps shall have a minimum overlap located over a purlin as per respective erection drawings. The fasteners shall be located on the centre of the flange of purlins. (Figs. 9 & 10)

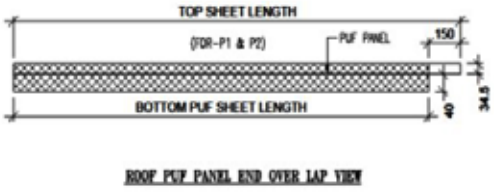


Fig.9 End Over Lap Detail

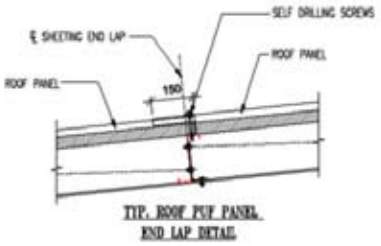


Fig.10 End Lap Detail

Wall Panel

Fastener installation
It must be ensured that the fasteners are installed at locations indicated on the building drawings. It is easy to misjudge the location of the structural member, resulting in a fastener off the structural member or below the sealant at the end lap. The fastener shall be driven in until it is tight and the washer is firmly seated. A slight extrusion of neoprene around the washer is a good visual tightness check. The fasteners shall be installed by drilling holes on the ridge and not on the valley as shown in Fig. 5.

Checking flatness and overhang

Before starting work it must be ensured that:

- the supports for cladding are truly in the same plane
- the overhangs of panels from the top and bottom supports shall not exceed the limit, whilst also overhanging at least 50 mm into gutters. Necessary adjustments shall be made before laying panels, because it will be difficult or impossible to rectify later.

Positioning first panel

First panel shall be positioned before fixing to ensure that it is correctly located in relation to other parts of the building.

It must be checked that the panel:

- aligns with the end-wall (or its barge or fascia), the type of flashing or capping treatment to be used; and
- aligns correctly at its ends in relation to the gutter and ridge (or parapet or transverse wall). (Figs. 11 to 14)

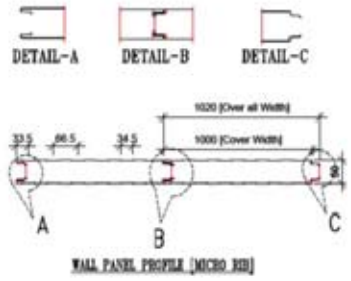


Fig.11Wall Panel Profile (Micro Rib)

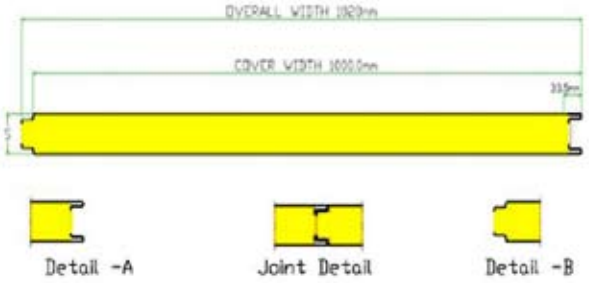
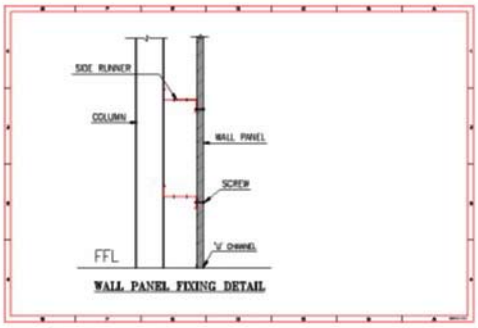
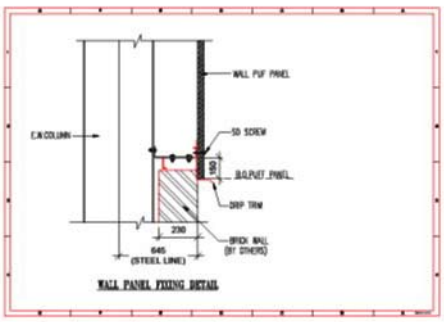


Fig.12 Panel for Wall cladding Rib)





Figs. 13 & 14 Wall Panel Fixing Details

Positioning other panels

After fixing the first panel in position, other panels shall be aligned using:

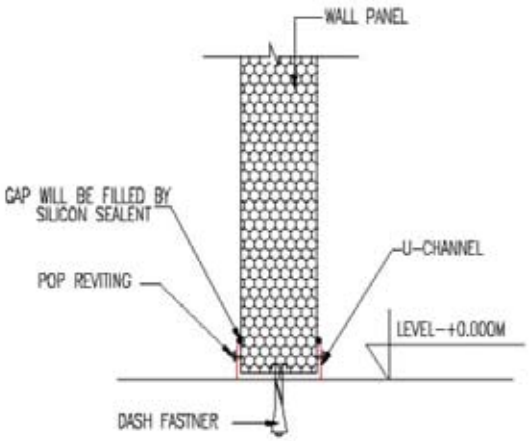
- the long edge of the previous pane;
- a measurement from the end of the panel to the fascia or purlin at the gutter. Gutter-end of all panels shall be kept in a straight line.
- each panel shall be fixed completely before laying the next; or
- the panel shall be fixed tightly to ensure it can't move, all panels shall be laid completely and then all the intermediate fasteners shall be placed later. (Figs. 15 & 16)

Checking alignment

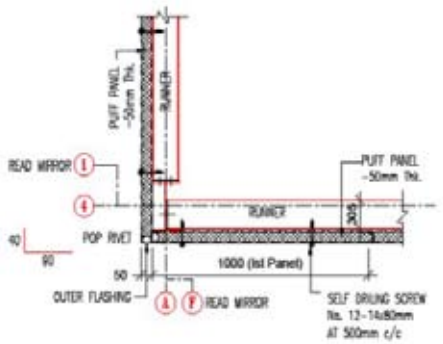
It must be checked that each panel is parallel with the adjacent panel and gap is within the allowed limit. (Fig. 17)

Wall panel fixing with floor

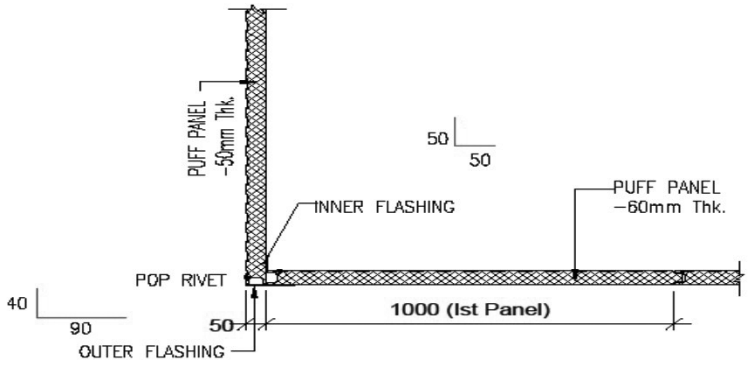
Wall panel of 80 mm for outer wall shall be fixed with U-channel of size 40x82x40x1.2mm on floor. U-channel shall be fixed with M6x65mm dash fastener at 300mm c/c spacing. (Fig. 18)



Figs. 15 UChannel Fixing Detail



Figs. 16 ***Outer Corner Flashing Fixing Details***



Figs. 17 Outer/Inner Corner Flashing Fixing Details at Partition Walls

Wall panel fixing with slab

Wall panel of 80 mm for outer wall shall be fixed with self-drilling screw of 12-14x120x4.8mm at 300mm c/c spacing using L-Angle of 50x50x2mm above slab. (Fig. 18)

Wall partition panel fixing with slab top & bottom

Wall partition panel of 80 mm shall be fixed over RCC slab by PVC gitti screw of 35mm and pop rivet at 200mm c/c spacing using L-Angle of 50x50x1.2mm on both side of panel above slab. (Fig. 18)

Vertical corner closer

Vertical corner shall be closed using pop rivet at 300mm c/c spacing by using L-Angle of 50x50x0.5mm. (Fig. 18)

Ceiling Panel

Fastener installation

It must be ensured that the fasteners are installed at locations indicated on the building drawings. It is easy to misjudge the location of the structural member, resulting in a fastener off the structural member or below the sealant at the end lap. The fastener shall be driven in until it is tight and the washer is firmly seated. A slight extrusion of neoprene around the washer is a good visual tightness check.

Orientation of panels before lifting

For maximum weather-tightness, start laying panels from the end of the building that will be in the lee of the worst-anticipated or prevailing weather. It is much easier and safer to turn panels on the ground than up on the roof.

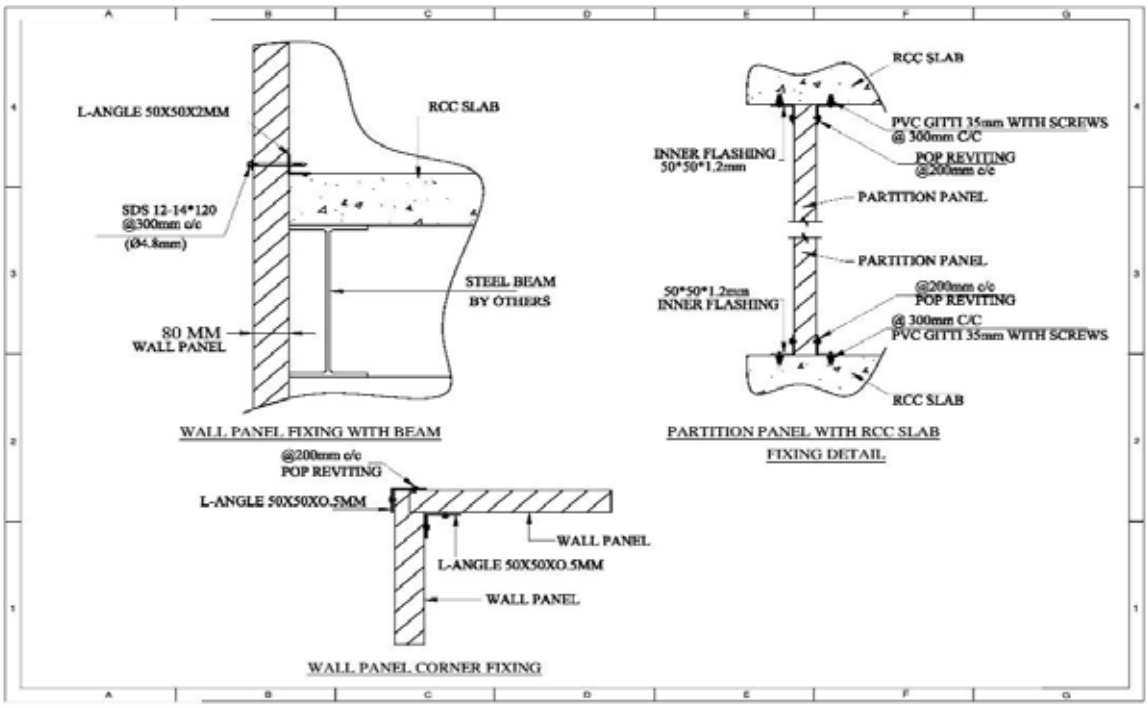


Fig. 18 Fixing Details of wall with floor, slab & partition

Before lifting panels on to the roof, it must be checked that this is the correct way up and the overlapping side is towards the edge of the roof from which side installation will start. Bundle of panels shall be placed over or near firm supports, not at mid span of roof members.

Fixing of Aluminium 'T'

Aluminium 'T' shall be marked on the structural members and holes shall be drilled in the structural members. Sag rod connector shall be assembled on ground for longer drop length. After that Aluminium 'T' shall be assembled on ground with all accessories and erected one by one at specified locations.

The level and alignment of 'T' line shall be checked before fixing the panels. Bottom level of the 'T' shall be adjusted for roof ceiling by adjusting nut. Coupling plates shall be erected to connect adjacent 'T' members. Same procedure shall be repeated in case of multiple lines. (Fig. 19)

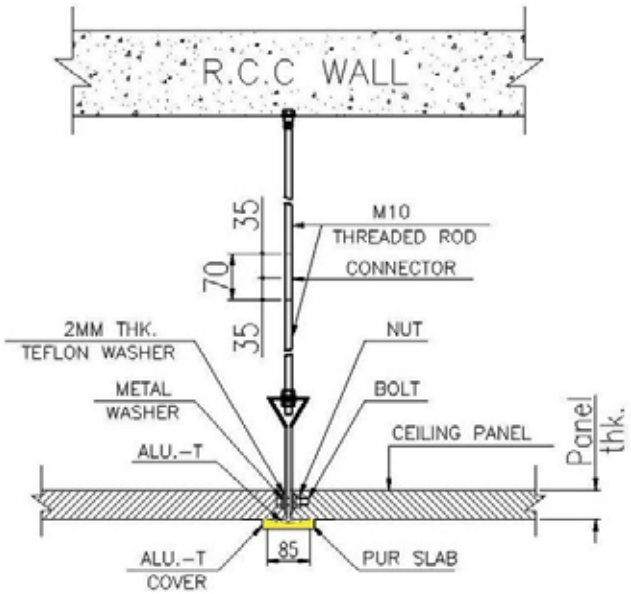


Fig. 19 Wall panel fixing with beam

Ceiling panel installation

Ceiling panel must be sheeted on both sides of the 'T' simultaneously. Proper coverage shall be checked frequently during progress. When lifting panels for laying and fastening, it must be ensured that all the panels are in the correct way up.

For panel installation steps given below shall be followed:

- Layout on the floor shall be marked as per the drawings.
- U Track/ base angle shall be installed in water level.
- Step cutting at wall panels shall be made to make provision for ceiling panel resting.
- Then wall panels shall be installed starting from one end wall and one side wall.
- Plumb and alignment of each panel shall be checked for starting the ceiling panels.
- Inner and outer flashings shall then be installed to give temporary hold at wall panels.
- Partition/other side wall panel shall also be installed with inner and outer flashings.
- Ceiling panels shall then be lifted to the location after chcking the orientation as per the drawings before lifting.
- Strip flashing shall be installed on top of the ceiling panel after checking the alignment.

The chamber shall then be completed by following the above steps. Silicon sealant shall be filled at inner and outer face of all the panels. All flashings and accessories shall be installed as shown in the drawings. After that chemical filling shall be done as per the specifications. (Fig. 20)

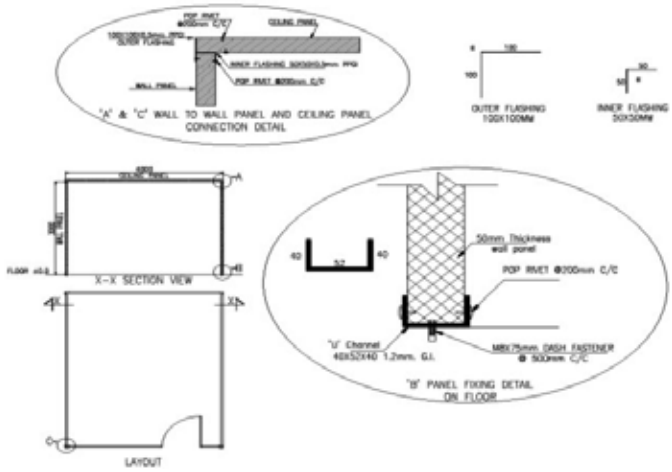


Fig. 20 Ceiling with Wall Fixing Detail

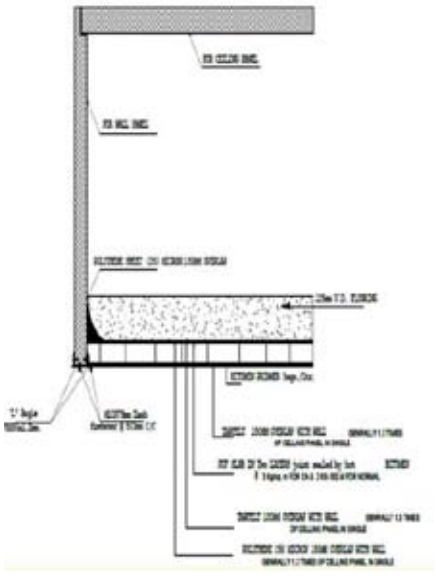


Fig. 21 Detail of Wall to Flooring

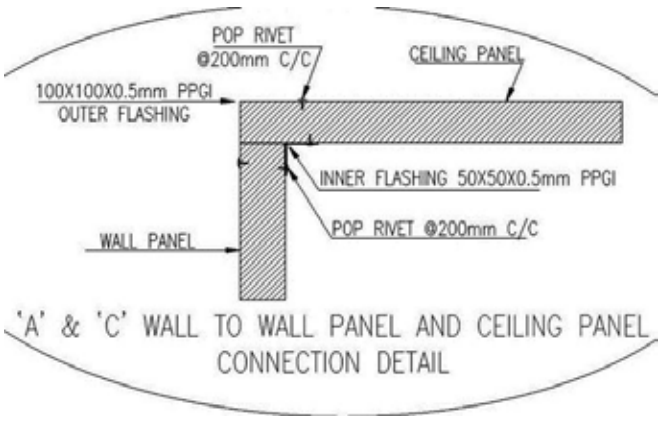


Fig. 22 Wall Panel Connection with Ceiling Panel

Sealing the side laps

Apply the side lap sealant to the weather side edge of the lower major. The sealant should only be applied to clean, dry surfaces. Press firmly along the length of the sealant to insure proper adhesion. Install the adjoining panel positioning the overlapping rib with care. Drill, at the centre of the clearance holes in the overlapping panel, required size pilot holes for the lap fasteners. Stitch the lap with the self-fastening fasteners supplied with the screw line. Sealant shall not be placed inside of the screw line.

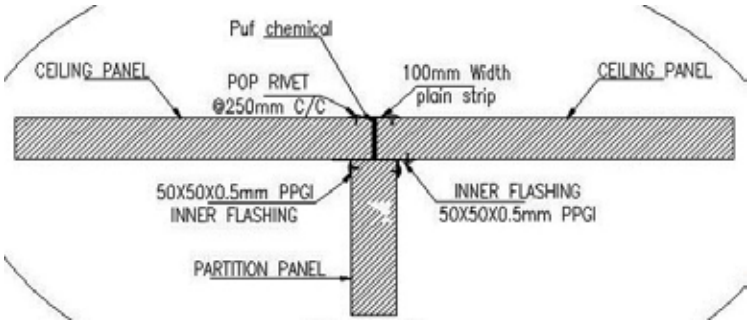


Fig. 23 Partition Wall Panel Connection with Ceiling Panel

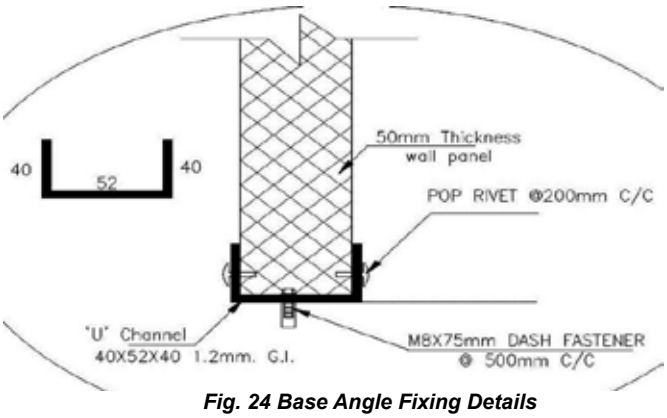


Fig. 24 Base Angle Fixing Details

MAJOR COMPLETED / UNDER COMPLETION PROJECTS

- Pre-engineered buildings with roofing for 14 elevated stations for DMRC, Delhi
- Shops and stores etc. of RCF Raebareli with roofing, cladding & partition walls for IRCON
- Workshops under NVEQF with roofing, cladding & partition walls for SSA, Haryana
- Sub-health centers in MP with roofing, cladding & partition walls for NRHM, Bhopal
- Pre-engineered buildings of RCF Raebareli with roofing, cladding & partition walls for IRCON
- Inverter and Switch gear rooms at Mundra, Gujarat for Adani Power Ltd.
- Sub-health centers with roofing & cladding for Govt. of Rajasthan
- PUF Panels to Tata Projects Ltd., at Kanpur (UP) for Power Grid Corporation,
- Panels for construction of a Warehouse for Hero Motorcorp of 10 m height at Neemrana (Rajasthan)

CERTIFICATION/VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No.: 1038-S/2018 has been issued to M/s Kingspan Jindal Pvt. Ltd., Gurgaon.

STANDARDS / GUIDELINES TO BE REFERRED

IS 277:2018	Specifications for galvanized steel sheets (Plain & corrugated)
IS 801:1975 (Reaffirmed 2010)	Code of practice for use of cold formed light gauge steel structural members in general building construction
IS 875 (Parts1 to 3):1987/2015	Code of Practice for design loads (other than earthquake) for buildings & structures
IS1893 (Part 1):2016	Criteria for earthquake resistant design of structures
IS 1904:1986 (Reaffirmed 2010)	Code of practice for design and construction of foundations in soils: general requirements.
IS 2062:2011 (Reaffirmed 2016)	Specifications for hot rolled medium & high tensile structural steel
IS 2380 (Part 10):1977 (Reaffirmed 2013)	Falling hammer impact test
IS 3346: 1980 (Reaffirmed 2017)	Method of determination of thermal conductivity of thermal insulation materials
IS 7888:1976 (Reaffirmed 2008)	Methods of test for Polyurethane Foam
IS 11239 (Part 1, 3, 4, 11 & 12):2009/1985/1988/2014	Method of tests for rigid cellular thermal insulations
IS 12436:1988 (Reaffirmed 2017)	Specifications for Performed Rigid Polyurethane foam for thermal insulation
IS 14246:2013	Specifications for continuously pre-painted galvanized steel sheets and coils
ISO 2796:1986	Cellular plastics -- Test method for dimensional stability of rigid materials
ISO 2896:2001	Cellular plastics --Test method for water absorption of rigid materials
IS 16700:2017	Criteria for structural safety of tall concrete buildings
ASTM C518	Standard test method for steady state thermal transmission properties by means of heat flow meter apparatus.
ASTM D1621	Standard test method for compressive properties of rigid cellular plastics
ASTM D1622	Standard test method for apparent density of rigid cellular plastics
ASTM D1623	Standard test method for adhesion properties of rigid cellular plastics
BS 476 (Parts 5, 6, 7)	Fire Tests on Building Materials & Structures– Method of test of Fire Ignitability, Fire Propagation & Surface spread of flame of Materials/Products

PUF Sandwich Panel with Pre Engineered Building Structure

(Suitable for Low Rise to High Rise Structures)

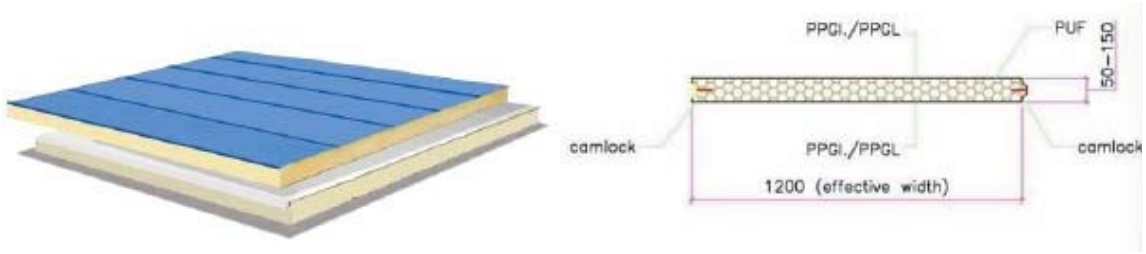
ABOUT THE SYSTEM

PUF Sandwich Panels with Pre Engineered Building structure is a combination of Structural Steel Framing System designed as per relevant Indian Standards, with PUF Sandwich Panels in wall and roofing system. PUF panels consist of a rigid PUF core sandwiched between color coated Galvanized Steel/Galvalume steel sheet facing on both sides, complete with joint sealants and fixing ancillaries, which is easy to install and affordable.

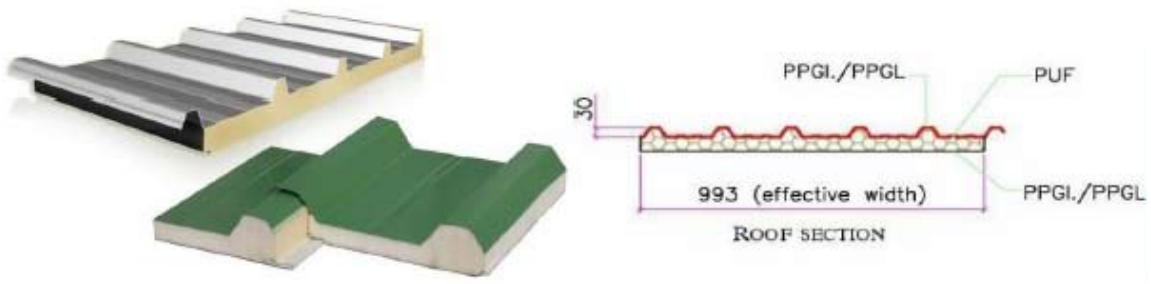
The sandwich panel offers high thermal efficiency, comes with variety of finishes and can be installed easily & quickly for being light in weight. The Steel structural system of Pre-engineered building offers flexible design option with diverse layout possibilities/ architecture. It helps achieve very fast installation & durable structure.

Types and sizes of PUF Sandwich Panel

Wall Panel: Standard size 1200 mm/customized (effective width), manufactured in thickness range from 50 mm to 150 mm as per requirement of customer, the panels have a CAM lock Jointing System.



Roof Panel: Standard size 993 mm (effective width) manufactured in thickness ranging from 30 mm to 150 mm as per requirement of customer, the roof panels have overlap jointing system. The advantage of roofing panels have of a large number of ribs, which increase the load carrying capacity of the panel and prevents deformation.



USES OF THE SYSTEM

The PUF Sandwich panels can be used in construction of walls and internal partitions, as well as for roofs. The typical applications of PUF Sandwich Panel with Pre Engineered Building Structures include exterior / interior wall and roof of Industrial buildings, Commercial buildings, Row Housing, Multistory Buildings, prefab buildings, Site offices, Cold storages, Warehouses, etc.

BASIC RAW MATERIAL REQUIREMENTS

Polyurethane Foam (PUF): It is a thermosetting material when it comes contact with fire, it does not drip or melt. It shall be Chlorofluorocarbon (CFC) free and self-extinguishing and shall conform to IS 12436: 1988.

Pre Painted Galvanized Iron (PPGI): The PPGI sheet shall have min. yield strength of 245 MPa conforming to IS 14246:2013 and shall have zinc coating of min. 90 Gsm as per IS 277:2018. The sheet shall have 5-7 micron epoxy primer on both sides and polyester top coat of 15-18 micron. The sheet shall also have plastic protective guard film (Optional) of min. 25 micron to avoid scratches during transportation.

Flashing/Accessories: Made of PPGI sheet conforming to IS 14246:2013 and shall have zinc coating of min. 70 Gsm as per IS 277:2018.

Specifications of raw materials:

Sl.No.	Raw Material	Specification Conforming to
1.	Insulated PUF Panels	Iso(55%)& Polyol(45%)
2.	Colour Coated Coils	Fy245MPa,120GSM or 550MPa, AZ120
3.	HR Plates	Fy 345 MPa
4.	Cold form GP Coils	Fy 245 MPa,120 GSM or 275 GSM

PUF Panel

Sl. No.	Product	PUR/PUF Panel							
1	Width-wall	1200mm (Standard/Customized)							
2	Width-roof	993mm							
3	Core thickness (mm)	30	40	50	60	80	100	120	150
4	Thermal Resistivity (U Factor) ($W/m^2\ ^OK$)	0.75	0.53	0.43	0.33	0.28	0.22	0.18	0.15
5	R value ($Btu/hr/ft^2/^0F$)	9.8	11	13	16	20	26	30	38
6	Fascia Options	PPGS/PPGI/Alu/Tarfelt/Cement Fiber Board/SS							
7	Density (Kg/m^3)	40 ± 2 Kg/m^3							
8	Thermal Conductivity at 10^0C mean Temperature (w/m^3k)	0.023							
9	Compressive Strength at 10% Deformation (Kg/cm^2)	2.1							
10	Bending Strength (Kg/cm^2)	4							
11	Tensile Strength (Kg/cm^2)	3.7							
12	Adhesive Strength (Kg/cm^2)-foam to steel	2.9							
13	Water Absorption (Volume %)	0.2% at 100%RH							
14	Closed Cell Content (%)	92-95%							
15	Vapor Permeability at 90% (RH) & 38^0C($Gms/Hr.m^2$)	0.12							
16	Fire Class	Fire Resistant							

Pre Engineered Structural components

S.No.	Material	Specification	Min. Strength
1	Built-Up Members	IS: 2062 / ASTM A 570M Grade 50 YS 345 Type 1 (or) its Equivalent	Fy=345 MPa
2	Hot rolled members a. Beams & Columns b. Tubes c. Channels d. Rods & Pipes	ASTM A 572 or equivalent for Hot rolled / IS 2062: 2006 Grade A (or) its Equivalent IS 4923: 1997 IS 2062: 2006 Grade A IS : 1161 / ASTM A 36 or equivalent	Fy=250 MPa
3	Cold formed secondary members	ASTM A 653M / IS:277 or Equivalent.	Fy=345 MPa
4	Sheeting & linear panels	ASTM A792M/IS:15961: Bare Galvalume Steel Sheets, ASTM A 755M/IS:14246/IS15965 for Pre-Painted Galvanized and Galvalume Steel Sheet	Fy=550 MPa
5	Flashing, trims, & valley gutters.	IS:14246	Fy=345 MPa
6	Deck Sheet for Mezzanine	ASTM A 653M / IS:277 or Equivalent.	Fy=345 MPa
7	X-Bracing members Rod Bracing Angle Bracing Pipe Bracing	 IS 2062: 2006 Grade A IS 2062: 2006 Grade A IS 2062: 2006 Grade A	 Fy=250 MPa Fy=250 MPa Fy=250 MPa
8	Anchor Bolts	IS : 2062 Gr A	Fy=250 MPa
9	High Strength Bolts & Nuts (Primary Bolts & Nuts)	IS: 1367 / ASTM A 325 M Class 8.8. Grade	Fy= 345 MPa
10	Machine Bolts (Secondary Bolts & Nuts)	IS:1364 / ASTM 307 Class 4.6 (Part 1 to 3)	Fy= 345 MPa
11	Self-Tapping Self-Drilling screws (STSD)	AS 3566.1 - 2002 Corrosion Resistance Class-3 or equivalent)	Fy= 345 MPa

MANUFACTURING PROCESS OF SANDWICH PUF PANEL

To make the panel, the 'Panel Press' equipment is used, which features a vertical hydraulic ram of the length and width of the largest panel desired to be produced.

Profiling of the two faces of metallic facing is done as an 'Off line' processes and brought to and stacked on either end of the press.

The base on which the bottom facing is placed is a precisely machined flat Platten equipped with a built in heating system. Sides of the mould are made of machined Aluminum extrusions (jigs), profiled to the male and female joint features. These jigs are specific to each thickness of panel being produced. Jigs also feature accurately positioned fixtures to mount "CAMLOCK" components, which get embedded in to the foam later. When the pre-profiled top and bottom facing sheets are placed in this mould with special spacers, a hollow space is created, which is ready for chemical injection.

This complete pre-assembly is moved laterally into the 'daylights' of the press by a positioning actuator. A heavy ram, which is a precision machined guided block, closes the mould tightly and holds the 'mould' firmly. The temperature controlled heated plattens keep the mould at the optimum reaction temperature.

Through many nozzles provided on the sides of the 'mould', PU chemicals mix is injected to precise volume as per settings in the microprocessor controlled delivery head. The liquid mix finds its level well before the 'cream time' of the chemicals is reached. The foaming reaction starts and the foam rise gradually to fill the nooks and corners of the mould. The rising of the foam is complete well before the 'tack-free' time, when the adhesion to the sheets starts- i.e., well after the foam has filled the 'mould'. The assembly is held in position, in the preheated mould till after the 'mould release' time has elapsed.

Maintenance of each of the time elements of the process is achieved using the microprocessor assisted control system.

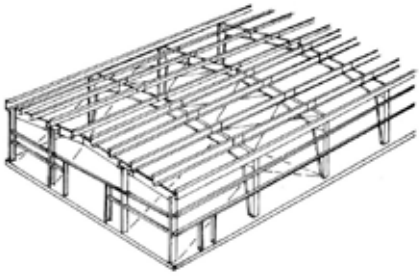
CONSTRUCTION PROCESS

The panels should be stored on a clean, flat hard surface area on the site. The panels should not be laid down directly on the ground to prevent them from getting dirty, which could lead to problems of plaster adhesion. Preferably, panels should be stored on timber battens approx. 2m apart. The panels should not be exposed to sunlight for not more than 1 month either in storage or during construction. The panels should be bound carefully to make sure these are not accidentally blown by the wind.

Long term storage of the panels shall be done in a covered, protected, dry environment so that corrosion of the reinforcement does not occur and the panels do not get damaged. Panels shall be stored and transported to site in a manner that prevents damage, buckling or sprawling of the polystyrene or bending of the mesh reinforcement. Operatives should place the panels in position and tie them down to starter bars of adjoining panels and slabs in the manner described in the Erection Method Statement Manual.
Panels should be properly braced to provide rigid temporary support to the walls during erection and concrete spraying and placing of concrete in slabs. Propping of walls and slabs should be in accordance with E Pack Erection Method Statement Manual. The panels shall be delivered to the site with an identification issued by the manufacturer that reports the element height. The panel layout shall provide instructions for laying the components correctly.

Framing of wall and roof

i. Finish Frames & Accessories – Complete erection of main and secondary framing as per the erection statement of the project.



ii. Upon Completion of all secondary framing in the braced bay, plumbing and squaring the braced bay, installing secondary framing in the end bay, paneling may commence and be worked in conjunction with the completion of the balance of the secondary framing. This could save time on larger buildings if separate sheeting crews are used.

iii. When the building reaches this stage of erection, sheeting should proceed immediately. The structure without sheeting should not be left standing for prolonged periods of time without taking proper precautions (temporary bracing, blocking etc.) to prevent wind damage especially to purlins and girts due to excessive vibration they are exposed to in the un-sheeted condition.

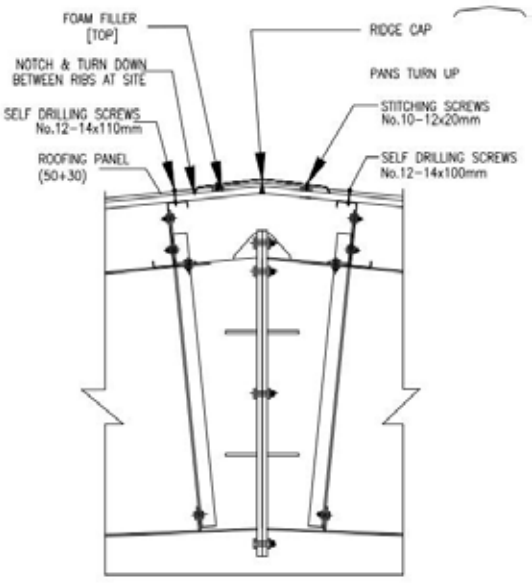
Roof Panel

Need to check that the C/Z purlins (supporting structure of the panels) comply with the erection drawings (span length, width of purlin's flange, etc.). Generally Panels are designed for installation on plane surfaces, of minimum slope 7%.

Ensure that installation workers bear the appropriate personal safety equipment, as per current regulations.

Roof Panel should be placed on the roof purlins, close to the main trusses (load bearing structure), and distributed along roof's length, taking into consideration the installation direction.

The Guard film on the internal side must be removed before panels' installation. On the external side, the Guard film should be partially removed (along panel's edges – joint), Film should be completely removed by the end of the working shift, and in any case, before panels' fixing on the internal trapezoidal ribs. Any eventual traces of adhesive (from the film) on panel's surfaces should be removed, with the use of a water-detergent mixture.



TYP. RIDGE CAP DETAIL

Place the first panel and fix it in place, making sure that it is perfectly aligned and squared with the roof structure. The second panel is installed by overlapping its first (empty) rib on the last (full) rib of the first panel and fixing them together on the roof purlins. Fixing element (self-drilling screw with saddle cap) should be placed perpendicularly to panel's surface, and positioned in the middle line of the rib. The use of original saddle caps is mandatory.

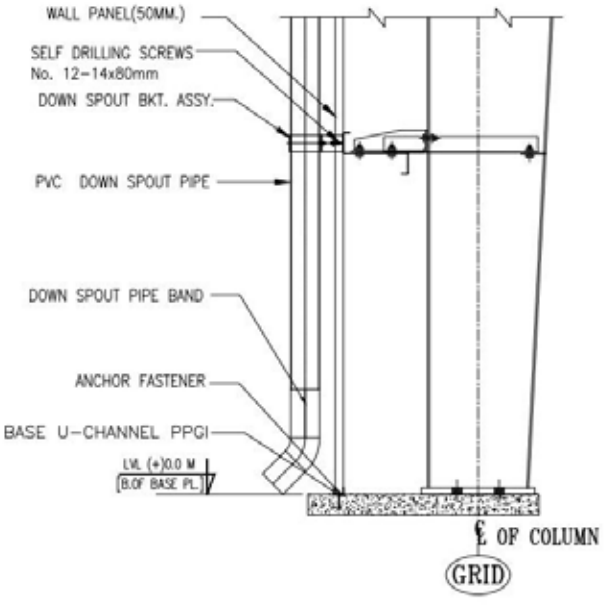
After installation of the first strip panels (downstream), the second strip panels are installed by longitudinal overlapping.

Longitudinal overlapping length can vary between 100mm and 300mm, also depending on roof slope. During drilling, fixing (and eventually cutting) operations, metal chippings are produced, that can damage panels' surface either by scratching, or by their rapid corrosion. Such metal chippings should be carefully removed with a vacuum cleaner, immediately after each operation.

Installation of Wall panels:

Installation direction of the panels, on each façade, should be opposite to the prevailing wind direction. Place the first panel and fix it in place, making sure that it is perfectly vertical and aligned with the wall structure (Girt – C/Z). The use of mechanical clamps before fixing the panel can assist the plumbing procedure.

The first panel is secured on the wall sub structure with a visible fixing element, close to its "groove" join on each wall purlin. Those fixing elements (self-drilling screw with metal washer & EPDM gasket) can be hidden later on by appropriate flashing elements (external corner profiles, base-drip cover profiles, etc.). The second panel is approached the first one, and with a slight inclination it must be pushed against the previous panel, in order to obtained a perfect coupling between the panels. After fixing second panel, the installation of every next panel is performed is similar way.

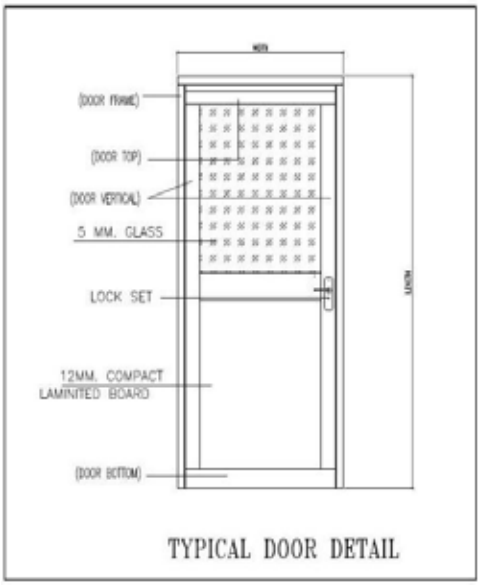


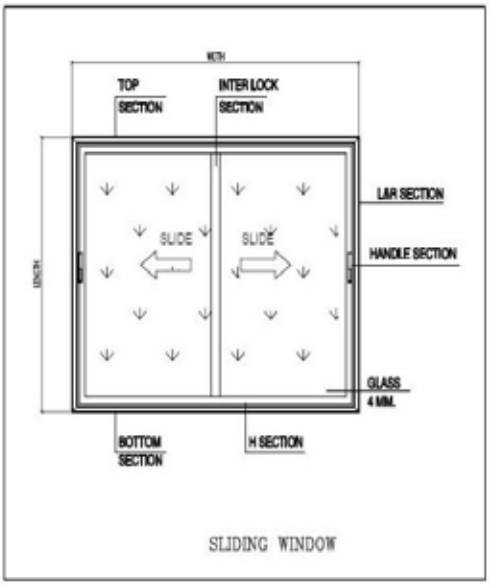
TYP. CLADDING BOTTOM DETAIL

Cutting of Panels for Door & Window Installation:

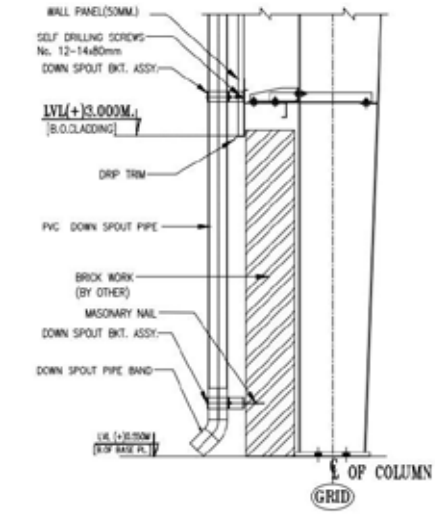
Any cutting operations on panels should be performed for Door & window installation with a circular saw or a jigsaw; the use of angle grinder is not acceptable.

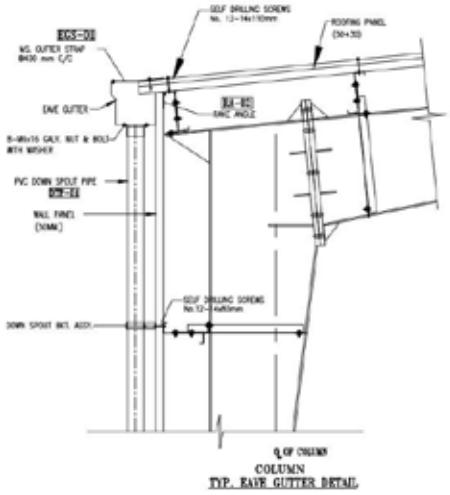
The outline is drawn of the cut to be made on the tape with a felt-tip pen. Cut with the use of suitable cutting tools. Clean panel's surface from shavings and chippings formed during cutting.

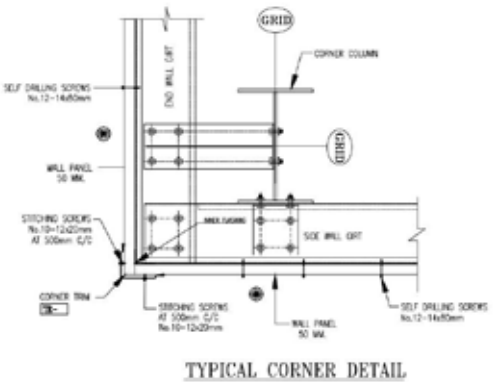




Sketches for other Typical Connection details;







Project Photographs



Field Maintenance Office, Reliance Industries Limited, Jamnagar



Warehouse Building (PEB), Aditya Moda, Ghaziabad



PEB Buildings (Canteen and Office), Hankuk, Greater Noida



PEB G+2 Building, Perfect IT, Noida



PEB GIS Building, GE T&D, Phagi, Rajasthan



PEB G+1, Hetero Health Care Ltd, Kamakhya, Guwahti



PEB G+1 Building, Dr Shroff Eye Hospital, Saharanpur, UP



PEB GIS Building, TOSHIBA Godishahi, Odisha

MAJOR COMPLETED / UNDER COMPLETION PROJECTS

1. Field Maintenance Office for Reliance Industries Ltd. at Reliance Industries Limited, Jamnagar (Area: 22,983 Sq.ft. completed in 2 months @ Rs.3.9 Cr.)
2. Warehouse Building (PEB) for Aditya Moda at Ghaziabad (Area: 37,674 Sq.ft. completed in 2 months @ Rs. 1.70 Cr.)
3. PEB Buildings (Canteen and Office) for Hankuk at Greater Noida (Area: 11,346 Sq.ft. completed in 1 month)
4. PEB G+2 Building for Perfect IT at Noida (Area: 6,45,840 Sq.ft. completed in 4 months)
5. PEB GIS Building for GE T&D at Phagi, Rajasthan (Area: 15,300 Sq.ft. completed in 1.5 months)
6. PEB G+1 Building for Hetero Health Care Ltd. at Kamakhya, Guwahti (Area: 35,840 Sq.ft. Ongoing)
7. PEB GIS Building for L&T at Meerut, UP
8. PEB for Wilson at Malda
9. PEB G+1 Building for Dr Shroff Eye Hospital at Saharanpur, UP
10. PEB GIS Building for TOSHIBA at Godishahi, Odisha

CERTIFICATION OF THE SYSTEM

Performance Appraisal Certificate No.: 1060-S/2022 has been issued to M/s Epack Polymers Pvt. Ltd., Greater Noida.

STANDARDS / REFERENCES

IS 277:2018	Specifications for galvanized steel sheets (Plain & corrugated)
IS 801:1975(Reaffirmed 2010)	Code of practice for use of cold formed light gauge steel structural members in general building construction
IS 875 (Parts1 to 3):1987/2015	Code of Practice for design loads (other than earthquake) for buildings & structures
IS1893 (Part 1):2016	Criteria for earthquake resistant design of structures
IS 1904:1986(Reaffirmed 2010	Code of practice for design and construction of foundations in soils: general requirements.
IS 2062:2011(Reaffirmed 2016)	Specifications for hot rolled medium & high tensile structural steel
IS 3346: 1980(Reaffirmed 2017)	Method of determination of thermal conductivity of thermal insulation materials
IS 7888:1976(Reaffirmed 2008)	Methods of test for Polyurethane Foam
IS 11239 (Part 1, 3, 4, 11 & 12):2009/1985/1988/2014	Method of tests for rigid cellular thermal insulations
IS 12436:1988(Reaffirmed 2017)	Specifications for Performed Rigid Polyurethane foam for thermal insulation
IS 14246:2013	Specifications for continuously pre-painted galvanized steel sheets and coils
IS: 15961:2012	Specification for Hot dip Aluminium zinc alloy Metallic coated steel sheet
IS: 15965:2012	Specification for Pre-Painted Aluminium zinc alloy Metallic coated steel sheet
ISO 2796:1986–Cellular plastics	Test method for dimensional stability of rigid materials
ISO 2896:2001 -- Cellular plastics	Test method for water absorption of rigid materials
ASTM C518	Standard test method for steady state thermal transmission properties by means of heat flow meter apparatus
ASTM D1621	Standard test method for compressive properties of rigid cellular plastics
ASTM D1622	Standard test method for apparent density of rigid cellular plastics
ASTM D1623	Standard test method for adhesion properties of rigid cellular plastics
BS 476 (Parts 5, 6, 7)	Fire Tests on Building Materials & Structures– Method of test of Fire Ignitability, Fire Propagation & Surface spread of flame of Materials/Products
ASTM:792	Pre-Painted Galvalume Steel Sheet
ASTM:755	Pre-Painted Galvanized Steel Sheet

Ferron Panel as part of Ferrobuild Design System

(Suitable for Low Rise to High Rise Structures)

ABOUT THE TECHNOLOGY

Ferron panel is cladding solution for light gauge steel frames. It consists of two layers of steel mesh of galvanized mild steel, 250 MPa yield strength (minimum) with minimum cover to mesh as 2.5 mm. The two layers of weld mesh, minimum 1 mm diameter, at required intervals on either side are encased in mortar of M35 Grade. The thickness of panel comprising of steel weld mesh and mortar composite is 18 mm or above (as per the requirement). This makes Ferron panel a light weight and sleek wall unit, easy to be fitted.

Since, ferrocement is the base material, the ferron panels have relatively high strength in direct tension, flexural tension, compression and shear. Ferron panels are screwed and/or glued to the light gauge steel frames mobilizing composite action and forming novel structural system for walls, beams and slabs. This structural system is also referred to as 'Ferrobuild Design System' or Light gauge steel and ferron composite structure.

Ferron cladding help achieve greater strength, reduced LGS consumption and durability of the structure. Transport and handling of structural components is easy as weight of individual component is less than 25 kg. On site wet work and curing is eliminated.

The Ferron Panels based Ferrobuild design system has following features;

i. Stronger walls having higher flexural strength compared to brick masonry walls
ii. For typical G+3 residential building, there is reduction in steel consumption, cement consumption, CO_2 emission, water consumption & dead weight in comparison to conventional RCC construction
iii. Smaller & economical foundation size due to reduced self-weight of the building
iv. Higher speed, quality & better seismic performance compared to RCC Construction
v. Composite action between steel and ferron panels enhance the capacity of bare LGS sections
vi. Higher thermal insulation of the wall. The same can be further improved with insulation material in cavities.
vii. In case of the failure in buildings, the debris will never be formed enabling easy evacuation. Hence, suitable for strategic buildings like fire stations, hospitals etc.
viii. For defence, ready to use bunkers can be made and transported easily. The walls have high strength under impact loads hence are suitable. The strength of the walls can be further enhanced as per the requirement.
ix. The Ferron panels are maintenance free & its replacement is easy.

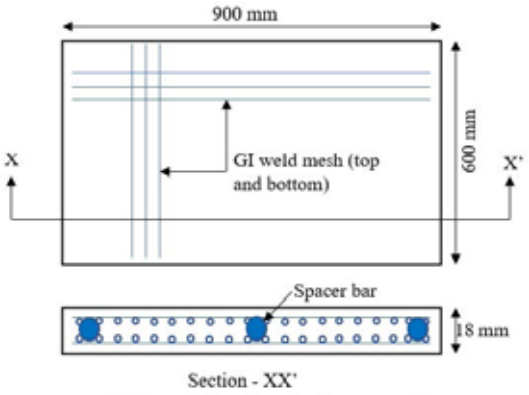
SPECIFICATIONS FOR THE SYSTEM

Sizes of Panels

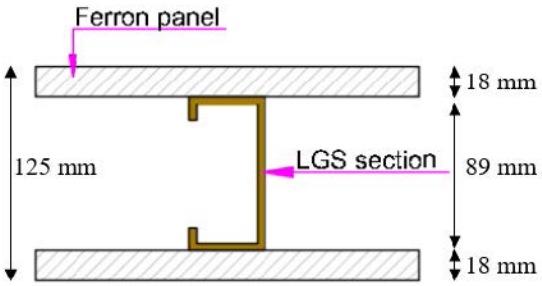
Materials used: Combination of light gauge steel (Galvanised iron) and Ferrocement (Ferron) panels

Dimension: Ferron Panel- 900x600x18mm, & Cold formed galvanised iron section having thickness 0.55 to 1.00mm





Not to Scale drawing of a ferron panel



Not to Scale cross section of ferron and Light gauge steel composite wall

Fig. 1 Ferron Panel Drawing

BASIC RAW MATERIAL REQUIREMENTS

The manufacturer shall only use the raw materials supplied with the relevant documents/ prescribed Quality Assurance Plan. The raw materials shall be subject to agreed controls and tests by the manufacturer before acceptance. The list of raw materials/component & its specifications used by the Agency to manufacture Ferron panels;

S. No.	Raw materials/ component	Specification
1	Cement – OPC 53 Gr	IS 269:2015
2	Sand	IS 383:2016
3	Water	IS 456:2000
4	Welded mesh	IS 1566:1982 (Reaffirmed: 2020)

USES OF THE SYSTEM

i. Ferron panels are used as Wall cladding on light gauge steel / mild steel & Lost form shuttering for slabs in various types of building construction.
ii. The capacity of ferron panels can be enhanced based on the requirement.

MANUFACTURING PROCESS

The manufacturing process comprises of the following steps;

i. Preparation of reinforcement cage as per design
ii. Preparation of mortar as per design
iii. Preparation of moulds for casting (cleaning and applying oil to moulds)
iv. Inspection of prepared mould prior to casting
v. Laying of the reinforcement in moulds
vi. Pouring of mortar inside the moulds
vii. Compaction of poured mortar
viii. Setting of poured mortar
ix. Demoulding of the panels
x. Curing of panels in water tanks for 7 days
xi. Curing of panels in stacking yard up to 14 days

xii. Subjecting panels to daylight up to 28 days

xiii. Check for quality

xiv. Transfer to dispatch yard

The process is in batches. The batch size depends on number of moulds available for casting on a given day. Usually, the batch size is 200 panels. Procurement of machinery to increase the batch size per day to 500 panels is in process.

CONSTRUCTION PROCESS

Construction Sequence for Ferrobuild Design System

This construction form involves two constituents namely;

a) Factory cast Ferrocement panels (600 mm x 900 mm x 18 mm)
b) Light Gauge Steel (LGS)

Ferrocement is thin reinforced cement mortar. It involves closely spaced small diameter reinforcement mostly in the form of mesh. The reinforcement details of the Ferrocement – panels employed in the present work are shown Fig. 2 as below. LGS steel is cold form steel. Due to slender cross sectional elements it is susceptible to local instability, if not stiffened. The Fig. 3 presents the plan view of Ferrocement-LGS composite wall. The wall has LGS section sandwiched between two Ferrocement panels. As per construction sequence, LGS column-beam framing is erected at the site, Ferrocement panels are subsequently attached (with 900 mm side vertical) from both sides employing self-taping screws at regular spacing along the length and polymer based binder (Fig. 3). The thickness of the wall works out to be 125 mm if LGS leap channel of 89 mm x 40 mm x 1 mm is employed.

The Fig. 4 provides a typical photograph of partially complete Ferrocement-LGS composite building. Under lateral loads, wall in such form of construction would behave more like a shear wall than infill in framed buildings, thus ensuring box action.

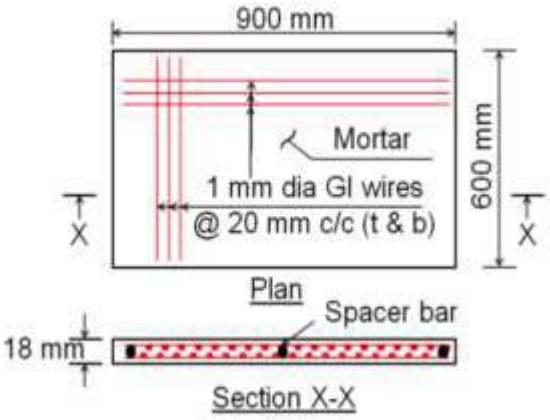


Fig. 2 Reinforcement details of Ferrocement panels

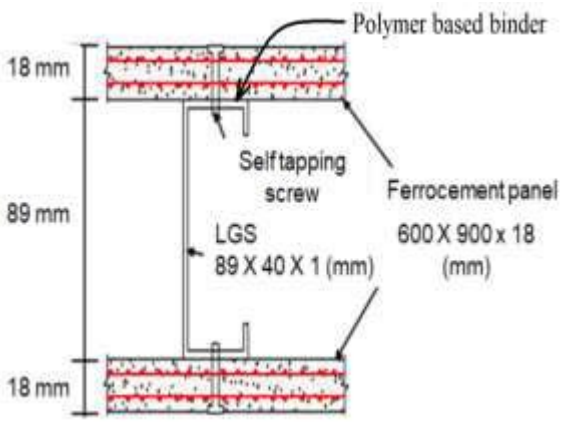


Fig. 3 Plan of Ferrocement-LGS wall section



Fig. 4 Photographic view of partially completed composite building

Panel Junction details

Jointing of panel including the joint treatment with recron tape and polymeric binder are as per the details below;

i. L Junction:

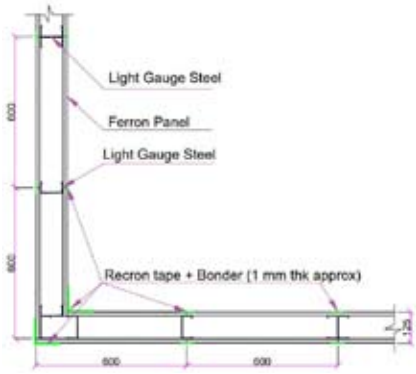


Fig. 5 L Junction

ii. T Junction:

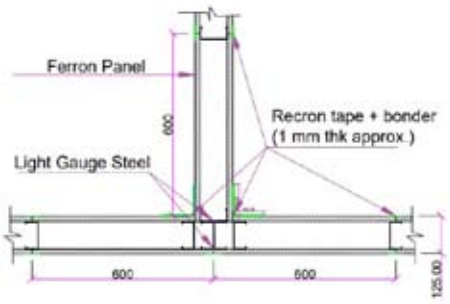


Fig. 6 T Junction

Treatment of Vertical and horizontal joints

Recron tape with high strength non shrink epoxy bonder (as seen green in colour in images below) is used at all the joints. The width of the recron tape is 50 mm and runs all along the length of the joint and the thickness is approximately 1 mm as seen in images below. At 90-degree junctions, the width of recron tape is increased to 100 mm for additional strength.



Fig. 7 Recron tape + epoxy bonder at joints for walls



Fig. 8 Recron tape + epoxy bonder at joints for slabs

Electrical & Plumbing Services

Electrical and plumbing services are outside the scope of this Certificate, however, in designing and installing these services, precautions must be taken to avoid the possible risk of long term damage to the structure or the services by e.g. the ingress of water, water vapour or condensation from water service pipes. The insulation may be provided as per the requirement. One unit with internal finishes has also been shown below.



Fig. 9 Electrical conduits



Fig. 10 Provision of Insulation



Fig. 11 Internal finish and Accessories

Design & Installation Procedure

i. The prerequisite in design for ferron installation is to have supporting light gauge steel members along the long edges of the ferron panels. This care is taken during the detailed design process.

ii. The panels are bolted with LGS Channel section with self-tapping screws (3-4 mm diameter), 4 in numbers along each of the long edges and 2 in numbers along each of the short edges.

iii. Typical drawing for ferron installation is provided during training and also on site.

iv. Care needs to be taken while cutting the ferron panels on site to meet the actual on site dimensional requirement.

v. Any person involved in fabrication of mild steel structures is suited to perform this job. All the resources are trained prior to work on site.

MAJOR WORKS UNDERTAKEN

I. Residential

i. G+2 Hybrid, 4500 sq.ft., Pune (Completed)
ii. G+1 LGS, 4000 sq.ft., Pune (Completed)
iii. Ground Floor structure, 2300 sq.ft., Sangli, Maharahtra (Completed)
iv. G+1 LGS, 4000 sq.ft., Nipani, Karnataka (Completed)
v. 5th Floor Extension, 1900 sq.ft., LGS with Ferron roof, Pune (Completed)
vi. G+1. LGS, 5000 sq.ft. Hedvi, Dist. Ratnagiri, Maharashtra (Completed)
vii. Terrace enclosure, 200 sq.ft., Pune (Completed)
viii. G + 1 Farmhouse, 2000 sq.ft., Pune (Completed)
ix. Terrace Extension, 300 sq.ft., Pune (Completed)
x. Terrace Extension, 150 sq.ft., Pune (Completed)
xi. Terrace Extension, 1200 sq.ft., Pune (Completed)
xii. G+1 Villa. 7500 sq.ft., Palghar (LGSF design Completed)



II. Non-residential

i. EnPro Engineering, 20,000 sq.ft., LGS- Ferron walling within steel foundry (Completed)
ii. ISB&M College, Lavale, Pune, Floors 3 & 4 of hostel, LGS with Ferron as slab (Completed)
iii. Primary Education Centres, 5000 sq.ft., Baramulla, J & K (Completed)
iv. Hangout Hotel, 1300 sq.ft., Pune (Completed)
v. Indian Consulate, 24,000 sq.ft., Kabul, Afghanistan (In-process)



III. Resorts

i. Anandam Resort, 1300 sq.ft., Villa, Velhe, Pune (Completed)
ii. Woolloomooloo Resort, 1600 sq.ft., Tiny Cottages, Shilimb (Completed)
iii. Karandi Valley Resort, LGS + Ferron walls (Completed)
iv. The Farmhouse, Hybrid, 1000 sq.ft., Karjat (Completed)
v. Chira Meadows, 8000 sq.ft., Dapoli (Completed)

IV. In process (Design + Supply)

i. Residential bungalow, 1500 sq.ft., Mauritius
ii. G + 3 residential building, 5200 sq.ft., Pune
iii. G+1 Farmhouse Villa, 4000 sq.ft., New Delhi
iv. Terrace Extension on residential building, (5th Floor) 2000 sq.ft., Pune

v. Terrace Extension on residential building, (5th Floor) 3800 sq.ft., Pune
vi. Kamayani School Extension, (3rd floor), 5000 sq.ft., Pune
vii. K.K. Wagh College Extension, (5th Floor), 60,000 sq.ft., Nashik

CERTIFICATION

Performance Appraisal Certificate No. 1066-S/2023 has been issued to M/s Sanjivani Cement Products, Pune.

STANDARDS / REFERENCES

IS 650:1991 (Reaffirmed: 2018)	Specification for standard sand for testing of cement
IS 3535:1986 (Reaffirmed: 2018)	Methods of sampling hydraulic cement
IS 4031:1996	Methods of physical tests for hydraulic cement
IS 4032:1985 (Reaffirmed: 2019)	Methods of chemical analysis of hydraulic cement
IS 8112:1989 (Superseded by IS 269:2015)	Specification for 43 grade ordinary Portland
IS 12269:1987 (Reaffirmed: 2008)	Specification for 53 grade ordinary Portland
IS 383:1970/ IS 383:2016	Specification for coarse and fine aggregates from natural sources for concrete
IS 2386:1963 (Reaffirmed:2021)	Methods of test for aggregates for concrete
IS 456:2000	Code of Practice for plain and reinforced concrete
IS 432:1982 (Reaffirmed: 2020)	Mild steel & medium tensile steel bars and hard drawn steel wires for concrete reinforcement
IS 16014:2012	Mechanically woven, double-twisted, hexagonal wire mesh gabions, revet mattresses and rock fall netting (galvanized steel wire or galvanized steel wire with PVC coating) – Specification
IS 1566:1982 (Reaffirmed: 2020)	Specification for Hard-Drawn Steel Wire Fabric for concrete reinforcement
IS 280:1982 (Reaffirmed: 2021)	Mild steel wire for general purpose
IS 516:1959 (Reaffirmed:2018)	Method of test for strength of concrete
IS 2770:1967 (Reaffirmed: 2022)	Methods of testing bond in reinforced concrete
IS 3085:1965 (Reaffirmed: 2021)	Method of Testing for permeability of cement mortar and concrete
IS 5816:1999 (Reaffirmed: 2018)	Method of test for splitting tensile strength of concrete
IS 14858:2000	Compression testing machine used for testing of concrete and mortar – Specification
IS 10430:2000	Criteria for design of lined canals and guidance for selection of type of lining (Second Revision)
IS 13356:1992 (Reaffirmed: 2022)	Code of Practice for Precast Ferrocement water tanks upto 10000 litre

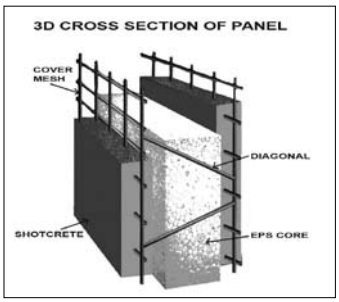


Prefabricated Sandwich Panel System

Advanced Building System - EMMEDUE

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE TECHNOLOGY



Expanded Polystyrene (EPS) Core Panel System is based on factory made panels, consisting of self extinguishing expanded polystyrene sheet (generally corrugated) with minimum density of 15 Kg/m^3, thickness not less than 60 mm, sandwiched between two engineered sheet of welded wire fabric mesh, made of high strength galvanized wire of 2.5 mm to 3 mm dia. A 3 mm to 4 mm dia galvanized steel truss wire is pierced completely through the polystyrene core at the offset angle for superior strength and welded to each of the outer layer sheet of steel welded wire fabric mesh. The panels are finished at the site using minimum 30 mm thick shotcrete of cement & coarse sand in the ratio of 1:4 applied under pressure. *(Refer sectional details as shown).* The shotcrete coat encases the EPS Core with centrally placed steel welded wire fabric mesh.



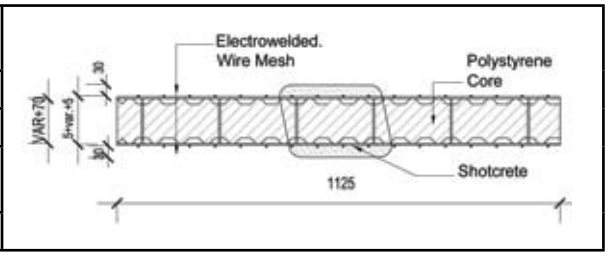
The technology (developed about 30 years back) has been successfully used in many countries like Morocco, Algeria, South Africa, Kenya, Austria, Malasiya, Ireland, Romania & Australia with involvement of different agencies and brand names.

PANEL TYPES

The Panels being manufactured are of different types depending upon the application. The details of different types of typical panels are given below:

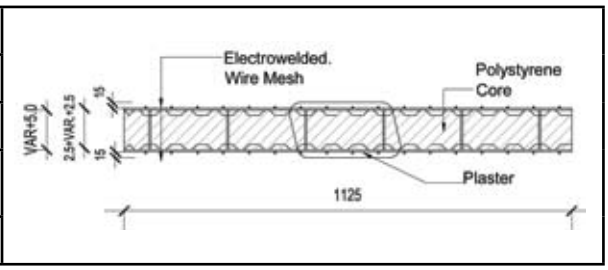
Single Panel for structural uses

Longitudinal wire	2.5 mm / 3.5 mm ø spaced @ 65 mm
Transverse Wire	2.5 mm ø spaced @ 65 mm
Cross Steel Wire	3.0 mm ø approx 68 nos. / m^2
Polystyrene Core	Density ≥15 Kg/m^3, Thickness not less than 60 mm
Finished Masonry	Not less than 130 mm thick



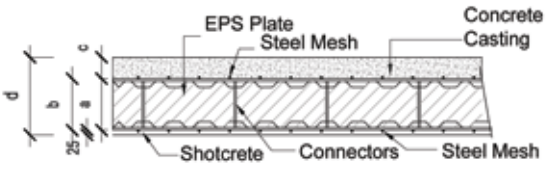
Single Panel for Internal partition, external walls and insulation

Longitudinal wire	2.5 mm ø spaced @ 70 mm
Transverse Wire	2.5 mm ø spaced @ 70 mm
Cross Steel Wire	3.0 mm ø approx 68 nos. / m^2
Polystyrene Core	Density ≥ 15 Kg/m^3, Thickness 40 mm to 320 mm
Finished Masonry	90 mm to 370 mm thick



Single Panel for horizontal structure for floor/ roof

Longitudinal wire	3.5 mm / 4.5 mm spaced @ 65 mm
Transverse Wire	2.5 mm ø spaced @ 65 mm
Cross Steel Wire	3.0 mm ø approx 68 nos. / m^2
Polystyrene Core	Density 15 - 25 Kg/m^3 Thickness 80 mm to 160 mm
Finished Masonry	155 mm to 235 mm thick

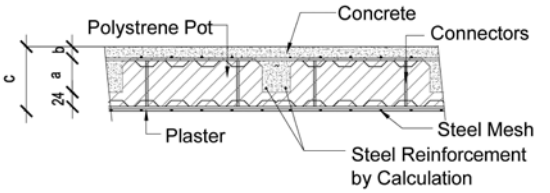


a = EPS Nominal Thickness (variable between 80 mm to 160 mm); b = Distance between thickness steel meshes (a + 10 mm); c = Shotcrete thickness (average ≥ 25 mm); d = Total thickness (2xc+a)

Generally used for buildings of not more than 4 storeys for floor and covering slabs with maximum span of 4 m.

Floor Panel with reinforcement at joist

Longitudinal wire	2.5 mm ø spaced @ 70 mm
Transverse Wire	2.5 mm spaced @ 70 mm
Cross Steel Wire	3.0 mm ø approx. 68nos. /m^2
Polystyrene Core	Density ≥ 15 kg/m^3



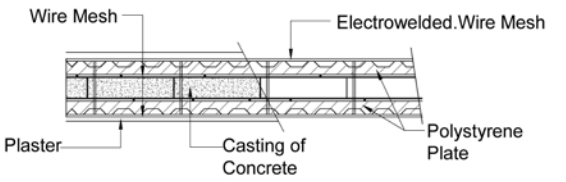
a = thickness of core; b = thickness of concrete; c = overall thickness

Panels are used for the floor and the roof system and reinforced in the joists with concrete casting on the site. The reinforcement of the panel is integrated during the panel assembly by additional reinforcing bars inside the joists as per the design.
Suitable upto 8m span with the live load of up to 4 kN/m^2.

Double Panel

External mesh

Longitudinal wire	2.5 mm ø spaced @ 65 m
Transverse Wire	2.5 m ø spaced @ 65 mm
Cross Steel Wire	3.0 mm ø approx 68nos. /m^2
Polystyrene Core	Density 25 Kg/m^3 thickness 50 mm to 80 mm
Finished Masonry	Finished inter-plate thickness 120 mm to 200 mm



Internal mesh

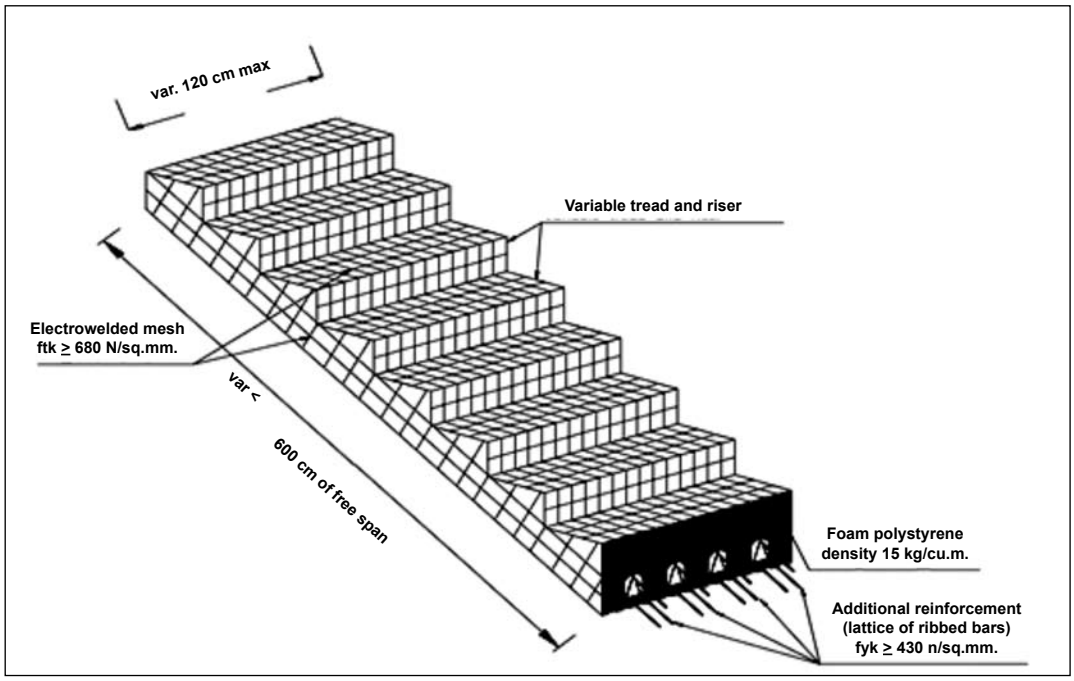
Longitudinal wire	5 mm ø spaced @ 100 mm
Transverse Wire	5 mm ø spaced @ 260 mm
Polystyrene Core	Density 25kg/m^3 thickness 50 mm to 80 mm

Externally the panels are sprayed with traditional pre-mixed cement based plaster. The space between the panels are filled with concrete. It functions as insulating elements as well as formwork.

Connections

Connecting the wall panel to the concrete substrata	By dowels embedded in concrete with adequate anchorage length.
Coplanar panels	By overlapping one row of electro-welded mesh and tying using 16 gauge wire.
Walls panels and ceiling panels of intermediate floors	By protruding the inner vertical dowels that connect the upper and lower wall panels through. Then putting corner mesh, tied with 16 gauge wire to the mesh of the lower wall panels as well as to the base mesh of the ceiling panel. Openings for doors & windows etc. are braced using flat mesh at 45° above and below corners of the opening.
Consecutive Floors	Using the same dowels utilized to connect the walls of the first floor to the foundation. Additional reinforcement of electro–welded mesh is provided on edges and diagonal fringe by tying on the inner and outer face of the panels by suitable wire.

Staircase Panel



Galvanized steel wire mesh:

Longitudinal wires:	2.5 mm dia
Transversal wires:	2.5 mm dia
Cross steel wire:	3.0 mm dia
Polystyrene slab density:	≥ 15 kg/m^3



FEATURES OF PANEL SYSTEM

Load carrying capacity

Numerous lab tests, performed in different parts of the world, have highlighted the high load carrying capacities of the panels which after compression testing with centred load performed on a single finished panel, 2700mm high, have shown that they withstand a maximum load of up to 1530 kN/m ≈ 153 ton/m. The Monolithic joints of the building system provide a high level of structural strength to buildings.



Seismic Performance

The prototype houses tested using both artificial and natural accelerograms with peak values over 1.0g, came through unscathed. Buildings made using panels are particularly lightweight, so have a low seismic mass, but are at the same time rigid due to two sheets of reinforced plaster that interact to create an enveloping 'shell' of the whole structure.



Thermal Behaviour

The thickness and density of the panel can be customised to deliver specific thermal insulation requirements. Furthermore, the EPS core extends throughout the surface which makes up the building envelope eliminating thermal bridging.

For example, a wall with a 80 mm core and finished thickness of about 150mm provides the same thermal insulation as an insulated solid masonry wall of about 400mm, with obvious advantages in terms of additional space.



Acoustic Behaviour

The panel has good acoustic behaviour, coupling with sound-absorbing materials (such as plasterboard, cork, coconut fibre, rock wool, etc.), further optimizes the acoustic insulation of walls.

Sustainability and Energy Efficiency

The insulating envelope provided by polystyrene core eliminates thermal bridges and ducts within the panel. This brings high level of energy efficiency. The system provides significant improvements in indoor thermal comfort by greatly reducing energy consumption and promoting strategies aimed at sustainable development.



Fire Resistivity

The expanded foam polystyrene used for panels is self-extinguishing and is perfectly encased by layers of reinforced concrete as external coat to sides of the panel and inhibit combustion. Fire resistance has also been verified in tests performed in various laboratories. For instance, a wall erected using a 80 mm core single panel

with 150 mm thickness provides REI* 150 fire resistance, which means that for 150 minutes, the panel can resist fire for 150 minutes with respect to load bearing capacity, integrity and insulation.

** R=Load bearing capacity; E=Integrity; I=Insulation*



Cost Effectiveness

Compared to traditional products, panels achieve far better results, at considerably reduced cost. The speedy construction represent additional savings.

Rapid Installation

The system has been used in many countries worldwide. The construction experiences using the system show a marked reduction in construction time compared to traditional building methods. Panels are industrialized, and for this reason, assembly processes are optimised, labour is significantly reduced, and construction time decreased by roughly 40%.



Lightness, Ease of Transport and Handling

Being light weight and rigid, panels are both easy to handle and transport even in the most adverse conditions. Prior to an application of shortcrete, a panel weighs between 3.5kg/m^2 to 5 kg/m^2 which means that a single worker can easily handle a 3 m^2 wall, that is, a panel as high as the storey height.

Versatility

The building system gives full design flexibility as it offers a complete range of building elements such as load-bearing walls, curtain walls, floors and stairs.

The panels are easy to use in the construction of any type of structure, and can be shaped to any geometric requirement i.e. flat or curved by simple cutting the panels at site.

Compatibility with Other Existing System

It is an extremely versatile building system which is completely compatible with all other existing construction systems; in fact, panels are even suitable for completing reinforced concrete or steel structures. In addition, panels can be easily anchored to other construction elements, such as steel, wood, and pre-stressed concrete.

Blast Resistance

A series of tests has been carried out on a variety of panels finished with different types of high strength concrete.







These tests were conducted using a powerful explosive, in a test chamber optimized to produce a uniform shock waves on the face of the panels.
The panels performed excellently withstanding explosions of 29.5 tons/m^2.

Wide Choice of Finishes

Buildings constructed using panels can be completed in a variety of finishes, or can be painted traditionally on smoothed plaster.
The surface of the walls has the appearance of a thin sheet of reinforced plaster that can easily accommodate all types of wall coverings including stone tiles and rain screen cladding.

Cyclone Resistant

Laboratory tests conducted on buildings, to determine the resistance of cyclone impact and damage caused by wind- borne debris confirm the strength of the building system against such loads.

Building constructed in cyclone prone area have shown very high resistance to cyclonic wind.



CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No 1010-S/2014 has been issued to M/s EMMEDUE SPA, Italy.

STANDARDS/REFERENCES

•	Manual on M2 System by EMMEDUE, S.P.A. Italy.
•	Manual on Schnell Home, Schnell Wire, Italy.
•	Certificate No. 06/0241, Irish Agreement Board, Ireland.
•	Technical Report on Experimental Evaluation of Building System M2 by Structure Lab. Department of Engineering, Ponitificia Universidad Catolica Del, Peru.
•	Review of EVG-3D Technology for residential buildings in India, IIT Mumbai, India.
•	Report on Performance Tests conducted on EMMEDUE Panel System at Hesarghalta, Bangalore Civil Aid Techno Clinic Pvt. Ltd., Bangalore.



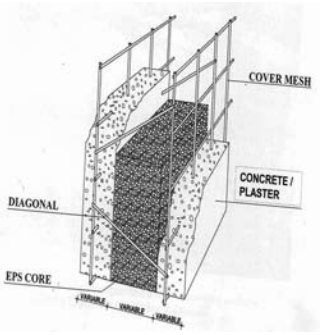


QuickBuild 3D Panels

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE TECHNOLOGY

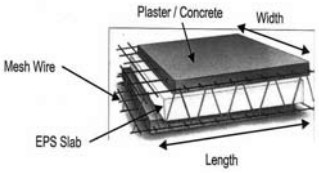
In quick build 3 D Panel system, the panels consist of fire resistant grade insulated polystyrene core, two engineered layers of Galvanized Steel Mesh and galvanized steel trusses. The steel trusses are pierced through the polystyrene core and welded to the outer layer sheets of Galvanized steel mesh.



The wall panel is placed in position and a wythe of structural plaster is applied to both sides. The wall panel receives its strength and rigidity from the diagonal cross wires welded to the welded-wire fabric on each side. This combination produces a truss behavior, which provides rigidity and shear terms for a full composite behavior.

The shell of the structure is built by manually erecting the panels directly onto the slab with reinforcement rods. Desired utilities like doors, windows and ventilators may be pre-built while plumbing, electrical conduits may be added onsite.

These panels are used in the construction of exterior and interior load-bearing and non-load bearing walls and floors of buildings of all types of construction.



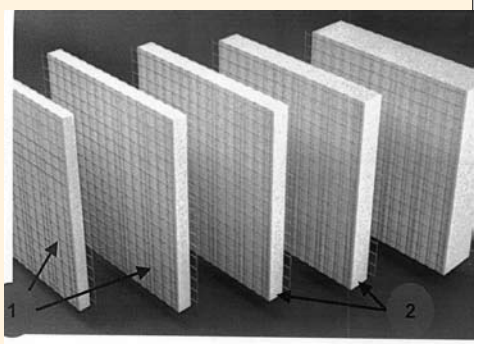
The details of these panels are shown in figures given at the right.

PANEL TYPES

The panels being manufactured are of three types depending upon the application. The details of different types of typical panels are given below:

Wall Panel

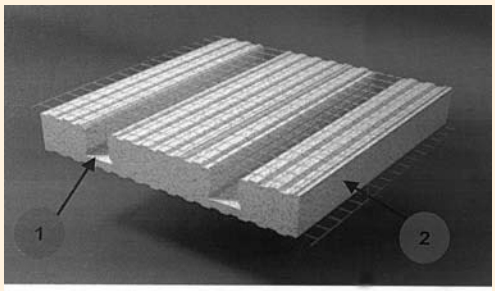
Longitudinal wire	2.5 mm Ø @ 50 mm
Transverse	2.5 mm Ø @ 50 mm
Steel truss wire	3.0 mm Ø pierced through the core at offset angle @ 100 mm spacing
Chemical Composition	C < 0.24%, P < 0.055% S < 0.055%, Ceq< 0.52%
Galvanizing	Zinc coating of 60 gm/ m^2 ± 5 gm/m^2
Mechanical characteristics: Yield stress Breaking load Elongation	> 600 N/ mm^2, > 680 N/mm^2, > 8%
Polystyrene Core	Density > 15 kg/m^3 thickness 50/80/100 mm
Self-load	120 kg/m^2
Load bearing	350 kN/m
Plaster ratio: In two coats	1st coat of 20 mm of 1:2:3 (1 cement: 2 sand: 3 chips) 2nd coat of 10 mm of 1:5 (1 cement: 5 sand)



1. Various Mesh configurations and Wire diameters available
2. Various Polystyrene core thickness available

Roof Panel

Longitudinal wire	2.5 mm Ø @ 50 mm
Transverse	2.5 mm Ø @ 50 mm
Steel truss wire	3.0 mm Ø pierced through the core at offset angle @ 100 mm spacing
Chemical Composition	C < 0.24%, P < 0.055% S < 0.055%, Ceq< 0.52%
Galvanizing	Zinc coating of 60 gm/ m^2 ± 5 gm/m^2
Mechanical characteristics: Yield stress Breaking load Elongation	 > 600 N/ mm^2, > 680 N/mm^2, > 8%
Polystyrene Core	Density > 15 kg/m^3 thickness 50/80/100 mm
Self-load	280 kg/m^2
Load bearing	10 kN/m^2
Plaster ratio 30mm thick: In two coats	1st coat of 20 mm of 1:2:3 (1 cement: 2 sand: 3 chips) 2nd coat of 10 mm of 1:5 (1 cement: 5 sand)
Concrete 75 mm thick:	1:2:4 (1cement: 2 sand: 4 chips 50% of size < 18mm + 50% of size < 10mm)



1. Groove (Approx 1" deep) for MicroBeam (with or without steel rod)
2. Minimum Thickness of core in panel is 80mm
Tongue and Groove joint also available at ends

Staircase Panel

This panel consists of expanded polystyrene block shaped according to designing requirements and reinforced by a steel mesh. The block is joined by steel wire connectors welded in electro-fusion across the polystyrene core. These are used for the construction of flight of stairs up to a max span <6m having a live load of 4kN/m^2. The reinforcement steel bars have to be placed inside the holes before concrete casting.

Longitudinal wire	2.5 mm Ø @ 50 mm
Transverse	2.5 mm Ø @ 50 mm
Steel truss wire	3.0 mm Ø pierced through the core at offset angle @ 100 mm spacing
Chemical Composition	C < 0.24%, P < 0.055% S < 0.055%, Ceq< 0.52%
Galvanizing	Zinc coating of 60 gm/ m^2 ± 5 gm/m^2
Mechanical characteristics: Yield stress Breaking load Elongation	 > 600 N/ mm^2, > 680 N/mm^2, > 8%
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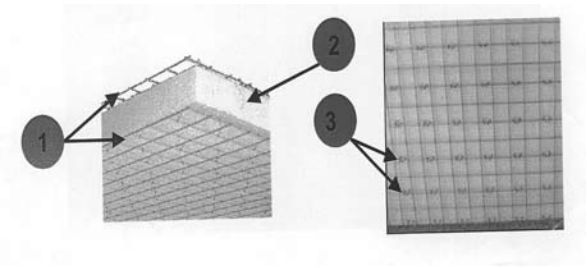
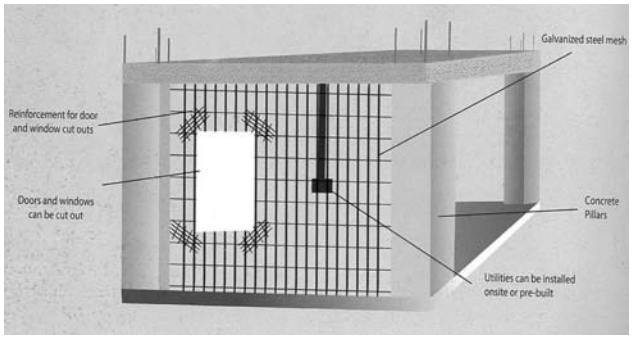
Concrete 75 mm thick:	1:2:4 (1cement: 2 sand: 4 chips 50% of size < 18mm + 50% of size < 10mm)



MANUFACTURING PROCESS

QuickBuild 3D panel is manufactured from welded wire space frame integrated with a polystyrene (EPS) insulation core sandwiched between two layers of engineered galvanized steel mesh that are held together with steel trusses. Steel trusses are pierced through the polystyrene core and welded to the outer layer sheets of galvanized steel mesh to form a rigid panel.





For any structure, foundation is built using conventional methods, starter bars are cast into the slab. The panels are erected vertical in plumb and temporarily supported by way of bracing Rebar which is set between the mesh and the polystyrene (for easy wall alignment). Splice meshes are then fixed using fasterner tool. Door & window openings can be cut both before or after panel erection. Roof panels are then erected and fastened with joining mesh. Concealed plumbing and electrical wiring can be pre-built into the panel using hot air torch. Subsequently, doors and windows are fixed. Structural plaster is finally applied pneumatically on both sides and concreting of exterior side of the roof panel is done. Natural Curing is done for concrete to gain strength.

FIXING OBJECTS TO WALLS

- Light weight object: 2.5 mm screws, pins or similar devices may be used.
- Heavy object (shelves, water tanks etc.): Plastic pins with 45 mm screws or similar devices are recommended.
- Very heavy object: During erection, metal pins may be inserted in plaster pallets. Alternatively, threaded pins fastened with epoxy resin may be used.



SPECIAL FEATURES

The panel receives its outer place strength and rigidity by truss action. Outer shortcrete layers are the chaired members.



Structural Stability

The monolithic structure of the panel in conjunction with concrete enables a structure built with it to withstand earthquakes, hurricanes and high winds.

For load bearing structure of G+3 or higher in seismic prone areas, analysis report from recognized Institute is recommended for its safety against earthquake forces.

Durability

- Concrete of adequate grade and cover as per IS 456:2000 provides required durability to this struc-

ture.

- Exterior coating may be applied to provide additional protection to the reinforcement against corrosion in aggressive environment.



Behavior in earthquake

Buildings made using panels are particularly lightweight, so have a low seismic mass, but are at the same time rigid due to two sheets of reinforced plaster that interact to create an enveloping shell of the whole structure.

Water Tightness

Externally the walls shall be protected by an approved render applied to minimum 35 mm sprayed 25 MPa concrete. DPC/radar barrier shall be installed at ground level to prevent rising damp. DPC shall also be used around window sills and a sealant shall be applied around window or door frames.

Thermal Performance

QuikBuild panels are an efficient and thermally advantageous solution for all construction needs. These panels are the rigid foam insulation that provides long term thermal resistance that does not need to be adjusted for age.

Acoustic Performance

The panels have superior sound dampening capability compared to masonry walls and this can be further enhanced by increasing the core thickness. Up to 50 dB insulation.

Behavior in moisture/humidity

The panel is excellent for preventing condensation/absorption on interior walls. The external walls/roof can use waterproofing mortar for additional protection.

Optimize Energy Performance

- QuikBuild panels are an efficient and thermally advantageous solution for all construction needs. The panels are manufactured in varying thicknesses to meet the environmental design criteria to deliver a range of R-value specifications.

Recycled Content

- About 10% to 20% of the materials are recycled.

PRECAUTIONS

- Do not overload partition walls on one side only. Instead, spray the concrete on both sides alternatively
- If the panel is cut during erection and its meshwork has no wire-crossing points, panels should be joined with flat meshwork (min. width 225 mm)

APPLICATIONS

- The technology is used in the construction of exterior and interior load-bearing walls upto 3 storeys and non-load bearing walls and floors of buildings of all types of construction.

MAJOR WORKS COMPLETED

- Christ College, Kilacherry (T N) in February 2012
- Meridian Hotel, White Field, Bangalore in May 2013
- Bethany School, Koramangalka, Bangalore in October 2013
- Sure Energy Systems Pvt. Ltd., Hyderabad (AP) in November 2013
- VTRC Ponmeni, Madurai (TN) in December, 2013
- Vineetha Industries, Adugodi, Bangalore in January 2014
- SERC Taramani, Chennai (TN) in February 2014
- VME Reality, Chembarabakkam (TN) in May 2014
- KPCL Wood House, Kovalam (TN), August 2014
- Champs Empowering Education, Hyderabad (AP) in August 2014

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No. 1019-S/2015 has been issued to M/s Beardsell Ltd, Chennai.

STANDARDS/REFERENCES

• Axial Compression Test and Static Flexural Test on Panels as Wall elements and Roof or Slab elements respectively by IIT Madras	
• Pull off test on plastered surface of structural concrete insulated panels at Bangalore by Civil-Aid Technoclinic Pvt. Ltd. Bangalore	
• Report on Shaking Table Test of a 1:2.35 Scale 4-Story Building Constructed with 3D Panel System University of Technology, Iran.	
IS 456:2000	Code of practice for plain and reinforced concrete (Reaffirmed 2016)
IS 875 (Part 1):1987	Code of Practice for Design Loads (Other than Earthquake) for buildings & structures: Part 1 Dead Loads (Reaffirmed 2013)



Reinforced EPS Core Panel System

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE TECHNOLOGY

Reinforced Expanded Polystyrene Core (EPC) Panel System is a factory produced panel system for the construction of low rise buildings upto G+3 and as filler walls in high rise RCC and steel frame buildings. In this technique, a core of undulated polystyrene is covered with interconnected zinc coated welded wire mesh on both sided reinforcement and shortcrete concrete.

The panels are finished on site by pouring concrete (double panel, floors and stairs) and spraying concrete to realise the following different elements of the system:

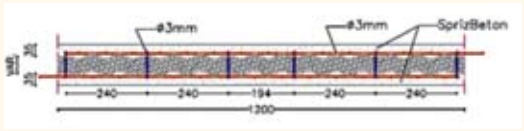
- Vertical Structural Walls
- Horizontal Structural elements
- Cladding elements

PANEL TYPES

The panels are of three types depending upon the application as shown below:

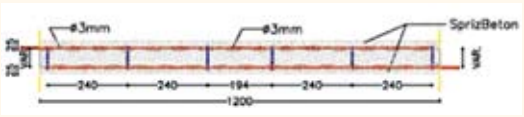
Single load bearing Panel

Longitudinal wires	2.5 /3.0 mm Ø @80 mm c/c
Transverse wires	2.5 /3.0 mm Ø @80 mm c/c
Connectors & cross wires	3.0 mm Ø @ 150 mm c/c
Polystyrene core conforming to IS 4671	Density : ≥ 15 kg/m^3 Thickness: 50 mm to 160 mm Wave Depth: 15 mm
Finished Masonry	Not less than 130mm thick



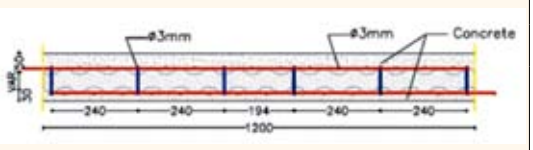
Single Non Load Bearing Panel

Longitudinal wires	2.5 /3.0 mm Ø @80 mm c/c
Transverse wires	2.5 /3.0 mm Ø @80 mm c/c
Connectors & cross wires	3.0 mm Ø @ 150 mm c/c
Polystyrene core	Density : ≥ 15 kg/m^3 Thickness: 40 mm to 280 mm Wave Depth: 5 mm
Finished Masonry	90 to 370mm thick



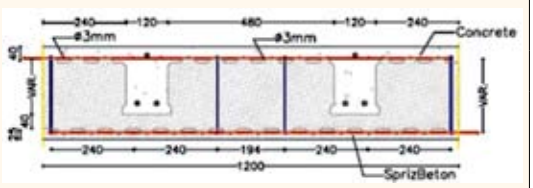
Single Floor Panel

Used as floors or roofs span upto 5 m x 5m and supported by the walls in all the sides. The panels are finished on site by 50 mm of casted concrete in upper side and 30 mm of projected plaster in the lower side.

Longitudinal wires	2.5 /3.0 mm Ø @80 mm c/c	
Transverse wires	2.5 /3.0 mm Ø @75 mm c/c	
Connectors & cross wires	3.0 mm Ø @ 150 mm c/c	
Polystyrene core	Density : ≥ 15 kg/m^3 Thickness: 80 mm to 160 mm Wave Depth: 5 mm	
Finished Masonry	Not less than 80mm thick	

Two Pot Floor Panel

With span up to 9 m, these panels are characterized by the presence of joist. The joists are reinforced on site by the steel bars according to the structural verification and are finished by 40 mm of casted concrete (M25) on the upper side and 25 mm of projected plaster (M15) in the lower side.

Longitudinal wires	2.5 /3.0 mm Ø @80 mm c/c	
Transverse wires	2.5 /3.0 mm Ø @75/150 mm c/c	
Connectors & cross wires	3.0 mm Ø @ 150 mm c/c	
Polystyrene core	Density : ≥ 15 kg/m^3 Thickness: 40 mm to 280 mm Wave Depth: 5 mm	
Finished Masonry	Not less than 65mm thick	

MATERIAL REQUIREMENTS

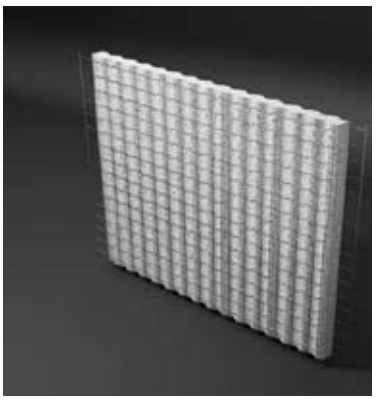
Steel for both wire mesh and connectors.
Zinc Coating – The zinc covering is variable with the diameter of the wire mesh. Standard wire mesh shall be 3.0 mm dia and minimum zinc coating galvanizing shall be of 60 gm/m^2.

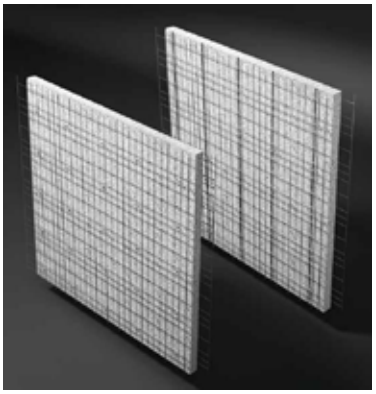
Mechanical characteristics

Tensile strength (2.5 mm Ø)	:	≮ 750 N/mm^2
Tensile strength (3.0 mm Ø)	:	≮ 700 N/mm^2
Yield strength (2.5 mm Ø)	:	≮ 680 N/mm^2
Yield strength (3.0 mm Ø)	:	≮ 600 N/mm^2
Elongation	:	> 8%

Chemical characteristics

% C	:	< 0.24
%P	:	< 0.055
%S	:	Max 0.045
%Ceq	:	<0.52
%Si	:	0.300 – 0.600





APPLICATIONS

The panels are used as:

i. load bearing walling in buildings
ii. non- load bearing wall panels
iii. partition infill wall in multi storey framed buildings
iv. floor / roof slabs

INSTALLATION PROCEDURE

Foundations

Foundations for the EPS Core Panel system whether strip or raft are conventional. If strip foundations are used, they should be levelled and stepped as this makes panel positioning easier.

For EPS Core panels, parallel sided timber or metal template of the width of panel shall be required to mark the position of the wall panels on the foundation and the spacing of the starter bar holes.

Wall start-up

- Line wall positions shall be marked and profiled.
- A timber or metal template of the exact width of panel (from wire to wire) shall be used to mark the position of the panels with chalk or pencil lines.
- On the panel, lines positions shall be marked to drill the starter bar holes. These should be in a zig zag pattern at 600 mm centres on each side of the panels. Starter bars should be at all panel joints and on the opposite side in mid panel plus at all wall corners and joints.
- Starter bars should be either 6 mm or 8 mm dia. 500 mm long with 100 mm drilled into the foundations and 400 mm above.
- Drill bits shall be used to give a tight fit with the starter bars.
- Once starter bars are in position, EPS Core panels shall be placed between the starter bars, starting from a corner. Starter bars shall be wire-tied to the panel mesh and the panels to each other on the overlapping mesh.

Wall construction

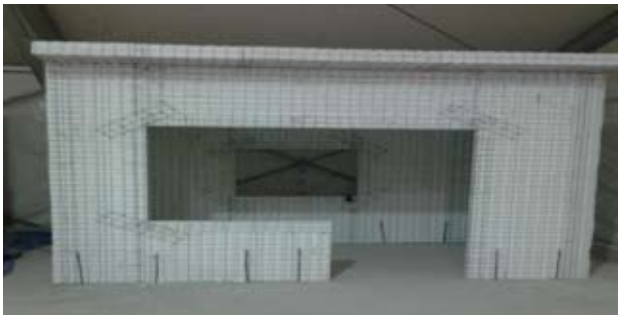
- All corners and wall joints shall be reinforced with right angled wire mesh to the full height of the walls.
- To cut panels to fit for door & window openings, wire should be cut with a wire cutter or angle grinder. Measure and mark the cut lines before starting to cut.
- After the wire mesh has been cut, EPS shall be cut with a hacksaw blade or stiff blade hand saw.
- Added steel mesh reinforcement shall be required around door and window openings to ensure that no plaster cracks form in these areas. Mesh reinforcement strips shall be tied diagonally with wire around openings before plastering.
- Once wall panels are in place and tied together, bracing shall be required to hold them vertical before plastering. This shall be done only on one side of the panels.
- Once the panels are plastered on one side, the wall bracing shall be removed after 24 h. Plastering on other side can be done without bracing.

Door and Window fittings

- Fix a metal angle iron or hollow tube sub frame into the openings before plastering. Fix and plaster these in place and then secure the frames to the sub frame.
- In order to secure heavy door/window frames, the EPS where the bolts are to be fixed to the wall, shall be



burnt or cut and this space shall be filled with mortar or concrete to hold the bolts.









Plastering

- Plastering shall be done by machine or hand. The indicative quantity of each material per m^3 shall be:
  (i) Cement: 350 kg
  (ii) Sand with mixed granulometry: 1600 kg. Sand should be without clay or any organic substance and totally washed.
  (iii) Water – 160 l. The quantity of water may be different according to the natural sand moisture. W/C = 0.52 and l/C = 4.50 shall be maintained.
- Any problem of workability should be solved without adding water. The retraction cracks formation may be avoided by adding polypropylene fibers in the mix (1kg/m^3).
- In order to control the final plaster thickness, some guides should be used. These shall be removed as soon as the plaster 'sets up' and the spaces are filled and are smoother before the plaster gets dry.
- Spray application should be done in two steps with a first layer covering the mesh applied on both the sides of the wall and the finishing layer as soon as the first layer gets dry.

Plumbing and electrical fittings

- Plumbing and electrical conduits shall be behind the panel wire mesh before plastering.
- The space behind the wire mesh shall be opened up by using a blow torch to partially melt the EPS along the lines of the conduits.
- As the EPS used in the panels is fire retardant, it will melt under the flame but not burn.
- The wire mesh shall be cut with wire clippers to make space for DB boards, switches and plug boxes.

Connection

The Reinforced EPS Wall system is composed by panels consisting of a polystyrene sheet assembled together with welded wire mesh.

SPECIAL FEATURES

Structural Stability

Numerous lab tests, performed in different parts of the world, have highlighted the high load resistance of the panels which after compression testing with centred load performed on a single finished panel, 2700 mm high, have shown that they withstand a maximum load of up to 1530 kN/m =153 ton/m. The Monolithic joints of the building system provide a high level of structural strength to buildings.

Durability

Durability is achieved with the use of proper grade and thickness of concrete as per IS 456. Minimum 45 mm thick plaster is recommended for structural and fire safety point of view.

Behaviour in earthquake

Buildings made using panels are particularly lightweight, so have a low seismic mass, but are at the same time rigid due to two sheets of reinforced plaster that interact to create an enveloping shell of the whole structure.

Fire Safety

The quality of the expanded foam polystyrene used for panels is self-extinguishing and is perfectly encased by layers of reinforced concrete as external coat to sides of the panel and inhibit combustion.

Thermal Performance

The thickness and density of the panel can be customized to deliver specific thermal insulation requirements. Furthermore, the EPS core extends throughout the surface, which makes up the building envelope eliminating thermal bridging. For example, a wall with 80 mm core and finished thickness of about 150 mm provides the same thermal insulation as an insulated solid masonry wall of about 400 mm, with obvious advantages in terms of additional space



During finishing



After finishing

Acoustic Performance

The panel has got good acoustic behaviour, coupling with sound-absorbing materials (such as plasterboard, cork, coconut fibre, rock wool, etc.), further optimizes the acoustic insulation of those walls.

Behaviour under high winds/Cyclone

Laboratory tests conducted on buildings, to determine the resistance of cyclone impact and damage caused by wind- borne debris confirm the strength of the building system against such loads. Building constructed in cyclone prone area have shown very high resistance to cyclonic wind.

Sustainability and Energy efficiency

The insulating envelope provided by polystyrene core eliminates thermal bridges and ducts within the panel. This brings high level of energy efficiency. The system provides significant improvements in indoor thermal comfort by greatly reducing energy consumption and promoting strategies aimed at sustainable development.

Cost Effectiveness

Compared to traditional products, panels achieve far better results at considerably reduced cost. The speedy construction represent additional savings.

Lightness, ease of transport and handling

Being light weight and rigid, panels are both easy to handle and transport even in most adverse conditions. Prior to an application of shotcrete, a panel weighs between 3.5 kg/m^2 to 5 kg/m^2 which means that a single worker can easily handle a 3 m^2 wall, i.e. a panel as high as a storey height.

MAJOR WORKS COMPLETED

Load Bearing Structures (at Angul, Odisha)

- Construction of C, D & F type flats of 3 to 4 storey having a total of 70 flats
- Construction of G type flats of 3 storey having a total of 60 flats
- Construction of Police Quarters of 3 storey having a total of 18 flats

Partition Walls for Non-load Bearing Structures (at Angul, Odisha)

- Construction of C & D type flats of 3 to 4 storey having a total of 38 flats

CERTIFICATION / VALIDATION OF THE SYSTEM

i) Performance Appraisal Certificate No. 1020-S/2015 on Reinforced EPS Core Panel System has been issued to M/s Jindal Steel & Power Ltd., Angul, Odisha.

OTHER SIMILAR SYSTEM SHORTLISTED UNDER GHTC-INDIA

i) Reinforced Expanded Polystyrene sheet core with sprayed concrete as wall & slab of M/s MSN Construction, Chennai has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

STANDARDS/REFERENCES

IS 456:2000	Code of practice for plain and reinforced concrete (Reaffirmed 2016)
IS 4671:1984	Specifications for expanded polystyrene for thermal insulation purposes



Rapid Panels

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE TECHNOLOGY

The Rapid Panel is a prefabricated assembly of high-strength steel wire forming a panel with a core of expanded polystyrene (EPS). During construction, Rapid Panels are installed as walls and/or slabs. Specified mixtures of mortar or concrete are applied to the surfaces of the panels to complete the structure.

The basic unit of the Rapid Panel is the zig-zag truss. Steel wire is bent into a zig-zag shape to form a continuous chain of web members. This bent wire is then welded to continuous chord wires at every node to form the complete truss. *(See Figs. 1 & 2)*

The Rapid panels are manufactured in a fully automated plant. This technology was initially developed in USA and the Indian firm has a collaboration with WorldHaus, California, USA. These panels are manufactured in Mexico and there is no plant in India at present.

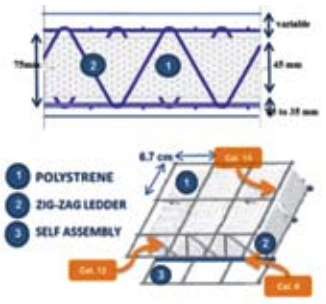


Fig.1 Rapid Panel

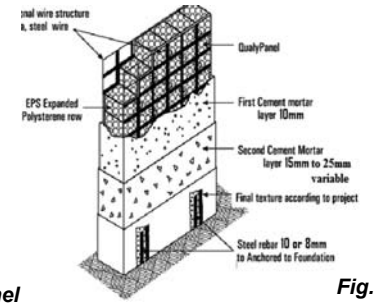
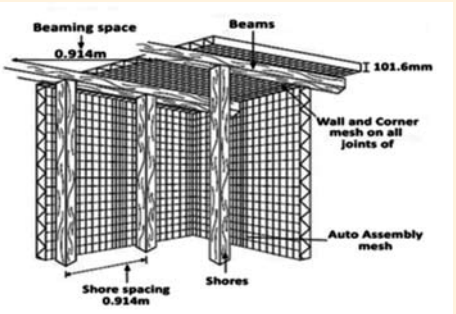


Fig. 2 Panel System Wall

PANEL TYPES

Wall panel

Top Wire	2.65 mm Ø	
Top distribution wire	1.90 mm Ø	
Truss wire	2.65 mm Ø	
Bottom wire	2.65 mm Ø	
Bottom distribution wire:	1.90 mm Ø	
Chemical Composition	C < 0.153%, P < 0.016% S < 0.015%, Mn < 0.893%, Si % < 0.134	
Galvanizing	Zinc coating of 60 gm/m^2 ± 5 gm/m^2	
Mechanical characteristics: *1.9 mm dia* Yield stress Breaking load Elongation *2.65 mm dia* Yield strength Breaking load Elongation	 > 680 N/ mm^2, > 687 N/mm^2, > 4.8% >618 N/mm^2 >632 N/mm^2 > 6.1 %	

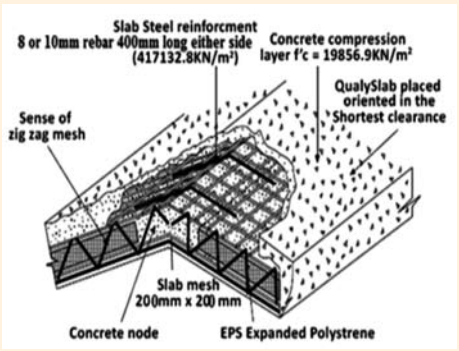


Wall Panel

Polystyrene Core	Density > 15 kg/m^3, Flammability: Non Flammable, Moisture Continent at 50ºC: <1.1% Thickness: not < 50 mm Bead size: shall be > 95% between 0.5 – 1.12 mm as per ASTM C 578	
Cast-in-place concrete	The min. grade of concrete is M20 and slump for walls, floors and roofs shall be as per IS 456:2000	
Cement Plaster	Shall have a minimum 28-day compressive strength	

Roof Panel

Top Wire	2.65 mm Ø	
Top distribution wire	1.90 mm Ø	
Truss wire	2.65 mm Ø	
Bottom wire	5.00 mm Ø	
Bottom distribution wire:	1.90 mm Ø	
Chemical Composition	C < 24%, P < 0.055% S < 0.055%, Ceq< 0.52%	
Galvanizing	Zinc coating of 60 gm/ m2 ± 5 gm/m^2	
Mechanical characteristics: *1.9 mm dia* Yield stress Breaking load Elongation *2.65 mm dia* Yield strength Breaking load Elongation 5.00 mm dia	 > 680 N/ mm^2, > 687 N/mm^2, > 4.8% >618 N/mm^2 >632 N/mm^2 > 6.1 %	
Yield strength Breaking load Elongation	670 N/ mm^2, 816 N/mm^2, > 14%	
Polystyrene Core	Density > 15 kg/m^3, Flammability: Non Flammable, Moisture Continent at 50ºC: <1.1% Thickness: not < 50 mm	



Roof Panel

MATERIAL REQUIREMENTS

Galvanised high strength steel wire: Fe 500 & Fe 550 as per IS 1786: 2008

Ordinary Portland Cement: 43 grade as per IS 269:2015.

Fine aggregate: 4.7 mm size for concrete as per IS 383:2016 and plaster of sand 150 micron – 2.36 mm as per IS 1542:1992

Coarse Aggregate: of 20 mm & 40 mm size as per IS 383:2016

Steel reinforcement: as per IS 1786:2008.

Gypsum Plaster board: as per IS 2095 (Part 1):2011.

Adhesive: as per ASTM C 881

Plasticizers: as per IS 9103:1999

Waterproofing compound: as per IS 2645:2003

Fibers: Polypropylene fiber mesh as per EN 14889-2:2006

Ledger Bolt: Consists of 12.7 mm diameter L-shaped bolt with washers and nuts as per ASTM A 307. It shall be fastened to the panel wire sand plastered.

Hartco clips: Formed from 11.11mm-wide, No. 20 gauge cold-rolled steel and manufactured by Stanley Hartco or Spenax Flex-C-Rings, No. 516 G100.

CONSTRUCTION PROCESS

The construction process of the panels is as follows:
The shop-fabricated panels consist of welded wire zig-zag trusses and a foam plastic core to which structure plaster shall be applied on each side. The panels have vertical 75 mm deep 14 gauge (1.63 mm) wire trusses spaced at 50 mm centers with preformed 57 mm thick expanded polystyrene (EPS) foam strips between. The assembly is held together with 14 gauge horizontal wires on each face at 50 mm centers electro welded to the truss chords. The horizontal wires and vertical truss chords shall project 10 mm approx. beyond each foam plastic face to permit wire embedment within cement and gypsum plaster finish applied to each face after erection on the site.

The panels are manufactured in 1.22 m widths and varying heights from 1.52 m to 3.55 m in increments of 100 mm. The nominal thickness of the panel is 75 mm resulting in a finished wall thickness, after plastering, of 100 mm or more.



Manufacturing Process of Rapid Panels

APPLICATIONS



The panels shall be used for construction of buildings consisting of frame structures, load bearing walls, floors and roof etc. for residential purposes up to G+3 storey.

IMPLEMENTATION

Panel System

Raft foundation

For only ground floor and G+1 unit constructions. When the soil is strong or when the soil is improved, this is done by using a slab/raft foundation.

Strip foundation

For only ground floor and G+1 unit constructions. When the surface soil is in a terrain with vegetation or lime, and it is required to locate the foundation in a stronger and deeper layer, this is done by using a strip footing.



Existing foundation

When a foundation already exists or when something is being constructed over existing construction, steps given below shall be followed:

(i) Holes of 8 or 10 mm dia. of 100 mm depth every 400 mm shall be drilled and lined up with inside of the wall.

(ii) High strength steel bars of 8 or 10 mm dia. shall be placed in every hole leaving 400 mm of height above the foundation.

(iii) The wall panel shall be tied with bars of 8 or 10 mm dia. on the outside of the mesh with steel wire, with a minimum of 3 ties per bar.

Boundary Wall

Following procedure shall be followed for construction of boundary walls:

(i) Bars of 8 or 10 mm dia shall be placed on top of the foundation, alternating one on the outside of the foundation and the other on the inside every 400 mm.

(ii) The bars that are placed on the inside shall be bent in such a way that they are rooted in the foundation.

(iii) The wall panel shall be located on the soil and plastered on the bordering side. They shall be placed in groups of two or three.

(iv) The mortar layer shall be dried, and the wall panel erected while straightening the interior bars.

(v) Finally, the wall panels shall be tied to the bars on both sides perfectly and plastered on the interior.

Wall Panels

Exterior wall panels shall be set with a minimum 6 mm clearance between the concrete slab edge and the panel reinforcement. The slab shall be attached with perimeter 63 mm-long by 3 mm thick steel hold-down connector channels and 13 mm diameter foundation bolts placed at a distance of 1.22 m max. centers along width and at each panel end. Panel reinforcement and connector channels shall be attached with 305 mm long, 12 gauge (2.06 mm) wires extending approximately 45 degrees upward along each panel face from each channel end. The upper end of the diagonal wires shall be attached to the panel reinforcement. Panels shall be joined along vertical edges with 203 mm wide strips of 14 gauge 51 square mm welded wire mesh on each face centered on the panel joint. The mesh shall be attached to the vertical panel wire reinforcement with Hartco clips spaced 305 mm on center at the edge wires and 610 mm on center at interior wire Panels shall also be joined on both sides with 14 gauge wire trusses).

Interior wall panels shall be set and attached to hold-down connector channels with 12 gauge wires in the same manner as exterior panels. Approved powder-actuated anchors shall be used, provided they are adequate for applicable uplift loads. A nonstructural plaster ground shall be attached at the base of the interior panels if desired.







Roof and Floor Panels

The panels shall not be permitted to bear on wood-frame walls. Horizontal diaphragms shall be permitted the same shear values as vertical racking shear, provided the panels are fastened to each other and to walls as described here.

Installation of Panels

The procedure for installing the panels shall be as follows:

i. The panels shall be put in place according to the building plan as follows:
   - It must be ensured that the rebar is on the bottom of the panel.
   - Each panel shall have a portion of wire mesh on the end without polystyrene.
   - The adjacent panel shall be inserted into this area thereby locking them together. The overlapping wire mesh should be tied together.
   - The vertical rebar in the wall shall be allowed to go through the polystyrene in the panels.
   - It shall be necessary to cut some of the wire mesh to allow this. The rebar on the bottom of the panel shall not be cut.

ii. The polystyrene in the areas directly over the walls shall be removed.

iii. The rebar that bends into the panels shall be placed according to the wall reinforcement and this bar shall be tied to the wire mesh on top of the panel. The vertical rebar shall be extended as necessary.

iv. The edge molds shall be placed around the perimeter of the panel as follows:
   - Each set of holes in the edge molds shall be tied tightly to the panel
   - It must be ensured that the edge molds are level and straight.
   - It must also be ensured that there is more than 50 mm clearance between the top of panels and top of edge molds.

vi. A minimum M20 grade of concrete shall be used.

Supports and Cambers

Slabs for roofs and floors shall be made with slab panels and supported during erection with temporary beams with props spaced at 900 mm, leaving a camber. The support beams shall be located on the bottom of the panel, always perpendicular to the direction of the zigzag trusses in the panel.

Connections

All the connections for walls and slabs shall use the self-connection system, where the mesh on the end of the panel shall be used to join the panels in different situations.

Door and Window



These shall be made by marking and cutting the mesh of the wall panel with a circular saw, reciprocating saw, or with wire cutters, and reinforcing the edges on both sides with zigzag mesh. The zigzag mesh should extend 300 mm from the edges of the doors and windows. Afterwards, diagonal zigzag mesh shall be installed on every corner of 400 mm.

Where edges and corners are reinforced, the polystyrene along the perimeter of the opening shall be removed and the space is filled with mortar or concrete to form a rigid boundary. In the area on top of the opening, the polystyrene shall be removed and reinforcing steel placed to form a lintel beam.

Plumbing and Electrical Fixtures



Water pipes and electrical conduits shall be placed within the panels as shown in the building plans by removing polystyrene from the portion. For layers pipes wire mesh shall be cut. Good practices of electrical and plumbing services shall be adopted.

Plumb and Alignment



It shall be assured that the wall panel is plumb and in line, and to maintain right angles between them, tension wire and metal rulers shall be used. The polystyrene in the center of the panel shall be toothed on the surface to ensure better mortar connection and less wastage.

Finishing

i. Floor finishing

- It must be ensured that the floor area is completely clear of any debris, dust and soil etc.
- It must be ensured that the floor surface is damp prior to finishing and it should be fully moist without any water stagnating on it.
- Cement mortar of mix 1 cement: 3 sand shall be prepared and required quantity of mortar shall be applied to the floor to provide a smooth finish.

ii. Ceiling finishing

- A stiff mix of 1 cement: 3 sand mortar shall be prepared and applied to the ceiling, providing a level but rough surface.
- It must be ensured that the first layer of plaster is damp prior to applying the finish layer.
- Cement mortar of mix 1 cement: 4 sand shall be prepared and required quantity of mortar shall be applied to the ceiling to provide a smooth finish.
- The total thickness of the ceiling finish should not exceed 19 mm below the panel wire mesh.

iii. Wall finishing

- Cement mortar of mix 1 cement: 4 sand shall be prepared and 25 mm plaster shall be applied to the predamp wall to give a finish surface.
- Wall plaster should be allowed to be cured for at least 7 days after placement.

Handling of Panels

These panels are composed of two layers of steel wire mesh with a layer of polystyrene in the middle. The bottom side of each panel has rebar welded in which provides the strength that allows the panel to be used as a slab. The wire mesh on the top and bottom are connected to each other with a 'zig-zag truss' of wire running between the two meshes, welded at each joint. Good practices for handling of the panels shall be followed.

Cutting of Panels

As the panels are manufactured in a few fixed sizes, it shall be necessary to cut the panels to a smaller size. The procedure for cutting of the panels shall be as follows:

- The length of the panel to be cut shall be measured and the measurement extended to the far-side of the nearest cross-wire.
- Bolt cutters shall be used to cut the wires along the measured length on one side of the panel.
- Panels shall be flipped to the other side and bolt cutters used to cut the wires along the measured length on the other side of the panel.
- Panels shall be allowed to stand on its end and bended to 90° to expose the 'zig-zag truss'. The bolt cutter shall be used to cut the exposed wires.

SPECIAL FEATURES

Structural Stability

IIT Madras has certified that RapidPanel Roofing slab system is found satisfactory for use in buildings, for imposed loads (live loads) defined in IS 875 (Part 2):1987 on the basis of static tests under gravity loading.

Durability

On the basis of test conducted, the wall panel is capable of taking the min. load of 12.0 ton and no crack observed on the surface of the wall panel

Behavior in earthquake

Load bearing wall panel system acts as a continuous shear wall system. It is analyzed as per box section and additional vertical bars are fixed to the panels according to lateral analysis. Load bearing/shear wall panel system is being used for structures upto G+5 in high seismic areas (zone v) having poor soil conditions to provide an economical and robust structure that meets codal seismic design requirements.

Fire Safety

For one hour fire-resistive wall assembly, the panels are covered with 29 mm thick cement plaster on both sides. For two hour fire-resistive wall assembly, the panels are covered with 25 mm thick cement plaster followed by 12 mm thick light weight gypsum plaster or light weight cement plaster on both sides.

Thermal Performance

As per the tests conducted, the thermal transmittance U works out to 0.503 W/mK.

Shuttering

Rapid panel slab does not require conventional shuttering/formwork, as the EPS filler acts in this capacity.

Limitations of Use

- Panel lengths shall be up to 5 m, simply supported on beams or bearing walls not less than 125 mm in width.
- Panels shall be installed with min. M20 grade of concrete and 1:3 cement plaster.
- Total dead load (including panel self-weight) shall not exceed 3.3 kN/m^2
- Total imposed load (live load) shall not exceed 3.0 kN/m^2.

WORKS COMPLETED

1. (GF) house at Sarjapura, Bangalore of 200 sqm area
2. (B+G) house at Coorg, Bangalore of 300 sqm area
3. (S+2) Nirmithi Kendra at Bangalore of 120 sqm area
4. (S+2+H) flat at Bangalore of 180 sqm area
5. (S+2) flat at Bangalore of 120 sqm area
6. CSI Church at Hosur, Bangalore of 350 sqm area
7. (G+2) flat at Bangalore of 120 sqm area
8. (G+3) flat at Bhubaneswar of 200 sqm area

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No. 1026-S/2016 has been issued to M/s Worldhaus Construction Pvt. Ltd., Bangalore.

STANDARDS/REFERENCES

• Legacy Report by ICC Evaluation Services Inc., USA	
• Construction Manual by WorldHaus Construction Ltd., USA	
IS 383:2016	Specifications for coarse and fine aggregates for concrete (Third Revision)
IS 456:2000	Code of practice for plain and reinforced concrete (Reaffirmed 2016)
IS 875 (Part 1&2):1987	Code of Practice for Design Loads (Other than Earthquake) for buildings & structures: Part 1 Dead Loads; Part 2 Imposed Loads (Reaffirmed 2013)
IS 1786:2008	Specifications for high strength deformed steel bars and wires for concrete reinforcement (Fourth Revision) (Reaffirmed 2013)
IS 1893 (Part 1):2016	Criteria for earthquake resistant design of structures (Part 1) - General Provisions and Buildings
IS 1904:1986	Code of practice for design and construction of foundations in soils: General requirements (Reaffirmed 2015)
IS 2095 (Part 1):2011	Specifications for gypsum plaster board (Part 1) - Plain gypsum plaster boards (Reaffirmed 2016)
IS 2645:2003	Specifications for integral water proofing compounds for cement, mortar and concrete (Reaffirmed 2016)





Prefabricated Fibre Reinforced Sandwich Panels (Aerocon)

(Suitable for Load Bearing Panels in Single Storey and as Non-Load Bearing Panels for Low to High Rise Structures)

ABOUT THE TECHNOLOGY

Aerocon panels are Prefabricated Fibre Reinforced Sandwich Panels, made of two fibre reinforced cement facing sheets, on either sides of a lightweight concrete core. The core is made from a mix of Portland cement, binders and silicaceous & micaceous material aggregate. These panels have a unique tongue and groove jointing system that facilitates rapid construction and are fully cured at the factory itself. These panels are of manufactured by using Flexo Board (FOB)/ Fibre Cement Board (FCB). Details of these panels are shown in Figs. 1 to 3:



Fig.1



Fig.2

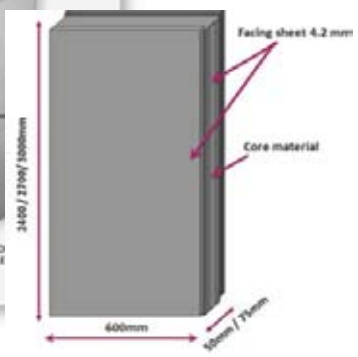


Fig.3

The product range of these panels shall be as under:

S. No	Sizes	Thickness	Edges
1.	2400 mm height x 600 mm width	50 mm & 75 mm	Square edge (Fig. 4) Recess edge (Fig. 5)
2.	2700 mm height x 600 mm width		
3.	3000 mm height x 600 mm width		

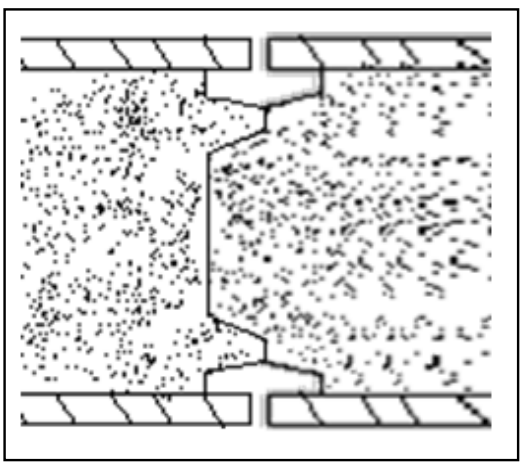


Fig.4 Square edge Panel

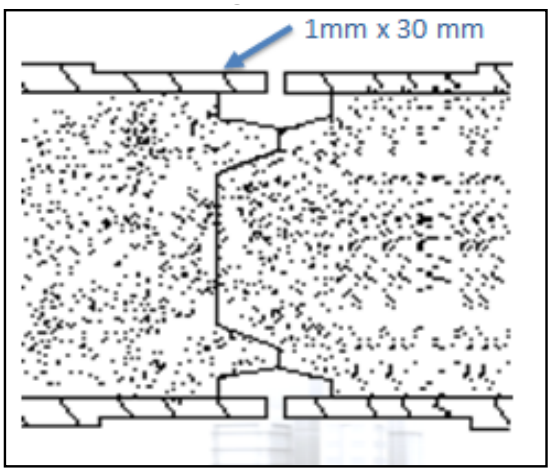


Fig.5 Recess edge Panel

USES OF AEROCON PANELS

These panels may be used for following applications:

- Partitions - In Offices, malls, educational institutions, hotels/restaurants, Residential, commercial, educational and industrial buildings
- Prefab Structures (Single story- as load bearing & Non-load bearing applications)- Accommodation units, site offices, security & store rooms, warehouse/go-downs, schools, army barracks, low-cost housing
- Mezzanine Flooring - Industrial/SEZ, warehouse/go-downs, storerooms, shopping malls, etc.
- Cladding - Shopping malls, school/college/university, duct covering, site offices & administration offices
- Boundary/Fencing - Residential, commercial, defence, etc.
- Fire Separation walls - Shopping malls, hotels, stair case enclosures etc.

MANUFACTURING PROCESS

Prefabricated Fibre Reinforced Sandwich Panels are made up of two fibre reinforced cement sheets with a core separating sheets. The core of the panels is of binders like portland cement and reinforcing bars such as cellulose and synthetic binders. The core contains materials such as pulverized fly ash, light weight aggregates as fillers and foaming agents. These materials are mixed thoroughly with water in conventional manner and sandwiched between a pair of fibre cement facing sheets which is separated and supported by using conventional jigs and fixtures.

The adhesion between the core material and fibre cement sheets is achieved by inorganic bonding by aeration while manufacturing the panel in-situ. The panels are allowed to harden for a predetermined period and thereafter jigs/ fixtures are separated. The panels are cured by retaining the humidity of the composite by wrapping the composite with polymeric films. No water is used for curing.

TECHNICAL SPECIFICATION

S. No.	Properties	Test Method	Requirements *			
			50 mm thick		75 mm thick	
			FOB	FCB	FOB	FCB
1.	Weight (dry) (kg/m^2)	Nominal weight	39	38	54	51
2.	Axial load (kN/m)	Factor of safety = 2.5	53	50	83	65
3.	Bending (kg/m^2) (a) 1.5m span (b) 2.9m span	Factor of safety = 2.5	 66 198	 -- 300	 95 265	 -- 400
4.	Flexural strength (kg/cm^2)	IS 2380 (Part 4):1977	67	42	58	48
5.	Compressive strength (kg/cm^2)	Typical test results	30	--	40	--
6.	Thermal conductivity (W/m°.K)	IS 3346:1980/ BS 4370 (Part 2): 1993	0.22	0.16	0.21	0.17
7.	Sound transmission class (dB)	IS 9901 (Part 3): 1981/ IS 11050 (Part 1):1984	34	37	37	39
8.	Fire resistance (minutes)	IS 3809:1979/ BS 476 (Part 20-22):1987	60	120	120	120
9.	Surface spread of flame	BS 476 (Part 7): 1997	Class I		Class I	
10.	Fire propagation index (I)	BS 476 (Part 6): 1989	3.7	4.7	3.7	4.7
11.	Ignitability	BS 476 (Part 5): 1979	Class P (not easily ignitable)		Class P (not easily ignitable)	

** The above requirements are the minimum values for the panels.*

INSTALLATION OF PANELS APPLICATIONS & JOINTING PROCEDURE

Partition Walls

Full height partition

- Recess or square edge panels shall be used for full height partitions.
- Floor plan shall be marked as per approved drawings. The floor channels (F.C.) & ceiling Channels shall be used for fixing of panels with self-expansion screws of size N 6x50 mm at every 600 mm center to center on 50 mm face of channel.
- The height needs shall be checked for each individual panel before inserting, the same method shall be followed for all panels.
- The 600 mm side of panel shall be lifted & kept parallel to floor. The groove side of panel shall be kept towards wall or column end.
- The panel shall be inserted by tilting it into ceiling channel first and then position the same from 14 mm side of the floor channel as shown in Fig. 6.
- The panel shall be slowly pushed into the floor channel with two heavy duty screw drivers without damaging the corners as shown in Fig. 7.
- The panel shall be positioned & pushed towards wall and right angle of panel shall be checked as shown in Fig. 8.
- Plugs/packings shall be inserted, if required in floor channel to ensure right angle.
- The jointing material shall be applied along entire length of tongue and groove for jointing and inserting the next panel. The panel shall be pushed to secure a rattle free joint.
- The partition shall be completed by jointing panel by panel as per the above procedure.

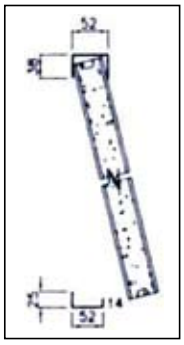


Fig.6

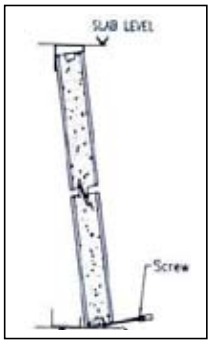


Fig.7

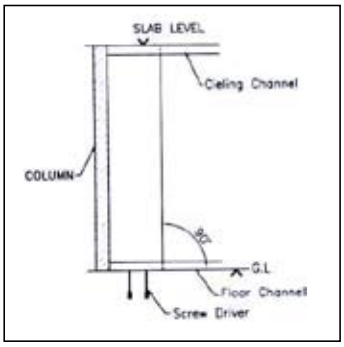


Fig.8

Half height partition

- The partitions shall always end in 'L' or 'T' shape of 300 to 600 mm panel width as shown in Fig 9.
- The floor channel shall be fixed with self -expansion screws at every 600 mm center to center.
- The first panel starting from the existing brick wall should be fixed as per the following two options:
  Option – 1 Starting with existing brick wall, a drill shall be made to brick wall and panel at the distance of 300 mm as shown in Fig. 10 from top and bottom side of the panel and insert the steel rod.

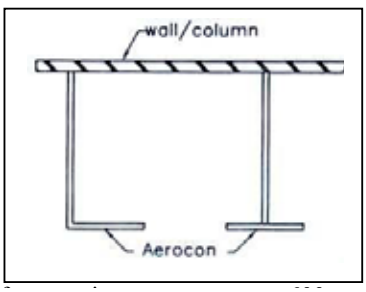


Fig.9

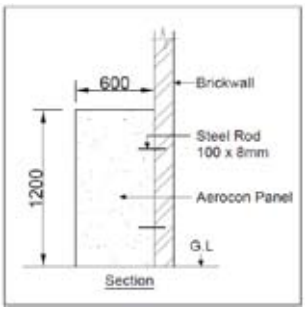


Fig.10

Option – 2 The L angle cleat shall be fixed at corner with nuts and bolts as shown in Fig. 11.

- The top end & free end walls must be covered using beading as shown in Fig. 12.
- Different materials like timber, medium density fibre boards, PVC, Aluminium etc. as per required design shall be used as shown in Fig. 13.
- Fevicol shall be applied on the inner surface of the beading before fixing to the panels.
- All screws should be dipped in Fevicol before fixing to the beading. In factories and workshops Aluminium/ galvanized iron channels (ceiling channel) shall be used as beading.
- Jointing material shall be applied on entire length of tongue & groove portion before fixing panels to improve stability & prevent the lateral movement.
- With this half height partition will be ready for finishing.

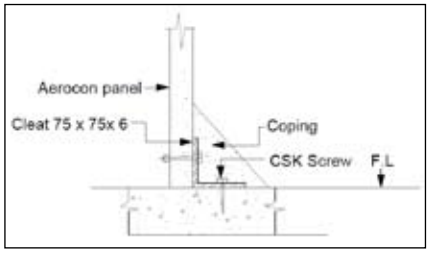


Fig.11

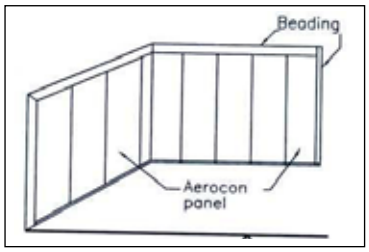


Fig.12

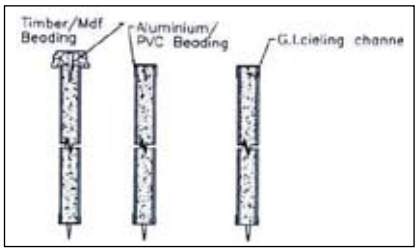


Fig.13

Jumbo height partitions (above 3.0m)

- Panel partition work can be done without steel frame up to 4.50 m height & 4.80 m width.
- Frame work shall not be required for these type of partitions up to 4.5 m.
- Panels shall be staggered for strength & rigidity as shown in Fig. 14. Height of the panels shall be decided accordingly.
- Partition shall be supplied with top support, such as steel, concrete etc.
- The floor & ceiling channel shall be fixed as per laid procedure.
- For horizontal joining, the full length panel shall be fixed first and jointing material shall be applied in the groove portion.
- Hexagonal PVC/wooden beading shall be placed on top groove of the 3 m panel before placing the 1.5 m panel and the same pushed into the ceiling channel as shown in Fig. 15.
- The 1.5 m panel should come next in lower side and 3 meter panel in upper side & proceed in the similar way. The partition shall be completed by fixing panels one by one as per the above procedure. For joint finishing of panels, Clause 2.3.2.7 may be referred.
- If the partition exceeds 4.50 m length and 4.80 m width, then steel support shall be provided as shown in Fig.16.

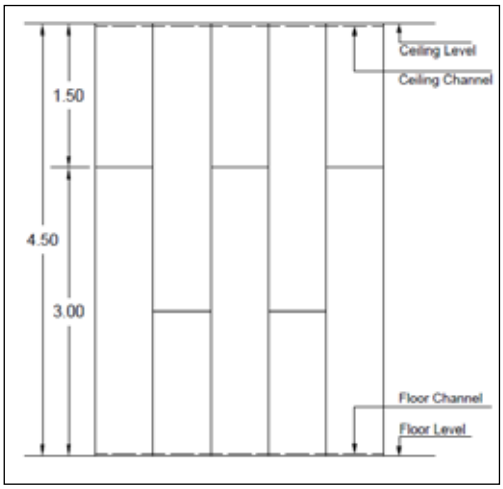


Fig.14

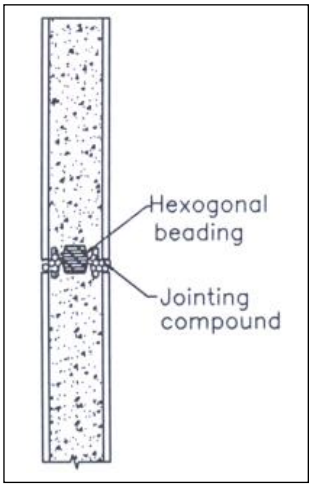


Fig.15

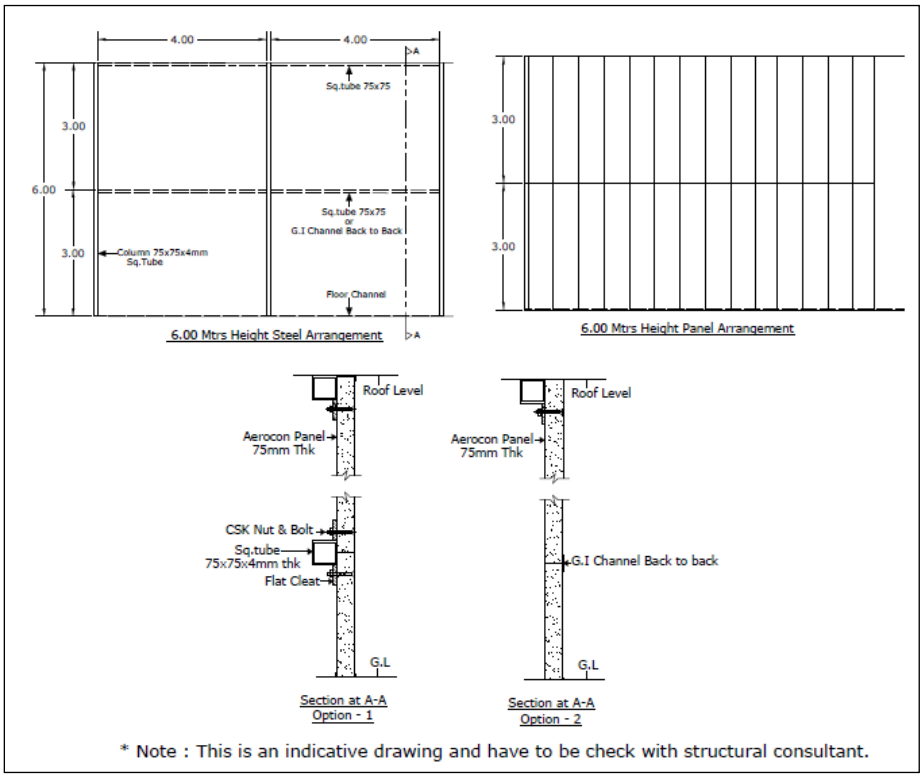


Fig.16

Load-bearing structures (Single storey)

These structures shall be made based on size, location and functional requirements. These load-bearing structures can be designed to a maximum span of 5.2 m as these are suitable with roofing option of the panels as shown below Fig. 17. The length of each room can be up to 6 m i. e. each room with a carpet area of 5.2 x 6 meter. These rooms can be constructed in a row, with multiples of 5.2 m x 6 m.

Typical layout for possible load bearing structures is shown in Figs. 18 to 20.

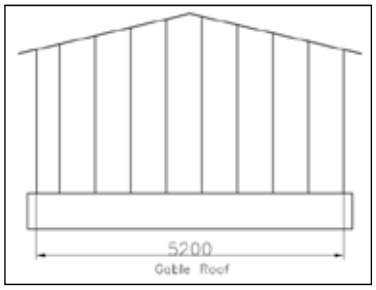


Fig.17

Row Houses

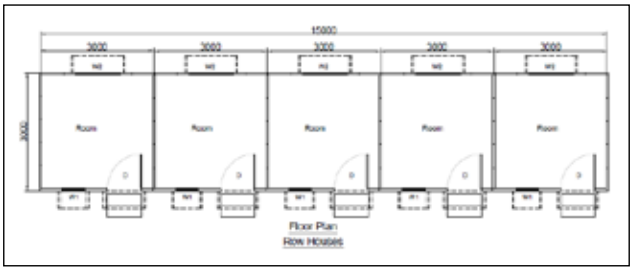


Fig.18

Individual House.

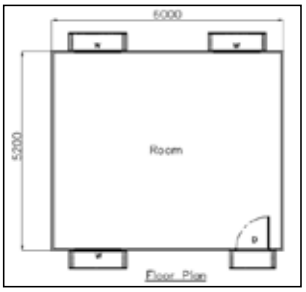
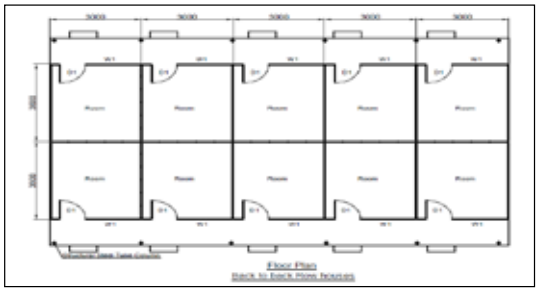


Fig.19



Back to Back Row Houses.

Fig.20

Details of typical foundation for walls and columns are shown below Figs. 21 & 22

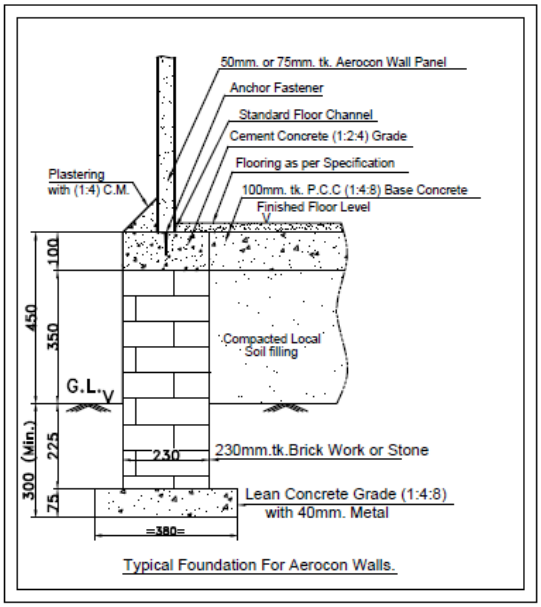


Fig.21

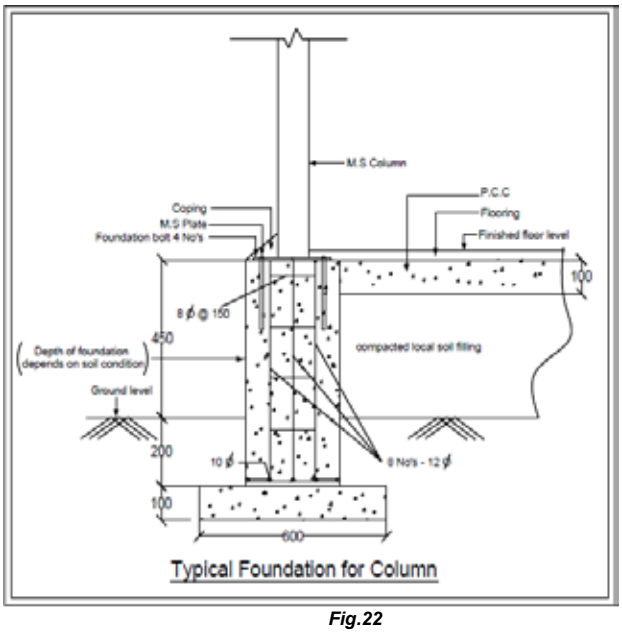


Fig.22

Panels with Recess/Square edge shall be used for construction of walls.

- The four corners shall be marked and position the 'L' Base plate component and diagonals checked as per the drawing as shown in Fig. 23.

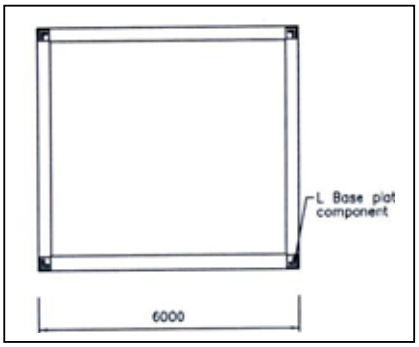


Fig.23

- The base plate shall be fixed by drilling 12mm dia holes with hammer drill and fasten self - expansion anchor fasteners of size M 8 x 65 mm (Hilti/Fischer) as shown in Fig. 24.

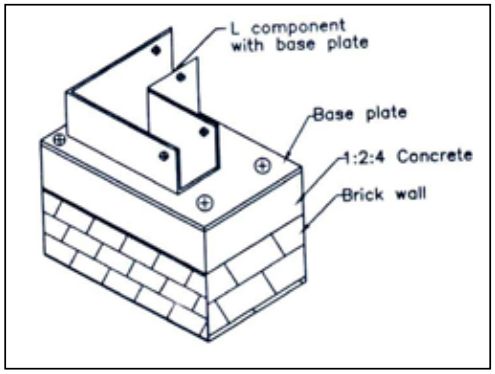


Fig.24

- The floor channel shall be fastened with N 6 x 60 mm self-expansion screws at 600 mm center to center.
- The panels shall be erected from a corner. It shall be ensured with plumb that the first panel is perfectly vertical. After fixing at least two panels on one side start fixing the panels at right angle as per the drawing to ensure stability to the structure.
- The corner cover plate shall be fixed from outside to make the corner rigid as shown in Fig. 25.
- Jointing material shall be applied on tongue & groove portion of the panels to make the joints firm.
- The second panel shall be positioned 550 mm away from the first panel and slowly drop slide towards first panel. This technique enables fast & proper joining of panels. It must be started from the gable side and all sides complete one by one.
- During installation suitable temporary support shall be provided using 75 mm dia. timber log or M.S. pipes of 50mm dia firmly grouted into the ground on either side of panels in 450 angle.
- Every 3rd panel on either side should be tied with temporary support.
- Fixing of purlin shall be completely resting on panels and duly connected with base plates by fixing with M 10 bolts & nuts.
- The day's work shall be stopped only after completing the four walls and tying each other by truss and purlins.
- All panels shall be fastened to the plinth with anchor bracket of size 75 x 75 x 75 x 6 mm thick as shown in Fig. 26.
- After completion of erection of pre-fab structure, the exposed anchor brackets shall be covered using M20 concrete with baby chips from outside.

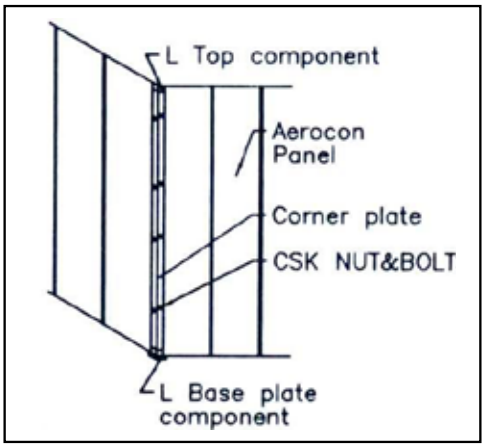


Fig.25

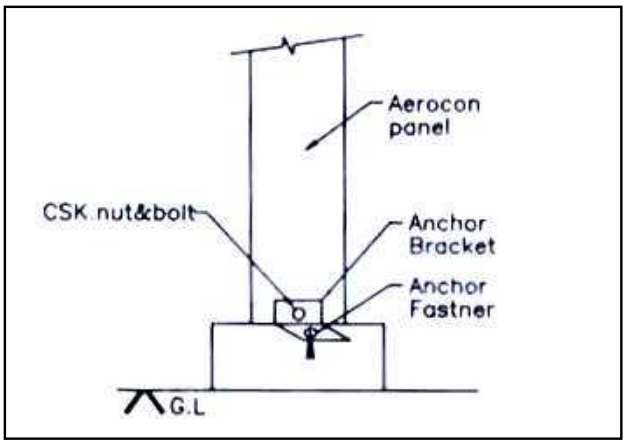


Fig.26

Corner Joints

The 'L' and 'T' joints shall be made by fastening straight ends of the panels with self-expansion screws or 10 dia. x 100 mm long pin as shown in Figs.27 & 28.

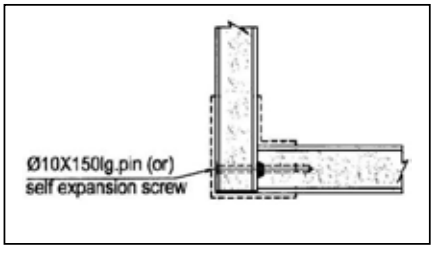


Fig.27

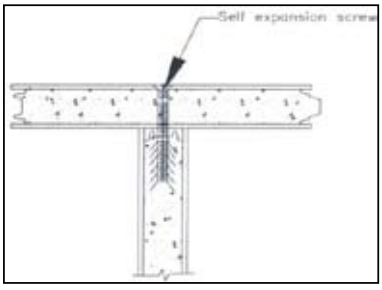


Fig.28

- The core of one panel shall be removed upto 15 mm depth in which the pin will be fastened only in the core, for filling grout cement.
- The panels shall be positioned in right angle and fastened with 150 mm long self-expansion screws at every 900 mm lengthwise using Hilti make or standard bolts 150 mm long galvanized/zinc coated threaded rod dipped in sodium silicate. The bore shall be filled with sodium silicate & fly-ash.

- 8mm dia. holes shall be drilled at 600 mm centres height wise and 15 mm prepared groove shall be filled with grout cement using cocking gun.
- The facing of core (exposed part) shall be finished using silicon acrylic paste. In case of external application, the joints shall be covered with steel cover plate to protect the corner from knocks and other mechanical impacts.
- Lintel panels shall be firmly fixed with fastening the same to lateral panels with 12 mm dia. rods and cement grout. Minimum bearing of 150 mm shall be maintained on either side.

Non-load bearing structures

For non-load bearing structures, steel columns, trusses and Purlins shall be designed as per soil condition and wind velocity. The floor channel shall be fixed between two columns using self- expansion screws at every 600 mm centers, leaving gaps at door positions.

Typical layout plan for a non-load bearing structure is shown below in Fig.29.

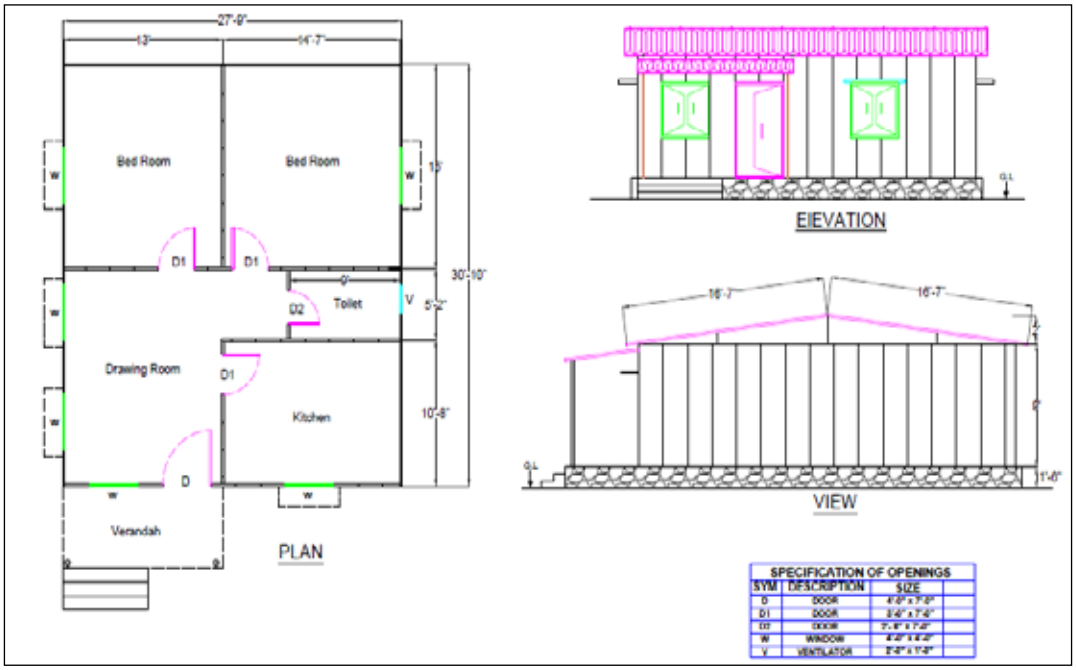


Fig.29 Typical layout plan for a non-load bearing structure

Doors and Windows

Mild Steel, Wooden and Aluminium doors and windows can be fixed with Prefabricated Fibre Reinforced Sandwich Panels.

Electrical Wiring

External wiring : External wiring shall be done on the panels by using PVC caps/pipes duly fixed to the surface.

Concealed wiring

- Surface routing shall be done by cutting the facing sheet and removing core.
- Face chasing should be avoided for panels used in prefab structure external and load bearing especially the panels on which the trusses & purlins are fixed.
- Maximum depth of route shall be 50 percent of the thickness of material
- Switch box upto 40 mm depth shall be fixed in 50 mm panels and upto 60 mm depth in 75 mm panels.
- Load bearing walls should not be routed horizontally.

Plumbing Installation

- In Prefab structures, the toilets can be constructed with these panels. The required pipelines shall be fixed on the panel externally.
- If pipe lines need to be concealed, a false wall should be created with 50/75 mm panel to the required height on the internal side only.
- Water Closet (WC) shall be fixed with bolts & nuts. However, detailing needs to be worked out based on site conditions. The WC shall preferably be fixed on floor and bolted to the panel wall.
- The surface of the panel shall be treated with marble/ granite/ceramic/glazed tiles using appropriate tile adhesive chemicals as per the procedure recommended by the tile adhesive manufacturer. It is recommended to use smaller tiles.

SUPPLY OF THE PANELS

The manufacturer has supplied the panels as per the details given below:

S. No.	Name & location of the Client	Quantity supplied (sqm) approx.	Period of supply
1.	Classic Mall, Mumbai for construction of Phoenix Mall	20000	2012
2.	D B Reality Pvt. Ltd., Mumbai for construction of Millan Mall	13000	2014
3.	Runwall Builders, Mumbai for construction of apartments	20000	2014
4.	Piramal Group, Mumbai for construction of housing complex	8000	2015
5.	Royal Palm, Mumbai for construction of a hotel	15000	2015
6.	ITC Ltd., Hyderabad for construction of a chocolate factory	6000	2015
7.	Gannon Dunkerley, Tanda, UP for construction of industrial complex	5000	2015
8.	Patel Engineering, Jammu (J&K) for construction of a hydro project	1000	2015
9.	DRDO, Panagarh (WB) for construction of staff accommodation	8000	2015
10.	Future Group, Mumbai for construction of City Centre Mall	4000	2015
11.	DLF, Noida for construction of Mall of India	3500	2015
12.	Larsen & Toubro, Hyderabad for construction of TOD Mall	4000	2015-16
13.	NTPC (Simplex), Noida for construction of industrial complex	5000	2015-16
14.	Shapoorji & Pallonji, Hyderabad for construction of warehouse	6000	2016
15.	Jaya Shree Textiles, Kolkata for construction of textile factory	6500	2016
16.	BGR Energy, Vijayawada for construction of housing complex	15000	2016
17.	MES, Leh (J&K) for construction of army accommodation	20000	2016
18.	Bihar Construction Deptt., Bihar for construction of District counselling centers	10000	2016
19.	Prime Hospitals, Hyderabad construction of a hospital	4500	2016
20.	GMR Infra, New Delhi for construction of Cargo at IGI Airport	4000	2016

CERTIFICATION / VALIDATION OF THE SYSTEM

i) Performance Appraisal Certificate No.: 1030-S/2017 on Prefabricated Fibre Reinforced Sandwich Panels (Aerocon) has been issued to M/s HIL Ltd., Hyderabad.

OTHER SIMILAR SYSTEM SHORTLISTED UNDER GHTC-INDIA

i) Prefabricated steel structural system with Dry wall system as AAC panels, etc. - M/s RCC Infra Ventures Ltd., Gurugram has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

ii) Sandwich panels as wall & slab - M/s Project Etopia Group has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

STANDARDS AND REFERENCES

Indian Standards

IS 712:1984	Specification for building limes (Reaffirmed 2014)
IS 2380 (Part 4):1977	Methods of test for wood particle boards and boards from other lignocellulosic materials – Determination of flexural strength (Reaffirmed 2013)
IS 2380 (Part 2):1977	Methods of test for wood particle boards and boards from other lignocellulosic materials – Determination of dimensional stability (Reaffirmed 2013)
IS 2547 (Part 1): 1976	Specification for gypsum building plaster: Part 1 excluding premixed lightweight plaster (Reaffirmed 2017)
IS 3346:1980	Method of determination of thermal conductivity of thermal insulation materials
IS 3809:1979	Fire resistance test for structures
IS 3812 (Part 2):2013	Specifications for pulverized fuel ash - Part 2 : for use as admixture in cement mortar and concrete (Reaffirmed 2017)
IS 11050 (Part 1):1984	Rating of sound insulation in buildings and of building elements - Part 1 : airborne sound insulation in buildings and of interior building elements (Reaffirmed 2017)
IS 12089:1987	Specifications for granulated slag for manufacture of portland slag cement (Reaffirmed 2013)
IS 12269:2013	Specifications for 53 grade Ordinary Portland Cement
IS 13000:1990	Specifications for Silica-Asbestos-Cement Flat Sheets (Reaffirmed 2015)
IS 14862:2000	Specifications for fibre cement flat sheets (Reaffirmed 2015)
BS 476 (Part 4):1970	Test method for non-combustibility of building and structures
BS 476 (Part 5):1979	Method of tests for ignitability
BS 476 (Part 6):1989	Method of tests for fire on building materials and structures
BS 476 (Part 4):1997	Method for fire classification of surface spread of flame
BS 476 (Part 20-22):1987	Fire resistance test to building materials and structures
BS 4370 (Part 2):1993	Method of tests for rigid cellular materials
ASTM E 72:2015	Standard test method for conducting strength test of panels for building construction

References

Fire propagation, fire resistance, Ignitibility evaluation & Surface spread of flame by Fire Research Laboratory, CBRI, Roorkee (IS 3614:1979)
Thermal Conductivity & Thermal Resistivity study of Panels by Indian Institute of Technology Bombay, Mumbai
Dimensions, Transverse strength, Deflection & Compressive strength study of Panels by JNTUH College of Engineering, Hyderabad

Concrewall Panel System

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE TECHNOLOGY

The Concrewall System is an industrial system for the construction of structural walls of reinforced concrete for building in single panel up to G+3.

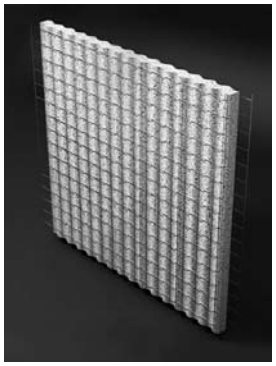


Fig.1: Single (core)

The system is composed of a factory produced panel of undulated (wave shape) polystyrene covered on both sides by an electro-welded zinc coated square mesh of galvanized steel and linked by 40 connectors per sq m made of high-elastic-limit, 3 mm dia wires realizing a 3 dimensional hyper-static reinforced steel. (Figs 1 & 2)

The panels are assembled on site and in-situ concrete (double panels, floors, stairs) and shotcreted concrete sprayed (single panel) to realize the following different elements of the system:

- Vertical structural walls
- Horizontal structural elements
- Cladding element
- Internal walls.

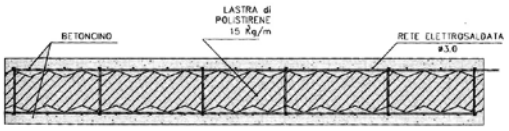


Fig.2: Cros-section

PANEL TYPES

Single Bearing Panel – Used as Load Bearing Wall

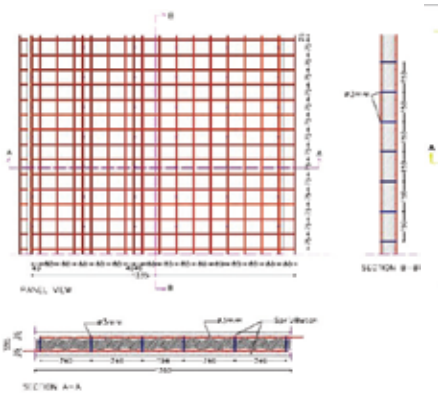


Fig. 3 Single Bearing Panel

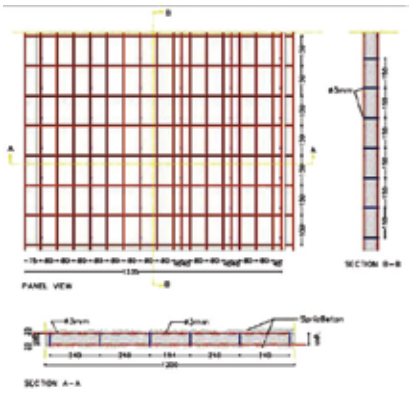


Fig. 4 Single Non-load Bearing Panel



Mesh

Width	: 1235 mm
Longitudinal wires	: 2.5/3.0 mm ø @ 80 mm c/c (max)
Transverse wires	: 2.5/3.0 mm ø @ 75 mm c/c (max)
Connectors & cross wire	: 3.0 mm ø @ 150 mm c/c

EPS

Density	: ≥ 15 kg/m^3
Thickness	: 40 mm to 240 mm

Wave Depth : 15 mm

Single Non Load Bearing Panel

Mesh

Width : 1235 mm
Longitudinal wires : 2.5/3.0 mm ø @ 80 mm c/c (max)
Transverse wires : 2.5/3.0 mm ø @ 75 /150 mm c/c (max)
Connectors & cross wire : 3.0 mm ø @150 mm c/c

EPS

Density : ≥15 kg/m^3
Thickness : 40 mm to 280 mm
Wave Depth : 5 /15 mm



Single Floor Panel

Used as floors or roofs span upto 5 m x 5m and supported by the walls in all the sides. The panels are finished on site by 50 mm of casted concrete in upper side and 30 mm of projected plaster in the lower side.

Mesh

Width : 1235 mm
Longitudinal wires : 2.5 / 3.0 mm ø @ 80 mm c/c
Transverse wires : 2.5 / 3.0 mm ø @ 75 mm c/c
Connectors & cross wire : 3.0 mm ø @ 150 mm c/c

EPS

Width : 1200 mm
Thickness : 80 mm to 200 mm
Density : ≥15Kg/m^3

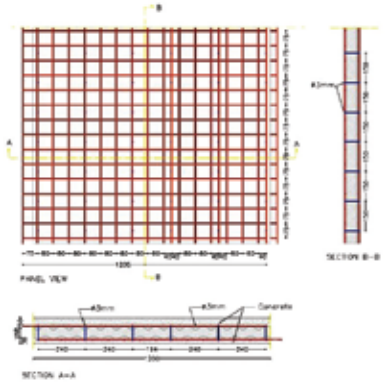


Fig. 5 Single Floor Panel

Floor Panel with Joists

Galvanized steel wire mesh

Longitudinal wires : 2.5 mm ø every 70 mm
Transversal wires: : 2.5 mm ø every 70 mm
Cross steel wire: : 3.0 mm ø (approx. 68 per m^2)
Polystyrene slab density : ≥15 kg/m^3

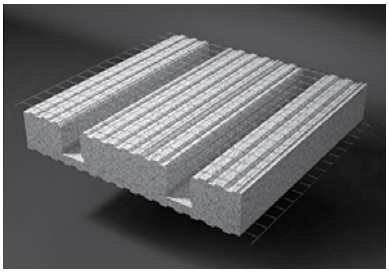


Fig. 6 Floor Panel with Joists

This panel is used for the floor and the roof system and it is reinforced in the joists with concrete casting on the site.

The reinforcement of the panel is integrated during the panel assembly by additional reinforcing bars inside the joists as per the design.

These are suitable for slabs having spans up to 8 m and with live loads up to 4 kN/m^2.



MATERIAL REQUIREMENTS

Raw Materials

- Steel for both wire mesh and connectors
  Zinc Coating – The zinc covering is variable with the diameter of the wire mesh. Standard wire mesh shall

be of 2.5/3.0 mm ø and zinc coating galvanizing shall be of 60/90 gm/m^2 with a tolerance of ± 5 gm/m^2.

Mechanical characteristics

Tensile strength (2.5mm ø)	: 750 N/mm^2
Yield strength (2.5mm ø)	: 680 N/mm^2
Tensile strength (3.0mm ø)	: 700 N/mm^2
Yield strength (3.0mm ø)	: 600 N/mm^2
Elongation	: > 8%

Chemical characteristics

% C	: < 0.24
% P	: < 0.055
% S	: < 0.055
% Ceq	: < 0.52



- ***Expanded Polystyrene*** – Self-extinguishing type EPS in accordance with IS 4671:1984 (UNI EN 13163:2013) having density not less than 15 kg/m^3.

PRODUCTION PROCESS

Concrewall Panels of different dimensions are produced with two raw materials namely steel wire in coils and polystyrene blocks.

1. *Galvanized wire:* It includes the following phases:
   - Perfect straightening and cutting of the required wires
   - Assembly by electrical welding of the wires of different dia to make mesh of pre-established lengths

2. *Polystyrene blocks EPS:* The most complete hypothesis shall include the following:
   Shape the dried blocks and cut sheets of a specific form and dimension according to the final type of product. The possible scraps are grounded and recycled, within certain limits, in the production of EPS blocks on the condition that these are first cleaned and are without any foreign substance, with particular attention to the presence of dust.

3. *Assembly:*
   Assembly of the Concrewall panel shall be made by electro-welding no.6 wires (in transversal and perpendicular position with respect to the panel surface) with two meshes, forming a sandwich including the EPS sheet between these, which has been previously inserted.

4. Operations 'out of line':
   The production line is complete after cutting and bending of the external overlapping meshes.

INSTALLATION PROCEDURE

1. *Foundations*
   Where Foundations for the Concrewall System are used, they should be levelled and stepped as this makes panel positioning easier.
   For concrewall panels, parallel sided timber or metal template of the width of panel shall be required to mark the position of the wall panels on the foundation and the spacing of the starter bar holes.

2. *Wall start up*
   - Line wall positions shall be marked and profiled.
   - A timber or metal template of the exact width of panel (from wire to wire) shall be used to mark the position of the panels with chalk or pencil lines.
   - On the panel lines, positions shall be marked to drill the starter bar holes. These should be in a zig

zag pattern at 600 mm centres on each side of the panels. Starter bars should be at all panel joints and on the opposite side in mid panel plus at all wall corner joints.

- Starter bars should be either 6mm or 8 mm dia, 500 mm long with 100 mm drilled into the foundations and 400 mm above.
- Drill bits shall be used to give a tight fit with the starter bars.
- Once starter bars are in position, place the Concrewall panels between the starter bars starting from a corner. Starter bars shall be wire-tied to the panel mesh and the panels to each other on the overlapping mesh.

3. Wall construction

- All corners and wall joints should be reinforced with right angled wire mesh to the full height of the walls.
- To cut panels to fit for door & window openings, wire should be cut with a wire cutter or angle grinder. Measure and mark the cut lines before starting to cut.
- After the wire mesh has been cut, EPS shall be cut with a hacksaw blade or stiff blade hand saw.
- Added steel mesh reinforcement shall be required around door and window openings to ensure that no plaster cracks form in these areas. Mesh reinforcement strips shall be tied diagonally at every corner of openings before plastering.
- Once wall panels are in place and tied together, bracing shall be required to hold them vertical before plastering. This shall be done only on one side of the panels.
- Once the panels are plastered on one side, the wall bracing shall be removed after 24 hours. The panels are now sufficiently stiff so that plastering on other side can be done without bracing.

4. Door and Window fittings

- Before plastering metal ‘cliscoe’ type window and door frames (which should be sized to the width of the panels) may be fitted into the pre-cut panels.
- Metal ‘cliscoe’ type window frame fitted into future house panel before plastering.
- Metal lugs from the back of metal frames shall be wire tied to the panel mesh to keep the frames in position.

For any other kind of frames, suitable method in accordance with the manufacturer’s specifications may be used.

5. Plastering

- Plastering shall be done by machine or hand. The indicative quantity of each material per cum. should be as follows:
- Cement: 350 kg
- Sand with mixed granulometry: 1600kg. Sand should be without clay or any organic substance and totally washed.
- Water – 160 litres. The quantity of water may be different according to the natural sand humidity. The parameters that should be constant are: W/C = 0.52 and I/C = 4.50.
- Any problem of workability should be solved without adding water. The retraction cracks formation may be avoided by adding Polypropylene fibers in the mix (1kg/m^3).
- In order to control the final plaster thickness, some guides should be used. These shall be removed as soon as the plaster ‘sets up’ and the spaces are filled and are smoother before the plaster gets dry.
- Spray application should be done in two steps with a first layer covering the mesh applied on both the sides of the wall and the finishing layer as soon as the first layer gets dry.

6. Roof/floor panel

- After the vertical panels are assembled, verticality of the walls should be checked and the bending meshes positioned on all the corners. Thereafter, horizontal bending meshes shall be placed to connect the floor/roof to the vertical panels. The bending meshes should be fixed throughout the

perimeter of the floor/roof, at the level of intrados.

- When the horizontal bending meshes are fixed and checked floor/roof panel shall be placed on these. The lower mesh of the panel shall be fixed by steel wire to the bending meshes.
- Between the edges of floor/roof panel and vertical panel, gap of 35 mm should be left to ensure structural continuity. The plaster applied on the walls shall be continued from one level to another level.

Placing of the Concrewall elements for the floor and/or roof should be done before the application of the external layer of plaster on the walls. Casting of concrete on the floor/roof panels (after placing the additional reinforcing bars, if required) should be done after the walls are plastered and a number of props shall be put to limit the deformation of the panel.

7. *Plumbing and electrical fittings*

- Plumbing and electrical conduits shall be behind the panel wire mesh before plastering.
- The space behind the wire mesh shall be opened up by using a blow torch to partially melt the EPS along the lines of the conduits.
- As the EPS used in the panels is fire retardant, it will melt under the flame but not burn.
- The wire mesh shall be cut with wire clippers to make space for DB boards, switches and plug boxes.

ADVANTAGES

Fast Construction

The speedy construction represent additional savings.

Design Flexibility

The building system gives full design flexibility as it offers a complete range of building elements such as load-bearing walls, curtain walls, floors and stairs.



Ease of Use

The panels are easy to use in the construction of any type of structure, and can be shaped to any geometric requirement i.e. flat or curved by simple cutting the panels at site.

LIMITATION OF THE TECHNOLOGY

Economical for mass housing only.

SPECIAL FEATURES

Structural Stability

The System receives its outer plane strength and rigidity by truss action where the shotcrete layers are the chord members.



Durability

Durability shall be in accordance with IS 456:2000 which specifies exposure conditions, concrete strength and cover requirements

Behavior in earthquake

Being light in weight, earthquake forces are less in the structure. With proper design and detailing, the structure

can be made safe.

Fire Safety
During the fire ignited inside the building (temp. raised up to 163°C), no distress/distortion of panels was observed in any part of the unit except breaking of a window glazing.
Water Proofing
No dripping or leakage of water through slab during 24 h of ponding was observed except for minor damp patches on the ceiling at few places.
The inner face of the wall was observed to be free from which was found to be within the permissible limits dampness or sweating during 10 h of jetting at regular intervals of 30 min.

Thermal Performance
The reduction in outside and inside temperature was recorded up to 5.8°C indicating a good thermal comfort.

Acoustic Performance
Sound intensity was measured outside and inside the unit to know the difference in sound levels using sound level meter. The results showed reduction of sound level by 35dB indicating a good acoustic comfort.

Behavior under high winds
The design of roof to wall connections shall be to a specific design to ensure that the roof structure is properly restrained against uplift.

WORKS COMPLETED

Following 3 plants in India have been set up using Schnell Machineries
- West: Maad Constructions Co Ltd, Pune, Maharashtra
- East: Jindal Steel & Power Ltd, Angul, Odisha
- North: Synergy Thryslington, Mohali, Punjab

Buildings Constructed
- Industrial Township at Angul, Odisha
- Mass Housing, G+3 Buildings, at Vasai, Maharahstra
- Hostel & Hospital Buildgins in Punjab & Himachal Pradesh
- Anganwadi Buildings across India by Vedanta Group
- In-fill Wall used in different regions

Use with Other Systems
- In-fill Walls for Steel-frame & Floor Buildings
- Use with Al/Plastic Monolithic Formwork

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No. 1031-S/2017 has been issued to M/s Schnell Home, Italy.

STANDARDS/REFERENCES

IS 456:2000	Code of practice for plain and reinforced concrete (Reaffirmed 2016)
IS 4671:1984	Specifications for expanded polystyrene for thermal insulation purposes
BS 476(Part 22):1987	Fire resistance

Rising EPS (Beads) Cement Panels

(Suitable as Load Bearing Panels for Single Storey Structures and as Non Load Bearing Panels in Low to High rise Structures with PEB)

ABOUT THE TECHNOLOGY

These are lightweight composite wall, floor and roof sandwich panels made of thin fiber cement/calcium silicate board as face covered boards and the core material is EPS granule balls, adhesive, cement, sand, fly ash and other bonding materials in mortar form.

The core material in slurry state is pushed under pressure into preset molds. Once set, it shall be moved for curing and ready for use with RCC or steel support structure beams and columns. These panels are primarily used as walling material but can also be used as floor and roof panels. These are non-load bearing panels to be used with structural support frame only.

SIZE AND TYPE OF PANELS

Size	:	Panels are normally produced in sizes and dimensions as given below:
Length	:	2440 mm (may be increased up to 3000 mm)
Width	:	610 mm (may be altered as per requirement but should not be too wide since handling of the panels become difficult)
Thickness	:	50-250 mm. Dimensions are shown in Fig. 1.

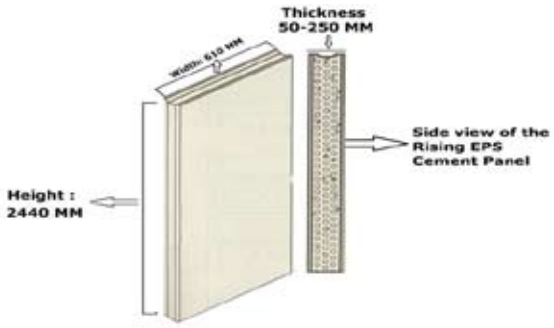
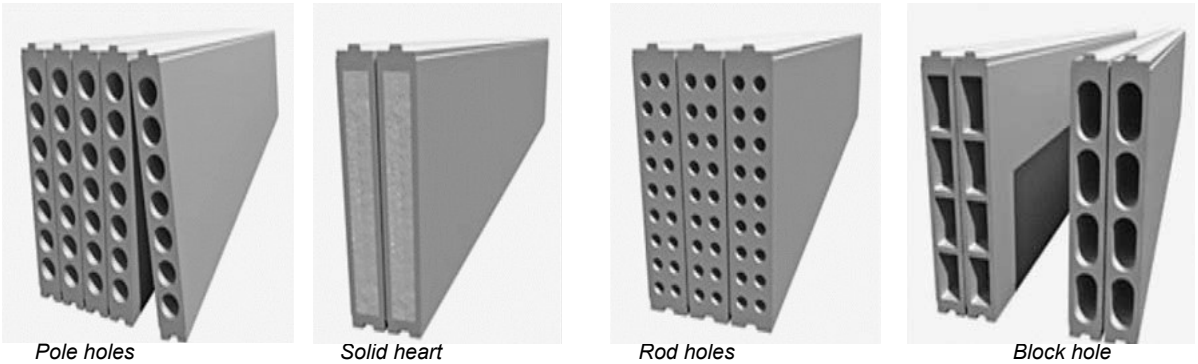


Fig.1

Type: Panels are produced in 4 types as shown in Fig. 2 below:



Pole holes *Solid heart* *Rod holes* *Block hole*

Fig.2

The above four types of panels have different applications depending on the requirements e.g. Solid heart should be used as walling material in any type of construction and pole, rod and block hole may be used where different types of inserts are used like iron rods or wires for security etc.

RAW MATERIALS

(i) OPC 43/53 grade cement shall conform to IS 8112:2013/12269:2013.
(ii) Fly ash shall conform to IS 3812 (Part 2):2003.
(iii) EPS beads shall conform to IS 4671:1984 and shall have density not less than 15 kg/m^3.
(iv) Fibre cement board shall conform to IS 14862:2000.

(v) Calcium silicate board shall conform to EN 14306:2009
(v) Fine (sand) & coarse aggregate shall conform to IS 383:2016.
(vi) Water shall conform to IS 456:2000.
(vii) Addage RD Powder, AKULPOL-9192, Akulcel 48000 (Additives & Bonding agents) shall conform to the manufacturer Ms. Sakshi Chem Science Pvt. Ltd. Mumbai specifications.

PERFORMANCE CRITERIA

Rising EPS panels shall meet the following performance criteria when tested in accordance with the relevant Standards:

Sl.No.	Performance Characteristics	Criteria	Test Method
1.	Flammability of EPS	≥ 600kgs/M³	IS ASTM D 7309:2013
2.	Axial compression	≥ 3.5MPa	IS 2095 (Part1):2011
3.	Resistance to continuous heating	≥ 70ºC	ASTM F 1939:2015
4.	Flexural Strength	≥ 1N/mm²	IS 516:1959
5.	Acoustic Performance	≥ 35dB	IS 9901:1981
6.	Thermal conductivity	≥ 0.1W/M² k	IS 3346:1980
7.	Thermal Resistance	≥ 0.40M² k/W	IS 3346:1980
8.	Water penetration	There should be no damage or leakage	EN1609:2013
9.	Fire rating of the panels	Should be Grade 1/3 Hrs	BS 476 (Part 20 & 22)
10.	Resistance to structural damage from a large light body	There should be no collapse or dislocation	BS 5234 (Part 2):1992, Annex E
11.	Anti-bending damage load	≥ 1.5 times of its weight	BS 5234(Part 2):1992
12.	Non-combustibility	Should be 'A' level	GB 8624:2012
13.	Water tightness behind panels after 24 Hrs at 250mm water head	No droplets should be observed	ASTM C1185:2016
14.	Drying Shrinkage value	≤ 0.1%	IS 2185 (Part 1):2005
15.	Single point hanging strength	≥ 1000N	BS 5234 (Part 2):1992

INSTALLATION OF EPS CEMENT PANEL, APPLICATIONS & JOINTING PROCEDURE

Procedure

With RCC frame structure: If RCC frame structure is used in the construction, then the panels should be directly fixed on the walls, pillars, beams and floor with the help of cement glue and later iron locking rods should be inserted into the panels and the pillars, beams and floors at 45° so that they are firmly locked with each other and become one single unit.

The manufacturer shall inform the specialized chemical "cement glue", if available in India/manufactured by reputed chemical/ water proofing companies to the customers.

With Steel frame structure: If steel structure frame is used in the construction, then U type channels should be used to hold the panels with the structure. In this case additional clips should be welded with the frame pillars and beams to hold the U cannel firmly with the pillars/beans and floor. Then only the panels should be inserted into the U channels. There after PU glue should be applied to hold the panels firmly. The thickness of the panels shall determine the size of U channel.

After installation of the panels in both the above systems, all gaps should be checked and filled with additives, PU and cement mixers and later thin putty should be applied to give uniform smooth surface ready for paint.

Installation of Panels

Receipt and inspection of Panels

Once the panels are received, it should be checked if the edges are safe and also there are no cracks or damages on the surface of the panels which can happen during transportation and handing.

Laying of panels as per drawings

Once panels received are as per the drawings, then it should be separated and laid down as per the drawings for easy installation and to avoid extra handling.

Marking and sizing the panels

Once panels are placed at the proper place, marking should be down as per drawing and proper sizing should be cut of the required panels as per the drawings. (See Figs. 3 & 4)



Fig.3 Marking of the panels as per drawings



Fig.4 Cutting of panels as per drawings

Actual installation as wall

The panels are lifted and placed as per the drawings. Fo installation of the panels, following points should be considered:

1.1 Joining of panels with each other

- The panels shall be placed at the marked space and adjusted together. Dust should be cleaned on the tongue and groove of the panel to be installed. Cement mortar shall be applied and glue filled in the gaps on the panel joining parts and force them together to form one panel. Levels of both panels shall be checked. (See Figs. 5 & 6)
- The panels shall be fixed with steel bar between each other or between the panels and the floor to lock them together. (See Fig. 7)

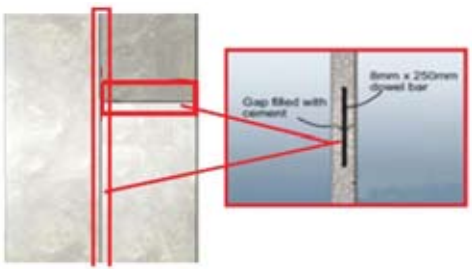


Fig.5 Placing panels together



Fig.6 Applying cement and glue

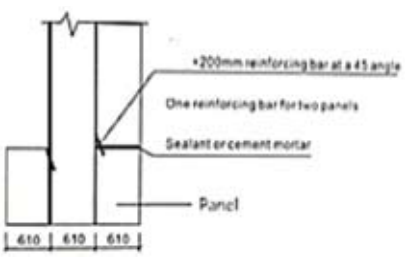


Fig.7 Part elevation of wall panels

1.2 Typical Joint between two panels side by side:

- The panels shall be fixed with dowel bars and the bars inserted in one panel at 45° and hammer it down to lock both the panels. (See Figs. 8, 9 & 10)

1.3 Typical joint with floor:

- The panels shall be placed on floor, cement and glue applied between panels and floor and L type steel bars inserted through the panels edge at 45° in the floor. The panel will then be locked to the floor. (See Figs. 11 & 12)



Fig.8 Steel bars

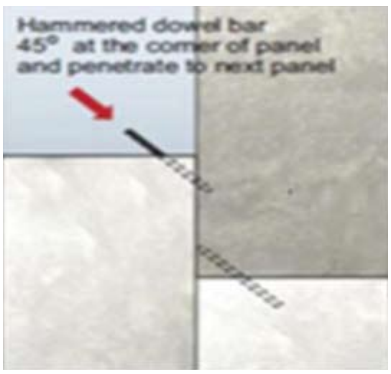


Fig.9



Fig.10

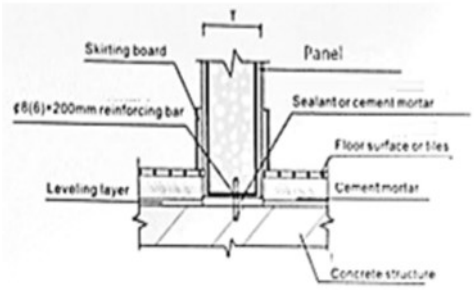


Fig.11



Fig.12

1.4 Typical L and T joint with panels:

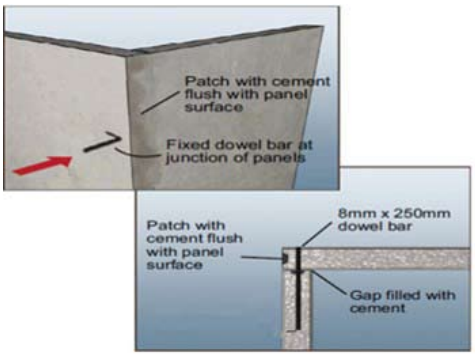


Fig.13

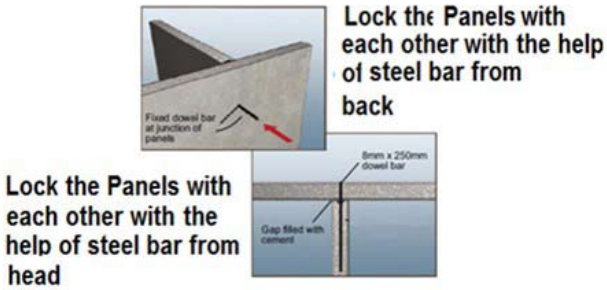


Fig.14

1.5 Joining of upper and lower panels together:

- The panels shall be placed one over the other vertical/ horizontal after applying cement and glue. The steel rod shall be inserted from the sides of the panels into each other to join them together and locked. (See Figs. 15 & 16)

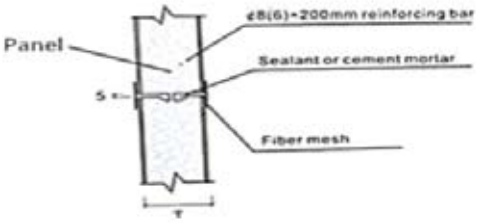


Fig.15



Fig.16

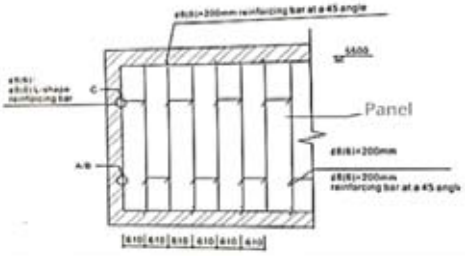


Fig.17

- A wall of these panels shall be inter-connected with steel bars inserted at 45° and fixed with cement and glue in between panels. (See Fig. 17)

2.1 Connecting panels with RCC pillar/RCC Walls/RCC beams:

- For connecting these panels with RCC pillars, the panels shall be placed with the pillar after applying cement and glue on the side of the panels and pushed to make the perfect position.

  Following are three types of connections depending on the situation:

  Steel rods/screw or bolt shall be inserted in the pillar and the panels locked with the help of the above. Thus the panel will be fixed and becomes part of wall connected with pillars. (See Figs. 18, 19 & 20)

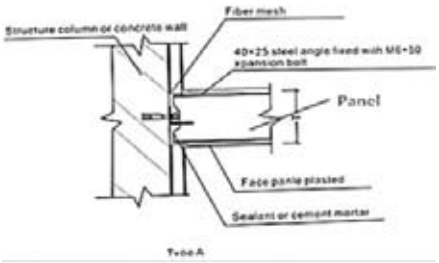


Fig.18

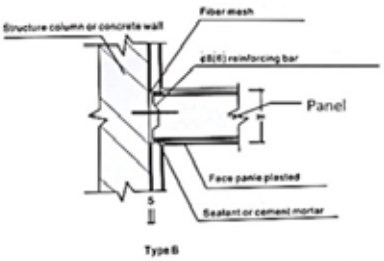


Fig.19

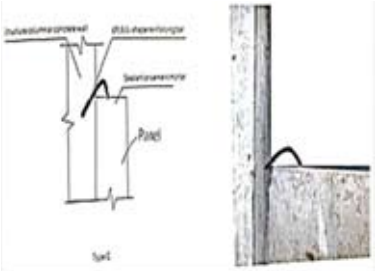


Fig.20

2.2 Wall head fixing:

- Dowel bar of 250mm length and 8mm dia shall be fixed into pre-drilled hole of the panels and lock the panel to the overhead beams or RCC roof slab. (See Figs. 21, & 22)

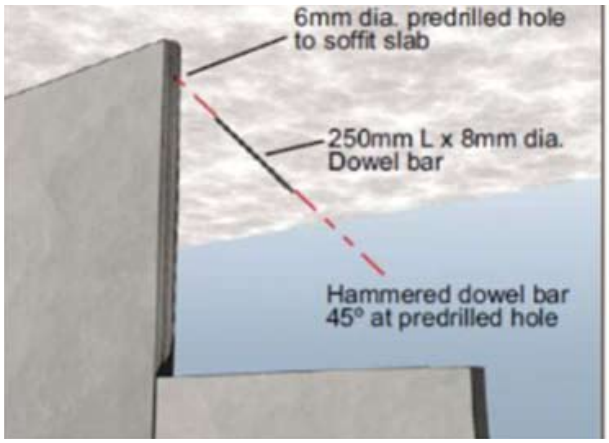


Fig.21

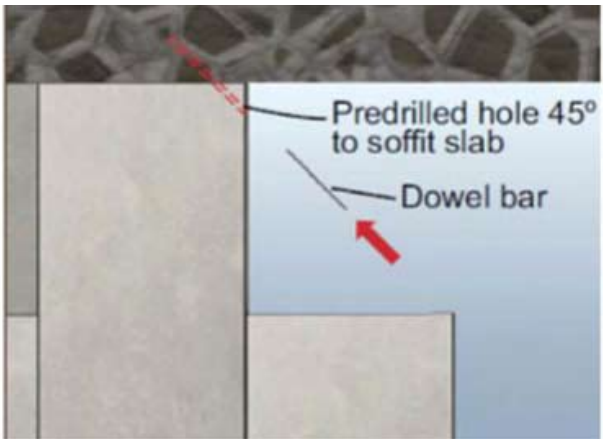


Fig.22

2.3 Fixing panels to the Steel frame (Pillars & Beams)

- *Connection of wall panel to RHS column*
  Steel L-angle/C Channel/Z channel shall be welded to the side of RHS column and the panel inserted inside the angle/channel and locked. The thickness of the panels shall determine the size of angle/channel. (See Figs. 23, 24 & 25)

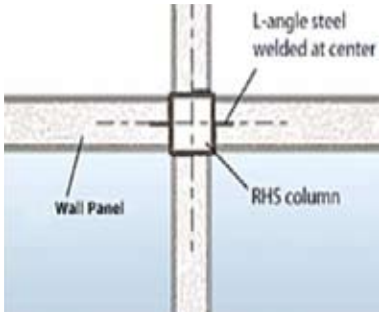


Fig.23

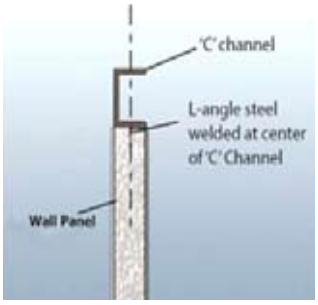


Fig.24

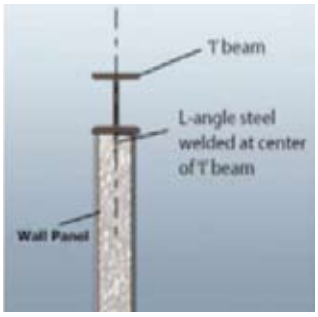


Fig.25

3.1 Cutting of space for doors and windows

- The space on the drawing where doors and windows are required to be placed shall be marked and then while making walls keep that space. There is another way also where the space is cut later on once the walls are set fully.

3.2 Door Opening

- The panels shall be placed horizontally to keep space for doors. (See Figs. 26 & 27)

3.3 Window Opening

- The panels shall be placed horizontally to keep space for windows. (See Figs. 28 & 29)

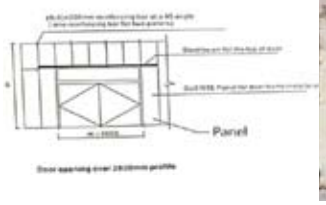


Fig.26



Fig.27

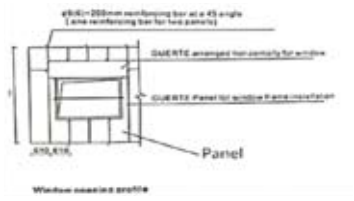


Fig.28



Fig.29

3.4 Cutting space for doors and windows after the panels are fixed.

- The position of steel inserts shall be marked to protect the wall from any movement while cutting of panels. All the steel bars shall be inserted at 45° angle to lock the panels with each other to stop further movement. (See Fig. 30)

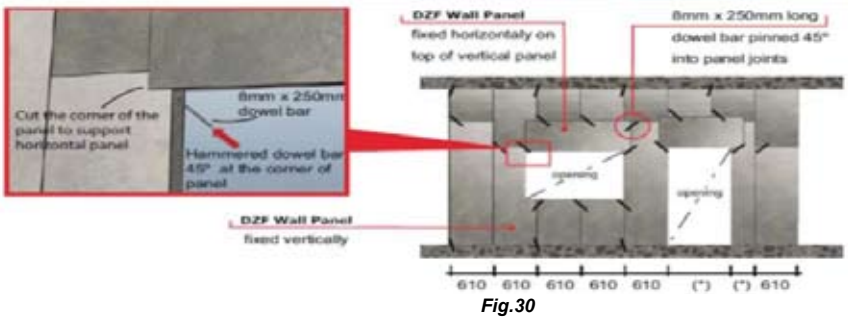


Fig.30

3.5 Frame Fixing (See Figs. 31, 32, & 33)

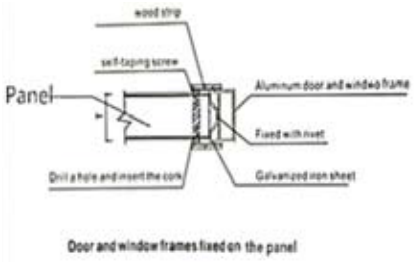


Fig.31

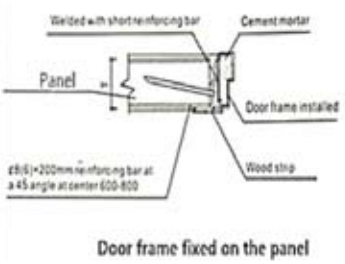


Fig.32

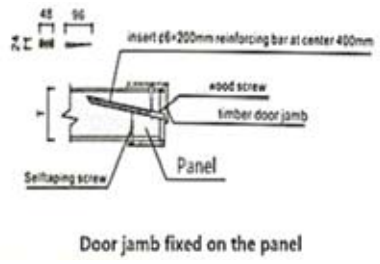


Fig.33

4. Laying of electrical conduits

- The wire shall be embedded from the ceiling into the trench. (See Figs. 34 & 35)

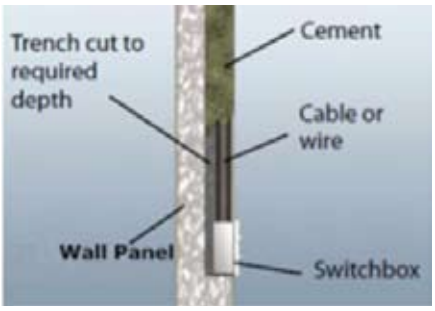


Fig.34

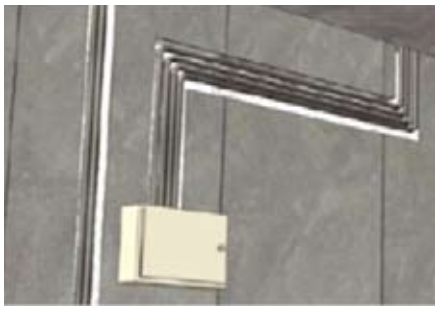


Fig.35

5. Hanging Force (See Fig. 36)

- Expandable metal bolt shall be used and hooked on the wall panel.
- Tile adhesive shall be used for fixing heavy granite tiles.

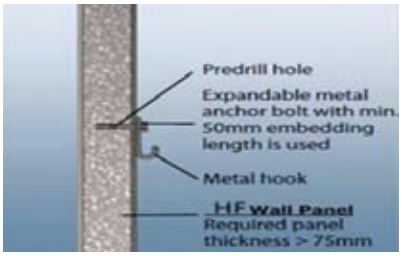


Fig.36

6. Fixing the Panels as floor (See Fig. 37)

- Steel frame shall be fixed if this is to be a raised platform otherwise the panels can be used directly as floor after making the ground level properly.
- Floor tiles can be fixed on these panel, if required.

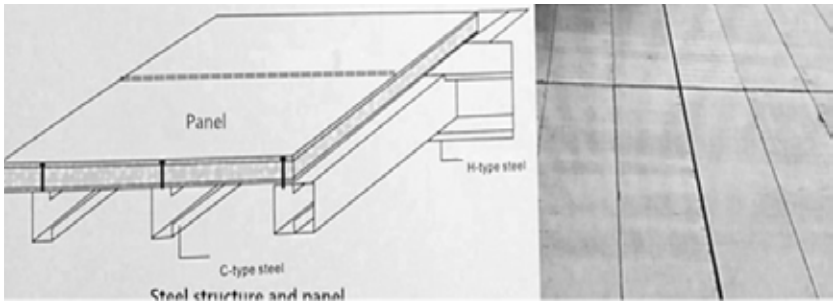


Fig.37 (Screeding concrete not shown in these drawing)

7. Fixing the Panels as roof (See Figs. 38 & 39)

- These panels can be used in the roofing as long as it is non-load bearing application.
- Steel frame shall be fixed as base for fixing the panels as roof.

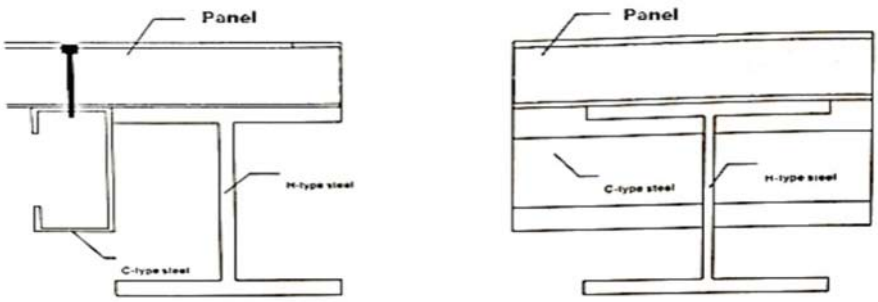


Fig.38 (Screeding concrete not shown in these drawing)

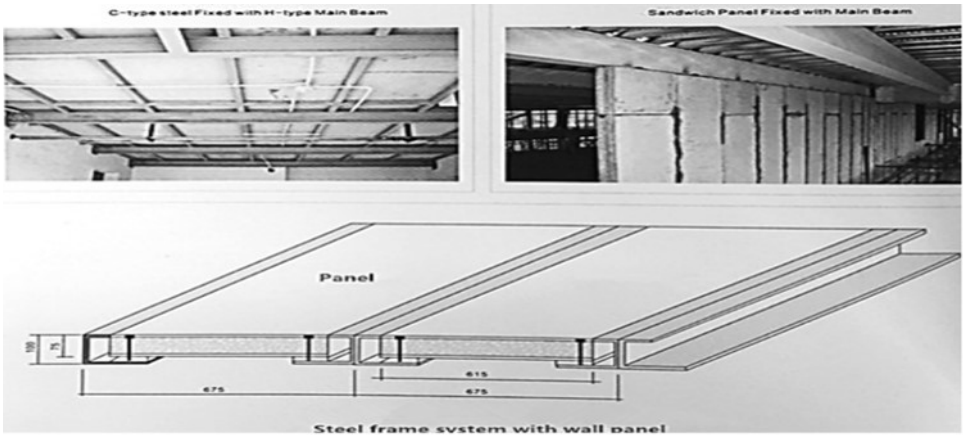


Fig.39 (Screeding concrete not shown in these drawing)

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No. 1032-S/2017 has been issued to M/s Rising Japan Infra Pvt. Ltd., New Delhi.

MAJOR PROJECTS

- Third floor of G+6 residential Complex constructed by NBCC at Kidwai Nagar, New Delhi.
- 1024 houses under Light House Project (LHP) at Indore (under construction).

USES, LIMITATIONS AND CRITICAL DETAILS OF PANELS

Uses:

These panels may be used for the applications in Housing, Commercial complexes, Schools, offices, Electric sub-stations, Hotels and resorts, High rise buildings, Boundary walls, Highway railings, Bridges side support, river lining etc.

Limitations :

These panels are non- load bearing only if they are used without any pillar and beam support. However, they may be used as walling material with RCC or steel frame structure.

The panels, if used for floors/roofs, shall require screeding concrete of 35mm thick with nominal reinforcement/ GI wire mesh for shrinkage monolithic action to avoid leakage through the panel joints.

STANDARDS AND REFERENCES

IS 383:2016	Coarse and fine aggregate for concrete - specification (Third Revision)
IS 456:2000	Plain and reinforced concrete - code of practice (Reaffirmed 2016)
IS 2185 (Part 1):2005	Specification for Concrete Masonry Units - Part 1 Hollow And Solid Concrete Blocks (Reaffirmed 2015)
IS 3346:1980	Method of determination of thermal conductivity of thermal insulation materials
IS 3809:1979	Fire resistance test for structures
IS 3812 (Part 2):2003	Specifications for pulverized fuel ash - Part 2 : for use as admixture in cement mortar and concrete (Reaffirmed 2017)
IS 8112:2013	Specifications for 43 grade Oordinary Portland Cement
IS 9901:1981	Measurement of sound insulation in buildings and building elements
IS 12269:2013	Specifications for 53 grade Ordinary Portland Cement
IS 14862:2000	Specifications for fibre cement flat sheets (Reaffirmed 2015)
IS 516:1959	Method of test for strength of concrete (Reaffirmed 2013)
IS 4671:1984	Specifications for expanded polystyrene for thermal insulation purpose.
IS 2095 (Part 1):2011	Specifications for gypsum plaster boards - part 1 plain gypsum plaster boards (Reaffirmed 2011)
ASTM C 1185(08):2016	Standard test method for sampling and testing non-asbestos fibre cement flat sheets
ASTM F 1939:2015	Standard test method for radiant heat resistance of combination of materials
BS 476 (Part 20-22): 1987	Method of determination of fire resistance of building materials and structures
BS 5234 (Part 2):1992	Specifications for performance requirements for strength and robustness of partitions including method of tests
EN 1609:2013	Specifications for thermal insulating products for buildings
GB 8624:2012	Classification of burning behavior of building materials







PIR Dry Wall Pre-fab Panel System

(Suitable as Non Load Bearing Panels)

ABOUT THE SYSTEM

PIR Dry Wall Pre-Fab Panel is a system where two fibre cement boards (FCB) of 10 mm thickness are filled with insulation material namely Poly Isocyanurate (PIR) in-situ and erected to produce straight to finish walls. The system shall be integrated with conventional column and beam for pre-engineered buildings. Insulation core provides effective insulation and strong bonding for better structural stability to facilitate higher loading and wider spans. This system can incorporate all types of services viz. electrical, gas and plumbing etc.

Size of Panels

Panels are normally produced in sizes and dimensions as given below:

Length: 2400/2700/3000mm or as per requirements.

Width: 1200 mm

Thickness: For external wall, thickness is 120mm having 10mm thick cement fiber board on both sides and inside filled with Poly Isocyanu Rate (PIR) of 100mm thick. For internal wall, thickness is 100mm/60mm having 10mm/6mm thick cement fiber board on both sides and inside filled with PIR depending upon thickness of wall.

Details of the panel is shown in Fig. 1.

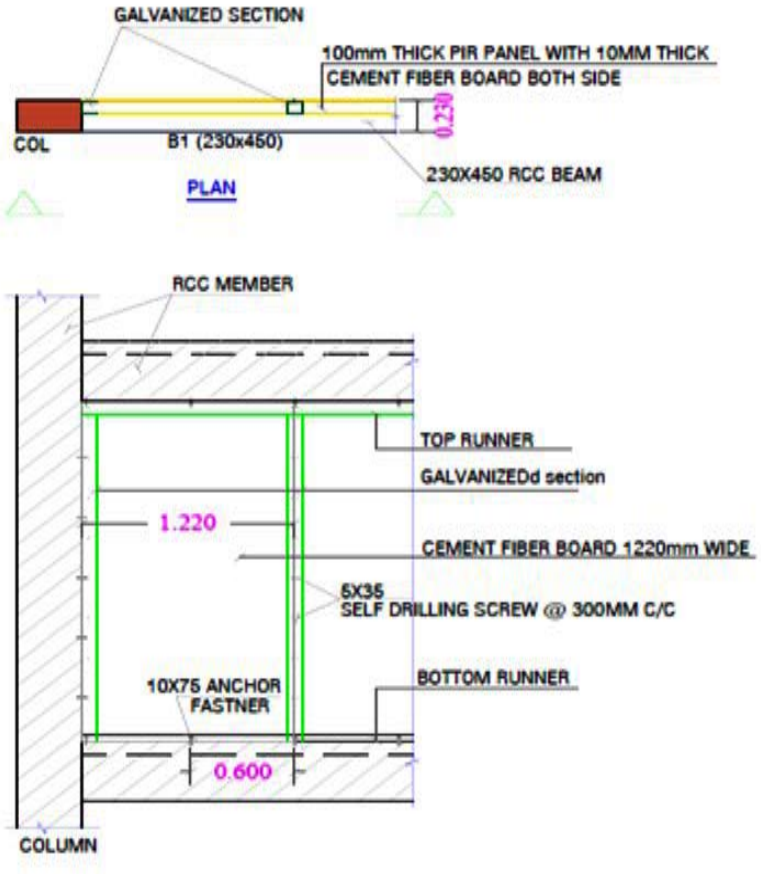


Fig.1

BASIC RAW MATERIAL REQUIREMENTS

(i) *Fibre Cement Board*: Shall be 100% asbestos free and of Type A, Category 3 min. as stipulated in IS 14862:2000.
(ii) *Poly Isocyanurate (PIR):* Shall be as per the specifications of the manufacturer
(iii) *PPGI sheet:* Shall be 0.5mm thick and as conform to IS 14246:2013
(iv) *Square Hollow Section (SHS)/C Channel*: Shall be manufactured from pre-galvanized high tensile steel conforming to IS 277:2003.
(v) Fibre glass mesh: Shall be as per manufacturer specifications.
(vi) *Acrylic based glue*: Shall be as per manufacturer specifications.
(vii) *Galvanized MS screws:* Shall be as per manufacturer specifications.
(viii) *Anchor fasteners:* Shall be of 10mm to 12mm dia., 50mm to 75mm length and as per manufacturer specifications.
(ix) *Premix Putty*: Shall conform to IS 419:1967.

MANUFACTURING PROCESS

Continuous and Discontinuous Panel Manufacturing Methods
There are basically two panel manufacturing methods: continuous and discontinuous. In the continuous process, all the materials used are processed together and completely formed panel is cut to the desired length without stopping the line. In the discontinuous process, the materials are processed separately; this means the facings are formed and cut to the desired length and then assembled together in a press where the foam is injected.

Continuous Process (For both Wall and Slab panels)
A typical continuous line is made up of the following three sections:
- External layers processing section
- Insulating material processing section
- Panels handling section

In case of a sandwich panel with both exterior surfaces in cement fibre board for walls and sheet metal for roof and an insulating core in PIR foam, the first section starts with the sheet de-coilers and continues with all the equipment for forming the two sheets into the desired shape. The panel could be a panel for walls or for roofs. Sandwich panels with flexible layers are not roll formed. Both surfaces of the final panels are entirely flat. The surfaces are pre-heated to the temperature required by the process (usually between 60ºC 65º C) and then the insulating material is prepared.

In PIR panels, the foam is generated by starting from the required chemical components metered and mixed together in the foaming machine. The resulting liquid mixture is evenly distributed over the lower metal sheet. The metallic facings, foam and possible side strips or gaskets are pressed inside the double conveyor or continuous press. This machine has to maintain the metal sheets separated at the desired distance while the foam expands.

In this way, the panel will have the desired thickness and shape once the foam has expanded and fully cured. The most critical parameter to ensure a good result from the process is the temperature control of the chemical components, metal sheets and press area.

Discontinuous Process (For Wall Panels only)
Such panels either rigid or flexible, with flat or grooved profile can be produced using cement fibre board for walls and pre-painted metal sheet for roof slab.

Diverse technologies apply to the discontinuous production process, namely:
- Manual mode injection technology at closed mould;
- Automatic mode lance displacement at closed mould;
- Automatic mode injection technology at closed mould.

Manual mode injection technology at closed mould
A standard plant composition is based on a low pressure metering machine and a single or multi-daylight press depending on the production requirements of the end-user.

The production process includes the pre-assembly of the panel on the tray which will be then conveyed to the press for the foaming. Some wooden or metal side containments are placed all around the panel perimeter to contain the foam expansion.

Along the longitudinal side of the panel containment there will be holes (their number depends on the panel dimensions to be produced) suitable for the mixing head to be inserted during the foaming. The mixing head movement is through either a manual or power-driven carrier for entering the injection holes. All panels foaming phases within the press will be manually carried out by the operator.

Automatic mode lance displacement at closed mould
This is an alternative solution to the previous illustrated technology and it ensure an optimal distribution of the foam with a constant density.

A standard plant composition is based on a high pressure metering machine with relative mixing head which, through an automatic movement system, is introduced inside the panel cavity to the furthest extremity of the panel, previously preassembled and conveyed into the press. The foam distribution takes place during the mixing head retrieving phase/backward movement from the panel.

Automatic mode injection technology at closed mould
This technology is mainly used for the production of panels for walk-in cold rooms and refrigerated containers where high thickness and large width are needed to ensure a smooth and even distribution of the foam with a constant density.

CONSTRUCTION PROCESS

The sequence of Installation of the panels is as follows:

With Floor Slab

- After concreting is done and RCC slab /surface is ready for the installation of PIR wall, it must be ensured that the concrete surface is smooth and not rough so that there won't be any undulation in the panel surface.
- Center line for wall shall be marked and cross check it with the drawings and after that fix the bottom runner section at the base to RCC slab with the help of anchor fastener.
- After fixing the runner base, cross check the dimensions with drawing and ensure that all walls are as per drawing straight and perpendicular. After checking, insert the PIR panels in the runner base and fix the supporting pipes at the end of panel after inserting the panels and pipe, fix the pipe with runner base with screws and PIR panels with supporting pipes by screws.



During installation the alignment of panel, verticality and perpendicularity shall be checked.

With Column

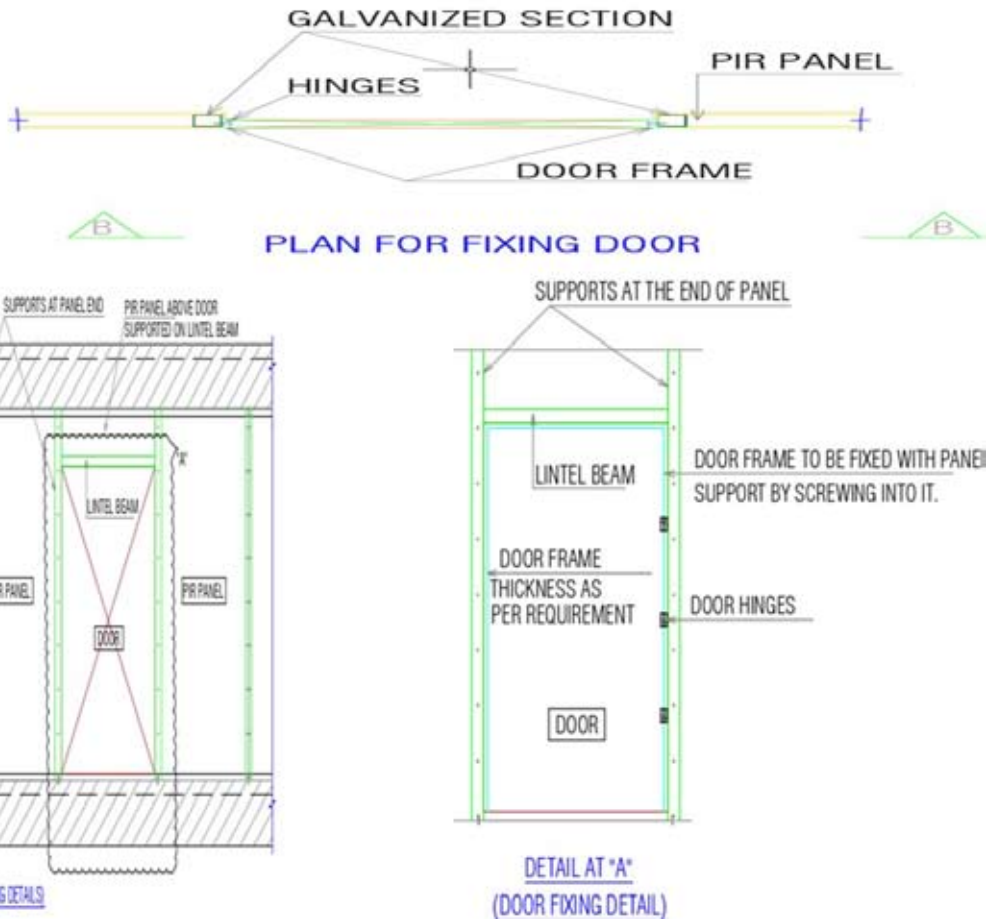
- After concreting is done and column surface is ready for the installation of PIR wall, it must be ensured that the concrete surface is smooth and not rough so that there won't be any undulation in the panel surface.
- Center line for column shall be marked and cross check it with the drawings and after that fix the runner section at the side of column or at the end of wall with the help of anchor fastener to be placed at 600mm c/c.

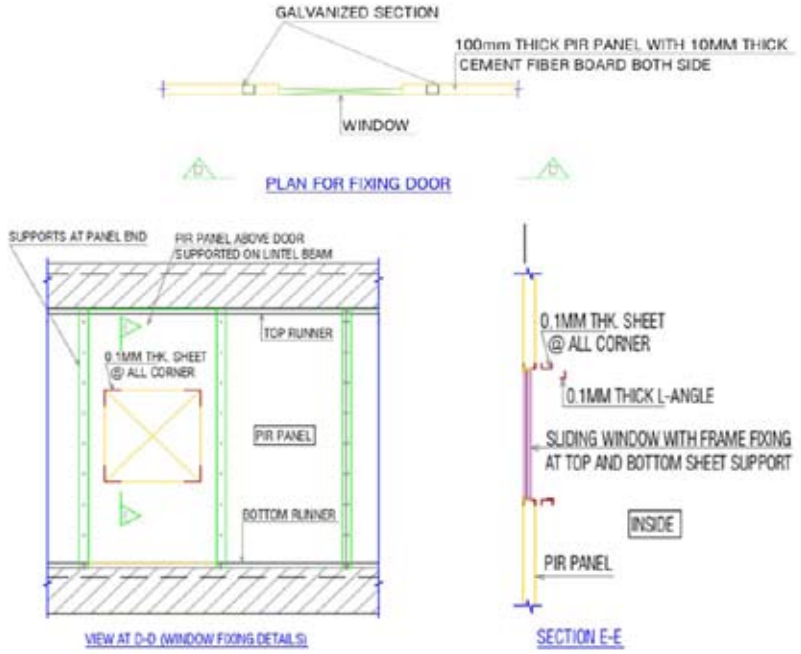




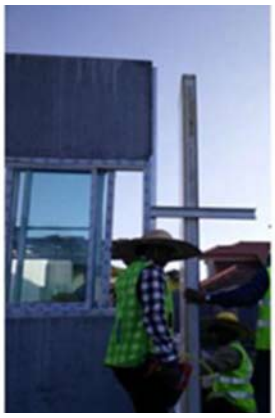
Fixing of door and window

- Cut the panel with the help of jig saw cutter / panel cutting machine for fixing of door and windows as per location in the drawing.
- Fix the door panel with supporting pipes which are placed at the end of each panel and fix the door panels and door.
- For the windows place the c-shape runner at all corner and fix the window frame on it as per the given images below.







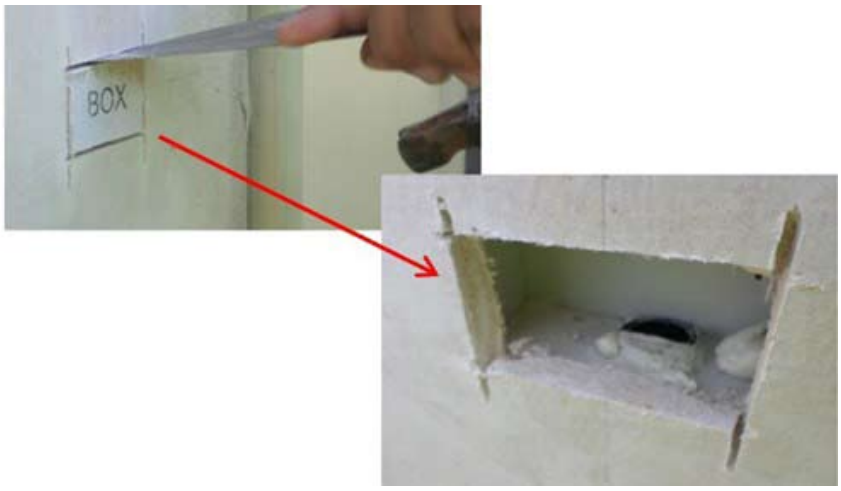




Electrical

Route of all planned electrical wiring or conduits inside of panel that won't be visible from outside and location of boxes on surface of the walls shall be marked with marker.

Electrical boxes with surface mounting side ears shall be Installed similarly by removing a piece of foam next to a stud flange and using course threaded screws secured to the flange.



Plumbing

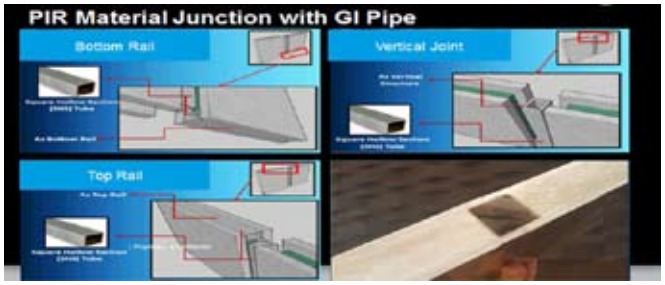
- Good practices of plumbing shall be followed. Plumbing pipes shall usually be not fixed on exterior walls, except kitchen sinks. A channel of required size shall be made for drain, vent and water supply pipes having 60mm foam on inside of the wall.

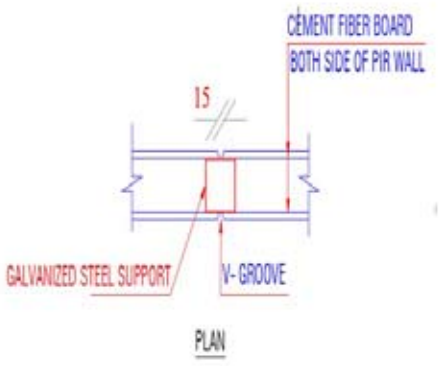
Joint Treatment

- Apply elastomeric putty at the joints between two panels and then allow it to dry. After that fix the glass fiber mesh on the joints, after fixing again apply putty on the net and then apply putty on all over cement fiber board and allow it to dry and apply final coat of paint on it.
- Provide V-groove at 3 to 5mm gaps at every joint and then fill these gaps with elastomeric putty and allow it to dry. After that fix glass fiber mesh at joints and again apply putty and final coat of paint on it

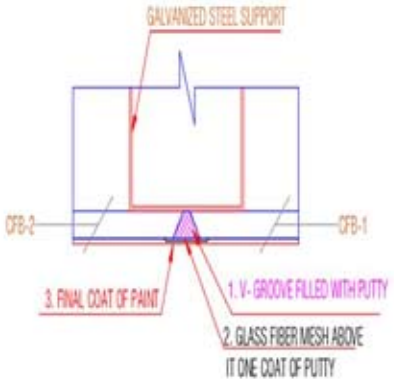




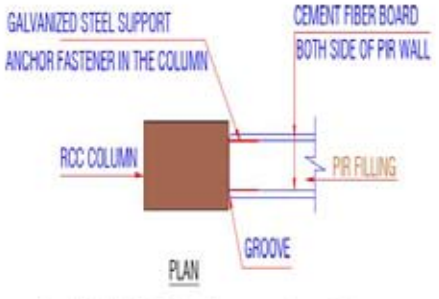




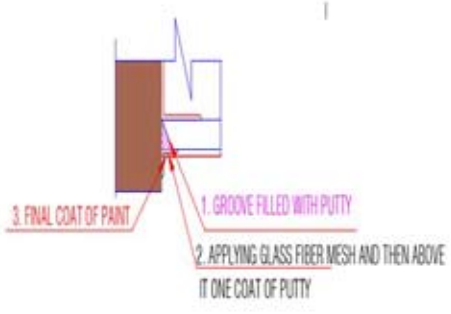
Panel to panel junction detail



Panel to panel joint treatment detail



Panel with RCC Column Junction



Panel to RCC Column joint treatment detail

ADVANTAGES

- PIR wall being non-loadbearing wall panels are to be supported with RCC/Steel Structural frame members.
- No plastering is required.
- Easy to paint on it as compared with convention system.
- PIR panels are thin and consumption of materials is less resulting into lighter structures and saving on building materials.
- PIR panels maintain its performance in the long term. Whilst a building remains fully insulated heating costs are kept under control, which also results in reduced CO_2 emissions.
- The durability of PIR insulation has a positive impact on the life cycle analysis (LCA) of a building project.

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No.: 1039-S/2018 has been issued to M/s Covestro (India) Pvt. Ltd., Thane (Maharashtra).

MAJOR COMPLETED/UNDER COMPLETION PROJECTS

- Affordable L.I.G Housing project for Rajasthan Housing Board (G+3) at Jaipur
- Private House (Ground) at Kanchipuram (TN)
- Model House (Ground) at Sri Lanka

STANDARDS / GUIDELINES TO BE REFERRED

IS 277:2018	Specifications for galvanized steel sheets (Plain & corrugated)
IS 419:1967 (Reaffirmed 2009)	Specifications for putty
IS 456:2000 (Reaffirmed 2016)	Code of practice for reinforced cement concrete
IS 800:2007 (Reaffirmed 2013)	Code of practice for general construction in steel
IS 801:1975 (Reaffirmed 2010)	Code of practice for use of cold formed light gauge steel structural members in general building construction
IS 875 (Parts1 to 3):1987/2015	Code of Practice for design loads (other than earthquake) for buildings & structures
IS 1893 (Part 1):2016	Criteria for earthquake resistant design of structures
IS 1904:1986 (Reaffirmed 2010)	Code of practice for design and construction of foundations in soils: general requirements.
IS 2062:2011 (Reaffirmed 2016)	Specifications for hot rolled medium & high tensile structural steel
IS 2380 (Part 5):1977 (Reaffirmed 2013)	Methods of test for wood particle board and other ligne cellulosic materials – tensile strength test.
IS 11239 (Part 1, 3, 4, 11 & 12):2009/1985/1988/2014	Method of tests for rigid cellular thermal insulations
IS 14246:2013	Continuously pre-painted galvanized sheets & coils
IS 14862:2000 (Reaffirmed 2010)	Specifications for Fibre Cement Flat Sheets
IS 16700:2017	Criteria for structural safety of tall concrete buildings
ASTM D 570-08	Standard test method for determination of Water absorption
ASTM D 695-15	Standard test method for determination of Compressive strength
ASTM D 790-17	Standard test method for determination of Flexural strength
BS 476 (Parts 5, 6, 7)	Fire Tests on Building Materials & Structures – Method of test of Fire Ignitability, Fire Propagation & Surface spread of flame of materials/products

Baupanel System

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE SYSTEM

BauPanel System consists of panels of expanded polystyrene (EPS) and steel wire mesh which are applied with concrete at site. The system comprises of a layer of steel mesh on either side of EPS core welded together by steel trusses (orthogonal) which penetrate through EPS core. The panels are joined together in a configuration on site and sprayed on both sides with shotcrete to form a sandwich panel type construction.

The exterior of the panels shall be finished with weather proof coating or lined with conventional lining material while interior surfaces (walls) and ceilings shall be finished with water/ solvent based coating or lined with conventional lining material.

BASIC RAW MATERIAL REQUIREMENTS

Zinc Coated Cold drawn Steel Wire – Standard wire mesh shall be of 2.5/3.0 mm dia. and zinc coating galvanizing shall be of 60gm/m^2 with a tolerance of ± 5 gm/m^2.

Mechanical characteristics

Yield strength (2.5mm dia)	:>700 N/mm^2
Breaking load	:>750 N/mm^2
Elongation	:> 8%

Chemical characteristics

% C	: < 0.24
% P	: < 0.055
% S	: < 0.055
% Ceq	: < 0.52

Expanded Polystyrene – Self-extinguishing type EPS in accordance with IS 4671:1984 (UNI EN 13163:2012) having density not less than 15 kg/m^3.

COMPONENTS OF BAU PANEL SYSTEM

The structural enclosure panel is made up of a straight undulation of expanded polystyrene plate with a density not less than15 kg/m^3 and a standard width of 1100mm. On both sides, it is covered with steel mesh grids connected to each other on both sides of the EPS panel, through a minimum of 40 steel bars of 3 mm dia. per square meter of panel surface.

Load Bearing Wall Panels: BauPanel System – Reinforced (BSR) and BauPanel System – Normal (BSN) – These panels are manufactured with EPS core of thickness varying from 30mm to 330mm, after concreting the final thickness for BSR panels will be from 112 to 412 mm and for BSN panels will be from 101 to 401 mm. The resultant enclosure reinforcement mesh grid measures 6.11 x 6.50 cm for BSR panels and 9.17 x 6.50 cm for BSN panels. Once the structural enclosure panels have been installed and concreted, these can be used vertically (BSR or BSN) as load bearing walls in buildings. However, selection of panels out of BSR & BSN shall depend upon the structural requirements as per calculations/design.

BSR Panel

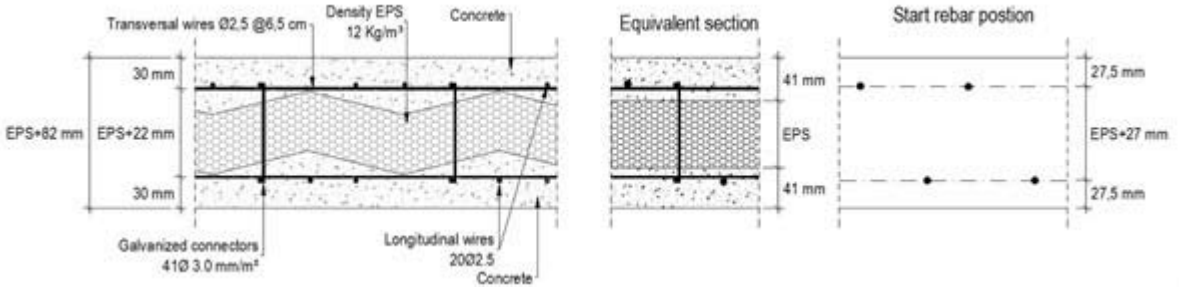


Fig.1

Galvanized steel wire mesh

Longitudinal wires	:	20 ø 2.5 @ 57 mm c/c
Transverse wires	:	ø 2.5 @ 65 mm c/c
Cross wire	:	ø 3.0 mm (41 per m^2 approx.)
EPS thickness	:	30mm to 330mm (according to design calculations)
Finished wall thickness	:	112mm to 412mm(according to design calculations)

These are load bearing panels and similar to the BSN panel except for its structural capacity due to greater thickness of concrete (41mm each side) and greater number of steel bars (20 each side).

BSN Panel

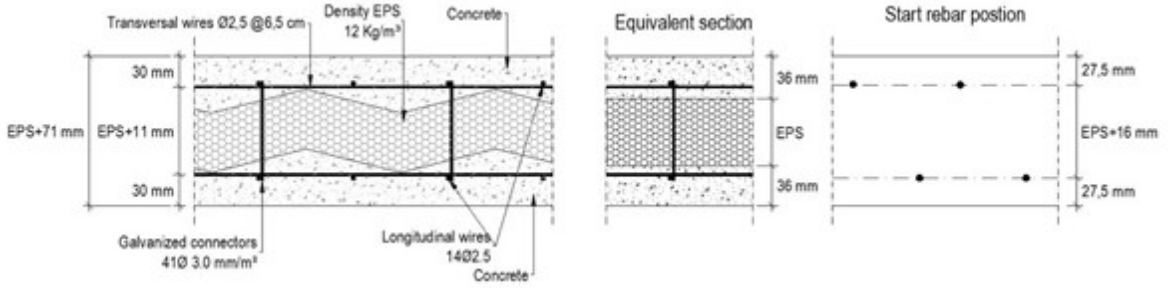


Fig.2

Galvanized steel wire mesh

Longitudinal wires	:	14 ø 2.5 @ 84 mm c/c
Transverse wires	:	ø 2.5 @ 65 mm c/c
Cross wire	:	ø 3.0 mm (41 per m^2 approx.)
EPS thickness	:	30mm to 330mm (according to design calculations)
Finished wall thickness	:	101mm to 401mm(according to design calculations)

For the structural use of these panels, polystyrene core shall be at least 30mm thick and an average quantity of traditional or pre-mixed cement based plaster shall be sprayed on each side of 30mm min. thick of M25 grade or above as required from environmental exposure conditions. These panels shall also be used for internal partitions and external curtain walls.

Slab Panel BSF (BauPanel System – Floor)

BSF panels are also manufactured in EPS of thickness varying from 30mm to 330mm according to design calculation and after concreting the final thickness for BSF panels will be from 132 to 442 mm.

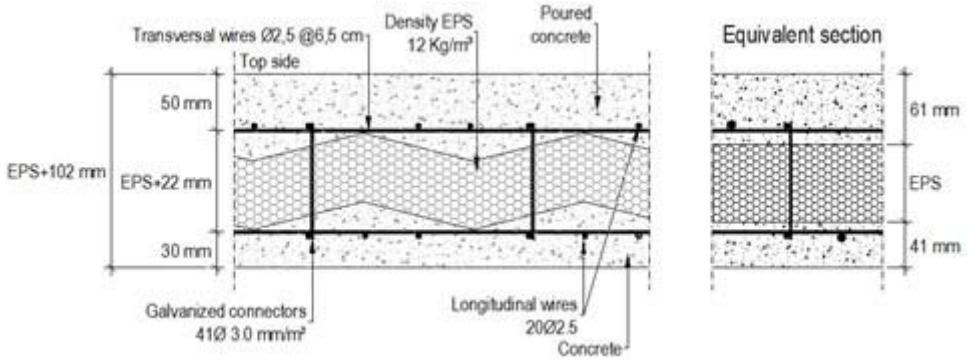


Fig.3

Galvanized steel wire mesh

Longitudinal wires	:	20 ø 2.5 @ 65 mm c/c
Transverse wires	:	ø 2.5 @ 65 mm c/c
Cross wire	:	ø 3.0 mm (41 per m2 approx.)
EPS thickness	:	30mm to 330mm (according to design calculations)
Finished wall thickness	:	132mm to 442mm (according to design calculations)

These panels are used for floors and roofs and are completed at site with concrete on the upper side and structural plaster sprayed on the lower side. These panels are generally used for slabs with a maximum span up to 5m. However, in some cases additional reinforcement of the panels with additional meshes shall be required as per the design of the particular structure.

The panels placed horizontally are capable of resisting flexure and shear forces. They are also intended to withstand the vertical loads that originate in the slab of each floor or roof. They also fulfil the function of transmitting and distributing the horizontal loads to the vertical supporting elements.

Those elements can also be placed inclined, flat or curved to adapt to different situations of the building cover.

The concrete cover thickness over the steel shall be at least 30mm on each side. In slabs, the minimum concrete compression layer thickness shall be 50mm. These concrete cover refer to the distance from the outside of the expanded polystyrene wave to the end surface.

Joints and reinforcements

Foundation joint

The panel joint with the concrete foundation is made through starter steel bars in staggered formation of minimum 8mm. dia., alternating in the faces of the panel. This basic mounting rebar and the rest of the necessary anchorage shall be defined by design calculations. (Fig. 4)

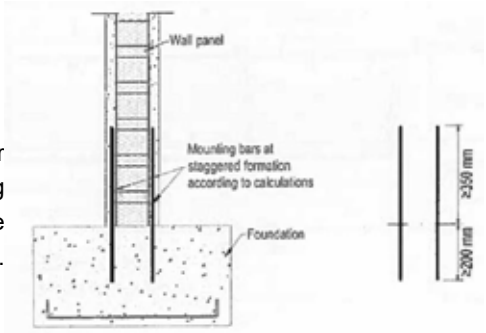


Fig.4

Vertical joint between panels

The steel mesh of each panel exceeds 50mm on opposite sides, so that when joining two panels they overlap each other ensuring continuity by overlapping, without the need to place additional overlap elements. (Fig. 5)

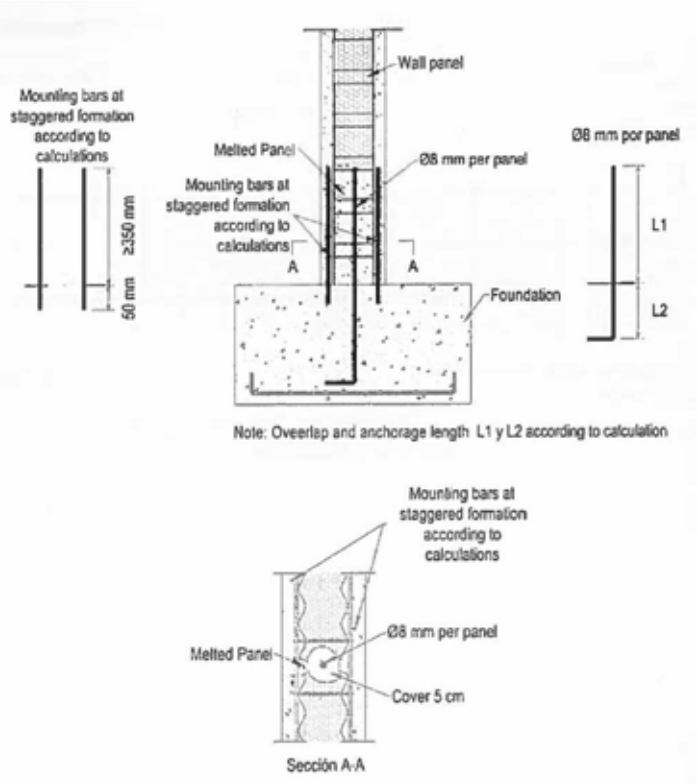


Fig.5

Reinforcement mesh

For the attachment or reinforcement of other auxiliary points, the following connecting steel meshes are used.

- For the joining of enclosures that form an angle to each other, the continuity is solved by the angular mesh (MA), made with the same steel as the panel mesh (galvanized steel with a diameter of 2.5mm at 6.11cm c/c).
- To ensure continuity on both sides of the panel without overlap and to reinforce the corners of wall openings, flat mesh shall be used made of the same steel used in panels mesh with dimensions 260mm x 1150mm.
- The continuity of a panel with another on top is solved by the use of flat mesh (MP) and angular mesh (MA) always according to the manufacturer instructions.

INSTALLATION PROCEDURE

Layout and starter bars installation

- The panels shall be fitted on a reinforced continuous foundation in accordance with conventional calculations. The dimensions shall depend on the permissible ground bearing capacity. (Fig. 6)
- The foundation shall have basic assembly bars, consisting of corrugated steel bars of diameter 8mm. The number of starter bars shall come from the structural calculations corresponding to each project and shall be in staggered position, i.e. placed on alternate sides of the panels. The distance between these rows of starter bars shall be the same as the distance between the mesh, i.e. the thickness of the

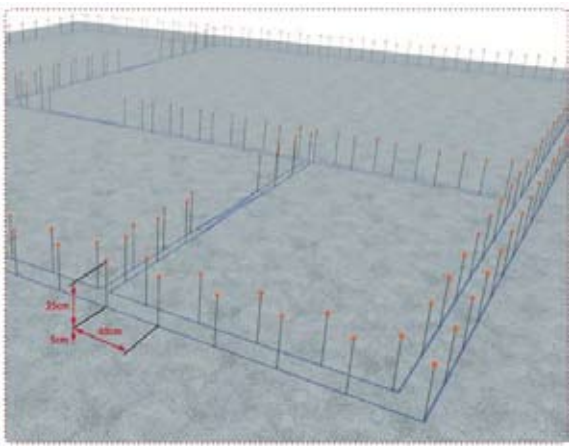


Fig.6

expanded polystyrene core plus 27mm. These bars shall be straight and must be embedded in the foundation no less than 5cm. They must stick out from the upper surface for a minimum length of 35cm. They shall simply be attached to the panel meshes by simple bonding.

- Another possible solution before pouring concrete into the foundation is to place waiting bars in the line of the panel axis, with a diameter equal to or greater than 8mm and a maximum separation of 1.10m (one per panel), in addition to the basic assembly armature of dia. 8mm with the number and separation defined in the previous paragraph, which will be anchored to the foundation in a length of 25cm. In this case, the EPS core shall be completely removed by 5cm around those bars.

Panel installation

- The series of panels joined together over the foundation base makes up all the enclosure surfaces in the building structure: exterior walls and interior walls; over them it shall be placed floor slabs and roof slabs. (Fig. 7)
- The panels shall be linked together via an overlap of 60 mm, which the meshes have on opposite sides of panels; these overlaps shall be interlinked by simply attaching the steel wires together at distances of about 50cm apart. (Fig. 8) Alternatively, the panels can be joined together using staples with an automatic or manual staple gun.
- The joint between panels where horizontal and vertical edges come together must be reinforced using angular meshes (MA) placed along their length and each of their sides. (Fig. 9
- The openings for windows and doors shall be made by cutting the panel while leaving a minimum clearance gap to prevent thermal bridge breakings (about 10 to 20mm). The frames shall be attached to the meshes with staples. (Figs. 10 & 11)
- The openings must have reinforcements at 45º at the Vertices thereof and longitudinal reinforcements obtained by calculation. These reinforcements shall be made with ¼ of flat mesh (MP) supplied together with the Bau panels, for these purposes.
- When previously cut panels have to be spliced and therefore, do not have mesh overlays of opposite faces, the mesh type MP shall be used for these joints, which shall allow a joint by juxtaposition. The same special mesh shall be used in every case when, for different work reasons, the pre-determined Bau panel meshes must be cut. (Fig. 12)
- It is important to ensure that the enclosure walls are properly aligned and plumbed. This can be achieved by using tie rods, metal rulers, telescopic struts or any other element suitable for that purpose. (Fig. 13)
- Subsequently, the conduits of the electrical and plumbing installations can be placed in channels made in the EPS core, by means of a hot air jet gun. Subsequently, the conduits can then be run on the

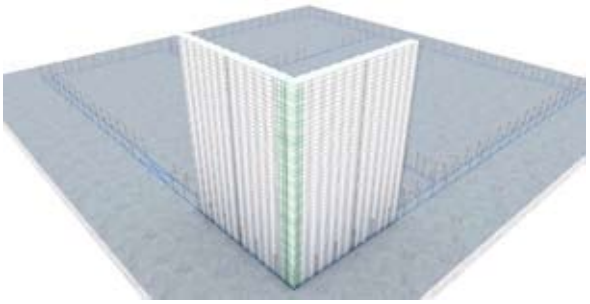


Fig.7

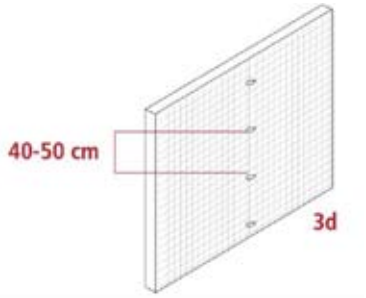


Fig.8

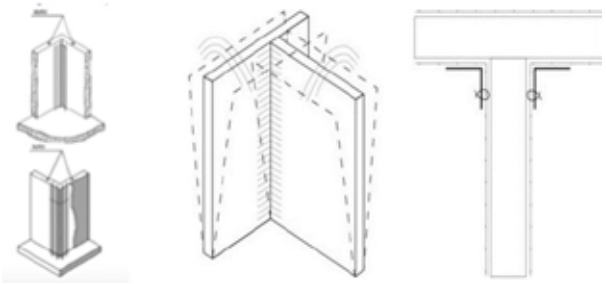


Fig.9

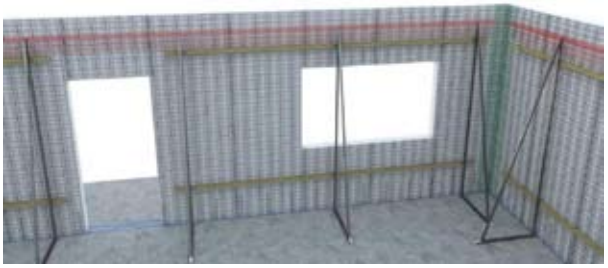


Fig.10

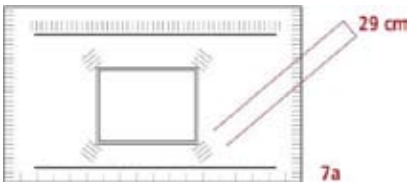


Fig.11



Fig.12

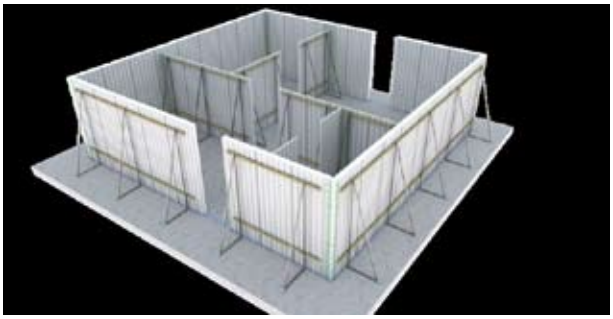


Fig.13

expanded polystyrene by melting it with a hot air gun. The conduits shall leave the corresponding spaces for the pipes that have been determined. (Fig.14)

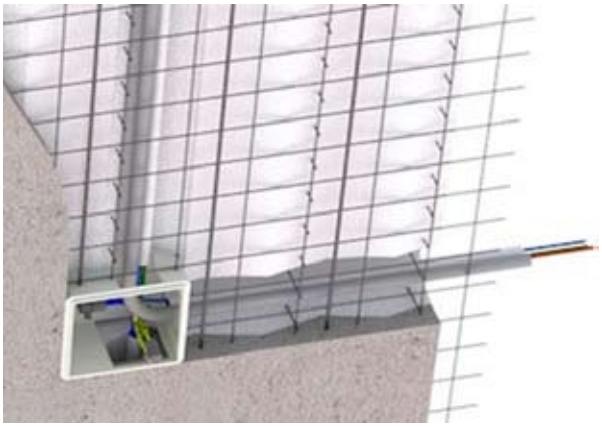


Fig.14

- The upper wall panels, if applicable, must be installed as for the ground floor wall panels. Any built-in hold down or fixing devices required shall be attached in the correct position before concreting commences.
- When the vertical panels are assembled on site, the verticality of the walls shall be checked and the bracing meshes positioned on all the corners.
- The horizontal bracing meshes are then put to connect the floor/ roof to the vertical panel. After checking of bracing meshes, the floor/roof panels are positioned on them.
- The reinforcement of the panel shall be integrated during the panel assembly by additional reinforcing bars – following the design inside the joists. The arrangement is for floor slab having span up to 8.50 m and with live loads up to 5KN/m^2. For large spans, steel stiffening ribs in the pods of the panel may be used. These shall be verified by the design engineer.
- Doors and windows shall be fixed in the panels as per the guidelines issued by the manufacturer. (For details of the joints, bracings and application of the panels see figures 9 to 11).

Services

- The laying of pipes for plumbing, electrical installation, heating services etc. takes place after the panels have been erected and before spraying of concrete takes place.
- Services may be concealed within the panels by installing them behind the welded wire fabric. The chases in the polystyrene shall be carried out by a hot-air gun or similar tools. If insufficient space exists between the welded-wire fabric and polystyrene, the polystyrene may be cut away sufficiently to form the chase for the services. The area surrounding the cut should be restored by the addition of extra mesh connected to the meshwork of the panel. Copper pipes, if used, should be insulated from the mesh work with felt PVC or similar protection.
- No props greater than 50mm dia. should be installed in the Polystyrene. Service pipes or ducts 100mm in diameter or more should be placed outside the structure or in ducts within them. The location of services should be as per the service drawing for the structure. Any alteration or change should be addressed to Bau Panel System and noted in the service drawings.
- PVC sheet and electric cables shall not come in contact with EPS and shall, therefore be contained within a conduit or be laid without conduits away from EPS. Where services penetrate the external panels, the penetration shall be made watertight on the outside. Clearances for service movement shall be made in accordance with the service element providers" specifications.

Concreting

- All concreting work shall be done in accordance with IS 456:2000 with regard to workmanship and materials.

- Concrete shall be sprayed on the walls and ceiling using shotcrete pumps and pumped in place for floor topping slabs. Upper level floor toppings slabs shall usually be placed before internal walls and ceilings to upper levels and allowed to cure to give a platform for spraying the interior.
- For shotcreting, reference may be made to IS 9012:1978. Some supports under slabs may be removed after 3 days but critical supports such as those at mid-span shall be left in place until the slab is fully cured. The structural engineering design shall provide the appropriate details for supports and sequence and timing of removal.
- Concrete shall be of correct strength and mix design as required by the structural engineering design. The pneumatic spray operation can be carried out in one or two phases.
- The first layer will be 2cm thick and cover the steel mesh. It shall be left rough so as to give adequate key to second layer. Correct concrete thickness shall be measured as work proceeds. Screed points of concrete shall be used as gauges to give correct thickness and lines. Hand trowel finishing of the second layer shall be required to give the appropriate finish and surface tolerances. The ability to provide concrete finishes to the tolerances required by the designer shall be dependent on the skill and workmanship of the concrete finishes.
- The second layer is a finishing layer applied until the final required thickness of a minimum 3cm is reached. To do so, guides could be used which may be just steel rods with square or rounded cross sections of 25mm or longer based on the required covering. These shall be used to divide the shotcreted thickness of the concrete. The architectural designer shall be free to choose the type of plastering from conventional materials (plastering and paint on finished surfaces, plaster, spray- on plastic coating, elastomeric paint, etc.).
- Formwork with braces and props should be used to fit Horizontal or sloped surfaces using any of the following procedure. A horizontal or inclined formwork is made with phenolic boards on which a layer of fluid concrete shall be applied to the panel supported in separating blocks that maintain the thickness of 3cm of minimum lower coating; the underside of the panel shall be immersed in the poured concrete. The task shall continue until the entire slab surface is completed. The correct compaction of the lower layer must be ensured.
- Once this task is finished, a 5cm thick compression layer shall be poured. The removal of formwork and uncasing shall be carried out following the standards. (Figs. 15, 16 &17)
- The concrete application can be carried out by using a pneumatic spray gun “hopper gun” type connected to a suitable air compressor, or with a plastering machine. The Hopper gun type, it uses as vehicle for the drive of the fresh mixture, a compressed circulation of air through a compressor that must operate at a constant air pressure of 500 to 600 KPa. This compressor must supply between 300 and 350 liters of air per minute for each of the devices used and connected to it.
- Concrete spraying makes a continuous and monolithic element out of the enclosures and slabs made up of panels as well as their joints.

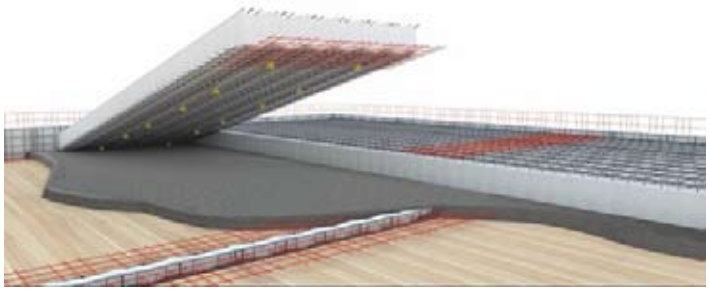


Fig.15



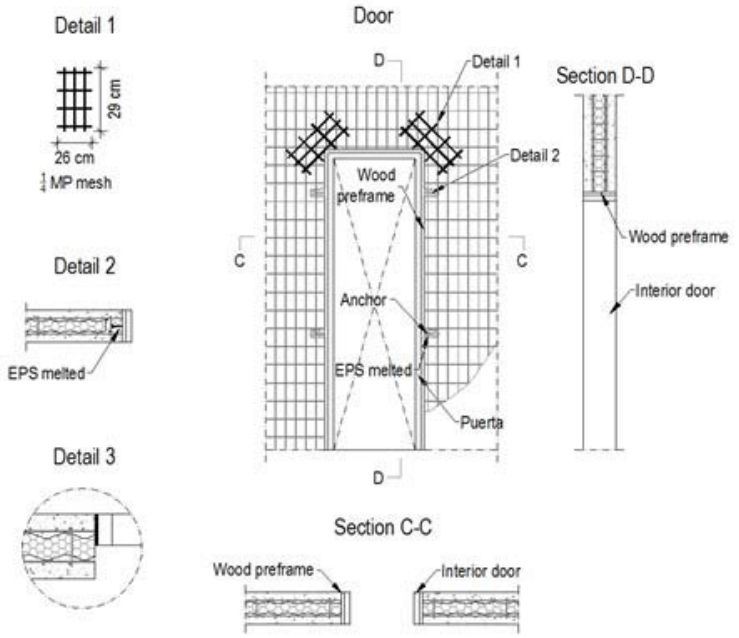
Fig.16



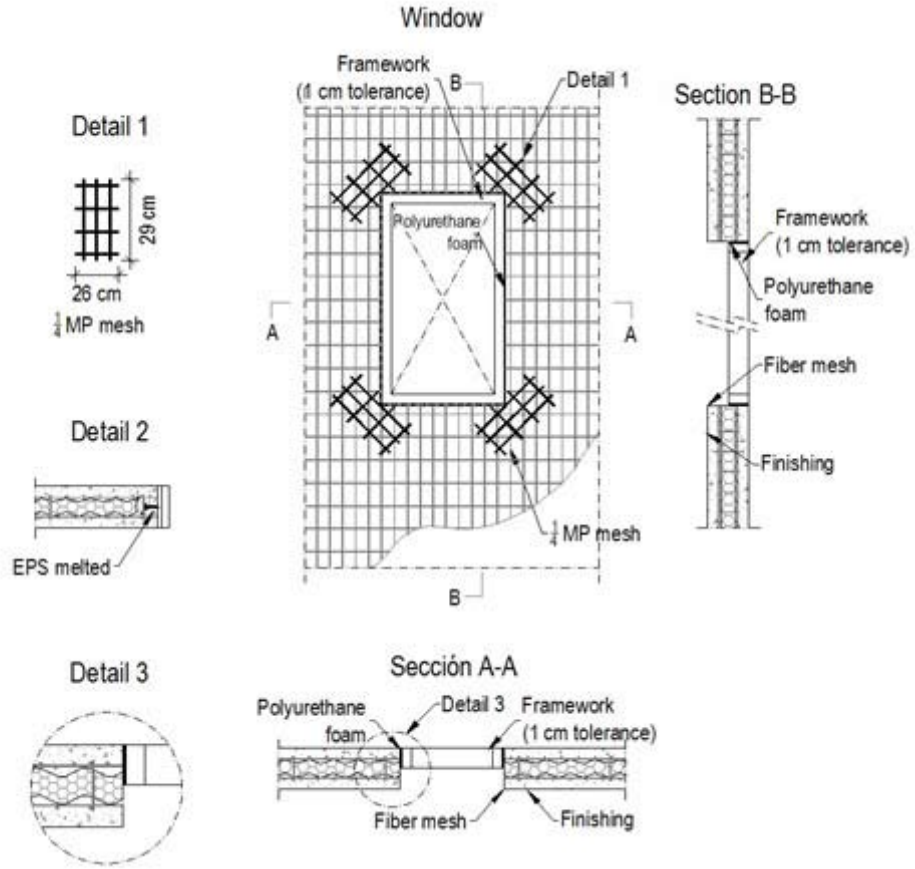
Fig.17

Door and window fixing details and other joining details:

Jointing and Construction Details

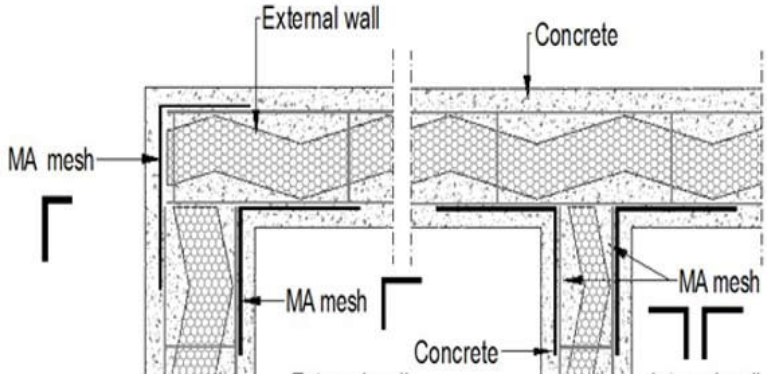


Door Detail

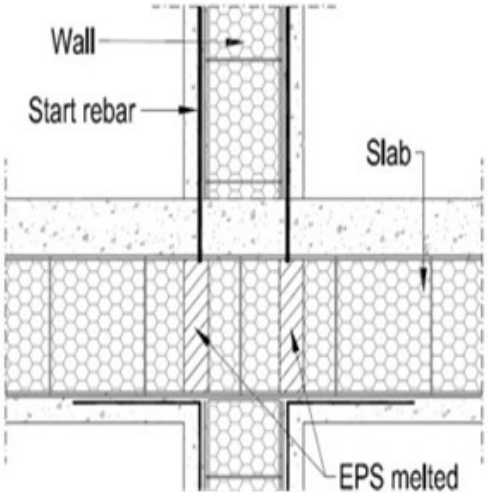


Window Detail

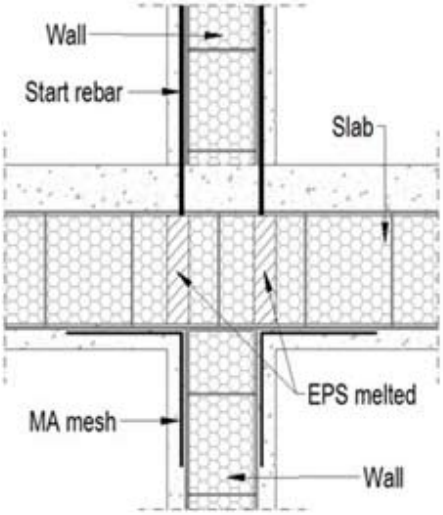
Construction detail



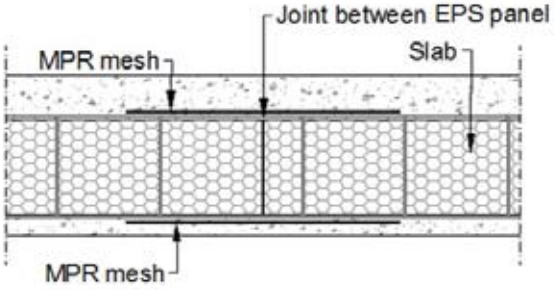
Joint detail of external wall interface



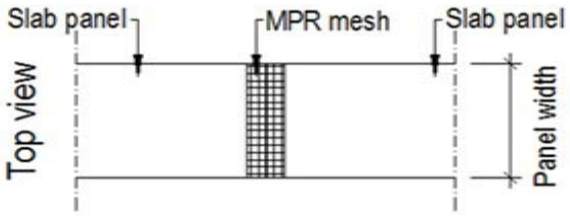
Joint detail of continuous internal Wall panel with slab panel



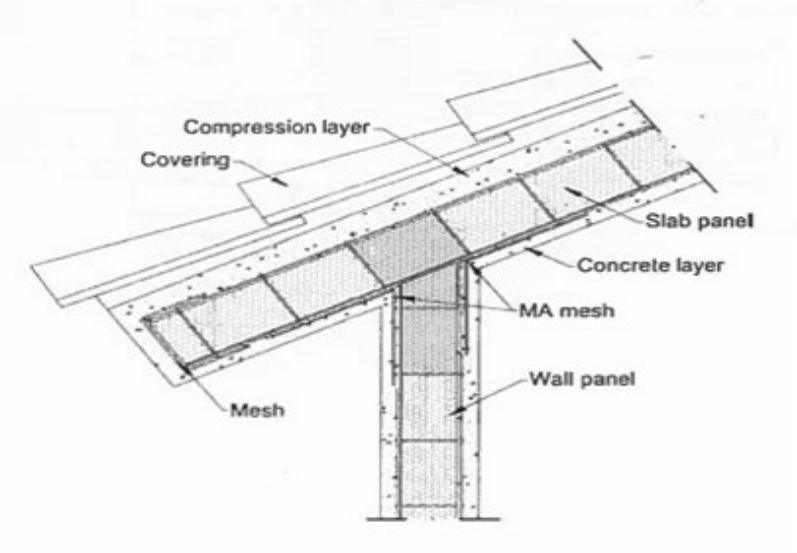
Joint detail of internal Wall and slab interphase



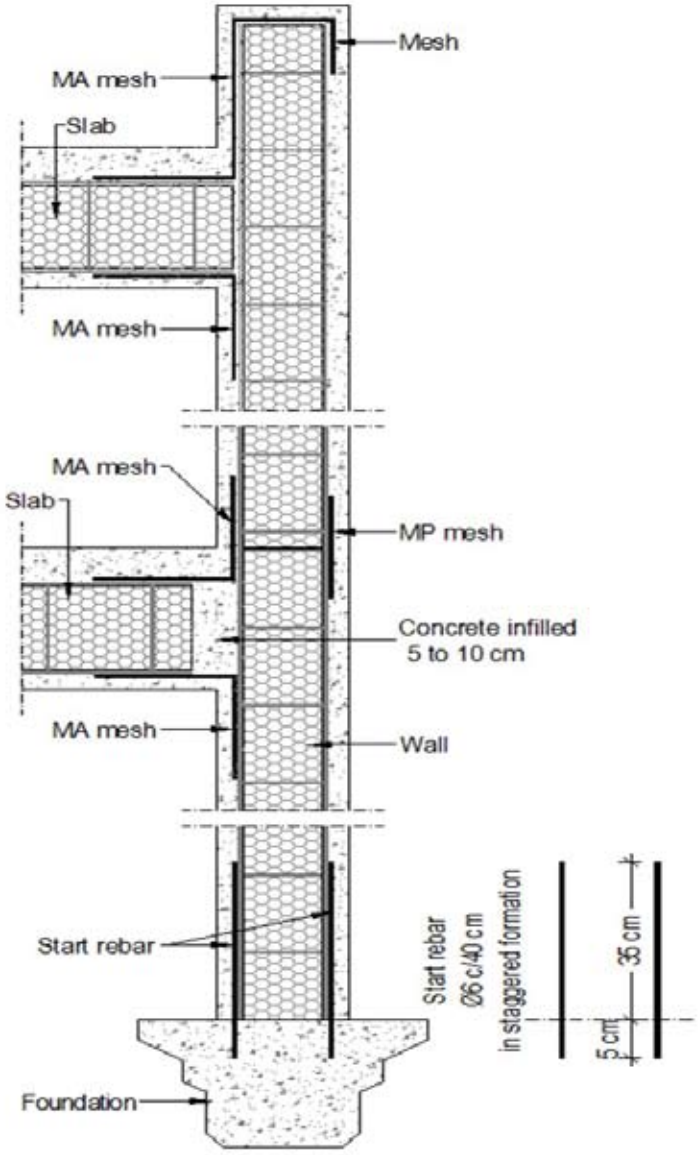
Longitudinal connection between panels



MPR mesh scheme



Joint detail between wall and sloping roof



Construction Details

Precaution

If the panel is cut during erection and its meshwork has no wire- crossing points, panels should be joined with flat meshwork (min. width 225mm).

Finishing

After joinery installation is completed using the details set out in the Technical literature, the interior and exterior finishes may be applied to the concrete surfaces. Interior surfaces walls and ceiling) may be finished with a thin coat interior plaster applied in accordance with the Technical literature. Alternatively, any other suitable lining system may be applied.

Fixing object to walls

Light weight object: 2.5mm screws, pins or similar devices may be used.
Heavy object (shelves, water tanks etc.): Plastic pins with 45mm screws or similar devices are recommended.
Very heavy object: During erection, metal pins may be inserted in plaster pallets.
Alternatively, threaded pins fastened with epoxy resin may be used.

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No.1041-S/2018 has been issued to M/s Bau Panel System India Pvt. Ltd., Pune.

MAJOR COMPLETED / UNDER COMPLETION PROJECTS

- Two storey model housing unit in Bangalore
- One villa in Chennai
- Various residential & commercial buildings, offices, hospitals & hotels etc. since 2003 in many countries namely Spain, Portugal, Great Britain, Holland, Russia, Antigua y Bermuda, Malaysia, Ghana, Ivory Coast, Cameroon, Gabon, Mozambique, Morocco, etc.

STANDARDS / GUIDELINES TO BE REFERRED

IS 383: 2016	Specifications for coarse and fine aggregates from natural resources
IS 456:2000 (Reaffirmed 2016)	Code of practice for plain and reinforced concrete
IS 516:1959	Method of tests for strength of concrete
IS 875 (Parts 1 & 2):1987 (Re-affirmed 2008)	Code of practice for design loads for buildings and structures
IS 1893 (Part 1):2016	Criteria for Earthquake Resistant Design of Structures
IS 1904:1986 (Reaffirmed 2007)	Code of Practice for design and construction of foundations in soils: General requirements.
IS 2062:2011 (Reaffirmed 2016)	Specifications for hot rolled medium & high tensile structural steel
IS 3346:1980 (Reaffirmed 2017)	Method of determination of thermal conductivity of thermal insulation materials
IS 4671:1984 (Reaffirmed 2017)	Specifications for expanded polystyrene for thermal insulation purposes
IS 4759:1996 (Reaffirmed 2016)	Hot Dip Zinc Coating on Structural Steel Products
IS 9012:1978 (Reaffirmed 2011)	Recommended practice for shotcreting
IS 9901:1981 (Reaffirmed 2007)	Measurement of sound insulation in buildings and building elements
BS 476 (Part 21):1987	Method for determination of fire resistance of load bearing elements of construction
BS EN 13163:2012	Thermal insulation properties of materials

Flyash EPS (Beads) Cement Sandwich Panels

(Suitable as Load Bearing Panels for Single Storey Structures and as Non Load Bearing Panels in Low to High Rise Structures)

ABOUT THE SYSTEM

Flyash EPS Cement Sandwich Panels are lightweight solid core sandwich panels made of 5mm non-asbestos fiber cement boards on both sides of panels as facing sheet and the core material of expanded polystyrene beads, admixture, cement, sand, fly ash and other bonding materials in mortar form.

The core material in slurry state is pushed under pressure into preset molds. Once set, it is moved for curing and ready for use with RCC or steel framed structure. These panels may be installed without any structural support up to 5m only. Due to the sheets, the panels do not require plastering and water curing. These panels are joined with tongue & groove jointing system. Isometric view of the panels are shown in Figs. 1 & 2.

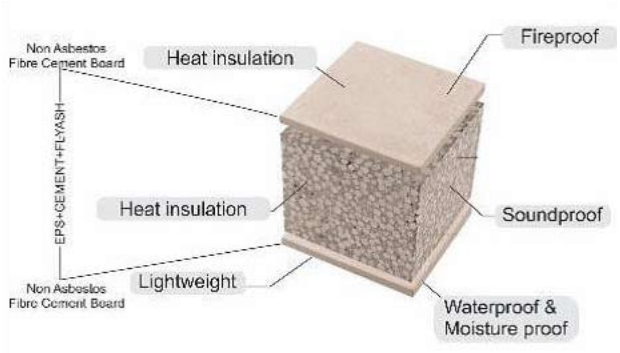


Fig.1

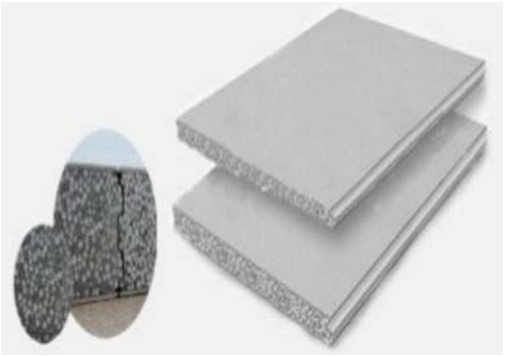


Fig.2

Size and Weight of Panels

Panels are normally produced in sizes and dimensions as given below:

Length: 2440mm (1500mm to 3000 mm)
Width: 610 mm (may be altered as per requirement but should not be too wide since handling of the panels become difficult)
Thickness: 60mm, 75mm, 90mm & 120 mm.
Weight:
60 mm: 44 kg/m^2, 75 mm: 54 kg/m^2, 90 mm: 75 Kg/m^2 , 120 mm: 100 Kg/m^2

BASIC RAW MATERIAL REQUIREMENTS

(i) OPC 43/53 grade cement shall conform to IS 8112:2013/ 12269:2013.

(ii) Fly ash shall conform to IS 3812 (Part 1):2013.

(iii) EPS beads shall conform to IS 4671:1984 and shall have density not less than 15 kg/m^3.

(iv) Fibre cement board shall be of Type A & category C as per IS 14862:2000.

(v) Calcium silicon board shall conform to EN 14306: 2009.

(vi) Fine sand & coarse aggregate shall conform to IS 383:2016.

(vii) MS-C Channel shall be manufactured from pre-galvanized high tensile steel conforming to IS 277:2018.

(viii) Adhesive & Bonding agents shall conform to the manufacturer specifications.

Size of MS '*C' Channel (see Figs. 3 & 4):*

For 60 mm panel

Size for bottom: (A) 28mm x (B) 61mm x (C) 18mm
Size for top: (A) 28mm x (B) 61mm x (C) 28mm

For 75 mm panel

Size for bottom: (A) 28mm x (B) 76mm x (C) 18mm
Size for top: (A) 28mm x (B) 76mm x (C) 28mm

For 90 mm panel

Size for bottom: (A) 28mm x (B) 91mm x (C) 18mm
Size for top: (A) 28 mm x (B) 91 mm x (C) 28 mm

For 120 mm panel

Size for bottom: (A) 28mm x (B) 121mm x (C) 18mm
Size for top: (A) 28mm x (B) 121mm x (C) 28mm

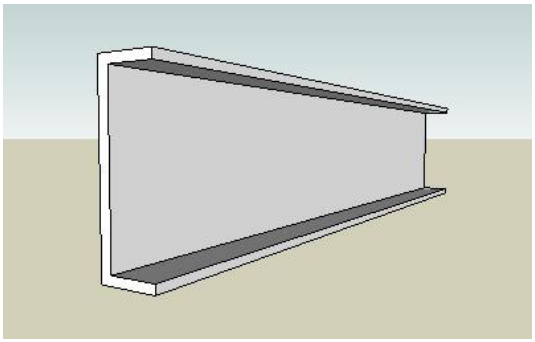


Fig.3

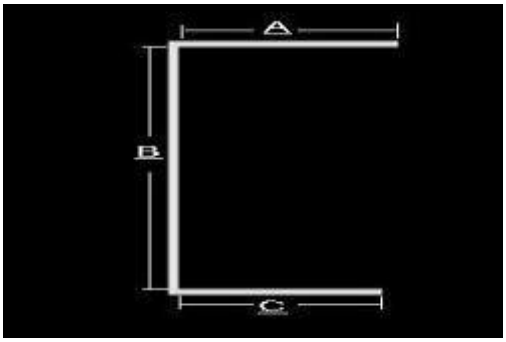


Fig.4

MANUFACTURING PROCESS

Raw materials preparation

- EPS granules shall be expanded into foam EPS by expanding machine/system with suitable size and store the foam EPS in storage silos ready for next production stage.
- Cement, fly ash and sand shall be transported from the storage silos by the screw conveyors to the mixer according to the programmed ratio and water shall be fed into the mixer in designated proportion.
- The foamed EPS shall be transported through the blower in a programmed quantity at the same time into the mixer and mixed with the slurry.
- Additives shall be added to the mixer at the same time.
- After about 8 minutes of mixing, the finished mixed materials shall be ready and discharged into the filling hopper.

Materials filling system

During the materials mixing process, the mould shall be set and two covers of fiber cement board inserted one by one in each mould. Thereafter, the ready-set mold shall be moved under the filling platform by winch machine.

Material Filling

Once the mould cars are under the filling hopper, the top platform will open and the material shall be filled into the moulds under pressure.

Curing

After the filling is over, the filled mold cars shall be transported by the ferry car to the curing area for about 5 to 6 hours curing. Curing time depends on the site temperature conditions.

De-moulding process

- After required period of curing, the panels in the mould shall have gained enough strength and suitable for de-moulding. The de-molding process can be automatic or manual depending on the mold car chosen.
- If the mould car is automatic type, de-moulding machine shall be used to pull the panels out of the mould car automatically. In one step, one panel will be pulled out from the car and stacked.
- If the mould car is manual type, the panels shall move out of the mould cars one by one and stacked.
- Once the stack is sufficient, the fork lift shall move them to the packing area for dispatch.
- After this process is completed, the mould cars shall re-set for the next production cycle.

INSTALLATION PROCEDURE

Installation of panels & Jointing Procedure

- The installation process and jointing procedure of the panels is given in the following steps:
- A line shall be drawn on the plinth where panel is to be fixed
- The panel shall be fixed on floor and top using 1mm/1.2mm thick galvanized C channel
- Screws shall be fixed in wall and pillar
- The panel shall be installed properly with correct alignment and then fixed
- Reinforcement bars shall be fixed in the beam and panels
- Panels shall be joined by tongue & groove joint (Figs. 5 & 6)
- The panels shall be cut for doors and windows, wherever required
- Panels shall be cut at appropriate places to accommodate plumbing pipes
- Panels shall be cut at appropriate places to accommodate electrical conduits and switches
- The panels shall be grouted and glue filled in the joints
- After that fibre mesh and putty shall be applied over the joints.
- On interior walls, paint comprising of 2 coats of acrylic water based emulsion/oil bound distemper/synthetic enamel paint, as required, shall be applied on the panels
- On exterior walls, paint comprising of 2 coats of synthetic enamel paint/exterior grade emulsion/texture paint, as required, shall be applied on the panels.

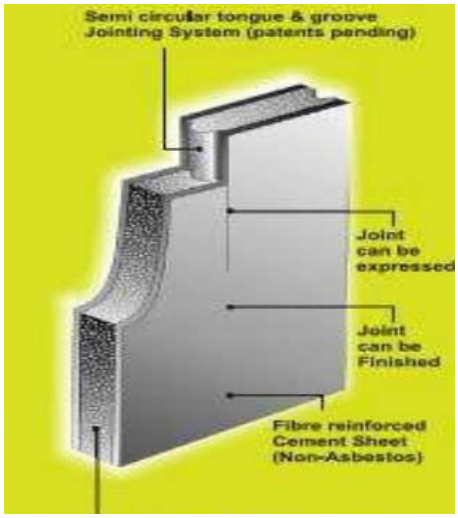


Fig.5

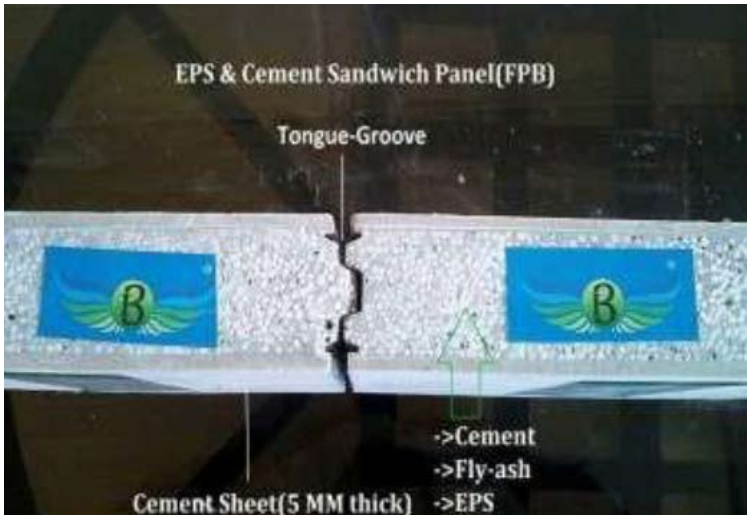


Fig.6

Details of installation and jointing procedure is given here below:

Typical Installation Process



1. Setting the Line



2. Fit the "C" Channel



3. Planting Screw in wall and pillar



4. Installation Panels



5. Correcting, Fixing



6. Planting Bars in Structure Beam



7. Planting Bars in panels



8. Door/Windows Cutting



9. Plumbing Work



10 Installing electrical wires and switches

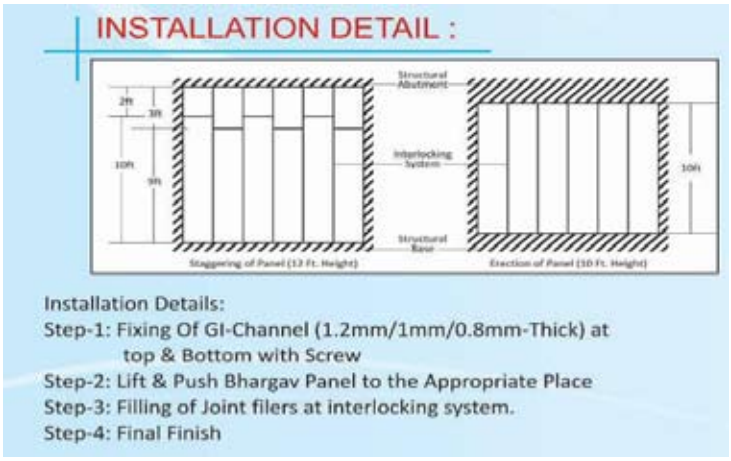


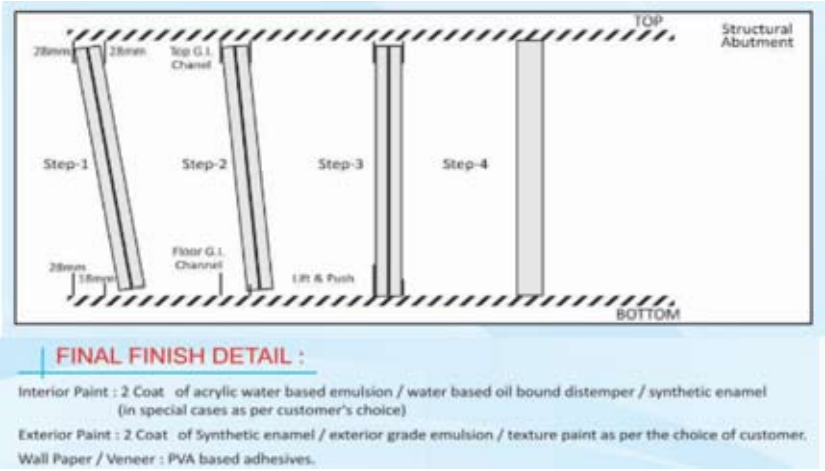
11. Grouting and filling starch



12. Chicken mesh tape and putty

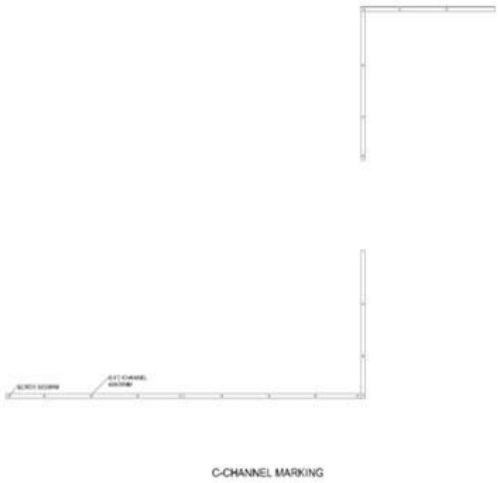
Jointing and Fixing Details





C-Channel marking & cutting of panel

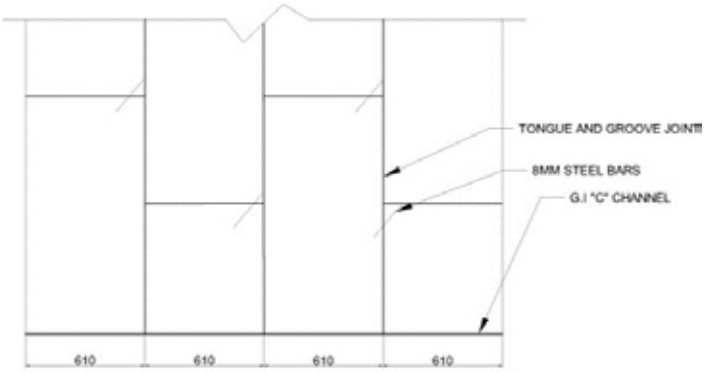


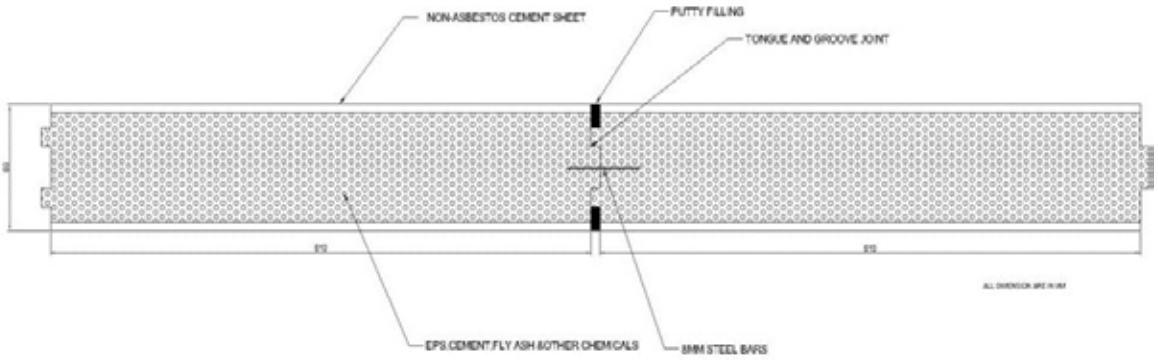


Joining of panels with each other



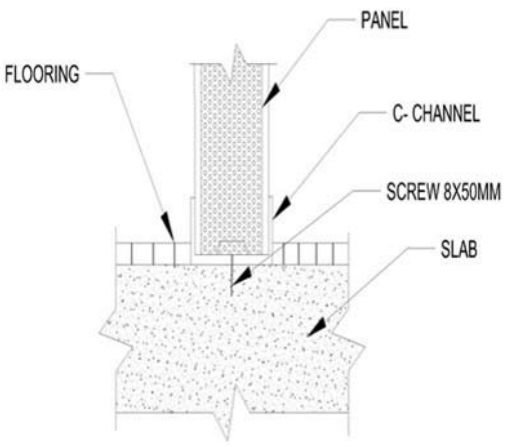






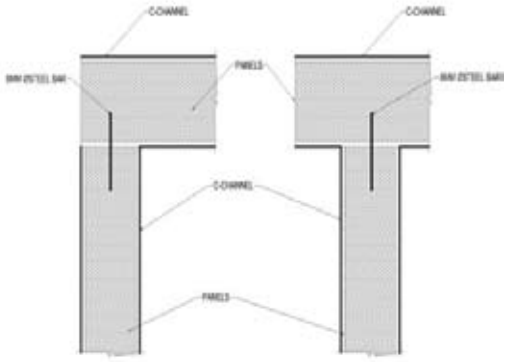
Typical joint with floor





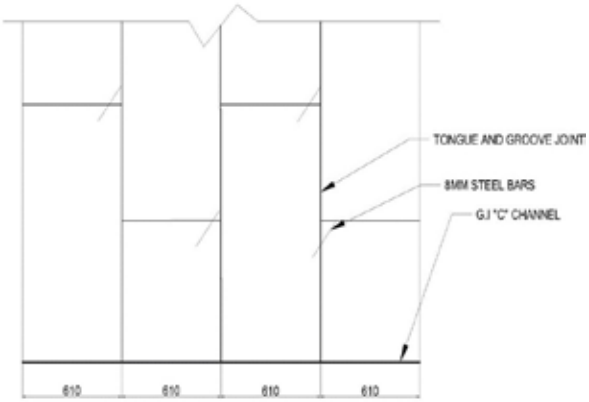
L and T joints with panels





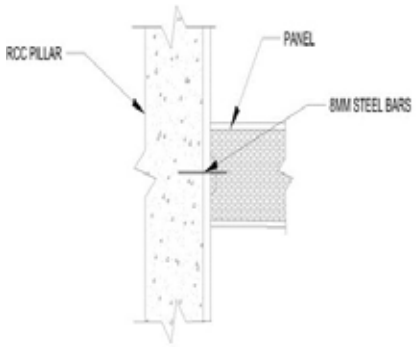
Joining of upper and lower panels together

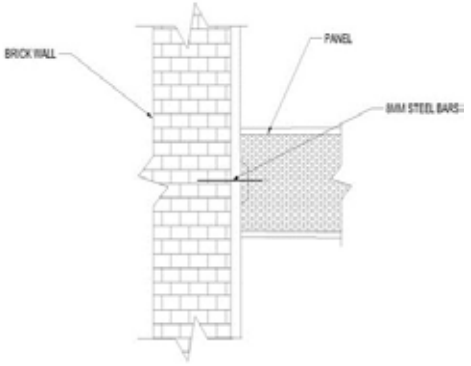




Connecting panels with RCC pillar/Brick walls/RCC beams



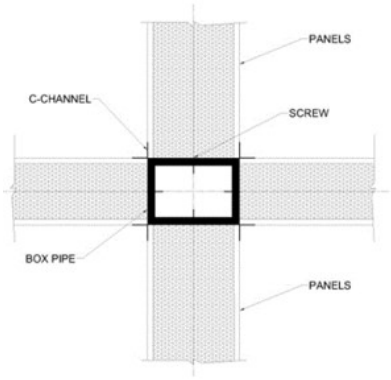


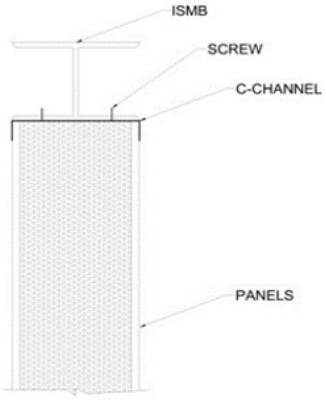


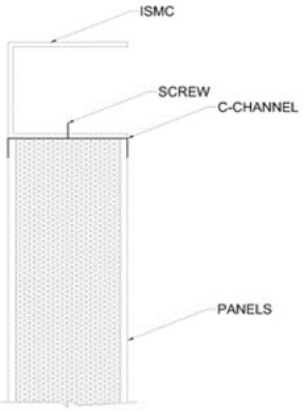
Fixing of panels to M.S frame (Beam & Channel)







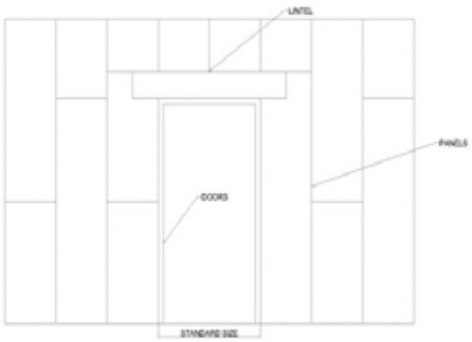


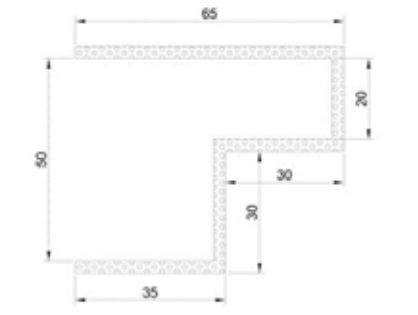


Door Fixing







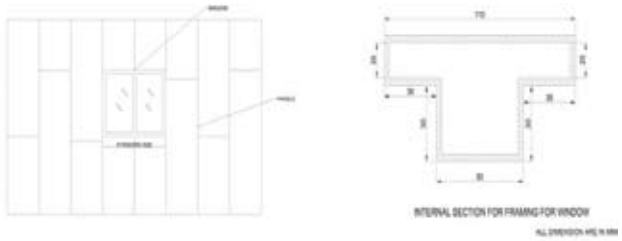


"C" CHANNEL FOR FRANING OF DOOR & WINDOW

ALL DIMENSION ARE IN MM

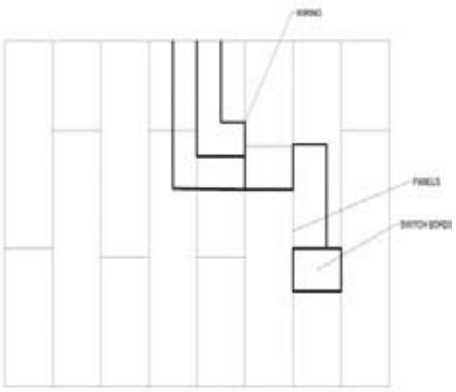
Window Fixing





Laying of electrical conduits

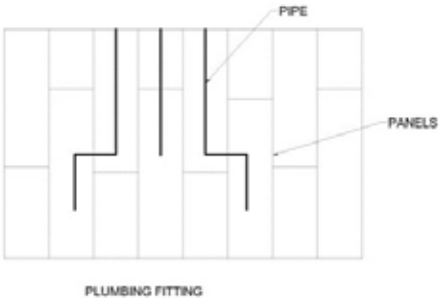




Laying of plumbing pipes







MAJOR COMPLETED/ UNDER COMPLETION PROJECTS

- Nav Rachana University, Vadodra, Gujarat
- Shelters on bank of Tapi river, Surat, Gujarat
- Maruti Showroom, Godhra, Gujarat
- The Times of India, Ahmedabad
- Royal Enfield Workshop, Surat, Gujarat
- Nexa Showrrom, Palanpur, Gujarat
- Chaitanya Vatika Banquet & Guest Rooms, Surat, Gujarat
- Sheetal Restaurant, (PEB Structure), Surat, Gujarat
- BMC Varsova & Dardar, (PEB Structure), Surat, Gujarat
- NIIT/BETA Class Rooms, South Gujarat

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No.1042-S/2018 has been issued to M/s Bhargav Infrastructure Pvt. Ltd., Surat.

STANDARDS/GUIDELINES TO BE REFERRED

IS 383:2016	Specifications for coarse and fine aggregates from natural resources
IS 456:2000 (Reaffirmed 2016)	Code of practice for reinforced cement concrete
IS 516:1959 (Reaffirmed 2013)	Standard test method for flexural strength of concrete specimens
IS 2185 (Part 1):2005 (Re-affirmed 2010)	Specifications for concrete masonry units – hollow and solid
IS 3346:1980 (Reaffirmed 2017)	Method of determination of thermal conductivity of thermal insulation materials
IS 3812 (Part 1):2013	Specifications for flyash for use as pulverized mixture in cement concrete
IS 4671:1984 (Reaffirmed 2017)	Specifications for expanded polystyrene for thermal insulation purposes
IS 9901:1981 (Reaffirmed 2007)	Measurement of sound insulation in buildings and building elements
IS 8112:2013	Specifications for 43 grade ordinary Portland cement
IS 12269:2013	Specifications for 53 grade ordinary Portland cement
IS 14862:2000 (Reaffirmed 2010)	Specifications for fibre cement flat sheets
IS 16700:2017	Criteria for structural safety of tall concrete buildings
ISO 179 (Part 2):1999	Determination of properties of charpy impact strength
ASTM C 293	Standard test method for determination of flexural strength of concrete
ASTM C 495	Standard test method for determination of compressive strength of concrete



V-Infill Wall (Light Weight EPS Wall)

(Suitable for Load Bearing Panels in Single Storey and as Non-Load Bearing Panels for Low to High Rise Structures)

ABOUT THE SYSTEM

V-Infill Wall is an innovative emerging building and construction technology using factory made 8/10mm fibre cement boards (V-board) on either side of GI studs and erected to produce straight to finish walls which are filled with light weight concrete made of EPS, cement, sand and additive. The system may be integrated with conventional column and beam for pre-engineered buildings. The walls may be used as partition walls for external and internal applications.

The GI studs are “C” cross-section with built in notch, slots, service holes etc. fixed with floor and ceiling channels using anchor fasteners at spacing of 300mm c/c. Provisions for doors, windows, ventilators and other cutouts as required shall be incorporated. Electrical and plumbing pipes/conduits shall be provided in the service holes of studs before concreting is done.



Fig. 1

Types of Walls

There are two types of V-Infill Walls as per details given below

1. 88 mm thick wall consists of 8mm thick board of size 1.22m x 2.44m on either side of 70mm G.I studs and screw of 8g x 25mm length.
2. 150mm thick wall consists of 10mm thick board of size 1.22m x 2.44m on either side of 130mm G.I studs and screw of 10g x 32mm length.

Size of Walls

Walls are made in-situ so there is no standard size of walls. However, height and length of wall shall not be more than 3m and 6m respectively. Details of V-Infill Wall is shown in fig. 2.

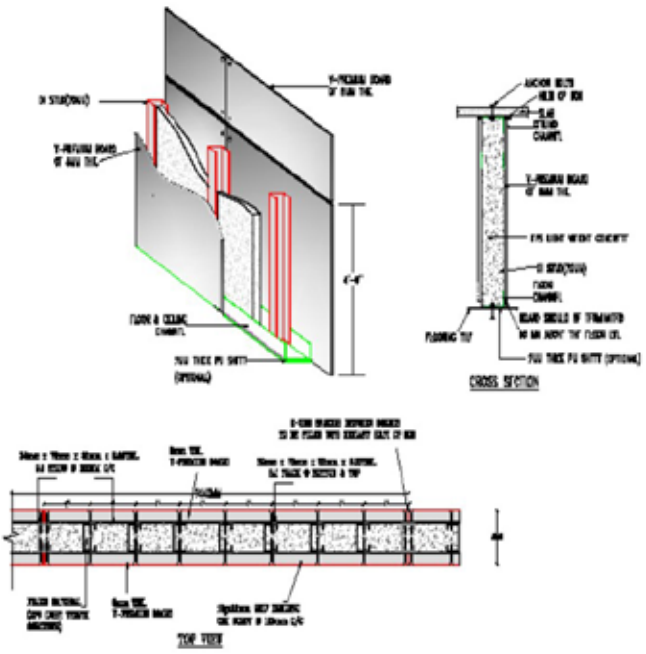


Fig. 2

BASIC RAW MATERIAL REQUIREMENTS

1. OPC shall conform to relevant grade of Indian Standard.
2. Fly ash shall conform to IS 3812 (Part 2):2003.
3. Coarse sand shall conform to IS 383:2016
4. Fibre cement board shall be 100% asbestos free and of Type A, Category 3 min. as stipulated in IS 14862:2000.
5. EPS beads shall conform to IS 4671:1984
6. GI stud and channel shall conform to IS 277:2003.
7. Adhesive shall conform to the specifications of the manufacturer.
8. Liquid bond shall conform to the specifications of the manufacturer.
9. Screws and anchors shall conform to IS 277:2018.

CONSTRUCTION PROCESS

Typical Activity for construction using V-Infill Wall is given below:

Pre-construction
Excavation, PCC and Raft foundation

Construction Activities

1) Erection of frame work with GI studs and channel
2) Placing 10mm & 8mm dia TMT bars as specified
3) Providing electrical and plumbing conduits
4) Fixing of fibre cement board on both sides of frame
5) V-Infill Concrete mixing and pumping
6) Finishing of joints with jointing powder mixed with fevicol.

Framing

The framing section shall be cold form “C’ type of 0.55 mm to 0.60 mm thickness in required length as per structural design requirements, duly punched with dimple slots at required locations as per approved drawings. The slots shall be along center line of the web and shall be placed at 250 mm min. away from both edges of the member. The studs shall be of specified dimensions and fastened with GI channel to both top and bottom slab. Frames shall be assembled together to fabricate structures using anchor fastener. The V-Infill Wall frames shall be connected by using special screws which shall conform to ASTM C 1513.

Fibre Cement Board shall be non-Asbestos autoclaved product. It hall be composed of a composite matrix containing special grade cellulose fibres, ordinary Portland cement, fine silica, quartz and mineral additives. It shall be manufactured as per IS 14862:2000 having good acoustic and thermal insulations.

Light Weight Concrete shall be prepared by mixing the raw materials in proportion as below:

1	Cement -Kg	50	per batch
2	Water -Ltrs	22.5	per batch
3	Visaka Additive- gms	100	per batch
4	EPS- 3 to 5 mm Dia beads- Kg	1	per batch
5	Sand - coarse- Kg	25	per batch

The concrete used shall be light weight and free flow. The light weight concrete shall be mixed and used at site. The light weight concrete shall be pumped into the gap between the panels.

Erection of V-Infill Wall

Line marking shall be as per wall layout with chalk or pencil.

The frame structure shall comprise of “C “cross section studs (vertical members) and tracks (horizontal members) frames assembled together by means of mechanical screws. GI Channel tracks (72mm) shall be placed on the foundation or on the floor and ceiling in alignment. They shall be fixed using anchor fasteners of 6mm dia. at spacing of 400mm c/c.

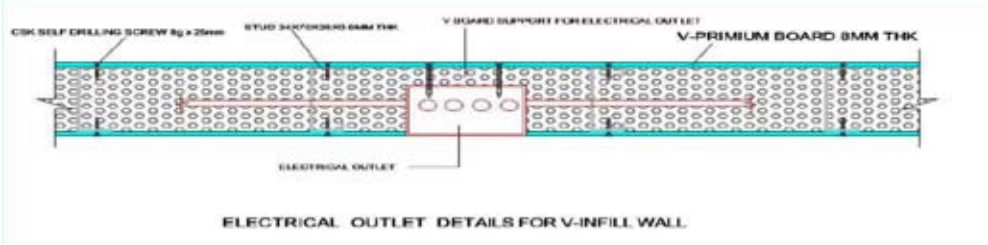
After fixing of floor and ceiling channels, GI “C” studs (70mm) shall be placed vertically with a minimum gap of 12mm to 20mm from top and bottom of floor channel webs. They shall be fixed together with self-driven metal screws at spacing of 300mm c/c. For provision of doors, windows and other openings, additional studs shall be provided. See in Fig. 4.



Fig. 4

Electrical conduits and plumbing pipes shall be placed through the slots/holes provided in the web of the studs. Electrical boxes and boards should be fixed and embedded in EPS concrete properly. See in Fig. 5

Before fixing of cement fibre board, adhesive (liquid PU) shall be applied on flanges of GI studs. After that Vpremium board of thickness 8/10 mm shall be fixed horizontally on both sides of the frame work up to 1200mm height using self-driven screws of 8g x 32mm at 200mm spacing. See in Fig.6.



ELECTRICAL OUTLET DETAILS FOR V-INFILL WALL

Fig. 5



Fig. 6

Concrete mix

Light weight and free flow concrete shall be used for this purpose. Concrete shall be prepared by mixing cement, coarse sand, EPS beads, water and additives in specified ratio.

Pouring of Concrete

Prior to start concrete pour, it must be re-checked to ensure that all members are properly aligned and plumbed. The concrete specified shall be highly workable, free flowing mix poured from the top into the cavities using a small hose for pumping. For small building construction, concrete can be poured manually using a funnel. Filling the cavities with concrete shall be done in two layers of 600mm height with an interval of 2 to 3 hours between each layer. Needle vibrator or rubber mallet may be used for equal distribution and compaction of concrete inside the cavities. Pouring shall be continued in the upper portion in a similar manner. Top portion shall be filled after cutting 150mm x 150mm U shape slot in the board.

Joint Treatment:

After walls are completely filled and mix dried, joint treatment shall be done using fibre mesh tape and putty mixed with binder (fevicol) in specified ratio on both exterior and interior joints.

One coat of putty shall be applied to close the joint, then second coat shall be applied in order to flush recessed part.

Mesh tape shall be sandwiched between first & second coats to have a hold over the wall. See in Fig.7

Wall is now ready to accept primer & paint.

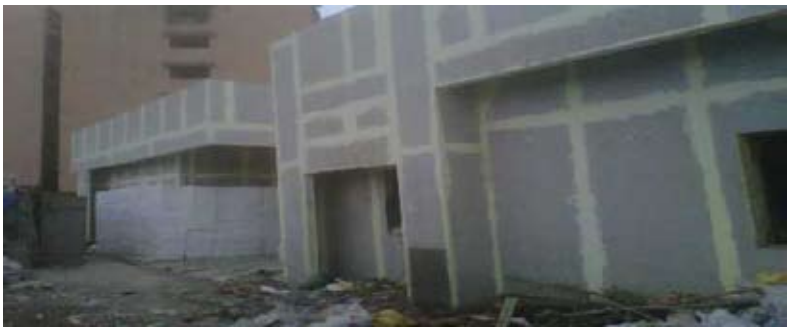


Fig. 7

Typical Connection Details

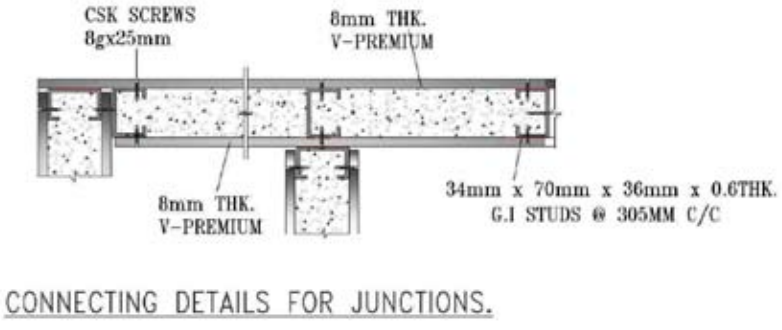


Fig. 8

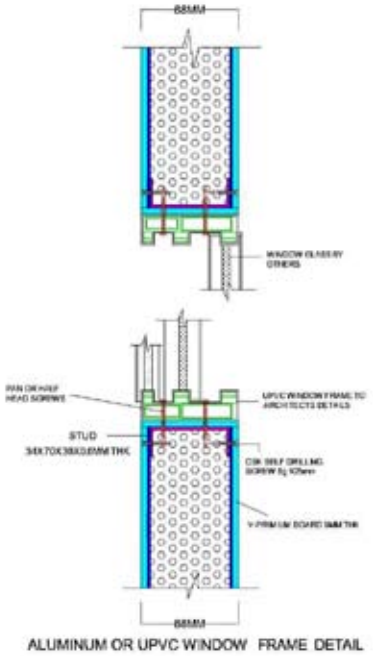


Fig. 9

LIMITATIONS

Limitations/precautions to be taken for using V-Infill Walls on the basis of performance, safety, geo-climatic Conditions:

- Height of 88mm wall thickness shall be limited to 3m only.
- Height of 150mm wall thickness shall be limited to 5m with intermediate nagging in the frame work.
- If wall tiles are to be changed, wall shall not be hacked for fixing new tiles for bonding. Instead, cementious tile adhesive shall be used which will act as bonding agent between the wall and tile instead of mortar

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No.: 1045-S/2019 has been issued to M/s Visaka Industries Limited, Secunderabad, Telangana.

MAJOR COMPLETED / UNDER COMPLETION PROJECTS

- G+3 residential building in Warangal
- City Land Bank and Properties at Madikonda (Telangana)
- G+1 Residential building in Hyderabad.

STANDARDS/GUIDELINES TO BE REFERRED

IS 383: 2016	Specifications for coarse and fine aggregates from natural resources
IS 456: 2000 Reaffirmed 2016	Code of practice for plain and reinforced cement concrete
IS 3346:1980 Reaffirmed 2004	Method for the determination of thermal conductivity of thermal insulation materials
IS 3809: 1979 Reaffirmed 2002	Fire resistance test for structures
IS 3812 (Part 2):2003	Specifications for fly ash for use as admixture in cement mortar and concrete
IS 8112:2013	Specifications for 43 grade ordinary portland cement
IS 9901(Part III):1981	Measurement of sound insulation in buildings and of building elements
IS 12269:2013	Specifications for 53 grade ordinary Portland cement
IS 14862:2000	Specifications for fibre cement flat sheets
IS 516:1969 Reaffirmed 2004	Standard test method for strength of concrete
ASTM C 1185(08):2016	Standard test methods for sampling and testing non-asbestos fibre cement flat sheets
IS 4671:1984 (Reaffirmed 2004)	Specifications for expanded polystyrene for thermal Insulation purposes
BS 476 (Part 20-22): 1987	Method of determination of fire resistance of elements of building materials and structures
BS 5234 (Part 2):1992	Specifications for performance requirements for strength and robustness of partitions including method of tests
GB 8624:2012	Classification of burning behavior of building materials
IS 277 –2003	Specification for GI section & channel

Nano Living System Technology

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE SYSTEM

Nano Living System Technology comprise of an inner and outer skin of magnesium oxide board, with an injected core of closed cell, polyurethane foam, free of Chlorofluorocarbon (CFC) blowing agent. Cold formed metal studs are incorporated within the foam and between the magnesium oxide board skins at nominal 600mm centres.

The panels are manufactured in 150mm thickness having 80 mm cold formed steel studs, 10mm magnesium oxide board on each side and 50mm thermal packer between the internal stud and exterior magnesium oxide board with core insulation of 130mm closed cell and polyurethane foam.

An isometric view of the Nano panels is shown in Fig. 1.

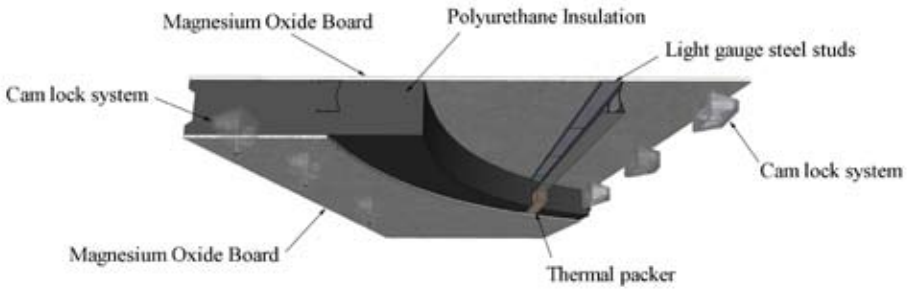


Fig. 1 Isometric view

Classification of the Panels

Panels are available in standard dimensions of 1200mm x 2400mm and thickness of 150mm with wide variety of widths and permissible heights of up to 3.1 metres. Typical weight is 32 kg/m^2 for 150 mm thick panel. Panels are also available to order with additional insulation and plasterboard components added to the inner face to improve the thermal properties. The core of the walling panels consists of polyurethane foam with a minimum density of 35 kg/m^3.

Head and base fixing channels/angles are manufactured from 1.2mm thick steel. The internal metal studs are manufactured from a variety of material thicknesses between 0.7mm and 3mm to suit loading conditions. These components are manufactured from steel conforming to *BS EN 10326:2004* with a hot dip galvanized grade of *S220 GD + Z275 N-A-U* (IS 801:175 with a hot dip coating of min. Z 275 conforming to IS 277:1992 or equivalent as per the performance requirement).

The base & head channels for the panels and metal sigma studs within the panels are manufactured from 1.2mm thick galvanized steel and lintel angles are made from 2.4mm thick steel. The channel dimensions are 154.5mm by 40mm deep for the base channel and 54.5 by 60mm deep for the head channel for two-sided fixing.

Each walling panel contains three camlocks on each vertical edge. The camlock casings are manufactured from high-impact styrene, and the hooks from 3mm thick mild steel with a zinc die-cast cam and mild steel-plated, hook-locating rivet (Fig. 2).

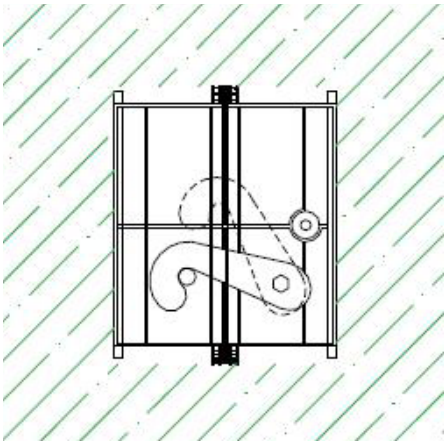


Fig. 2 Camlock detail

BASIC RAW MATERIAL REQUIREMENTS

(i) Stud & Track profiles: Shall be manufactured from pre-galvanized high tensile steel conforming to IS 801:1975 and IS 277:2018/ BS EN 10346:2004 Grade 350 having Yield stress of min.350 MPa & Tensile stress of min. 380 MPa and coating of min. Z 275 or equivalent as per the performance requirement.

(ii) Polyurethane Core (PUF): Shall be Chlorofluorocarbon (CFC) free & self-extinguishing and shall conform to IS 12436: 1988.

(iii) Magnesium (MgO) Board: Shall conform to the manufacturer's specifications.

FABRICATION PROCESS OF PANELS

- Initial design work shall be conducted using specialized computer aided design and drafting software that is integrated with all of the machinery involved in development of the Nano Living System.
- Once finished, the final design work shall be transferred electronically to the various machines for maximum accuracy and efficiency.
- Once the data has been received by the machine, the computer automated systems shall initiate the steel forming process.
- The final result is the production of light gauge steel framing studs and tracks, as well as floor joist and roof truss systems.
- Frames shall then be assembled in accordance with the design plans and drawings.
- Upon completion, the frame shall be placed inside of the mold and entered into the polyurethane injection machine.
- Once finished the NLS panels shall be moved to a storage area to be shipped out.

INSTALLATION PROCEDURE

General

- The installation of the Nano Living System must comply with the Certificate holder's installation instructions. Installation should be carried out by an approved contractor who has completed the Certificate holder's training programme.
- For loadbearing walls and infill panels the main contractor should provide all setting-out grid lines for locating the outer face of the angle supports and centre point of window, door and service openings. The external face of the base channel is positioned from the setting-out lines.
- For infill walls the main contractor should provide the setting-out grid line for base and head channels. (Fig. 3)

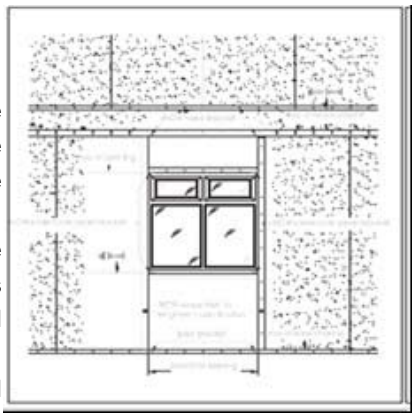


Fig. 3 Typical infill construction

- The overall plan dimensions are checked for squareness and size against the construction drawings before installation commences. The high point of the bearing must be identified and used as a datum to which all base channels on the bearing will be set.
- Base channels may be raised above the bearing by packing to level. Any void under the channel must be filled with a loadbearing material (e.g. mortar) as work proceeds.
- Where any galvanized steel base channel, head channel or corner angle or lintel is cut on site, the cut face must be re-treated with a zinc-rich paint.
- It is essential that the design and installation is strictly in accordance with good building practice and the requirements of this Certificate, to ensure that paths for sound transmission through the separating wall assembly and the flanking elements are minimized.

Procedure

- Base channels must be fixed to the bearing using the appropriate self-tapping anchor fixings at 200 mm c/c, installed working away from the first corner.
- The first section of the walling panel is erected working from the corner for stability and head channels located onto the walling as work proceeds away from this point. (Fig. 4)
- The corner panels are joined together vertically using site-formed lapped joints (see Figure 8). Top and base channels lock the corner panels into position with self-drilling screws being provided at 200 mm c/c. A pressed steel corner angle is screw fixed to the external face to provide additional protection. (Fig. 5)
- The next walling panel in the sequence is erected and the joint is secured using the camlocks within the panel (see Fig. 2). The walling must be supported at a maximum of 3600 mm c/c, i.e. every third walling panel. This process is repeated accordingly.
- Walls are checked for line and level and props adjusted as necessary.
- The wall panels are secured to the base, head, corner channels and lintel sections, using the self-drilling fasteners provided and the pre-drilled holes in the channel and lintel sections, at 200 mm c/c (Fig. 6).
- Where internal intersecting walling panels are required, a vertical channel is fixed to the internal face of existing external or cross-walls and secured with screws at 200 mm c/c through the vertical channel pre-drilled holes. The installation is then completed as for external walls.
- On external walls, the joint between the external up stand of any galvanized channel and the walling panel must be sealed with proper sealant.
- Additional storeys can be constructed using the same procedures. Intermediate floor connections are detailed in the Certificate holder's installation instructions and can be adapted according to the walling panel height and detail required (Fig. 7).
- The legs of joist hangers must be bent over the top and down the back face of the panel. The hanger and the leg are fixed by screws. Details of suitable hangers and screws (including number and positioning) can be obtained from the Certificate holder. (Fig. 8)

Openings

- Openings should be carefully planned and the preferred method of forming the opening selected. Two methods for forming openings are detailed in the Certificate holder's installation instructions: (Fig. 9)
- Method 1: Openings are cut into the skin of the erected walling panel. A lintel must be installed over the opening.
- Method 2: Openings are formed as work proceeds by the installation of cut panel sections over and/or under the required opening. A lintel must be installed over the opening.
- Where cut walling panels are used, a butt joint is necessary due to the removal of the camlocks. Joint stability is maintained by the use of metal plates, and foam applied to the joint to reinstate the insulation properties of the walling panel.
- Where openings continue to floor level, the base channel may be omitted from the area of the opening as work continues, or removed at a later stage. A lintel must be installed over the opening.
- Structural openings are formed within loadbearing walls using cut down sections of wall panel and steel corner angle brackets fixed each side of the panel using *PF27C* screws. For infill panels, an arrangement of galvanized steel reveal channels and corner brackets can be used. Reveal channels require sizing by
- The structural engineer responsible for the building design and depend on storey height, opening dimensions and local wind conditions.

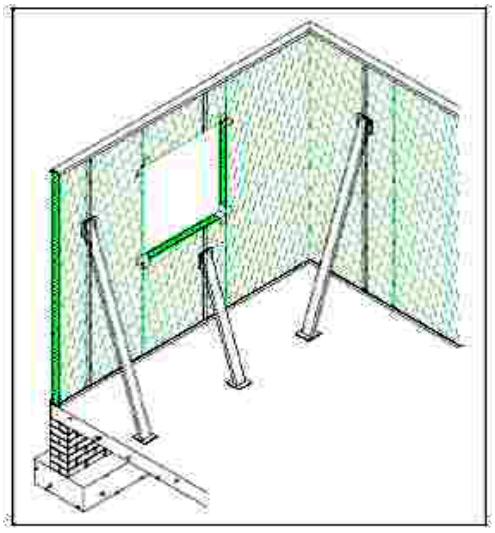


Fig. 4 Erection showing propping

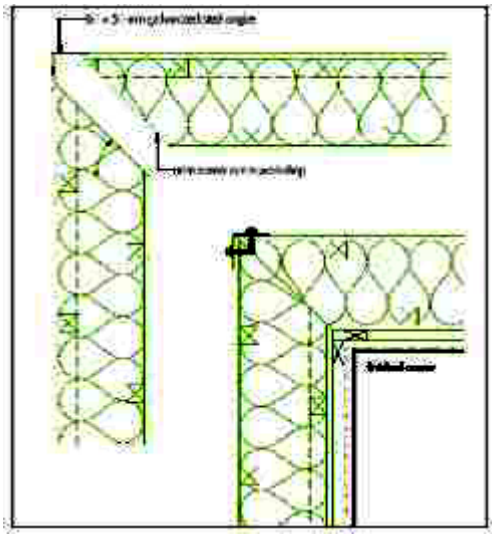


Fig. 5 Corner detail

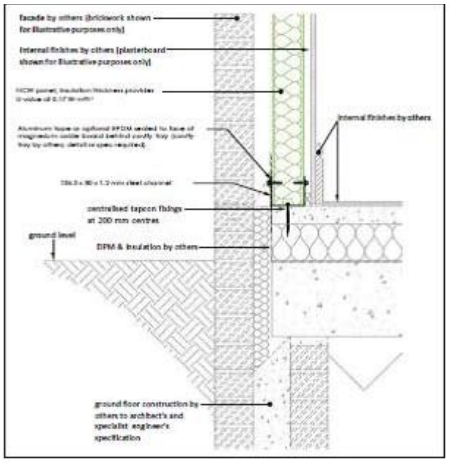


Fig. 6 Panel connection to base channels

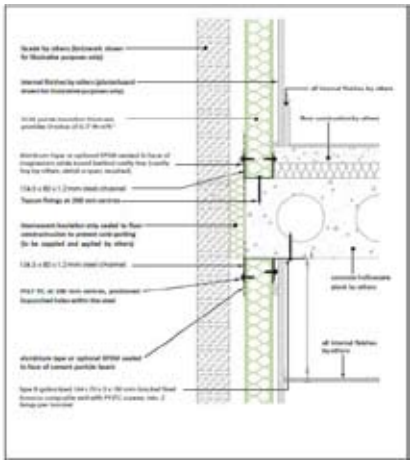


Fig. 7 Intermediate floor jointing



Fig. 8 Joist hangar detail

Fixing of windows and door frames, service battens and wall ties

- Window and door frames are fixed to the external face of the panels using brackets (Fig. 10).
- Services battens are fixed to the inner face of the panels at 600 mm c/c using the fixings provided. A plasterboard facing is then fixed to the battens to provide a service void and a surface for internal decoration.
- Approved wall ties to receive external brick leaf must be screwed into the face of the panels, or through the face into the metal studs or packers at the required spacing using suitable fasteners. Dovetail slot ties in accordance with BS 5628-1: 1992 or frame cramps to BS EN 10327: 2004 can also be used.

Infill Panels

- The base channel is secured to the structural floor or edge beam using the setting out lines and specified screw fixing (Fig. 11).
- The head channel is positioned along the setting out line, plumbed up from the base channel, and secured to the structure using the specified screw fixing. A 1200 mm length of channel is left out to allow for the insertion and positioning of the panels or where a gap in the channel has been left for a door or window opening.
- Panels are slid from the pallet and the bottom edge of the panel butted against the base channel adjacent to the 1200 mm gap.
- The panel is then lifted into the upright position and slid into and along the base channel into its final position.
- The procedure is repeated for the next panel and once butted against the first panel is mechanically locked using the camlocks.

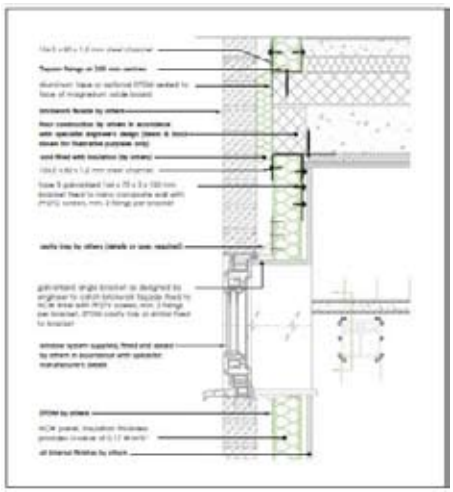


Fig. 9 Forming a structural opening

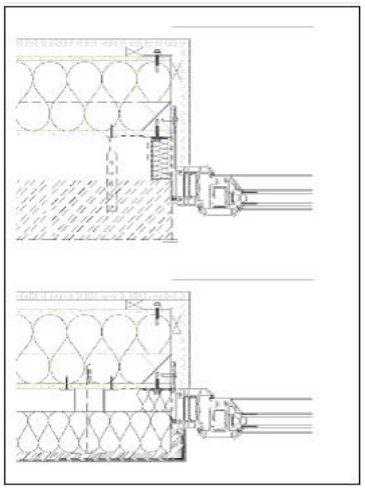


Fig. 10 Typical window fixing detail

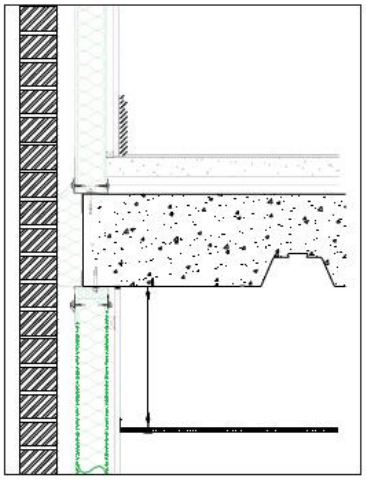


Fig. 11 Infill panel head & foot detail

- When the last section of wall panel is installed the base and head angle (replacing the channel) can be located at the same time.
- As installation of the wall panel's proceeds low profile screws 12-14x15mm, at 20 mm centres each side, are used to mechanically fix panels to base and head channels.

MAJOR COMPLETED/UNDER COMPLETION PROJECT

- Construction of 350 rooms for Student accommodation at St. Georges, London (UK)
- Construction of 43 flats for Minerva Care Home at Islington, North London (UK)
- Construction for Brightwell Court Care Home at Islington, North London (UK)
- Construction of Calgary Hotel at Ontario, Canada
- Construction of Oakville Hotel at Ontario, Canada
- Construction of Vancouver Hotel at British Columbia, Canada
- Construction of Tucson Hotel at Arizona, USA

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No.1047-S/2019 has been issued to M/s Nano Living System Pvt. Ltd. (India), New Delhi.

STANDARDS/GUIDELINES TO BE REFERRED

IS 277:2018	Specifications for galvanized steel sheets (plain & corrugated)
IS 801:1975 (Reaffirmed 2010)	Code of practice for use of cold formed light gauge steel structural members in general building construction.
IS 456:2000 (Reaffirmed 2016)	Code of practice for plain & reinforced concrete (fourth revision)
IS 875 (Parts1 to 3):1987 (Re-affirmed 2008)	Code of practice for design loads (other than earthquake) for buildings & structures
IS1893 (Part 1):2016	Criteria for earthquake resistant design of structures
IS 1904:1986 (Reaffirmed 2010)	Code of practice for design and construction of foundations in soils: General requirements.
IS 1905:1987 (Reaffirmed 2007)	Code of practice for structural use of un-reinforced masonry
IS 12436:1988 (Reaffirmed 2017)	Specifications for performed rigid polyurethane foam for thermal insulation.

IS 14246:2013	Specifications for continuously pre-painted galvanized steel sheets and coils
IS14862:2000 (Reaffirmed 2010)	Code of practice for fiber cement flat sheets
ASTM A 568	Standard specifications for thickness tolerances of cold rolled steel sheets & coils
ASTM A 653(9)	Standard specifications for steel sheet, zinc coated or zinc-iron-alloy coated
ASTM C 423	Standard test method for sound absorption by reverberation room method
ASTM C 518	Standard test method for steady state thermal transmission properties by means of heat flow meter apparatus.
ASTM C 955:2007	Standard specifications for load-bearing (transverse and axial) steel studs, runners (Tracks) and bracing or bridging for screw application of gypsum panel products and metal plaster bases
ASTM C1513	Standard specifications for steel tapping screws for cold formed steel framing connections
ASTM D1621	Standard test method for compressive properties of rigid cellular plastics
ASTM D1622	Standard test method for apparent density of rigid cellular plastics
ASTM D1623	Standard test method for adhesion properties of rigid cellular plastics
ASTM E 72	Standard test method for conducting strength tests of panels for building construction
ASTM E 84	Standard test method for surface burning characteristics of building materials
BS 476-21:1987	Fire tests on building materials and structures — Methods for determination of the fire resistance of loadbearing elements of construction
BS 2750-3:1995	Measurement of sound insulation in buildings and of building elements — Laboratory measurements of airborne sound insulation of building elements
BS 5250:2002	Code of practice for control of condensation in buildings
BS 5950 (Part 5):1998	Code of practice for design of cold formed thin gauge sections
BS 6093:1993	Code of practice for design of joints and jointing in building construction
BS EN 10326:2004	Code of practice for continuously hot dip coated steel strip and sheet



Factory Assembled Insulated Sandwich Panels using Mineral Wool

(Suitable as Non-Load bearing Panels)

ABOUT THE SYSTEM

The panels are factory assembled insulated sandwich panels consisting of an insulating layer 'sandwiched' between two layers of metal sheets. The panels are manufactured using mineral wool bonded between pre-coated steel sheets to produce profiled finish panels. The steel sheets can either be PPGI or PPGL, and, with a maximum thickness of 0.8 mm. An insulation core provides insulation and sturdy bonding for better structural stability and facilitates better load bearing capacity and wider spans for panels.

The system can incorporate all types of architectural features like coving, boxes, cantilevers, projections, infill walls, mezzanine floors etc. This system can also incorporate all types of services viz. electrical, gas and plumbing etc. The design and engineering of the structures is executed by following the norms & guidelines stipulated in relevant Indian Standards.

Size and profiles of Panels

Size of panels

Panels are available in thickness from 50 mm to 120 mm, with standard width of 1000 mm and length as per customer requirement.

Profiles of the Panels

Hipertec Roof

These panels are self-supporting insulation panels insulated with mineral-wool for roof and wall applications, requiring a high degree of resistance to fire, combined with sound absorption. The Hipertec roof panels are manufactured in accordance with a system patented by Metecno and consists of a profiled external steel facing, an internal flat line with an insulation core of orientated fibre high density rockwool, arranged perpendicular to the plane of the panel and positioned in strips, laid longitudinally with off-set joints and transversally compacted, in such a way as to completely fill the void between the two metal facings. The ribs of the external metal sheet are filled with shaped mineral wool strips.

The Metecno patented mechanism ensures precise interlocking, dimensional accuracy and eliminates the risk of air gaps and thermal bridging and joints are covered with butyl tape, sealants and flashings.

Facing Options: Pre-painted galvanized steel/aluminium, stainless steel and craft paper and perforated metal sheet for inner skin.

Surface finish: Colour coated PPGI/PPGL with Regular Modified Polyester (RMP), Silicone Modified Polyester (SMP), Super Durable Polyester (SDP) and Polyvinylidene fluoride (PVDF) coating systems

Detail of this panel is shown below :



Hipertec Wall

These are self-supporting insulation panels with rockwool for wall and partition applications, which require a high degree of fire-resistance and acoustic insulation.

The Hipertec Wall panel, manufactured in accordance with a system patented by Metecno, consists of two micro-ribbed steel sheets, with an insulation core of oriented fibre high-density rockwool, arranged perpendicularly to the plane of the panel and positioned in strips, laid longitudinally with off-set joints and transversely compacted, in such a way as to completely fill the space between the two metal facings. The Metecno patented mechanism guarantees precise interlocking, dimensional precision and eliminates the risk of air gaps and thermal bridging as the joints are covered with butyl tape, sealants and flashings.

Facing Options: Pre-painted galvanized steel/aluminium, stainless steel and craft paper and perforated metal sheet for inner skin.

Surface finish: Colour coated PPGI/PPGL with RMP,SMP, SDP and PVDF coating systems, as per details below;



BASIC RAW MATERIAL REQUIREMENTS

1. Rockwool Mineral
2. Prepainted Steel as per following specification:

Parameters	Tech. Specifications / Standards
REFERENCE STANDARDS	ASTM.A 755
STRIP THICKNESS (TCT) -mm	0.5 TO 0.8
STRIP WIDTH - mm	1060 TO 1220
SUBSTRATE MATERIAL	Zinc coating as per ASTM A653/ A 653M with steel base as per ASTM Std.
SUBSTRATE COATING MASS Gms/m2 , SUBSTRATE COATING MASS CLASS	90 TO 275, Z90,Z120; Z150; Z180 & Z275 as per ASTM Std.
GRADE DESIGNATION	Gr 50/ Gr80 / CS Type A,B as per ASTM std.
MOISTURE ABSORPTION	BELOW 2%
PAINT TYPE	Regular Polyester / Silicon polyester / PVDF
PAINT COATING THICKNESS (DFT)	Top coat 18 to 22 microns (+5 microns primer), Back Coat 5 to 8 microns (Including Primer).
GLOSS	15-80% at 60 degrees ASTM D 523

INSTALLATION PROCEDURE

Panels with damaged side joints, surface dents or scratches shall be set aside. Excess foam (if any) shall be removed from panel joints to allow proper panel engagement. The first panel shall be installed plumb/level. A spirit level or transit shall be used on each panel. Adjoining panels shall be installed with overlapping rib/inserting tongue-in to the groove toward the last erected panel. Structural members shall be drilled, if required and fasteners installed at lapped rib. A chalk line shall be used to mark the girt location and maintain a straight line of screws, thus avoiding miss-drilling and possible leakage. The preferred procedure is to complete all wall sheeting before starting the roof sheeting.

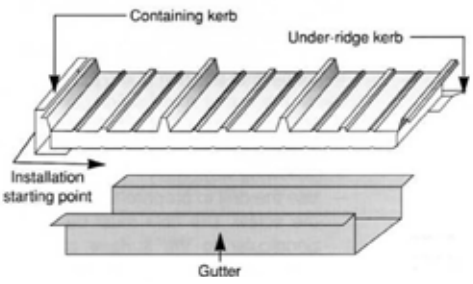
Preliminaries

- Check that the storage has been carried out according to the directions in 1.3.2
- Check that the panel support structures are level.
- Position the packages of panels near the points of use.
- Prepare a fixed or cradle scaffold, according to the working height, 30/40 cm far from the external edge of the main columns and comply with the rules on safety in the workplace.
- Control that all workers are equipped with individual safety equipment according to current regulations.
- Prepare all the power supply lines for tools according to current regulations.
- Prepare the panel lifting vehicles.
- In addition to the traditional scaffolding, when assembling wall panels horizontally, automatic scaffolds with platform can be profitably used.
- These platforms may be either the type with masts starting from the ground or the self-propelled type with telescopic arms

Roof Panel

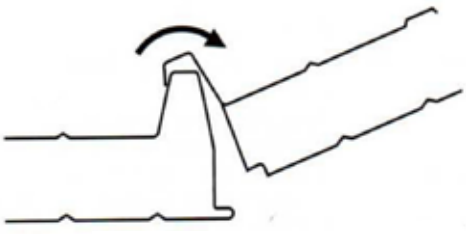
Fastener installation

It must be ensured that the fasteners are installed at locations indicated on the building drawings. It is easy to misjudge the location of the structural member, resulting in a fastener off the structural member or below the sealant at the end lap. The fastener shall be driven in until it is tight and the washer is firmly seated. A slight extrusion of neoprene around the washer is a good visual tightness check.



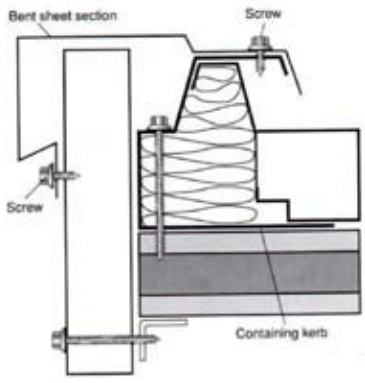
Orientation of panels before lifting

For maximum weather-tightness, start laying panels from the end of the building that will be in the lee of the worst-anticipated or prevailing weather. It is much easier and safer to turn panels on the ground than up on the roof. Before lifting panels on to the roof, it must be checked that this is the correct way up and the overlapping side is towards the edge of the roof from which side installation will start. Bundle of panels shall be placed over or near firm supports, not at mid span of roof members.



Roof paneling sequence

It is advised that both sides of the ridge of a building be sheeted simultaneously. When lifting panels onto the roof frame for laying and fastening, care should be taken to make sure all panels are the correct way up with the overlapping side towards the edge of



the roof from which installation will commence.

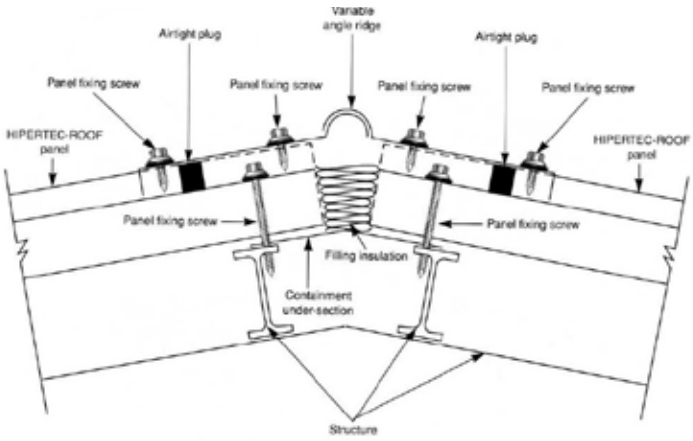
Installation of the first roof panel

The roof panel shall be set in place over the inside closure ensuring the major ribs of the panel rest properly with the inside closure. The panel edge shall be aligned with the edge of the end wall roof line. With the panel properly placed, the line of panel shall be adjusted for squareness.

A nylon line projected from the eave strut by a certain distance shall be used to give correct distance and line. A chalk line shall be used to mark the location and maintain straight line of screws, thus avoiding miss-drilling and possible leakage. The panel shall be secured to the structure with appropriate fasteners. The fasteners will be installed after the overlapping is installed.

Sealing the side laps

The side lap sealant shall be applied to the weather side edge of the lower major. The sealant should only be applied to clean, dry surfaces. Press firmly along the length of the sealant to insure proper adhesion. The adjoining panel shall be installed positioning the overlapping rib with care. Required size pilot holes for the lap fasteners shall be drilled at the centre of the clearance holes in the overlapping panel. The lap shall be stitched with the self-fastening fasteners supplied with the screw line. Sealant shall not be placed inside of the screw line.



Installation of remaining roof panels

With the first panel run installed & secured and side lap sealant applied, the second panel run may be started. The eave shall be prepared with an inside closure and sealant. The panel shall be positioned so that the overlapping ribs will rest properly. Proper overhang and panel coverage shall be checked. The major ribs of the two panels shall be stitched together and panels attached to the purlins.

Sealing the end laps

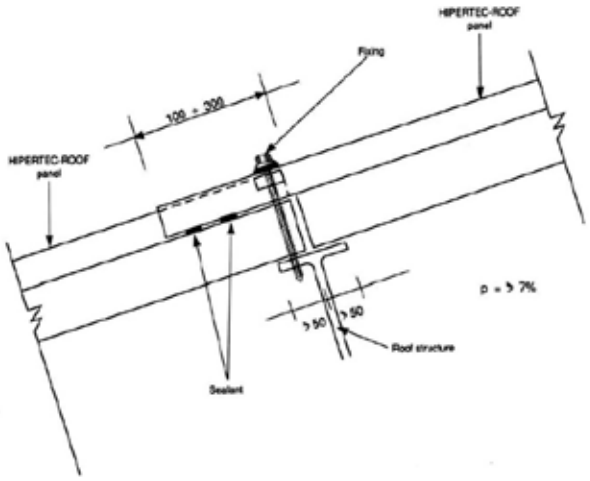
At the panel end laps, sealant shall be placed across the full panel below the fastener line. The panel end laps shall have a minimum overlap located over a purlin as per respective erection drawings. The fasteners shall be located on the centre of the flange of purlins.

Wall Panel

Fastener installation

It must be ensured that the fasteners are installed at locations indicated on the building drawings. It is easy to misjudge the location of the structural member, resulting in a fastener off the structural member or below the sealant at the end lap. The fastener shall be driven in until it is tight and the washer is firmly seated. A slight extrusion of

neoprene around the washer is a good visual tightness check. The fasteners shall be installed by drilling holes on the ridge and not on the valley.



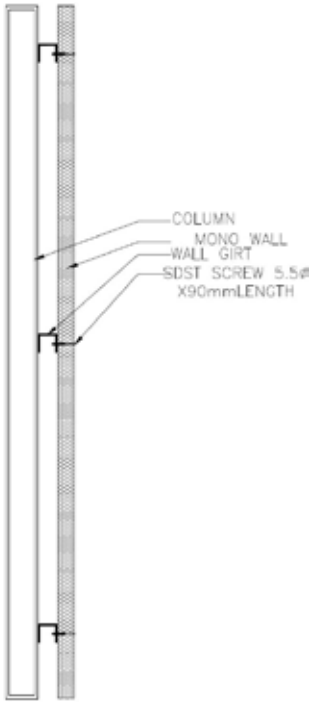
Checking flatness and overhang

Before starting work it must be ensured that:

- The supports for cladding are truly in the same plane
- The overhangs of panels from the top and bottom supports shall not exceed the limit, whilst also overhanging at least 50 mm into gutters. Necessary adjustments shall be made before laying panels, because it will be difficult or impossible to rectify later.

Positioning first panel

First panel shall be positioned before fixing to ensure that it is correctly located in relation to other parts of the building.



It must be checked that the panel:

- Aligns with the end-wall (or its barge or fascia), the type of flashing or capping treatment to be used; and
- Aligns correctly at its ends in relation to the gutter and ridge (or parapet or transverse wall).

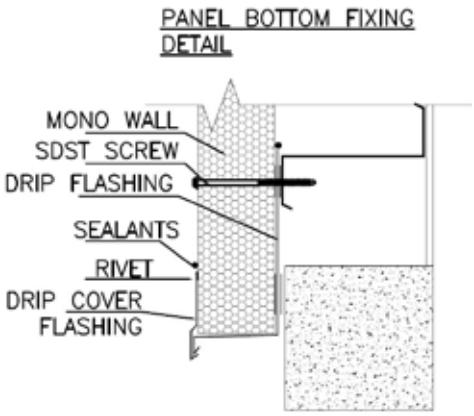
Positioning other panels

After fixing the first panel in position, other panels shall be aligned using:

- The long edge of the previous pane;
- A measurement from the end of the panel to the fascia or purlin at the gutter. Gutter-end of all panels shall be kept in a straight line.
- Each panel shall be fixed completely before laying the next; or
- The panel shall be fixed tightly to ensure it can't move, all panels shall be laid completely and then all the intermediate fasteners shall be placed later.

Checking alignment

It must be checked that each panel is parallel with the adjacent panel and gap is within the allowed limit.

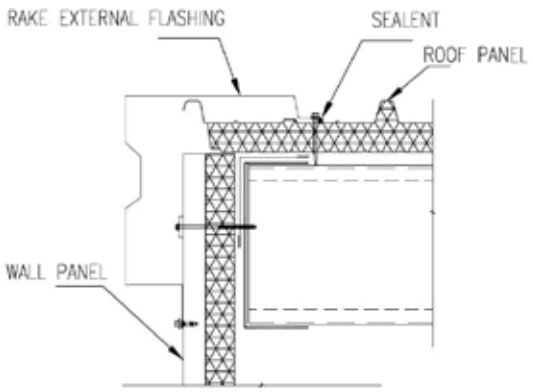


Wall panel fixing with floor

Wall panel of 80 mm for outer wall shall be fixed with U-channel of size 40x82x40x1.2mm on floor. U-channel shall be fixed with M6x65mm dash fastener at 300mm c/c spacing.

Wall panel fixing with slab

Wall panel of 80 mm for outer wall shall be fixed with self-drilling screw of 12-14x120x4.8mm at 300mm c/c spacing using L-Angle of 50x50x2mm above slab.



Wall partition panel fixing with slab top & bottom

Wall partition panel of 80 mm shall be fixed over RCC slab by PVC gitti screw of 35mm and pop rivet at 200mm c/c spacing using L- Angle of 50x50x1.2mm on both side of panel above slab.

Vertical corner closer

Vertical corner shall be closed using pop rivet at 300mm c/c spacing by using L-Angle of 50x50x0.5mm.

Ceiling Panel

Fastener installation

It must be ensured that the fasteners are installed at locations indicated on the building drawings. It is easy to misjudge the location of the structural member, resulting in a fastener off the structural member or below the sealant at the end lap. The fastener shall be driven in until it is tight and the washer is firmly seated. A slight extrusion of neoprene around the washer is a good visual tightness check.

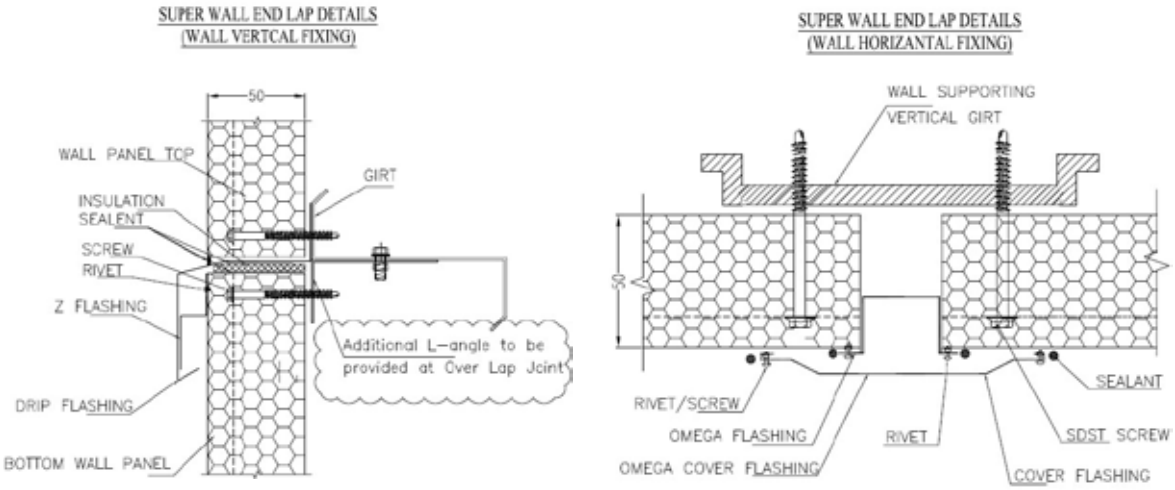
Orientation of panels before lifting

For maximum weather-tightness, start laying panels from the end of the building that will be in the lee of the worst-anticipated or prevailing weather. It is much easier and safer to turn panels on the ground than up on the roof. Before lifting panels on to the roof, it must be checked that this is the correct way up and the overlapping side is towards the edge of the roof from which side installation will start. Bundle of panels shall be placed over or near firm supports, not at mid span of roof members.

Fixing of Aluminium 'T'

Aluminium 'T' shall be marked on the structural members and holes shall be drilled in the structural members. Sag rod connector shall be assembled on ground for longer drop length. After that Aluminium 'T' shall be assembled on ground with all accessories and erected one by one at specified locations.

The level and alignment of 'T' line shall be checked before fixing the panels. Bottom level of the 'T' shall be adjusted for roof ceiling by adjusting nut. Coupling plates shall be erected to connect adjacent 'T' members. Same procedure shall be repeated in case of multiple lines.



Ceiling panel installation

Ceiling panel must be sheeted on both sides of the 'T' simultaneously. Proper coverage shall be checked frequently during progress. When lifting panels for laying and fastening, it must be ensured that all the panels are in the correct way up.

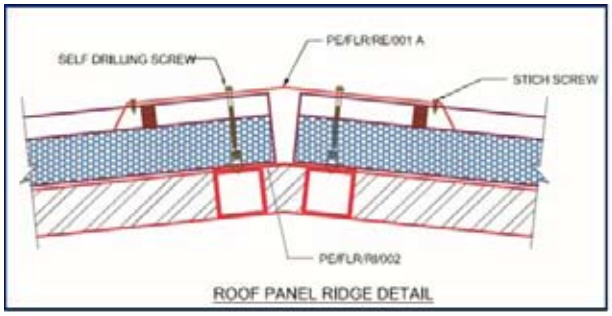
For panel installation steps given below shall be followed:

- Layout on the floor shall be marked as per the drawings.
- U Track/ base angle shall be installed in water level.
- Step cutting at wall panels shall be made to make provision for ceiling panel resting.
- Then wall panels shall be installed starting from one end wall and one side wall.
- Plumb and alignment of each panel shall be checked for starting the ceiling panels.
- Inner and outer flashings shall then be installed to give temporary hold at wall panels.
- Partition/other side wall panel shall also be installed with inner and outer flashings.
- Ceiling panels shall then be lifted to the location after chcking the orientation as per the drawings before lifting.
- Strip flashing shall be installed on top of the ceiling panel after checking the alignment.

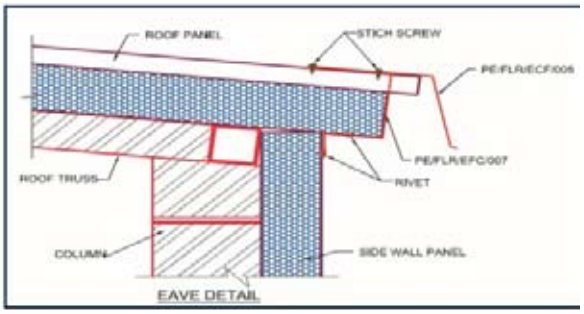
The chamber shall then be completed by following the above steps. Silicon accessories shall be installed as shown in the drawings. After that chemical filling shall be done as per the specifications.

Sealing the side laps

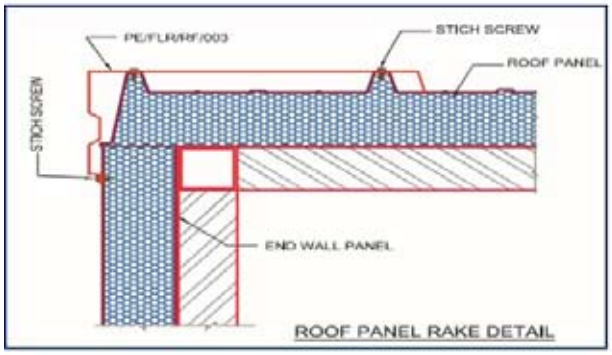
Apply the side lap sealant to the weather side edge of the lower edge of the crest. The sealant should only be applied to clean, dry surfaces. Press firmly along the length of the panel to ensure proper adhesion. Install the adjoining panel positioning the overlapping/side-lapping rib with care. Drill, at the centre of the clearance holes in the end-lapping panel, required size pilot holes for the lap fasteners. Stitch the lap with the self-fastening fasteners supplied with the screw line. Sealant shall not be placed inside of the screw line.



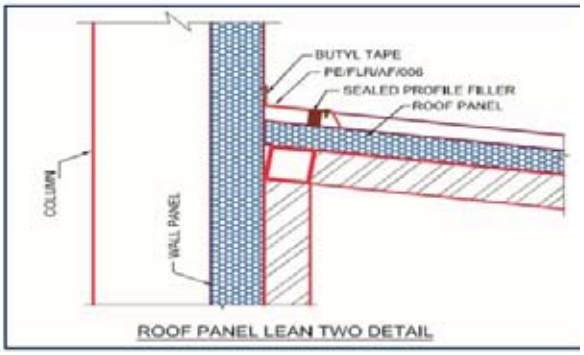
ROOF PANEL RIDGE DETAIL



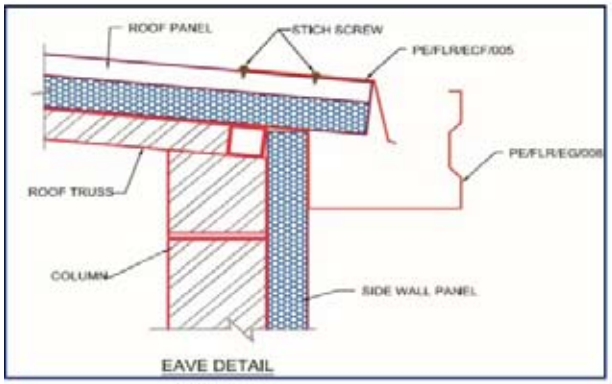
EAVE DETAIL



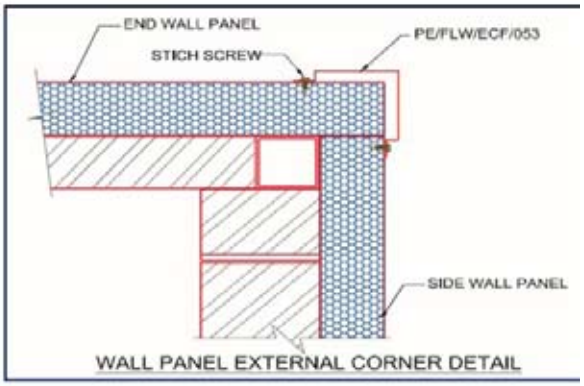
ROOF PANEL RAKE DETAIL



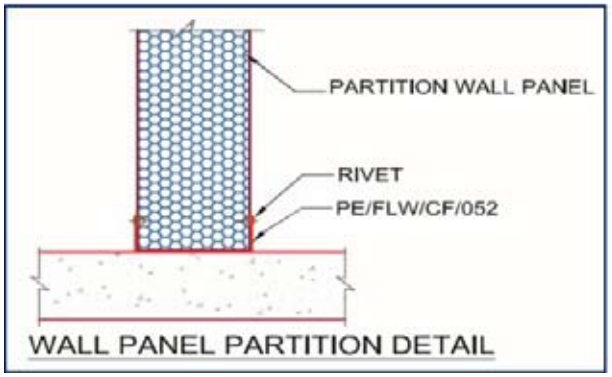
ROOF PANEL LEAN TWO DETAIL



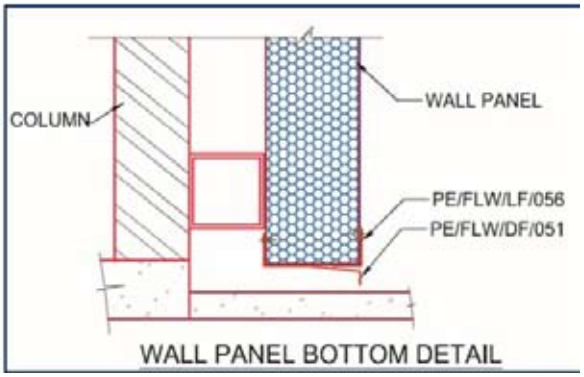
EAVE DETAIL



WALL PANEL EXTERNAL CORNER DETAIL



WALL PANEL PARTITION DETAIL



WALL PANEL BOTTOM DETAIL

APPLICATION

These panels are factory assembled composite panels having high strength-weight ratio and ensuring structural stability on the building envelope. These are used for residential and commercial buildings, school & training centers, steel structures, modular & monolithic cabinets, management blocks & site offices, guard room/ porta cabins, etc.

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No.: 1057-P/2021 has been issued to M/s Metecno (India) Pvt. Ltd., Chennai.

MAJOR COMPLETED/UNDER COMPLETION PROJECTS

The product has been used by M/s Mars International India Pvt. Ltd., Keppel Seggers, Singapore and SEPCO, Orissa.

STANDARDS/GUIDELINES TO BE REFERRED

IS 277:2018	Specifications for galvanized steel sheets (Plain & corrugated)
IS 801:1975 (Reaffirmed 2010)	Code of practice for use of cold formed light gauge steel structural members in general building construction
IS 875 (Parts 1 to 3):1987/2015	Code of Practice for design loads (other than earthquake) for buildings & structures
IS 3346: 1980 (Reaffirmed 2017)	Method of determination of thermal conductivity of thermal insulation materials
IS 8183 :1993	Bonded mineral wool specification
IS 3144:1990	Mineral wool thermal insulation material method of test
IS 14246:2013	Specifications for continuously pre painted galvanized steel sheets and coils
BS 476 (Parts 20)	Fire Tests on Building Materials & Structures





Factory Assembled Insulated Sandwich Panels using PUF

(Suitable as Non-Load bearing Panels)

ABOUT THE SYSTEM

The panels are factory assembled insulated sandwich panels consisting of an insulating layer 'sandwiched' between two layers of metal sheets. The panels are manufactured using rigid Polyurethane Foam (PUF) bonded between pre-coated steel sheets to produce profiled finish panels. The steel sheets can either be PPGI or PPGL, and, with a maximum thickness of 0.8 mm. An insulation core provides insulation and sturdy bonding for better structural stability and facilitates better load bearing capacity and wider spans for panels.

These panels can be used for both walling and roofing applications. Structures built using these panels can incorporate MEP (mechanical, electrical and plumbing) services along with architectural elements/features such as coving, cantilevers, mezzanine floors etc. The design and engineering of structures are done following guidelines specified in Indian Standards.

Size and profiles of Panels

Size of panels

Panels are available in thickness from 30 mm to 120 mm, with standard width of 1000 mm and length as per customer requirement.

Profiles of the Panels

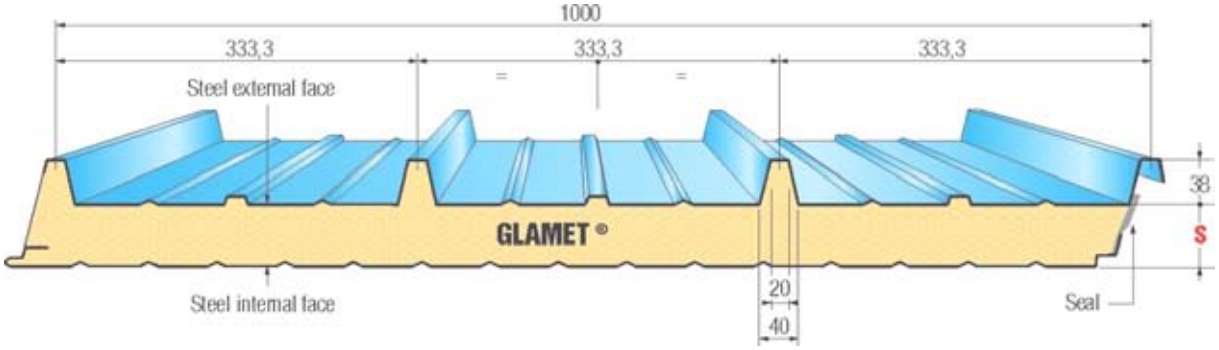
Glamet panels

Glamet panels are manufactured in accordance with a system patented by Metecno and consists of a profile external steel facing, an internal flat liner with an insulation core of PUF. The panels have a mechanism of panel-to-panel interlocking which provides an effective seal. The panels are suitable for general purpose and application in roofing for buildings and shelters. However, it is also suitable for wall and ceiling applications. The Metecno patented mechanism ensures precise interlocking, dimensional accuracy and also eliminates the risk of air gaps and thermal bridging. All joints are covered with butyl tape, sealants and flashings.

Facing Options: Pre-painted galvanized steel/aluminium, stainless steel and craft paper and perforated metal sheet for inner skin.

Surface finish: Colour coated PPGI/PPGL with Regular Modified Polyester (RMP), Silicone Modified Polyester (SMP), Super Durable Polyester (SDP) and Polyvinylidene fluoride (PVDF) coating systems.

Detail of this panel is shown below :



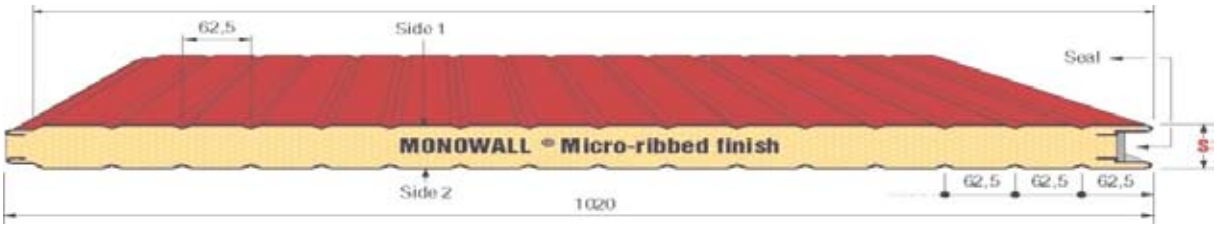
Monowall panel

Monowall is self-supporting insulation material for use in industrial and commercial buildings and refrigerated rooms with positive temperature. They can be used as partition as façade cladding with permanent finishing and can be integrated well with structural glazing, curtain walls, windows and other type of fenestrations and openings. The Metecno patented mechanism ensures precise interlocking, dimensional accuracy and eliminates the risk of air gaps and thermal bridging and joints are covered with butyl tape, sealants and flashings.

Facing Options: Pre-painted galvanized steel/aluminum, stainless steel and craft paper and perforated metal sheet for inner skin.

Surface finish: Colour coated PPGI/PPGL with RMP,SMP, SDP and PVDF coating systems

Profile of this panel is given below:



Superwall

Superwall panels are self-supporting polyurethane insulation material based panel system, with a concealed-fixing method for high quality industrial and commercial buildings, where good aesthetics are paramount.

The special double labyrinth joint of this panel, provide mechanical resistance and insulation superior to any other wall panel product of this kind, the panel external micro-V increases the aesthetic appeal of this panel, which can be oriented both vertically and horizontally as required.

Due to the particular shape of the joint, blind fastening are applied to the V-cut on the male edge of the outside sheet. Two screws with center distance of 30mm should be used for each panel and each stud. Outside walls are made mounting such panels one next to the other.

The Metecno patented mechanism ensures precise interlocking, dimensional accuracy and eliminates the risk of air gaps and thermal bridging and joints are covered with butyl tape, sealants and flashings.

Facing Options: Pre-painted galvanized steel/aluminium, stainless steel and craft paper and perforated metal sheet for inner skin.

Surface finish: Colour coated PPGI/PPGL with RMP, SMP, SDP and PVDF coating systems

Profile of this panel is given below:



BASIC RAW MATERIAL REQUIREMENTS

1. PUF/PIR chemicals
2. Prepainted Steel with specification as under:

REFERENCE STANDARDS	ASTM.A 755
STRIP THICKNESS (TCT) -mm	0.5 TO 0.8
STRIP WIDTH - mm	1060 TO 1220
SUBSTRATE MATERIAL	Zinc coating as per ASTM A653/ A 653M with steel base as per ASTM Std.
SUBSTRATE COATING MASS Gms/m2 , SUBSTRATE COATING MASS CLASS	90 TO 275, Z90,Z120; Z150; Z180 & Z275 as per ASTM Std.
GRADE DESIGNATION	Gr 50/ Gr80 / CS Type A,B as per ASTM std.
YIELD STRENGTH - Mpa Min.	280 For Gr 40,340 for Gr 50 & 550 for Gr 80.
PAINT TYPE	Regular Polyester / Silicon polyester / PVDF
PAINT COATING THICKNESS (DFT)	Top coat 18 to 22 microns (+5 microns primer), Back Coat 5 to 8 microns (Including Primer).
GLOSS	15-80% at 60 degrees ASTM D 523

INSTALLATION PROCEDURE

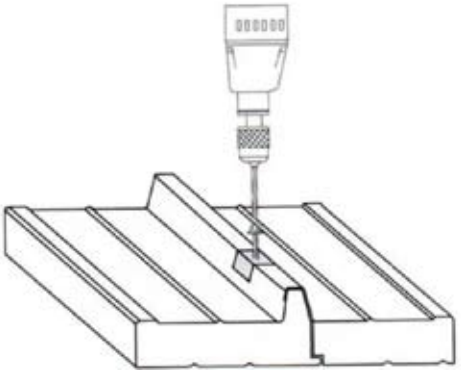
Preliminaries

- Check that the storage has been carried out according to the directions in 1.4.2
- Check that the panel support structures are level.
- Position the packages of panels near the points of use.
- Prepare a fixed or cradle scaffold, according to the working height, 30/40 cm far from the external edge of the main columns and comply with the rules on safety in the workplace.
- Control that all workers are equipped with individual safety equipment according to current regulations.
- Prepare all the power supply lines for tools according to current regulations.
- Prepare the panel lifting vehicles.
- In addition to the traditional scaffolding, when assembling wall panels horizontally, automatic scaffolds with platform can be profitably used.
- These platforms may be either the type with masts starting from the ground or the self-propelled type with telescopic arms

Roof Panel

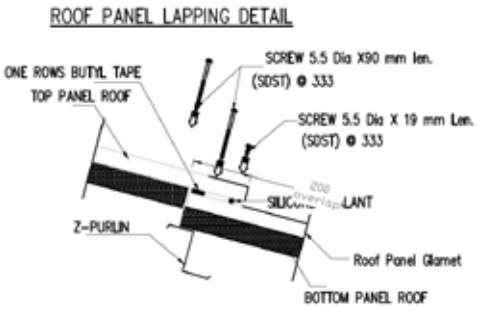
Fastener installation

It must be ensured that the fasteners are installed at locations indicated on the building drawings. It is easy to misjudge the location of the structural member, resulting in a fastener off the structural member or below the sealant at the end lap. The fastener shall be driven in until it is tight and the washer is firmly seated. A slight extrusion of neoprene around the washer is a good visual tightness check.



Orientation of panels before lifting

For maximum weather-tightness, start laying panels from the end of the building that will be in the leeward or the worst-anticipated prevailing weather. It is much easier and safer to turn panels on the ground than up on the roof. Before lifting panels on to the roof, it must be checked that this is the correct way up and the overlapping side is towards the edge of the roof from which side installation will start. Bundle of panels shall be placed over or near firm supports, not at mid span of roof members.



Roof paneling sequence

It is advised that both sides of the ridge of a building be sheeted simultaneously. When lifting panels onto the roof frame for laying and fastening, care should be taken to make sure all panels are the correct way up with the overlapping side towards the edge of the roof from which installation will commence.

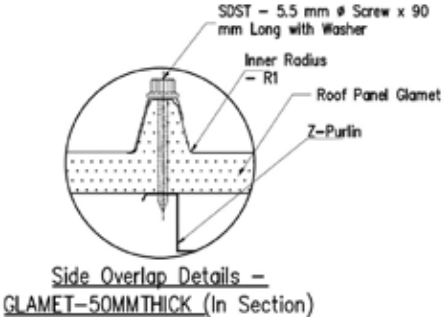
Installation of the first roof panel

The roof panel shall be set in place over the inside closure ensuring the major ribs of the panel rest properly with the inside closure. The panel edge shall be aligned with the edge of the end wall roof line.

A nylon thread, projected from the eave strut, shall be used to give correct distance and line. A chalk line shall be used to mark the location and maintain straight line of screws, thus avoiding miss-drilling and possible leakage. The panel shall be secured to the structure with appropriate fasteners. The fasteners will be installed after the overlapping is installed.

Sealing the side laps

The side lap sealant shall be applied to the weather side edge of the lower major. The sealant should only be applied to clean, dry surfaces. Press firmly along the length of the sealant to insure proper adhesion. The adjoining panel shall be installed positioning the overlapping rib with care. Required size pilot holes for the lap fasteners shall be drilled at the centre of the clearance holes in the overlapping panel. The lap shall be stitched with the self-fastening fasteners supplied with the screw line. Sealant shall not be placed inside of the screw line.



Installation of remaining roof panels

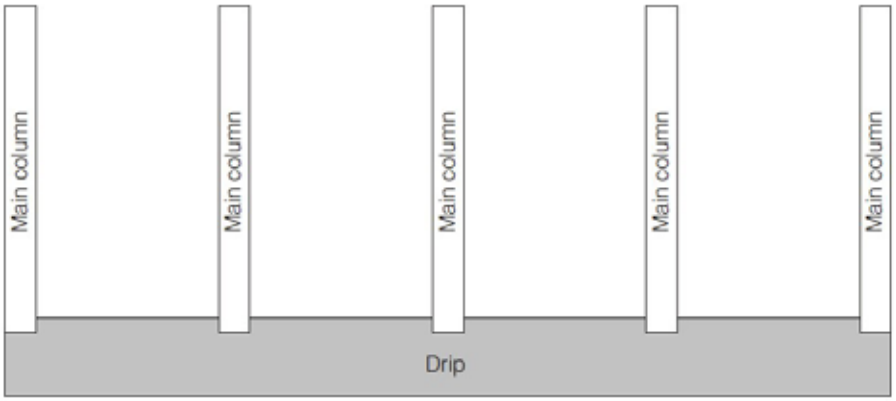
With the first panel run installed & secured and side lap sealant applied, the second panel run may be started. The eave shall be prepared with an inside closure and sealant. The panel shall be positioned so that the overlapping ribs will rest properly. Proper overhang and panel coverage shall be checked. The major ribs of the two panels shall be stitched together and panels attached to the purlins.

Sealing the end laps

At the panel end laps, sealant shall be placed across the full panel below the fastener line. The panel end laps shall have a minimum overlap located over a purlin as per respective erection drawings. The fasteners shall be located on the centre of the flange of purlins.

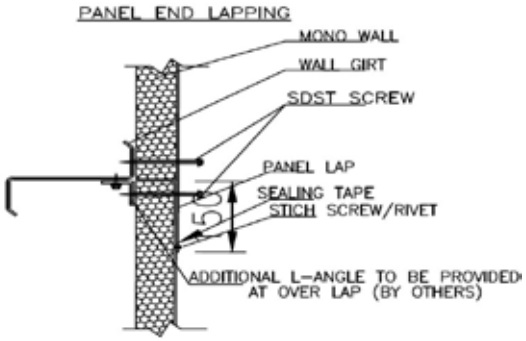
Wall Panel

Metecno wall panels, depending on the distances between centers of the main columns, can be assembled on single, double and multiple spans. Due to space limitations, only the assembly on double spans is illustrated here. For single and multiple spans, adopt similar assembly methods.



Fastener installation

It must be ensured that the fasteners are installed at locations indicated on the building drawings. It is easy to misjudge the location of the structural member, resulting in a fastener off the structural member or below the sealant at the end lap. The fastener shall be driven in until it is tight and the washer is firmly seated. A slight extrusion of neoprene around the washer is a good visual tightness check. The fasteners shall be installed by drilling holes on the ridge and not on the valley.



Checking flatness and overhang

Before starting work it must be ensured that:

- The supports for cladding are truly in the same plane
- The overhangs of panels from the top and bottom supports shall not exceed the limit, whilst also overhanging at least 50 mm into gutters. Necessary adjustments shall be made before laying panels, because it will be difficult or impossible to rectify later.

Positioning first panel

First panel shall be positioned before fixing to ensure that it is correctly located in relation to other parts of the building.

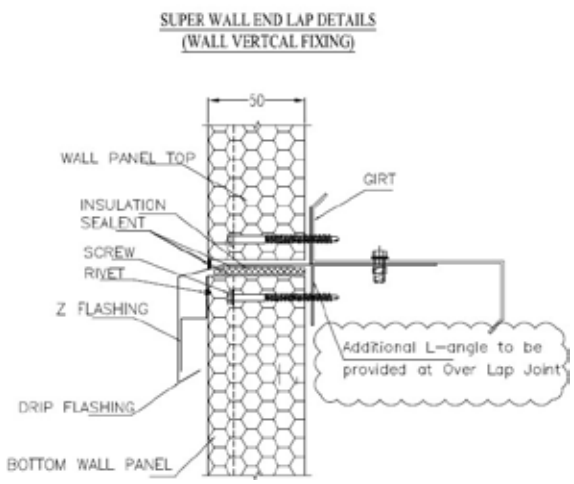
It must be checked that the panel:

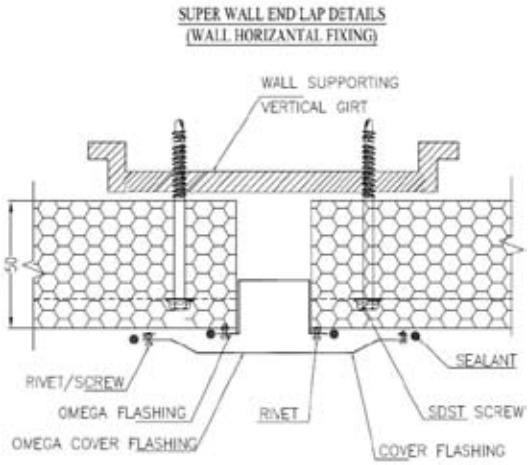
- Aligns with the end-wall (or its barge or fascia), the type of flashing or capping treatment to be used; and
- Aligns correctly at its ends in relation to the gutter and ridge (or parapet or transverse wall).

Positioning other panels

Before assembling the second panel, check that the joints are thoroughly clean. After fixing the first panel in position, other panels shall be aligned using:

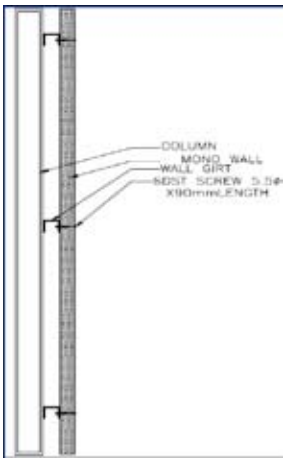
- The long edge of the previous pane;
- A measurement from the end of the panel to the fascia or purlin at the gutter. Gutter-end of all panels shall be kept in a straight line.
- Each panel shall be fixed completely before laying the next; or
- The panel shall be fixed tightly to ensure it can't move, all panels shall be laid completely and then all the intermediate fasteners shall be placed





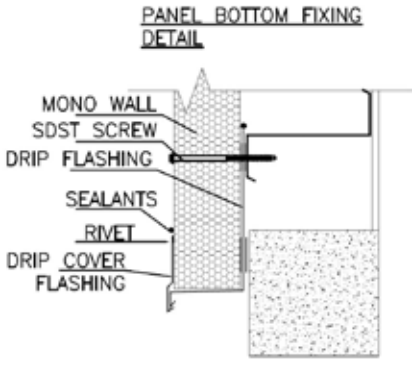
Checking alignment

It must be checked that each panel is parallel with the adjacent panel and gap is within the allowed limit.



Wall panel fixing with floor

Wall panel of 80 mm for outer wall shall be fixed with U-channel of size 40x82x40x1.2mm on floor. U-channel shall be fixed with M6x65mm dash fastener at 300mm c/c spacing.

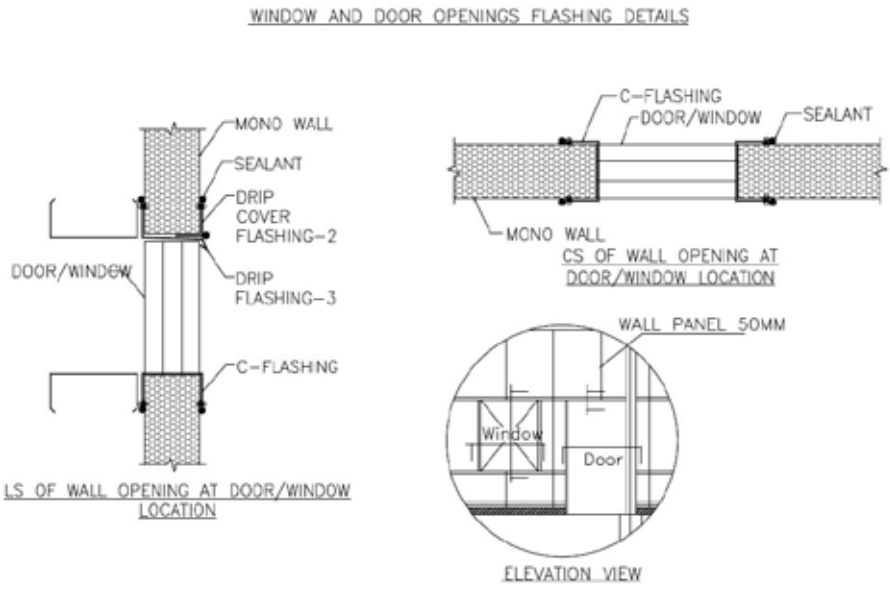


Wall panel fixing with slab

Wall panel of 80 mm for outer wall shall be fixed with self-drilling screw of 12-14x120x4.8mm at 300mm c/c spacing using L-Angle of 50x50x2mm above slab.

Wall partition panel fixing with slab top & bottom

Wall partition panel of 80 mm shall be fixed over RCC slab by PVC gitti screw of 35mm and pop rivet at 200mm c/c spacing using L- Angle of 50x50x1.2mm on both side of panel above slab.



Vertical corner closer

Vertical corner shall be closed using pop rivet at 300mm c/c spacing by using L-Angle of 50x50x0.5mm.

Ceiling Panel

Fastener installation

It must be ensured that the fasteners are installed at locations indicated on the building drawings. It is easy to misjudge the location of the structural member, resulting in a fastener off the structural member or below the sealant at the end lap. The fastener shall be driven in until it is tight and the washer is firmly seated. A slight extrusion of neoprene around the washer is a good visual tightness check.

Orientation of panels before lifting

For maximum weather-tightness, start laying panels from the end of the building that will be in the lee of the worst-anticipated or prevailing weather. It is much easier and safer to turn panels on the ground than up on the roof. Before lifting panels on to the roof, it must be checked that this is the correct way up and the overlapping side is towards the edge of the roof from which side installation will start. Bundle of panels shall be placed over or near firm supports, not at mid span of roof members.

Fixing of Aluminium 'T'

Aluminium 'T' shall be marked on the structural members and holes shall be drilled in the structural members. Sag rod connector shall be assembled on ground for longer drop length. After that Aluminium 'T' shall be assembled on ground with all accessories and erected one by one at specified locations.

The level and alignment of 'T' line shall be checked before fixing the panels. Bottom level of the 'T' shall be adjusted for roof ceiling by adjusting nut. Coupling plates shall be erected to connect adjacent 'T' members. Same procedure

shall be repeated in case of multiple lines.

Ceiling panel installation

Ceiling panel must be sheeted on both sides of the 'T' simultaneously. Proper coverage shall be checked frequently during progress. When lifting panels for laying and fastening, it must be ensured that all the panels are in the correct way up.

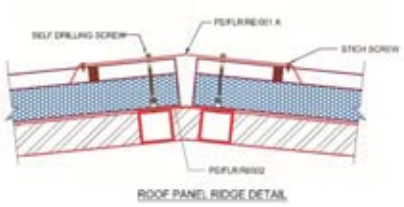
For panel installation steps given below shall be followed:

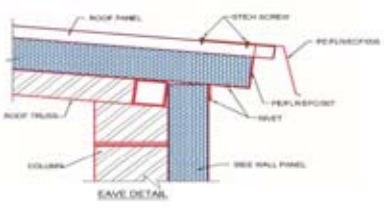
- Layout on the floor shall be marked as per the drawings.
- U Track/ base angle shall be installed in water level.
- Step cutting at wall panels shall be made to make provision for ceiling panel resting.
- Then wall panels shall be installed starting from one end wall and one side wall.
- Plumb and alignment of each panel shall be checked for starting the ceiling panels.
- Inner and outer flashings shall then be installed to give temporary hold at wall panels.
- Partition/other side wall panel shall also be installed with inner and outer flashings.
- Ceiling panels shall then be lifted to the location after checking the orientation as per the drawings before lifting.
- Strip flashing shall be installed on top of the ceiling panel after checking the alignment.

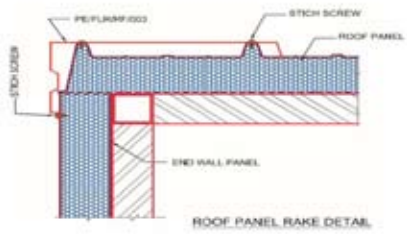
The chamber shall then be completed by following the above steps. Silicon sealant shall be filled at inner and outer face of all the panels. All flashings and accessories shall be installed as shown in the drawings. After that chemical filling shall be done as per the specifications.

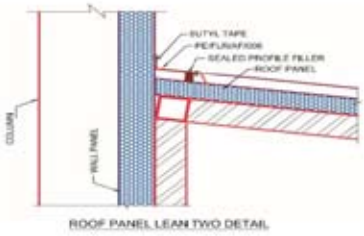
Sealing the side laps

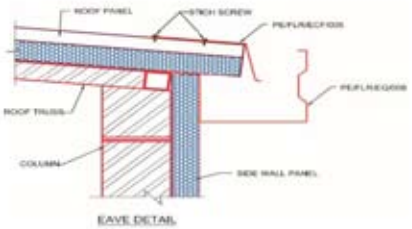
Apply the side lap sealant to the weather side edge of the lower edge of the crest. The sealant should only be applied to clean, dry surfaces. Press firmly along the length of the panel to ensure proper adhesion. Install the adjoining panel positioning the overlapping/ side-lapping rib with care. Drill, at the centre of the clearance holes in the end-lapping panel, required size pilot holes for the lap fasteners. Stitch the lap with the self-fastening fasteners supplied with the screw line. Sealant shall not be placed inside of the screw line.

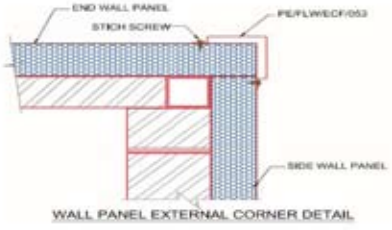


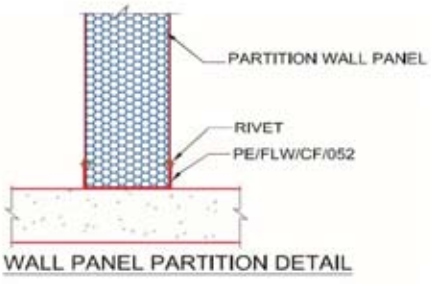


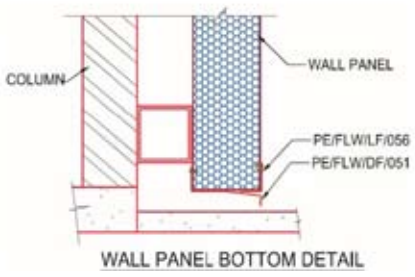












APPLICATIONS

These panels are factory assembled composite panels having high strength-weight ratio and ensuring structural stability on the building envelope. These are used for residential and commercial buildings, school & training centers, steel structures, modular & monolithic cabinets, management blocks & site offices, guard room/ porta cabins, etc.

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No. 1058-P/2021 has been issued to M/s Metecno (India) Pvt. Ltd., Chennai.

MAJOR COMPLETED/UNDER COMPLETION PROJECTS

Used in Cyber Park (Kochi) and Hanyang, Oragadam.

STANDARDS/GUIDELINES TO BE REFERRED

IS 277:2018	Specifications for galvanized steel sheets (Plain & corrugated).
IS 801:1975 (Reaffirmed 2010)	Code of practice for use of cold formed light gauge steel structural members in general building construction.
IS 875 (Parts1 to 3):1987/2015	Code of Practice for design loads (other than earthquake) for buildings & structures.
IS 3346: 1980 (Reaffirmed 2017)	Method of determination of thermal conductivity of thermal insulation materials.
IS 11239 (Part 1, 3, 4, 11 & 12)	Method of tests for rigid cellular thermal insulations.
IS 12436:1988	Specifications for Performed Rigid Polyurethane foam for thermal insulation.
IS 14246:2013	Specifications for continuously pre-painted galvanized steel sheets and coils.
BS 476 (Parts 5, 6 & 7)	Fire Tests on Building Materials & Structures

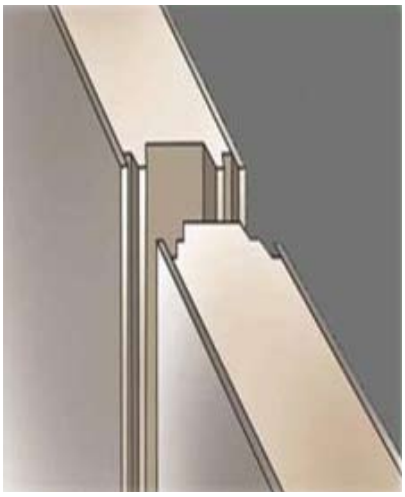


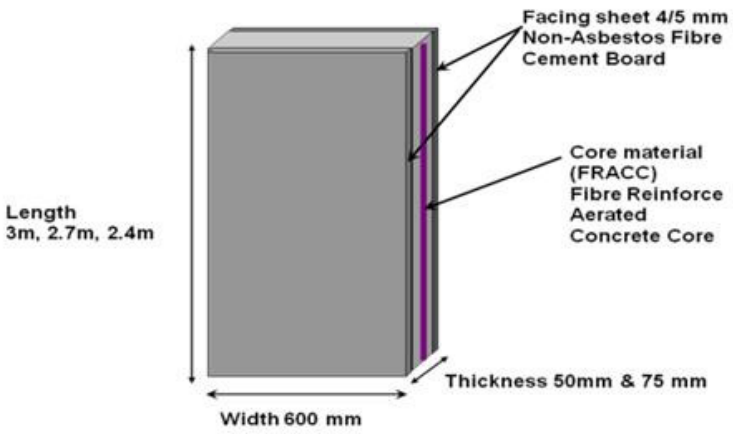
Everest Rapicon Panel/ Solid Wall Panel

(Suitable as Load Bearing Panels in Single storey building and as non load bearing panels for low rise to high rise structures)

ABOUT THE SYSTEM

Rapicon panels are sandwich panels, made of two non asbestos fibre reinforced cement facing sheets of Everest wall boards as per IS 14862, on either sides of a lightweight foam concrete core. The core is made from a mix of Portland cement, fly ash, cellulose, lime, gypsum, synthetic fibre, fillers & water. These panels have a unique tongue and groove jointing system that facilitates rapid construction and maximizes space utilization. The details of these panels are shown in Figs.1 & 2 below;





Size and Thickness of Panel

S. No	Sizes	Thickness	Edges
1	2400 mm height x 600 mm width	50 mm & 75 mm	Square edge Panel& Bevelled edge Panel
2	2700 mm height x 600 mm width		
3	3000 mm height x 600 mm width		

BASIC RAW MATERIAL REQUIREMENTS

i. OPC 43 Grade & OPC 53 Grade shall conform to IS:269:2015 & IS 12269:2013 respectively

ii. Flyash shall conform to IS: 3812(P-1) 2013

iii. Quick Lime shall conform to IS 712:1984

iv. Gypsum shall conform to IS 2547 (Part 1):1976

v. Cellulose (Pulp) shall conform to Manufacturer's Specifications

*Specification of **Rapicon** Panels/Walls*

Sr. No.	Property	Units	Standard/Test Method	Specification Requirements	
1	Length*	mm		3000, 2700, 2400	3000, 2700, 2400
2	Width*	mm		600	600
3	Thickness*	mm		50	75
4	Edge Profile			Square, Beveled	Square, Beveled
5	Standard Weight	kg/m^2		min 35	min 50
6	Apparent Density	kg/m3	IS:2380 (Part.3) – 1977	min 700	min 700
7	Modulus of Rupture (MOR)	MPa	IS:2380 (Part.5) – 1977	min 3.5	min 2.5
8	Screw Withdrawal Strength	kN	IS:2380 (Part.14) – 1977	min 0.3	min 0.3
9	Axial Compressive Strength	kN/m^2	IS2380 (Part.8) – 1977	min 36	min 54
10	Thermal Conductivity	K.cal/ h.m°C	ASTM C177	0.12	0.12
11	Sound Transmission Class	dB	IS:9901 (Part3) - 1981	38	40
12	Fire Rating	min-utes	Bs 476 part 20 & 22	108	134
13	Fire Resistance Properties				
a	Surface Spread of Flame		BS 476 Part 7 - 1971	Class I	Class I
b	Fire Propagation Index (I)		BS 476 Part 6 - 1981	< 3	< 3
c	Ignitability		BS 476 Part 5 – 1968	Class ‘P’ (Not eas-ily ignitable)	Class ‘P’ (Not easily ignitable)
** Subject to tolerance*					

USES OF THE PRODUCT

i. Partitions: Residential, commercial, educational and industrial buildings
ii. Prefab Structures: Accommodations units, Site offices, security rooms, ware house/godowns, schools, army barracks etc.
iii. Cladding: Shopping malls/Hospitals/School/college/university, duct covering, site offices & administration offices,
iv. Boundary Walls: Residential, commercial etc.
v. Fins/ vertical louvers: Residential & commercial buildings,
vi. Fire separation walls: Shopping malls.

MANUFACTURING PROCESS

Rapicon panels are sandwich panels, manufactured with two non-asbestos fibre reinforced cement facing sheets on either sides of a lightweight foam concrete core. The manufacturing process of the panel involves following steps;

i. Production trolleys are assembled with fibre reinforced cement facing sheets into the profiles in the trolleys, 16 panels can be made in each trolley and the assembled trolley is shifted under the pouring station where the slurry is prepared.

ii. Slurry mixing process involves mixing of the fixed quantity of raw materials such as Cement, Fly Ash, Lime, Gypsum, Pulp and fresh water/Process water into the primary mixer through Programmable Logic Controller (PLC).

iii. After proper mixing of raw materials in primary mixer, its spread/viscosity test is carried out to check its consistency before it goes to the final mixer unit where other ingredients are mixed together and thereafter it goes to the pouring hopper. In the pouring hopper there are dividing plates to distribute the final mixed slurry into the each part of pouring hopper, which are connected to the each panel mould with flexible Hose Pipe to pour the slurry. Then plug is fitted on the part from where slurry poured into the mould panel of the production trolley.

iv. The trolley is shifted for procuring chamber for 16 hours when the production of panels is in summer climatic condition and 22 hours in heating chamber in winter condition. After precuring of 16 hrs/ 22hrs of moulded panels, trolley goes in to the stripping section and the panels are stripped with the help of Crane from trolley. The stripped panels from the trolley are shifted over Pallet with the spacer rods fixed for air passage in between the panels. The panels are kept under shade for self curing for at least 21 days. After curing of 21 days, the panels of every batch are tested for Modulus of Rapture (MOR), Density & Moisture. Subject to conformance with specified requirements of tests, the panels are dispatched for use.

v. The maximum production capacity of the factory at Bhagwanpur, Uttrakhand is 704numbers of panels per day and storage capacity is 25,000 panels.

Handling & Storage

- Everest Rapicon Walls should be handled vertically by 3-4 peoples.
- During transportation, bottom and corner should be protected with packing material.
- Handle one panel at a time with gloves to avoid patch marks.
- Panels to be stacked vertically and 150–200 mm above the ground level along the length of panel.
- Panels should be positioned using three metal spacers in between the panels, one at the centre of the panel and other two on either side to maintain air gap between panels.
- The panels should not be kept in open/ uncovered areas. If fully covered area is not available, then panels may be kept outdoors provided it is for a maximum of 10 days and covered by a tarpaulin or plastic cover (Minimum 200gsm) from all four sides.
- Panels stacked horizontally should be covered by a tarpaulin or plastic cover (Minimum 200gsm) from all four sides& must be utilized in maximum 7 days. The stack of panel should not exceed 20 Nos. of panels.
- Panels can be kept in a covered room for a maximum period of 30 days provided panels are stacked vertically and 150–200 mm above the ground level along the length and there is air circulation between the panels.

Installation Procedure of Rapicon Panels

Internal wall & External wall

With 50mm / 75 mm Rapicon Panelsfor Wall height upto 3 meters

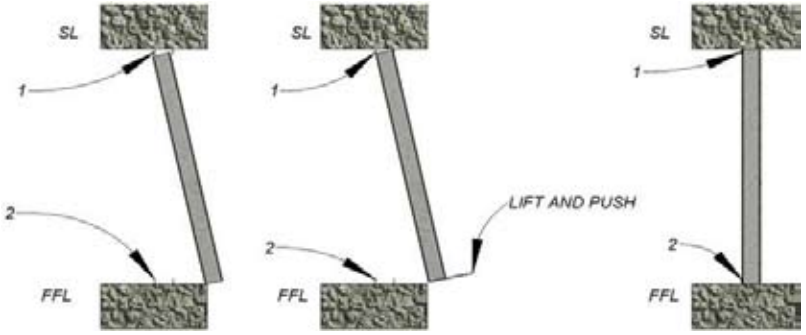
1. Check the level of the ground with water tube level.
2. Mark the layout of the partitions plan on the floor.
3. Cut the floor track profile for 50 & 75 mm panels, respectively to the required lengths and anchor them to the floor using 45 x 8mm metal fasteners @ 600 mm centre to centre, staggered within the web of the profile. The ceiling track profile is similarly fixed to the RCC soffit/ steel structure frame with metal fastener / hex-head screws in plumb to the floor track.



4. The panels are inserted into the track profiles, from the side of the smaller floor track flange by lifting and tilting the same, simultaneously & then pushing it to its position within the track profile.

5. Check the right angle of the panel (using try square tool) and adjust by inserting wooden packing in between floor channel and module, if required, to ensure the panels in right angle.

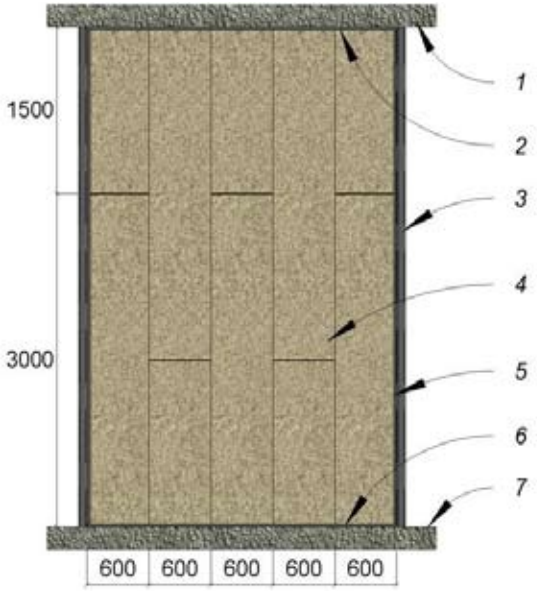
6. Apply sodium silicate (bonding agent), in between the tongue and groove joints of every single panel for joint rigidity as we slide one panel after another, within the ceiling and floor track profile, during required wall assembly. Thereafter the joints at the surface are jointed and finished with Everest acrylic resin based cementicious jointing compound and joint fibre tape for the required seamless finish.



1. Ceiling Track Profile
2. Floor Track Profile

7. For external walls subjected to high wind loads, the joints to the exterior shall be sealed with weather resistant acrylic / silicon sealant with fibre mesh tape.

For wall height above 3 meters till 4.2 and 4.5 meters with 50 mm and 75 mm panels respectively, through staggering of joints.



1 Ceiling Slab
2 Ceiling Track Profile
3 Concrete Column
4 75 mm Thick Everest Rapicon Wall Panel
5 Ceiling Track Profile
6 Floor Track Profile
7 Floor Slab

For Wall height beyond 4.2 and 4.5 meters with 50mm and 75mm panels respectively

For Internal wall heights above 4.2 / 4.5meters for 50 / 75mm panels& External walls beyond 3 meters height respectively, MS structural horizontal and vertical supports shall be provided. The 50 x 50mm / 75 x 75mm SHS profile for 50 / 75 mm panels respectively and of thickness 2.6 to 5.7mm (depending on the subjected load onto the wall) shall be provided as horizontal supports at every 3meterscentre to centre. The same profile shall also be used as vertical supports at 3meters or to a greater span depending upon the subjected load onto the wall. The horizontal members shall be either welded or fixed through MS cleats to the vertical structural members. The structure shall be anchored to the floor and RCC soffit with MS cleats or base plates and metal expansion fasteners. (In case of truss the structural members shall be either welded or anchored with cleats and hex head screws). 50 / 75mm Rapicon walls shall then be used as filler walls within the grid created through the structural members.

Door fixing

Case 1: Door Frame 300mm away from Column / Wall

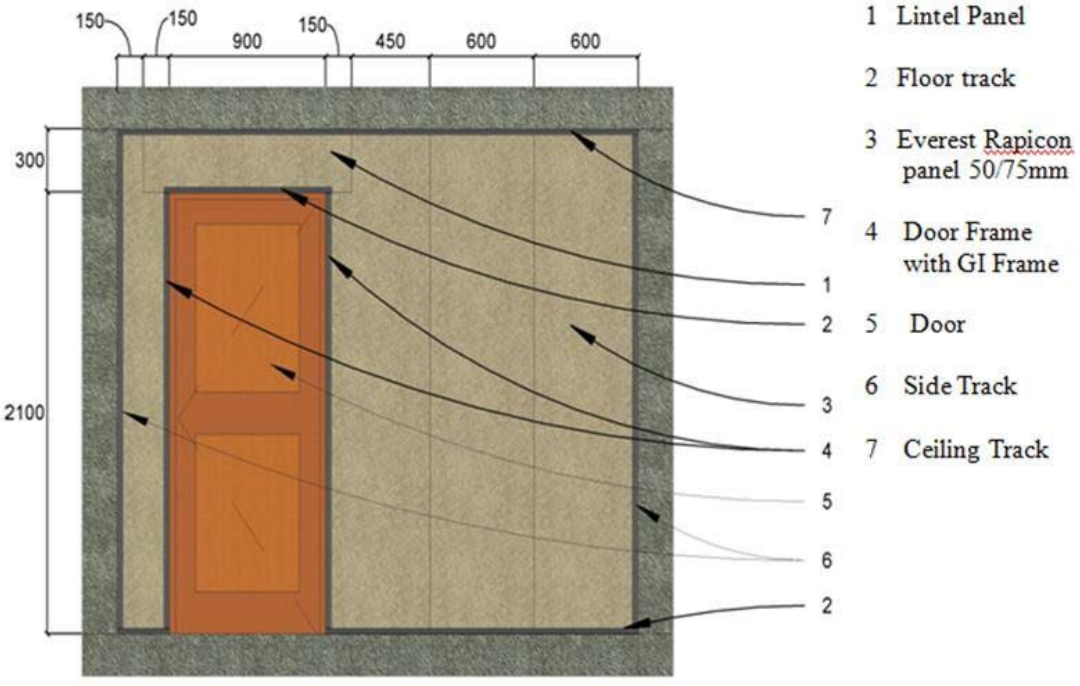
1. Fix the floor track to the floor minus the door opening, to the entire length of the wall.

2. For the required lintel the standard 600mm wide panel are to be cut to 300mm width, where by its length will be in accordance to the door width which includes 2x150mm minimum increased length, for the required overlap of the lintel on the vertical wall panels to the either side of the door opening. For resting of the lintel panel on the wall panels to the either side of the door opening, the two wall panels adjacent to door opening are to be cut to required L shape. While the bottom of the L will be cut to a minimum length of 150 mm or more depending upon the required offset of the lintel panel, the height of the L which is to be cut has to coincide with the required door height (Refer Fig.8).

3. To continue beyond the door opening (& window opening, explained later in this section), vertical wall panels are then inserted and fixed into the floor & ceiling track profile to complete the required wall length, following the procedure, as explained above.

4. Post assembly of the wall, the door frame is to be fixed to it position within the created opening and the door installed, thereafter.

5. The partition wall is then ready for the required finishing procedures.



Case 2: When the door is to be fixed from the starting of the partition i.e. Brick Wall / Column

1. Start assembly of the wall partition with the panels from the side extreme to the door opening.

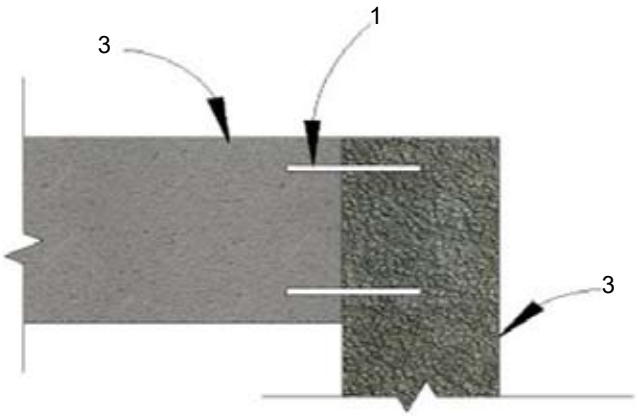
2. Assembly procedure to continue till the door opening.

3. The last panel, adjacent to door opening is to be cut to the required L shape (as mentioned in above case; whereby the bottom & height of the L, which is to be cut, will be as per the requirements for resting of the lintel panel.

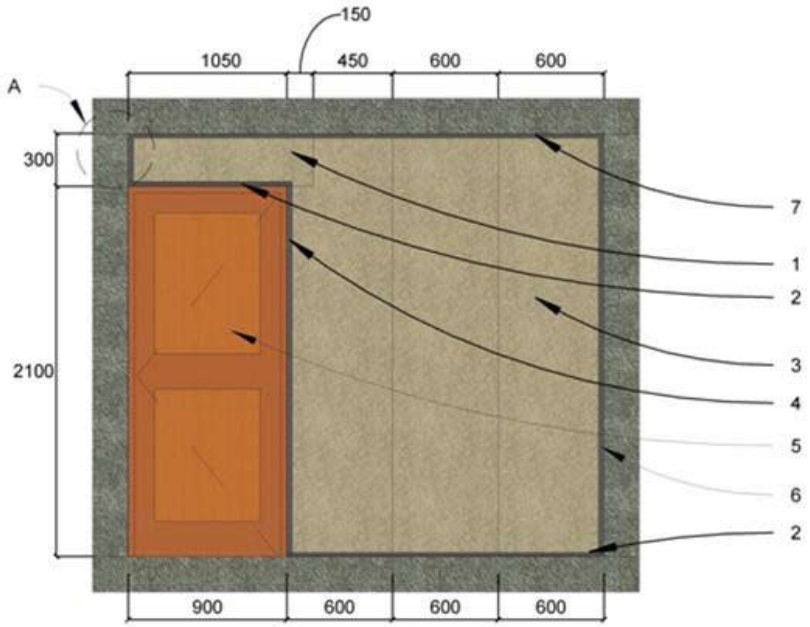
4. To address the fixing of the lintel member (which includes the door frame) to the adjacent brick/ block/ RCC wall or column, M.S. twin rods of dia 8mm are anchored both into the wall/ column & the lintel in combination with chemical fasteners/ cement slurry mix, for the required rigidity and stability.

5. Post assembly of the wall, the door frame is to be fixed to it position within the created opening and the door installed, thereafter.

6. The partition wall is then ready for the required finishing procedures.



1 Reinforcement Steel Rod 8mm Dia. Min
2 Lintel Panel
3 Concrete Column

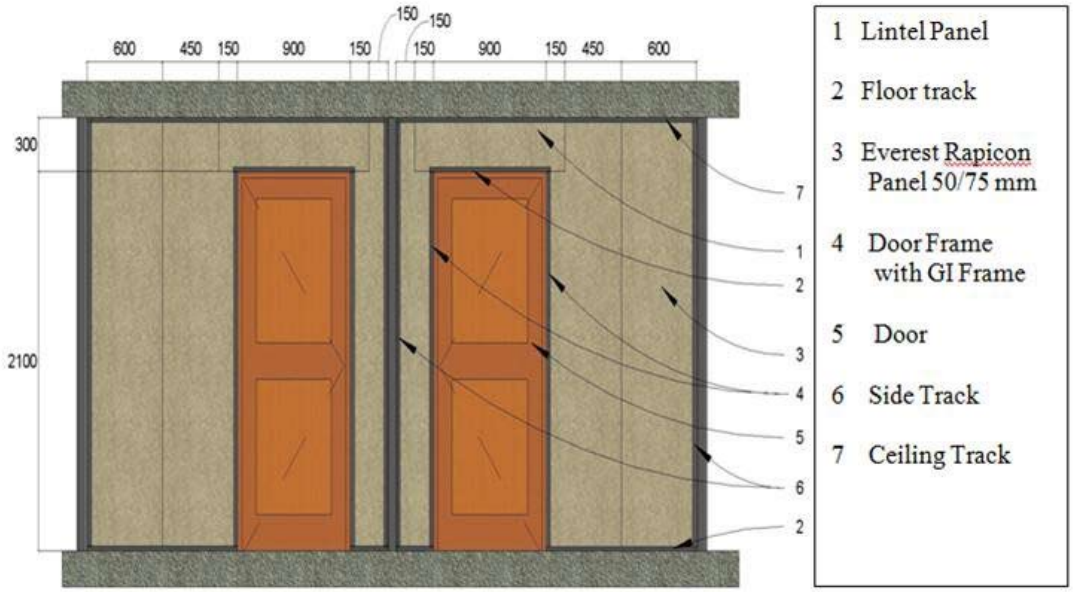


1 Lintel Panel
2 Floor track
3 Everest Rapicon panel 50/75mm
4 Door Frame with GI Frame
5 Door
6 Side Track
7 Ceiling Track

Case 3: When two doors are fixed at one place

The assembly of all walls without door openings, perpendicular to the wall with the opening has to be completed first. The door position should be at a minimum distance of 600mm (equal to or more than the width of a single panel) from junction of two walls.

A minimum distance of 300mm to be maintained between two adjacent door frames, which is achieved by insert fixing a 300 mm or more width panel. The height of this panel should be equal to the wall height or till the door frame for individual door lintel or a common lintel for both the doors arrangement, respectively.

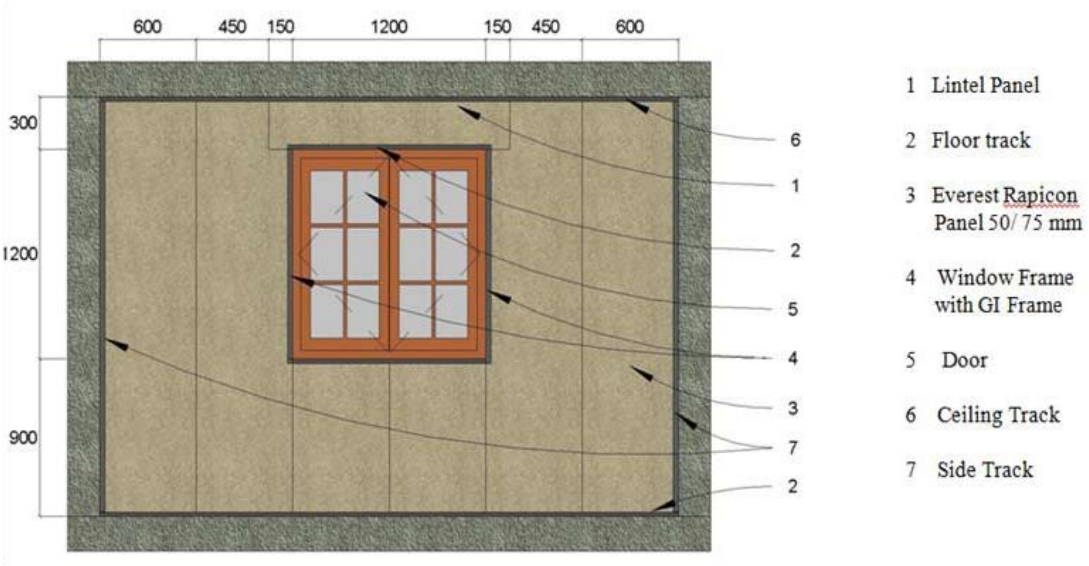


Window fixing

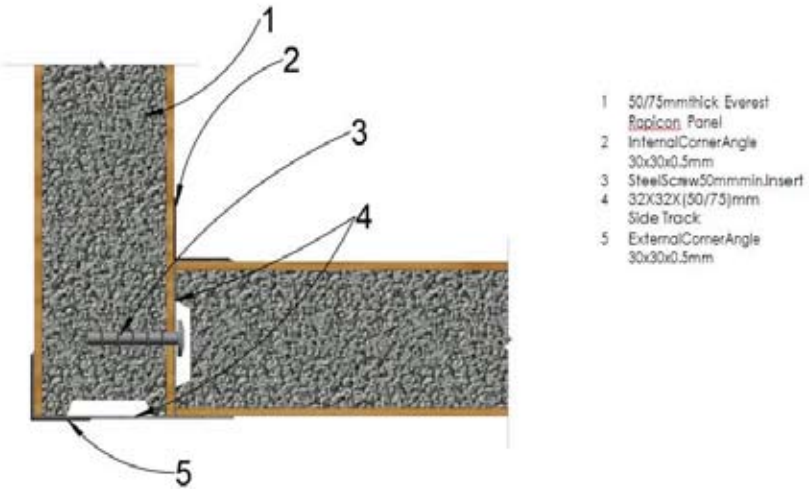
1. Partition wall to be constructed as per the above laid procedures.

2. Glass/ grills/ AC units can then be fixed within the opening, using timber/ MDF/ aluminium/ steel frames with machining trims and beadings.

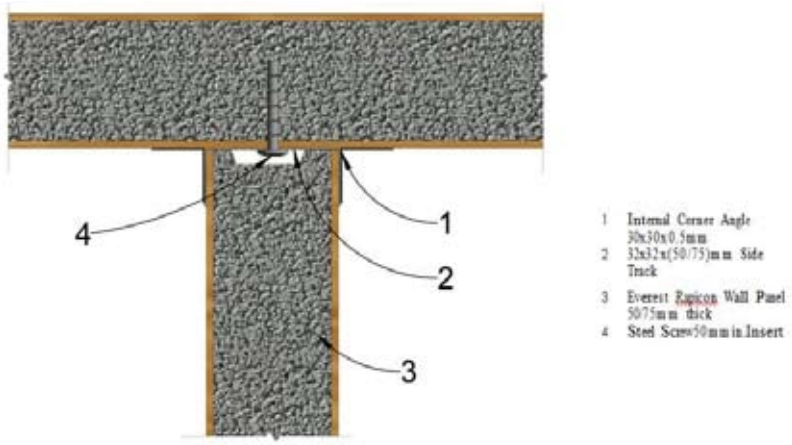
3. At least one panel is required on either side of the glass to support the lintel panel.



Corner Junction details



Typical L Junction

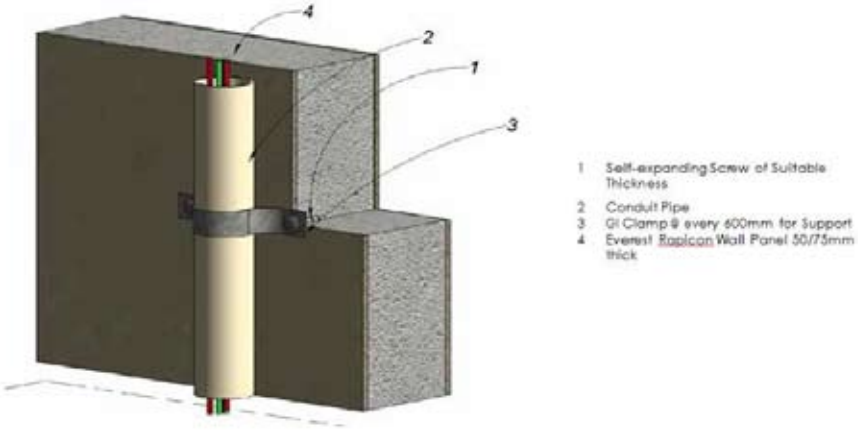


Typical T Junction

Conduiting

External Wiring for 50 mm thick panel

External wiring on Rapicon shall be done by using PVC casing and capping / pipes, mounted and fixed with screws and clamps, to the surface of the panels, post installation of the wall.



Conduit Wiring in 50mm Rapicon Panel

Concealed Wiring for 75 mm thick panel

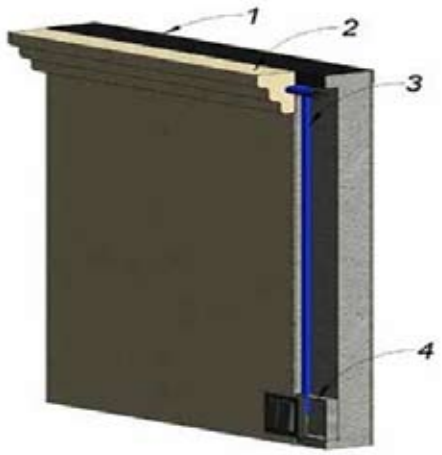
1. Concealed wiring can be done in Rapicon Panel by routing (chasing) on the surface of the panel, vertically from top to bottom. Surface routing is done by a routing tool, cutting the face cement sheet & removing the core the required depth. Continuous horizontal routing of successive panels shall be avoided.

2. Horizontal face routing in non-load bearing walls shall be at a distance of 300mm maximum from the longitudinal edge of the panel.

3. In 75mm Rapicon Walls chasing is also recommended for switch junction boxes. For 50mm Rapicon walls, the surface mounting of switch junction boxes are only recommended.

4. Post installation of conduit pipes and fittings, the chased core shall then be filled and finished with sodium silicate & Fly Ash slurry paste. Electrical wires then shall be managed through the concealed PVC pipes after setting of the slurry.

5. In case of concealed wiring, jointing and finishing of the panels with Everest acrylic resin based cementicious jointing compound and joint fibre mesh tape for a seamless finish, will only be executed after managing the services.



KEY
1 Everest Rapicon Wall Panel 50/75mm thick
2 Cornice of Wood or POP
3 Wiring Conduit
4 Junction Box

Jointing & Finishing

Jointing and finishing involves covering and reinforcing the joints of two adjacent Aerated concrete sandwich Rapicon panels. Jointing and finishing provide seamless finishing and also help in delivering required sound insulating and fire resistant properties to a wall application with Rapicon panels.

Everest acrylic resin based jointing compound is an universal two part jointing compound comprising of powder based special cement and liquid based special synthetic acrylic polymer mixed together in proportion of 3:1 by volume. The product has good expansion and contraction properties and used for monolithic and joint less solution, both in exterior & internal application. Everest Jointing Compound is suited for areas subjected to frequent climatic changes conditions. It is durable, flexible, resistance to chemical attacks, atmospheric pollution, fungal effects and UV radiation, and

- It comes in 10 and 20 kg pails,
- Coverage of the jointing compound is 0.55kg per sqm of the board surface area,
- Setting time of Jointing compound is 3 hours in normal climate condition.

Finishing of joints (Interior / Exterior application)

Factory finish beveled edged panels or panels beveled at site are recommended for monolithic joint finish. For site beveled boards 25mm bevel width and 1.5-2mm bevel depth are recommended along the longitudinal side of the fascia board (while beveling of boards are done at site, the transverse side of the panel also can be beveled for superior finish). Beveling at site can be done using suitable router machine. For seamless finish a gap of 2-3mm between two adjacent joints of the panel is recommended. Finally the joints of panel shall be finished with Everest acrylic resin based cementicious compound and joint fiber tape.

Before jointing and finishing over the surface of the panels, the gap in between the tongue and groove joints shall be sealed with mixture of sodium silicate and fly ash mixed in proportion of 1:1 by volume.

The Square edge panels are only recommended for complete rendering of the panel surface, post treatment of the joints (in case of rendering a gap of 10mm in between the board joints is recommended, which shall be filled with Everest acrylic resin based cementicious compound, prior to the rendering process). The rendering application with polymer based cement mortar and alkaline resistant glass fiber mesh may be with or without an insulation substrate in the form of expanded polystyrene or extruded polystyrene.

The gap in between the tongue and groove joints shall also be sealed with mixture of sodium silicate and fly ash mixed in proportion of 1:1 by volume, prior to the sealing of the joints in between the fascia board of the adjacent panel, with acrylic / silicon based sealant.



Mixture of Sodium Silicate and Flyash



Everest Jointing Compound (Pail Size – 10kg and 20kg)

Preparation of Jointing Compound

Everest acrylic resin based jointing compound comprising of powder based special cement and liquid based special synthetic acrylic polymer is mixed together in proportion of 3:1 by volume. The mixture has to be thoroughly mixed using manual or power agitator, vigorously, for 5- 10 minutes to achieve the desire homogeneous mixture. The prepared jointing compound shall be used within 45 minutes of preparation. (Compound as required based on site conditions and which can be utilized within 45 minutes of preparation, shall only be prepared to avoid wastages).





3 Powder Based Special Cement (Part A)
4 Liquid Based Special Synthetic Acrylic Polymer (Part B)

5 Manual Agitator

Non-Woven Synthetic Glass Fibre Joint Mesh Tape

Post filling of grooves a coat of Everest resin based cementicious compound shall be applied to a width of 53mm coinciding with the extreme edges of the beveling in two adjacent fascia boards, using a flexible steel knife. 50mm wide non woven synthetic glass fibre mesh tape shall be embedded to the applied wet jointing compound. A minimum drying of 15 minutes shall be allowed before second application of jointing compound.

MAJOR WORKS UNDERTAKEN

The manufacturer has supplied the panels at the projects given below;

S.No.	Name of Project	Location	Applications	Area in square feet	Completion Period
1	NIIT	Sikkim	Dry Wall Partition with 75mm Rapicon Panel.	50000	2015
2	SRM University	Tadong, Sikkim	Dry Wall Partition with 75mm Rapicon Panel.	15000	2019
3	School Project	Dimapur	Dry Wall with 50 mm and 75 mm Rapicon panels	20000	2019-20
4	BSNL	Guwahati	Dry Wall Partition with 75mm Rapicon Panel.	18000	2012
5	UNICEF Health Posts	All Over Nepal	Dry Wall with 50 mm and 75 mm Rapicon panels	500000	2015-2017
6	Mistri Khola Hydel Electric Project	Myagdi	Dry Wall Partition with 50mm Rapicon Panel.	10000	2017
7	Sumeru City Hospital	Kathmandu	Dry Wall with 50 mm and 75 mm Rapicon panels	20000	2019
8	Gilly Academic	Dhangadi	Dry Wall Partition with 50mm Rapicon Panel.	12000	2019
9	Party Palace	Dhangadi	Dry Wall Partition with 50mm Rapicon Panel.	14000	2019
10	CMC Hydro Power Project	Solukhumbhu	Dry Wall Partition with 50mm Rapicon Panel.	22000	2018
11	TATA POWER	Jaipur	Dry Wall Partition with 50mm Rapicon Panel.	12300	2020
12	Panchbadra Refinery	Barmer, Raj	50mm rapicon	30,000	2018-19
13	Mittal Hospital	Jaipur, Raj	50mm rapicon	11000	2019-20
14	Apex Crical Mall	Jaipur, Raj	50mm rapicon	100,000	2015-16
15	Gaur City Mall	Ghaziabad, UP	75mm rapicon	50,000	2019-20
16	Gudawara Bohari saheb	Batala, Panjab	50mm rapicon	20000	2019
17	RCC construction company	Chandigarh	50mm rapicon	13000	2019
18	Musahasi	Bawal, Haryana	75mm rapicon	37103	2018-19
19	Yokohama	Bhadurgarh,HR	75mm rapicon	46379	2018-19
20	Subroj	Manesar, HR	75mm rapicon	55655	2018-19
21	Maruti	Manesar, HR	75mm rapicon	18551	2019-20
22	HMI	Gurgaon, HR	75mm rapicon	74206	2019-20
23	HMI	Gurgaon, HR	50mm rapicon	74206	2019-20
24	Emmar Digital	Gurgaon, HR	75mm rapicon	74206	2019-20
25	The Hive	Gurgaon, HR	75mm rapicon	148413	2019-20
26	Cyber Park DLF	Gurgaon, HR	75mm rapicon	74206	2019-20
27	DLF Down Town	Gurgaon, HR	75mm rapicon	37103	2019-20
28	Alkone Business Park	Faridabad, HR	75mm rapicon	18551	2017-18
29	Allahbad Institute of Medical College	Khaga, UP	75mm rapicon	14000	2019-20

S.No.	Name of Project	Location	Applications	Area in square feet	Completion Period
30	Phonomix Plassio Mall	Lucknow, UP	75mm rapicon	120560	2019-20
31	L&T (wipro)	Bangalore	Internal wall(75mm)	17000	2017-18
32	malabar medical college	calicut	50 mm and 75 mm	28000	2015-16
33	Kims Hospital	Trivandrum	75mm	12000	2018-2019
34	Kottayam Medical College	Kottayam	50 mm	26000	2018-2019
35	Mims Hospital	Malappurem	50 mm and 75 mm	16000	2018-2019
36	Wayanadu Gate Hotel	Wayanadu	50 mm and 75 mm	28000	2015-16
37	Amritha College	Ernakulam	50mm rapicon	26000	2015-16
38	Wipro (L & T)	Hyderabad	Internal wall with 75mm	12000	2019-20
39	SKS Hospital	Bhopal	75 mm Rapicon panel	60,000	2015-16
40	City Center Mall	Raipur	75 mm Rapicon panel	15,000	2012-13
41	PGH Group	Jabalpur M.P.	75 mm Rapicon panel	80,000	2013-14
42	Sanitation Project	M.P.	50 mm Rapicon Panel	40000	2014-15
43	C-21 Mall	Indore M.P.	75 mm Rapicon panel	15000	2015-18
44	Naman Mall	Indore M.P.	75 mm Rapicon panel	10000	2016-19
45	Liquore Shop	Bilaspur CG	50 mm Rapicon Panel	15,000	2014-15
46	Star Acadmy	Indore M.P.	50 mm Rapicon Panel	12000	2019
47	NMRCL	Nagpur	75mm Shops Partition	30000	2019-2020
48	Raynolds Hospital	Washim	75mm Partition	13500	2019-2020
49	Tuli College	Nagpur	75mm Partiton	13000	2020

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No.: 1061-S/2022 has been issued to M/s Everest Industries Ltd., Nasik.

STANDARDS / REFERENCES

IS 712:1984	Specification for building lines
IS 2380 (Part 3):1977	Method of tests for wood particle boards – Determination of flexural strength
IS 2380 (Part 4):1977	Method of tests for wood particle boards – Determination of dimensional stability
IS 2547 (Part 1): 1976	Specifications for gypsum building plaster – premixed light weight plaster
IS 3346:1980	Method of determination of thermal conductivity of thermal insulation materials
IS 3614:1979	Code of practice for Standard heating conditions
IS 3809:1979	Fire resistance test for structures
IS 3812(Part 2):2003	Specifications for flyash for use as pulverized mixture in cement concrete
IS 9901:1981	Measurement of sound insulation in buildings and building elements
IS 11050 (Part 1):	1984 – Rating of sound insulation in buildings
IS 12089:1987	Specifications for granulated slag for manufacture of Portland slag cement concrete
IS 12269:2013	Specifications for 53 grade ordinary Portland cement
IS 13000:1990	Specifications for fibre cement flat sheets
IS 14862:2000	Specifications for silica- asbestos cement flat cement sheets
BS 476 (Part 4):1970	Test method for non-combustibility of building and structures
BS 476 (Part 5):1979	Method of tests for ignitability
BS 476 (Part 6):1989	Method of tests for fire on building materials and structures
BS 476 (Part 4):1997	Method for fire classification of surface spread of flame
BS 476 (Part 20-22): 1987	Fire resistance test to building materials and structures
BS 4370 (Part 2):1993	Method of tests for rigid cellular materials
ASTM E 72:2015	Standard test method for conducting strength test of panels for building construction



Monolithic Concrete Construction

Monolithic Concrete Construction System – using Plastic-Aluminium Formwork

(Suitable for Low Rise to High Rise Structures)

ABOUT THE TECHNOLOGY

The technology intents to replace the conventional steel/plywood shuttering (formwork) system with customised engineered formwork which is manufactuered in the factory set up under controlled conditions. In this system, in place of traditional RCC framed construction of columns and beams and infill walls; all floors, slabs, columns, beams, walls, stairs, together with door and window openings are cast-in-place monolithically using appropriate grade of concrete in one operation. The specially custom designed modular formwork made up of Aluminium/ Plastic/Aluminium-Plastic Composite is used for the purpose which facilitates easy handling with minimum labour & without use of any equipment. Being modular formwork system, it enable fast construction of multiple/mass modular units.







BASIC MATERIAL REQUIREMENTS

Formwork system

Formwork system is manufactured by various firms in India and abroad and shall have to be designed as per loading requirements of the structure. It must have adequate stiffness to weight ratio, yielding minimum deflection during concreting & operation. The panel formwork should fix precisely, securely and require no bracing. Being recent advancement in technology, IS 14687 : 1999 Guidelines for falsework for concrete does not cover requirements of special type of formwork system, however, it is being covered in NBC - 2016.

Concrete

Shall be of appropriate grade based on environment condition (exposure) as per IS 456:2000.

Reinforcement

Shall conform to IS 1786:2008.

DETAILS OF FORMWORK

The formwork made of Aluminium Extruded Section conforming to IS 733:1983 and PVC of Grade PVC 67G ER01 is in accordance with IS 10151:1982. It consists of different sections including starter of MS Angle, top frame of aluminium channels, wall panels, slab panels & truss.

The formwork is designed based on the structural requirements of building units. A quality control system is required to be followed in manufacturing of formwork components.

STRUCTURAL REQUIREMENTS OF THE CONSTRUCTION

The Monolithic RCC construction is considered as shear wall system. The maximum spacing between cross wall shall be limited to 1.5 times the floor height if supported on two edges and 2.0 times the floor height, when supported on all four edges.

The walls are designed primarily for vertical loading and also for in-plane lateral load (shear) and out of plane (bending) due to wind load and earthquake forces as per relevant Indian Standard Code IS 875(Pt.3):2015 and IS1893(Pt.1):2016 respectively. For out of plane loading, the walls can be assumed to be supported by floor slabs / diaphragm and cross walls and continuity can be assumed, wherever applicable.

The structural design of plain & RCC shall be as per IS 456:2000 while IS 13920:2016 is referred for ductile detailing of reinforced concrete structure. Thickness of wall below plinth level should be minimum 200 mm with double layer reinforcement.

Guidelines on Monolithic Concrete Construction prepared by BMTPC may be referred for material requirements & design aspects of this system.

DURABILITY



Since concrete is main constituent material in this system, durability of the structure can be achieved by using proper ingredient, grade of concrete as per IS 456:2000 and mix design in accordance with IS 10262:2009.

Thickness of the wall is generally 100 mm with the centrally placed reinforcement. Therefore, adequate cover is likely to be maintained, for higher durability.

THERMAL BEHAVIOUR OF STRUCTURE



100 mm thick RCC walls and slab has thermal transmittance (*U*) value as 3.59 W/m^{2}K) (as per IS 3792:1978). As, it is more than the normal plastered brick masonry walls (thermal transmittance (*U*) 2.13 W/m^{2}K), it is advised that implementing agency shall ensure proper planning for heat insulation and air ventilation in the housing units through proper orientation, shedding etc. (*see* IS 3792:1978 for guidance).

ACOUSTIC



Average sound reduction for 100 mm concrete is ≥ 45db (IS 1950:1962), which is considered as reasonable acoustic insulation.

EASE OF FIXING SERVICES



All electric and plumbing fixtures, service lines have to be pre-planned and placed appropriately before pouring concrete in RC walls & slabs. Post construction alternations are not desirable.

ECONOMY OF SCALE

Economies of scale depend upon the volume of work and number of repetition of the formwork. To achieve economy, minimum 100 repetitions are desirable.

For very small project of less than 500 units, this system may not prove to be economical. However, now with number of formwork manufacturers available, the project with less number units may also be feasible.

OTHER FEATURES



1) Pre designed formwork acts as assembly line production and enables rapid construction of multiple/mass scale units of repetitive type.
2) Varying work cycle is possible, however, for speed and economy, 3 to 4 days cycle is desirable.
3) It is flexible in design and can form any architectural or structural configuration, such as stairs, windows, etc.

LIMITATIONS

1) A lead time of about 3 months is required for initiation of work, as the formwork are custom designed, manufactured and prototype approved before manufacturing required number of sets of formwork.
2) Capital cost to initiate construction is high and may require regular flow of funds.
3) Post construction alterations are difficult.
4) All the service lines are to be pre-planned in advance.
4) Not much saving in construction in one storey structure.

MAJOR COMPLETED/UNDER COMPLETION PROJECTS

1) 5008 houses at Kanjhawala Narela, Delhi for DSIIDC.
2) 512 houses in Bawana, Delhi for DSIIDC.
3) 3000 houses in Ahmedabad for Ahmedabad Municipal Corporation.
4) 3000 houses in Lucknow for Lucknow Development Authority
5) 4,52,656 houses under PMAY (U) in various parts of Andhra Pradesh
6) 4,586 houses under PMAY(U) in Naya Raipur, Chhattisgarh
7) 30,000 houses under PMAY(U) in Maharashtra

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No. 1006-A/2011 has been issued to M/s Sintex Industries, Ahmedabad.

STANDARDS/GUIDELINES REFERRED

IS 456 : 2000	Code of Practice for plain and reinforced concrete (Fourth Revision)
IS 733 : 1983	Wrought Aluminium and Aluminium Alloy Bars, Rods and Sections (for General Engineering Purposes)
IS 875 (Pt.3) : 2015	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Part 3 : Wind Loads
IS 1786 : 2008	High strength deformed steel bars and wires for concrete reinforcement-
IS 1893 (Pt.1) : 2016	Criteria for Earthquake Resistant Design of Structures - Part 1 : General Provisions and Buildings (Sixth Revision)
IS 1950 : 1962	Code of practice for sound insulation of non-industrial buildings (Reaffirmed 2010)
IS 3792 : 1978	Guide for heat insulation of non-industrial buildings (Reaffirmed 2013)
IS 10151 : 1982	Polyvinyl Chloride (PVC) and its Copolymers for its Safe Use in Contact with Foodstuffs, Pharmaceuticals and Drinking Water
IS 10262 : 2009	Concrete Mix Proportioning - Guidelines (First Revision) (Reaffirmed 2014)
IS 13920 : 2016	Ductile detailing of reinforced concrete structures subjected to seismic forces - Code of practice (First Revision)
IS 14687 : 1999	Falsework for Concrete Structures - Guidelines (Reaffirmed 2014)
BMTPC Guidelines : 2011	Guidelines on Monolithic Concrete Construction
PAC No. 1006-A/2011	Performance Appraisal Certificate issued by BMTPC on Formwork for Monolithic Construction

Monolithic Concrete Construction System – using Aluminium Formwork

(Suitable for Low Rise to High Rise Structures)

ABOUT THE TECHNOLOGY

The technology intents to replace the conventional steel/plywood shuttering (formwork) system with customised engineered formwork which is manufactuered in the factory set up under controlled conditions. In this system, in place of traditional RCC framed construction of columns and beams and infill walls; all floors, slabs, columns, beams, walls, stairs, together with door and window openings are cast-in-place monolithically using appropriate grade of concrete in one operation. The specially custom designed modular formwork made up of Aluminium/ Plastic/Aluminium-Plastic Composite is used for the purpose which facilitates easy handling with minimum labour & without use of any equipment. Being modular formwork system, it enable fast construction of multiple/mass modular units.

BASIC MATERIAL REQUIREMENTS

Formwork system

Formwork system is propriety system and designed as per loading requirements of the structure. It has adequate stiffness to weight ratio, yielding minimum deflection under concrete loading. The panel should fix precisely, securely and require no bracing. Being recent advancement in technology, IS 14687 : 1999 Guidelines for falsework for concrete does not cover requirements of special type of formwork system.

Concrete

Shall be of appropriate grade based on environment condition as per IS 456:2000



Reinforcement

Shall conform to IS 1786:2008

DETAILS OF FORMWORK



The formwork systems used are made of light weight Aluminium.
The recommended concrete forms generally use robotics welding system for manufacturing. A soft alloy weld wire is utilized in the concrete form weld process. Fixing of the formwork is done using tie, pin & wedges system. Does not require very skilled labour to do the job.
The formwork can be designed based on requirements of dwelling unit and the project. A repetition of about 1000 cycle is claimed (This, however, needs, verification).



STRUCTURAL REQUIREMENTS OF THE CONSTRUCTION

The Monolithic RCC construction is considered as shear wall system. The maximum spacing between cross wall shall be limited to 1.5 times the floor height if supported on two edges and 2.0 times the floor height, when supported on all four edges.

The walls are designed primarily for loading and also for in-plane lateral

load (shear) and out of plane (bending) due to wind load and earthquake forces as per relevant Indian Standard Code IS 875(Pt.3):2015 and IS1893(Pt.1):2016 respectively. For out of plane loading, the plate can be assumed to be supported by floor slabs / diaphragm and cross walls and continuity can be assumed, wherever applicable.

The structural design of plain & RCC shall be as per IS 456:2000 while IS 13920:2016 is referred for ductile detailing of reinforced concrete structure. Thickness of wall below plinth level should be minimum 200 mm with double layers reinforcement.

Guidelines on Monolithic Concrete Construction prepared by BMTPC may be referred for material requirements & design aspects of this system.

DURABILITY

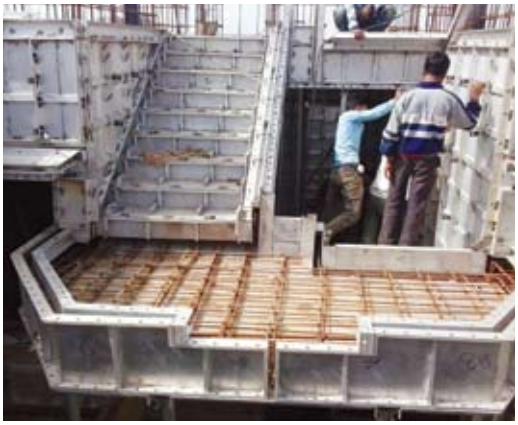
Since concrete is main constituent material in this system, durability of the structure can be achieved by using proper ingredient, grade of concrete as per IS 456:2000 and mix design in accordance with IS 10262:2009.

Thickness of the wall is generally 100 mm with the centrally placed reinforcement. Therefore, adequate cover is likely to be maintained, as a result high durability is achieved.



THERMAL BEHAVIOUR OF STRUCTURE

100 mm thick RCC walls and slab has thermal transmittance (*U*) value as 3.59 W/m^{2}K) (as per IS 3792:1978). As, it is more than the normal plastered brick masonry walls (thermal transmittance (*U*) 2.13 W/m^{2}K), it is advised that implementing agency shall ensure proper planning for heat insulation and air ventilation in the housing units through proper orientation, shedding etc. (*see* IS 3792:1978 for guidance).



ACOUSTIC

Average sound reduction for 100 mm concrete is ≥ 45db (IS 1950:1962), which refers reasonable acoustic insulation.

EASE OF FIXING SERVICES

All electric and plumbing fixtures, lines have to be pre-planned and placed appropriately before pouring concrete in RC walls & slabs. Post construction alternation is not desirable.

ECONOMY OF SCALE

Economies of scale depend upon the volume of work and number of repetition of the formwork. To achieve economy, minimum 100 repetitions are desirable.



For very small project of less than 500 units, this system may not prove to be economical. However, now with number of formwork manufacturers available, the project with less number units may also be feasible.

For very small project of less than 500 units, this system may not prove to be economical.

OTHER FEATURES

1) Pre designed formwork acts as assembly line production and enables rapid construction of multiple/mass scale units of repetitive type.
2) Varying work cycle is possible, however, for speed and economy 3-4 days cycle are desirable.
3) It is flexible in design and can form any architectural or structural configuration, such as stairs, windows, etc.

LIMITATIONS

1) A lead time of about 3 months is required for initiation of work, as the formwork are custom designed, manufactured and prototype approved before manufacturing required number of sets of formwork.
2) Capital cost to initiate construction is high and may require regular flow of funds.
3) Post construction alterations are difficult.
4) All the service lines are to be pre-planned in advance.
4) Not much saving in construction in one storey structure.

MAJOR COMPLETED PROJECTS

1) Houses in Bangalore for Karnataka Slum Development Board.
2) Houses in Mysore for Karnataka Slum Development Board.
3) 2,112 houses under PMAY(U) in Tamil Nadu
4) 34,928 houses under PMAY(U) in Gujarat
5) 1,136 houses under PMAY(U) in Puducherry
6) Houses in Bangalore for Bangalore Development Authority & several other projects in major cities of India, among many others...

OTHER SIMILAR SYSTEMS SHORTLISTED UNDER GHTC-INDIA

i) Aluminium formwork system for Monolithic Concrete construction on M/s Maini Scaffold Systems Pvt. Ltd., New Delhi has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

ii) Aluminium formwork system for Monolithic Concrete – construction on M/s KumkangKind India Pvt. Ltd., Gurugram has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

iii) Aluminium formwork system for Monolithic Concrete construction on M/s S-form India Pvt. Ltd., Gurugram has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

iv) Aluminium formwork system for Monolithic Concrete construction on M/s ATS Infrastructure Ltd., Noida has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

v) Monolithic Concrete construction using MIVAN technology on M/s Innovative Housing & Infrastructure Pvt. Ltd., Chandigarh has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

vi) Aluminium formwork system for Monolithic Concrete construction on M/s MFS formwork Systems Pvt. Ltd., Faridabad has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

vii) Aluminium formwork system for Monolithic Concrete construction on M/s Knest Manufacturers LLP., Pimpri has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

viii) Aluminium formwork system for Monolithic Concrete construction on M/s Brilliant Etoile Pvt. Ltd., Delhi has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

STANDARDS/GUIDELINES REFERRED

IS 456 : 2000	Code of Practice for plain and reinforced concrete (Fourth Revision)
IS 733 : 1983	Wrought Aluminium and Aluminium Alloy Bars, Rods and Sections (for General Engineering Purposes)
IS 875 (Pt.3) : 2015	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Part 3 : Wind Loads
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IS 10151 : 1982	Polyvinyl Chloride (PVC) and its Copolymers for its Safe Use in Contact with Foodstuffs, Pharmaceuticals and Drinking Water
IS 10262 : 2009	Concrete Mix Proportioning - Guidelines (Reaffirmed 2014)
IS 13920 : 2016	Ductile detailing of reinforced concrete structures subjected to seismic forces - Code of practice
IS 14687 : 1999	Guidelines for Falsework for Concrete Structures (Reaffirmed 2014)
BMTPC Guidelines : 2011	Guidelines on Monolithic Concrete Construction
PAC No. 1006-A/2011	Performance Appraisal Certificate issued by BMTPC on Formwork for Monolithic Construction

Modular Tunnelform

(Suitable for Low Rise to High Rise Structures)

ABOUT THE TECHNOLOGY

Tunnel formwork is customized engineering formwork replacing conventional steel/plywood shuttering system. It is a mechanized system for cellular structures. It is based on two half shells which are placed together to form a room or cell. Several cells make an apartment. With tunnel forms, walls and slab are cast in a single day. The structure is divided into phases. Each phase consists of a section of the structure that will be cast in one day. The phasing is determined by the program and the amount of floor area that can be poured in one day. The formwork is set up for the day's pour in the morning. The reinforcement and services are positioned and concrete is poured in the afternoon. Once reinforcement is placed, concrete for walls and slabs shall be poured in one single operation. The formwork is stripped the early morning next day and positioned for the subsequent phases.



The formwork is manufactured in a fully automated plant. Presently, it is imported from France and there is no plant in India.

The on-site implementation of 24 hour cycle is divided into following operations.

1. Stripping of the formwork from the previous day.
2. Positioning of the formwork for the current day's phase, with the installation of mechanical, electrical and plumbing services.
3. Installation of reinforcement in the walls and slabs.
4. Concreting and if necessary, the heating equipment.

TYPES OF FORMWORK SYSTEM

TMPH Modular Tunnelform

Tunnel forms are room size formworks that allow walls and floors to be caste in a single pour. With multiple forms, the entire floor of a building can be done in a single pour. Tunnel forms require sufficient space exterior to the building for the entire form to be slipped out and lifted up to the next level.

This Tunnelform consists of inverted L-shaped half tunnels (one vertical panel and one horizontal panel) joined together to create a tunnel. Articulated struts brace the horizontal and vertical panels. These struts enable the adjustment of the horizontal level of the slab and simplify the stripping of the formwork. The vertical panel is equipped with adjustable jacking devices and a triangular stability system. Both devices are on wheels.

A range of spans is possible by altering the additional horizontal infill panel's dimensions. Due to the distribution of the horizontal beams on the vertical plank, the formwork also cast staggers and offsets in the layout of the walls as well as differing wall thicknesses. The half-tunnels shall be equipped with back panels to cast prependicular shear walls or corridor walls. Assembly and levelling devices ensure that the frormwork surfaces are completely plumbed and levelled.

Standard Characteristics

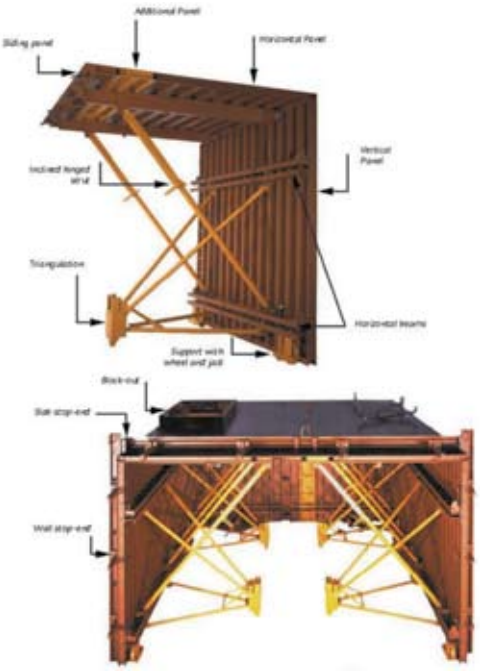


Standard dimensions: TMPH & Modular
Unit width : 2.40 m to 6.00 m
Type 1 horizontal panel : 1.20 m to 1.60 m
Type 2 horizontal panel: 1.80 m to 2.40 m
Type 3 horizontal panel: 2.40 m to 3.00 m
The span can be adjusted by fitting an additional panel measuring between 0.05 and 0.60 m
Package length: Up to 12.50 m in length as a function of the hoisting facilities and availability
Basic length: 1.25 m
Average weight: 90 Kg/m^2
Handling: Lifting triangle or sling
Transportation: 180 m^2 per truckload.

Wallforms



Wallforms are temporary moulds in which concrete is poured in order to build a structure. Once the concrete is poured into the formwork and has set, the formwork is stripped to expose perfect finished concrete. These forms constitute a system approach for construction and are particularly suited to build structural walls, columns, bridge piers, culverts etc. This system adopts well to daily work-phase of both repetitive and non-repetitive tasks. The equipment used each day is productive and is reused in subsequent phases. The four daily operations which outlines the daily production cycle for wall form equipment are identical to those for Tunnel form equipment with the exception that it is solely used for casting concrete walls. The slabs are cast as a secondary phase. The existing equipment can be adapted on a day-to-day basis by the addition of standard elements and corner-wall formwork to take into account different wall configurations on site. All safety and stability devices shall be fully integrated into the standard version of Wallform equipment.



B 8000 Wallforms

These Wallforms are tools specially designed to be used on specific buildings and structures. This vertical wallform panel is a multi-purpose formwork system. This system has been designed and developed to ensure that it is simple and quick to assemble and position the following:

- A full range of standard dimensioned components
- Multiple combination of panels for simple adoption to specific configurations
- Basic standard equipment incorporates complete safety, circulation and stability equipment
- Caliper–device opposing Wallform packages are craned into position in one lift.

Standard characteristics

Standard dimensions:
Standard height: 2.80 m
Upper extension: 0.50 m
Lower extension: 1.00 m-1.50 m
Average weight: 135 Kg/m^2
Assembly: 0.80 H/m^2 of formwork
Use: 0.15 to 0.30 H/m^2 of formwork, depending on complexity
Wind stability: by prop
Access: inner ladder accessed via hatch
Superposition: up to 22.5 m with specific engineering performed to determine hoisting and stability characteristics
Transportation: 24 wall forms per container/ truckload

Angle Formwork

Inner and outer angle configurations are designed to attach to 1.25 m wall forms to obtain a 160 mm wall. Spacers shall be installed for producing wall thicknesses.

Back Panel

The back panel allows pouring of cross walls, other walls, walls and slab in one operation.

Slab Stop End and Wall stop

These can be adjusted to fit the lengths of wall and slabs. These remain fixed to the form during all handling operations.

Kicker Form

In order to guide the walls of the upper floor precisely above the walls of the floor below, a kicker form is fixed to the tunnel form before pouring the concrete. Slab and starting walls are then poured during the same phase.

Box Out

During each phase, window box out, door box out and slab box out are mounted on the tunnel using a magnetized system.

MATERIAL REQUIREMENTS

i. Hot dip galvanized steel sheet – 3 mm thick shall conform to IS 277:2003
ii. Steel for Angle section – 80 mm x 80 mm x 6 mm shall conform to IS 2062:2011
iii. Cold rolled U-sections – 60 mm x 30 mm shall conform to IS 2062:2011.

Mechanical properties:

Yield stress : ≥ 23.5 daN/mm^2
Breaking load : ≥ 36 daN/mm^2
Elongation : ≥ 20%
Steel for spacer pins – Apart from the requirements given above, the steel used for the manufacture of the spacer pins, the gripping mechanisms, anchoring points for the rear stabilizing and adjusting mechanisms shall guarantee a KCV resilience at –20ºC of at least 28J.

CHARACTERISTICS OF THE SYSTEM

- Maximum span between walls shall be 5.60 m without accessory units and 7.00 m with accessory units.

- Height of the formwork – The forms are designed for floor to ceiling height of 2.51 m minimum with the possibility to increase this by action of the leg jacks or with the use of movable panels in the event of extra heights.
- Appearances of the faces after form removal – The surfaces obtained allow direct application of finishing paint or wallpaper after sanding off the fins at the joints connecting the units and smoothing with paint filler.
- Working rhythm using the system – Under average temperature conditions, with the use of ordinary cement, the normal rhythm is two days per cycle with one day and two nights for drying and setting of the concrete.
- Time period required for execution of the process – The time required for execution shall vary according to the cell plan. For a type cell consisting of two formed wall surfaces and a floor surface, the average time is less than one & one half hours per square meter of building. This time includes the form removal, oiling, displacement of the units, formwork and adjustment.

UTILIZATION OF THE FORMWORK SYSTEM

At each stage, utilization of the system requires the following successive operations:

i. The placing of the vertical wall reinforcement of the floor and possibly the door frames provided for in the erection drawing;

ii. Dismantling of the movable form units of the preceding storey. This shall be carried out in two stages:
   a) Loosening of the normal units (half-shells), by removal of the spacers passing through the walls, by unlocking the tunnel keys and disassembly of the sections. This work is executed in principle by two non-specializes maneuvers.
   b) Striking and removal of the forms. This shall be carried out by using the special dolly and two maneuvers in the tunnel and by two other maneuvers at the new location (usually on the storey above). This suite of operations shall be carried out by bringing the dolly under the half-shell to be removed and then working the different jacks for the striking operation itself. The leg jacks are lifted first, then a slight deformation of the half-shell is provoked by working the diagonal bracing jacks (shortening). This deformation is sufficient to strip the form progressively. It drops down automatically onto the dolly. The dolly half-shell assembly shall then be rolled across the service platform where the form is cleaned and oiled with a sprayer, then picked up with a crane and hoisted to its new location site, the dolly remaining in place. The half-shell design makes it possible to remove the whole side of a tunnel, then to prop the slab near the key before removing the other half, permitting if necessary, a faster rotation of the equipment.

iii) Reassembly of the units on the floor above. This assembly consists of the following operations:
   a) A half-shell shall be positioned on its leg jacks and knee brace, and adjustment shall be squared by blocking the diagonal bracing jacks, then adjustment of the height and plumb by working the leg jacks and the knee brace jack.
   b) The half-shells shall be assembled together.
   c) The opposite half-shells shall be positioned, and adjacent half-shells of the ‘tunnel’ half-shells shall also be positioned using the same procedure.
   d) The half-shells shall be blocked by constituting the two faces of the wall on the ‘starters’ with the help of the lower spacers; the upper spacers shall be tightened without being forced, only after verification of the general adjustment; positioning of the butt end forms of the walls and floors.
   e) The key-locks solidifying the opposite half-shells shall be positioned and blocked. If necessary, a light action on the knee brace and diagonal bracing jacks shall be used to bring the locking units into line.
   f) The starter forms shall be positioned and blockouts, if necessary for anticipated door and window frames.
   g) The overall adjustment and finish making–up shall be verified, if necessary, after lifting of the knee braces.
   h) The suspended floor shall be reinforced and concrete shall be poured in the walls and slab.

iv) The service platform shall be removed and this platform shall be installed on the storey above.

APPLICATIONS

Designed to cast concrete load-bearing walls and slabs in a single monolithic pour, tunnel forms are suited for the construction of following structures:

- Multiple residential dwellings
- Housing projects
- Garden apartments
- Town homes
- Condomiums
- Hotels etc.

SPECIAL FEATURES

Behavior in earthquake

Formwork shall be designed to meet the requirement of permanent structures using specified Indian Standards for material used. The design should take into account the conditions of materials to be actually used for the formwork, environment, site condition loads on formwork and combination of loads shall be taken in accordance with the clause 7.3 of IS 14687:1999.

Behavior under high winds

The design for wind loads shall be in accordance with the provisions given in IS 875 (Part 3):2015 and IS 14687:1999.

Productive

The equipment used each day is productive and is reused in subsequent phases.

Day-to-day basis

The existing equipment can be adapted on a day-to-day basis by the addition of standard elements and corner-wall formwork to take into account different wall configurations on site.

LIMITATIONS

- The floor spans executed with movable forms shall not be more than 5.60 m, unless accessory units are used.
- The thickness of vertical in-situ walls shall not be more than 120 mm, unless justified by special provisions.

MAJOR WORKS COMPLETED USING THE FORMWORK

- Apartments by M/s Runwal Group at Mumbai in 2000
- Apartments complexes by M/s B G Shirke Construction Technology Pvt. Ltd., Pune at Navi Mumbai, and Tirupati in 2001
- Apartments by M/s L&T South City Projects Ltd., at Chennai in 2008
- Slum Rehabilitation by M/s Pawar Patkar Construction Pvt. Ltd., at Nasik in 2014
- 1144 houses under Light House Project at Rajkot, Gujarat.

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No. 1018-S/2015 issued to M/s Outinord Formworks Pvt. Ltd., Pune.

STANDARDS/REFERENCES

Agreement No. 2569 relating to New Materials and Non-traditional Construction Processes between Cashiers of the C.S.T.B, Paris, France and Outinord, Company, S.A.	
Case studies of the projects carried out by various agencies throughout the world including India using Outinord Formwork.	
Design of the Formwork submitted by the manufacturer	
Quality Management Manual and Maintenance Manual followed by the manufacturer	
Application of accelerated curing to Apartment Formwork System – Advisory Note from British Cement Corporation	
IS 277 : 2003	Specifications for plain and corrugated galvanized steel sheets (sixth revision)
IS 456 : 2000	Code of practice for plain and reinforced concrete (fourth revision)
IS 875 (Part 3) : 2015	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Part 3 : Wind Loads
IS 2062 : 1999	Hot rolled medium and high tensile structural steel
IS 14687 : 1999	Falsework for concrete structures





Stay in Place Formwork Systems

Glass Fibre Reinforced Gypsum (GFRG) Panel Building System

(Suitable for Low Rise to High Rise Structures)

ABOUT THE TECHNOLOGY







Glass Fibre Reinforced Gypsum (GFRG) Panel also known as Rapidwall is made-up of calcined gypsum plaster, reinforced with glass fibers. The panel was originally developed by GFRG Building System Australia and used since 1990 in Australia for mass scale building construction. In recent times, these panels are being produced in India and the technology is being used in India.

The panel, manufactured to a thickness of 124mm under carefully controlled conditions to a length of 12m and height of 3m, contains cavities that may be unfilled, partially filled or fully filled with reinforced concrete as per structural requirement. Experimental studies and research in Australia, China and India have shown that GFRG panels, suitably filled with plain reinforced concrete possesses substantial strength to act not only as load bearing elements but also as shear wall, capable of resisting lateral loads due to earthquake and wind. GFRG panel can also be used advantageously as in-fills (non-load bearing) in combination with RCC framed columns and beams (conventional framed construction of multi-storey building) without any restriction on number of storeyes. Micro-beams and RCC screed (acting as T-beam) can be used as floor/ roof slab.

The GFRG Panel is manufactured in semi-automatic plant using slurry of calcined gypsum plaster mixed with certain chemicals including water repellent emulsion and glass fibre rovings, cut, spread and imbedded uniformly into the slurry with the help of screen roller. The panels are dried at a temperature of 275°C before shifting to storage area or the cutting table. The wall panels can be cut as per dimensions & requirements of the building planned.

It is an integrated composite building system using factory made prefab load bearing cage panels & monolithic cast-in situ RC infilled for walling & floor/roof slab, suitable for low rise to medium rise (single to 10 storeys) building.

CLASSIFICATION

Class – 1 – Water resistant grade – GFRG panel for external walls, in wet areas and / or as floor and wall formwork for concrete filling.

Class – 2 – General Grade – GFRG panels for structural application or non–structural application in dry areas. These panels are unsuitable for use as wall or floor formwork and

Class – 3 – Partition Grade – GFRG panel as non–structural internal partition walls in dry areas only.

APPLICATION

GFRG panels may generally be used in following ways:



i) As load Bearing Walling – With cavities filled with reinforced concrete is suitable for multi – storeyed housing. In single or two storeyed construction, the cavities can remain unfilled or suitably filled with non – structural core filling such as insulation, sand, quarry dust, polyurethane or light weight concrete.

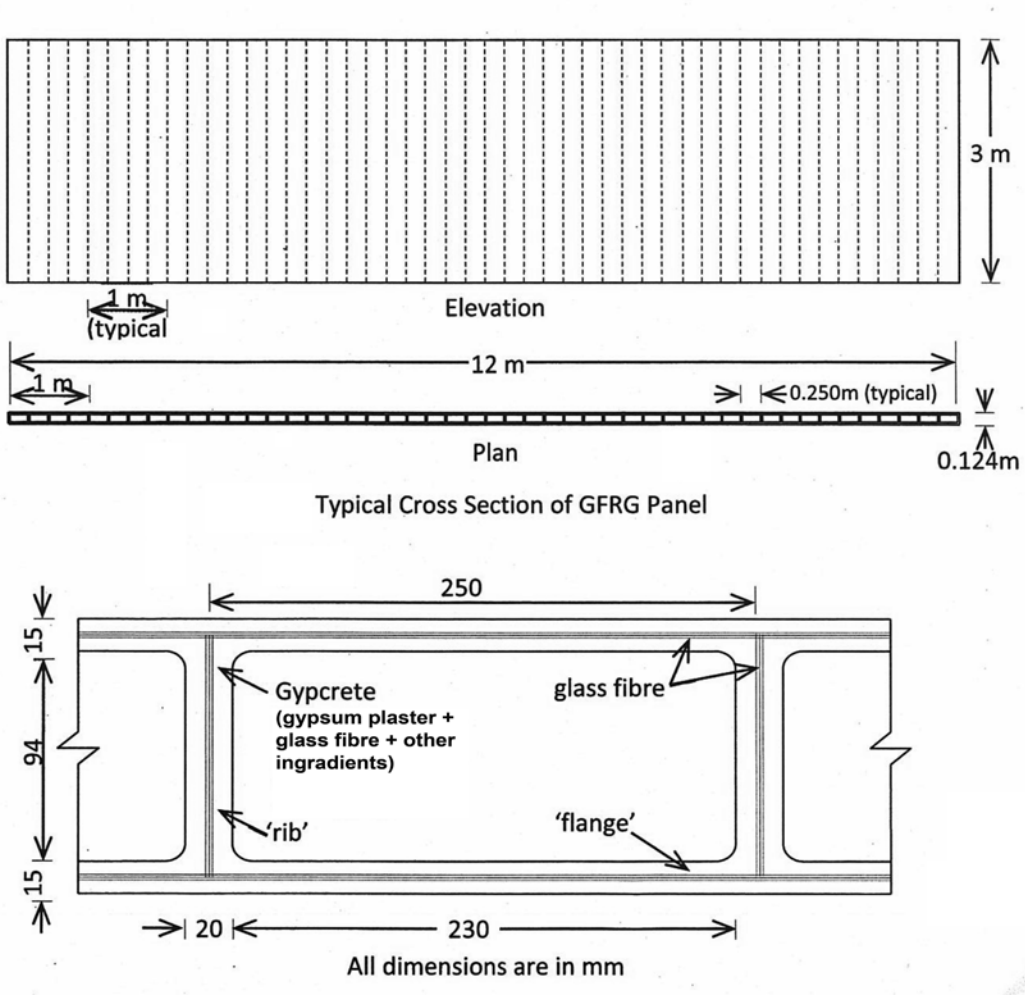
ii) As partition walls in multi storeyed frame buildings. Panels can also be filled suitably. Such walls can also be used as cladding for industrial buildings or sport facilities etc.

iii) As compound walls / security walls.

iv) As horizontal floor slabs / roof slabs with reinforced concrete micro beams and screed (T-beam action). This system can also be used in inclined configuration, such as staircase waist slab and pitched roofing.

DIMENSION

Typical Dimension of GFRG building panel are 12.0m x 3.0m x 0.124m
Each 1.0m segment of the panel contains four cells. Each cell is 250mm wide and 124mm thick (as shown below)



Enlarged view of a Typical Cell of GFRG Panel

MECHANICAL PROPERTIES (UNFILLED PANELS) : TEST RESULTS

Mechanical Properties	Nominal Value	Remarks
Unit weight	0.433 kN/m^2	
Modulus of elasticity, $\mathbf{E_G}$	7500 N/mm^2	
Uni-axial compressive strength, P_{uc}	160 kN/m (4.77 MPa)	Strength obtained from longitudinal compression / tension tests with ribs extending in the longitudinal direction.
Uni-axial tensile strength, T_{uc}	34 – 37 kN/m	
Ultimate shear strength, V_{uc}	21.6 kN/m	
Out-of-plane moment capacity, Rib parallel to span, M_{uc}	2.1 kNm/m	
Out-of-plane moment capacity, Rib perpendicular to span, M_{uc}, perp	0.88 kNm/m	
Mohr hardness	1.6	
Out-of-plane flexural rigidity, **EI**, Rib parallel to span	3.5 x 10^{11} Nmm^2/m	
Out-of-plane flexural rigidity, **EI**, Rib perpendicular to span	1.7x$10^{11}$$Nmm^2/m$	
Coefficient of thermal expansion, Cm	12x10^{-6}mm/mm/^oC	
Water absorption	1.0% : 1 hr 3.85% : 24 hrs	Average water absorption by weight % after certain hours of immersion.
Fire resistance : Structural adequacy / integrity / insulation	140/140/140 minutes	CSIRO, Australia/ IS 3809:1979
Sound transmission class (STC)	40 dB	ISO 10140-3:2010*

** ISO 10140-3:2010 - Acoustics – Laboratory measurement of sound insulation of building elements – Part 3: Measurement of impact sound insulation*

Source: GFRG/Rapidwall Building Structural Design Manual

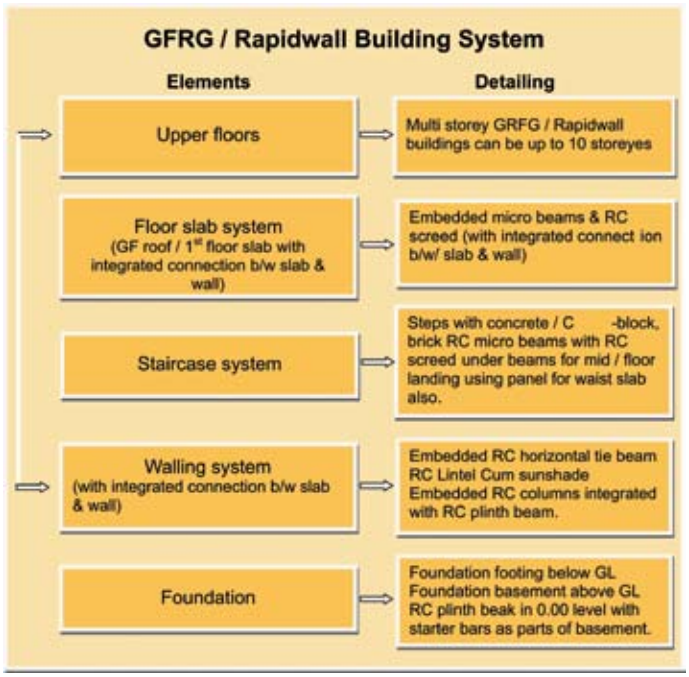
DESIGN

The design capacities of GFRG panel is based on limit state design procedures, considering the ultimate limit state for strength design, treating the 3.0 m high GFRG panel as the unit material and considering the strength capacity as obtained from the test results. The design shall be carried out by considering all possible loads (as per relevant Indian Standards) to which the structure is likely to be exposed in its service life. It shall also satisfy the serviceability requirements, such as limitations of deflection and cracking. In general the structure shall be designed on the basis of the most critical limit state and shall be checked for other limit states.

Detailed design Guidelines are available in “Use of Glass Fibre Reinforced Gypsum (GFRG) Panels in Buildings - Structural Design Manual” prepared by IIT Madras and published by BMTPC. It may be obtained on request from BMTPC.

Experimental studies and research have shown that GFRG Panels, suitably filled with reinforced concrete, possess substantial strength to act not only as load bearing elements, but also as shear wall, capable of resisting lateral loads due to earthquake and wind. It is possible to design such buildings upto 10 storeys in low seismic zone. (and to lesser height in high seismic zone). However, the structure needs to be properly designed by a competent structural engineer. Manufacture of GRFG Panels with increased thickness (150 mm – 200 mm) with suitable flange thickness can facilitate design and construction of taller buildings.

The basis arrangement of GFRG Panel Building System is as follow:







TRANSPORTATION

The GFRG panels are transported from factory to site, generally through trucks or trailers. The panels are kept in a vertical position using “stillages” so as to avoid any damage during transportation. The panels after reaching the site are taken out from trucks using cranes. Forklifts can be used for easier movement of panels.



CONSTRUCTION

The foundation used for the construction is conventional and is designed generally as strip footing depending upon the soil condition.

For superstructure – plinth beams are cast all around the floor, where walls have to be erected. The superstructure is entirely based on prefabricated panels. The procedure mainly include fixing of wall panels and roof panels using mechanical means, preferably a crane and filling the required joint with reinforced cement concrete as per structural design.



Waterproofing is an essential requirement of the construction at different stages. Detailed guidelines for waterproofing are required to be followed during construction.

LIMITATION

- The shorter span of slab (floor / roof) should be restricted to maximum of 5 m.
- The system is ideal if the same floor / roof is replicated for all floors in multi storeyed structure. For any variations, a structural designer needs to be consulted.

- The panels are not suitable for curved walls or domes. In case it is essential, use masonry / concrete for that particular area.
- The electrical / plumbing system should be such that most of the pipes go through the cavities (in order to facilitate minimum cutting of panel)

OTHER FEATURES

Green Technology

It makes use of industrial waste gypsum, does not need any plastering, uses much less cement, sand, steel and water than conventional building materials. It consumes much less embodied energy and less carbon footprint.

Reduced built area

Panels being only 124 mm thick, for the same carpet area, the built up area and the building footprint is much less than conventional buildings. This is particularly advantageous in multi storeyed mass housing.

Versatility

Panels can be used not only as walls but also as floors, roofs and staircase.

Speed of Construction

Using the system, the construction of a building is relatively faster as compared to the conventional building. One building of two storeyed (total 185 sqm with four flats) was constructed in IIT Madras in one month.

Lightness of structures bringing safety against earthquake forces

These panels are very light weight (43 kg/m^2). Even after filling some of the cavities with concrete, the overall building weight is much less, contributing to significant reduction in design earthquake forces and savings in foundation and overall buildings cost especially in multi – storeyed buildings.

FEW BUILDING CONSTRUCTED/UNDER CONSTRUCTION IN INDIA

- Residential buildings at Udipti Karnataka owner Mr. Satish Rao, built by Harsha Pvt. Ltd., Udipi, Bangalore.
- Utility Building for Konark Railways at Madgao, South Goa, built by Harsha Pvt. Ltd., Udipti, Bangalore.
- Residential building at Udipti by Harsha Pvt. Ltd.
- 3 storey residential building at Calicut by NMS Rapidwall Construction Company, Calicut (2014).
- Two storeyed building at IIT Madras.
- Residential building at RCF Mumbai.
- Model house at Cochin.
- Demonstration houses (36 DUs) at Nellore, Andhra Pradesh.
- Construction of IIT Tirupati Building at Tirupati.





CERTIFICATION / VALIDATION OF THE SYSTEM

- Performance Appraisal Certification PACs No. 1008-S/2011 has been issued to M/s Rashtriya Chemicals and Fertilizers Limited, “Priyadarshini”, Sion, Mumbai.
- Performance Appraisal Certification PACs No. 1009-S/2012 has been issued by FACT – RCF Building Products Ltd., FACT Cochin Division Campus, Ambalamedu, Kochi.

REFERENCES

• GFRG / Rapidwall Building Structural Design Manual, prepared by IIT Madras, published by BMTPC, New Delhi.	
• Schedule of Item & Rate Analysis for GFRG Construction, BMTPC, New Delhi.	
IS 3809:1979	Fire Resistance Test of Structures

Sismo Building Technology

(Suitable for Low Rise to High Rise Structures)

ABOUT THE TECHNOLOGY

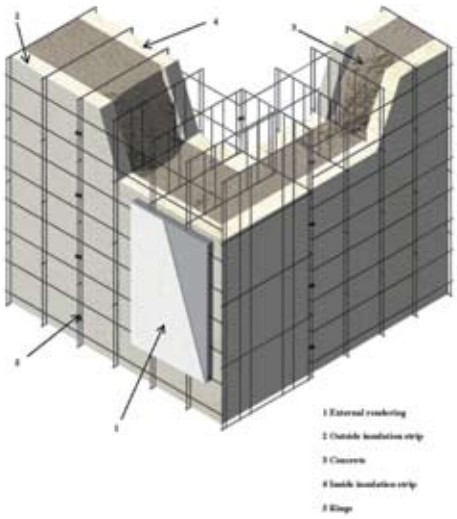
Sismo Building Technology is an insulating shuttering kit for whole building based on a three-dimensional lattice made of galvanized steel wire. The lattice is filled with materials of different nature to serve as formwork. The basic structure of the Sismo building module is steel wire lattice. At the exterior sides of the lattice, infill panels are inserted, which transform the lattice into a closed structure that can be filled with concrete. The type of infill panels used depends on the purpose of the wall: load bearing or not, insulated or otherwise, etc. The steel wire also acts as armature and anchoring for the finished material and it holds reinforcement bars in place during concrete filling.



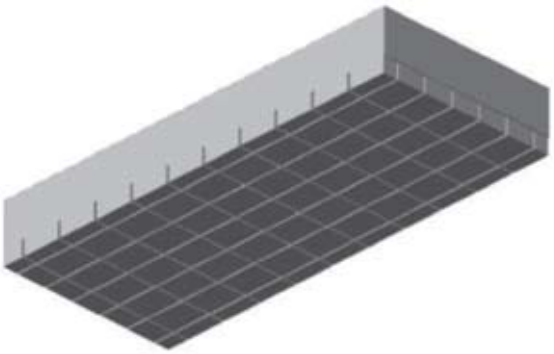
This technology was initially developed in Belgium and the firm in India has a collaboration with n. v. Desmo-Home “Sismo” Ltd., Belgium.

Description of the components is as follows:

- 3D lattice (2.2 mm Ø galvanized steel wire)
- Infill panels (EPS, rock wool, mineral board)
- Structural filler (concrete)
- Finishing (plastering, natural stone, paneling etc.)



Sismo Wall



One-way girder-slab floor

MODULES

Type of Modules

Depending on the internal and external material, the walls may be divided into following types:

(i) Inside & outside insulation (EPS) strips symmetrical and asymmetrical

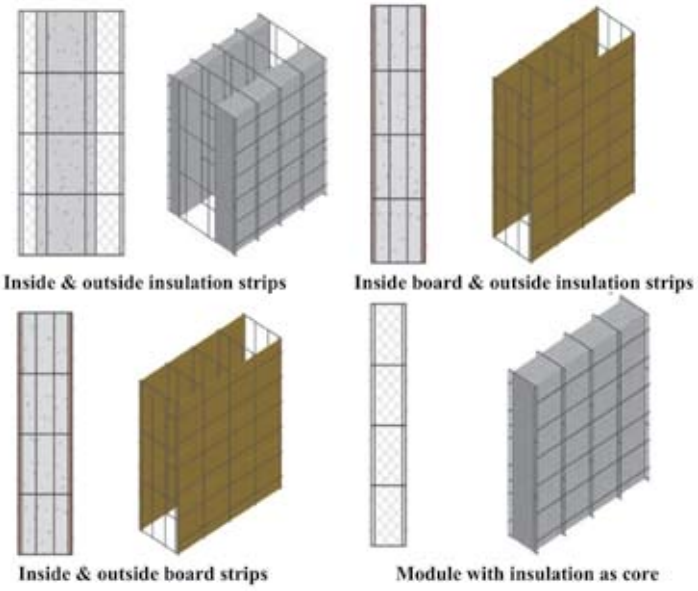
(ii) Inside board and outside insulation (EPS) strips

(iii) Inside & outside board strips

(iv) Inside & outside insulation strips

(v) 2 Sismo walls decoupled and insulated for an optimized acoustic performance. This type is typically used as separating wall between apartment and houses.

(vi) Module with insulation strips as core material Sismo floors and roofs may be plain, one and two-way slabs; as per requirement.



DESCRIPTION OF THE COMPONENTS

Steel Lattice

The steel wire frame, lattice formwork for the walls, are available in panels of different dimensions as follows:

- Height: in multiples of 150 mm, with a max. of 12 m
- Length: in multiples of 100 mm, with a max. of 1.2 m
- Thickness: Max. 500 mm, depending on the type of wall /roof required

Functions of steel lattice

The steel wire lattice has the following basic functions:

(i) To resist hydraulic pressure of fresh concrete during pouring and first hours of hardening
(ii) To keep reinforcement bars in place during pouring of concrete
(iii) To ensure adhesion (and reinforcement) of finishing when using mineral based renders

Insulation strips and Interjoists

The insulation strips have following functions:

- Maintain fresh concrete during the provisional phase of pouring
- Thermal insulation in final phase
- Support of interior and exterior finishing

The strips have fixed dimensions and shall be fixed with tongue and groove: 15 mm x 20 mm for EPS strips of thickness 38 mm to 118 mm and 10 mm x 15 mm (h x w) for other strips of thickness 38 mm.

The interjoists have following functions:

- Creation of ribs in order to have a one or two-way girder-slab floor
- Thermal insulation in final phase

The inter joists have fixed dimensions (length 1200 mm & width 450 mm) but may be cut in length in multiples of 100 mm and width in multiples of 150 mm. These shall be available in various thicknesses from 100 mm to 350 mm. These shall have a ‘waffle’ structure (100 mm x 75 mm) and the groove has depth of 30 mm and a width of 10 mm. Their shape ensures a good grip on the metal frame of the floor modules.

The details of one-way girder-slab floor are as follows:

- The center to center distance between the ribs is in multiples of 150 mm
- The width of the ribs is 150 mm or in multiples thereof.

The details of two-way girder-slab floor are as follows:

- The center to center distance between the ribs is in multiples of 150 mm on one side and 10cm on the otherside
- The width of the ribs is 150 mm or in multiples thereof on one side and 100 mm on the other side.

MATERIAL REQUIREMENTS

Hot galvanized steel wire shall conform to the specifications as given below:

- Zinc coating shall not be less than 60 g/m^2
- The dia. of the wires and rings shall be 2.2 mm ± 0.03 mm.
- Tensile strength: 680 N/mm^2 min.
- Chemical composition: C = 0.020 % min., Mn = 0.150 % min, Si = 0.250% max., P = 0.030 % max., S = 0.030 % max.

Rings: Rings shall be used to hold the panels together during installation phase.

Insulation strips and panels:

- Expanded polystyrene (EPS): shall conform to IS 4671:1984 and shall have density not less than 15 kg/m^3.
- Fibre cement board (FCB) 5 mm thick: shall conform to IS 14862:2000.

Cast-in-place concrete: The ingredients, grade of concrete & slump for walls, floors and roofs shall be used as per IS 456:2000.

APPLICATIONS

The technology shall be used for construction of structures consisting of load bearing walls, foundations, cellars, floors and roof etc. for residential, commercial and industrial purposes.

PRODUCTION PROCESS

The production of the modules is carried out in the Sismo Production Station (SPS). The main stages of production include:

- Unwinding of steel wire rolls
- Cutting and straightening of steel wire
- Assembly and welding of two-dimensional lattices
- Assembly and welding of three-dimensional lattices
- Cutting of insulation strips and interjoists
- Insertion of the insulation strips into three-dimensional lattice at the lateral intervals intended for this purpose.

The fixing of the panels and placing of interjoists on respective walls and floors is done at site. Panels are installed after hardening of concrete.

The production is carried out according to an internal factory production control plan.

Conformity checks are done on incoming materials and at regular stages throughout the production sequence to ensure the fitness of the components.

Accessories

The accessories required for erection of the walls in construction site shall be as follows:

- *Struts:* to support the panels during installation and pouring of concrete (max. distance of 2 m between two panels).
- *Strut for stanchion*: to support stanchion for guard rail and used to align and support the top of panels at floor level during installation and pouring of concrete.
- *Hollow profiles*: to support the panels during installation and pouring of concrete (max. distance of 2 m between two panels).
- *U-profiles*: to connect the hollow profiles with horizontal steel wire supporting the panels during pouring of concrete.

- *Stapler & Rings*: to connect the panels (7 rings per linear meter, on each side of the wall, back and front).
- *Lop ties and Tie twister*: to secure the reinforcement bars to the metal frame.
- *Cutter*: to cut the steel wire at the openings (doors, ceilings etc.) after hardening of the concrete.
- *Boards*: (30 mm/120 mm) for proper alignment of the walls.
- *Props and Shuttering boards* : as support for floors to spread the concentrated loads of the vertical props. The number of vertical props may be reducing by using load spread beams.

IMPLEMENTATION

Handling, transportation and storage of panels

- The handling of panels on site shall be done with gloves and protective glasses as they have sharp points.
- Loading and unloading of modules shall be done either manually or by machine.
- The modules shall be transported and stored sideways, standing or in a horizontal position. When stored and transported in horizontal position, extra care should be taken to limit stress because bottom panels of a pile horizontal staked modules have a higher risk of deformation.

Erection of Panels

- The panels shall be placed on the foundation or on the floors. They shall be held together by rings longitudinally placed every 150 mm on both sides of the wall.
- In the initial phase, the panels shall be supported on one of their sides by struts specially developed for this purpose. They shall provide lateral support to the panels till hardening of the concrete. The maximum distance between lateral supports should not exceed 2 m. It should be possible to transform the struts to scaffolding to allow access at the top of the casing to monitor pouring of the concrete.
- The free end of the panels (in case of openings, windows, doors or ceilings) shall be closed in the same manner as the common parts to ensure holding of fresh concrete.
- The verticality of the walls shall be checked before and during casting.
- The floor modules shall be temporarily, till hardening of the concrete, be supported by shuttering panels, beams and props. When props are used only for supporting the weight of fresh concrete, circulation and curing platform shall be used.

Placing of reinforcement

- The modulated dimensions of the lattice shall be 100 mm horizontally and 150 mm vertically and in multiples thereof. The securing of the bars through the lattice, shall ensure a correct positioning of the reinforcement after pouring of concrete.
- Stirrups, straight, L and U shaped bars shall be placed during mounting of the modules. The lattice should not be combined with welded reinforcement mesh.
- The placing of vertical bars shall be done through the top of panels and shall progress together with the mounting of the panels.
- Horizontal bars for ties, lintels etc. shall be inserted sideways and progresses together with the mounting of the walls. It is sometimes required to remove the insulating strips used as formwork at the edge of the panels to be able to insert the horizontal reinforcement bars and then slide them back into position.
- Length of U-shaped horizontal bars used shall be 1 m for straight length and 300 mm for bend portion, wherever required.

i. Corner –connection

- U-shaped horizontal reinforced bars
- U-shaped horizontal reinforced bars in the second wall
- Common vertical reinforced bars

ii. T-connection

- U-shaped horizontal reinforced bars in the wall to join
- Installation of the wall in T-connection
- Horizontal reinforced bars of a wall

- Common vertical reinforced bars

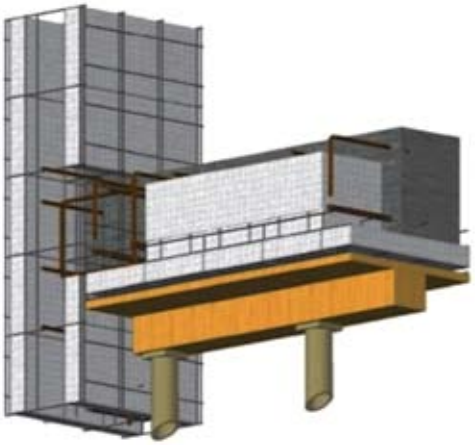
iii. Beam

- Vertical stirrups
- Horizontal reinforced bars

iv. Wall-floor connection

v. Starter bars

vi. Floor



Pouring of concrete

The pouring of concrete shall be done with a pump device or a tipper. The following requirements shall be adhered to:

- The speed of concrete filling shall be limited to 1000 mm per hour. Concrete is filled in layers up to 500 mm and shall be filled up to a maximum height of 6 m in a day.
- If filling is done with a pump device, suitable measures should be taken to cut the dynamic pressure of concrete. A flexible rubber sleeve is secured with retaining rings to the pipe of the pump device in order to limit the pressure of concrete by compressing the hose manually.



In order to ensure the geometrical and mechanical properties of the finished wall, the following checks are carried out during concrete filling:

- Control and possible correction of verticality of the wall before hardening of concrete
- Visual verification of penetration of cement concrete in joints between the strips so that all gaps are completely filled. Cores shall be taken through the insulation at critical positions, such as below windows and at corners, to establish integrity of concrete.

Roofs with pitch below and over 30º shall be constructed with open and closed lattices respectively.
Insulating strips shall be cleaned with a water jet or brushed after pouring of concrete to remove light leakage of laitance.



Finishing

Rendering
As there are significant regional differences due to availability of local materials and climatic conditions, the recommendations of the manufacturer of the material should generally be followed and good trade practice regarding installation and sealing should be observed. Renders should contact the local supplier to ascertain the product best suited for finishing of the modules. If plastering with cement mortar is to be done, the thickness of plaster shall be 15-20 mm.

Imbedding of ducts

- In self-extinguishing polystyrene panel conduits path shall be made.
- When thin hard panels are used for shuttering, conduits

may either be surface mounted or inserted before the concrete is poured.
- Alternatively, polystyrene strips may be inserted allowing the conduits to be installed at a later stage.

Fixing of objects

- It is possible to fix objects up to 80 kg per fixing device in the insulation strips.
- For other cases, the fixing devices should be inserted in the concrete.

SPECIAL FEATURES

Structural Stability

The technology used is to exploit concrete to the ultimate and standard solutions for reinforcement are used, wherever required. Reinforcement, shall be placed according to the specifications, depending on the application and shall be determined by structural calculations performed according to the IS 456:2000. In seismic prone areas requiring seismic resistant construction, relevant provisions of IS 1893 (Part 1):2016, IS 4326:2013 and IS 13920:2016 shall apply.

Durability

The modules provide maximum strength during concrete placement. Once complete, structures reach an incredible structural integrity. When concrete is hardened, durability of steel wire is necessary in only those applications where the adhesion of finishing depends on it, in addition to the adhesion between concrete and insulation and between insulation and rendering.

Behavior in earthquake

The structure can be made earthquake resistant by applying provisions of IS 1893 and IS 13920.

Fire Safety

The assembled system is a continuous monolithic concrete system, thus without fire leakage through the assembled system. The required rating is achieved with proper thickness of concrete and polystyrene/other strips.

Thermal Performance

Depending on the climate, a variety of infill materials that completely and permanently insulate the building without thermal bridges, can be chosen

Behavior in wind/hurricane

A Sismo building is extremely resistant to the complex strains and thrusts due to the force emitted by wind, hurricanes and cyclones.



Light weight

Sismo modules weigh between 2 & 7 kg, eliminating the need for heavy and expensive building equipment on site. These can easily be handled and assembled manually.

Fast implementation

The time required to raise buildings using this technology is significantly shorter than any conventional building method.

MAJOR WORKS COMPLETED/UNDER COMPLETION

Sismo Building Technology, Belgium has constructed numerous residential and utility projects mostly in Belgium, France, Portugal, Italy, Turkey, Korea and Middle East etc. The Indian firm is constructing about 70 (G to G+2) housing units at Kashipur (Uttarakhand) by using this technology. The project is likely to be completed by 2017. Police Barracks (2500 sqft.) has been constructed at Siliguri. A project of construction of District Magistrate Office (7000 sqft.) at Cooch Behar, West Bengal is under progress. A Demonstration Housing Project of BMTPC at Lucknow comprising of 40 houses in G+1 configuration has been completed.

CERTIFICATION / VALIDATION OF THE SYSTEM

Performance Appraisal Certificate No. 1025-S/2016 has been issued to M/s M K S Infosolutions Pvt. Ltd., Manesar (Haryana) by BMTPC.

STANDARDS/REFERENCES

European Assessment Technical Regulation	
Sismo technology: Plain concrete in high rise buildings by Sismo Engineering, Belgium	
Guideline for European Technical Approval of 'Non-load bearing permanent shuttering systems based on hollow blocks or panels of insulating materials' by EOTA, Brussels, Belgium	
Experimental Research in 92-93 & 93-94 by Sismo Engineering & CE Deptt., University of Leunen, Belgium	
IS 456:2000	Code of practice for plain and reinforced concrete (Reaffirmed 2016)
IS 875 (Parts 1,2, 4 & 5) :1987	Code of Practice for Design Loads (other than earthquake) for Buildings & Structures (Part 3 : 2015)
IS 1893 (Part 1):2016	Criteria for Earthquake Resistant Design of Structure
IS 4326:2013	Code of Practice for Earthquake Resistant Design and Construction of Buildings
IS 4671:1984	Specifications for expanded polystyrene for thermal insulation purposes
IS 14862:2000	Specifications for Fibre Cement Flat Sheets (Reaffirmed 2015)



Insulating Concrete Forms (ICF) and Monolithic Insulated Concrete Systems (MICS)

(Suitabvle for Low Rise Structures)

ABOUT THE TECHNOLOGY

Insulating Concrete Forms (ICF) & Monolithic Insulated Concrete Systems (MICS) comprise of panels of two walls of Expandable Polystyrene (EPS) separated by a nominal distance of 150mm by hard plastic ties. These are assembled on site to hold reinforced concrete. The forms are open ended hollow polystyrene blocks which fit tightly together to form a shuttering system. Concrete is poured into the hollow space to form a continuous wall. When cured, this wall supports the structural loads from floors and roofs, and the shuttering provides thermal insulation. Reinforcing steel shall be as required from design. Upper and lower surfaces of the polystyrene panels are castellated and the vertical mating surfaces are tongue-and-groove to form a tight fit when joined together. The rigid formwork does not require supporting false work. The inner surfaces have tapered grooves running vertically and have offset on opposite faces to ensure uniform concrete thickness. They also form locks for end stops. The outer surfaces are grooved vertically at 50mm centers to aid cutting and trimming.

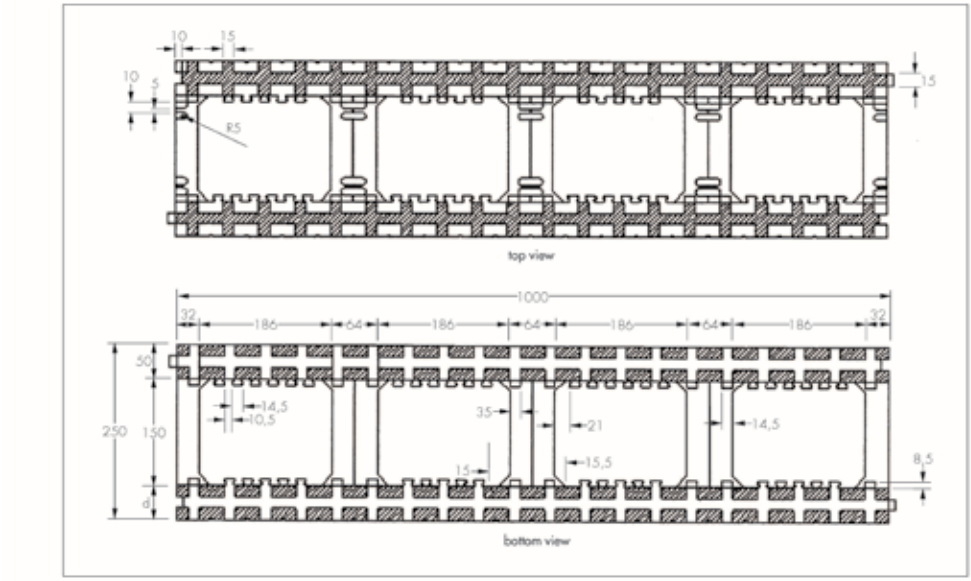


Fig. 1 Plan View

CLASSIFICATION AND TYPES OF FORMS

Standard Forms – These form bulk of the forms and have 50mm EPS panels on both sides with 8 nos. hard plastic ties holding the panels. Dimensions of these forms are 1000 x 250 x 250mm. (See Fig. 2)

Half Height Forms – Together with the lintel, these form the top layer of all gaps in the wall and hold the required steel reinforcement. Dimensions of these forms are 1000 x 150 x 250mm. (See Fig. 3)

Lintel Forms – In combination with Half Height forms, these form the top layer of all wall gaps and hold the concrete thus preventing thermal leaks. Dimensions of these forms are 1000 x 125 x 250mm. (See Fig. 4)

Floor Edge Forms – These form the top most layer, where the wall ends and floor begins. This envelopes the floor slab and thus prevents thermal bridging. Dimensions of these forms are 1000 x 375/125 x 250mm. (See Fig. 5)

Corner Forms – These constitute 90º corner of the building. The two sides are 50mm EPS panels held together with 8 nos. hard ties. Dimensions of these forms are 750/500 x 250 x 250mm. (See Fig. 6)

End Forms – These create wall ending by fitting in inside the Standard or Corner form and provide a smooth and thermal bridge ending to the wall. Dimensions of these forms are 150 x 125 x 50mm. (See Fig. 7)



Fig. 2 Standard



Fig. 3 Half Height



Fig. 4 Lintel

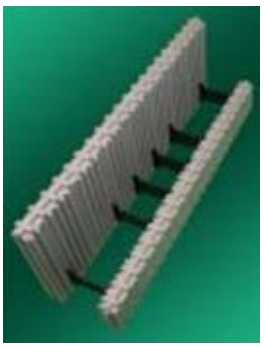


Fig. 5 Floor Edge



Fig. 6 Corner



Fig. 7 End

RAW MATERIALS

- Expanded Polystyrene (EPS): Self-extinguishing type EPS shall conform to IS 4671: 1984 having density not less than 25 kg/m^3 and valid Restriction of Hazardous Substance (ROHS) test certification.
- Polyurethane (PU) Foam Adhesive: Shall have Skin Formation of 8 min, Density 25 kg/m^3, Sound insulation 58 dB, Insulation factor 35 mW/mK, Shrinkage< 2%, Fire rating B3, Insulation factor 35 mW/m.K and Water absorption of 1 % volume
- Plasticizer: Slump retaining super plasticizer for self-compacting plastic concrete (CEMWET SP-3000) shall conform to IS 9103:1999
- Hard Plastic Tie: Shall be made with High density polyethylene and shall be as per manufacturer's specifications.
- Cast-in-place concrete: The ingredients, grade of concrete & slump for walls, floors and roofs shall be used as per IS 456:2000.

STRUCTURAL

The Insulating Concrete Forms (ICF) & Monolithic Insulated Concrete Systems (MICS) may be designed using the appropriate design software. The buildings constructed with EPS shall be studied and designed as reinforced concrete structure since the parameters required for their design are the same as needed for traditional reinforced concrete. In the calculation model, the building shall be designed in accordance with IS 456:2000, as applicable, as structure composed of load bearing walls with a box-like structure.

The system is intended for use where architectural drawings are available and satisfy the various requirements. The system shall be designed to provide the required performance against the loads to be taken into account in accordance with IS 875 (Parts 1,2,4&5):1987 and the data given by manufacturer for various panels. It shall also provide the required bearing resistance for earthquake and wind forces as per IS 875 (Part 3):2015 and IS 1893 (Part 1):2016, wherever applicable.

Foundation shall be specifically designed in accordance with provision given in IS 1904:1986. The design concept is same as that of the conventional building design. The safe bearing capacity and soil properties (soil investigation report)) shall be provided from the site after soil investigations. Foundation shall be designed based on the soil investigation report. Both single and double panels should have starter bars from either foundation or ground floor slab. All foundations should be designed by experienced engineer with appropriate reference. In addition, any other requirement regarding safety against earthquake need to be ensured by the designer as per prevailing codal requirements.

Typical construction

Construction process

The construction of most Insulating Concrete Forms (ICF) & Monolithic Insulated Concrete Systems (MICS) buildings is fundamentally a process of stacking lightweight blocks together in a similar manner to building bricks, laying reinforcement where necessary and pouring concrete into the voids of the block work. It does not call for the same skill set as solid brick or brick veneer construction.

Footings
The footings for Insulating Concrete Forms (ICF) & Monolithic Insulated Concrete Systems (MICS) buildings are usually reinforced concrete rafts or strips that are flat and even enough to enable stacking of the form blocks, with reinforcement starter bars set ready to connect with the concrete when poured into the formwork.

Load bearing walls
Any Insulated Concrete System/Forms wall can be designed to be load bearing.

Joints and connections
Joints and connections with other building elements are kept to a minimum, especially when the flooring or roofing elements are also made from Insulated Concrete System/Forms.

Fixings
The foam block work or formwork forms a poor basis for any fixings. Light loads are generally carried by the lining or facing materials, such as plasterboard, and heavier loads can be carried by supporting points drilled into the concrete that forms the inner material of the Insulated Concrete System/Forms.

Openings
Major openings for doors, windows, etc., need to be set out in the formwork as it is relatively difficult to make changes later, owing to the fundamentally monolithic nature of the structural elements. Once openings have been made, they can accommodate window and door frames of any type. A typical kind of fixing uses timber blocks set into the ends of the form blocks around the opening.
Electrical conduit and plumbing is generally run in chasing in the depth of the form blocks.

Finishes
Finishes are dependent on the materials used to face the Insulated Concrete System/Forms units. Typically, the main finish is a render or render-equivalent covering or paint. Any additional cladding can be added to the Insulating Concrete Forms (ICF) & Monolithic Insulated Concrete Systems (MICS) walls subject to making appropriate supports for it, although many sheet finishes, such as plasterboard, can be glued directly to the surface of the formwork. External renders require a base or skim coat embedded with fibreglass mesh, followed by a second coat and then a texture coating, finally finished with an ‘armour coat’.

BASE: Insulated Concrete System/Forms can be built on footings similar to conventional masonry footings, slabs-on-grade or piles or can also be built on step footings & shallow foundation systems.





FORMWORK: Walls built by assembly of interlocking, moulded hollow forms.





REBARS: Fixing reinforcement steel bars with hard ties inside formwork as per calculated structural requirement.

TRESTLES: Fixed for plumb straight walls & support during concrete pour





SCAFFOLD: Platform on trestles for access & assembly of high walls
PROPPING: Fixing framework as props around Doorways & window frames.



CONDUITS & PIPES: Inside chased lines





CONCRETE: High slump concrete poured inside formwork




SPECIAL FEATURES

- Cost Effective - Saves 70% or more in energy equipment & consumption bills for maintaining cooling temperatures
- Quicker - Commissioned in nearly half the normal time period, with less manpower & no heavy machines
- Resource Conserving - No water for curing, hence time & labour also saved at site
- Load bearing external walls - With minimized need for columns or beams

- Minimal on site waste - Modular form work enables any wall height or design complexity with ease,
- 100% insulation - With zero thermal leaks (R-Value = 19, higher than any other new or traditional constructions
- Durable - Monolithic structure for highest degree of fire & disaster resistance 3 hours of fire rating, can withstand earthquakes of Magnitude +7
- Sound Insulation - Up to 60 Db
- Maintenance free - Fibre glass mesh reinforced, crack resistant plaster on walls
- Heat resistant external roof - With interlocking insulation tiles of uniformly high R-Value
- Code Compliance - System designed to meet International Standards & Building Codes

ADVANTAGES

- Not just Walls: But multiple building steps with one product
- Form system -- light weight, interlocking
- Wall structure -- strong, load bearing, disaster proof
- Insulation -- thermal & acoustic, on both sides
- Air barrier -- no drafts with monolithic insulation
- Vapour barrier -- moisture & condensation kept out
- Smooth, straight surface -- less finishing time for Interior/exterior Render

USES AND LIMITATIONS OF ICF/MICS

Insulating Concrete Forms (ICF) & Monolithic Insulated Concrete Systems (MICS) may be used as a load bearing and non-load bearing internal or external walls to build residential and other buildings. This construction technology may be used for wide variety of buildings including apartments, villas, low-rise buildings, commercial complexes, hotels, industrial buildings, etc.

LIMITATIONS

1. Door and window position can't be changed after pouring of concrete
2. Forms are not reusable as compared to conventional materials

EXECUTED PROJECT

S. No.	Name of Project	Location	Period of Supply
1.	Construction of Farmhouse of approx. 110 sqm area	Manesar (Haryana)	January 2015
2.	Construction of G+3 showroom of total area of approx. 1600 sqm	Indore (MP)	Mar-April 2015
3.	Construction of G+1 Hillside Cottage of approx. 250 sqm area	Theog, Shimla (H P)	June – Aug., 2015
4.	Construction of G+5 Multi storey residence of total area 900 sqm	New Delhi	Nov. – April 2016
5.	Construction of G+1 Office & godown of 590 sqm area each	Greater Noida (UP)	2014-15
6.	Construction of a single storey Prototype house	VDOS Colony, Khammam (Telangana)	2016
7.	Demonstration Housing Project consisting of 40 dwelling units with other provisions for use as sports hostel	Bhopal, Madhya Pradesh	2022

CERTIFICATION / VALIDATION OF THE SYSTEM

i) Performance Appraisal Certificate No. 1029 -S/2018 on Insulated Concrete Forms has been issued to M/s Reliable Insupacks (P) Ltd., Greater Noida.

ii) Performance Appraisal Certificate No. 1036-S/2018 on Monolithic Insulated Concrete System has been issued to M/s Maiwir Ecotech Pvt. Ltd., Khammam (Telangana).

OTHER SIMILAR SYSTEM SHORTLISTED UNDER GHTC-INDIA

i) FastBloc, Insulated Concrete Form (ICF) of M/s Fastbloc Building Systems has been shortlisted under Global Housing Technology Challenge – India (GHTC-India).

STANDARDS/REFERENCES

Following Standards are referred:

IS 383:2016	Specifications for coarse and fine aggregate for concrete (Third Revision)
IS 456:2000	Code of practice for plain and reinforced concrete (Reaffirmed 2016)
IS 875 (Parts 1,2,4&5):1987 IS 875 (Part 3):2015	Code of Practice for Design Loads (Other than Earthquake) for Buildings & Structures (Parts 1,2,4&5 – Reaffirmed 2013)
IS 1346:1991	Code of practice for waterproofing of roofs with bitumen felts (Reaffirmed 2016)
IS 1542:1992	Specifications for sand for plaster (Reaffirmed 2014)
IS 1786:2008	Specifications for high strength deformed steel bars and wires for concrete reinforcement (Reaffirmed 2013)
IS 1893 (Part 1):2016	Criteria for Earthquake Resistant Design of Structure - Part 1 : General Provisions and Buildings (Sixth Revision)
IS 1904: 1986	Code of practice for design and construction of foundations in soils: General requirements (Reaffirmed 2015)
IS 3346:1980	Method of determination of thermal conductivity for thermal insulation materials
IS 4326:2013	Code of Practice for Earthquake Resistant Design and Construction of Buildings (Third Revision)
IS 4671:1984	Specifications for expanded polystyrene for thermal insulation purposes
IS 4759:1996	Hot Dip Zinc Coating on Structural Steel Products
IS 8112:2013	Specifications for 43 grade Ordinary Portland Cement (Second Revision)
IS 9103:1999	Specifications for concrete admixtures (Reaffirmed 2013)
ISO 9705:1983	Fire tests for evaluating contribution of wall & ceiling interior finish to room fire growth
ACI 318:2014	Building code requirements for structural concrete, structural design for flat wall ICF systems
ASTM C 578:2015	Standard specifications for rigid, cellular polystyrene thermal insulation
ASTM E 119:2014	Standard test methods for fire tests of building construction and materials
ASTM E 2634:2011	Standard specifications for flat wall ICF systems

Lost-in-Place Formwork System – Plasmolite Wall Panel

(Suitable for Non Load Bearing Structures)

ABOUT THE TECHNOLOGY

Plasmolite Panels are lost in place formwork system comprising of two fibre cement boards (FCB) of 6 mm thickness and High Impact Molded Inserts (HIMI) bonded between two sheets which also acts as spacers. The panel is erected to produce straight to finish walls which are filled with light weight foam concrete. The system may be integrated with conventional column and beam and also with pre-engineered buildings. The panels may be used as non load bearing walls for external and internal applications.

The firm imports the fibre cement board (FCB) manufactured by Hume Cemboard Industries, Malaysia for use in the technology. An Isometric View of the Plasmolite panel is shown in Fig. 1 below;

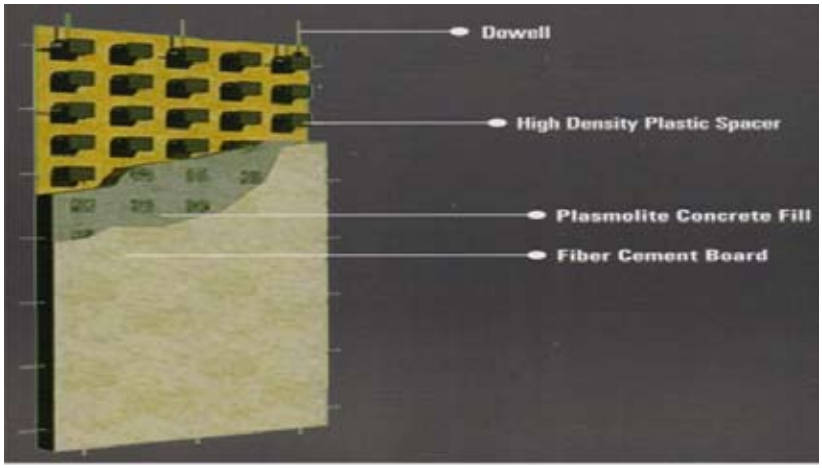


Fig. 1 Isometric View of Plasmolite Panel

SIZE OF PANELS

Size: Panels are normally produced in sizes and dimensions as given below:

Length:	2400/3000 mm
Width:	1200 mm
Thickness:	87 mm, 112 mm, 137 mm, 162 mm & 230 mm including two fibre cement boards of 6mm thickness each.

Typical dimensional diagrams are shown in Fig. 2.

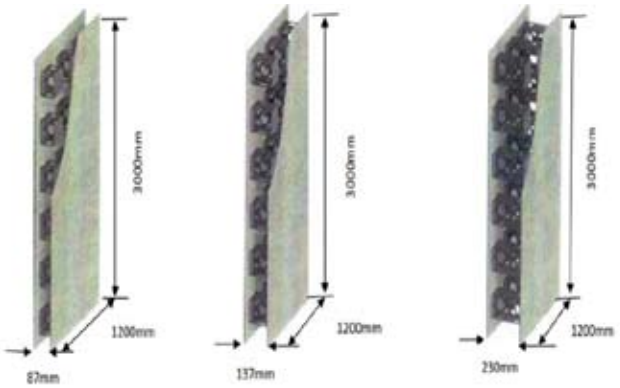


Fig.2 Dimensional Diagrams

RAW MATERIALS

- Fibre cement board shall be 100% asbestos free and conform to Type A, Category 3 min. as stipulated in IS 14862:2000.
- Recycled plastic spacers made of High Impact Molded Inserts shall conform to the specifications of the manufacturer.
- PU Adhesive Glue shall conform to the specifications of the manufacturer.
- Foaming agent shall conform to the specifications of the manufacturer.
- Putty shall conform to IS 419:1967.
- Cement, sand, aggregate and reinforcement steel shall be as per the relevant Indian Standards.

USES AND LIMITATIONS

Uses: Plasmolite Panels may be used as partition walls for external and internal applications for residential and commercial buildings, schools, hospitals, factories and malls etc.

Limitations:

- Nails/screws should not be inserted directly on the walls by using hammer. Instead, a hole shall be drilled by using drilling machine and then plastic sleeves or rawl plugs be inserted for fixing the nails/screws.
- Chisel shall not be used to chase directly on the wall for providing additional services. Instead, 100 mm grinder machine shall be used to cut out exact portion of wall and then rendering of the wall with mortar and putty.
- If wall tiles are to be changed, walls shall not be hacked for fixing new tiles. Instead, a cementitious tile adhesive should be for fixing new tiles.

PANEL FABRICATION

Fibre Cement Edge Recessing

After cutting fibre cement sheet to the desired dimensions, the edge of the sheet shall be recessed using recessing machine.

Panel Lamination (Fig. 3)

- Using the panel jig, one fibre cement sheet 6mm thick shall be placed on top of jig with the smooth face touching the jig flat form.
- Desired number of HIMI spacers shall be placed on top of fibre cement sheet and PU adhesive applied on the stud flanges (32 pieces for full panel 1200mm x 2400mm). HIMI spacers shall be aligned using pattern board.



Fig. 3 Marking & fixing of Spacers, formation of successive layers of panels

- Another 6mm thick fibre cement sheet shall be placed on top of the studs to close the first panel.
- The same process as above shall be repeated until jig is filled with panels.
- Flat plywood covers shall be laid to compress the panel for 4 to 5 hours.

PANEL INSTALLATION

Dowelling

- Holes shall be drilled & dowels shall be grouted by using epoxy resins in the holes.
- Centre to centre spacing between dowels shall be 300 mm as per design
- Dowels shall be installed on beams, columns and slab (Fig. 4)



Fig. 4 Dowelling

Installation

- The panel shall be lifted slightly and then placed along the bottom angles. The panel shall be plumbed at edge and face sides with provision of shims, if needed.
- It is essential that panels be first installed starting from face of supporting column
- The panel shall be screwed both sides at bottom at 250 mm center to center, while glue is applied & Stacy. If glue is not available, spacing shall be kept at 200mm center to center. (Figs. 5, 6 & 7)
- Support the temporarily angle installed on other side of panel to hold it in position for concreting (Fig. 8)



Fig. 5



Fig. 6



Fig. 7



Fig. 8

Joint Splicing

Joints between two panels shall be fixed by using FCB strips 50 mm wide inside the panel with help of glue, screws and tacking pins. (Fig. 9)

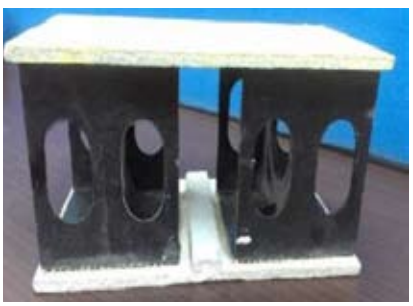


Fig. 9 Tongue and Groove Systems

Embedment of Services

After installation of panel, electrical and plumbing pipes shall be inserted into the panel as per the drawings.

Concrete mix

Plasmolite foam generator and mixer shall be used for this purpose. An elaborated mix of cement, sand/fly ash and water shall be prepared, quantities of which vary depending upon required density and strength of foam concrete.

Pouring of Concrete

Concrete can be poured in the panel by pumping or manually directly from top or intermediate position depending on floor to floor height and site conditions.



Fig. 10 Plasmolite set for pouring



Fig. 11 Gap Filling

Joint Treatment

- After walls are completely filled and mix dried, joint treatment shall be done using fibre mesh tape and putty.
- Mesh tape shall be sandwiched between first & second coats to have a hold over the wall. (Fig. 12)
- Wall is now ready to accept primer & paint.

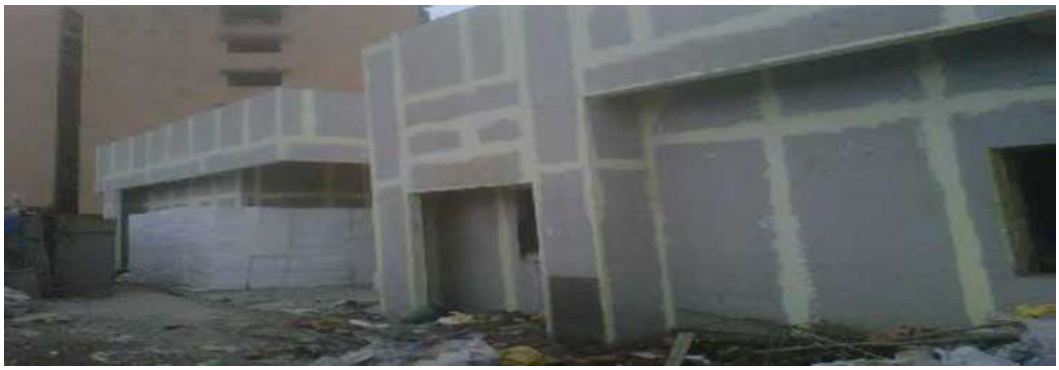


Fig. 12 Yellow Putty with Fibre Mesh Tape

DESIGN PARAMETERS

The technology provider shall provide design data for good practices and as ready reckoner for users.Typical design sketches for non-load bearing walls are shown in Figs. 13 & 14.

PROJECT EXECUTED

1. Supply, Fabrication & Installation of wall panels at Goa for construction of a high rise building for M/s JVS Infrastructure & Environment, Goa
2. Supply, Fabrication & Installation of panels at TCS Sahyadri Park, Hinjawadi, Pune for M/s Shapoorji Pallonji, Pune
3. Supply, Fabrication & Installation of wall panels at Dahej, Gujarat for M/s Indo Baijin Chem Pvt. Ltd., Bharuch, Gujarat

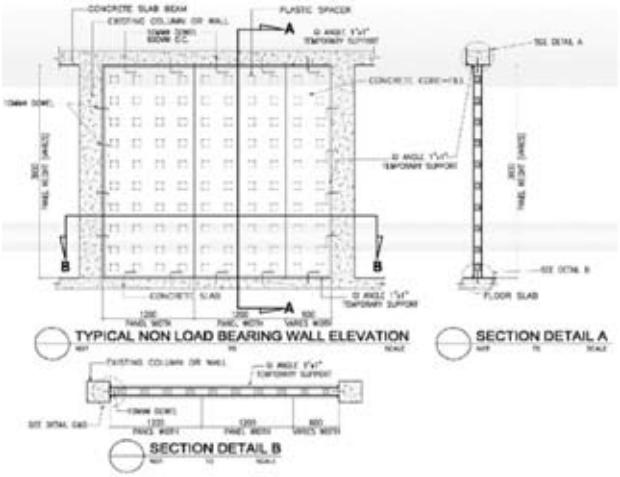


Fig. 13

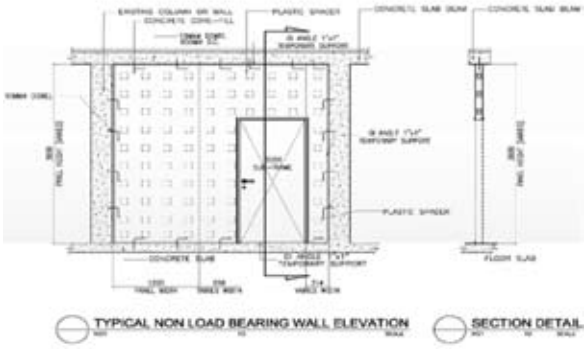


Fig. 14

4. Supply, Fabrication & Installation of panels at Future Towers, Amanora Park Town, Pune for Amanora, Pune
5. Design, Supply & Installation of panels at residential building at Vikhroli, Mumbai for Shubam Dynamic, Mumbai
6. Supply, fabrication & installation of wall panels at Pune for construction of IT Park for M/s Tata Consultancy Ltd., Pune.

ADVANTAGES

- Faster construction
- Eco-friendly
- Good thermal & acoustics insulation

CERTIFICATION

Performance Appraisal Certificate No. 1033-S/2018 has been issued to M/s FTS Buildtech Pvt. Ltd., Mumbai.

LIST OF STANDARDS, REFERENCES USED IN ASSESSMENT

Indian Standards

IS 383:2016	Specifications for coarse and fine aggregates (Third Revision)
IS 419:1967	Specifications for putty.
IS 456:2000	Code of practice for plain and reinforced concrete (Reaffirmed 2016)
IS 516:1959	Method of test for strength of concrete (Reaffirmed 2013)
IS 2380 (Part 14):1977	Methods of test for wood particle board and other Ligno cellulosic materials – screw & nail withdrawal test (Reaffirmed 2013)
IS 3809:1979	Fire Resistance Test for Structures
IS 8112:2013	Specifications for 43 grade Ordinary Portland Cement
IS 14862:2000	Specifications for Fibre Cement Flat Sheets (Reaffirmed 2015)
ASTM C900	Standard test method for pullout strength of hardened concrete
ASTM 322:09	Standard test method for thermal conductivity
ASTM E119	Standard test method for fire tests of building construction and materials

References

1.	Tests Performed on samples of Fibre Cement Board and Panels by Indian Institute of Technology Bombay, Mumbai
2.	Tests Performed on Panels by Civil-Aid Technoclinic Pvt. Ltd., Bangalore
3.	Test Performed on samples of spacers i.e. High Impact Moulded Inserts (HIMI) of size 125mm collected by the Inspection Officer for carrying out the tests by Central Institute of Plastics Engineering and Technology (CIPET), Ahmedabad

Lost-in-Place Formwork System – Plaswall Panel System

(For Structural Applications)

(Suitable for Low Rise to Medium Rise Structures)

ABOUT THE TECHNOLOGY

Plaswall Panel System is a lost in place formwork, where two fiber cement boards (FCB) of 6mm thickness each and HIMI spacers (High Impact Molded Inserts) bonded between two sheets of FCB (in- situ) are erected to produce straight-to-finish panels. A monolithic structure is then created by filling the entire structure with M20 or higher grade of concrete as per the design. Additional load capacity can be obtained by providing extra reinforcing bars and/or by increasing grade of the concrete.

At present, the firm imports the fibre cement board (FCB) manufactured by Hume Cemboard Industries, Malaysia for use in the construction of structures.

An Isometric View of the Plaswall is shown in Fig. 1 below:

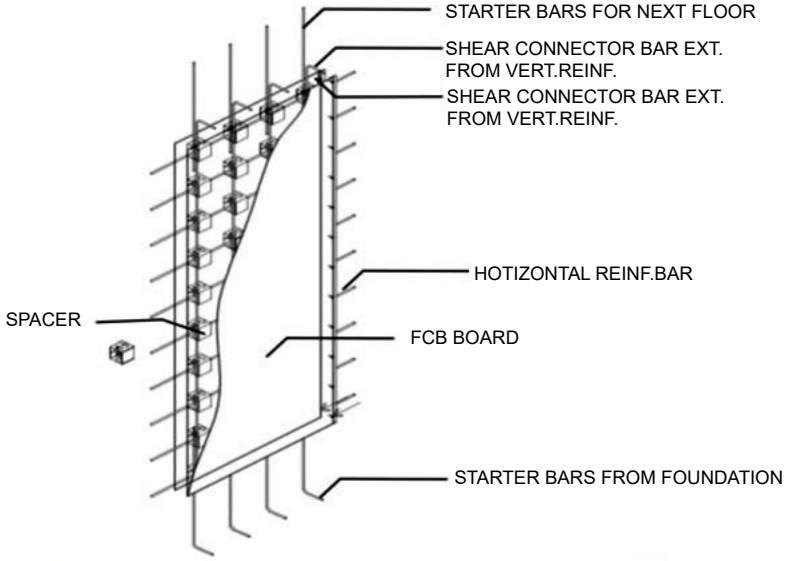


Fig. 1 Isometric View

SIZE OF PANELS

Panels are normally produced in sizes and dimensions as below:

Length:	2400mm/3000 mm
Width:	1200 mm
Thickness:	87 mm, 112 mm, 137 mm, 162 mm & 230 mm including two fiber cement boards of 6mm thickness each and infill of concrete of 75mm, 100mm, 125mm, 150mm and 218mm.

The dimensional sketches are shown in Fig. 2

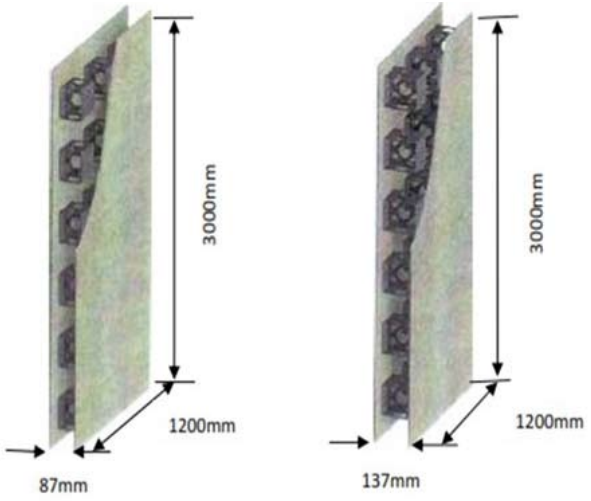


Fig. 2 Dimensional sketches

RAW MATERIALS

- Fibre cement board shall be 100% asbestos free and conform to Type A, Category 3 min. as stipulated in IS 14862:2000.
- Recycled plastic spacers made of High Impact Molded Inserts shall conform to the specifications of the manufacturer.
- PU Adhesive Glue shall conform to the specifications of the manufacturer.
- Putty shall conform to IS 419:1967.
- Cement, sand, aggregate and reinforcement steel shall be as per the relevant Indian Standards.

USES AND LIMITATIONS

Uses:

Plaswall panels may be used upto G+3 storey residential and commercial buildings, villas, apartments, factories and malls, etc.

Limitations:

- Nails should be inserted in walls by first making a hole by drilling and fixing a plastic sleeves or rawl plugs.
- Chisel shall not be used to chase directly on the wall for providing additional services. Instead 100 mm grinder machine shall be used to cut out exact portion of wall and then rendering of the wall with mortar and putty.
- If wall tiles are to be changed, walls shall not be hacked for fixing new tiles. Instead, a cementitious tile adhesive should be for fixing new tiles.
- Post construction alternations are difficult. All the service lines are to be pre-planned in advance.

DESIGN PARAMETERS

- All concreting work shall be done in accordance with IS 456:2000 with regard to workmanship and materials. M20 or higher grade of concrete as per the design shall be used for construction and mix should be prepared in accordance with Clause 9.2 of IS 456:2000.
- The Reinforcement shall be placed according to the specifications, depending on the application and shall be determined by structural calculations performed according to the IS 456:2000.
- The lateral forces as applicable shall be taken into account based on relevant Indian Standards.

PANEL FABRICATION

Fibre cement edge recessing

After cutting fibre cement sheets to the desired dimensions, the edge of the sheets shall be recessed using recessing machine.

Panel Lamination

- Plastic pallets and jigs shall be arranged perpendicular to each other
- Fibre sheet shall be laid in alignment with respect to pallet and jig setup
- Marking of spacer with use of specific stencil positions shall be done on the sheet
- Glue @ 250gm min. is the standard consumption. Reusable bottom angles shall be laid as per alignment of walls where panels are to be installed.
- Desired number of plastic spacers (32 nos. of spacers for panel of size 1200 mm x 2400 mm) shall be placed on the top of the fibre sheet, where glue is applied and kept in linear manner for 4 to 5 hours.
- Glue shall be applied on upper faces of spacers and upper sheet is laid perfectly in line with lower sheet. (Fig. 3 & 4)
- Ten number of panels shall be fabricated on each side of jig and stacked on pallets. (Fig. 5)
- These panels then shall be cut as per the specified dimensions and sizes such as rectangular, square, curves etc.



Fig. 3



Fig. 4



Fig. 5

Joint Splicing

Joints between two panels shall be fixed by using FCB strips 50 mm wide inside the panel with help of glue, screws and tacking pins. (Fig. 6).

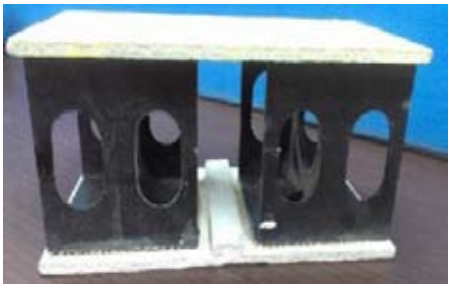


Fig. 6 Splicing

CONSTRUCTION, INSTALLATION AND JOINTING PROCEDURE OF PLASWALL

Foundation

The foundation type as raft, strip, isolated footing shall be decided based on bearing capacity of the soil, site condition, etc. However, the provision for starter bars for walls shall be ensured in all foundation scenarios. Typical sketch for starter bars from foundation are given below (Fig.7).

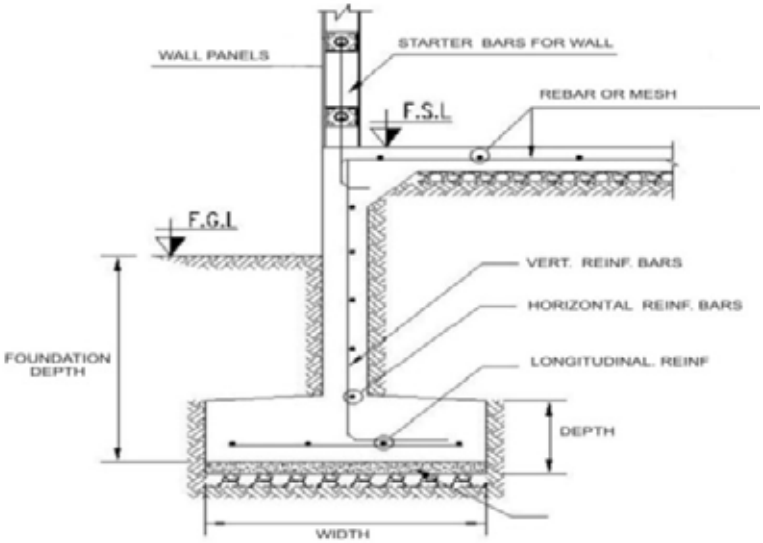


Fig. 7 Typical Strip footing

Panel Installation

Installation

The panel shall be lifted slightly and then placed along the bottom angles. The panel shall be plumbed at edge and face sides with provision of shims, if needed.

- The panel shall be screwed both sides at bottom at 250 mm center to center, while glue is applied & tacky. If glue is not available, spacing shall be kept at 200mm center to center.
- Support the temporarily angle installed on other side of panel to hold it in position for concreting (Fig. 8)
- Corner connection details shall be followed as shown in Fig. 9.



Fig. 8 Diagonal bracing

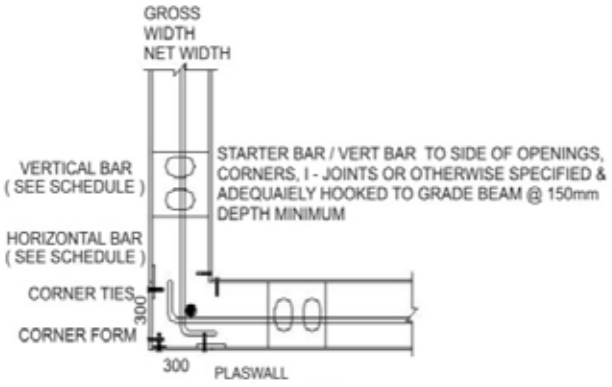


Fig. 9 Corner connection

T-Section

- After installing the primary walls, mark the place where corner will be constructed.
- The joiner stud shall be placed and marked by pencil to have a vertical line reference.
- The joiner stud shall be moved up by 60mm from slab to bottom of joiner stud. The stud hole shall be marked by pencil.
- The marked slots shall be cut by 100mm angle grinder with dry type diamond blade.
- Reinforced dowels shall be prepared, inserted & tied just after screwing the joiner stud corner connection. (Fig.9)
- In case, the holes intersect with panel stud of the primary wall, the portion of primary stud shall be cut to accommodate the marked holes for T-connection. One 12mm vertical bar shall be provided as replacement.
- In case of cross-connection, horizontal bars shall be provided.

Nib End Wall Detail

- For nib, end cap shall be provided.
- Glue shall be applied on end cap stud which shall be inserted to correct position and screwed. (Fig. 10)

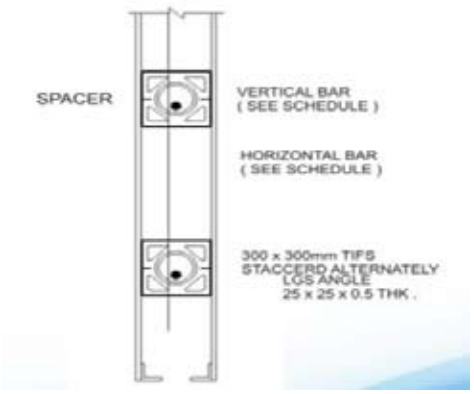


Fig. 10 Nib End Wall Detail



Fig. 11 Door & Window Jambs

Door & Window Jambs Installation

- Light gauge door & window jambs shall be provided for the panels
- Door jambs shall be installed along with the panel. (Fig. 11)
- Window jambs shall be installed (not fixed) to accommodate concrete at window sills. This will eliminate honey-comb and ease pouring of concrete.
- The window sill shall be overflowed by concrete and then push down window frame. The lintel panel shall be screwed to press down the window frame. Spacing of screws shall be the same.

Embedment of Services

After installation of the panels, electrical and plumbing pipes shall be inserted into the panel as per the drawings.

Concreting

After placing of reinforcement and services in the panel, designed grade/mix of concrete shall be poured manually or by Pumping system. The concrete shall be poured from top of the wall or by cutting slit and attaching chute in the panel.

Joint Treatment

After walls are completely filled and mix dried, joint treatment shall be done using fibre mesh tape and putty. (See Figs. 12 & 13)

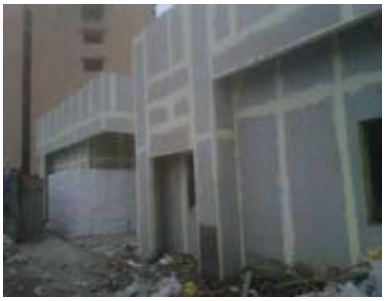


Fig.12 Yellow Putty with Fibre mesh tape

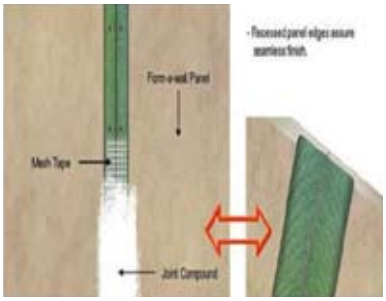


Fig.13 Joint Treatment

Construction of Slab

Once construction of panels is completed, slab construction shall be done as per the structural drawings with wall reinforcement and connection with slab reinforcement.

KEY FEATURES OF "PLASWALL" LOAD BEARING SYSTEM

- It is significantly faster than conventional technology.
- Brick work & plastering is eliminated
- Curing of concrete is not required & hence considerable water is saved
- Inlaid plumbing & electrical lines, superior quality finish.
- Better Acoustic Insulation
- Termite & Algae Resistant.
- Applicable in Humid conditions.
- HIMI is manufactured from 100% recycled plastics.
- Fire Resistance: PLASWALL™ is non-combustible and has fire resistance for one hour as determined by ASTM E 119 tests. Its excellent thermal insulation acts as a thermal shield. A 112mm thick wall will withstand fire for 2 hours 20 minutes and a 162mm thick wall has fire resistance for 3 hours.
- Acoustic Insulation: Its inbuilt sound reduction properties make it excellent for sound absorption and noise isolation. Concrete walls carry sounds, thus hampering privacy.

MAJOR PROJECTS EXECUTED

- Construction of Row Houses (Area= 675 sq.mts) at Boisar.
- Sales Gallery at Vaisind for Tata Housing, Mumbai.
- Construction of Villas at Cupertino, Bangalore for M/s Concorde Group, Bangalore
- Construction of 4 Villas at Goa (Area= 1085 sq.mts) for M/s Naiknaware Developers, Pune.
- Construction of 113 no .of Villas (G+1 configuration) at Sawantwadi, Maharashtra(Area= 6200 sq.mts) for M/s Ranco Reality, Mumbai
- Construction of Villas & School at Ooty for M/s Ground Reality, Bangalore

CERTIFICATION

Performance Appraisal Certificate No. 1034-S/2018 has been issued to M/s FTS Buildtech Pvt. Ltd., Mumbai.

LIST OF STANDARDS AND CODES USED IN ASSESSMENT

Standards: These Standards are referred for carrying out a particular test only and do not specify the requirement for the whole product as such.

IS 383:2016	Specifications for coarse and fine aggregates (Third Revision)
IS 419:1967	Specifications for putty.
IS 456:2000	Code of practice for plain and reinforced concrete (Reaffirmed 2016)
IS 516:1959	Method of test for strength of concrete (Reaffirmed 2013)
IS 2380 (Part 14):1977	Methods of test for wood particle board and other Ligno cellulosic materials – screw & nail withdrawal test (Reaffirmed 2013)
IS 3809:1979	Fire Resistance Test for Structures
IS 8112:2013	Specifications for 43 grade Ordinary Portland Cement
IS 13920:2016	Ductile detailing of reinforced concrete structures subjected to seismic forces - code of practice
IS 14862:2000	Specifications for Fibre Cement Flat Sheets (Reaffirmed 2015)
ASTM C 518-02	Standard test method for steady state thermal transmission properties by means of heat flow meter apparatus
ASTM C779	Standard test method for abrasion resistance of horizontal concrete surfaces
ASTM C873	Standard test method for compression strength of concrete cylinders
ASTM C900	Standard test method for pullout strength of hardened concrete
ASTM 322:09	Standard test method for thermal conductivity
ASTM E119	Standard test method for fire tests of building construction and materials
ASTM E 152-58	Non-combustibility test for materials and heat emissions from building materials
ASTM E413	Classification of rating of sound insulation and field transmission class
ASTM E2179	Standard test method for lab measurement of effectiveness of floor coverings
BS 476 (Part4):1970	Fire tests on building materials and structures—Method of test to determine classification of surface spread of flame

References:

1.	Evaluation of Structural Design of G+2 storey 30m x 40m Villa Project at Cupertino, Bangalore using Plaswall Technology by IIT Bombay.
2.	Design of a G+2 storey with Roof Deck Residential Villa Project at Djibouti, Africa by Senior Consultant Engineer
3.	BBA Agreement Certificate No. 16/5380 pertaining to Greenspan Permanent Shuttering Systems on which Plaswall Technology is based
4.	Report on Thermal Transmission Properties of Plaswall (Load bearing walls) by calculation method by Material Lab, Dubai, UAE
5.	Small –Scale Fire Resistance Test on a 110mm thick panel by Firelab, Glenstantia, South Africa
6.	Tests performed on Plaswall Panel for Fire Resistance at the Forest Products Research & Development Institute Fire Testing Laboratory, Philippines as per ASTM E152-58.
7.	Tests performed on samples of spacers i.e. High Impact Moulded Inserts (HIMI) of size 125mm collected by the IO for carrying out the following tests by Central Institute of Plastics Engineering and Technology (CIPET), Ahmedabad
8.	Tests Performed on samples of Fibre Cement Board and Panels by Indian Institute of Technology Bombay, Mumbai.

Structural Stay-in-Place Formwork System (Coffor Technology)

(Suitable for Low Rise to Medium Rise)

ABOUT THE TECHNOLOGY

It is a patented structural stay in place formwork system known as 'Coffor' to build load bearing monolithic concrete wall structures based on shear wall concept.

The formwork system comprises of two filtering grids made of rib mesh reinforced by 'C' channel vertical stiffeners. The grids are connected by rebar which act as horizontal stiffeners and connector which act as a shear link. The grids on both faces act as sacrificial formwork in which concrete is poured in-situ.

After the erection of formwork panels in alignment, corners, edges of doors and windows frame are closed with rebar positioning & concrete of required grade is poured in the panels. The concreting may be done with a pump, bucket or with a shovel loader. The inside and outside walls are finished with cement plaster of suitable grade.





The panels are prefabricated according to a structural plan (based on client's architectural plans) designed by structural engineers.

Product assembly Components in Coffor Panel:

The various parts of Coffor panel are explained briefly below:



Part – 1: C-Chanel

– These are vertical stiffeners, work as vertical steel in Reinforced Concrete wall
– It is made up of 0.6 mm thick galvanized sheet. The 180 GSM to 275 GSM zinc coating is used based on geological location to prevent rusting of steel.
– Area of profile is 60.6 mm^2 (i.e > 8 mm dia bar)
– Placed at every 200 mm distance along the width

Part – 2: Rebar

– Rebar's are horizontal stiffeners at every 200 mm or 100 mm centre to centre
– It is 5 mm dia MS bars and work as distribution bar.
– Made up of Fe 415 Grade steel

Part – 3: Connector

– Connects C profile & Rebar.
– It is made up of 1.6 thick Cold Rolled Cold Annealed (CRCA) plates of 120 gm/m^2 zinc coated sheet to prevent rusting
– Works as shear link to connect steel on both face of form work.
– Also helps to avoid bulging of formwork during concrete pouring.

Part – 4: Rib Mesh

– Rib meshes are filtering grids.
– They are made up of 0.42 mm thick high galvanized sheet with 180 GSM to 275 GSM zinc coating used as per geological location to prevent rusting of steel
– It works as reinforcement to plaster to prevent crack generated due to contraction and expansion.
– Also provide good bonding to plaster.

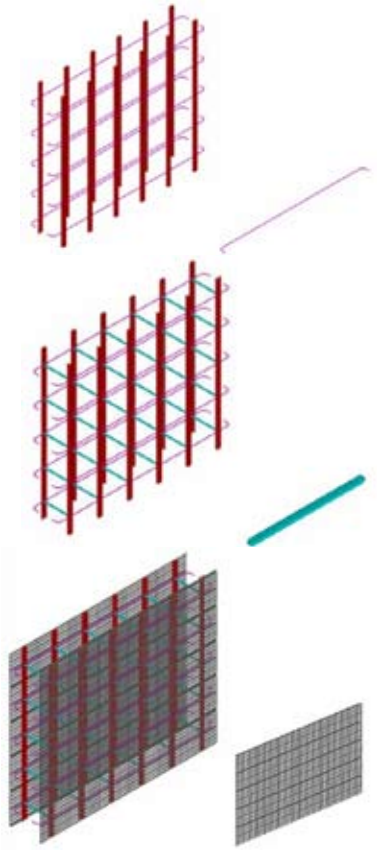
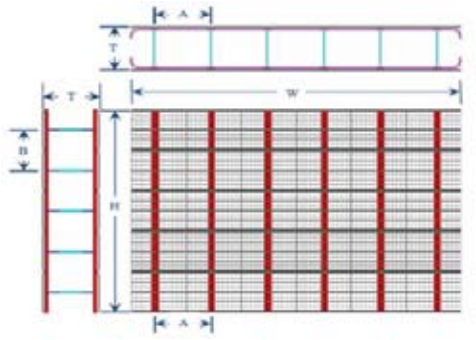


Fig.1

Size and Types of Panels

Panels are normally produced in sizes as given below (See Fig. 2):

Width (W): 300mm, 500mm, 700mm, 900mm & 1100mm
Height (H): 500mm to 5000mm in multiples of 100 mm.
Thickness (T): 100mm, 140mm, 160mm, 200mm & 250mm.
However, customized sizes also be made available on demand.



Panel Type	T mm	A mm	B mm	W mm	H mm
C10	100	200	100, 200	300,	Min.
C14	140	200	100, 200	500,	500
C16	160	200	100, 200	700,	then
C20	200	200	100, 200	900,	in multiples
C25	250	200	100, 200	1100	of 100

Fig.2

Types of panels are given below:

i. Standard single panels – These panels shall be used for slab shuttering but may also be used as shuttering option for RCC wall having thickness of more than 350mm. (Fig. 3)

ii. Double panels – Double panels shall have inbuilt steel and not require extra reinforcement. In double panels, the grids shall be connected by articulated rebar loops and connectors that fold.

These panels are of two types:

(a) Standard double panels shall be of fixed size and need to be cut on site for openings etc.

(b) Customized double panels from the factory shall have required cutting for openings as per drawing and there is no need for cutting on site.

(c) These panels create a monolithic structure as it allows pouring of walls and slab together.

These panels shall be used for load bearing walls, retaining walls and shear walls. (Fig. 4)

iii. Insulated Double panel – These panels shall have an integrated insulation on the exterior side. The insulated material shall be of polystyrene or polyurethane of required thickness as per design.(Fig. 5)

iv. Fiber Cement Double panel – These panels shall have its interior face as fibre cement board which has smooth surface and avoid plastering of walls. (Fig. 6). These panels may be used for water retaining structures.



Fig.3 Standard Single Panel

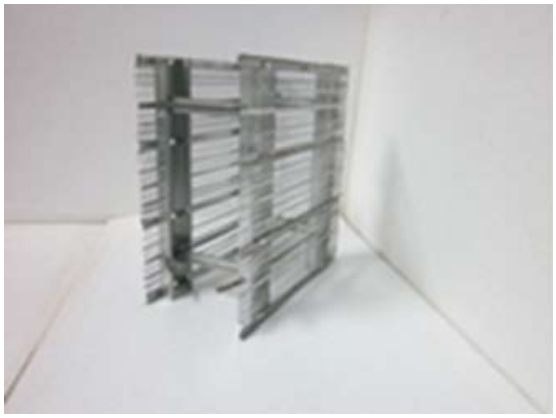


Fig.4 Standard Double Panel

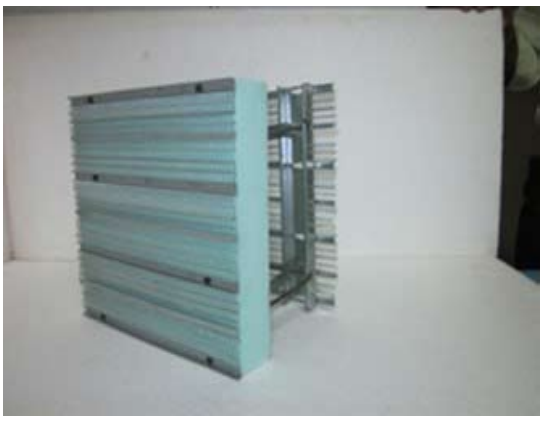


Fig.5 Insulated Panel



Fig.6 Fiber Cement Panel

BASIC STEPS TO CONSTRUCT WITH COFFOR PANELS

Foundation

Strip Footing or normal column and beam structure up to Plinth level based on soil condition.
In case of Strip footing, Coffor panels will start from foundation and on the top of strip concrete raft which increase speed to come out from the ground.

Installation of Panel:

Layout and Blocking

- The alignment shall be traced with chalk on the two sides. Boards/battens shall be nailed on the ground to indicate the positioning of one face of the panels.

Positioning the Panel

- The Structural formwork panels shall be fitted over projecting vertical reinforcing rods. Each panel shall be held vertically with wood pieces (boards/battens) or metal pieces (L-sections/tubes). The minimum length of these bracing elements shall not be less than 1.80m. The panels shall preferably be positioned beginning from the angles and from the doors. Whenever length of the wall does not correspond to a multiple of width of the panels, the last panel shall be cut with a rotary saw to adjust to length of the wall. The horizontal

battens shall be installed on a single side. The verticality shall be checked using a plumb line or level.



- Shuttering of Slab: after completion of Coffor panel installation of the wall, slab shuttering will start either with use of Coffor single panels or normal conventional shuttering for RCC or any other slab.
- Plumbing and Electrification: After installation of slab shuttering, electrical and plumbing conduits can be placed in between panels. For installing the electrical box, panels can be cut with small grinder machine.
- Panel alignment & slab steel needs to be checked & ensured prior to concreting.
- Concrete Pouring: The placing of concrete of specified grade is done in wall and slab in one go with either with Boom placer, stationary pump or manually. As all concreting is done in one go, a monolithic reinforced concrete structure is created.

STRUCTURAL REQUIREMENTS OF THE CONSTRUCTION

The design strategy is to utilize concrete and formwork steel to the ultimate and to provide standard solutions for minimum reinforcement to be used, wherever required, depending on the application and will be determined by structural calculations performed according to the IS 456:2000. In seismic prone areas requiring seismic resistant construction, relevant provisions of IS 875 (Part 1, 2, 4 & 5):1987, IS 875 (Part 3):2015, IS 1893 (Part 1):2016, IS 4326:2013 and IS 13920:2016 shall apply.

Design analysis of the Structural formwork walls, panels, floor slabs etc. shall be done using Staad Pro Software or equivalent. The Optimal result is obtained when walls shall be designed as braced construction elements whose horizontal loads are supported by other bracing elements belonging to the same construction e.g. shear walls. The panels with concrete shall act as “lightly reinforced RCC walls” as per clause 32 of IS 456:2000 and as “prefabricated concrete load bearing walls” as per IS 15916:2010 & IS 15917:2010 & amp; IS 15971:2010.

Structural design and analysis of the formwork shall be based on relevant Indian and International standards. The panel construction assembly shall be used for free standing walls when designed and anchored as cantilever walls. Panels shall be reinforced and tied at vertical joints to maintain alignment. Additional reinforcement and cement plaster shall be provided as required by the design.

The technology is intended for use where Architectural drawings are available. The Architect and Engineer designer team of the concerned developer/owner (client) is responsible for the drawings and overall building design to comply with the various regulatory requirements applicable to the area.

Foundation shall be specifically designed in accordance with provisions given in IS 1904:2005. All foundations should be designed by structural engineer with appropriate reference.

DURABILITY



Since concrete is main constituent material in this system, durability of the structure can be achieved by using proper ingredients, grade of concrete as per IS 456:2000 and mix design in accordance with IS 10262:2009.
Thickness of the wall is minimum 120 mm thick, with 100 mm concrete thickness & 10-12 mm plaster on both sides.

THERMAL BEHAVIOUR OF STRUCTURE

100 mm thick RCC walls and slab has thermal transmittance

(U) value as 3.59 W/m^{2}K) (as per IS 3792:1978). As this system uses 10-12 mm plaster on both sides of the walling unit, the thermal transmittance value is going to be slightly lower than 100 mm thick RCC wall. Further, in G+3/G+4 building units, the panel thickness used is generally 140 mm, which will have still lower thermal transmittance value. However, it is more than the normal plastered 9" brick masonry walls (thermal transmittance (U) 2.13 W/m^{2}K), hence it is advised to ensure proper planning for heat insulation and air ventilation in the housing units through proper orientation, shedding etc. (see IS 3792:1978 for guidance).

ACOUSTIC

Average sound reduction for 100 mm concrete is ≥ 45db (IS 1950:1962), which is reasonable acoustic insulation.

EASE OF SERVICES

All electric and plumbing fixtures, lines have to be pre-planned and placed appropriately before pouring concrete in RC walls & slabs. Post construction alteration is not desirable.

MAIN ADVANTAGES OF THE SYSTEM

- Creates good quality monolithic earthquake resistant structure.
- Ensures significant reduction in construction time, labour requirement, overheads, etc.
- Easy to use system with no need for heavy machinery, Cranes, etc.
- Simplifies the construction process
- No need of skilled labor, the labor can easily be trained in a short span of time
- Maintenance free building as the outer surface having mesh provides good bonding to plaster and helps to prevent cracks, water seepage, etc.

THE APPLICATION OF THE SYSTEM & ITS LIMITATIONS

This sacrificial Formwork System is used for load bearing walls/ retaining walls/shear walls for residential buildings upto G+4 storey, Industrial buildings, Underground Tanks, Water retaining, structures, Storm water drains, Compound walls etc. and as shuttering material for slabs. The limitations of the system are;

- For construction of high rise buildings beyond G+ 4 storeys, extra steel in walls shall be required.
- Post construction alterations are difficult.
- All the service lines are to be pre-planned in advance.

EXECUTION OF PROJECTS

- Coffor France SNC, France for construction of various projects, with total built-up area of approx 17839 sqmt during 2008 -15
- Coffor France SNC, France for construction of Swimming pools, with total built-up area of approx 22770 sqmt during 2008-15
- West Coast Contractors Pvt. Ltd., Vadodra, Gujarat for construction of P+4 apartments, with total built-up area of approx 1596 sqmt during 2012-13
- Sandeep Shah & Associates, Surendranagar, Gujarat for construction of G+4 structure, with total built-up area of approx 1251 sqmt, during 2013-14
- Lubi Pump Pvt. Ltd., Ahmedabad, Gujarat for construction of Retaining wall, with total built-up area of approx 1400 sqmt during 2013-14
- The demonstration housing project under PMAY by BMTPC with 36 DUs (G+2) at Biharsharif, Bihar, 16 DUs (G+3) at Hyderabad, Telangana and 40 DUs with other provisions (G+1) at Agartala, Tripura.

CERTIFICATION

Performance Appraisal Certificate No.: 1035-S/2018 on Structural Stay-in-place Formwork System has been issued to M/s Coffor Construction Technology Pvt. Ltd., Vadodra (Gujarat).

STANDARDS & REFERENCES

IS 456:2000	Code of Practice for plain & reinforced concrete (Reaffirmed 2016)
IS 15916:2010	Code of practice for Building design and erection using prefabricated concrete
IS 15917:2010	Code of practice for Building design and erection using mixed/composite construction (Reaffirmed 2014)
IS 875 (Part 1):1987	Code of practice for design loads (other than earthquake)for buildings and structures part 1 dead loads - unit weights of building material and stored materials (incorporating IS:1911-1967) (Reaffirmed 2013)
IS 875 (Parts 2,4&5):1987 IS 875 (Part 3):2015	Code of practice for design loads (other than earthquake) for buildings and structurres: Imposed Loads, Wind Loads, Snow Loads and Special loads & combinations
IS 1893 (Part 1):2016	Criteria for Earthquake resistance design of structure
IS 10262:2009	Concrete mix proportioning - Guidelines (Reaffirmed 2014)
IS 13920:2016	Code of practice for Ductile detailing of reinforced concrete structures subjected to seismic force
IS 4759:1996	Hot Dip Zinc coating on structural steel products.
Technical Assessment No. 16/10-607 of Coffor Structural Formwork by CSTB, Paris, France	
Structural Evaluation of Prefabricated Concrete Wall System made of Coffor Steel panels comprising tests of Lateral load, Flexural strength and Axial load of the Panels by IIT Bombay	
Project Report of Flexural, Compression, Shear & Deflection tests by Geo Test House, Vadodra	
Quality Assurance Procedure Manual	
Operating Manual giving details of Installation and Execution of the panels	







Stay-In-Place PVC Wall Forms

(Suitable for Low Rise to High Rise Structures)

ABOUT THE SYSTEM

The stay in place PVC wall forms system consists of rigid poly-vinyl chloride (PVC) based polymer components that serve as a permanent stay-in-place durable finished form-work for concrete walls. The extruded components slide and interlock together to create continuous formwork with the two faces of the wall connected together by continuous web members forming hollow rectangular components. The web members are punched with oval-shaped cores to allow easy flow of the poured concrete between the components. The hollow Wall components are erected and filled with concrete, in situ, to provide a monolithic concrete wall with enhanced curing capacity due to water entrapment, as the polymer encasement does not allow the concrete to dry prematurely with only the top surface of the wall being exposed to potential drying. The polymer encasement provides crack control vertically and horizontally for the concrete, and provides vertical tension reinforcement thus increasing the structural strength of the wall. The resulting system is unique and provides substantial advantages in terms of structural strength, durability enhancement, weather resistance, seismic resistance, design flexibility, and ease of construction. Steel dowels are necessary to anchor the wall to the concrete foundation.

This system is adaptable to any building design i.e. residential, commercial, industrial, low and high rise buildings. The system is very efficient in terms of acoustic performance, weather proof and highly resistant to termites attack, and is virtually maintenance free. The polymer components contain up to 55% recycled content and are recyclable. The system has specific advantage to use near coastal areas as durability not affected due to salt-peter action.

SIZE OF PANELS

PVC Wall Forms have been developed in various cross-sectional sizes as per project requirement. The common sizes are 64mm, 126mm, 166mm & 206mm. However available thickness are as follow:

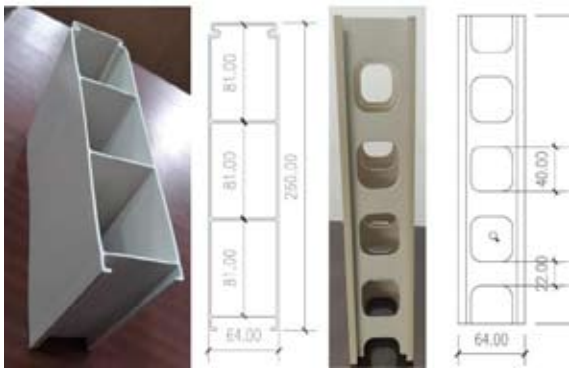
Novel	Wall Thickness	
	Overall (Nominal)	Concrete Core
N64	64 mm	60 mm
N126	126 mm	120 mm

- N64 walls are erected individually and not preassembled, except for headers and sills.
- Pre-assembled walls sections are used for walls over 4300 mm (14') high
- The height of walls made with the Formwork vary according to the requirement.
- N126 walls less than 4300 mm (14') high are erected individually except for walls of unique projects and for headers and sills.

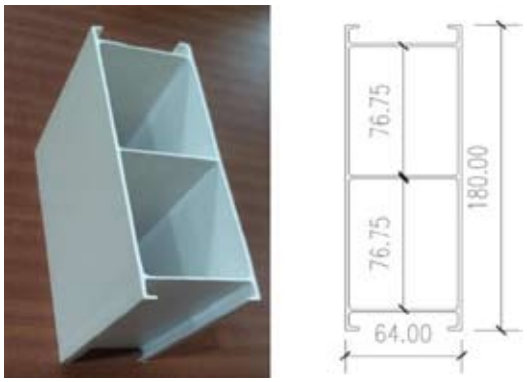
BASIC RAW MATERIAL REQUIREMENTS

- PVC-Resin conforming to IS 9766-2013
- Calcium carbonate ($CaCO_3$) conforming to IS 8767-2014
- Titanium dioxide (TiO_2) conforming to IS 9788-2014
- Polyethylene Wax conforming to ISO 1133-2011
- TMT Steel conforming to IS 1786-2013
- RMC-M20 grade or as per requirement conforming to IS 42926-2017

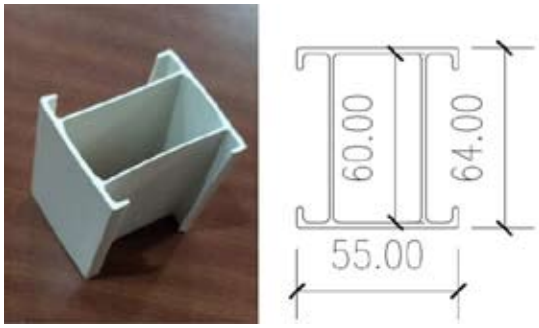
PANEL COMPONENTS



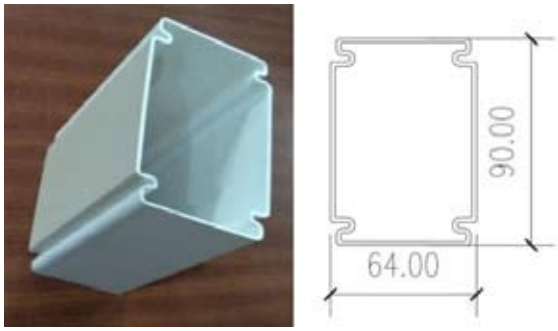
Main Panel – 250 mm



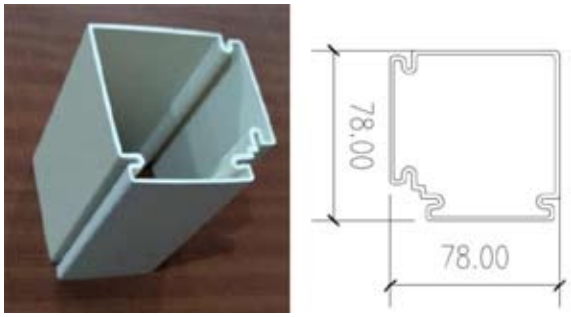
Connector – 158mm



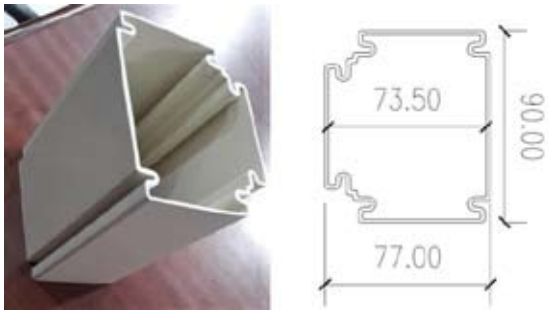
Connector -33mm



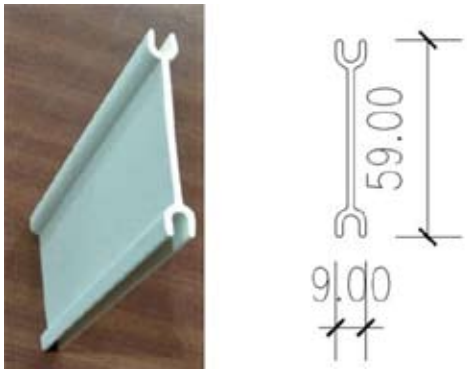
Panel – 91mm



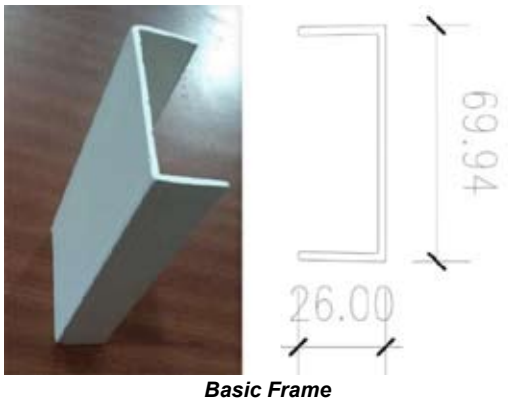
Corner Panel



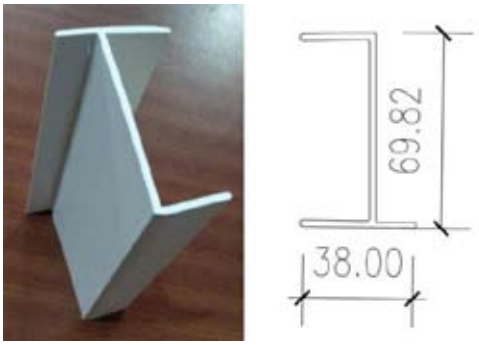
3-WAY (T-Connector)



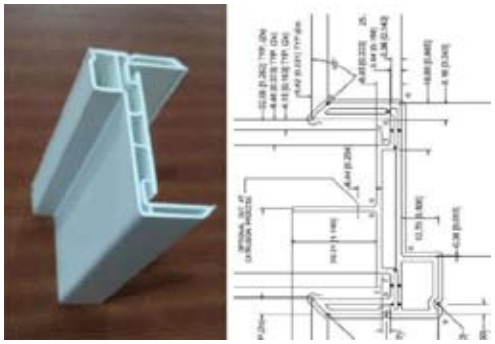
Jointer Connector



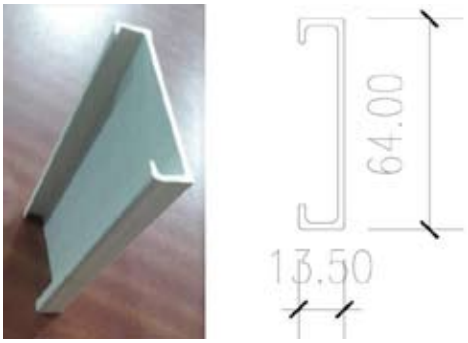
Basic Frame



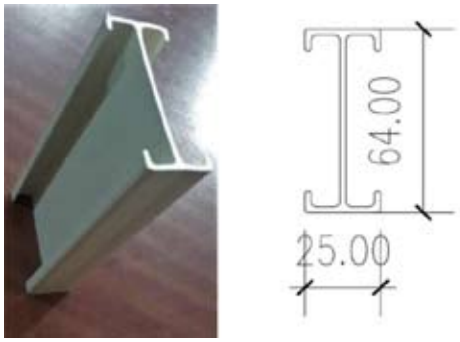
Window Frame



Azteca Frame



Starter



Jointer Panel

MANUFACTURING PROCESS

Extrusion Process

1. PVC Wall Forms components are manufactured from extruded polyvinyl chloride (PVC). The extrusions consist of two layers, the substrate (inner) and Modifier (outer). The two layers are co- extruded during the manufacturing process to create a solid profile. A few of the components are manufactured with a single extrusion of solid Modifier material.
2. The extruder for the substrate material laying horizontally and the extruder for the modifier is on approximately a 45° angle. The two extruders operate concurrently. Each extruder has a separate, individual hopper that is filled with the appropriate material. The raw material is fed into the screw barrels of the extruders. The material is heated in the barrels to molten form where the temperature is electronically controlled. The screws push the molten raw material through the die. The substrate and Modifier are combined in the die, with the Modifier covering the base layer substrate.
3. The extruded profile is run through one or more water-cooled vacuum dies until it hardens and is approximately at room temperature. Then the profile is pulled by a belt-puller and is extended through to a chop saw that is activated by a measuring wheel, which ensures pieces are cut to the correct length.
4. Labeling of the components takes place in the coring, cutting, foaming or assembly areas, whichever is performed last.

Storage

1. Before and after fabrication, the product is stored on carts, pallets or in isolated stacks. The carts, pallets and stacks are tagged with the Sales Order and Bill of Material Number to provide tracking.
2. Material is stored flat and in a manner that prevents distortion and warping of the finished profiles.

Packaging and Shipping

1. Product is normally held for a minimum of 24 hours prior to shipping. Product is packaged in skids, loaded as loose components into trailers or containers, or loaded as assembled sections onto flatbed trucks. Final

inspection is performed during packaging and shipping.
2. Packing materials such as cardboard are used to protect product loaded as loose component.

CONSTRUCTION PROCESS

Erection of panels

1. As per the building plan and design, each wall components shall be cut at the factory using an automated cutting saw.
2. The first course shall be begin with a box connector at a corner or a T-intersection and the two adjacent panels. The corner box connector or three way box connector shall be lifted and guided 100 mm (4”) onto the top of one panel.
3. These two components shall be lifted together to allow the box connector to be joined onto the top of the other panel. The box connector shall be slide down between the two panels and is located over the foundation dowel.
4. The pieces shall be checked to ensure that the correct components are installed and properly oriented and that the coring is aligned.
5. Bracing shall be provided at the top and bottom of the corner or T-intersection assembly and the components are screwed together at the top after the assembly is accurately plumbed.
6. The erection of Novel components shall continue sequentially, in accordance with the Novel layout drawings, including the components for doors, windows and openings.
7. Temporary bracing and steel reinforcing bars shall be installed as the wall erection proceeds.

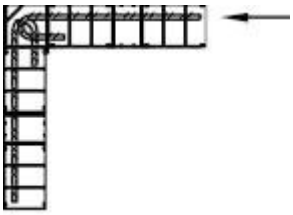
Placing of Reinforcement

Reinforcing steel bars are provided as specified on the structural drawings for the project.

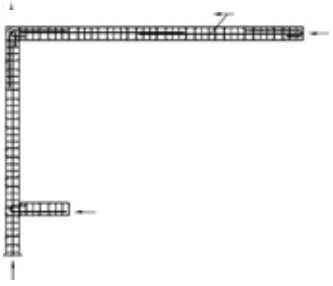
Vertical steel reinforcement (re-bar) required as per design shall be placed in the box connectors or in the cells of the panels at regular intervals to correspond with the design of reinforcement required in the wall. The vertical bars shall be tied to the foundation dowels by lifting the box connectors approximately 12”. This must be done prior to placing the horizontal bars except corners. This will provide solid attachment to footings. The vertical re-bar is most easily put in place full length after the wall assembly is erected and prior to concrete placement.

Horizontal bars shall be installed after the vertical bars are placed through the coring in the Novel components. The recommended length for a horizontal bar is 5500 mm (18’). The horizontal bars shall be installed after each 4667 mm (16’) length of wall is erected. The spacing of performed cores can be adjusted as per structural requirement of spacing of horizontal bars. The horizontal bars shall be lapped with the previous bars, as specified in structural drawings.

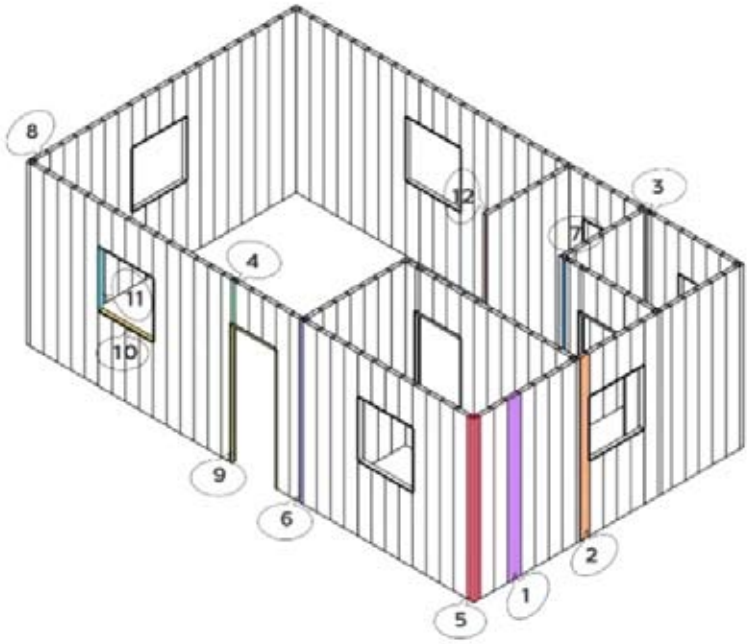
At the first corner, the hooked horizontal bars are installed from both directions.



Horizontal hooked bars are installed at the ends of straight walls prior to installing the next corner and are installed at intersections after erecting a sufficient length of wall.

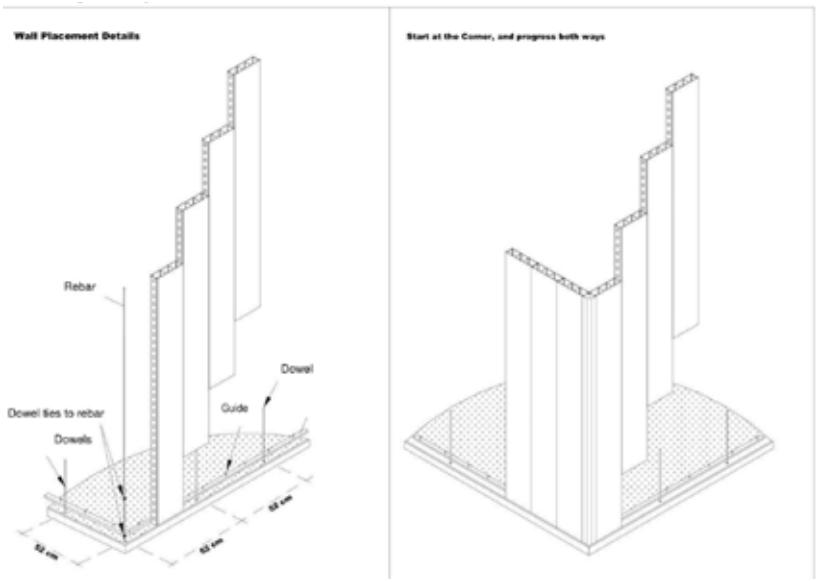


ERECTION DETAILS

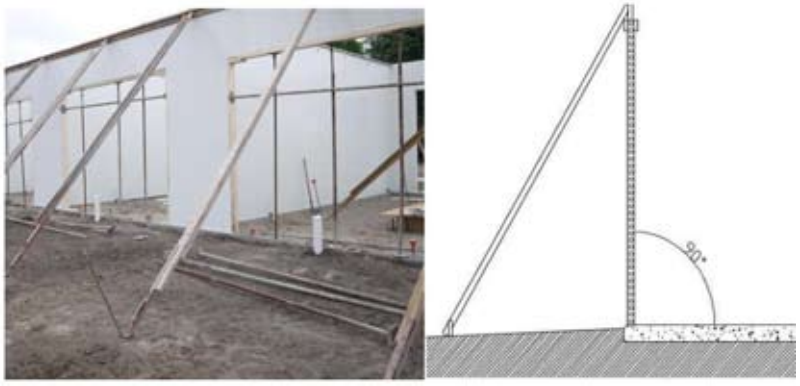


Label	Description
1	Main panel-250mm
2	Connector 158mm
3	Connector-33mm
4	Panel-91mm
5	Corner panel
6	3-way(t-connector)
7	Jointer panel
8	Jointer connector
9	Basic frame
10	Window frame
11	Azteca frame
12	Starter

Walls Erection



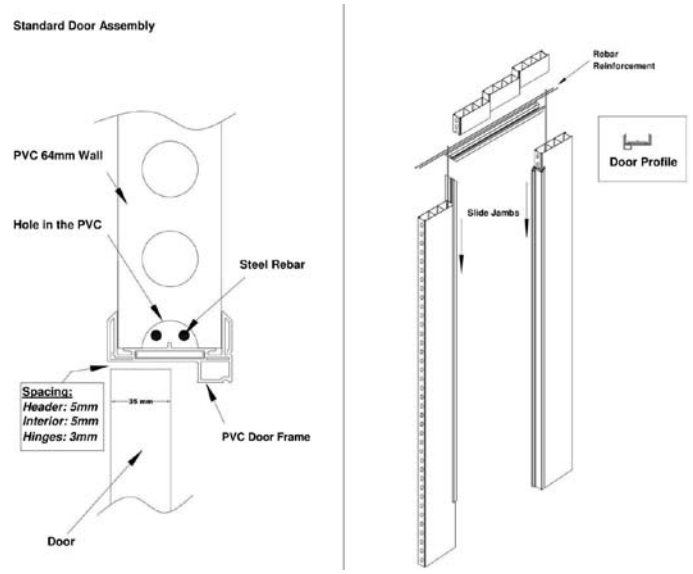
Bracing



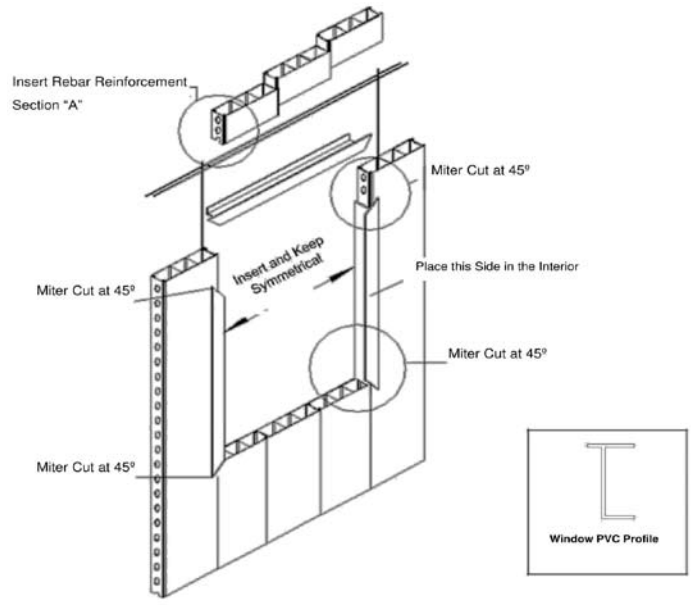
Assembly of Door / Window Frame



Sequence of Door Opening Assembly – Technical etails



Assembly of Window Opening



Concrete Pour

Prior to start concrete pour, the bracing must be re-checked to ensure that all members are properly installed and that the Novel System components are located, aligned and plumbed. The concrete specified shall be highly workable, free flowing mix poured from the top into the cavities using a small hose to go down at least 1.5 to 2m into the cavities for directly pumping the concrete from ready mixed concrete truck. For small building construction, concrete can be poured manually using a funnel. Filling the panels with concrete shall be done in three layers of 1m height with an interval of 1 hour between each layer. There is no need to use vibrator because gravitational pressure acts to self-compact the concrete inside the water tight cavities when self-compacting concrete is used. When normal concrete is used the vibration is provided with flat hand floater at the lower joint of stay form.

Electric and Plumbing Ducts

The electric and plumbing ducts etc. shall be placed inside the ducts. For connectors, small openings shall be made in the expanded metal.

Inspections & Testing

Inspections & testing shall be done at appropriate stages of manufacturing process of all the elements. The inspected panels shall be stored & packed to ensure that no damage occurs during transportation.

ADVANTAGES

The system is unique and provides substantial advantages in terms of structural strength, durability enhancement, weather resistance, seismic resistance, design flexibility, and ease of construction.

The system has specific advantage to use near coastal areas as durability not affected due to salt-peter action.

LIMITATIONS

Limitations for using Novel System on the basis of performance, safety, geo-climatic Conditions:

- Stay in Place PVC Forms Walls shall need preplanned & installed MEP/Services for concealed network.
- Door and Window position shall not be changed after pouring of concrete.
- Erection of panels shall be under supervision of trained staff.

MAJOR COMPLETED / UNDER CONSTRUCTION PROJECTS

- Demo building at Khajaguda, Hyderabad Telangana
- Residential building at Village, Machilipatnam, Distt.- Krishna
- Office building of Kuni Umi Asset Management, Behind Preca Site, Beside E3 Road, Rayapudi Village, Tulluru, Mandalam, Guntur District- AP
- 1040 DUs (G+13) under Light House Project at Lucknow, Uttar Pradesh (under construction).

CERTIFICATION OF THE SYSTEM

Performance Appraisal Certificate No.: 1044-S/2019 has been issued to M/s Novel Assembler Pvt.Ltd, Mumbai.

STANDARDS/ GUIDELINES TO BE REFERRED

IS: 875 (Part-1) -1987 (Reaffirmed 2008)	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures-Unit Weights of Building Materials and Stored Materials.
IS: 875 (Part-2) -1987 (Reaffirmed 2008)	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures-Imposed loads
IS: 875 (Part-3) -1987 (Reaffirmed 2003)	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures –Wind Loads
IS: 875 (Part-5) -1987 (Reaffirmed 2003)	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Special Loads and Load Combinations
IS: 456-2000 (Reaffirmed 2005)	Code of Practice for Plain and Reinforced Concrete
IS: 1893 (Part-1) -2002	Criteria for Earthquake Resistant Design of Structures - Part 1: General Provisions and Buildings
IS: 13920-1993 (Reaffirmed 2008)	Ductile Detailing of reinforced concrete structures subjected to seismic forces –code of practice.
IS 16700-2017	Criteria for structural safety of Tall Concrete Buildings.
IS: 1904–1986 (Reaffirmed 2006)	Code of practice for Design & Construction of foundations in Soils: General Requirements.
IS: 1642-1989 (Reaffirmed 2000)	Code of practice for Fire Safety of Buildings (General): Details of Construction.
IS 2950 (Part 1):1981 (Reaffirmed 2008	Code of Practice for Design & Construction of raft foundation
IS 2974: 1992 (Part 3) (Reaffirmed 2006)	Code of Practice for Design & Construction of machine foundations.
IS 10262:2009	Guidelines for Concrete Mix Proportioning
ASTM C 518:2017	Standard test methods for steady state thermal transmission properties by means of heat flow meter apparatus
ASTM D 638:2014	Standard test methods for tensile properties of plastic
ASTM D 1621	Standard test methods for compressive properties of rigid cellular plastic
ASTM D 1622:2008	Standard test methods for apparent density of rigid cellular plastic
ASTM D 4226:2016	Standard test methods for impact resistance of rigid PVC building products
ASTM E 84:2007	Standard test methods for surface burning characteristics of building materials
ASTME119-2019	Standard test methods of tests of building construction and materials

Permanent Wall Form (PERMAFORM)

(Suitable for Low Rise to High Rise Structures)

ABOUT THE SYSTEM

Permaform is an innovative permanent structural walling system consisting of rigid poly-vinyl chloride (PVC) based polymer components that serve as a permanent durable finished form-work for concrete walls. The extruded components slide and interlock together to create continuous formwork with the two faces of the wall connected together by continuous web members forming hollow rectangular components. The web members are punched with holes to allow easy flow of the poured concrete between the components. Wall components are erected and filled with concrete, in situ, to provide a monolithic concrete wall with enhanced curing capacity due to water entrapment, as the polymer encasement does not allow the concrete to dry prematurely with only the top surface of the wall being exposed to potential drying. The polymer encasement provides crack control vertically and horizontally for the concrete, and provides vertical tension reinforcement thus increasing the structural strength of the wall. The resulting system is unique and provides substantial advantages in terms of structural strength, durability enhancement, weather resistance, seismic resistance, design flexibility, and ease of construction. Steel dowels are necessary to anchor the wall to the concrete foundation.

This system is adaptable to any building design i.e. residential, commercial, industrial, low- and high-rise buildings. Wall is very efficient in terms of acoustic performance, weather proof and highly resistant to termites' attack, and is virtually maintenance free. The system has specific advantage to use near coastal areas as durability not affected due to salt-peter action.

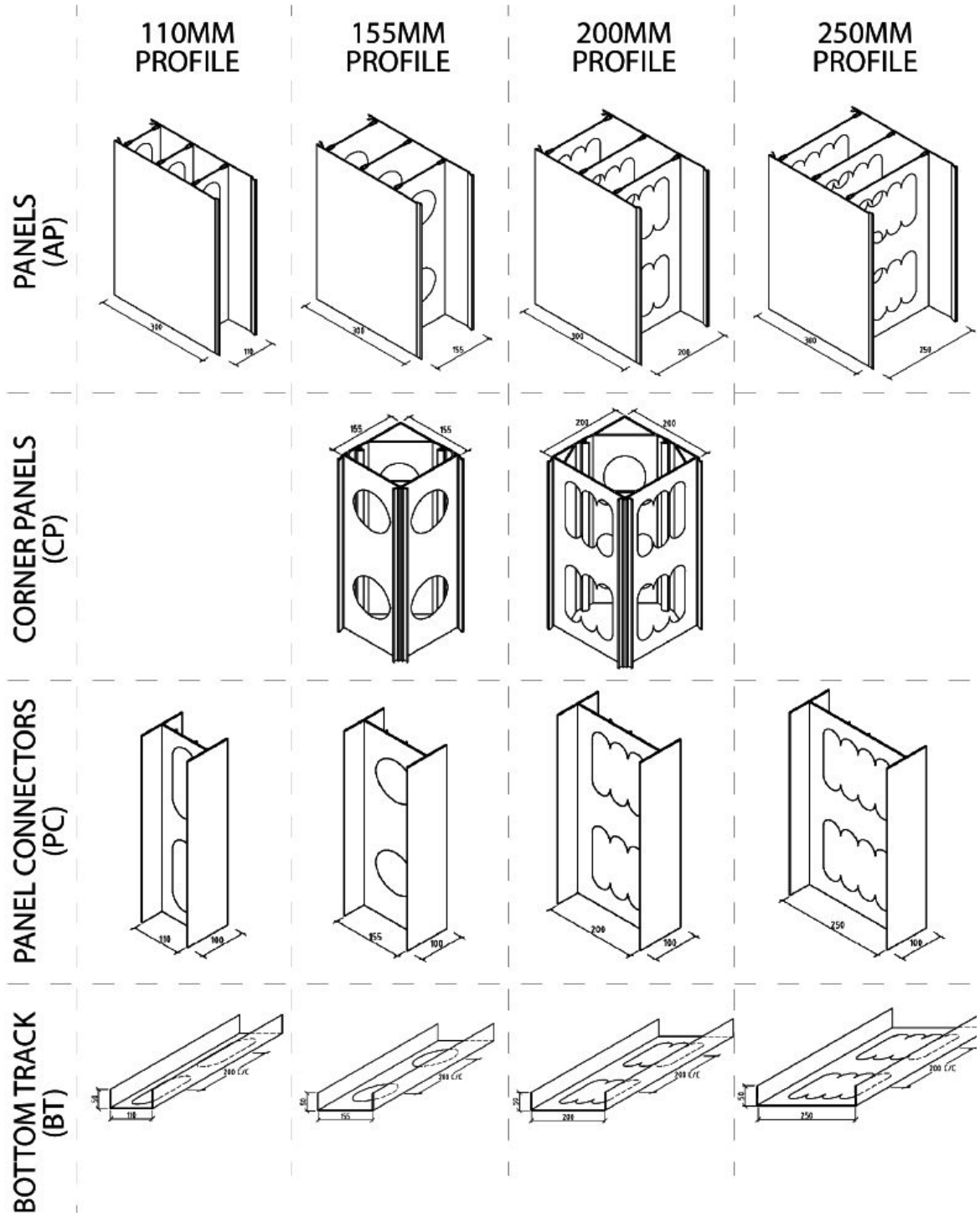


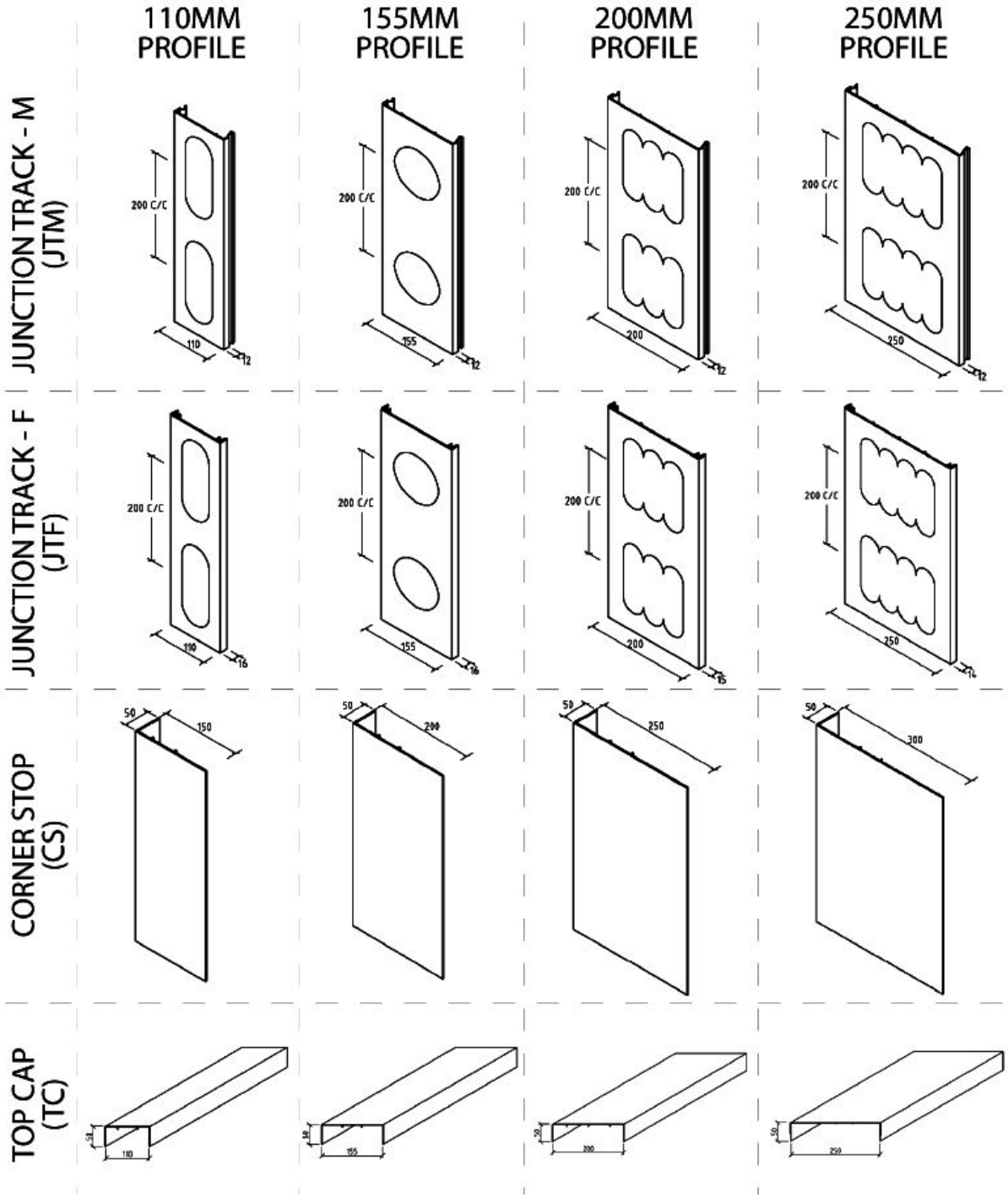


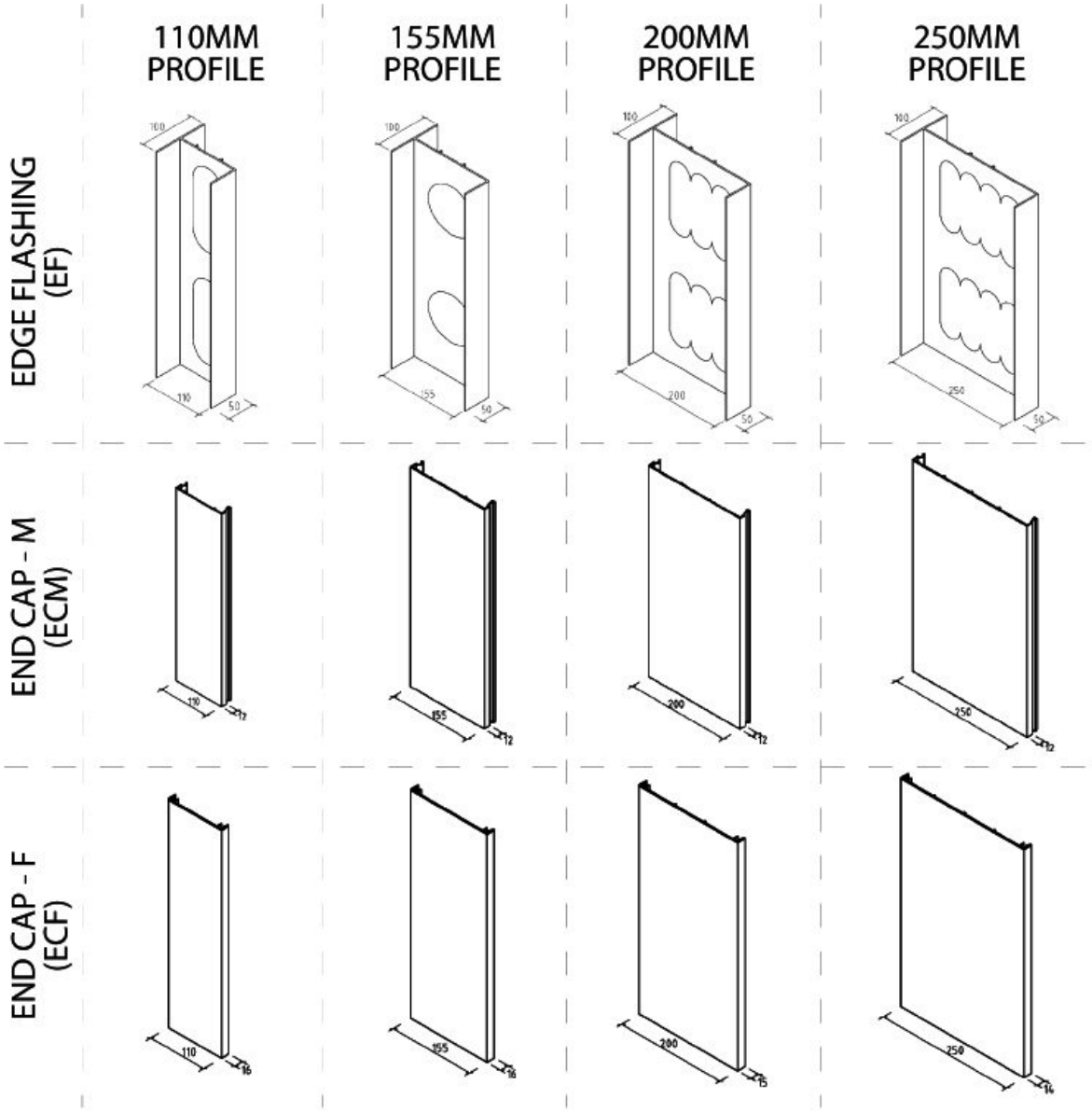
Size of Panels

The Permaform PVC panels are available in various cross-sectional sizes as per project requirement. The common sizes are 110mm, 155mm, 200mm & 250mm. However customized sizes can also be produced on demand.

Panel Components




110MM PROFILE
155MM PROFILE
200MM PROFILE
250MM PROFILE
JUNCTION TRACK - M (JTM)
JUNCTION TRACK - F (JTF)
CORNER STOP (CS)
TOP CAP (TC)
200 C/C
110
155
200
250
12
16
50
150
200
250
300



BASIC RAW MATERIAL REQUIREMENTS

1 PVC-Resin
2. Calcium carbonate (CaCO3)
3. Titanium dioxide (TiO2)
4. Polyethylene Wax

CONSTRUCTION PROCESS

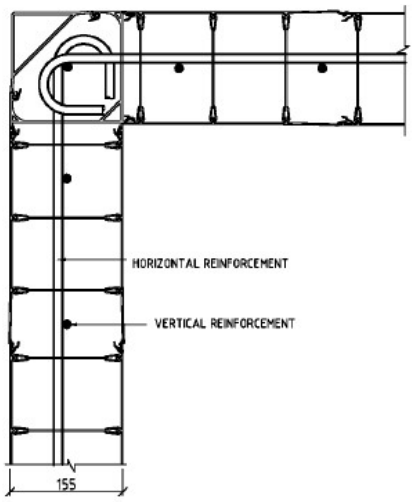
Erection of panels

1. As per the building plan and design, each wall component shall be cut using an automated cutting saw with a fine-tooth blade or grinder fitted with a cutting blade.
2. The Surveyor shall ensure that the walls are clearly and accurately set out. Alignment of bottom track shall be marked and fixed with enough fixtures to ensure the bottom track is securely fastened to the concrete footing or slab.

3. The first course shall begin with a corner piece and the two adjacent panels. The corner piece and adjacent panels needs to be plumbed from adjacent faces.
4. If a panel needs to be cut down to fit within the required dimension (therefore removing a panel anchor), a panel connector shall slide down between the two panels and be secured by screws. It shall be ensured that all the internal rib holes align with each other for the free circulation of concrete through the panels.
5. The pieces shall be checked to ensure that the correct components are installed and properly oriented and that the coring is aligned.
6. Bracing shall be provided at the top and bottom of the corner assembly and the components are screwed together at the top after the assembly is accurately plumbed. Bracing shall be screwed to the panels using one screw per brace ensuring that the screws engaged with the panel face.
7. The erection of Permaform components shall continue sequentially, in accordance with the layout drawings, including the components for doors, windows and openings.
8. Temporary bracing and steel reinforcing bars shall be installed as the wall erection proceeds.
9. A brief checklist of points before pouring of concrete:
    - Metal strip on external wall corners secured by screws to the adjacent panels
    - Aluminum angles on top third of walls
    - Screws on window panels and bottom connectors
    - Sealant on all gaps Bracing for walls at regular intervals
    - Frames for doors and windows
    - 10mm holes on window sill to ensure adequate concrete circulation eliminating voids in the panels

Placing of Reinforcement

1. Reinforcing steel bars are to be provided as specified in the structural drawings for the project.
2. Horizontal bars shall be placed through the coring in the components. The horizontal bars shall be spliced to wall at a maximum of 6m length. Once the next stages of panels are installed, it shall be ensured that the concurrent horizontal bar splices over the first bar as per detailed in drawings. The horizontal bars shall be lapped with the previous bars, as specified in structural drawings.
3. Vertical steel reinforcement (re-bar) required as per design shall be placed within the panel cells created by the diaphragms of the panels at regular intervals to correspond with the design of reinforcement required in the wall. The vertical bars shall be tied to the foundation dowels by lifting the connectors approximately 12” (300 mm). This must be done prior to placing the horizontal bars except corners. This will provide solid attachment to footings. The vertical re-bar is most easily put in place full length after the wall assembly is erected and prior to concrete placement. The top of the vertical bar must be tied to the top horizontal bar securing its location.
4. At the first corner, the hooked horizontal bars are installed from both directions. Horizontal hooked bars are installed at the ends of straight walls prior to installing the next corner and are installed at intersections after erecting a sufficient length of wall.



Concrete Pour

1. Prior to starting concrete pour, the bracing must be re-checked to ensure that all members are properly installed and that the Permaform walling System components are located, aligned and firm.
2. Concrete shall be poured by boom pump with a 50mm dia. end hose. The concrete specified shall be self-compacting, highly workable, free flowing mix poured from the top into the cavities or as detailed. For small building construction, concrete can be poured manually using a funnel.
3. Filling the panels with concrete shall be done as per pour sequence table shown below. The panels will withstand the dynamic bursting pressure of fresh concrete. Extra midway horizontal bracing is required for panels more than 4m in height.

4. When normal concrete is used, then the use of 25mm concrete vibrator may be recommended to achieve full circulation of concrete around congested areas of reinforcement. Gravitational pressure acts to self-compact the concrete inside the water tight cavities when self-compacting concrete is used.
5. It is preferable and recommended to use SCC (Self compacted concrete) at 150mm slump, such that, it flows freely to all the corners. Gravitational pressure acts to self-compact the concrete inside the water tight cavities when self-compacting concrete is used.

WALLS ABOVE GROUND OR BASEMENT INTERNAL WALLS

Wall	110MM WALL			155MM WALL				200MM WALL				250MM WALL			
Hf(m)	1st pour	2nd pour	3rd pour	1st pour	2nd pour	3rd pour	4th pour	1st pour	2nd pour	3rd pour	4th pour	1st pour	2nd pour	3rd pour	4th pour
2.8	1.2	1.6		1.2	1.6			1.2	1.6			1.2	1.6		
3.0	1.2	1.8		1.2	1.8			1.2	1.8			1.2	1.8		
3.3	1.2	2.1		1.2	2.1			1.2	2.1			1.2	2.1		
3.6	1.2	1.2	1.2	1.2	1.2	1.2		1.2	1.2	1.2		1.2	1.2	1.2	
4.0	1.2	1.2	1.6	1.2	1.2	1.6		1.2	1.2	1.6		1.2	1.2	1.6	
5.0				1.2	1.8	2.0		1.2	1.8	2.0		1.2	1.8	2.0	
5.6				1.2	1.2	1.4	1.8	1.2	1.2	1.4	1.8	1.2	1.2	1.4	1.8
6.0				1.2	1.2	1.6	2.0	1.2	1.2	1.6	2.0	1.2	1.2	1.6	2.0
6.6				1.2	1.4	1.8	2.2	1.2	1.4	1.8	2.2	1.2	1.4	1.8	2.2

USE FLOWING SLUMP CONCRETE. ALLOW A MINIMUM OF **45 MINUTES** BETWEEN POURS.
FOR WALLS GREATER THAN 6.6M AND UP TO 8.0M THE FIRST 3 LAYERS FROM THE 6.6M SCHEDULE TO BE ADOPTED

Electric and Plumbing Ducts

The electric and plumbing ducts etc. shall be placed inside the ducts prior to the concrete pour.

MAJOR COMPLETED/UNDER COMPLETION PROJECTS

1 Structure at Vetalpalem village in Guntur District, Andhra Pradesh.
2 Sanotio Apartments, Client:Allied Construction, 75-77, West Gosford, NSW, (5 storeys, 41 residences+ basement)
3 Melrose Park, Client: Dasco, 661, Victoria (6500 units)
4 Lyons Road, Client:Momento projects, 197-199, Lyons Road, Drummoynee, NSW, (15 residences + retail)
5 K Apartments, Client:Raw Constructions, 218, Railway PDE, Kograh, NSW, (9 storeys + basement, 45 residences)
6 Fleet Lane, Client:RGD, 25-27, Hope Street, South Brisbane, QLD, (66 residences, 10 storeys + 2 basements)
7 The Governor, Client:RGD, 44 Brookes Street, Bowens Hill, QLD, (40 residences + retail, 12 storeys + 2 basements)
8 The Jade, Client:Monarch, 14 storeys + 3 basements, (172 residences + 5 commercial tenancies)
9 Thornton, Client:Urban Property Group, 314 apartments
10 Arbor Apartments, Client:RGD, 13 Railway Terrace, Milton QLD, (70 residences, 15 storeys + 3 levels basement)

CERTIFICATION OF THE SYSTEM

Performance Appraisal Certificate No. 1050-S/2020 has been issued to M/s Kalzen Realty Pvt.Ltd., Hyderabad.

STANDARDS/GUIDELINES TO BE REFERRED

IS: 875 (Part-1) -1987 (Reaffirmed 2008)	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures-Unit Weights of Building Materials and Stored Materials.
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IS: 875 (Part-3) -1987 (Reaffirmed 2003)	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures –Wind Loads
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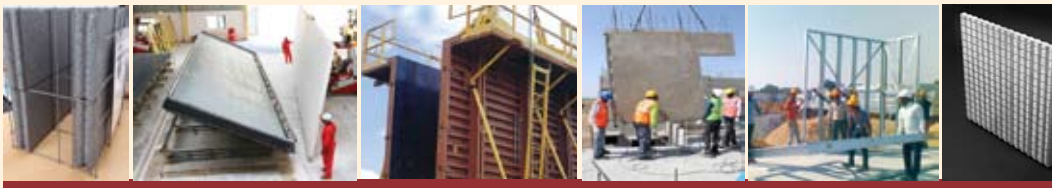
ASTM D 638:2014	Standard test methods for tensile properties of plastic
ASTM D 1621	Standard test methods for compressive properties of rigid cellular plastic
ASTM D 1622:2008	Standard test methods for apparent density of rigid cellular plastic
ASTM D 4226:2016	Standard test methods for impact resistance of rigid PVC building products
ASTM E 84:2007	Standard test methods for surface burning characteristics of building materials
ASTME119-2019	Standard test methods of tests of building construction and materials





APPENDICES

महानिदेशालय, के.लो.नि.वि.
महा.नि./दि.द.अनु./11
निर्माण भवन, नई दिल्ली–110011
कार्यालय ज्ञापन

निर्माण भवन, नई दिल्ली

दिनांक /11/2022

Sub:-Correction Slip No. 11 to DSR-2021 Vol-2 under SH- 26 New Technologies and Materials

The following new items are approved for inclusion in DSR -2021 Vol-2

S.No	Existing Provision	Modified Provision			
		Code No	Description	Unit	Rate ₹
		SH:00 Basic Rates			
1		8996	125 mm / 165 mm wide Stay in Place Wallform 2.50 mm thick of extruded Unplasticised Poly Vinyl Chloride (uPVC).	kg	145.00
		SH:26 New Technologies and Materials			
	New item	26.96	Providing and placing "Stay in Place PVC Wall formwork" made up of extruded Unplasticised Poly Vinyl Chloride (uPVC) consisting of Main panel, 3 way Connector, Starter Channel, Joint Panel, Connection Panels, Door/Window frame/trim panels etc. all complete as per manufacturer design and for all heights as per direction of Engineer-in-charge. (Note: Suitable for in fill walls with appropriate Structural system).		
2		26.96.1	125 mm wide Stay in Place PVC Wallform made of minimum 2.50 mm thick sections and minimum weight 21.97 kg /sqm of formwork.	sqm	2491.60
3		26.96.2	165 mm wide Stay in Place PVC Wallform made of minimum 2.50 mm thick sections and minimum weight 29.00 kg /sqm of formwork.	sqm	3240.75

CIESH.

AE (THS)

यह ज्ञापन सक्षम अधिकारी के अनुमोदन से जारी किया जाता है ।

(एस. एन. जायसवाल) 25-11-2022
(कार्यपालक अभियंता टास)
सी.एस.क्यू. के.लो.नि.वि., निर्माण भवन,
नई दिल्ली

फाईल सं0 133/अधी अभि (टास)/दि.द.अनु/2021/ 477-हि०
ई फाईल 9139313

दिनांक 25/11/2022

प्रतिलिपि : के0 लो0 नि0 वि0 की वेबसाइट http://cpwd.gov.in द्वारा सभी विषेश महानिदेशक/अपर महानिदेशक/मुंख्य अभियन्ता/अधी0 अभि0/कार्य0 अभि0 एवं लो0नि0वि0, दिल्ली।

C.E.SH.

AE (THS)

(कार्यपालक अभियंता टास) 25/11/2022

महानिदेशालय, के.लो.नि.वि.
महा.नि./दि.व.वि./12
निर्माण भवन, नई दिल्ली–110011

कार्यालय ज्ञापन

निर्माण भवन, नई दिल्ली दिनांक /11/2022

Sub:-Correction Slip No. 12 to DAR-2021 Vol-2 under SH- 26 New Technologies and Materials .

The following item are approved for inclusion in DAR-2021 (Vol-2)

S. No.	Existing Provision	Modified Provision						
		26.96	**Providing and placing "Stay in Place PVC Wall formwork" made up of extruded Unplasticised Poly Vinyl Chloride (uPVC) consisting of Main panel, 3 way Connector, Starter Channel, Joint Panel, Connection Panels, Door/Window frame/trim panels etc. all complete as per manufacturer design and for all heights as per direction of Engineer-in-charge.** **(Note: Suitable for in fill walls with appropriate Structural system).**					
1		26.96.1	125 mm wide Stay in Place PVC Wallform made of minimum 2.50 mm thick sections and minimum weight 21.97 kg /sqm of formwork.					
		Code	Description	Qty	Unit	Rate	Amount	
			Detail of cost for 20 sqm surface area					
			MATERIAL					
		8996	125 mm wide Stay in Place Wallform 2.50 mm thick of extruded Unplasticised Poly Vinyl Chloride (uPVC).					
	New item		Cost of Raw Materials for 20/2 = 10 sqm of 125 mm Wallforms @21.97 kg/sqm = 219.70 kg + 5% wastage (10.98 kg) = 230.68 kg	230.68	kg	145.00	33448.60	
		9999	Transportation Charges	610.38	L.S.	2.12	1294.01	
			Labour for Installation					
		0123	Mason 1st Class	1.00	day	784.00	784.00	
		0115	Beldar	2.50	day	645.00	1612.50	
		9999	Sundries	50.00	L.S.	2.12	106.00	
			TOTAL				**37245.11**	W
			Add 1% Water charges on "W"				372.45	
			TOTAL				37617.56	X
			Add GST on "X" (multiplying factor 0.1405)				5285.27	
			TOTAL				42902.82	Y
			Add 15% CPOH on "Y"				6435.42	
			TOTAL				49338.25	Z
			Add Cess @ 1% on "Z"				493.38	
			Cost of 20 sqm				49831.63	
			Cost for 1 sqm				2491.58	
			Say				2491.60	

C. Estt.

AE (TMS)

2							
	26.96.2	165 mm wide Stay in Place PVC Wallform made of minimum 2.50 mm thick sections and minimum weight 29.00 kg /sqm of formwork.					
	Code	**Description**	**Qty**	**Unit**	**Rate**	**Amount**	
		Detail of cost for 20 sqm (165 mm wide Stay in Place (PVC) wall forms)					
		MATERIAL					
	8996	165 mm wide Stay in Place Wallform 2.50 mm thick of extruded Unplasticised Poly Vinyl Chloride (uPVC).					
		Cost of Raw Materials for 20/2 = 10 sqm of 165 mm Wallforms @29.00 kg/sqm 290.00 kg + 5% wastage (14.50 kg) = 304.50 kg	304.50	kg	145.00	44152.50	
	9999	Transportation Charges	684.90	L.S.	2.12	1451.99	
		Labour for Installation					
	0123	Mason 1st Class	1.00	day	784.00	784.00	
	0115	Beldar	3.00	day	645.00	1935.00	
	9999	Sundries	50.00	L.S.	2.12	106.00	
		TOTAL				**48429.49**	W
		Add 1% Water charges on "W"				484.29	
		TOTAL				48913.78	X
		Add GST on "X" (multiplying factor 0.1405)				6872.39	
		TOTAL				55786.17	Y
		Add 15% CPOH on "Y"				8367.93	
		TOTAL				64154.09	Z
		Add Cess @ 1% on "Z"				641.54	
		Cost of 20 sqm				64795.64	
		Cost for 1 sqm				3239.78	
		Say				3240.75	

यह ज्ञापन सक्षम अधिकारी के अनुमोदन से जारी किया जाता है।

(एस. एन. जायसवाल) 25/11/2022
कार्यपालक अभियंता (टास)
सी.एस.एम्.टी., के.लो.नि.वि. नई दिल्ली

फाईल सं0 133/अधी अभि. (टास)/दि.द.वि/2021/ 478-हि०

दिनांक 25/11/2022

ई फाईल:9139313

प्रतिलिपि : सभी विशेष महानिदेशक/अपर महानिदेशक/मुख्य अभियन्ता/मुख्य परियोजना प्रबन्धक/परियोजना प्रबन्धक को के0 लो0 नि0 वि0 की वेबसाइट http://cpwd.gov.in के द्वारा.

C. Exch.

AE(TAS)

कार्यपालक अभियंता (टास) 25/11/2022

Appendix - 2

महानिदेशालय, के.लो.नि.वि.
महा.नि./दि.द.अनु./10
निर्माण भवन, नई दिल्ली–110011
कार्यालय ज्ञापन

निर्माण भवन, नई दिल्ली

दिनांक 02/11/2022

Sub:-Correction Slip No.10 to DSR-2021 Vol-2 under SH- 26 New Technologies and Materials

The following new items are approved for inclusion in DSR -2021 Vol-2

S.No	Existing Provision	Modified Provision			
		Code No	Description	Unit	Rate ₹
		SH:00 Basic Rates			
1		8991	Standard double panel of design width, height and thickness with minimum weight of panel as 11.05 kg per sqm	sqm	1883.00
2		8992	Corner pieces L-Shape	sqm	739.00
3		8993	Flat strips for soffits	sqm	756.00
4		8994	G.I binding wire	kg	60.00
5		8995	Single panel (Weight not less than 4.05 kg/sqm)	sqm	756.00
		SH:26 New Technologies and Materials			
	New item	26.95	Providing and installation of factory made Structural Stay in place' form work system with double faced panels for walls, single faced panels for roof / floor slabs, L-shaped single faced panels for corners, with necessary scaffolding, struts, bracing etc. Complete as per CPWD specification and directions of the Engineer in Charge. Design of walls and other members to be provided by the supplier & shall be duly vetted by any engineering institute of National repute such as IITs NITs etc. and nothing extra shall be payable on this account (Additional steel reinforcement/dowels, design mix concrete of specified grade, electrical and plumbing conduits insert for services and plastering on either side of walls shall be paid for separately).		
			Note:- This item shall be adopted for building upto G+3 Storeys only excluding seismic zone V.		
6		26.95.1	Double panel of required thickness (110mm & above) with minimum weight of panel as 11.05 kg per sqm for walls with corresponding corners and jambs strips.	sqm	2721.75
7		26.95.2	Single panel for slabs with minimum weight of panel as 4.05 kg/sqm for walls with corresponding corners and jambs strips.	sqm	1463.35

This correction slip No. 10 issued vide OM No. 133/अधी अभि (टास)/दि.द.अनु/2021/394 **दिनांक** 23.09.2022 **is supersede by this OM**

(AP HECTAS)

यह ज्ञापन सक्षम अधिकारी के अनुमोदन से जारी किया जाता है ।

(इं. सी एस आजाद)
(कार्यपालक अभियंता टास)
सी.एस.क्यू., के.लो.नि.वि., निर्माण भवन,
नई दिल्ली

फाईल सं0 133/अधी अभि (टास)/दि.द.अनु/2021/ 01-E
ई फाईल 9113663

दिनांक 02/11/2022

प्रतिलिपि : के0 लो0 नि0 वि0 की वेबसाइट http://cpwd.gov.in द्वारा सभी विषेश महानिदेशक/अपर महानिदेशक/मुंख्य अभियन्ता/अधी0 अभि0/कार्य0 अभि0 एवं लो0नि0वि0, दिल्ली।

(कार्यपालक अभियंता टास)

महानिदेशालय, के.लो.नि.वि.
महा.नि./दि.द.वि./11
निर्माण भवन, नई दिल्ली–**110011**

कार्यालय ज्ञापन

निर्माण भवन, नई दिल्ली

दिनांक 02/11/2022

Sub:-Correction Slip No. 11 to DAR-2021 Vol-2 under SH- 26 New Technologies and Materials .

The following item are approved for inclusion in DAR-2021 (Vol-2)

S. No.	Existing Provision	Modified Provision						
		26.95	Providing and installation of factory made Structural Stay in place' form work system with double faced panels for walls, single faced panels for roof/ floor slabs, L-shaped single faced panels for corners, with necessary scaffolding, struts, bracing etc. Complete as per CPWD specification and directions of the Engineer in Charge. Design of walls and other members to be provided by the supplier & shall be duly vetted by any engineering institute of National repute such as IITs NITs etc. and nothing extra shall be payable on this account (Additional steel reinforcement/dowels, design mix concrete of specified grade, electrical and plumbing conduits insert for services and plastering on either side of walls shall be paid for separately).					
			Note:- This item shall be adopted for building upto G+3 Storeys only excluding seismic zone V.					
1		26.95.1	**Double panel of required thickness (110mm & above) with minimum weight of panel as 11.05 kg** per sqm for walls with corresponding corners and jambs strips.					
		Code	**Description**	**Unit**	**Quantity**	**Rate**	**Amount**	
			Details of cost for 450 sqm					
			MATERIALS					
		8991	Standard double panel of design width, height and thickness	sqm	440.00	1883.00	828520.00	
		8992	Corner pieces L-Shape	sqm	10.00	739.00	7390.00	
		8993	Flat strips for soffits (L.S.)	sqm	20.00	756.00	15120.00	
		9999	Transportation of panel	L.S.	2122.64	2.12	4500.00	
			Assuming Strengthening of panels material (structs,bracis and propes) will become unserviceable after use of 40 times, adding for maintenance @ 10% of cost, taking salvage value after full use of material @ 25% cost.					
		9999	For diagonal Bracing on outer face 60mm dia M.S Pipe (5 to 6 mtr long) = 600 meter @ 5.54 kg/m = **3324 kg** 50mm dia, M.S pipes for shorter length outer bracing and internal bracing. = 650 meter @ 3.96 kg/m = **2574 kg.** Total Weight = **5898 kg** 5898 kg @ Rs. 60 per kg (code No. 4009) = 353880/- Add maint. @ 10% = 35388/- Total = 389268/- Less Salvage @ 25% (-) = 97317/ Cost of using 40 times Rs. **= 291951/-** Cost of using Once = **7298.78** Say = **Rs.7299/-**	L.S.	3442.92	2.12	7299.00	

8724	12 mm thick marine plywood	sqm	12.00	720.00	8640.00	
8994	G.I binding wire	Kg	25.00	60.00	1500.00	
1219	Nails 75 mm	Kg	15.00	58.00	870.00	
	LABOUR					
0116	Fitter (Grade-I)	Day	20.00	784.00	15680.00	
0114	Beldar	Day	40.00	645.00	25800.00	
9999	Sundries	L.S	54.24	2.12	114.99	
	TOTAL				915433.99	
	Add 1% water charges				9154.34	
	TOTAL				924588.33	w
	Add GST on "X" (multiplying factor 0.1405)				129904.66	
	TOTAL				1054492.99	x
	Add 15% CPOH on "Y"				158173.95	
	TOTAL				1212666.94	y
	Add Labour Cess @ 1% on "Z"				12126.67	
	Cost for 450 sqm				1224793.61	z
	Cost of 1 sqm				2721.76	
	Say				2721.75	

26.95.2	**Single panel for slabs with minimum weight of panel as 4.05 kg/sqm for walls with corresponding corners and jambs strips.**					
Code	**Description**	**Unit**	**Quantity**	**Rate**	**Amount**	
	Details of cost for 15 sqm					
	MATERIALS					
8995	Single panel (Weight not less than 4.05 kg/sqm)	Sqm	15.00	756.00	11340.00	
9999	Transportation of panel	L.S.	35.30	2.12	74.84	
8724	12 mm thick marine plywood	Sqm	3.25	720.00	2340.00	
	Assuming Strengthening of panels material (structs,bracis and propes) will become unserviceable after use of 40 times, adding for maintenance @ 10% of cost, taking salvage value after full use of material @ 25% cost.					
	Telescopping to support horizantel single panel stey in place form work for slabs 3 mtr long adjustable telescopic propes = 36 Nos. @ Rs. 955 each (Code No. 7343) = 34380/- Add maint. @ 10% = 3438/- Total = 37818/- Less Salvage @ 25% (-) = 9455/- Cost of using 40 times Rs. = 28363/- Cost of using Once = 709.08/- Say **Rs. 709.10/-**					
9999		L.S.	334.48	2.12	709.10	
8994	G.I binding wire	Kg	1.50	60.00	90.00	
1219	Nails 75 mm	Kg	1.50	58.00	87.00	
	LABOUR					
0116	Fitter (Grade-I)	Day	1.20	784.00	940.80	
0114	Beldar	Day	1.20	645.00	774.00	
9999	Sundries	L.S	23.59	2.12	50.01	
	TOTAL				16405.75	w

2

New item

Use
AE(T&S)

	Add 1% water charges				164.06	
	TOTAL				16569.81	X
	Add GST on "X" (multiplying factor 0.1405)				2328.06	
	TOTAL				18897.87	Y
	Add 15% CPOH on "Y"				2834.68	
	TOTAL				21732.55	Z
	Add Labour Cess @ 1% on "Z"				217.33	
	Cost of 15 sqm				21949.88	
	Cost of 1 sqm				1463.33	
	Say				1463.35	

This correction slip No. 11 issued vide OM No. 133/अधी अभि (टास)/दि.द.वि/2021/395 दिनांक 26.09.2022 is supersede by this OM

यह ज्ञापन सक्षम अधिकारी के अनुमोदन से जारी किया जाता है।

(ई सी एस आजाद)
कार्यपालक अभियंता (टास)
सी.एस.क्यू. के.लो.नि.वि. नई दिल्ली

02/11/22
AE(TAS)

फाईल सं0 133/अधी अभि. (टास)/दि.द.वि/2021/ 02-E

दिनांक 02/11/2022

ई फाईल 9113663

प्रतिलिपि : सभी विशेष महानिदेशक/अपर महानिदेशक/मंडल अभियन्ता/मुख्य परियोजना प्रबन्धक/परियोजना प्रबन्धक को के0 लो0 नि0 वि0 की वेबसाइट http://cpwd.gov.in के द्वारा

कार्यपालक अभियंता (टास)

Appendix - 3

महानिदेशालय, के.लो.नि.वि.
महा. नि./दि.द.अनु/04
निर्माण भवन, नई दिल्ली–110011

कार्यालय ज्ञापन

Sub:- In corporation of New technology item Delhi Schedule Rate 2021.

The following new items for providing "Tunnel Formwork System" for wall panel and Floor/Roof panels are proposed for inclusion in DSR -2021 under SH:- 26 (New Technologies and Materials).

Code No	Description	Unit	Rate (in Rs)
26.94	Designing, shop fabricating, supplying , erecting, stripping and shifting of customized Modular Tunnel Formwork system for cast-in-situ monolithic RCC structures, using precision steel cubical formworks are molds with minimum 3mm thick **hot rolled plain painted/hot dip galvanized M.S. sheets** for panel in contact area with necessary framing and allied accessories as per CPWD specificationsincluding transporting, storage, assembly, hoisting and placing in position for supporting and holding the formwork in place till initial setting of the concrete then stripping the formwork, propping to support horizontal surface cleaning and oiling etc. for shifting to the next cycle, inclusive of all labour, machines and T&P requirements taking all safety measures etc. as per design and cycle programme all complete as per directions of the Engineer-in-Charge. Design of Tunnel Formwork system shall be provided by concerned service provider/vendor and the rate is inclusive of all the elements and all operations for all heights.	sqm	232.00

यह ज्ञापन सक्षम अधिकारी के अनुमोदन से जारी किया जाता है।

(इं. सी. एस. आजाद)
कार्यपालक अभियंता (टास–II)
सी.एस.क्यू. के.लो.नि.वि. नई दिल्ली

फाईल सं0 133/अधी अभि. (टास)/दि.द.अनु./2022/263-150 दिनांक 27/06/2022

प्रतिलिपि : सभी विषेश महानिदेशक/अपर महानिदेशक/मंख्य अभियन्ता/मुख्य परियोजना प्रबन्धक/परियोजना प्रबन्धक को के0 लो0 नि0 वि0 की वेबसाइट http://cpwd.gov.in के द्वारा.

कार्यपालक अभियंता (टास–II)

महानिदेशालय, के.लो.नि.वि.
महा.नि./दि.द.वि/05
निर्माणभवन, नई दिल्ली–110011

कार्यालय ज्ञापन

Sub:- In corporation of New technology item Delhi Analysis Rate 2021.

The following new items for providing "Tunnel Formwork System" for wall panel and Floor/Roof panels are proposed for inclusion in DAR -2021 under SH:- 26 (New Technologies and Materials).

26.94	Designing, shop fabricating, supplying , erecting, stripping and shifting of customized Modular Tunnel Formwork system for cast-in-situ monolithic RCC structures, using precision steel cubical formworks are molds with minimum 3mm thick **hot rolled plain painted/hot dip galvanized M.S. sheets** for panel in contact area with necessary framing and allied accessories as per CPWD specificationsincluding transporting, storage, assembly, hoisting and placing in position for supporting and holding the formwork in place till initial setting of the concrete then stripping the formwork, propping to support horizontal surface cleaning and oiling etc. for shifting to the next cycle, inclusive of all labour, machines and T&P requirements taking all safety measures etc. as per design and cycle programme all complete as per directions of the Engineer-in-Charge. Design of Tunnel Formwork system shall be provided by concerned service provider/vendor and the rate is inclusive of all the elements and all operations for all heights.					
Code	**Description**	**Quantity**	**Unit**	**Rate**	**Amount**	
	Details of cost for 530 sqm (Total contact area) Horizontal (plan/floor area) = 124 sqm Vertical (Walls area)= 406 sqm Accessories include vertical support, slant support, tunnel lifting equipment, wallstopper, slab stopper, starter caster, doors/ window boxout, tie road, safety platforms brackets and anchors, inner safety & working platform, outer safety & working platform					
	MATERIALS: Horizontal Panels 124 sqm @ 90 kg/ sqm = **11160 kg** Vertical Panels 406 sqm @ 135 kg/ sqm = 54810 kg = **65970 kg** Additional steel for accessories @ 20% = 13194 kg = **79164 kg** Add 5% wastage = 3958 kg = **83122 kg**	83122.00	kg	77.50	6441955.00	(a)
	Painting with synthetic enamel paint over priming coat with red oxide primer on the opposite side of contact area and accessories of tunnel foam work system = 875 sqm {(530 sqm + 65% of 530 sqm for framing & accessories) = 530 + 345 = 875 sqm say 875 sqm)} Rate as per item 13.50.3 + 13.61.1 excluding W.C. , GST , CP & OH and Labour Cess (414.94 + 962.61 = 1377.55/10 = 137.75)	875.00	sqm	137.75	120531.25	(b)
	Designing, Fabrication and transportation cost on 79164 kg	79164.00	kg	50	3958200.00	(c)
	Total formwork and accessories cost				10520686.25	

	Add maintenance charges @ 5% on net cost of formwork and assuming fabrication cost being 60% of b i.e. 60% of 3958200 = 2374920 therefore 5% of 8908203.25 (6441955 + 2374920 + 91328.25) = 445410.16				445410.16	(d)
	Add salvage value at the rate of Rs. 25/kg on (b)	79164.00	kg	20	-1583280.00	
7343	Adjustable telescopic Props 3 mtr for supporting slab area after removal of tunnel form (7x36=252) = 252 Nos	252.00	each	955	240660.00	
	Net cost for 150 repetitions				9623476.41	
	Cost for using once				64156.51	(A)
	Labour :					
,0160	Supervisor/technician	1.00	day	833.00	833.00	
,0116	Skilled fitter	4.00	day	784.00	3136.00	
,0114	Helpers/beldar	16.00	day	645.00	10320.00	
	Hire charges for crane (upto 40 tonne capacity)	1.00	day	9600.00	9600.00	
5773	Shuttering Oil (@ 20 sqm per litre for 530 sqm =26.50 litre)	26.50	litre	90.00	2385.00	
Sub-AR	Add for GP2 compound for tie rod holes found out of conical concrete pegs @ 1 hole/sqm of wall area i.e. 406.5 / 2 =203.25 Say 204	204.00	each	8.00	1632.00	
					92062.51	(W)
	Add 1% water charges				920.63	
					92983.13	(X)
	Add GST @ 12% (0.1405)				13064.13	
					106047.26	(Y)
	Add CPOH @ 15%				15907.09	
					121954.35	(Z)
	Add 1% LWC				1219.54	
	Total cost for 530 sqm				123173.90	
					232.40	
	Say				**232.00**	

सक्षम अधिकारी के अनुमोदन से जारी किया जाता है।

(इं. सी. एस. आजाद)
कार्यपालक अभियंता (टास–II)
सी.एस.क्यू. के.लो.नि.वि. नईदिल्ली

फाईल सं0 133/अधीअभि. (टास)/दि.द.वि./2022/ 264-80 दिनांक 27/06/2022

प्रतिलिपि : सभी विषेश महानिदेशक/अपर महानिदेशक/मंख्य अभियन्ता/मुख्य परियोजना प्रबन्धक/परियोजना प्रबन्धक को के0 लो0 नि0 वि0 कीवेबसाइटhttp://cpwd.gov.inके द्वारा.

कार्यपालक अभियंता (टास–II)

Appendix - 4

File No.RW/NH-34049/01/2020-S&R (B)
Government of India
Ministry of Road Transport & Highways
(S&R (P&B/New Technology) Zone)
Transport Bhawan, 1, Parliament Street, New Delhi-110001

Dated: 08th April, 2022

CIRCULAR

To

1. The Chief Secretaries of all the State Governments/ UTs.
2. The Principal Secretaries/ Secretaries of all States/ UTs Public Works Department/ Road Construction Department/ Highways Department (dealing with National Highways and other centrally sponsored schemes).
3. The Chairman, National Highways Authority of India, G-5 & 6, Sector-10, Dwarka, New Delhi-110 075.
4. The Managing Director, NHIDCL, PTI Building, New Delhi-110001.
5. The Director General (Border Roads), Seema Sadak Bhawan, Ring Road, New Delhi-110 010.
6. All Engineers-in-Chief and Chief Engineers of Public Works Department of States/ UTs/ Road Construction Department/ Highways Departments (dealing with National Highways and other centrally sponsored schemes).
7. All CE-ROs, ROs and ELOs of the Ministry.

Subject: - National Highway Pre-cast Concrete Policy - Reg

Madam/Sir,

Industrialised Pre-cast Concrete (factory manufactured pre-cast concrete elements) has the benefits of all-weather and fast construction, reliable quality & enhanced performance durability, aesthetics due to uniformity in appearance and minimum user time delay/reduced carbon emission/reduced noise & air pollution due to reduced construction activities at site, etc. To add to that, it will also play an integral role in accelerating the growth of the MSME sector. To harness the benefits of pre-fabrication in construction of National Highways, Expressways & Other Centrally Sponsored Road Projects, following policy decisions have been taken:

2. Contract/Concession agreement document shall include the provision of mandatory use of factory manufactured pre-cast concrete elements in projects within 100 km radius of Pre-cast factory. The minimum mandatory usage should be 25% of total concrete volume other than the foundations & sub-structures of Bridges/Viaduct/RoB. Any relaxation may be granted by Authority only if the contractor/concessionaire is able to demonstrate that the manufacturer(s) is not able to provide such products matching to the works programme of the contractor or the prices demanded by the manufacturer is more than the prices derived for cast-in-situ condition at the rates of SoR prevailing on 28th days before the bid due date.

3. Standardization is the key to promote the use of pre-cast concrete elements to take advantage of volumes and repetitive use of molds. Therefore, It is beneficial to keep the spans/sizes of different structures as uniform as possible.

4. Design and Construction of pre-cast concrete elements will be done as per relevant IRC/BIS standards/guidelines/codes furthermore taking into consideration expected

Bidur Kant Jha. Page 1 / 2

handling/lifting stresses, etc. Any international guidelines such as AASHTO, FHWA (Accelerated Bridge Construction Guidelines), Japan & Euro codes, may be followed in case of any gaps in IRC/BIS standards/ guidelines/codes till such time IRC/BIS guidelines are developed.

5. To start with Quality Council of India (QCI) shall be entrusted to certify pre-cast concrete factory. As the number of factories go on increasing, MoRT&H may entrust certification to other agencies like NCCBM/RDSO/IITs etc. Certification shall not be required for pre-casting being done at Project site.

6. The pre-cast factory shall have minimum facility of fully automatic RMC plant for better quality, arrangement for steam curing, mechanical handling of concrete and pre-cast components, bar bending machines, stacking yard, in-house design team and NABL accredited quality control laboratory, RO plant for water purification etc.

7. It is requested that the contents of the letter may be brought into the notice of all concerned for needful compliance.

7. This issues with the approval of Competent Authority.

Yours sincerely,

Bidur Kant Jha
08.04.2022

(Bidur Kant Jha)
Director
(New Technology for Highway development)
For DG (RD) & SS

Copy to:

1. All CEs in the Ministry of Road Transport & Highways
2. All ROs of the Ministry of Road Transport & Highways
3. The Secretary General, Indian Roads Congress
4. Technical circular file of S&R (P&B) Section
5. NIC-for uploading on Ministry's website under "What's new"

Copy for information and necessary action to:

1. Sr. PPS to Secretary (RT&H)
2. PPS to DG (RD) & SS
3. Sr. PPS/ PPS to Addl. Secretary (Road Safety)/ Addl. Secretary (RT&H & LA)
4. Sr. PPS/ PPS to AS&FA
5. Sr. PPS/ PPS to ADG (SKN) / ADG (RP)/ ADG(DS)
6. Sr. PPS/ PPS to JS (RT&MVL)/ JS (EIC) / JS (Logistics)/ JS (NHIDCL)

Appendix - 5

भारत सरकार
केंद्रीय लोक निर्माण विभाग
तकनीकी अनुप्रयोग एवं मानक एकाई
कमरा सं0 418 ए–विंग, निर्माण भवन, नई दिल्ली।
टेलीफैक्स–011–23062339 ईमेल–delsetascsq.cpwd@nic.in

F. No. 17/SE(TAS)/BMTPC/2022/ 105-120 Dated: 24/03/2022

कार्यालय ज्ञापन

Subject: **Adoption of New & Emerging Technologies in construction works undertaken by CPWD- reg.**

Reference:
1. OM No. 133/SE(TAS)/DSR/2018-19/464-H dated 06.11.2018
2. OM No. 133/SE(TAS)/DSR/2018-19/519-H dated 16.11.2018
3. OM No. 133/SE(TAS)/DSR/2018-19/16-H dated 07.01.2019
4. OM No. 133/SE(TAS)/DSR/2019/115-H dated 12.03.2019
5. OM No. 17/SE(TAS)/BMTPC/2019/531-E dated 03.04.2019
6. OM No. 133/SE(TAS)/DSR/2019/376-H dated 17.09.2019
7. OM No. 17/SE(TAS)/BMTPC/2020/381-H dated 23.09.2020

Structural system of any building is based on the capacity of the materials used to bear the imposed loads and vulnerability of the site where the structure is to be constructed. Above referred OMs were issued from time to time to authorize use of new and emerging technologies in public works. In order to streamline and in supersession of above OMs, it is now decided to categorize these technologies as per structural systems into Permanent Structures-Concrete and Steel Structural Systems Table-1A & 1B respectively, Semi-permanent Structures-Structural Systems Table-2 and Construction Materials Table-3. The Tables 1A, 1B & 2 also show the suitability of the technology with respect to seismic zone and restrictions on number of storey for each technology for guidance.

Table-1A
Permanent Structures- Concrete Structural System Technologies

S. No.	Name of Technology	Seismic zone Suitability	Maximum number of Storeys
1	2	3	4
	A. Precast Concrete Construction Systems		
1	Pre-cast concrete system with columns, beams, walls, slabs, hollow core slabs & also 3D Volumetric components– Technology needs special transport logistics	All zones except zone V	Any number
2	3D Modular casting using steel mould and high performance concrete of building modules in factory. These modules are transported to the construction site & assembled – Technology needs special transport logistics	All zones except zone V	Any number
3	Modules with 3D volumetric precast concrete unit, various units make a house - Technology needs special transport logistics	All zones except zone V	Any number
4	Precast Large Concrete Panel (PLCP) system with structural members (wall, slab etc.) cast in a factory / casting yard and brought to the building site for erection &assembling	All zones except zone V	Any number
5	Industrialized 3-S system using RCC precast with or without shear walls, columns, beams, Cellular Light Weight Concrete Slabs/Semi-Precast Solid Slab.	All zones except zone V	Any number

6	Pre –cast sandwich panel system & light weight precast concrete slab (Wall is sandwich panel comprising of structural concrete inside panel, insulation layer & finishing external layer) Light weight concrete slab (comprises of bottom concrete / mortar layer, Light weight concrete blocks & reinforcement & in-situ concrete)	All zones except zone V	Any number
7	Large Hollow wall prefab concrete panel (Lightweight, interlocking, concrete panel) using factory produced large standard hollow interlocking concrete block	All zones except zone V	Any number
	B. Cast-in-Situ Structural Systems		
8	'Tunnel form' construction technology, a cast-in-situ RCC system, based on the use of high-precision, re-usable, room-sized, steel forms or moulds for monolithic concrete construction	All zones	Any number
9	Monolithic Concrete Construction system using Aluminum formwork	All zones	Any number
10	Monolithic Concrete Construction system using Plastic Aluminum formwork	All zones	Any number
11	RCC framed structure system using steel formwork	All zones	Any number
12	Factory Produced PVC stay in place formwork with in-situ concrete & reinforcement in walling units and cast-in-situ RCC Slab	All zones	Any number
13	Stay in place preassembled PVC wall forms along with cast-in-situ RCC slab	All zones except zone V	Any number
14	Structural Stay in Place Galvanized Steel formwork system for walling with the same bottom single layer formwork for slabs/in-situ slab	All zones except zone V	G+3
	C. Others		
15	Use of confined Masonry	All zones	G+3

Table-1B

Permanent Structures- Steel Structural System Technologies

S. No.	Name of Technology	Seismic zone Suitability	Maximum number of Storeys
1	2	3	4
	D. Steel Structural systems		
16	Prefabricated Steel Structural systems with appropriate wall system -PEB- Pre-Engineered Buildings using a combination of built-up sections, hot rolled sections and cold formed elements with various options for walling & flooring	All zones	Any number
17	Factory made fast track modular building system -Hot rolled steel frame structure with different walling components	All zones	Any number
18	Speed floor System- Hot rolled steel frame with speed floor	All zones	Any number
19	Hot rolled steel section / frame with prefabricated fibre reinforced sandwich panels.	All zones	Any number

Table-2

Semi-Permanent Structures-Structural System Technologies

S. No.	Name of Technology	Seismic zone Suitability	Maximum number of Storeys
1	2	3	4
	E. Light Gauge Steel Structural System		
20	Light Gauge Steel Framed Structure (LGSFS)	All zones except zone V	G+3

21	Light Gauge Steel Frame structure with infill concrete Panel– the light weight concrete (using a special mixing & pumping machine) is filled in between two prefabricated concrete panels	All zones except zone V	G+3
	F. Precast Concrete Construction Systems		
22	Vertical Structural modules cast in plant/casting yard are assembled together through casting of floor panel at site-Technology needs special transport logistics	All zones except zone V	G+3
23	Prefabricated interlocking Technology (without mortar) with Roofing as Mechanized Precast R.C. Plank & Joist system	All zones except zone V	G+3
	G. Cast-in-Situ Structural Systems		
24	Expanded-steel panel reinforced with all-galvanized steel wire-Struts serving both as load-bearing steel structures and as stay-in-place steel formwork filled with EPS-alleviated concrete	All zones except zone V	G+3
25	Factory made prefab Glass fibre reinforced Gypsum (GFRG) cage panels suitable for wall & slab with reinforcement &concrete in cavities as per the requirement	All zones with specified restrictions on number of storeys	1. G+9 for all seismic zones except seismic zone IV & V 2. G+5 storeys in seismic zone-IV& V.
26	Fully Load bearing walls with 150 mm monolithic concrete core sandwiched inside two layers of EPS as walling. The forms are open ended hollow polystyrene interlocking blocks which fit together to form shuttering system	All zones with specified restrictions on number of storeys	1. Higher than G+3 as per structural design for all seismic zones except seismic zone V 2. G+3 storeys in seismic zone-V.
27	Fast Bloc, insulated Concrete Form (ICF), acting as formwork for concrete and rebar, Column/post and beam construction, creating a strong skeleton in the walls	All zones with specified restrictions on number of storeys	1. Higher than G+3 as per structural design for all seismic zones except seismic zone V 2. G+3 storeys in seismic zone-V.
28	Formwork system "Plaswall" with Two fibre cement boards (FCB) & HIMI (High Impact Molded Inserts) bonded between two sheets of FCB and erected to produce a straight-to-finish wall with in-situ concrete	All zones with specified restrictions on number of storeys	1. Higher than G+3 as per structural design for all seismic zones except seismic zone V 2. G+3 storeys in seismic zone-V.

	H. Prefabricated Panel System		
29	Advanced building system-EMMEDUE – Factory made panels consisting of self-extinguishing expanded EPS sandwiched between two welded high strength galvanized wire fabric mesh	All zones except zone V	G+ 3
30	Rapid panels–It is a prefabricated assembly of high-strength steel wire, which is bent into a zig-zag shape	All zones except zone V	G+ 3
31	Reinforced EPS Core Panel System	All zones except zone V	G+3
32	Concrewall panel system	All zones except zone V	G+3
33	Bau panel system	All zones except zone V	G+3
34	Fly ash EPS (Beads) cement sandwich panels	All zones except zone V	G+1
35	Pre-fab PIR (Poly-isocyanurate) based Dry wall panel system as non-load bearing wall- Suitable with Steel frame.	All zones	G+1
36	SRPL Building System (Waffle- Crete)	All zones except zone V	G+3
37	Robomatic Hollow concrete wall panel	All zones except zone V	G+1
38	Wall tech Hollow core concrete panel	All zones except zone V	G+1
39	Quick Build 3D panels	All zones except zone V	G+3
40	EPS Cement sandwich wall/roof/floor light weight solid core panel	All zones except zone V	G+1
41	Sandwich panels as wall & slab	All zones except zone V	G+3

Note: Any Prefabricated panels can be used as non load bearing partitions, paneling etc. in steel frame or RCC frame buildings irrespective of number of storeys depending upon the design and functional requirements.

Table-3

Construction Material Technologies

S. No.	Name of Technology
42	Use of self compacting concrete
43	Use of C&D waste Products in Constructions
44	Block Masonry using AAC blocks
45	Brick Masonry using fly-ash bricks
46	Reinforced soil Technology using Technical Textiles
47	Stamping Concrete
48	Rigid EPS (Cellular plastic material) blocks
49	Crushed Sand (As per IS 383 :2016 amended from time to time)
50	Manufactured Sand (The extent of utilization shall be as per IS 383:2016 amended from time to time).

Note:

1. G+3 may be read as "Ground storey (stilt is ground storey) plus three storeys above ground storey.
2. Basements, if to be provided, shall invariably be of cast-in-situ reinforced cement concrete.
3. Seismic zone suitability and number of storey restriction is based on MoHUA OM No. I-11019/05/2019-HFA-V-UD-(FTS-9058698) dated 28.05.2019 & BMTPC OM No. BMT/ED/Misc./2021 dated 24.11.2021, BMTPC PACS of corresponding technology and BMTPC publications.

4. As per NDMA guidelines on Hospital safety; flat slab, pre-stressed floor systems, precast construction, pre-engineered structures, large cantilever, long span and unreinforced masonry structural systems shall be prohibited for use in new hospitals.
5. This OM shall be applicable for NITs uploaded /invited after the date of issue of OM.

This issues with the approval of competent authority.

(दिवाकर अग्रवाल)
अधीक्षण अभियंता(टास)

केलोनिवि तथा लोनिवि दिल्ली के सभी अधिकारियों को आवश्यक सूचना एवं कार्यवाही हेतु।
(केलोनिवि वेबसाईट के माध्यम से)

24/03

Appendix - 6

भारत सरकार
केंद्रीय लोक निर्माण विभाग
तकनीकी अनुप्रयोग एवं मानक एकाई
कमरा सं0 418 ए–विंग, निर्माण भवन, नई दिल्ली।
टैलीफैक्स–011–23062339 ईमेल–delsetascsq.cpwd@nic.in

F. No. 17/SE(TAS)/BMTPC/2020/ 381-Del Dated 23 /09/2020

OFFICE MEMORANDUM

Sub:- Adoption of New & Emerging Technologies in construction works undertaken by CPWD regarding.

Ref:-

1. OM No.133/SE(TAS)/DSR/2019/115-H dated.12.03.2019
2. OM No.133/SE(TAS)/DSR/2019/376-H dated.17.09.2019
3. OM No. 9076576/36(11)/New Tech./CE CSQ (E)/2019/277 dated 21.10.2019
4. OM No. 9076576/36(11)/New Tech./CE CSQ (E)/2019/570 dated 22.11.2019

The MoHUA, GOI organized Global Housing Technology Challenge-India (GHTC India) with the objective to identify and mainstream a basket of innovative technologies from across the globe that are sustainable, disaster-resilient, cost effective, speedier and ensure a higher quality of construction of houses, while meeting our diverse geo-climatic conditions and functional needs. The Technologies were invited online through a Global Expression of Interest (EoI). Technical Evaluation Committee (TEC) was constituted by MoHUA under the Chairmanship of DG, CPWD, which assessed the technologies & recommended 54 technologies. MoHUA has directed CPWD, through BMTPC to adopt these 54 technologies shortlisted under GHTC-India.

The 54 shortlisted New and Emerging technologies are grouped in 6 broad categories. It is seen that in each of the categories same/similar technology has been approved for more than one technology provider, thereby 37 out of 54 of the technologies (Civil) stand approved under 43 (29 civil and 14 electrical) technologies already approved by CPWD vide OMs referred above. Thus out of 54, there are 17 nos. New & Emerging technologies (civil) need to be further approved by CPWD.

So, additional 17 nos. New & Emerging technologies (civil) as listed below are approved for adoption in CPWD, irrespective of location and cost of the project.

Sl. No.	Name of Technology
	A. PRECAST CONCRETE CONSTRUCTION SYSTEM – 3D PRECAST VOLUMETRIC (4)
1	Pre-cast concrete system with columns, beams, walls, slabs, hollow core slabs & also 3D Volumetric components
2	Vertical Structural modules cast in plant/casting yard are assembled together through casting of floor panel. The unit is transported & installed at site
3	3D Modular casting using steel mould and high performance concrete of building modules in factory. These modules are transported to the construction site & assembles
4	Modules with 3D volumetric precast concrete unit, various units make a house
	B. PRECAST CONCRETE CONSTRUCTION SYSTEM-PRECAST COMPONENTS ASSEMBLED AT SITE (3)
5	Pre –cast sandwich panel system & light weight precast concrete slab (Wall is sandwich panel comprising of structural concrete inside panel, insulation layer & finishing external layer) Light weight concrete slab (comprises of bottom concrete / mortar layer, Light weight concrete blocks & reinforcement & in-situ concrete)
6	Prefabricated interlocking Technology (without mortar) with Roofing as Mechanized Precast R.C. Plank & Joist system
7	Large Hollow wall prefab concrete panel (Lightweight), interlocking, concrete panel) using factory produced large standard hollow interlocking concrete block.
	D. PREFABRICATED SANDWICH PANEL SYSTEM (2)
8	Pre-fab PIR (Poly-isocyanurate) based Dry wall panel system as non-load bearing wall.
9	Sandwich panels as wall & slab
	E. MONOLITHIC CONCRETE CONSTRUCTION (1)
10	'Tunel form' construction technology, an cast in situ RCC system, based on the use of high-precision, re-usable, room-sized, steel forms or moulds for monolithic concrete construction

	F. STAY IN PLACE FORMWORK SYSTEM (7)
11	Expanded steel panel reinforced with all galvanized steel wire-Struts serving both as the load-bearing steel structures and as the stay-in-place steel formwork filled with EPS-alleviated concrete
12	Structural Stay in Place Galvanized Steel formwork system for walling with the same bottom single layer formwork for slabs/in-situ slab
13	Factory Produced PVC stay in place formwork with in-situ concrete & reinforcement in walling units and cast in situ RCC Slab
14	Fully Load bearing wall with 150 mm monolithic concrete core sandwiched inside two layers of EPS as walling. The form are open ended hollow polystyrene interlocking blocks which fits together to form shuttering system
15	Stay in place light weight polymer formwork with cast in situ reinforced concrete & in-situ reinforced concrete & in-situ flooring slab
16	Fast Bloc, insulated Concrete Form (ICF), acting as formwork for concrete and rebar, Column/post and beam construction, creating and strong skeletion in the walls
17	Formwork system "Plaswall" with Two fibre cement boards (FCB) & HIMI (High Impact Molded Inserts) bonded between tow sheets of FCB and erected to produce a straight-to-finish wall with in-situ concrete

For the 17 nos. New & Emerging technologies approved herein, DSR, DAR & Specifications of respective items are under process and shall be issued in due course.

As per mandate of MoHUA at least one of the approved New and Emerging Technology (which now are 60 nos. including 43 approved earlier and additional 17 nos. as listed above) is to be adopted in future projects, irrespective of location and cost. Accordingly as decided earlier, in case it is not found feasible to implement this mandate/direction in a particular project, specific permission must be obtained from DG, CPWD on case to case basis with detailed justification.

This issues with the approval of DG, CPWD.

(Divakar Agrawal)
Superintending Engineer (TAS)

Copy to:

1. All the SDGs/ADGs/CE cum EDs/CEs/SE cum PDs/SEs/EE & SMs/EEs of CPWD & PWD (GNCTD) for information and necessary action please. (through http:/cpwd.gov.in).

(Divakar Agrawal)
Superintending Engineer (TAS)

Appendix - 7

भारतसरकार
केंद्रीय लोकनिर्माणविभाग
तकनीकीअनुप्रयोग एवंमानक एकाई
कमरा सं0 418 ए–विंग, निर्माणभवन
नईदिल्ली
http://cpwd.gov.in
टैलीफैक्स–011–23062339 ईमेल–delsetascsq.cpwd@nic.in

F. No. 133/SE(TAS)/DSR/2019/ 376-Hे Dated 17/09/2019

OFFICE MEMORANDUM

Subject: Adoption of New & Emerging Technologies in Construction works undertaken by CPWD – regarding.

Ref:-

1. OM JS/Works/OM/2016 dated 30.05.2016
2. OM No. 28012/7/2016/W-3 dated 28.12.2016
3. OM no. 28012/7/2016-W-3 dated 20.03.2018
4. OM No 133/SE(TAS)/DSR/2018-19/464-H dated 06.11.2018
5. OM No. 133/SE(TAS)/DSR/2018-19/519-H dated 16.11.2018
6. OM no. 133/SE(TAS)/DSR/2018-19/16-H dated 07.01.2019
7. OM no. 133/SE(TAS)/DSR/2019/115-H dated 12.03.2019

As per the above OMs, at least one of the 16 already approved new and emerging technologies is mandatory to be adopted for all the projects across the country irrespective of location and cost.

The following 13 new and emerging technologies are approved in addition to the existing 16 new and emerging technologies.

S.No	Name of Technologies	DSR items (Reference)
1.	Advanced building system- EMMEDUE	26.46 & 26.47 (already available since DSR-2016) 26.66 (OM No. DG/DSR/27 dated 13.08.2018), 26.67 (OM No. DG/DSR/31 dated 19.11.2018),
2.	Rapid panels	
3.	QuickBuild 3D panels	
4.	Concrewall panel system	
5.	Bau Panel system	
6.	Fly ash EPS (Beads) cement sandwich panels	26.49 (OM No. DG/DSR/20 dated 10.11.2018)
7.	Rigid EPS (Cellular plastic material) blocks	26.82 (OM No. DG/DSR/37 dated 06.08.2019)
8.	Light Gauge Steel Framed Structure with infill Concrete panel technology	26.41 to 26.43 (already available since DSR-2016)
9.	SRPL Building System (Waffle-Crete)	26.73 to 26.80 (OM No. DG/DSR/18 dated 20.07.2017)
10.	Precast Large concrete Panel System	
11.	Walltech Hollow core concrete panel	
12.	Robomatic Hollow concrete wall panels	
13	Stamping concrete	26.83 (OM No. DG/DSR/41 dated 06.08.2019)

The following modification is made in the existing approved technologies

Existing name of Technology	Modified name of Technology
Expanded Polystyrene core panel system	Reinforced EPS core panel systems

As decided earlier, in case it is not found feasible to implement these provisions in a particular project, specific permission must be obtained from DG, CPWD on case to case basis with detailed justification.

This issues with approval of DG, CPWD.

Superintending Engineer (TAS)

Copy to:-

(Through website)

1. PS to HUAM
2. Sr. PPS to Secretary (HUA)
3. PS to Ass/JSs in MoHUA
4. All the SDGs/ADGs/CEs/CPMs/PMs of CPWD and PWD (GNCTD) through CPWD website https://cpwd.gov.in for information and necessary action please.

Superintending Engineer (TAS)

Appendix - 8

No. I-11019/05/2019–HFA-V-UD (FTS-9058698)
Government of India
Ministry of Housing and Urban Affairs
(HFA-V Section)
*****

Room No.3, Technical Cell, Gate No. 7,
Nirman Bhawan, New Delhi-110011,
Dated: 28.05.2019.

OFFICE MEMORANDUM

Sub: **Technical Evaluation Committee (TEC) report for shortlisting of Proven Technologies for Participation in bidding for construction of Light House Projects (LHPs) – reg.**

The undersigned is directed to state that the Ministry of Housing and Urban Affairs (MoHUA) has conceptualized the Global Housing Technology Challenge – India (GHTC-India) as a platform with which a holistic eco-system can be facilitated such that appropriate technologies from around the world and relevant stakeholders can be catalyzed towards effecting a technology transition in the country's housing and construction sectors. The challenge has three components i.e. (i) Conduct of a biennial Construction Technology India, Expo-cum-Conference, to provide a platform for all stakeholders to exchange knowledge and business, (ii) Identifying Proven Demonstrable Technologies from across the world, and mainstreaming them through use in Light House Projects (LHPs), (iii) Promoting Potential Future Technologies through the establishment of Affordable Sustainable Housing Accelerators- India (ASHA-India) for incubation and accelerator support.

2. GHTC-India was launched by Hon'ble Minister of State (Independent Charge), MoHUA on 14.01.2019 at Press Conference Hall, National Media Centre, Press Information Bureau, New Delhi. Subsequently, Construction Technology India – 2019 (CTI-2019): Expo-cum-Conference was held at Vigyan Bhawan, New Delhi during 02-03 March, 2019 to bring together multiple stakeholders involved in innovative and alternative housing technologies, for exchange of knowledge and business opportunities through an exhibition, thematic sessions, panel discussions and master classes. The Expo was inaugurated by Hon'ble Prime Minister of India in the presence of Hon'ble MoS (I/C), MoHUA.

3. The applications were invited online globally through a dedicated websitefrom proven technology providers, potential technology providers, Indian partners and delegates consisting representatives from various Academic Institutes, representatives of technology providers and Government officers/ officials. The last date for submission of forms online for Proven Technology was 28 February 2019.

4. CTI-2019 had about 3500 visitors including 2500 delegates from 32 countries. The exhibition had 188 stalls in which 60 Proven Technology Providers, 72 Potential Technology Providers and 51 Indian Partners applied and participated in CTI-2019. 23 States/ UTs also exhibited progress of PMAY(U) in the Expo through showcasing prototypes of housing projects constructed. The stalls of various Missions such as Smart City,Atal Mission for Rejuvenation and Urban Transformation(AMRUT), Heritage City Development and Augmentation Yojana(HRIDAY), Swachh Bharat Mission (SBM) and National Urban Livelihoods Mission (DAY-NULM) of MoHUA were also exhibited in the Expo.

5. A Technical Evaluation Committee (TEC) under the chairmanship of the Director General, CPWD has been constituted for detailing the technical parameters for inviting and evaluating the eligibility of applicants for the various streams including LHPs. TEC interacted with applicants, who submitted online applications under Proven Demonstrable Technology category for GHTC-India. Technical presentations of their technologies were made before the TEC during CTI-2019. Out of 60 applications, 54 applications were for Proven Technologies, which were finally evaluated as per eligibility criteria. The remaining 6 applicants were mainly equipment/product manufacturers which did not qualify under Proven Technology.

6. Based on the TEC recommendations, 54 technology providers were found eligible for participating in bidding for construction of LHPs. The list of 54 eligible technology providers is attached herewith.

7. This issues with the approval of competent authority.

28/5/19

(B.K. Mandal)
Under Secretary to the Government of India
Tel: 23061825
E-mail: clsshfa5@yahoo.com

Encl: As above.

To:

All the concerned technology providers

Copy for information to:

i. PS to Hon'ble MoS (I/C), MoHUA
ii. PSO to Secretary, MoHUA
iii. PS to JS&MD (HFA), MoHUA
iv. PA to Director (HFA-V), MoHUA
v. GHTC-India website for information

TEC's recommendations on technologies along with recommended locations for Light House Projects:

S. No.	Technology broad specification	Applicants	Recommendations	Recommended Locations for Lighthouse Projects
A. Precast Concrete Construction System - 3D Precast volumetric (4)				
1	Pre-cast concrete system with columns, beams, walls, slabs, hollow core slabs & also 3D Volumetric components	Katerra	Suitable up to seismic zone IV.	1.Lucknow, Uttar Pradesh 2.Rajkot, Gujarat 3.Ranchi, Jharkhand 4.Indore, Madhya Pradesh, 5.Chennai, Tamil Nadu(with external wall insulation)
2	Vertical structural modules cast in Plant/Casting yard are assembled together through casting of floor panel. The unit is transported & installed at site.	Moducast Pvt. Ltd	Suitable up to seismic zone IV. Requires proper access to site & special transport logistics. Suitable up to G+3 due to limited hoisting capacity	
3	3D Modular casting using steel mould and high performance concrete of building modules in factory. These pods are transported to the construction site & assembled	Magicrete Building Solutions,	Suitable up to seismic zone IV. Site must have accessibility & technology needs special transport logistics	
4	Modules with 3D Volumetric Precast concrete unit, various units make on house	Ultratech Cement Ltd,	Suitable up to seismic zone IV. Site must have accessibility & technology needs special transport logistics	
B. Precast Concrete Construction System – Precast components assembled at site (8)				
5	Precast Large Concrete Panel (PLCP) System with structural members (wall, slab etc.) cast in a factory/ casting yard and brought to the building site for erection & assembling	Larsen & Toubro	Suitable up to seismic zone IV.	1.Lucknow, Uttar Pradesh 2.Rajkot, Gujarat 3.Ranchi, Jharkhand 4.Indore, Madhya Pradesh, 5.Chennai, Tamil Nadu (external wall insulation needed in case brick/block masonry not used in external walls)
6	Pre-cast Concrete Structural system comprising of pre-cast column, beam, precast concrete / light weight slab, AAC blocks/ infill concrete walls.	B.G. Shirke Construction Technology Pvt. Ltd	Suitable up to seismic zone IV.	
7	Optimal Pre-cast concrete System through structural Analysis, design & equipment support	Elematic India,	Suitable up to seismic zone IV. The firm needs to tie up with a construction Agency.	
8	Precast concrete construction system using precast walls with precast plank floor	PG Setty Construction Technology Pvt Ltd,	Suitable up to seismic zone IV	
9	Pre cast components comprising of beams, coloumns, staircase, slab, hollow core slab etc. manufactured in plant & erected on site	Teemage		
10	Pre-cast sandwich panel system & Light weight Pre cast Light Weight concrete slab	Nordicflex		
11	Prefabricated Interlocking Technology (without mortar) with Roofing as Mechnized Precast R.C. Plank & Joist system	Adalakha Associates Pvt. Ltd	Suitable up to G+3 storeys & Seismic Zone – IV	

S. No.	Technology broad specification	Applicants	Recommendations	Recommended Locations for Lighthouse Projects
12	Large Hollow wall prefab concrete Panel (lightweight, interlocking, concrete panel) using factory produced large standard hollow interlocking concrete block	William Ling,	Suitable up to seismic zone IV.	
C. Light Gauge Steel Structural System & Pre-engineered Steel Structural System (16)				
13	LGS Framing with various walling & roofing options	Mitsumi Housing Pvt. Ltd,	Suitable for G+ 3 storeys. Hybrid with steel frame for high rise Panelling materials to be used should meet the site specific quality and durability requirements .	1.Lucknow, Uttar Pradesh 2.Rajkot, Gujarat 3.Ranchi, Jharkhand 4.Agartala, Tripura 5.Indore, Madhya Pradesh, 6.Chennai, Tamil Nadu
14	LGS Framing with various walling & roofing options	Everest Industries Ltd,		
15	LGS Framing with various walling & roofing options	JSW Steel Ltd.,		
16	LGS Framing with various walling & roofing options	Society for Development of Composites,		
17	LGS Framing with various walling & roofing options	Elemente Designer Homes,		
18	LGS Framing with various walling & roofing options	MGI Infra Pvt. Ltd.,		
19	LGS Framing with various walling & roofing options	RCM Prefab Pvt. Ltd,		
20	LGS Framing with various walling & roofing options	Nipani Infra and Industries Pvt. Ltd.,		
21	LGS Framing with various walling & roofing options	Strawcture Eco		
22	LGS Framing with various walling & roofing options	Visakha Industries Ltd.		
23	Prefabricated steel structural system with Dry wall system as AAC panels, Puf panels etc	RCC Infra Ventures Ltd.	Suitable technology	
24	Hot rolled steel frame with speed floor	Jindal Steel & Power Ltd.	Suitable technology with accepted walling components.	
25	Hot rolled steel section with AAC Panels as floor & slab	HIL Ltd.		
26	AAC wall and roof panel system to provide integrated solution. AAC products are reinforced and used in both load and non-load bearing applications.	Biltech Building Elements Ltd	Suitable up to G+1 (Load bearing) Suitable with steel frame for high rise	
27	AAC Panels are Wire mesh/ steel reinforced for use as wall & slab. Appears to be non load bearing panels to be used with structural framing.	SCG International India Pvt Ltd		
28	Precast Light Weight Hollow-core wall Panel is a non-structural construction material with framed structures.	Pioneer Precast Solutions Private Limited	Suitable with steel frame	
D. Prefabricated Sandwich Panel System (9)				
29	Reinforced Expanded Polystyrene sheet core Panel with sprayed concrete as wall & slab	Worldhaus	Suitable for G+ 3 storeys.	1.Lucknow, Uttar Pradesh 2.Rajkot, Gujarat 3.Ranchi, Jharkhand 4.Agartala, Tripura 5.Indore, Madhya Pradesh, 6.Chennai, Tamil Nadu
30	EPS Cement sandwich Panel): wall & slab with EPS Cement sandwich Panel to be used with RCC or Steel structural frame. Load bearing upto G+1 storey	Bhargav Infrastructure Pvt.Ltd	Suitable up to G+1 (Load bearing) Hybrid with Steel/RCC frame for multi storey	

S. No.	Technology broad specification	Applicants	Recommendations	Recommended Locations for Lighthouse Projects
31	EPS Cement sandwich Panel): wall & slab with EPS Cement sandwich Panel to be used with RCC or Steel structural frame. Load bearing upto G+1 storey	Rising Japan Infra Private Limited		
32	Reinforced Expanded Polystyrene sheet core Panel with sprayed concrete as wall & slab	Bau Panel Systems India Pvt Ltd,	Suitable for G+ 3 storeys.	
33	Reinforced Expanded Polystyrene sheet core Panel with sprayed concrete as wall & slab	BK Chemtech Engineering		
34	Reinforced Expanded Polystyrene sheet core Panel with sprayed concrete as wall & slab	MSN Construction		
35	Reinforced Expanded Polystyrene sheet core Panel with sprayed concrete as wall & slab	Beardshell Ltd.		
36	Pre-fab PIR (Poly-isocyanurate) based Dry Wall Panel System" as non-load bearing wall	Covestro India Pvt. Ltd.,	Suitable with steel frame	
37	Sandwich panels as wall & slab	Project Etopia Group	Suitable for G+ 3 storeys.	
E. Monolithic Concrete Construction (9)				
38	Aluminium form work system for Monolithic Concrete construction	Maini Scaffold Systems	Suitable technology	1.Lucknow, Uttar Pradesh 2.Rajkot, Gujarat 3.Ranchi, Jharkhand 4.Agartala, Tripura 5.Indore, Madhya Pradesh, 6.Chennai, Tamil Nadu(with external wall insulation)
39	Aluminium form work system for Monolithic Concrete construction	KumkangKind India Pvt. Ltd		
40	Aluminium form work system for Monolithic Concrete construction	S-form India Pvt. Ltd.,		
41	Aluminium form work system for Monolithic Concrete construction	ATS Infrastructure Ltd.		
42	Aluminium form work system for Monolithic Concrete construction	Innovative housing & Infrastructure Pvt. Ltd		
43	Aluminium form work system for Monolithic Concrete construction	MFS formwork Systems Pvt. Ltd.		
44	Aluminium form work system for Monolithic Concrete construction	Knest Manufacturers LLP		
45	'Tunnel form' construction technology, an cast in situ RCC system, based on the use of high-precision, re-usable, room-sized, steel forms or moulds for monolithic concrete construction	Outinord Formworks Pvt. Ltd.	Suitable technology	
46	Aluminium form work system for Monolithic Concrete construction	Brilliant Etoile	Suitable technology	
F. Stay In Place Formwork System (8)				
47	Expanded-Steel Panel reinforced with all-galvanised Steel Wire-Struts serving both as the load-bearing steel structure and as the stay-in-place steel formwork filled with EPS-alleviated concrete	JK Structure	Suitable for G+3 storeys	1.Lucknow, Uttar Pradesh 2.Rajkot, Gujarat 3.Ranchi, Jharkhand 4.Agartala, Tripura 5.Indore, Madhya Pradesh,

S. No.	Technology broad specification	Applicants	Recommendations	Recommended Locations for Lighthouse Projects
48	Factory made prefab Glass fibre reinforced Gypsum cage panels suitable for wall & slab with reinforcement & concrete as infill as per the requirement	FACT RCF Building Products Limited,	Suitable up to 10 storeys in seismic zone–III, & up to 6 storeys in seismic zone-V if conforming to design requirements.	6.Chennai, Tamil Nadu
49	Structural Stay In Place Galvanized Steel formwork system for walling with the same bottom single layer formwork for slabs/ in-situ slab	Coffor Construction Technology Pvt.Ltd	Suitable for G+3 storeys.	
50	Factory produced PVC Stay in place formwork with concrete & reinforcement in walling units with cast in-situ RCC Slab	Joseph Jebastin (Novel Assembler Private Limited),	Suitable Technology	
51	Fully load bearing walls with 150 mm monolithic concrete core sandwiched inside two layers of EPS as walling The forms are open ended hollow polystyrene iterlocking blocks which fits together to form shuttering system	Reliable Insupack	Suitable up to G+3 in Seismic Zone V and higer storeys in Seismic Zone IV as per design	
52	Ready to use Stay in place polymer formwork, light weight, with flooring slab (combination of ferro cement and natural stone) placed on RCC precast joists)	Kalzen Realty Pvt. Ltd	Not suitable as the system presented by the applicant does not qualify as a proven technology. However, it is suitable Technology as Stay in place preassembled PVC wall forms along with cast in-situ RCC slab.	
53	Fast Bloc, Insulated Concrete Form (ICF), acts as formwork for concrete and rebar, Coloumn/post and beam construction, creating an strong skeleton in the walls.	Fastbloc Building Systems	Suitable up to G+3 in Seismic Zone V and higher storeys in Seismic Zone IV as per design	
54	Formwork system "Plaswall" with Two fibre cement boards (FCB) & HIMI (High Impact Molded Inserts) bonded between two sheets of FCB in situ and erected to produce a straight-to-finish wall with in-situ concrete	FTS Buildtech Pvt.Ltd	Suitable up to G+3 in Seismic Zone V and higher storeys in Seismic Zone IV as per design	

Eligible technologies grouped by TEC in six broad categories

S. No.	Broad Technologies	Number of Applicants
A.	Precast Concrete Construction System - 3D Precast volumetric	04
B.	Precast Concrete Construction System – Precast components assembled at site	08
C.	Light Gauge Steel Structural System & Pre-engineered Steel Structural System	16
D.	Prefabricated Sandwich Panel System	09
E.	Monolithic Concrete Construction	09
F.	Stay In Place Formwork System	08
	Total	**54**

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Appendix - 9

भारत सरकार
केंद्रीय लोक निर्माण विभाग
तकनीकी अनुप्रयोग एवं मानक ईकाई
कमरा सं0 418 ए–विंग, निर्माण भवन
नई दिल्ली
http://cpwd.gov.in
टैलीफैक्स–011–23062339 ईमेल–delsetascsq.cpwd@nic.in

F. No. 133/SE(TAS)/DSR/2019/ 115-Pt Date: 12/03/2019

OFFICE MEMORANDUM

Subject : Adoption of New & Emerging Technologies in construction works undertaken by CPWD -Regarding.

In continuation of Ministry of Housing and Urban Affairs O.M. JS/Works/OM/2016 dated 30.05.2016, O.M. No 28012/7/2016-W-3 dated 28.12.2016 and O.M. No 28012/7/2016-W-3 dated 20.03.2018, eight (8) technologies were decided to be adopted in construction works.

Since then 8(eight) more New & Emerging Technologies have been approved by DG, CPWD and now in all total sixteen (16) New & Emerging Technologies are being as given here under for adoption in CPWD works for the benefit of all users.

S. No.	New and Emerging Technologies	Item no. and reference of OMs issued
1.	Monolithic concrete construction system using Aluminum formwork.	26.48 (already available since DSR-2016)
2.	Monolithic concrete construction system using Plastic - Aluminum formwork.	26.48 (already available since DSR-2016)
3.	Expanded Polystyrene Core Panel System	26.66 (OM No. DG/DSR/27 dated 13.08.2018), 26.67 (OM No. DG/DSR/31 dated 19.11.2018)
4.	Light Gauge Steel Framed Structures (LGSFS)	26.41 to 26.43 (already available since DSR-2016)
5.	Industrialized 3-S system using RCC Precast with or without shear wall, columns, Beams & Cellular Light Weight Concrete slabs/ semi precast solid slab.	26.73 to 26.80 (OM No. DG/DSR/18 dated 20.07.2017)
6.	Speed Floor System	26.62 to 26.64 (OM No. DG/DSR/26 dated 13.08.2018)
7.	Glass Fibre Reinforced Gypsum (GFRG) Panel Building System	26.51 to 26.61 (OM No. DG/DSR/25 dated 13.08.2018)
8.	Factory Made Fast Track Modular Building System	26.65 & 26.66 (OM No. DG/DSR/27 dated 13.08.2018)
9.	Non Asbestos fibre Reinforced aerated sandwich wall/ roof/ floor light weight solid core panel.	26.50 (OM No. DG/DSR/23 dated 02.01.2018)
10.	EPS cement sandwich wall/roof/floor light weight solid core panel.	26.46 , 26.47 (already available since DSR-2016) , 26.49 (OM No. DG/DSR/20 dated 10.11.2018) & 26.67 (OM No. DG/DSR/31 dated 19.11.2018)
11.	Use of Self Compacting Concrete	5.49 (already available since DSR-2016)
12.	Confined Masonry in Building construction	6.3, 6.4, 6.13 &7.8 (already available since DSR-2016)
13.	C&D Recycled Waste Products in constructions and C&D Recycled Waste Block Masonry.	26.68 to 26.72 (OM No. DG/DSR/29 dated 02.11.2018)

14.	AAC Block masonry.	6.38 & 6.47 (already available since DSR-2016)
15.	Fly ash Brick masonry.	6.32, 6.34, 6.36, 6.37 & 6.45 (already available since DSR-2016)
16.	Reinforced Soil Technology using Technical Textiles.	26.18.1 to 26.18.15 (already available since DSR-2016) 26.12 to 26.17 (already available since DSR-2016)

As decided earlier in case it is not found feasible to implement these provisions in particular project, specific permission should be accorded by DG, CPWD on case to case basis with detailed justification.

This issues with approval of DG, CPWD.

Superintending Engineer (TAS)

Copy to: (Through CPWD web site)

1. PS to Hon'ble Minister HUA
2. Sr. PPS to Secretary (HUA)
3. PS to all ASs/JSs in MoHUA.
4. PPS to DG, CPWD, Nirman Bhawan, New Delhi
5. All the SDGs, all the ADGs, All the CEs CPWD, All the SEs & EEs CPWD/ E-in-C (PWD) GNCTD

Superintending Engineer (TAS)

Appendix - 10

F.No.28012/7/2016-W-3
Government of India
Ministry of Housing and Urban Affairs
(Works Division)
*****

/04/017

Nirman Bhawan, New Delhi
Dated: 20.03.2018

OFFICE MEMORANDUM

ıb:- Adoption of New & Emerging Technologies in construction works undertaken by CPWD, DDA and NBCC – regarding.

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In continuation of this Ministry's O.M. JS/Works/OM/2016 dated 30.05.2016 and O.M. .28012/7/2016-W-3 dated 28.12.2016 it has been decided that CPWD, DDA & NBCC may opt the following technologies, which have been validated by Building Materials and chnology Promotion Council (BMTPC) under the Ministry of Housing and Urban Affairs, in their projects irrespective of location and project cost:

a. Monolthic concrete construction system using Aluminium Formwork
b. Monolithic concrete construction system using Plastic – Aluminium Formwork
c. Expanded Polystyrene Core Panel System
d. Light Gauge Sheet Framed Structures (LGSF)
e. Industrialized 3-S System using RCC precast with or without shear walls, columns, beams, Cellular Light Weight Concrete Slabs/Semi-Precast Solid Slab
f. Speed Floor System
g. Glass Fibre Reinforced Gypsum (GFRG) Panel Building System
h. Factory Made Fast Track Modular Building System.

As decided earlier, in case, it is not found feasible to implement these provisions in licular project, specific permission should be accorded by DG, CPWD/CMD, NBCC/Vice irman, DDA respectively on case to case basis, with detailed justification.

The aforesaid modern technologies may be incorporated as per the Schedule of es (SoR) issued by CPWD. Further, in future, new emerging technologies, as validated BMTPC and for which DG, CPWD has issued the SoR will also be included in the list. For purpose, DG, CPWD is authorized to issue directions in continuation of this Office norandum.

This has the approval of Hon'ble HUAM.

(J. Roy Chowdhury)
Deputy Secretary (Works)
Tel. no. 23062425

1. Director General, CPWD, Nirman Bhawan, New Delhi.
2. Vice Chairman, DDA, Vikas Sadan, INA, New Delhi-110023
3. Chairman-cum-Managing Director, NBCC Limited, NBCC Bhawan, Lodhi Road, New Delhi-110003

/ to:

1. PS to HUAM
2. Sr. PPS to Secretary (HUA)

Appendix - 11

F.No.28012/7/2016-W-3
Government of India
Ministry of Urban Development
(Works Division)
****

Nirman Bhawan, New Delhi
Dated the 28th December, 2016

OFFICE MEMORANDUM

Subject:- Adoption of New & Emerging Technologies in construction work of value not less than Rs.100 crores in Metropolitan cities, undertaken by CPWD, DDA and NBCC – reg.

Reference is invited to Ministry of Urban Development's OM dated 30.05.2016 on the above mentioned subject wherein inter alia it was mandated that CPWD, DDA and NBCC would adopt 3 (three) new Technologies viz. (i) Monolithic Concrete Construction System using Aluminium Formwork, (ii) Industrialized 3-S System using Cellular Light Weight Concrete Slabs & Precast Columns (Precast/prefab) and (iii) Monolithic Concrete Construction System using Plastic – Aluminium Formwork, initially in the Metropolitan Cities of India, where the value of works is Rs.100 crore or more.

2. The matter has been considered further. It has been now decided that the aforesaid new technologies may be mandatorily adopted for all projects across the country, irrespective of location and project cost **with effect from 01.04.2017**. In case, it is not found feasible to implement these provisions in a particular project, specific permission should be accorded by DG, CPWD/CMD, NBCC/Vice Chairman DDA respectively on case to case basis, with detailed justification.

3. This has the approval of Hon'ble UDM.

(J. Roy Chowdhury)
Deputy Secretary (Works)
Tel. No. 23062425

To
1. Vice Chairman, DDA, Vikas Sadan, INA, New Delhi-110023.
2. Director General, CPWD, Nirman Bhawan, New Delhi -110011.
3. CMD, NBCC Limited, NBCC Bhawan, Lodhi Road, New Delhi-110003.

Copy for information to :
1. PS to Hon'ble UDM, PS to Hon'ble MoS, PPS to Secretary(UD), PPS to AS(UD) & PPS to AS(SC).
2. All Joint Secretaries/Economic Adviser/OSD(UT)/JS&FA in M/o UD.
3. All Director/D.S. in M/o UD.
4. Office Memorandum file – US(W-3).
5. IT Cell for uploading in e-office.

Appendix - 12

CENTRAL PUBLIC WORKS DEPARTMENT
OFFICE MEMORANDAM
DG/DSR/011
ISSUED BY AUTHORITY OF DIRECTOR GENERAL, CPWD
NIRMAN BHAWAN NEW DELHI DATED 17/08/2016
OFFICE MEMORANDAM

Subject: Adoption of New & Emerging Technologies in projects/ Works of value not less than100 crores in Metropolitan Cities.

MoUD vide No. JS/Works/OM/2016 dated 30th May, 2016 has issued an office memorandum for use of following three technologies in CPWD works:-

1. Monolithic Concrete Construction System using Aluminium Formwork.
2. Industrialized 3-S system using Cellular Light Weight Concrete Slabs & Precast Columns (Precast/Prefab)
3. Monolithic Concrete Construction System using Plastic – Aluminium Formwork.

Adopting the above technologies, a Turnkey project item with scope and payment schedule is here by added to DSR 2016. The rates of the items are according to the scope of work as mentioned in annexure and are indicative only; the NIT approving authority may modify and add or delete these rates as per the work/ project requirements/conditions/scope.

Construction shall be done on turnkey basis by adopting monolithic concrete construction system using customized aluminium /plastic aluminium form, or industrialized system using partly / fully precast slabs, beams and columns (Precast / prefab) with cast in situ joints for the superstructure and cast in situ methodology for foundation.

Payment shall be made stage wise; a payment schedule is provided as guideline. Payment schedule is indicative, NIT approving authority shall further breakup the payment stages but above percentage limits must not be exceeded for any particular stage.

The industrialized 3-S system using Cellular Light Weight Concrete Slabs & Precast Columns (Precast/Prefab) is restricted up to seismic Zone IV only.

The technology is new and idea of turnkey project/work based on these technologies is not experienced by the CPWD hence experience/suggestions/ inputs are also invited for future refinements.

This issued with the approval of DG, CPWD.

17.08.16
(Kunwar Chandresh)
Executive Engineer
CSQ, CPWD, Nirman Bhawan, New Delhi

No.133/SE(TAS)/CS-DSR-2016/2016-17/ 198-E Dated: 17.08.2016
Copy to: All the SDG/ADG/CEs/CPMs through CPWD website http://cpwd.gov.in

17.08.16
Executive Engineer
CSQ, CPWD, Nirman Bhawan, New Delhi

S.No.	Item	Unit	Rate in Rs.
1	**TURNKEY PROJECTS (Item)** Construction of multi-storeyed RCC residential buildings six storeys and above including planning and designing by incorporating stipulated specifications, internal and external services (E&M and Civil), external development, horticulture works on design built and handover basis adopting monolithic concrete construction system using customised aluminium/plastic aluminium form, or industrialised system using partly/fully precast slabs, beams and columns (Precast/prefab) with cast in situ joints for the superstructure as detailed in the Annexure all complete		
	1.1 Foundation work upto plinth level (without basement) (Complete in all respect as detailed in Annexure).	Per sqm of plinth area of ground floor	
	1.1.1 Isolated footing		4620
	1.1.2 Raft foundation		10110
	1.1.3 Pile foundation		14610
	NOTE: NIT approving authority will pick up any one type of the foundations. Rates of raft foundation not to be included in single basement.		
	1.2 Single Basement (Complete in all respect as detailed in Annexure) NOTE: Single basement rate includes raft foundation in addition to items in the Annexure.	Per sqm of plinth area of basement	17770
	1.3 Stilt portion (Complete in all respect as detailed in Annexure)	Per sqm of plinth area of stilt.	9440
	1.4 Super Structure (Complete in all respect as detailed in Annexure)	Per sqm of plinth area of superstructure	16820
	1.5 Development works (Complete in all respect)	Per sqm of area developed	*

* The scope and rate of development works shall be decided by the NIT approving authority as per requirements and site conditions.

NOTE:

1. These rates are indicative; the NIT approving authority may modify and add or delete these rates as per the work/ project requirements/conditions.
2. Development area means plot area minus plinth area at ground floor.
3. Mumty and appendages shall not be counted towards a storey.
4. The industrialised 3-S system using Cellular Light Weight Concrete Slabs & Precast Columns (Precast/Prefab) is restricted up to seismic Zone IV only.

Annexure

Scope of Work

The work shall be executed on Turnkey (Design, Built and handover) basis from conception to commissioning, including all services (E&M and Civil), in situ & pre cast RCC components, in accordance with layout plan and architectural / structural / Services / landscaping / Horticulture works drawings. All drawings shall be prepared by the contractor and got approved from CPWD and also from the statutory bodies. However, the scope of the work shall include but not limited to as under.

1. PLANNING

1.1 Architectural Planning.

1.1.1 Architectural planning shall be done by the agency on the basis of requirement and Architectural control parameters supplied by CPWD Architect / Senior Architect / Chief Architect based on local byelaws/government norms, OM No. 22011/01/2008-W3 DG/Arch/6 dated 07/08/2013 etc. (NIT approving authority to give these parameters in NIT)

1.1.2 All Architectural provisions shall conform to local byelaws, ECBC and minimum three star GRIHA rating. Presentation drawings including 3D modeling, walk-through and building models may be prepared by the contractor to obtain approval from CPWD before submitting it to local bodies / authorities.

1.1.3 Contractor has to obtain all required statutory approval before starting the construction works from authorities concerned for example local bodies, NGT, PCBs, Ground water board etc.

1.1.4 Contractor shall carry out site survey of its own to verify the details including dimensions and levels of the available site.

1.2 Structural Design

1.2.1 Structural designs shall be carried out by the contractor based upon approved Architectural designs / drawings.

1.2.2 Structural design shall be done in accordance to National building code 2005 and referred IS Codes therein; International good practices and sound Engineering practices in that order of precedence.

1.2.3 All structural designs shall be got proof checked from agency to be decided by NIT approving authority.

1.2.4 The soil investigation shall be carried out by the contractor as per IS codes before commencing the design works.

1.3 Planning and designing of Mechanical, Electrical and Civil services.

1.3.1 Contractor shall plan and design all possible services including Civil, Electrical and Mechanical services etc. as per site requirements and Architectural requirements conforming to relevant IS codes and local bye-laws.

1.3.2 Designs shall be got proof checked from agency to be decided by NIT approving authority.

1.4 Horticulture / landscaping works: contractor shall prepare Horticulture / landscaping works as per local byelaws and requirements specified.

2. CONSTURCTION

Construction shall be done on turnkey basis by adopting monolithic concrete construction system using customized aluminum/plastic aluminum form, or industrialized system using partly / fully precast slabs, beams and columns (Precast / prefab) with cast in situ joints for the superstructure and cast in situ methodology for foundation. The different component shown in schedule shall have the following scope.

2.1 Foundation up to plinth level - Construction of foundation shall be done as per the approved structural drawings.

2.1.1 Isolated footing (cast in situ) - It includes Excavation, lean concreting, reinforcing, shuttering and casting of footing, columns, beams up to plinth level as per the approved concrete design mix, all complete.

2.1.2 Raft foundation (cast in situ) - It includes Excavation, lean concreting, reinforcing, shuttering and casting of raft foundation, columns, and beams up to plinth level as per the approved concrete design mix, all complete.

2.1.3 Pile foundation - It includes all types of piles (Pre cast, bored cast in situ etc.), pile caps, including reinforcement, concreting, columns, and beams up to plinth level as per the approved concrete design mix, all complete.

2.2 Single Basement including foundation - Construction of Single basement includes excavation , leveling of surface ,lean concreting, reinforcement ,shuttering and casting by concrete of design mix as approved, all works required for raft foundation and all columns beams, slabs upto roof level of basement, including concrete retaining wall all around in the basement up to the basement roof height (Height of the basement taken 3.35 metre below soffit of beam),Pressurized mechanical ventilation system, Firefighting with sprinkler system, Automatic fire alarm system, lifts serving basement, Water proofing of basement, flooring and finishing with electrical light fittings drainage system

etc, all complete but excluding equipments pertaining to DG set , Air-conditioning, Substation.

2.3 Stilt portion - Construction of stilt includes flooring and finish as per the specifications with all services required in the stilt portion (E&M and Civil) including Fire fighting, Automatic fire alarm system, lifts serving stilt floor and finishing all complete with electrical lighting, fan fittings, internal services etc. all complete but excluding equipments pertaining to DG set , AC, Substation.

2.4 Super structure shall be constructed adopting monolithic concrete construction system using customized aluminum/plastic aluminum form, or industrialized system using partly / fully precast slabs, beams and columns (Precast / prefab) with cast in situ joints or any combination thereof including all internal Civil, Electrical and Mechanical services including plumbing ,drainage, fire fighting, fire alarm, lifts , lighting etc, all complete but excluding equipment pertaining to DG set , Air-conditioning and sub-station etc.

2.5 Development work - The scope of development works shall be decided by the NIT approving authority as per requirements and site conditions and accordingly rates are to be worked out based upon area to be developed.

2.6 Specifications / Amenities - The Specifications / Amenities shall conform to MOUD office memo OM No. 22011/01/2008-W 3 DG/Arch/6 dated 07/08/2013

2.7 The construction in general shall be carried out as per the CPWD Specifications Vol-I and Vol-II 2009

3. HANDING OVER

3.1 The contractor shall hand over the completed work / project to CPWD after removing all defects and after :

3.1.1 Obtaining completion certificate from local bodies.

3.1.2 Obtaining GRIHA certificate.

3.1.3 Water and sewer line connection.

3.1.4 Road / path connection.

3.1.5 Electricity connection.

3.1.6 Fire clearance certificate.

3.1.7 Obtaining certificate for lift operation.

3.1.8 And any such certificate / compliance that may be required as per prevailing Bye Laws, Rules / Regulations and Court Order / Judgment etc.

3.2 The contractor shall submit all such certificate and receipt to CPWD as mentioned above for their verification and acceptance.

4. Measurement:- Methodology of measurement shall conform to Annexure-III of CPWD Plinth Area Rates 01.10.12 (PAR 2012) for payment.

4.1 Foundation work upto plinth level (without basement) - Plinth area of the ground floor shall be measured for payment.

4.2 Single Basement upto plinth level - Plinth area of the basement floor shall be measured for payment. Considered height of single basement is minimum 3.35 meter below soffit of beam.

4.3 Stilt portion - Plinth area of the stilt floor shall be measured for payment.

4.4 Super Structure:-

4.4.1 Plinth area of the superstructure shall be measured for payment.

4.4.2 Plinth area of the stilt floor shall be measured separately for payment

4.5 Development works - Development area shall mean plot area minus plinth area at ground floor. Developed area shall be measured for payment.

PAYMENT SCHEDULE (Guidelines only)

S.No.	Description	Individual %age	Cumulative %age
1	Submission and approval of all architectural drawings, layout, building plans containing all details, specifications required for execution of work including development plans.	0.40	0.40
2	Submission and approval of foundation designs and complete structural drawings for superstructure, UG Tank complete and other works to be executed at site for its completion.	0.40	0.80
3	Submission and approval of all services plans from local bodies/Authorities etc.	0.10	0.90
4	EIA and Environmental Clearance	0.10	1.00
5*	Completion of structure work including foundation, superstructure and corresponding electrical and civil works etc.	50.00	51.00
6*	Finishing all complete including all civil ,electrical and mechanical works/services etc. fully functional	40.00	91.00
7	On completion of project	5.00	96.00
8	On handing over of flats as per scope of work.	4.00	100.00

(*) Payment schedule is indicative NIT approving authority shall further breakup the payment stages according to factual situation of project and for maintaining regular cash flow, but the sum total of percentages of the breakup stages shall not exceed the above percentage limits.

Appendix - 13

F.No.JS/Works/OM/2016
Government of India
Ministry of Urban Development

Maulana Azad Road,
NirmanBhawan,
New Delhi

Dated: 30/05/2016

OFFICE MEMORANDUM

Sub: Adoption of New & Emerging Technologies in construction work of value not less than Rs.100 crores in Metropolitan cities, undertaken by CPWD, DDA and NBCC – reg.

The subject of using Modern Technologies in the construction works of CPWD, DDA and NBCC under the Ministry of Urban Development has been under consideration of the Ministry. CPWD has recommended to MOUD, adoption of the following three Technologies, which are validated by Building Materials and Technology Promotion Council (BMPTC) under the Ministry of Housing and Urban Poverty Alleviation:

1. Monolithic Concrete Construction System using Aluminium Formwork.
2. Industrialized 3-S System using Cellular Light Weight Concrete Slabs & Precast Columns (Precast/ prefab)
3. Monolithic Concrete Construction System using Plastic - Aluminium Formwork.

2. CPWD has recommended that the adoption of the above 3 new technologies will result in the following benefits: -

(a) Significant reduction in air & noise pollution and construction waste
(b) Optimum use of water
(c) No use of timber/ plywood for shuttering
(d) Form finish elements, good workmanship, assured quality and durable construction
(e) Increased labour productivity due to working in controlled environment
(f) All weather site execution

(g) Cost saving due to compressed completion time and rental cost reduction

(h) Better site organization, utilization of resources

3. CPWD has stated that adoption of the above mentioned 3 technologies will ensure neat and tidy work place with minimal environmental pollution and will be in sync with the objectives of 'Swatch Bharat Mission'. Further, adoption of these technologies will result in skill up-gradation of workers.

4. Accordingly, the Ministry of Urban Development has decided that CPWD, DDA and NBCC would mandatorily adopt the 3 Technologies enumerated in para 1 above and validated by BMPTC at their construction sites initially in the Metropolitan Cities of India, and where the value of works is Rs.100 crores or more. It has also been decided that these organizations (CPWD, DDA and NBCC) will also invariably obtain Third Party Certification related to Green Building Concept from agencies recognized by MoEF, apart from installing rooftop solar power plants, wastewater recycling and rainwater harvesting in all such projects.

5. This issues with the approval of Hon'ble Minister for Urban Development.

B. Anand 30/5/16

(B. Anand)
Joint Secretary (W&H)

To

1. Vice Chairman, DDA, Vikas Sadan, INA, New Delhi- 110 023.
2. Director General, CPWD, Nirman Bhawan, New Delhi – 110 011.
3. CMD, NBCC Limited, NBCC Bhawan, Lodhi Road, New Delhi – 110 003.

Copy for information to :

1. PS to Hon'ble UDM, PS to Hon'ble MoS, PPS to Secretary(UD), PPS to AS(UD) & PPS to AS(SC).
2. All Joint Secretaries/Economic Adviser/OSD(UT)/JS&FA in M/o UD.
3. All Director/D.S. in M/o UD.
4. Office Memorandum file – US(W-3).
5. IT Cell for uploading in e-office.

Ps to JS(H)
114-C

Appendix - 14

SCHEDULE OF RATES ISSUED BY CPWD ON NEW TECHNOLOGIES

A - DELHI SCHEDULE OF RATES 2021 (VOLUME 2)

Code No.	Description	Unit	Rate ₹
26.1	Providing & fixing in position Phenol bonded Bamboowood flooring with planks of sizes 14mm thick, minimum 1800mm length and minimum 100 mm wide, in approved colour, texture and finish, having Performance Appraisal Certificate (PAC) issued by Building Materials & Technology Promotion Council (BMTPC). The flooring shall be fixed with tongue and groove interlocking system, with underlayment of 4mm thick expanded polyethylene foam sheets having density 40kg/cum, over prepared surface with necessary quarter round planks of size 1900mm x 18mm and door reducer of size 1900mm x 44mm, wherever required. The bamboowood planks shall have minimum density of 1000 Kg/cum & minimum Hardness 1000 Kgf. with Eco friendly UV coating, all complete as per direction of the Engineer in-charge.	sqm	5289.05
26.2	Providing & fixing in position Phenol bonded Bamboo wood in wall skirting with planks of sizes 14mm thick, 1900mm length (minimum) and 85mm wide(minimum), in approved colour, texture and finish, having Performance Appraisal Certificate (PAC) issued by Building Materials & Technology Promotion Council (BMTPC). The skirting shall be fixed with SS screws & rawl plugs, over underlayment of 4mm thick, expanded polyethylene foam sheets having 40kg/cum density over prepared surface. The bamboowood planks shall have minimum density of 1000Kg/cum & minimum Hardness 1000 Kgf. with Eco friendly UV coating, all complete as per direction of the Engineer in-charge.	sqm	5191.10
26.3	Providing & fixing in position Phenol bonded Bamboowood wall cladding at all height with planks of sizes 10mm thick, minimum 1800mm length and minimum 100 mm wide, in approved colour, texture and finish, having Performance Appraisal Certificate (PAC) issued by Building Materials & Technology Promotion Council (BMTPC), with necesasary profiled edges fixed with 40mm SS screws 5 nos in each tile to frame work made of second class teak wood of size 20x15 mm in centre of each tile and bottom and top of work height, 40x15mm placed at ends of each tile. The cladding shall be laid over backlayment of 1.00 mm thick expanded polyethylene foam of density 40kg/cum in two layers, first layer on wall surface before fixing wooden frame and second layer on frame under cladding. The bamboowood planks shall have minimum density of 1000 Kg/cum & minimum Hardness 1000 Kgf. with Eco friendly UV coating, all complete as per direction of the Engineer in-charge.	sqm	5609.20
26.4	Providing & fixing in position Phenol bonded Bamboowood panelled or panelled and glazed shutters for doors windows, clerestorey windows with pre-molded minimum 30mm thick planks, in approved colours, texture & finish. It shall have 10mm wide, 25mm deep grove to fit in panels.The bamboo wood shall have minimum density of 1000 Kg/cum, minimum Hardness 1000 Kgf. All styles and rails shall have profiled interlocking system locked in place by bamboo pins, all complete as per direction of Engineer in charge. (The panelling will be paid for separately).	sqm	5504.70

Code No.	Description	Unit	Rate ₹
26.5	Providing & fixing in position Phenol bonded Bamboo wood panelling of 10mm thick, in 25 to 40 mm thick panelled or panelled & glazed shutters for doors, windows, clerestorey windows, in approved colour, texture & finish. The bamboowood planks shall have minimum density of 1000 Kg/cum & minimum Hardness 1000 Kgf. The panels shall have profiled interlocking system locked in place with bamboo pins all complete as per direction of the Engineer in-charge. (area of opening for panel inserts excluding portion inside grooves or rebates to be measured)	sqm	3609.00
26.6	Providing & fixing in position 65 mm thick factory made door frame of Phenol bonded Bamboo wood (superior class, interior use), in approved colour, texture and finish.The bamboo wood shall have minimum density of 1000 Kg/cum, minimum hardness 1000 Kgf. The door frame shall have tenon & mortise interlocking system, to be fixed to the wall with 100 mm size G.I screws all a complete as per direction of Engineer-in charge.	cudm	255.60
26.6A	Providing, erecting, laying and fixing in position in 3.5 to 4 mm thick bamboo mat corrugated sheet (BMCS) as per IS: 15476-2004 in roofing with self drilling screws along with EPDM washers complete or with galvanized iron J or L hooks 8mm dia G.I. plain and bitumen washers etc, all complete as per direction of Engineer-in-Charge.	sqm	5188.65
26.6B	Providing and fixing in position ridges of 3.5 to 4 mm thick bamboo mat ridge cap (BMRC) as per IS: 15476-2004 in roofing with self drilling screws along with EPDM washers complete or with galvanized iron J or L hooks 8mm dia G.I. plain and bitumen washers etc, all complete as per direction of Engineer-in-Charge.	metre	4152.45
26.6C	Providing and fixing at all height false ceiling of 4mm thick phenol bonded Bamboo Mat board (595x595mm) conforming to IS:13958-1994 including providing and fixing of frame work made of GI angle 25x25x0.4 mm thick all around suitably fixed to wall with the help of dash fastener and hanger frame (600x600 c/c) made GI slotted Tee having powder coating on bottom side (30x25x0.3 mm thick for main member & 25x25x0.3 mm for cross member) connected to ceiling with 2.64mm GI wire and anchor fastener at every junction and also including cost of making openings for light fittings, grills, diffusers, cut outs made with frame of perimeter channels suitably fixed all complete as per direction of Engineer-in-charge.	sqm	3375.50
26.6D	Providing and fixing at Bamboo Mat board conforming to IS:13958-1994 for partition to frame by bucking or studding with screws etc. complete (Frames, backing or studding to be paid separately)		
	26.6D.1 3mm thickness	sqm	2443.15
	26.6D.2 4mm thickness	sqm	2800.10
	26.6D.3 6mm thickness	sqm	3339.65
	26.6D.4 9mm thickness	sqm	4236.20
	26.6D.5 12mm thickness	sqm	4869.90

Code No.	Description	Unit	Rate ₹
26.6E	Providing and fixing at all height wall panelling with phenol bonded Bamboo Mat board conforming to IS:13958-1994 including providing and fixing to frame work made of 50mm x 50mm hardwood plugs including cutting brick work and fixing in cement mortar and making good the wall etc. and also providing and fixing wooden moulded corner beading of triangular shape to the junction of panelling etc. with iron screws all complete as per direction of Engineer-in-Charge.		
26.6E.1	9mm thickness	sqm	4459.70
26.6E.2	12mm thickness	sqm	5095.05

Code No.	Description	Unit	Rate ₹
	NEW TECHNOLOGY ITEMS		
26.41	Designing, providing, installing and fixing factory finished custom designed cold form Light Gauge Steel Framed super structure comprising of steel wall panel, trusses, purlins etc manufactured out of minimum 0.75 mm thick steel sheet as per design requirements. The steel sheet shall be galvanized (AZ-150gms Aluminium Zinc Alloy coated steel having minimum yield strength 300-550 Mpa) conforming to AISI specifications and IBC 2009 for cold formed steel framing and construction and also as per IS: 875-1987, ISO 800-1984 and IS:801-1975. The wind load shall be as per provisions of IS 875 (part -III). LGSFS frame shall be designed as per IS: 801 using commercially available software such as Frame CAD Pro-11.7/ STAAD PRO-V8i/ ArchitekV2.5.16/ Revit architecture-2011 or equivalent. Proper usage of Connection Accessories like Heavy Duty Tension Ties, Light Duty Hold-ons, Twist Straps (to connect truss with wall frames), Strong Tie, Tie Rod, H-Brackets, Boxing Sections, L-Shaped Angles for better structural stability. The framing section shall be cold form C-type having minimum web depth 89 mm x 39mm flange x 11mm lip in required length as per structural design requirement duly punched with dimple/ slot at required locations as per approved drawings. The slots will be along centre line of webs and shall be spaced minimum 250mm away from both ends of the member. The frame can be supplied in panelized or knock down condition in specific dimensions and fastened with screws extending through the steel beyond by minimum of three exposed threads. All self drilling tapping screws for joining the members shall have a Type II coating in accordance with ASTM B633(13) or equivalent corrosion protection of gauge 10 & 12, TPI 16 & 8 of length 20mm. The frames shall be fixed to RCC slab or Tie beam over Neoprene rubber using self expanding carbon steel anchor bolt of dia as per approved drawings. design subject to minimum 12mm diameter and 121mm length conforming to AISI 304 and 316 at 500mm c/c with minimum embedment of 100mm in RCC (RCC to be paid separately) and located not more than 300mm from corners or termination of bottom tracks complete in all respects. The item also includes the submission of stability reports duly examined and issued by any NIT/IIT. The rate includes the concept design, detailed design, fabrication of sections, transportation, installation and all required fixing arrangement at site as described above.	kg	235.70

Code No.	Description	Unit	Rate ₹
26.42	Providing and fixing of external wall system on Light gauge steel frame work with outer face cement boards as per standard sizes fixed with self- drilling / taping screws / fasteners @ 60cm c/c of approved make. A groove of 2 mm to 3mm shall be maintained and grooves shall be sealed with silicon based sealant. The board shall be fixed in a staggered pattern. Screws shall be of counter sunk rib head of 1.60mm to 4 mm thick or 8 to 10 gauge of length varying from 25 to 45 mm and. Internal face 12.5 mm thick gypsum plaster board fixed on cement board as per standard sizes fixed with self-drilling / taping screws / fasteners @ 60cm c/c of approved make, proper taping and jointing to be done using fiber mesh tape and epoxy and acrylic based jointing compound for seamless finish.(cost of frame work to be paid for separately)		
	26.42.1 Outer face: Outer face having 6mm thick fiber cement board fixed on 9mm thick fiber cement board, Type A, as per IS:14862:2000 (high pressure steam cured) Inner Face :- 12.5 mm thick gypsum plaster board conforming to IS 2095:2011 fixed on 8 mm thick fibre cement board confirming to IS:14862:2000 of type B (High pressure steam cured)	sqm	3485.20
	26.42.2 Outer face: Outer face having 8 mm thick cement bonded particle Board fixed on 10 mm thick cement bonded particle board. (Termite, Fire and Moisture Resistance) as per IS 14276:1995. Inner face:-12.5 mm thick gypsum plaster board conforming to IS 2095:2011 fixed on 8 mm thick cement bonded particle board (Termite, fire and moisture resistance) confirming to IS:14276:1995)	sqm	2764.05
26.43	Providing and fixing internal wall panels on Light gauge steel frame work with 12.5mm thick gypsum plaster board conforming IS 2095:2011 fixed on cement board as per standard sizes fixed with self-drilling / taping screws / fasteners @ 60cm c/c of approved make, Screws shall be of counter sunk rib head of 1.60mm to 4 mm thick or 8 to 10 gauge of length varying from 25 to 45 mm. Proper taping and jointing to be done using fiber mesh tape and epoxy and acrylic based jointing compound for seamless finish.(cost of frame work to be paid for separately		
	26.43.1 Cement Fiber Board 8 mm thick as per IS 14862:2000 of type B (High pressure Steam Cured)	sqm	2170.40
	26.43.2 Cement Bonded particle board 8 mm (Termite, Fire & Moisture Resistance), as per IS:14276 : 1995	sqm	1920.20
26.44	Providing and fixing in all exterior face panels breathable vapour barrier underneath the cement fiber board as per National Building Code 2009 complete as per direction of Engineer-in-charge.	sqm	304.90
26.45	Supplying and installation of moisture resistant/fire resistant cement board as per standard sizes fixed with self-drilling / taping screws. Screws shall be of counter sunk rib head of 1.60mm to 4 mm thick or 8 to 10 gauge of length varying from 25 to 45 mm.		

Code No.		Description	Unit	Rate ₹
	26.45.1	Cement Fiber Board 6 mm thick as per IS 14862:2000 of type B (High pressure Steam Cured)	sqm	1226.20
	26.45.2	Cement Bonded particle board 8 mm thick (Termite, Fire & Moisture Resistance), as per IS:14276 : 1995	sqm	850.90
26.46		Providing and fixing in position, 200 mm thick factory made Expanded Polystyrene Core (EPS Core) wall panels consisting of EPS core sandwiched between two Engineered sheets of welded wire fabric mesh duly finished with shortcrete materials on outer faces. The fabric mesh shall be made of 3 mm dia G.I. wire mesh with 50 mm pitch in both the directions and on both faces of the wall, kept at 120-135 mm gap and connected by the zig zag G.I. wire of 3 mm dia at alternate row by welding (at an angle ranging from 50-70 degree) . The EPS core shall consist of 100 mm thick EPS of density not less than 20 kg/ per cum. Both the outer faces of the panel shall be finished by applying the layer of 50 mm thick cement mortar 1:3 {1 cement: 3 coarse sand (not having more than 40% stone chips of size upto 6 mm)} À with the help of shotcreting/guniting equipment etc at a pressure not less than 1 bar (100Kn/m2) and both surfaces finished with trowel. Fixing operations of wall panels shall be completed in all respect as per drawings and specifications and under the overall direction of the Engineer-in-charge.	sqm	3957.45
26.47		Providing and fixing in position, 230mm thick factory made Expanded Polystyrene Core (EPS Core) roof/floor panels made of 3 mm dia G.I. wire mesh with 50 mm pitch in both the directions and on both faces of panel, kept at 120-135 mm gap and connected by the zig zag G.I. wire of 3 mm dia at alternate row by welding (at an angle ranging from 50-70 degree). The EPS core shall consist of 100 mm thick EPS of density not less than 20kg/ per cum. The bottom side of the panel shall be finished by applying a layer of 60-65 mm thick cement mortar 1: 3 {1 cement: 3 coarse sand (not having more than 40% stone chips of size upto 6 mm)} À with the help of shotcreting equipment etc at a pressure of not less than 1 bar (100Kn/m2) and surface finished with trowel. The top face of the panel shall be provided and finished by applying 70-75 mm thick layer of cement concrete 1:1.5: 3 (1 cement :1.5 coarse sand : 3 graded stone aggregate 20 mm nominal size). Fixing operations of roof/floor panels shall be completed in all respect as per drawings and specifications and under the overall direction of the Engineer-in-charge.	sqm	4286.85
26.48		Providing and fixing of customized Aluminium form work for monolithic construction on RCC members with repetitive usage made up of aluninium sheets/plates of minimum 4mm thickness and grade 6061 (Type-6). The formwork comprises of (a) wall panel, roccker, kickerand internal soffit corner, external soffit corner, external corner, internal corner etc., (b) beam components i.e, beam side panel prop head for soffit beam, beams soffit panel, beam soffit bulk head and (c) deck components i.e. deck panel, deck prop, prop length, deck mid, soffit length, deck beam bar. The panels are held in position by a simple pin and wedge system that passes thorugh holes in the out		

Code No.	Description	Unit	Rate ₹
	side rib of each panel. The tolerance of finished panel shall not be less than (-1 mm) and shall conform to IS 14987-1999. Pins and wedges to be made of high grade hot dipped galvansied mild steel. This form work also comprises of M.S. angle iron, "Z" shaped brackets braced diagonally at 0.90 to 1.00 mtr. centre to centre on extrenal wall face just the level below on which to lay M.S. square tube panels (Challis) and guard railing supports to form working platform and 40 mm dia G.I. telescopic adjustable props to support deck formwork and beam soffit panels including de-shuttering the formwork from odd/even level to be shifted/lifted to next alterante odd/even level before which the points and shuttering surface to be thoroughly cleaned, pins greasing and shuttering surface oiling propoerly before fixing all complete including sealing of gap between kicker plates of wall panel and floors (if any) as per design of formwork as provided by shuttering supplier and as per direction of the Engineer-in-charge including filling and finishing the holes of varied sizes and shapes (left by keys/pins of aluminium form work shuttering while de-shuttering) with GP-2 cementeous polymer compound mixed with water in ratio prescribed by manufacturer to form consistent workable dough for pushing it in the holes upto full depth of wall using appropriate tools and finishing smooth all complete as per directions of the Engineer-in-charge.	sqm	924.60
26.49	Providing and fixing in position factory made EPS cement sandwich wall/roof/floor light weight solid core panels made of core material of EPS granule balls/beads (conforming to IS 4671:1984 and shall have density not less than 15kg per cum) adhesive, cement, sand, flyash and other bonding material in mortar state processed to form in a preset mould. The outer face on both sides of the panels will be non asbestos fiber cement board confirming to IS 14862:2000 or Calcium silicate board confirming to EN 14306:2009 of 5mm thick each. Panel shall be laid on 6mm thick cement mortar (1 cement: 2 fine sand) mixed with chemical adhesive of 0.5kg per 50kg of cement or shall be preferably fixed into 'C' channel made of 1.2mm thick MS plate screwed/fastenened to the slab/column/beam etc. The panel shall fixed vertically with tongue and groove joint and horizontally locked with steel bar between each other and floors and filled with cement mortar and adhesive. Panels should be used as floor & roofing with additional structural support, steel or RCC depending upon the design. All the operation shall be completed in all respect as per drawings, Manufacturers specifications and under the overall direction of Engineer-in-Charge (Cost of all the material is included except "C channel" which will be paid seperately).		
	26.49.1 Non load bearing panels 50mm thick of required size	sqm	1182.15
	26.49.2 Non load bearing panels 60mm thick of required size	sqm	1336.30
	26.49.3 Non load bearing panels 75mm thick of required size	sqm	1658.70
	26.49.4 Non load bearing panels 90mm thick of required size	sqm	1930.55
	26.49.5 Non load bearing panels 100mm thick of required size	sqm	2273.85

Code No.	Description	Unit	Rate ₹
26.50	Providing and fixing in position factory made non asbestos fibre reinforced aerated cement sandwich wall/roof/floor light weight solid core panels made of light weight cement concrete core composed of OPC cement, pulverized flyash, quick lime, cotton pulp & Gypsum in mortar state mixed with aeration agent in a preset mould. The outer face on both sides of the panels will be non asbestos fibre cement board confirming to IS 14862:2000. These solid wall panels are installed using Galvanized iron steel tracks/C channel of 1mm thick of required sizes as recommended by manufacturer's and fixed to floor and RCC soffit in plumb to each other with steel screw/ fasteners. The panel shall be fixed vertically with tongue & groove joint with cement based polymer modified jointing compound. The exposed surface finished with fibre mesh/glass fibre tape with polymer based jointing compound having superior flexibility. Panels should be used as floor & roofing with additional structural support, steel or RCC depending upon the design. All the operation shall be completed in all respect as per drawings, Manufacturers specifications and under the overall direction of Engineer-in-Charge (Cost of all the material is included except "tracks/C channel" which will be paid separately).		
26.50.1	Non load bearing panels 50mm thick of required size (minimum 4mm thick fibre cement board)	sqm	1357.75
26.50.2	Non load bearing panels 75mm thick of required size (minimum 5mm thick fibre cement board)	sqm	1575.50
26.51	Supplying of standard quality GFRG panel of 124 mm thickness with modular cavities purchased from GFRG panel manufacturing plant in the country, cut to required wall sizes and floor/ roof slab sizes in correct length and height, including cutting of door, window and ventilator opening as per the cutting drawing prepared by architects /design engineers for the construction of GFRG building and loaded in stillages for transportation to the construction site. Cost of panel includes security deposits, hire charges of stillages & jaws, cost of transportation in trucks/ lorries without any damages upto 300kms including all leads and lifts from GFRG manufacturing plant to construction site and unloading at site using suitable fork lift/ crane. (Payment shall be made on the basis of area of one side of panel without reduction of opening of door/ window / ventilator). For transportation above 300kms, additional charges to be paid.	sqm	1309.05
26.52	Erection of GFRG Panels in walls in all floors using suitable crane as per instructions of Engineer-in-Charge, as per cutting drawings and structural drawings, in perfect line and plumb, above RCC plinth beam/GFRG panel below and provide necessary lateral/ slanting support to keep the wall panel in safe position, providing & tieing of Reinforcement as per structural drawings and applying a coat of water repellant coating Zycosil/equivalent or equivalent product (1 Zycosil/equivalent compound :10 water) to saturation level over RCC plinth beam to provide water proofing treatment to joint between wall panel & plinth beam as per the guide lines / instruction by the engineer in charge. (Cost of reinforcement, water proofing of walls and plinth beam/GFRG panel below joints and installation of door/ window frames		

Code No.	Description	Unit	Rate ₹
	before filling of concrete shall be paid separately). The rate quoted shall include making provision for laying of lintels, beams, sunshades, staircase beams, lofts, plumbing work, electrical conduits and any structural insertion etc., as per the drawing and direction of the engineer in charge. The payment shall be made based on the actual exposed area (one side only) of the panel.The work shall be carried out as per the Special Conditions For Glass Fibre Reinforced Gypsum (GFRG) Structures mentioned in NIT.Note: i) When cutting panel, "A" side is to be for outside or external surface of respective external wall and B side is to be for internal surface of wall ii)Erection of panel is to be with reference to both building plan & cutting drawing by following notational mark indicated in the cutting drawing as well as notional mark written on each panel cut as per cutting drawing	sqm	234.80
26.53	Filling of empty cavities (as shown in the structural design drawing) with quarry dust mixed with 5% cement (by volume). After initial infill of 50 mm thick with M25 concrete at base/bottom of cavities to seal off, infill wall panel cavities in 3 stages as detailed below, (i) 1st pour / infill to be limited to 0.3 to 0.50 m height from bottom of the panel.(ii) 2nd Pour/ infill: infilling shall be done only after 90 minutes interval between successive pours. The maximum height of infill shall be restricted to 1.5m height or up to the top level of door / window.(iii) 3rd pour/infill: After an interval of 90 minutes of second pour, infill or pour the balance height up to the bottom of embedded RCC tie beam. Pour enough water just required to dampen the dry mix enough to form cake form after each stage.(cost of laying M25 concrete shall be paid separately)(If any rain falls in between any stages of concrete pour, make sure to cover the panel top to prevent ingress of water or water falling into the cavities. In case of water collection over the concrete inside the panel, drill 10mm hole in GFRG panel immediately above concrete filled level to drain out water before pour/in-fill of balance concreting)	cum	2375.90
26.54	Laying of GFRG panel as roof / floor slab panel and staircase panel using suitable crane as per instructions of Engineer-in-Charge, including providing support system with 25mm x 300mm-400 mm wide plywood, as runner with proper prop below proposed micro beams including(a) Cutting of top flange of panel to 180 mm wide (leaving 25mm projection on either side) to provide RCC embedded micro beam as per cutting drawings and structural drawings. (b) Reinforcement for micro beams and tie beams to be provided in position with proper anchorage as per structural drawings. (c) Provision for Electrical cabling, fan hooks and laying of pipes for plumbing work. (d) Concreting of Tie beam, micro beam and top of GFRG panels (50 mm thick) with M-25 cement concrete mix using coarse aggregate of size less than 20 mm including laying of 10 gauge 100x100 size weld mesh with 25 mm effective cover from the panel top.	sqm	238.45
26.55	Supplying and fixing 10 Gauge weld mesh of size 100mm x 100 mm for floor/roof slab concrete screed over the micro beams as reinforcement. The weld mesh shall be fixed as per drawing.	sqm	236.00

Code No.	Description	Unit	Rate ₹
26.56	Application of ZMB 60/equivalent solution (100 Kg ZMB 60/equivalent, 1 litre ZMB Nano Thinner, 20 litre water & 1 Litre Zycoprime/equivalent = 122 litre/kg) over already applied coat of Zycosil/equivalent & Zycoprime/equivalent solution on the top of all the RCC plinth beams by brush/spray coat before erection of GFRG over RCC plinth beams in GF. In the case of upper floors 150 mm wide on floor slab for all the external walls, bath/toilet/wet areas (3 hrs drying time) before erection of wall panel on upper floors including erection of parapet wall.	sqm	302.20
26.57	After erection of GFRG wall panels, seal all GFRG wall joints with paper tape temporarily. Water proofing treatment of vertical joints with Zycosil/equivalent water proofing Solution (1 litre of Zycosil/ equivalent & 20 litres of water stirred first & 2 litres of Zycoprime/ equivalent added and stirred (total 23 litres)) with 50 ml syringe till the gap and in filled concrete is completely saturated. After removing the paper seal, seal off the vertical joints with water proofing material "Grout RW/equivalent " (Sealing cost excluded.)	metre	85.15
26.58	Filling of joints between RCC plinth beam / floor slab and wall panel of external walls, toilet / bath room / wet areas walls on all floor and parapet wall over roof slab, stair case head room at the time of erection of GFRG panels with Grout RW/equivalent sealant compound after the erection of panel before the infill of concrete in panel cavities and fine finish. This applies for all horizontal and vertical joints between GFRG wall and slab panels.	metre	41.55
26.59	Water proofing treatment of Vertical joints (of external side and internal side) between door frame, window & ventilator frames (on all four sides) of outer wall over the Zycosil/equivalent & Zycoprime/equivalent solution already applied (before the installation of door / window / ventilator frames in position) and fine finish with Grout RW/equivalent.	metre	42.35
26.60	Water proofing treatment of RCC sunshade with Zycosil/equivalent water proofing Solution (1 litre of Zycosil/equivalent & 20 litres of water stirred first & 2 litres of Zycoprime/equivalent added and stirred (total 23 litres)) till it meets the saturation level and testing as per RILEM or by water drops test in which water drops do not absorb but drops remain or rolls.	sqm	135.80
26.61	In-filling / sealing of joint between RCC lintel cum sunshade and wall (on external side) in all floors by pushing in Grout RW/equivalent in paste form and coving 20 mm x 20 mm after applying a coat of Zycosil/equivalent & zycoprime/equivalent solution before cement plastering of top, bottom and sides of RCC sunshade.	metre	42.35
26.61	In-filling / sealing of joint between RCC lintel cum sunshade and wall (on external side) in all floors by pushing in Grout RW/equivalent in paste form and coving 20 mm x 20 mm after applying a coat of Zycosil/equivalent & zycoprime/equivalent solution before cement plastering of top, bottom and sides of RCC sunshade.	metre	42.35

Code No.	Description	Unit	Rate ₹
26.62	Designing, Providing, installing and fixing factory finished customed design pregalvanized high tensile steel joists manufactured from G350 Z275 confirming to IS:277-1992, minimum coating of galvanizing 275 gm/sqm, minimum yield stress 35 MPa & minimum tensile strength of 380 MPa placed 1.23 metre apart to support the load of slab etc as per the design & directions of Engineer-in-Charge.	kg	141.45
26.63	Providing and fixing special adjustable lockbars of mild steel E-250 to support the temporary plywood for work between joists during construction as per design & directions of the Engineer-in-charge.	kg	22.35
26.64	Centering and shuttering with 12mm thick shuttering plywood confirming to IS 4990:2011 and removal of form at all heights. Plywood will be supported on lock bars.		
	26.64.1 Suspended floors, roofs, landings, balconies and access platform.	sqm	90.60
26.65	Providing and fixing roofing consist of 0.8 mm thick galvanized steel deck sheet confirming to IS 277:1992 used as permanent shuttering over which MS wire mesh 3mm laid at 100x100 mm grid including edge trim covered with concrete. This metal deck will be supported on structural steel beam with shear studs. (Structural steel like Beam, column, joists etc. & concrete of different grade as per design will be paid separately).	sqm	1630.40
26.66	Providing and fixing in position, 130 mm thick factory made Expanded Polystyrene Core (EPS Core) wall panels consisting of EPS core sandwiched between two Engineered sheets of welded wire fabric mesh duly finished with shortcrete materials on outer faces. The fabric mesh shall be made of 3 mm dia zinc coated G.I. wire mesh with 50 mm pitch in both the directions and on both faces of the wall and connected by GI wire of 3mm dia at alternate row by welding. The EPS core shall consist of 60 mm thick EPS of density not less than 16 kg/ per cum. Both the outer faces of the panel shall be finished by applying the layer of 35 mm thick cement mortar 1:3 {1 cement: 3 coarse sand (not having more than 40% stone chips of size upto 6 mm)} with the help of shotcreting/guniting equipment etc at a pressure not less than 1 bar (100KN/m2) and both surfaces finished with trowel. Fixing operations of wall panels shall be completed in all respect as per drawings and specifications and under the overall direction of the Engineer-in-charge.	sqm	2415.85
26.67	Providing and fixing of external thermal insulation and composite system with First layer of self-extinguishing type Expanded Polystyrene (EPS) insulation boards of 120 mm thick (max 1mX0.5m section), confirming to IS 4671:1984, having thermal conductivity of 0.034 W/mK, (measured as per IS 3346-1980), density of 20-24 kg/ m^3 measured as per IS 5688-1982, Fire retardant property self-extinguishing type as per EN 13501-1, bonded with special polymer modified cementitious adhesive confirming to EOTA ETAG 004 (European Technical Approval) formulated to bond polystyrene insulation boards to typical mineral substrate (according to ETAG 004) and Polypropylene mechanical fasteners with plastic pin		

Code No.		Description	Unit	Rate ₹
	sizes for services in slab element after achieving required strength, yard handling & stacking all complete as per approved shop drawings & design mix as per the direction of the Engineer-in-charge. (Cost of strands should be paid separately).			
	Note: Excess/less cement over the specified cement content used as per design mix is payable/recoverable separately)			
26.73.1	Concrete Grade-M-40 (cement content 400 kg)			
	26.73.1.1	100 mm thick hollow core slab	metre	1252.95
	26.73.1.2	120 mm thick hollow core slab	metre	1449.35
	26.73.1.3	150 mm thick hollow core slab	metre	1767.40
	26.73.1.4	200 mm thick hollow core slab	metre	2157.65
	26.73.1.5	250 mm thick hollow core slab	metre	2652.75
	26.73.1.6	300 mm thick hollow core slab	metre	3147.85
	26.73.1.7	350 mm thick hollow core slab	metre	3642.95
	26.73.1.8	400 mm thick hollow core slab	metre	4138.05
26.73.2	Extra for using M-50 (Cement content 425 kg) instead of M-40			
	26.73.2.1	100mm thick hollow core slab	metre	17.25
	26.73.2.2	120mm thick hollow core slab	metre	20.70
	26.73.2.3	150mm thick hollow core slab	metre	25.85
	26.73.2.4	200mm thick hollow core slab	metre	32.15
	26.73.2.5	250mm thick hollow core slab	metre	40.20
	26.73.2.6	300mm thick hollow core slab	metre	48.25
	26.73.2.7	350mm thick hollow core slab	metre	56.30
	26.73.2.8	400mm thick hollow core slab	metre	64.35
26.73.3	Extra for using M-60 (Cement content 440 kg) instead of M-40			
	26.73.3.1	100mm thick hollow core slab	metre	27.60
	26.73.3.2	120mm thick hollow core slab	metre	33.05
	26.73.3.3	150mm thick hollow core slab	metre	41.35
	26.73.3.4	200mm thick hollow core slab	metre	51.45
	26.73.3.5	250mm thick hollow core slab	metre	64.35
	26.73.3.6	300mm thick hollow core slab	metre	77.25
	26.73.3.7	350mm thick hollow core slab	metre	89.75
	26.73.3.8	400mm thick hollow core slab	metre	102.95

Code No.		Description	Unit	Rate ₹
26.74	Fabrication and manufacturing of solid precast concrete element with provisions of shear keys, connecting loops, dowel tubes and proper lifting accessories for walls, beams, slabs, stairs, column etc, of various thickness, shape and size of different concrete grades manufactured in controlled factory environment with approved methodology including moulds (Pallet system, Tilts form, table moulds, battery moulds, vertical moulds, beam moulds, column moulds, staircase moulds, Facade mould, etc.), mixing, transporting and placing of concrete, vibrating, curing, finishing, making necessary cutout/holes of required sizes for services, yard handling & stacking all complete as per IS 11447:1985 and as per approved shop drawings and design mix as per the direction of Engineer-in-Charge (Cost of reinforcement, Mechanical, Electrical and Plumbing inserts will be paid separately).			
	26.74.1	Concrete grade M-35 (Cement content 370 kgs)	cum	19488.05
	26.74.2	Extra for using M-40 (Cement content 400 kg) instead of M-35	cum	229.80
	26.74.3	Extra for using M-50 (Cement content 425 kg) instead of M-35	cum	421.35
	26.74.4	Extra for using M-60 (Cement content 440 kg) instead of M-35	cum	536.25
26.75	Providing & laying in position Prestressing steel strands (low relaxation) on hollow core bed by using mechanical pulling arrangement like Rabbit/ Bed master including all accessories for Stressing & destressing operations as per approved make conforming to IS1343 & grade FY-1860 etc, complete as per drawings and direction of Engineer -in-charge.		kg	147.05
26.76	Transportation of Precast Elements by flat bed Trailor (Double / Triple axle 40ft Length with proper accessories like A frame etc) from factory, including the cost of loading , unloading & stacking at site with the help of required capacity cranes.			
	26.76.1	Lead within 15km	MT	464.80
	26.76.2	Add/Deduct over item 26.76.1 for every additional lead of 5 km	MT	103.00
26.77	Erection & Installation of Precast/Prestressed Concrete elements in correct & final position with proper line level and plumb at site making all arrangements (i.e cranes, push-pull jacks & all another T & P for lifting Placing & Alignment of elements, within erection tolerance as per IS 15916 as per approved shop drawings and all complete as per the direction of Engineer-in-Charge but excluding the cost of sim pads, non shrink grout and steel works i.e hangers. All work up to fifth floor.			
	26.77.1	Prestressed hollow core Slab up to 200 mm thickness	sqm	169.65
	26.77.2	Prestressed hollow core slab above 200 mm up to 400 mm thickness	sqm	288.05
	26.77.3	Solid concrete wall elements	cum	2284.75

Code No.	Description	Unit	Rate ₹
26.78	Providing & Applying weather proof sealant on outer joints of approved make confirming to IS & directed by Engineer-in-charge.		
	26.78.1 Sealant 25mmx10mm at joints	metre	152.50
26.79	Providing & Laying of levelling sim pads required sizes (5x5cm to 10x10cm) of PVC / Rubber to adjust level of bearing surface of supporting members as per the direction of Engineer in charge.		
	26.79.1 2mm thick	each	24.30
	26.79.2 5 mm thick	each	31.00
	26.79.3 10 mm thick	each	44.35
26.80	Providing & Grouting of dowel tubes / Shear keys / Joints of precast members with M-60 grade cementitious grout (Non Shrink) of approved make by suitable means (Free flowing /pump),curing etc. Complete as per directions of Engineer-in-charge. (The payment shall be made on the basis of actual weight of approved grout injected.)		
	26.80.1 Stirrer mixed cementitious grout (non shrink) of approved make in dowel tubes / Shear keys / Joints of precast members.	kg	76.70
26.81	Providing and fixing Scaffolding net of required width made of high density Polyethylene UV stabilized knitted on warp knitting machines having density 100grams/sqm and shading coefficient minimum 75% around the construction site/ for vertical extension as per requirement including fastening/tying with building/scaffolding pipes or with any other fixtures etc. complete as per direction of Engineer-in-Charge. (One time payment shall be made for providing Scaffolding net from start of work till completion of work including shifting if any. The Scaffolding net shall be the property of the contractor on completion of the work)	sqm	25.10
26.82	Providing and laying rigid EPS (cellular plastic material) blocks conforming to ASTM standards/specifications of minimum density 21.60 Kg/cum on floors, steps, stage etc. of required size and shape as per direction of the Engineer-in-Charge. This shall include the following operation. “The EPS blocks shall be cut to required shape and sizes including cuttings for passing of services, joined together with synthetic resin adhesives as per relevant specifications and packed/placed in position for stepped floor or platform formation. The top and sides surfaces to be provided with GI woven wire mesh of aperture 5.45 mm (with wire dia 0.90 mm) secured to EPS blocks with wire pins/clips. Horizontal top surface to be provided with 20 mm thick cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate upto 6mm chippings) and vertical surface to be provided with 12mm cement plaster 1:4 (1 cement : 4 coarse sand). The concrete/plastered surfaces so prepared shall be scratched with wire brushes to form burrs, so as to act as base for flooring or veneering/panelling to be done later as per approved design (which shall be paid for separately complete as per direction of the Engineer-in-Charge.	sqm	2027.65

Note: Kindly refer the latest Correction Slips / Circulars issued by CPWD on the above items.

Notes:

Notes:



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