Special Issue

निर्माण सारिका

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Municipal Solid Waste Management

bmtpc

निर्माण सामग्री एवं प्रौद्योगिकी संवर्द्धन परिषद्
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BUILDING MATERIALS & TECHNOLOGY PROMOTION COUNCIL
Ministry of Housing & Urban Affairs, Government of India

"Creating Enabling Environment for Affordable Housing for All"

6Rs for Sustainable Development by Hon'ble Prime Minister

- Reduce
- Reuse
- Recycle
- Recover
- Redesign
- Remanufacture

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From the Desk of Executive Director

Being promotional council to transfer clean & green housing technologies from lab to land, BMTPC publishes quarterly newsletter Nirman Sarika bringing out state-of-the-art systems along with good construction practices. To commemorate World Habitat Day of UN-Habitat, BMTPC publishes special edition of its quarterly newsletter Nirman Sarika on the theme chosen by UN-Habitat. This year's theme is **Municipal Solid Waste Management** which gels well with the Swatch Bharat Mission being implemented by the Govt. in mission mode to clean our cities.

Urbanization, Industrialization, Economic and Population growth have resulted in increased municipal solid waste (MSW) generation making waste management in India a major problem. MSW generation per capita in India ranges from approximately 0.10 kg per person per day in small towns to approximately 0.50 kg per person per day in cities. As per CPCB annual report of 2015-16, the total quantity of waste generation has been 135,198 tonnes per day (TPD), out of which 111,028 TPD is collected, 25,572 TPD is treated and 47,456 TPD landfilled. This indicates poor compliance of waste management rules by ULBs in India. The current situation is that India relies on inadequate waste infrastructure, the informal sector and waste dumping. Waste dumps have adverse impacts on the environment and public health. Open dumps release methane causing fires and explosions and is a major contributor to global warming. There are also problems associated with odour and migration of leachates to receiving waters. Uncontrolled burning of waste at dump sites releases fine particles which are a major cause of respiratory disease and cause smog. The impacts of poor waste management on public health are well documented, with increased incidences of nose and throat infections, breathing difficulties, inflammation, bacterial infections, anaemia, reduced immunity, allergies, asthma and other infections. Therefore, sustainable and economically viable waste management ensuring maximum resource extraction from waste, combined with safe disposal of residual waste through the development of engineered landfill and waste-to-energy facilities is call of the day.

The UN Environmental Programme defines landfill as the controlled disposal of MSW on land in such a way that contact between waste and the environment is significantly reduced, with waste disposal concentrated in a well-defined area. Engineered landfill allows the safe disposal of residual MSW on land, but protects ground and surface water from pollution and avoids air emissions, wind-blown litter, odour, fire hazards, problems with animals, birds and other pests/rodents, and reduces greenhouse gas (GHG) emissions and slope instability issues. Properly managed engineered landfills should replace dumps in India. This would significantly reduce the environmental impact of waste.

Waste-to-energy technologies produce energy, recover materials and free land that would otherwise be used for dumping. The most widely used waste-to-energy technology for residual waste uses combustion to provide combined heat and power. Adopting maximum recycling with waste-to-energy in an integrated waste management system would significantly reduce dumping in India. Waste-to-energy technologies are available that can process unsegregated low-calorific value waste, and industry is keen to exploit these technologies in India. Waste-to-energy development in India is based on a build, operate and transfer model. Increased waste-to-energy would reduce disposal to land and generate clean, reliable energy from a renewable fuel source, reducing dependence on fossil fuels and reducing GHG emissions. In addition, generation of energy from waste would have significant social and economic benefits for India.

Come, join & pledge together to keep India clean

(Dr. Shailesh Kr. Agrawal)

सत्यमेव जयते

HARDEEP S PURI
Minister of State (I/C)
Housing and Urban Affairs
Government of India

MESSAGE

The first Monday of October is marked as World Habitat Day and celebrated world over by United Nations to reflect on the state of our towns and cities and on the basic right of all to adequate shelter. It is also intended to remind the world that we all have the power and the responsibility to shape the future of our cities and towns. This year the United Nations has chosen *"Municipal Solid Waste Management"* as the theme of the World Habitat Day.

Rising incomes, rapidly growing urbanisation and changing lifestyles have resulted in increased volumes and changing composition of municipal solid waste in India. The volume of municipal solid waste is projected to increase manifold. The Swachh Bharat Mission, aims to make India open defecation free and 100% scientific management of solid waste by October 2019. Solid Waste Management Rules 2016 published by the Ministry of Environment, Forest & Climate Change, lay emphasis on decentralized waste management as an efficient, economical and sustainable option involving close stakeholder participation. The Ministry of Housing & Urban Affairs is taking various steps to create awareness about the decentralized solid waste treatment systems among various stakeholders including the ULBs.

I understand that Building Materials & Technology Promotion Council (BMTPC) is actively involved in utilisation of Construction & Demolition (C&D) Waste by way of publishing the Guidelines for Utilization of C&D Waste - for Construction of Dwelling Units & related Infrastructure in various Housing Schemes of the Government.

I am happy that BMTPC is bringing a special issue of 'Nirman Sarika' on the occasion of World Habitat Day.

I wish them success in their future endeavours.

(Hardeep S Puri)

New Delhi
25 September, 2018

सत्यमेव जयते

DURGA SHANKER MISHRA
Secretary
Ministry of Housing & Urban Affairs
Government of India

MESSAGE

The United Nation has chosen "Municipal Solid Waste Management" as this year's theme for World Habitat Day. This gives us an opportunity to look into the gigantic issue of collection, management and utilization of Municipal Solid Waste.

2. The present generation of municipal solid waste will exacerbate the problem if not handled effectively. Ideally, the infrastructure and delivery mechanisms for solid waste management, drainage, sewerage, and waste water treatment should be planned and implemented in a co-ordinated framework of a city development plan. An effective strategy for managing waste has to start with segregation of solid waste at the source of generation and the treatment of different components of the waste in appropriately different ways, thereby reducing the residual waste that may otherwise go to landfills.

3. Swachh Bharat Mission launched on 2nd October, 2014 aims to make India clean. This Mission, besides other activities, envisages processing of 100 percent solid waste generated in cities / towns by 2nd October, 2019 as key objective, which includes effective management of Construction & Demolition (C&D) waste also.

4. The Ministry of Environment, Forest and Climatic Change has notified Rules for Management of Construction and Demolition Wastes in 2016. Defining duties of Waste Generators, Service Provider and their Contractors, Local Authorities, State Pollution Control Boards, Central Pollution Control Board, Central & State Governments; the notification advocates for proper management of C&D wastes from collection to its proper disposal and use.

5. The traditional disposal mechanism for C&D waste in India is landfills, which has been a great cause of concern from environmental point of view in urban areas. With the ambitious schemes in the housing sector launched by Govt. of India, where it is envisaged to construct one million of houses by 2022 in urban sector, the amount of C&D waste generated will be several thousand metric tonnes. Therefore, it calls for a concerted effort to efficiently utilize this refuse with the know-how already available and make it a viable preposition for the construction sector.

6. All over the world, the useful materials from C&D waste are segregated and reused with little or no processing. The rest of the material can be recycled and gainfully utilized for manufacturing building materials such as aggregates, sand and components such as bricks, blocks, panels etc. The concept is not new and being practiced world over, however in India, it is about time to reorient our approach and treat this refuse as a resource.

7. I congratulate BMTPC for bringing out the Special Issue of their Newsletter "Nirman Sarika" on the occasion of the World Habitat Day to address important burning issues related to Municipal Solid Waste Management.

I wish BMTPC all the best in its efforts.

(Durga Shanker Mishra)

सत्यमेव जयते

SHIV DAS MEENA
Additional Secretary (AMRUT)
Ministry of Housing & Urban Affairs
Government of India

MESSAGE

Since 1986, World Habitat Day is being celebrated around the world to reflect on the status of our cities and towns and remind the world of its responsibility to shape the future of our cities and towns. Every year a new theme is selected which needs attention at all levels for implementation of the Global Urban agenda as well as achievement of Sustainable Development Goals. This year "Municipal Solid Waste Management" has been selected as the theme on World Habitat Day.

Solid waste management is a global issue as waste generation is increasing day by day, and is posing huge challenges to urban managers. Ministry of Housing and Urban Affairs, Government of India, through its flagship Mission Swachh Bharat Mission-Urban, has taken several initiatives to address this issue. Swachh Bharat Mission-Urban has made several strides in effective solid waste management in cities and towns of the country, especially by bringing behavioural changes.

The Government of India has launched the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) with the aim of providing basic civic amenities like water supply, sewerage, non-motorized urban transport, green spaces & parks for improving the quality of life in urban areas, especially of the poor and the disadvantaged. The focus of AMRUT Mission is on infrastructure creation for water supply and sewerage, that has a direct link to provision of better services to the citizens. AMRUT also has a reform agenda, comprising of 11 reforms spread over 54 milestones, which focusses on improving administrative, institutional and financial capacities of the Urban Local Bodies (ULBs). AMRUT reform agenda gives special thrust to sustainable development by encouraging the States and ULBs to take measures such as water conservation, reuse /recycling of water, rainwater harvesting, energy conservation, scientific management of waste, development of green spaces, etc.

I am glad to know that BMTPC, under Ministry of Housing and Urban Affairs, Govt. of India is bringing out a special edition of 'Nirman Sarika' on the occasion of World Habitat Day 2018 with a focus on this year's theme.

I take this opportunity to congratulate BMTPC and wish them every success in their efforts.

(Shiv Das Meena)

सत्यमेव जयते

V. K. JINDAL
Joint Secretary & Mission Director
Swachh Bharat Mission
Ministry of Housing & Urban Affairs
Government of India

MESSAGE

I am delighted to know that BMTPC is bringing out Special Issue of Newsletter "Nirman Sarika" on the occasion of the World Habitat Day with this year's theme of 'Municipal Solid Waste Management'.

In India, an estimated 62 million tonnes of Municipal Solid Waste is generated annually by 377 million citizens residing in urban areas. It is estimated that 165 million tonnes of waste will be generated by 2030 and 450 million tonnes by 2050, along with resultant public health and environmental challenges. We are also losing 1,240 hectares of additional precious land every year to accommodate un-processed municipal solid wastes. The challenge is further aggravated by limited capacities among our urban local bodies to address the issue of solid waste management, coupled with behavioural issues - indifference and apathy among urban citizens towards taking responsibility for managing their own waste.

The Swachh Bharat Mission-Urban (SBM-U) has as one of its objectives 100% scientific management of municipal waste in all statutory towns in the country. The key to Solid Waste Management lies in managing all stakeholders to segregate their waste at source and effectively managing the different waste fractions. Thus, the need of the hour is on building capacities of our ULBs to effectively 'manage' the Solid Waste, while parallelly investing time and effort in bringing about attitudinal and mind-set change among citizens. Swachhata not only leads to a clean and healthy environment, but also generates employment and entrepreneurial opportunities for economically weaker sections of the society, and ensures greater social equity through women's empowerment and dignity of life for all, thus creating a *Swachh*, *Swasth*, and *Samriddh Bharat* embodying the vision of a 'New India'.

Under the SBM (Urban), Government has introduced various interventions including the Swachh Survekshan surveys conducted through independent third party to foster healthy competition among cities. The Star rating initiative of MOHUA for creating Garbage Free Cities has provided further emphasis on effective solid waste management, leading to encouraging progress in the country's Solid Waste Management.

I congratulate BMTPC for being a partner with the Swachh Bharat Mission on this exciting journey towards a 'Clean and Garbage Free India'.

V. K. Jindal

Place: New Delhi
Date: 27.09.2018

(V. K. JINDAL)

सत्यमेव जयते

AMRIT ABHIJAT
Joint Secretary & Mission Director (Housing for All)
Ministry of Housing & Urban Affairs
Government of India

MESSAGE

Like past years, this year also the world Habitat Day will be celebrated on 1st Monday of October. This year's theme "Municipal Solid Waste Management" is very important as it affects all sections of the society in one way or other. In Indian context, it's relevance become more crucial because of rapid urbanization which leads to higher generation of municipal waste. Traditionally, in India, solid waste management has lagged behind in the priority of the cities authorities. As a result, most of the cities and towns are now facing environmental, health, pollution issues much more aggravated than ever before.

UN-HABITAT envisages cities to be "Waste-Wise" and act towards fulfillment of SDG-12 which targets among other things, environmentally sound management of all waste through prevention, reduction, recycling, reuse and reduction of food waste.

Hon'ble Prime Minister envisioned Housing for All by 2022 when the Nation completes 75 years of its Independence. In order to achieve this objective, Central Government has launched a comprehensive mission "Pradhan Mantri Awas Yojana – Housing for All (Urban)". The mission seeks to address the housing requirement of urban poor including slum dwellers. More than 54 lakhs houses have been sanctioned all over the country and construction is going on at a rapid pace. With construction of lakhs of houses in coming years, there will be increased municipal waste generation. The city administration will have to be ready with their Waste Management Plans accordingly and in synchronization with the Central and state Government schemes.

On this occasion, I am glad to know that Building Materials and Technology Promotion Council (BMTPC) under Ministry of Housing and Urban Affairs, Government of India, has brought out 'Nirman Sarika', a newsletter which focuses on the theme of this year's World Habitat day.

I congratulate BMTPC on publishing this special edition of 'Nirman Sarika' on this occasion and extend best wishes in their future endeavors.

(Amrit Abhijat)

सत्यमेव जयते

KUNAL KUMAR
Joint Secretary (Mission Director Smart Cities)
Ministry of Housing & Urban Affairs
Government of India

MESSAGE

The theme "Municipal Solid Waste Management" chosen for this year's World Habitat day is very appropriate & timely.

The generation of municipal solid waste per capita is increasing at a fast rate & projected to grow manifold in urban areas of the world including in our country. Considering the criticality of the issue, it has been addressed as a key issue in Sustainable Development Goals (SDGs), the Paris Agreement and the New Urban Agenda. In view of our commitment towards clean technologies, environmentally sound management of all waste through prevention, reduction, reuse, recycling and the reduction of food waste needs to be addressed. The Paris Agreement also includes action on waste management to reduce greenhouse gas emissions.

The Government of India has launched the Smart Cities Mission on 25th June 2015, with the objective to promote sustainable and inclusive cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions. It is needless to emphasize that solid waste management is one of the core infrastructure elements of smart city. The Smart Cities Mission is meant to set examples that can be replicated both within and outside the Smart City, catalyzing the creation of similar Smart Cities in various regions and parts of the country.

Several significant initiatives have been taken by Govt. of India, including Swachh Bharat Mission being implemented by Ministry of Housing & Urban Affairs, GoI and 'Solid Waste Management Rules, 2016' & 'Construction and Demolition Waste Management Rules, 2016' as notified by Ministry of Environment, Forest and Climate Change (MoEF&CC), GoI towards environmentally sound management of solid waste. The waste management rules enumerate duties of various stakeholders such as waste generators, MoEF&CC, various Central Ministries, State Authorities, Central Pollution Control Board, State Pollution control boards, ULBs, etc. in this regard. Concerted efforts by all stakeholders would help in achieving effective management of municipal solid waste.

I appreciate the efforts of BMTPC in bringing out the Special Issue of the Newsletter "Nirman Sarika" on the occasion of the World Habitat Day to address important issues related to Municipal Solid Waste Management.

(KUNAL KUMAR)

Municipal
Solid Waste Management

*Dr. Sunil Kumar**

"We won't have a society if we destroy the environment" is a well-known quote by Margaret Meal. This quote well suits in the present context. Human population in the wake of urbanization and to fulfill the basic needs of knowing or unknowingly is impairing the environment. Since the early decades, nature has been considered as a sink for all the different types of waste produced by the human civilization. Human activities contribute to all kind of pollution viz., air pollution, water pollution, etc. one of the most common but neglected sectors is solid waste which has a very deadly environmental concern.

Items which are discarded by a human after use on an everyday basis are known as solid waste (SW). Municipal solid waste (MSW) is a kind of waste which is generated from household or collected through street sweeping. MSW is highly heterogeneous. An average MSW contains a substantial amount of food waste, paper, plastic, metal, construction, and demolition waste, inerts, etc. According to the World Bank report (2018), the generation of solid waste in the year 2012 was approx. 1.3 billion tonnes which amount to a footprint of 1.2 kg/person/day. This report also estimated that by the year 2025, the MSW generation is expected to rise by 2.2 billion tonnes [1]. According to Ministry of Urban Development (MoUD 2016), CPCB reported that in the year 2014-2015, the total waste generated for 34 States and Union Territories was 1,43,449 TPD and out of the total waste generated, approx. 1,17,644 TDP (82%) of MSW was collected and 321,871 TDP (22.9%) was processed [2].

According to the information given by Ministry of New and Renewable, Government of India discussed on 04/01/2018 in Lok Sabha, it was found that on an average the solid waste generation from different states of India is approx. 1,45,626 million tonnes per day. The amount of solid waste generation in (MT/D) of different states is shown in fig nos. 1 through 3 [3].

According to the census of 2011, the progressive growth rate of MSW in India was found to be 407.64% which is quite high as compared to the progressive growth rate since 1911 [4-5]. The report published by the Shanghai Manual 2010 for the Sustainable Urban Development in the 21st century mentions that the world's waste production is expected to be approx. 27 billion tonnes per year by 2050, one-third of which will come from Asia. The major contribution is expected to be from China and India [6].

SDG Goals and the Waste Management

Thus, managing MSW properly has now become very essential and crucial parameter to deal with. Time has now come to achieve a solution for global sustainable development. One cannot achieve the Sustainable Development Goals (SDGs) without solving the problem of waste management. The SDG, in fact, is woven around the very concept of waste management. SDG 1 focuses towards no poverty concept; this correlates with the report published in the Waste Aid (2016). This report informs that 1%

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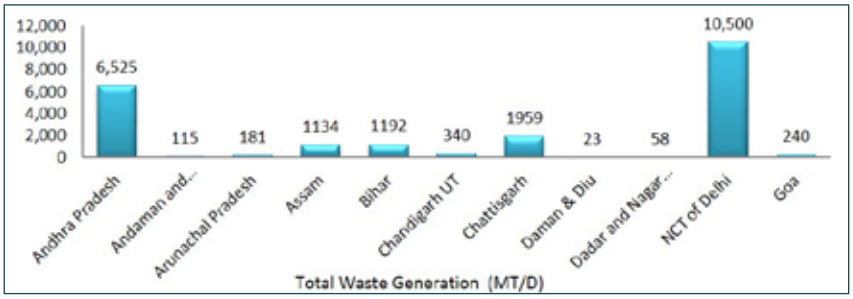

Fig 1: Total waste generated in MT/D in different states [3]

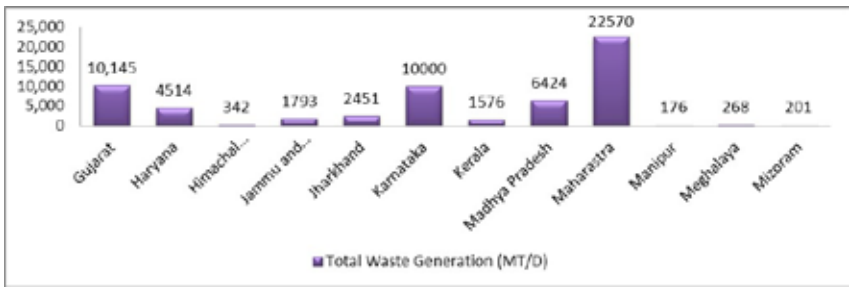

Fig 2: Total waste generated in MT/D in different states [3]

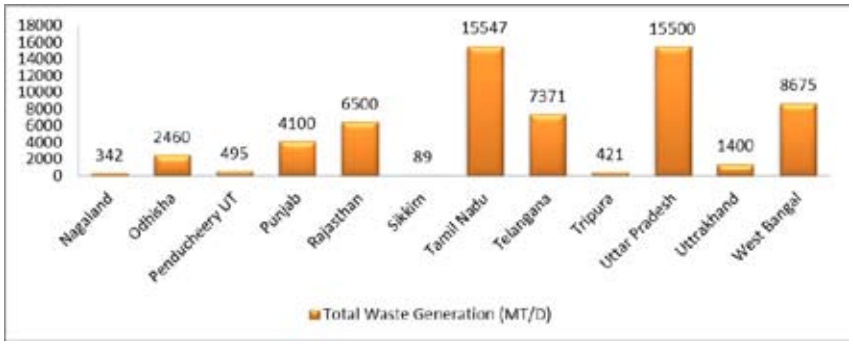

Fig 3: Total waste generated in MT/D in different states [3]

of the urban marginal poor population earn through recovering waste from the recyclable material present in the waste stream. The work output of formal and informal sector is working together to boost the economy satisfy SGD 8 (Decent Work and economic growth) and SGD 9 i.e. (Industry innovation and infrastructure: Recycling innovation is growing and scalable). The informal sector work effortlessly day and night, but are given not much credit. Even their health aspects are totally ignored. To justify their importance in society along with their health in concern the SGD 10 (Reduced inequality and SGD 17 (Partnerships for the goals) are formulated to look after them. Likewise, other development goals viz., SDG 3 (Good health and Well-being), SDG 13 (Climate Action) and SDG 6 (Clean water and sanitation) give emphasis on the solution to combat the adverse effect of MSW. To focus on the education and environmental awareness among the people and to enhance the importance of women in the waste management sector, two of the SDGs viz., SDG 4 (Environmental and health training and awareness) and SDG 5 (Gender Equality) is present in the SDG list [7].

Municipal Solid Waste Management (MSWM) in Developed and Developing Countries

Waste management practices prevail both in developed and developing countries. But when the condition of waste management for both is compared, then it is found that developing country still lacks in progress. The urban poor of the developing countries is especially suffered by the unsustainable waste management. Lower and middle-income countries always end the cycle of the MSW either through open burning or by unregulated dumping resulting in an array of problems [8]. Developing countries are also having a low collection of MSW due to irregular collection service. The problem and constraints associated with waste management in developing country are shown in Fig 4.

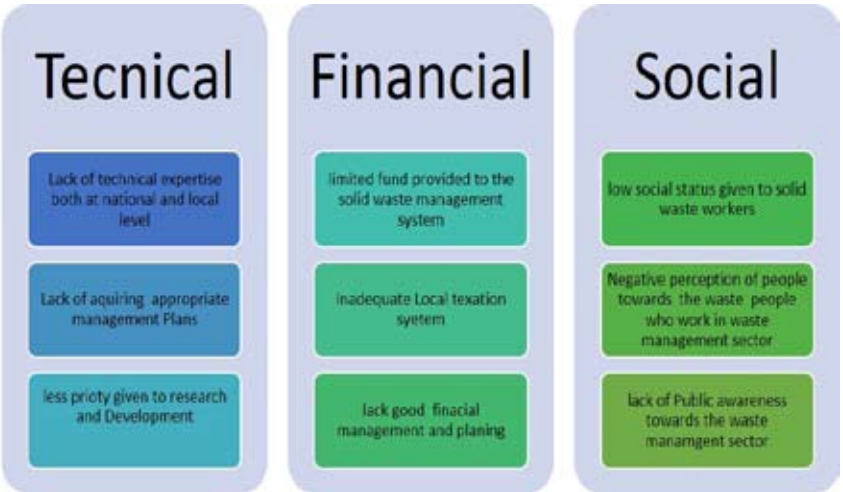

Fig 4: Technical Financial and Social Constraints of MSWM in developing Country [8]

Integrated Solid Waste Management Program to Mitigate the Problem of Waste Management

The developing countries immensely need integrated Solid Waste Management (ISWM). This management practice covers the complete life cycle of waste along with the information related to the environmental impacts and the financial aspects of the proposed waste management plan. Regarding economic and environmental benefits integrated municipal solid waste management (IMSWM) is the best methodology which can solve the consisted problem of waste management [9]. IMSWM considers both the direct factors, such as such as transformation, collection, treatment, and disposal and in direct factors viz., use of raw material and energy coming out of the waste. By considering both the factors, IMSWM also follows the 'Waste-Hierarchy Law.' IMSWM keenly considers the goal and focus of the waste management.

In the category of goal, IMSWM emphasized on the reduction of waste at the point source, Enhancement in the rate of recycling and reuse, promotion of the appropriate waste processing and it also encourages the safe disposal of the waste. IMSWM focus on the organizational setup and assesses the basic condition of the waste stream. It promotes 4R principle and also looks upon the coordination between NGOs and government bodies to keep running the SWM program without any hindrance. The tactical and Strategic planning system is also important in the waste management systems along with the IMSWM. Short and long-term planning should also be chock out properly while implementing an IMSWM [10].

Fig 5: The Aid provided by the World Bank to support Solid Waste Management Plans [11]

World Bank Global Aid towards MSWM

A municipal budget often comprises 20%-50% to have an effective waste management plan. The World Bank offers and advises on the SWM through its diverse services and range of products [11]. It emphasizes the entire life cycle of the waste. The World Bank supports capital investment to build up the basic infrastructure of the system. It also advises on sound policy and long-term planning. It also promotes the citizen engagement and uplifts the social inclusion through its projects [11].

The World Bank has spent over $4.7 billion in 340 solid waste management programs in different parts of the worlds since 2000 [11].

Conclusions

Solid waste plays an important role in attaining the sustainable goal. Post 2015-SDG, SWM sector is considered as a striving objective which is interconnected to the different SDG goals. A proper MSWM can help to provide sanitation, sustainable human settlement, and sustainable consumption. It can help to reduce the adverse effect on the climate change [12]. Proper MSWM considers the following aspects:

Along with the above aspects, enriched awareness of the decision-makers helps to achieve a sustainable solid waste management plan. An informed decision leads to sound socio-economic and industrial development. Encouragement of financial aids and tax incentives helps to develop recycling industries and business

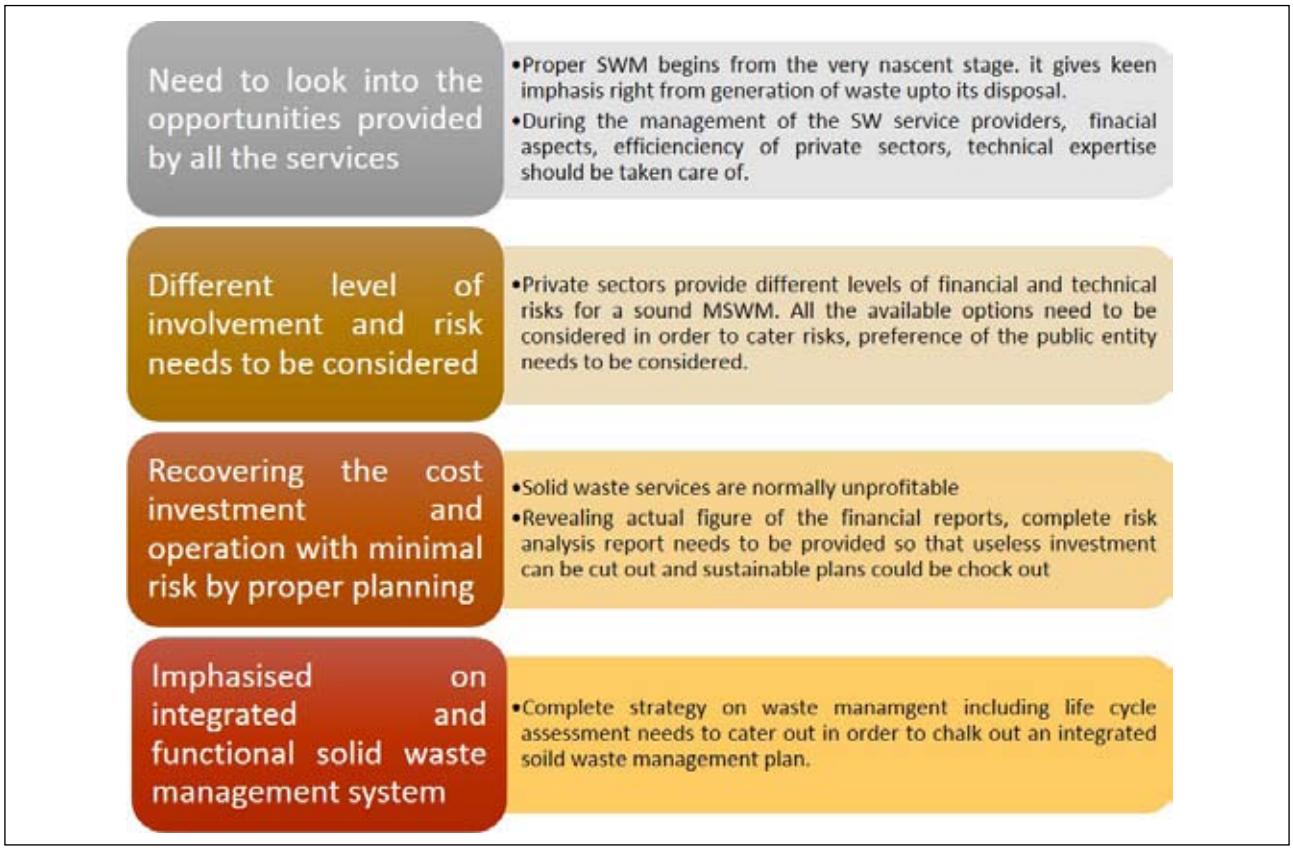

Fig 6: Aspects of Proper MSWM [12]

related to solid waste. A change of policy is required while transferring technology to the recipient countries so that the technology would be more beneficial in the recipient countries.

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Municipal Solid Waste Utilization for Development of Value Added Building Components

*Dr. Neeraj Jain** *Dr. A. K. Minocha***

ABSTRACT

The environmental problem arising from unscientific and indiscriminate disposal of municipal solid waste (MSW) is a real menace for the whole society. The provision of land filling for MSW management is not a primary solution, the technology and science has to play the major role in the successful implementation of waste management. It needs paradigm shift in vision in managerial concept to focus more on waste minimization or complete recycling of waste rather than getting rid of landfilling. As far as possible, the landfill step has to be omitted from the mind by giving more emphasis on 100% recycling of waste to achieve "Zero Garbage" strategy" in concurrence to Municipal Solid Waste (management and Handling) Rules. The MSW contains about 55-65 % of compostable material, 25-35 % of dry/recyclable materials and 15-20 % of inert material. The inert waste consist of demolition waste (bricks, concrete and stones) apart from gravel, silt, sludge, laminated plastic, polythene etc. which could be utilized as building material and filling of low lying areas. In the present studies, fraction of inert waste containing bricks and stones was successfully utilized as aggregate for development of low cost value added building components like road pavers and bricks as per Indian standard. The utilization of inert waste may give complete solution to the MSW issues and problems faced by the implementing authorities and also may be the road- map for future management of municipal solid waste in concurrence to municipal solid waste management and handling rules.

INTRODUCTION

Solid wastes are all the wastes arising from human and animal activities that are normally solid and that are discarded as useless or unwanted. These wastes are increasing day by day due to increase in population, urbanization and industrialization. A solid waste may be categorized in (i) municipal (ii) industrial and (iii) hazardous depending upon its source of generation. Municipal solid wastes (MSW) comprises of food wastes, rubbish, ashes and residues, demolition and construction wastes (inert waste), road sweeping waste, treatment plant wastes etc. The amount of MSW generated per capita is estimated to increase at a rate of 1-1.33% annually (Pappu et al., 2007, Bhide and Shekdar 1998 and Shekdar, 1999). It has been reported (Siddiqui et al., 2006 and Sharholy et al., 2005, 2008) that per capita MSW generation ranges from 0.2 to 0.5kg/day. The environmental problem arising from unscientific and indiscriminate disposal of municipal solid waste (MSW) is a real menace for the whole society. The provision of land filling for MSW management is not a primary solution, the technology and science has to play the major role in the successful implementation of waste management. It needs paradigm shift in vision in managerial concept to focus more on waste minimization or complete recycling of waste rather than getting rid of landfilling. As far as possible, the landfill step has to be omitted from the mind by giving more emphasis on 100% recycling of waste to achieve "Zero Garbage" strategy" in concurrence

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to Municipal Solid Waste (management and Handling) Rules. Waste minimization can be achieved in an efficient way by focusing on the 4Rs, "reduce", followed by "reuse" and then "recycle" and finally "recover". Recycling and recovery (treatment/processing) plays a large role in solid waste management. The inert which was previously thought of non-usable, now it is proved that it could be utilized completely with the help of proper studies. Studies have shown that inert waste could be utilized for brick manufacturing, road making, filling of plinth/ foundation and filling of low lying areas. In the present study, the inert waste (C & D) has been utilized in development of value added products like road paving blocks and bricks.

CHARACTERIZATION OF MSW

Samples of MSW were collected from a Kanpur based integrated MSW processing plant and characterized for proximate (Table 1) and ultimate analysis (Table 2). The Table 1 shows that maximum fraction of the MSW is wet organic material (55-65 %) which is processed for composting. The MSW also contains about 25-35 % of dry organic waste including negligible amount of recyclables like plastic, metals etc. The dry organic waste is used for making RDF blocks after making fluffs. The rest of waste (15-20 %) contains inert materials like brick, concrete, stones, gravel, silt, sludge, laminated plastic, polythene etc. The fraction of inert waste consisting of demolition waste could be utilized in value added products, road making, filling of plinth/ foundation and filling of low lying areas.

Table 1: Composition of raw MSW (proximate analysis)

Type of Material	*Percentage (%)
Compostable Material (wet organic matter)	59.0 % (55-65 %)
Fuel Material (Including textile, light and hard plastic, rags, rubber, paper etc.)	28.0 % (25-35 %)
Total Inert Material (Brick, concrete, stones, silt, glass, plastic etc.)	13.0 % (15-20 %)

* Values are on wet weight basis.

CHARACTERIZATION OF RECYCLED AGGREGATES

The inert waste collected was processed as aggregate to carry out the feasibility studies for development value added building components like road paving blocks and bricks as per Indian standard. After crushing the samples in a jaw crusher, grading for various sizes was carried out as per IS 383: 1970 and tested as per IS 2386: 1963. The various physical and mechanical properties of coarse (10 mm down) and fine aggregates (4.75 mm down) are given in Table 3 and 4 respectively. Cement (43 G) was utilized as binding material as per IS 8112: 1969 and stone dust (4.75 mm down) is used as fine aggregate.

Table 2: Average values of chemical analysis of MSW (ultimate analysis)

Parameters	Values*
pH	7.64
Organic Matter (%)	48.28
C (%)	27.98
N (%)	0.83
C/N ratio	33.71
K_2O (%)	0.65
P_2O_5 (%)	0.77
Moisture (%)	48.0
Calorific Value(kcal/kg)	1580
LOI (%)	39

* All values are given on dry weight basis except pH, moisture (on wet weight basis) and C/N ratio.

Table 3: Physical and Mechanical Properties of Natural and Recycled Coarse Aggregates

Parameters	Natural aggregate	Recycled aggregate
Flakiness index (%)	9.14	14.33
Elongation index (%)	12.88	16.90
Water absorption (%)	0.42	4.40
Specific gravity	2.70	2.37
Bulk density (kg/l)	1.57	1.36
Crushing value (%)	13.25	22.85
Impact value (%)	9.78	17.50
Fineness modulus	6.85	6.65

Table 4: Physical properties of natural (stone dust) and recycled fine aggregates

Parameters	Stone Dust	Recycled fine aggregate (RFA)
Specific gravity	2.74	2.49
Water absorption (%)	4.50	5.90
Bulk Density (kg/m^3)	1510	1240
Fineness modulus	2.48	4.10

FABRICATION OF PAVING BLOCKS

Two concrete mixtures of zero slump were used for fabrication of two layered interlocking paving blocks (M-35 Grade) of 200 mm x 160 x 75 mm size. The mix compositions and their designations used for control and recycled coarse aggregates (10 mm) were given in Tables 5. The fabrication of paving blocks was carried out using compaction method following the procedure and specifications described in IS: 15658: 2006. A hydraulic pressure of 50 tonnes was applied for 30 seconds on the mixture for compaction. After releasing the pressure, the paving block was removed from the mould, placed at room temperature for 24 h and then cured at a RH of over 90 % at room temperature (25±2°C) for 28 days. The cured blocks were tested for physical and mechanical properties. A photograph of fabricated paving blocks is shown in Fig. 1(a).

FABRICATION OF BRICKS

For fabrication of bricks, cement and fine aggregates were used in a proportion of 10 : 90 % by weight. Stone dust was replaced by 50-100 % of recycled fine aggregate. The mix compositions and their designations used for control and recycled fine aggregate replaced mixes are given in Table 6. The bricks of size 225 mm x 106 mm x 76 mm were fabricated as per specification of IS: 1077: 1992 by using vibration-compaction technique with a vibration time of 15 sec. The bricks were removed from the mould, placed at room temperature for 24 h and then cured at a relative humidity of over 90 % at room temperature (25±2°C) for 28 days. The cured bricks were tested for physical and mechanical properties as per procedure given in IS 3495: 1992. A photograph of fabricated bricks is shown in Fig. 1(b).

Table 5: Mix proportion of paving blocks

Mix designation	Proportion by weight (%)				
	Cement	Stone dust	NCA	RCA	W/C
A-0 (control)					
Top layer	33.3	66.7	---	---	0.32
Bottom layer	20.0	20.0	60.0	---	0.36
B-50	20.0	20.0	30.0	30.0	0.39
C-100	20.0	20.0	---	60.0	0.46

* NFA: natural fine aggregates; NCA: natural coarse aggregates; RCA: recycled coarse aggregates

(a) Road Paving Blocks (b) Bricks

Fig. 1: Photograph of fabricated (a) paving blocks and (b) bricks

Table 6: Mix proportion of bricks

Mix designation	Proportion (%) by weight			
	Cement	Stone dust	RFA	Water
A-0 (control)	10	90	----	11.0
B-50	10	45	45	12.0
C-100	10	----	90	13.0

* RFA: recycled fine aggregates

PHYSICAL AND MECHANICAL PROPERTIES OF PAVING BLOCKS

The physical properties like density, water absorption and abrasion of paving blocks are shown in Table 7. A perusal of table shows that water absorption was less than 6.0 in both the compositions (B-50 and C-100) having recycled aggregates meeting the requirement of IS: 15658.

The compressive strength of concrete paving blocks determined after 28 days of curing has been shown in Fig. 2. In general it depicts that the compressive strength is lower for blocks using recycled aggregates content as compared to control specimens and it decreases with increase the replacement percentage from 50 to 100 % of recycled aggregates content. This may be due to the extra amount of water added in mixtures containing recycled aggregates in addition to their inferior quality. The mixtures B-50 and C-100 can also be recommended for light traffic purpose as these are satisfying the minimum strength requirements of M-30 grade as per IS: 15658.

The 28-day flexural strength of paving blocks (Fig. 2) using recycled

Table 7: Physical properties of paving blocks at the age of 28 days

Mix designations	Density (kg/m³)	Water absorption (%)	Abrasion Δ_1 (±0.2 mm)
A0 Control	2210	1.5	2.2
B-50	2115	3.5	3.1
C-100	2045	4.2	3.5

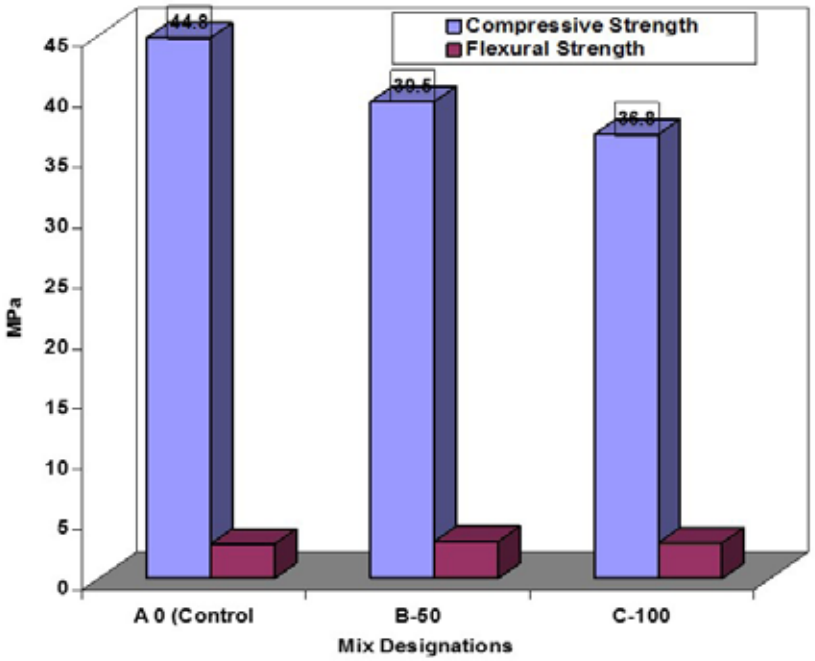

Fig. 2: Mechanical Properties of paving blocks

aggregates are higher than control specimens. Further, it is observed that flexural strength decreases with increase in recycled aggregate content. High flexural strength with recycled aggregates may be accompanied with the angular shape and rough surface of the recycled aggregates which is generally beneficial for good bond between the crushed aggregates and the cement paste as is reported by Dedieb and Kenai [7].

PHYSICAL AND MECHANICAL PROPERTIES OF BRICKS

Water absorption of bricks after 24 hours was calculated and results shows that percent water absorption increases with increase in recycled fine aggregate. Maximum water adsorption of 8.87 % is shown by B-100 mix at 100 % replacement while data reveals that the water absorption at 50 % replacement is 6.50 % which is comparable to control mix (6.40 %). The high water adsorption capacity of RFA mixed samples is due to its porous nature than stone dust. These results of water absorption were in compliance to IS: 1077 where water absorption shall not be more than 20 % by weight up to class 12.5 and 15 % for higher classes.

Fig. 3 shows the test results of the compressive strength of bricks after 28 days of curing. It has been observed that with the incorporation of 50-100 % of recycled fine aggregate, reduction in compressive strength takes place as compared to controls. Although this reduction is slight at 50 % replacement and the strength observed is 7.60 as compared to control mix (8.80). The strength observed at 100 % replacement by RFA is 5.75 MPa. However, it has also been observed that the compressive strength of all the bricks prepared using recycled fine aggregates meet the 28-day target strength as per IS: 1077 and was not less than 5.0 MPa in any case.

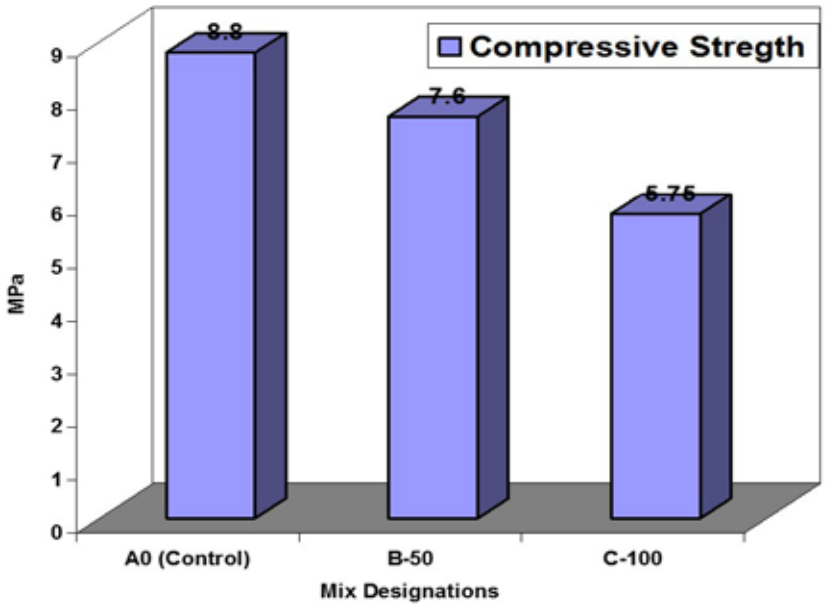

Fig.3: Compressive strength of bricks

CONCLUSIONS

Laboratory trials were carried out for fabrication of paving blocks and bricks from using recycled aggregates obtained from MSW. Based on the results, the following conclusions can be drawn:

1. The mixtures containing recycled coarse aggregates (50-100 %) can be recommended for development paving blocks for light traffic purpose.
2. Recycled fine aggregate may be utilized for partially replacement of natural fine aggregate in mortars for development of bricks.
3. Utilization of inert waste from MSW minimizes the quantity of wastes generated, increase the life of landfill liners, save natural resources as well as energy and provide low cost construction materials. The utilization of inert waste may give complete solution to the MSW issues and problems faced by the implementing authorities. The present solution also may be the road- map for future management of municipal solid waste in concurrence to municipal solid waste management and handling rules.

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Launch of Android and iOS Mobile Application on Earthquake Hazard Map of India - A joint initiative of NDMA & BMTPC

On the occasion of World Habitat Day celebrations 2017, Shri Hardeep S. Puri, Hon'ble Minister of State (I/C) for Housing & Urban Affairs, Government of India, launched the Android and iOS based Mobile App on Earthquake Hazard Map of India, in the august presence of Shri Durga Shanker Mishra, Secretary, Ministry of Housing & Urban Affairs on October 5, 2017 at Vigyan Bhawan, New Delhi.

The Mobile App on "Earthquake Hazard Map of India" has been developed by BMTPC. The Mobile App is available on the Google Play Store and Apple App Store for android and iOS users respectively. As a part of Digital India programme of Government of India, the Mobile App will be useful resource in providing necessary information with regard to earthquake zonation of the country to the professionals in particular and other users in general.

World Habitat Day

October 1, 2018

The United Nations designated the first Monday of October of every year as World Habitat Day to reflect on the state of our towns and cities, and on the basic right of all to adequate shelter. It also reminds us we all have the power and the responsibility to shape the future of our cities and towns.

This year's theme is Municipal Solid Waste Management, with the main global observance taking place in Kenya.

Solid Waste Management is an issue that affects everyone. The amount of waste being produced is growing daily, accounting for a large portion of local governments' budget and affecting public health. Poor solid waste collection and disposal results in uncontrolled dump sites and waste burning. It also leads to polluted air and water. A change in public attitudes to minimize waste and stop littering, the regularization of informal waste pickers, increased recycling and reusing, sufficient funding and solid waste planning including adequate landfill sites, can help cities to improve the current state of solid waste management and save money to become 'Waste-Wise Cities'.

The need for responsible Solid Waste Management reflected in several Sustainable Development Goals (SDGs):

- Make cities and human settlements inclusive, safe, resilient and sustainable. – SDG11
- Reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination SDG3
- Strengthen partnerships that focus on improving municipal solid waste management in our cities SDG17
- Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning. SDG13
- Responsible consumption and production patterns SDG12
- Improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials SDG 6

To improve Solid Waste Management, local governments need to:

- Develop solid waste management policies and plans with clear outcomes
- Increase budgets for waste management through landfill levies, increasing the proportion of municipal taxes and revenues allocated to SWM and using the "polluter pays" principle to charge households and businesses;
- Develop performance indicators for SWM such as percentage of waste generated, collected and disposed;
- Implement incentives for waste reuse and recycling;
- Provide options for segregating wet and dry waste in public spaces;
- Promote partnerships with the private sector and Community Based Organizations including youth

groups to provide waste management services;
- Ensure health and safety provisions for waste pickers

The private sector needs to:
- Partner with public institutions, businesses and local communities to collect, process or dispose of solid waste.
- Purchase and recycle recovered materials;
- Analyse the life cycle of materials produced or sold and build in incentives for reuse and recycling;
- Operate composting technologies/businesses;
- Set up recyclable collection system where customers can return reusables and recyclables with incentives;
- Ensure manufacturers and suppliers accept back reusable containers/items

Financial institutions and donors need to:
- Prioritise financing in solid waste management projects;
- Devise financial instruments to tap into the value of urbanisation;
- Support initiatives to strengthen the technical and financial ability of local authorities to properly manage solid waste management.

Schools need to:
- Introduce training and orientation on better waste management for teachers and pupils;
- Introduce waste sorting and recycling initiatives in schools;
- Increase student awareness through class projects using recycled materials;
- Educate parents to cooperate on initiatives such as banning single use containers/water bottles.

NGOs and CBOs can
- Carry out awareness raising to motivate residents to dispose of waste properly Encourage source separation and enhanced door-to-door collection especially in informal settlements
- Identify opportunities for utilizing waste as raw materials, composting to reduce the amount of organic waste disposed and generating employment opportunities.
- Actively engage with local authorities to prioritise SWM sector in their budget allocations.

Call for action – become a 'Waste-wise City'.
- Urbanization and economic growth is creating a potential "time-bomb" due to increasing amount of poorly managed solid waste impacting health and the environment;
- All cities regardless of size and financial capacity can improve their solid waste management to become 'Waste-wise Cities' to reduce costs and the impact of solid waste on health and environment;
- Cities and national government should empower and work with civil society and NGOs;
- Cities should learn from other cities and examine technological solutions implemented elsewhere;
- Cities should make long-term strategic plans for urbanization which fully consider solid waste generation, treatment (including recycling) and identify adequate space for future sanitary land-fill sites;
- Cities and national governments should design financial and other incentives that will promote a transition to a more circular economy, built around resource use and efficient recycling and reuse;
- Cities that improve their solid waste management and reduce their expenditure on waste management should be publicly recognized as "Waste-wise Cities".

Source: https://unhabitat.org/whd-2018/

Construction and Demolition Waste Management

*Dr. K. M. Soni**

The objective of the solid waste management plan including construction and demolition waste (C & D) is to save natural resources and reuse them for sustainable development. C & D waste is nearly one third of solid waste in India hence its management is extremely important as C & D waste mixed with municipal waste leads to non utilisation of municipal waste also for converting it into resource through energy production. Also, C & D waste without segregation cannot be recycled and thus complete solid waste is sent to landfill or dumping yard leading to creation of hills of such waste. Even fire and slide incidences have occurred in the country leading to severe accidents at such sites. Public residing near such dumping yards objects for dumping municipal waste now therefore there is a need to adopt effective solid waste management plan in the country.

Hierarchy of the effective solid waste management plan is prevention or reduction of waste generation followed by reuse, recycle, energy recovery and safe disposal. Unfortunately, last and least favoured method in hierarchy is mostly being followed in the country including for C & D waste management. Basic reason of not using C & D waste as a resource is public unawareness, mixing with municipal waste, non availability of C & D recycling plants and non-inclusion of the items produced from C & D waste in the schedule of rates. This has led to non-availability of recycling facilities in the country at large.

Realising the necessity, the Ministry of Environment, Forests and Climate Change (MoEF&CC), Government of India has notified "Construction and Demolition Waste Management Rules, 2016" for management of C & D waste vide GSR 317 (E) dated 29th March 2016 in which C & D waste generated by an individual, organisation or authority is also covered. The states are now required to submit their waste management policies. In the Rules, various government organisations have been made responsible for promotion and use of C & D waste also as a resource. Based on these Rules, Central Pollution Control Board (CPCB), Government of India has brought out guidelines on environmental management of C & D waste management in India recently in March 2017.

Few C & D waste recycling plants have already been installed in the country but considering large requirement such plants are required almost in every city.

C & D Waste Management

C & D waste means the waste comprising of building materials, debris and rubble resulting from construction, re-modelling/renovation, repair and demolition of any civil engineering structure. Most of the C & D waste is generated in the cities and towns due to redevelopment and construction activities.

C & D Waste Management Rules, 2016 classify C & D producing organisations into two categories as C & D waste generators and C & D waste bulk generators. Bulk generators are those generating C & D waste 20 tonnes or more in a day or 300 tonnes per project in a month. As they are generat-

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ing large amount of C & D waste, greater responsibility has been entrusted on them. They are required to segregate the waste into four categories as concrete, soil, steel - wood - plastic, and bricks and mortar.

Any solid waste management plan includes 3Rs i.e. reduce, recycle and reuse. Segregation is first step in the process. In case of C & D waste management, reuse is adopted by salvaging usable materials through "de-construction" technique in place of demolition, defined as planned way of taking out reusable materials from the structure before demolition thus selective demolition in which salvage, re-use and recycling of the demolished structure is maximized while "demolition" is breaking down structures either manually or by way of using mechanical force. It has been observed in Mumbai that the agencies engaged in demolition have already started adopting de-construction technique in demolition projects and sell salvaged materials for reuse in construction.

C & D waste management hierarchy pyramid is shown in Fig.1

Figure 1: C & D waste management hierarchy pyramid

where prevention is most preferred choice while disposal is the least. It must be understood that every material has embodied energy and water hence prevention and reuse saves energy, water and human effort. Though recycling requires additional energy and water but overall it is energy and water efficient compared to disposal in the landfill area. Disposal in landfill also requires considerable land which becomes unsuitable for construction of any civil engineering structure hence disposal is highly detrimental.

As may be seen in Fig. 1, prevention is most favoured option followed by minimization in C & D waste management plan. Deconstruction, reuse and recycling are the parts of a structure being demolished. Demolition also constitutes major component in C & D waste. Demolition becomes essential if the structure has become unsafe. Prevention and minimisation are possible only if structures need not to be demolished. A structure may need demolition if unsafe due to poor quality of construction or maintenance or non engineered unsafe construction before expiry of its useful life which must be prevented. Minimisation of C & D waste is possible if re-development is taken up only after expiry of useful life of structure and not for additional FSI allowed before or frequent renovations carried out without structural requirements.

Any structure requiring demolition before expiry of its useful life is undesirable. For example, carpeting of a road having a life of ten years if requires to be re-laid say in five years, it tantamount to creation of C & D waste of same quantities used originally. Similarly if a building having a life of 100 years needs demolition in 50 years, it creates same quantity of C & D waste as that of materials used in new construction. This happens due to poor quality of construction and maintenance. Unauthorised and non-engineered (un-designed or under designed) constructions (Fig. 2) also do not sustain for prescribed life and even collapse during normal loading or disasters thus creating large C & D waste. Thus, poor quality structures (Fig. 3) generating large quantities of C & D waste are to be stopped. Hence quality in construction and maintenance is pre requisite for prevention and minimisation of C & D waste and thus needs to be made part of C & D waste management policy.

C & D waste is also generated due to poor techniques adopted during construction and maintenance. For example, re-carpeting is resorted on roads mostly without recycling of original surface leading to raising the road level. Thereafter, footpaths, kerb stones and drains are relayed after demolition of existing structures resulting into generation of considerable C & D waste. Services are not laid in in-

Fig. 2: Non engineered unsafe structures

Fig. 3: Poor quality construction

tegrated way or through trenches even in new constructions. Trenchless technology though available is not adopted and road cutting resorted to. In some places, the structures are replaced without actual requirements just for utilisation of funds. Prevention of C & D waste can be minimised by following quality in construction and maintenance and minimisation through use of green technologies. Deconstruction and reuse of the materials in the works directly or after recycling help in saving natural resources as well generation of C & D waste.

C & D Waste Generation

Generation of C & D waste cannot be stopped altogether but quality management, material management and C& D waste management help in reduction of quantity of waste going to landfill and thus these are to be made of parts of C & D waste management plan. C & D waste management plan requires assessment of C & D waste generated. There is no standard assessment of C & D waste in India and data from different sources vary from 12-15 to 25-30 million tonnes per year or even more. As a rough assessment, C & D waste accounts for about 30% of solid waste in the cities which is quite high meaning thereby large demolition activities in the country.

It is estimated that new construction produces 11% waste in residential and 6% in non residential works while renovation 55% and 36% respectively. Demolition produces maximum waste as 34% in residential and 58% in non residential (Fig. 4).

As a thumb rule, 40-60 kg per sqm is the C & D waste in new construction so also in repair and renovation while in demolition it is 300-500 kg per sqm. Major constituents of Indian C & D waste include concrete, soil, bricks, wood, asphalt, and metal. Bricks and masonry, soil/sand and gravel constitute about 60% as per the data of recycling plant of Burari, Delhi. Concrete, brick masonry, and sand/gravel together are around 90%. Bhattacharya et al (2013) also reported from the study of a DST project that about 90% C & D waste is from concrete, bricks and tiles (Fig. 5). As per TIFAC (technology Information, Forecasting and Assessment Council, 2001, C & D waste in India constituents 36% soil, sand and gravel, 31% brick and masonry. 23% concrete, 5% metal, 2% bitumen, 2% wood and 1% others. Therefore major recycled materials are sand and aggregates and thus products manufactured from C & D waste are tiles, interlocking blocks, concrete blocks and kerb stones. More than 90% C & D waste can be reused and even slurry mixed with soil can be used for horticulture operations and producing mud bricks.

Recycling of C & D Waste

Recycling is next method after deconstruction and reuse. Segregation is first step of recycling hence habit of segregating different types of wastes has to be inculcated at

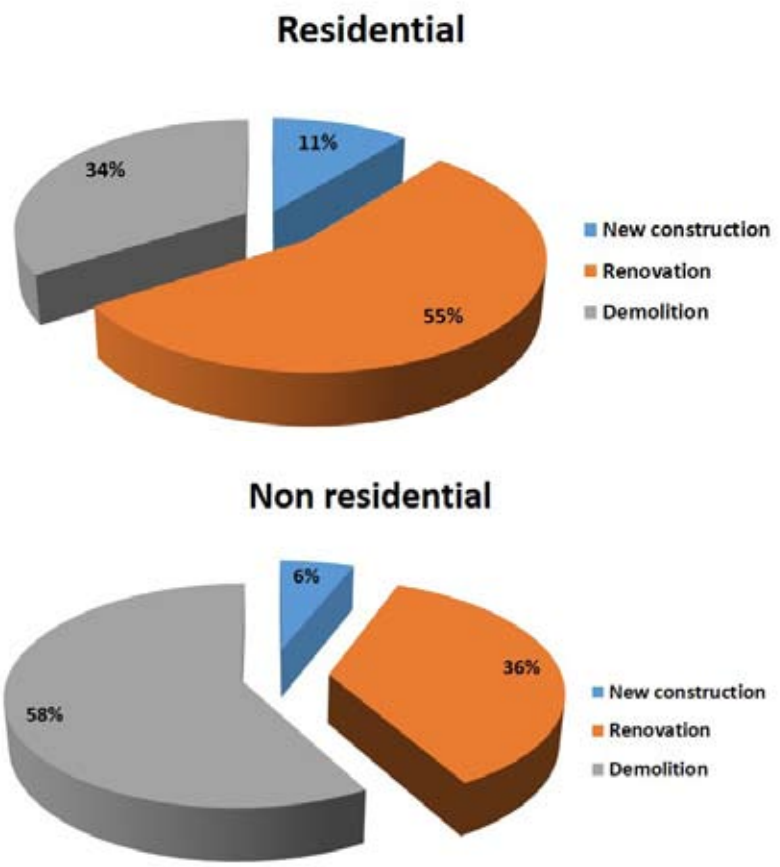

Figure 4: C & D waste in residential and non residential buildings

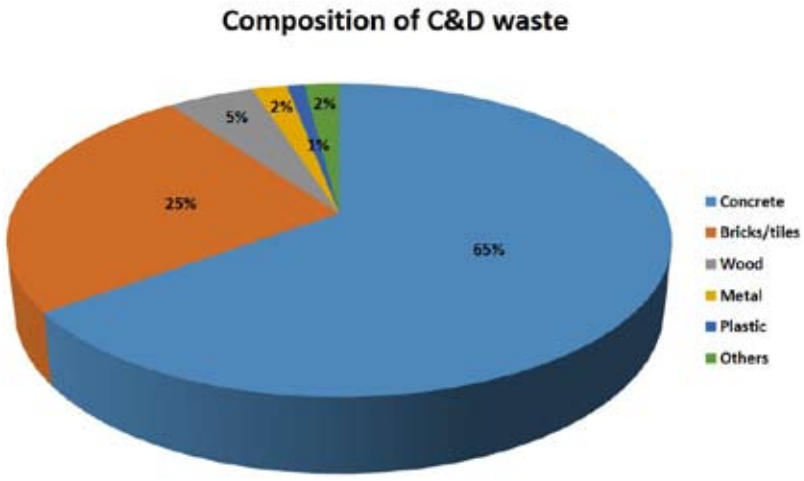

Figure 5: Composition of C & D waste

the level where the waste is generated whether home or construction place. Gradually Urban Local Bodies (ULBs) are now stressing on this aspect. Even Municipal Corporation of Greater Mumbai has issued notice to all residential colonies to segregate wet, dry and C & D wastes and they have stopped picking up mixed waste. CPWD has installed two organic waste converters in Hyderabad Estate, Mumbai for converting wet waste into manure. Till complete awareness is generated, ULBs have large responsibilities in segregation through incentives and awareness programmes. ULBs are also required to make available separate dumping yard facilities where public can dump small quantity of C & D waste, preferably along with municipal waste dumping facilities. From such dumping yards, C & D waste can be transported to the recycling plants. In absence of such facilities, C & D waste is dumped unauthorised into rivers, seas, lakes, roadsides etc. Some ULBs are already charging tipping fees from the agencies involved in construction, repair/renovation and demolition.

Recycling of C & D waste is essential as large demolition is expected in near future. Redevelopment of the government residential colonies constructed after independence upto late 1980s has started in various cities. Some of such colonies in Delhi are Moti Bagh, East Kidwainagar, Srinivaspuri, Mohammadpur, Sarojini nagar, Nauroji nagar, Netaji nagar, Kasturba nagar and Thayagraj nagar. Maharashtra Housing and Area Development Authority formed in 1977 has already permitted to redevelop its colonies in Mumbai. Therefore, recycling plants will be required to be installed at the site as well in the cities.

Three types of C & D waste recycling plants are available as mobile, semi-mobile and stationary. Mobile plants can be transported to the demolition sites and are suited to process only non-contaminated concrete or masonry waste. In the semi-mobile recycling plant, removal of contaminants is carried out manually and the end product is also screened and magnetic separation carried out for removal of ferrous materials.

In such a plant, quality of end product is better than that of a mobile unit though not capable to process mixed demolition waste containing matters like metal, wood, plastic etc. Stationary C & D waste recycling plant plants are capable of carrying out all the operations such as crushing, screening as well as purification to separate the contaminants. Operations required in recycling plants are sorting, crushing, classification/sieving and washing.

First C & D waste plant in India was set up in Burari, New Delhi in 2012 by Infrastructure Leasing & Financial Services Limited (IL&FS) in collaboration with Municipal Corporation of Delhi having a capacity of 2500 tonnes per day on PPP model collecting C & D waste from three designated zones from Karol Bagh, Sadar Paharganj and City. The waste is recycled into sand and aggregates and converted to Ready Mix Concrete (RMC), pavement blocks, kerb stones, and concrete blocks. Second plant of 500 MTP capacity is established in East Delhi, near Shastri Park. A plant has been set up in Ahmadabad having operating capacity of 300 TPD. Gurugram, Hyderabad and Greater Mumbai Municipal Corporations have planned C & D waste recycling plants which are likely to come soon. In Bangaluru, a private plant is installed with operating capacity of 1000 MTP and the corporation is also planning to install a plant. Many more plants are planned in various cities and in near future, C & D waste recycling plants may be operating in every major city. Hon'ble Supreme Court has also taken a note of submission of solid waste management policy by the states and thus environmental issues are going to take front seat in the country restricting and even ban on the use of sand mining, stone blasting and stone crushing by the courts and tribunals. Being a public issue, C & D waste management policies are likely to be monitored by the courts also.

Unfortunately, existing capacity of recycling C & D waste plants is almost negligible compared to the requirements. Government of India and state governments have already taken up various schemes of construction under various schemes like Smart cities, PMAY-Urban and Gramin, SBM, HRIDAY, AMRUT etc. Private and government construction under various budgeted schemes is also continuing. Further, renovation, repair and maintenance are recurring sources of C & D waste. Such infrastructure development is going to generate large amount of C & D waste requiring many C & D waste plants. Under PMAY-Urban itself, government has a target of 20 million houses. Even if 50 kg average C & D waste is generated per sqm of area and area of a unit is considered 30 sqm, new construction itself would generate 50*1000000*20*30/1000 tonnes of C & D waste. In such a case 67 number of 500 MTPD capacity C & D waste recycling plants operating for next 3 years would be required running for average 300 days in a year. In brief even if 30 million TPD waste is considered annually based on old data, it would require 200 plants of 500 MTPD capacity operating for 300 days in a year however even 10 plants are not in operation in the country.

Initiatives Taken by Government Organisations

Erstwhile Ministry of Urban Development directed states to setup C & D recycling facilities vide circular dated 28th June 2012 in all cities having population over 10 lakhs. Though more than six years have passed, country is yet to see the implementation of such directions. Now Swachh Bharat Mission (SBM) also recognises the need of C & D waste management. MoEF&CC included integrated waste management in various policies, reports and rules and notified "The C & D waste Management Rules, 2016" as mentioned before. These rules may have better impact as NGT and Courts may pass orders in case these are not implemented by the states. The Bureau of Indian Standards (BIS) and Indian Roads Congress have been made responsible under the Rules for preparation of codes using C & D recycled materials and products for wide acceptability and techno-feasibility.

BIS has included recycled aggregates in IS 383: 2016 "Indian Standard on Coarse and fine aggregate for concrete – specification (Third Revision)". These aggregates are classified of two types namely recycled aggregate (RA) made from C & D waste which may comprise concrete, brick, tiles, stone, etc. and recycled concrete aggregate (RCA) derived from concrete after requisite processing.

The code was revised in January 2016 permitting use of recycled aggregates up to 25% in plain concrete, 20% in reinforced concrete of M-25 or lower grade and up to 100% in lean concretes of grade less than M-15 as given in Table 1.

As per National Building Code, recycled coarse aggregate may be used in concrete for bulk fills, bank protection, base/fill of drainage structures, pavements,

Table 1: Provisions of IS 383:2016

C & D waste IS: 383	Plain concrete	Reinforced concrete	Lean concrete	Extent of utilization
Recycled Concrete Aggregate (RCA)	25%	20% (Only up to M 25 grade)	100%	As coarse aggregate
Recycled Aggregate (RA)	nil	nil	100%	As coarse aggregate
Recycled Concrete Aggregate (RCA)	25%	20% (Only up to M 25 grade)	100%	As fine aggregate

sidewalks, kerbs and gutters etc, and up to 30 percent of natural crushed coarse aggregate can be replaced by the recycled concrete aggregate which can be increased up to 50 percent for pavements and other areas specific to the standards and practices pertaining to construction of roads. Therefore, confidence is yet to be developed on recycled aggregates for their use in structural members.

Building Material & Technology Promoting Council (BMTPC) released "Guidelines for utilization of Construction & Demolition waste in construction of dwelling units and related infrastructure in housing schemes of the Government" in 2016.

Central Pubic Works Division (CPWD) issued "Guidelines for Sustainable Habitat (March 2014)". To address utilization of C & D waste, CPWD and National Building Construction Company have recommended use of recycled C & D wastes in their construction activities or if the same is available within 100 km from construction site. Recently, CPWD also issued instructions for use of products of C & D waste in Delhi. Makkar (2018) has reported use of blocks in Supreme Court additional office complex, New Delhi (Fig. 6) by CPWD, produced from C & D waste from Burari plant, Delhi. These blocks were used in external walls, toilet walls and lift well walls. These were tested and when the company was able to produce them of desired compressive strength of 10 MPa, they were used in the project. Pull out strength for the fasteners used in the project was also found satisfactory. The size of the blocks used was 400x200x100 mm and in total 17.50 lakh blocks were used. The supply of the blocks has to be ensured as per the requirements hence it is suggested that before stipulating in the NIT, supply should be ensured.

CPWD and Stiftelsen SINTEF signed an MoU on 25.02.2016 with the objective of cooperating on all aspects of recycling of C & D waste for an institutional and technical assistance programme on "Treatment and utilisation of construction and demolition waste in India" on capacity building and technical support. The Ministry of Foreign Affairs (MFA) of Norway have entered into an agreement with SINTEF on 19.12.2016 allocating a grant to be used exclusively to finance the programme during 2017-21. The goal of the programme is to increase the utilisation level of recovered C & D waste in the building and construction sector in India by increasing the treatment and recycling capacity. Target groups are CPWD, ULBs and other institutions and academia on the one side, and industry and waste management companies on the other side.

Fig. 6: Blocks from C & D waste used in Supreme Court additional office complex

In a recent move the Delhi Government has issued an advisory on the use of the products made out of recycled waste by Delhi PWD. All Delhi Government agencies will incorporate a clause in their tenders that mandates use of a minimum of 2 percent recycled products from construction waste in all future contracts for building works and 10 percent recycled products for road works. Other governments are also going to issue similar guidelines and thus C & D waste is going to be a resource for building industry rather than a waste in future.

Concluding Remarks

Recycling of C & D waste has become essential as per "Construction and Demolition Waste Management Rules, 2016", and also from the environmental and Swachh Bharat mission requirements. Awareness has also to be generated among the administrators, engineers, and public. Private entrepreneurs need to come forward for setting up of C & D waste recycling plants. Once, it is implemented, C & D waste will no

longer remain a waste but will become a resource material. Further to prevent and minimise C & D waste generation, the country has to implement quality in construction and maintenance works and adopt green technologies.

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National Workshop on "Processing and Use of Construction & Demolition Waste"

BMTPC organized a National Workshop on "Processing and Use of Construction & Demolition Waste" with theme 'Deconstruction & in-situ processing for Ecology and Economics' on November 21, 2017 at New Delhi.

The National Workshop was inaugurated by Shri Hardeep S Puri, Hon'ble Minister of State (I/C) for Housing & Urban Affairs, Government of India. Hon'ble Minister in his inaugural speech said that sustainable waste management is the need of the hour keeping in view the ongoing Swachh Bharat Abhiyan of Govt. of India, which involves managing waste in an environmentally sound, socially satisfactory and techno-economically viable manner. The waste management hierarchy demands firstly, avoiding generation of waste, followed by reducing, reusing, recycling, recovering, treating and disposing whatever wastes produced. There is also pressing need to bring awareness about the problem of waste management and the necessity to adopt proper procedure of collection, processing, recycling and use of C&D wastes in manufacturing of building components among different stake holders of the country.

Shri Durga Shanker Mishra, Secretary, Ministry of Housing & Urban Affairs while addressing the participants pointed out that various Central Schemes such as Smart Cities, Pradhan Mantri Awas Yojana and Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and other similar schemes are bringing increased activities in construction sector. Management and handling of solid wastes including C&D waste is a serious concern and has serious consequences due to the increasing quantum of waste, continuing shortage of dumping sites, and increase in transportation and disposal cost and various associated environmental issues. The construction and demolition waste generated through redevelopment process are required to be utilized as resources to not only reduce the cost of construction but also to help the movement of pollution control.

The National Workshop was organized by BMTPC jointly with Centre for Fly Ash Research and Management (C-FARM), New Delhi in association with Indian Building Congress, Builders' Association of India and IL&FS Academy of Applied Development. The programme was attended by more than 100 participants from research and academic institutions, government organisations, municipal corporations, etc.

Management, Re-Use & Recycling of C&D Waste@

*Dr. Vimal Kumar** *G.K.Jha***

Preamble

India's Urban Population has grown from 109 million in 1971 to 419 million in 2014 and is expected to grow to almost 600 million by 2030. While rapid urbanization and growing cities provide various opportunities, there is fallout in terms of proliferation of slums, high prices of land and building materials which render houses unaffordable for the segment at the bottom of the pyramid. The technical committee constituted by Ministry of Housing & Urban Poverty Alleviation (MHUPA), Government of India has estimated housing shortage for urban areas at 18.78 million during the 12th FYP period of which over 95% of this housing shortage is estimated in the Economically Weaker Sections (EWS) and Low Income Group (LIG) categories. Housing for All Mission launched in June, 2015 envisages construction of 2 crore dwelling units by 2022.

The demand of building materials for 2021-22 has been reckoned by Building Materials and Technology Promotion Council (BMTPC) as cement 380 million tonne, steel 50 million tonne, bricks 600 billion numbers, aggregate 400 million cubic meters and timber 40 million cubic meters. Data show that there is a considerable amount of shortage of conventional and traditional building materials in India. Re-use and recycling of C&D waste would help in reducing cost of dwelling per family unit as well as reduce the pressure on scarce building material from natural sources, especially, sand, stone chips etc.

In many industrialized countries, C&D waste is being recycled and used for housing and infrastructure, for example, Germany, Netherlands, Japan, South Korea, Singapore, etc. Number of C&D waste recycling plants in operation in 2012 as reported by European Demolition Association for some of the countries are given in Table-1.

In India, in many areas, due to over extraction of natural resources for building construction products such as sand, stone etc. there is a very tangible shortage of material. It is high time, C&D waste is properly recycled and used effectively to ease the pressure on natural resources as well as to provide economics.

Table-1: Number of C&D waste recycling plants

Sl. No.	Country	No. of plants
1.	Belgium	60
2.	France	50
3.	Netherland	70
4.	UK	120
5.	Germany	220
6.	Denmark	20
7.	Italy	43

2. Indian Scenario

In India, most of the old buildings are made up of good quality bricks. The foundations and walls are load bearing, except new constructions in major cities, which are concrete frame structures. When old buildings are demolished, the major demolition waste is soil, sand and gravel (26%), bricks & masonry (32%), Concretes (28%), metal (6%), wood (3%) others (5%).

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Bricks, tiles, woods and iron metal are sold for reuse / recycling. The balance materials generally go for landfills. The realization of seriousness of the problem of disposal of C&D waste in Indian cities has started recently. Most of the municipalities have started working towards re-use and recycling of C&D waste. C&D waste is generally consisting of concrete, broken bricks and the mixed dirt. As stated earlier the bricks, wood, iron, glass, plastics, electrical, plumbing items and bathroom / kitchen fillings, etc. are already being reused /recycled in India.

In Indian context, the problem of C&D waste is getting aggravated due to rapid economic growth leading to urbanization and industrialization. Large construction projects of housing, related infrastructure as well as industrial infrastructure projects are becoming very common site across the country. Development of economic zones, industrial corridors, reconstruction of old building structures adds to the magnitude of C&D waste. The population living in cities and urban areas has increased from 14% at the time of independence to about 30% (2011 census). The increase in absolute number is much more.

Stringent laws are being formulated by the municipalities but enforcement has it's limitations. Private contractors remove this waste to privately owned, low-lying land for a price, or more commonly, dump it in an unauthorized manner along roads or other public land. C&D waste from individual households finds its way into nearby municipal bins and waste storage depots making the municipal waste heavy, and degrading its quality for treatments such as composting or energy recovery. In addition, the C&D debris is being indiscriminately dumped along the roads, in nallah, low lying areas, vacant plots and other unauthorized places.

2.1 Statutory Regime

The major issue in Indian context is that at Government level itself there *has been* (is) laxity. A study by Ministry of Environment and Forests during 2010 found that C&D waste has a potential use after processing and grinding. "But so for in India there has been little effort to manage and use it", the study said. Further, at national level, there *has been* (seems to be) less urgency to regulate, facilitate and manage C&D waste. It is very evident from the following facts:

1. 2010 Working Committee Report on MSW Management recommended that C&D waste collection, utilization and safe disposal be addressed during amendment of MSW Management Rules. But there is no explicit dealing with C&D waste in draft MSW Management Rules 2013.

   The draft Solid Waste Management Rules, 2015 with a separate chapter on construction and demolition waste were published by the Central Government in the Ministry of Environment, Forest and Climate Change vide G.S.R. 452 (E), dated 3rd June, 2015. These draft rules are yet to be finalized. C&D waste Management Rules, 2016 have now been issued by MoEF&CC vide notification no. G.S.R. 317(E) dated 29th March, 2016.

   The rules delineate the duties and responsibilities of waste generator, service provider as well as administrative and statutory bodies with a time line.

2. There are no specifications, codes, guidelines for C&D waste processing and recycling as well as the products manufactured from recycled waste. BIS has yet to bringing out standard on these. However, IS: 383 the standard for coarse and fine aggregates for use in concrete has been revised during January, 2016, permitting use of recycled aggregates up to 25% in plain concrete, 20% in reinforced concrete of M-25 or lower grade and up to 100% in lean concretes of grade less than M-15. BIS has yet to bring out/ amend the standards of bricks, blocks, kerb stones, tile, ready mix concrete and concrete, etc. with use of recycled concrete aggregates/ recycles aggregates. Most of the prevailing standards state that the aggregates be from natural sources as per IS: 383. These standards need to state that manufactured and recycled aggregates can also be used as per IS: 383, Jan., 2016.

   Indian Road Congress (IRC) need to bring out standards & specifications for use of manufactured and recycled aggregates in construction of roads and allied structures.

2.2 Estimate of C&D waste

No authenticated C&D waste data is available with any of the Government bodies / agencies; let it be Central or State Government. Figures being quoted by different Government agencies vary from 10 Mt -15 Mt a year. While Centre

for Science & Environment (CSE) estimates 625 Mt / year generation of C&D waste.

The estimates provided by various Government agencies for annual generation of C&D waste in India appear to be quite low, such as 10-12 Mt by MoUD (2000); 12-15 Mt by TIFAC (2001); 10-12 Mt by MoEF (2010) and 12 Mt by CPCB. The estimates of 625 Mt by CSE appears to be quite high.

TIFAC report states that C&D waste generation is 40-60 kg per sq.m of new construction, 40-50 kg per sq.m of building repair and 300-500 kg per sq.m for demolition of buildings.

Even if we consider a moderate figure of 50 kg C&D waste generation per sq.m of new constructions and that India has added 1 billion sq.m housing in 2013, the **C&D waste generated from new construction in 2013 is 50 Mt**. The new constructions during 2005-12 are reported as 5.75 billion sq.m, which would have produced C&D waste of 287.5 Mt in 7 years. The average annual figure being 41 Mt.

In addition, C&D debris is generated by demolition/ renovation of housing stock. As per census of India 2011, the housing stock is:

Rural houses	- 220, 695, 914
Urban housing	- 110, 139, 853
Total	**- 330, 835, 763**

Considering only the urban houses and with an assumption that the average area of a house is 75 sq. m. and that 5 per cent of housing stock comes for renovation a year. The annual **C&D waste generated from renovation works out to 123.90 Mt** taking 300 kg debris generation per sq.m area.

Thus, the total annual generation of C&D waste in India can be said to be in the range of 165-175 Mnt per annum during 2005-2013.

2.3 C&D waste recycling plants

The Government and civic bodies are now very alert and active on the front of C&D waste management. Four plants, summarized below are operational for recycling of C&D waste.

Burari, New Delhi: India's first plant for recycling of C&D waste has been commissioned during 2009 at 10 acre site at Burari, Jahangirpuri in North Delhi by Infrastructure Leasing & Financial Services (IL&FS) under an agreement with North Delhi Municipal Corporation. The plant was initially set up to process 500 tpd C&D waste. Processing of 1200 tpd was achieved during 2014 and Delhi Pollution Control Committee has awarded the permission to expand the capacity to 2000 tpd.

The products being manufactured at this facility are sand, coarse aggregate, RMC, bricks, blocks, curbstones, pavement blocks, hollow bricks etc.

East Kidwai Nagar, New Delhi: M/S Enzyme India Pvt. Ltd. has set up C&D waste recycling plant in 2014 on PPP model with 100% by back by NBCC with a capacity of 150 tpd at the project site of "RE-development of East Kidwai Nagar, New Delhi". The construction project involves demolition of 2444 existing houses and allied structures. Construction of 4747 houses covering 60 lakh sq. ft. area and commercial area of 12 lakh sq. ft. on a plot area of 86 acres with 12.7 lakh sq. ft. green area.

Shashtri Park, New Delhi: Third plant in Delhi for recycling of C&D waste has been commissioned at Shashtri Park in East Delhi at 2.5 acre site to process 500 tonne C&D waste per day. The plant has been built in partnership with IL & FS, which would run it for 15 years before transferring it to EDMC. The facility will get mixed C&D waste from 15 designated sites of East Delhi.

Ahmedabad, Gujarat: Ahmedabad Enviro Projects Pvt. Ltd. (AEPL) has commenced a 100 tonne per hour capacity plant for recycling of C&D waste in phase wise from December, 2013. The plant is fully operational since June, 2014 and is located at Pirana, Ahmedabad.

Earlier experience at Mumbai: Youth for Unity and Voluntary Action (YUVA), a non profit, non Govt. organization has recycled 1500 tonne of C&D waste during 2002-06 at CIDCO-YUVA Building Centre (CYBC), Kharghar. CYBC is a joint venture of City and Industrial Development Corporation of Maharashra Ltd. (CIDCO) and YUVA. The C&D recycling demonstration plant has manufactured building materials like bricks, blocks, paving blocks, concrete, sand substitute and coarse aggregates. The laboratory test results proved the quality of end products. The products were used to private builders. However, Govt. projects could not accept the products for want of standards, specifications and departmental approvals.

The estimated cost saving of building products manufacturers from recycled C&D waste was reported as given below in Table-2.

The CYBC project of C&D waste

Table-2: Cost saving in recycled C&D waste products-CYBC

Building products	% saving
Solid block	25
Hollow block	30
Paving block (60 mm thick)	25
Paving block (80 mm thick)	20

Source: Project report CYBC-Mr. N. M. Shirgonkar

recycling was shut down due to no support from the policy makers as well as the market.

3. Quality of recycled C&D waste products

The building construction products manufactured at Burari, New Delhi; Pirana, Ahmedabad and YUVA-CIDCO Centre, Mumbai have been taken up by various R&D and user agency's laboratory tests for quality evaluation. The building construction components manufactured at the C&D recycling plants such as bricks, blocks, paving blocks and kerb stones, etc. have satisfactorily met the requirements of 75-150 kg/cm^2 compressive strength and water absorption below 20 per cent.

Use of fine aggregates and coarse aggregates manufactured by recycling of C&D waste has also been validated scientifically for part replacement of natural aggregates up to 50%. Illustrative results are given in Table-3 and 4.

Good amount of data has been generated on quality aspect of the recycled building construction products manufactured from C&D waste. Accordingly, Bureau of Indian Standards (BIS) has amended IS:383, the specification of coarse and fine aggregates in January, 2016, permitting part substitute of aggregates from natural source by aggregates manufactured from recycled debris, is given in Table-5.

Table-3: Results for replacement of natural fine aggregate by recycled fine aggregate

Sr. No.	Replacement %	Compressive Strength as per IS-516 (MPa)			
		07 days	28 days	56 days	90 days
1.	0	25.93	38.98	46.14	52.00
2.	25	31.84	42.90	51.16	58.80
3.	50	34..27	46.14	53.87	61.82
4.	75	30.55	39.87	47.15	53.62
5.	100	24.77	37.97	44.42	51.30

Source: Nikhil Kaushik, V.V. Arora and P.N. Ojha, National Council for Cement and Building Materials, India

Table-4: Results for replacement of natural coarse aggregate with recycled coarse aggregate

Sr. No.	Replacement %	Compressive Strength as per IS-516 (MPa)			
		07 days	28 days	56 days	90 days
1.	0	25.93	38.98	46.14	52.00
2.	25	26.28	44.48	51.59	55.29
3.	50	25.36	38.56	45.05	51.31
4.	75	22.80	36.42	41.54	45.50
5.	100	21.60	32.29	37.18	41.62

Source: Nikhil Kaushik, V.V. Arora and P.N. Ojha, National Council for Cement and Building Materials, India

4. C&D Waste Recycling Process

A line diagram of C&D waste recycling process is given in figure-1 and the list of major equipments is at Table-6.

5. Suggestions for Specific uses including International Practices

Suggestion for specific uses in housing along with list of possibilities of application of recycled C&D waste products including listing of usable building products/technology/ practices are:

(i) The re-usable items recovered specially during demolition or segregated from debris of new construction such doors and windows, bricks, reinforcement from RCC components, structural steel, electricals, kitchen and sanitary fittings, iron grills, partitions, wooden and other fittings & fixtures, etc. can be used in construction of low income housing.

Internationally, in developed countries, the re-usable items of C&D waste are certified for worthiness and quality by authorized inspection and certification agencies. In India, the assessment of quality of these items is made informally by the re-user (buyer) or by the skilled/ semi skilled worker/ mistry.

The inspection/ test/ certification of re-usable items may be

Table-5: Extent of Utilization Permitted by IS: 383 (2016)

Sr. No.	Type of Aggregate	Maximum Utilization		
		Plain Concrete (%)	Reinforced Concrete (%)	Lean Concrete (Less than M-15 Grade) (%)
(i)	Coarse aggregate			
(a)	Recycled concrete aggregate (RCA)	25	20 (Only up to M-25 Grade)	100
(b)	Recycled aggregate (RA)	Nil	Nil	100
(ii)	Fine aggregate			
(a)	Recycled concrete aggregate (RCA) (See Note 1)	25	20 (Only up to M-25 Grade)	100

Notes:

i. It is desirable to source the recycled concrete aggregates from sites being redeveloped for use in the same site.

ii. In any given structure, only one type of manufactured coarse aggregate and one type of manufactured fine aggregate shall be used.

iii. While using manufactured aggregate as part replacement for natural aggregate, it should be ensured that the final grading meets the requirements specified in tables 7, 8, 9 of this standard.

Table-6: Major Equipments for Recycling of C&D Waste

S. No.	Equipment
1.	Dump hopper
2.	Grizzly feeder
3.	Impact crusher
4.	Vibratory screen-1
5.	Cone Crusher
6.	Vibratory screen-2
7.	Grizzly set filters
8.	VSI crusher
9.	Vibratory washing screen/ log washer
10.	Hydraulic press for brick making
11.	Egg lying block making machine
12.	Paver block vibratory table/hydraulic press
13.	Tile making vibratory tables/ hydraulic press
14.	Kerb stone – Egg laying machine
15.	Ready mix concrete plant

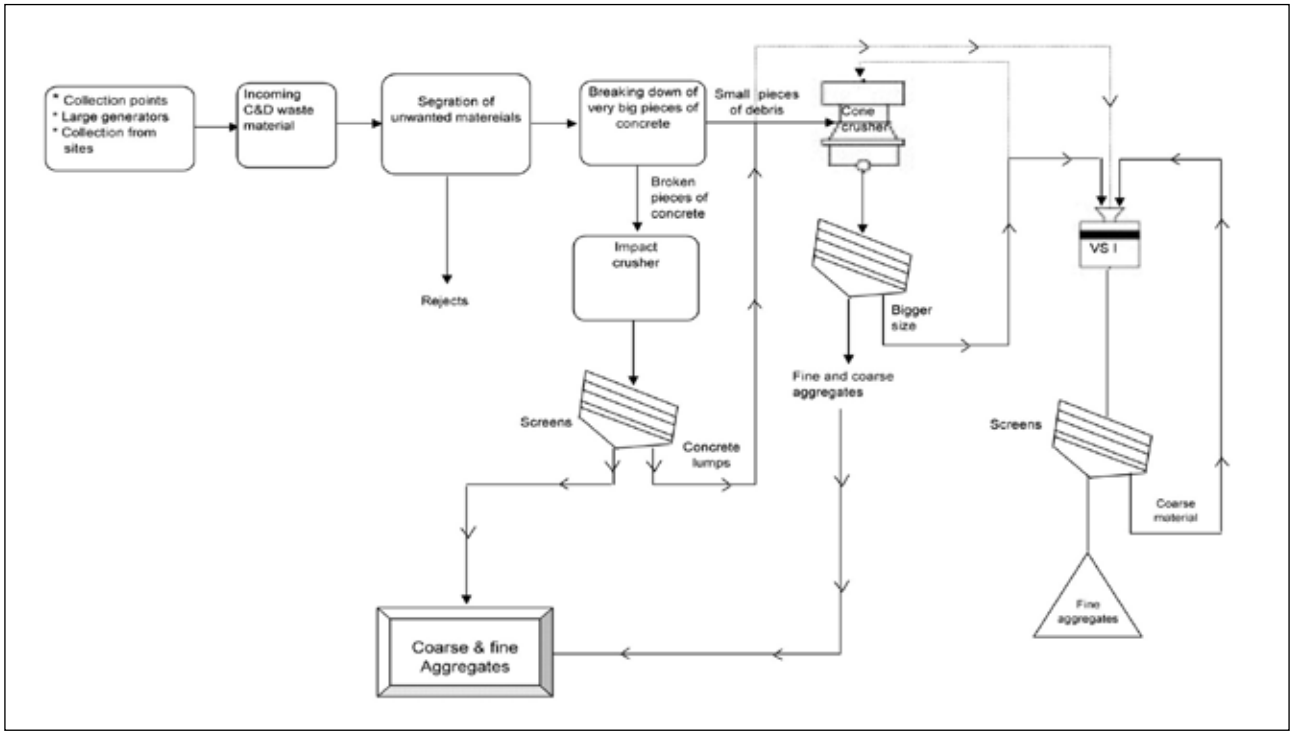

Figure-1: C&D Waste Recycling Process

institutionalized.

(ii) Re-cycled C&D waste can be used to produce many products as listed below, that can be generally utilized in low income housing and related infrastructure.

(a) Sand for use in concrete and masonry

(b) Coarse aggregates for use in concrete

(c) Bricks, blocks, tiles

(d) Pavers blocks

(e) Kerb stones

(f) Pre cast items such as: slabs drain covers, manholes, manhole covers, louvers fins, pillars, for fencing, wall slabs, door/window frames, etc.

(g) Broken brick bats or other mix debris of size 10 to 80 mm be used for filling under the floors or in internal roads/ pavements.

(h) The waste fines and dirt at the recycling plant of C&D waste is, internationally, sent to MSW land fills. It is suggested that this material may be used in low income housing projects for plinth filling and landscaping.

Internationally, in developed countries, all the above said products are manufactured through fully automated process/ technologies. In Indian scenario, considering the current low volume of operations and the cost controls required, it is suggested to use semi-automatic processes/ technologies.

6. Road Map for gainful utilization of C&D Waste usable in Housing Sector

The road map to maximize the re-use of C&D waste as well as that of the products manufactured from recycled C&D waste in housing is as given below:

i) Reuse of C&D waste

The items which are usable directly like doors and windows, bricks, reinforcement from RCC components, structural steel, electricals, kitchen and sanitary fittings, iron grills, partitions, wooden and other fittings & fixtures, etc. can be taken out with little extra care and efforts so that these items are not damaged much. All these items can be put into re-use without much processing. Sufficient precautions be taken specially during demolition and renovation to recover more of material that can directly be re-used. The re-using a waste item is a better service to the environment and the environment is saved from further impacts due to recycling activities.

ii) Recycling of C&D waste

Once the re-usable elements have been segregated, the items like metal, glass, plastics, non usable waste items, etc. be removed and sent to remelters / re-processors or to land fill.

The balance debris can be processed to produce usable building materials such as fine aggregate, coarse aggregate, ready mix concrete, bricks/ blocks, tiles, paver blocks, kerb stones, pre-fab slabs, etc.

The capacities created at recycling plants be such that it can accommodate the increase in C&D waste generation over next 10 years by installing additional balancing equipments and/or by extending the working hours.

iii) As already advised by MoUD vide its circular dated 28th June, 2012 all states to set up C&D waste recycling facilities in all cities with population of over 1 million. As of March, 2016 such facilities have been created only in 2 cities i.e. New Delhi and Ahmedabad. The implementation of the directive may be facilitated through availability of funds and creation of market for reprocessed building construction materials.

iv) Sensitization and facilitation for re-use and recycling of C&D waste may also be taken up in cities of population less than 1 million to encourage such initiative. This is because mega cities and cities with million plus population account for only 23 per cent of urban population (Census 2011).

v) The agencies that generate C&D waste in bulk quantity may deliver the C&D debris at the recycling plant and others may deliver it at collection points.

vi) Collection points be provided so that small quantity generator of C&D waste is not required to transport the debris to a distance more than 2.5 to 3.0 km.

vii) The transportation cost and a part of processing charges may be paid by C&D waste generator. These charges may be on telescopic scale i.e. low charges for small volume generators.

viii) The terms and conditions with the concessionaire and the fee levied bulk producer of C&D

waste are made available at a price at least 20% lower than corresponding materials from natural resources.

ix) The easy availability and quality of recycled products be ensured.

x) As and when C&D waste recycling plant is commissioned at a city, it may be made mandatory for all construction activities to use a specified percentage of building construction materials manufactured from recycled debris.

xi) The marketing and use of C&D waste items that have been segregated at the initial stages for re-use may be streamlined.

xii) The successful experiences may be disseminated and replicated.

7. Conclusion

Re-use and recycling of C&D waste is no more a concept. It is a reality. It is being practiced worldwide. A few plants have started functioning in India. Technologies are available. Mindset has started changing. The formalization through legislative means supported by Standards, & Specifications of end products and transparent guideline by the Civic bodies can boost use of C&D waste, which would reduce pressure on natural resources and the environment.

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Emerging Housing Technologies – Are they really Green ?

Dr. Shailesh Kr. Agrawal*

Prologue

With the global buzz about sustainability, reduction of carbon emissions, climate change mitigation, the use of greener practices in the construction sector has gained importance and has become relevant in today's context. BMTPC under Ministry of Housing & Urban Affairs, Govt. of India has been promoting sustainable technologies for field level applications since 1990, however, during last few years, BMTPC is in the process of mainstreaming emerging housing technologies other than conventional ones which are suitable for affordable mass housing specially in urban areas. These emerging construction systems offer a basket of appropriate structural systems which are not only superior than the existing RCC/load bearing construction methodology but also deliver quality, safe & sustainable houses at a much faster rate with much improved functional performance.

BMTPC also 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) under which 24+ new technologies for mass housing have been identified, assessed for their suitability in different geo-climatic regions of the country & certified for usage by public & private agencies. The certified technologies are from the specific firms/agencies/ technology providers with their specific trade names, however, they can be generalized and classified broadly. These technologies along with other potential technologies under broad classification are as follows:

Engineered Formwork Systems

- *Monolithic Concrete Construction using Plastic/Aluminium/composite formwork*
- *Modular Tunnel form*
- *Slip form work systems*

Lost Formwork Systems

– Insulated Form work systems
  - *Glass Fibre Reinforced Gypsum (GFRG) Panel System*
  - *Sismo Building Technology*
  - *Insulating Concrete forms - Reliable Insupacks*
  - *Monolithic Insulated Concrete System (MICS)*
  - *Plaswall – lost in place formwork system with fibre Cement board, plastic spacer & concrete*

– Stay-in-place Structural Form work systems
  - *Coffor*

Precast Sandwich Panel Systems

– EPS Core Panels
  - *Advanced Building System – EMMEDUE*
  - *Rapid Panels*
  - *Reinforced EPS Core Panel System*
  - *QuickBuild 3D Panels*
  - *Concrewall Panel System*
  - *BAU Panels*

– Other Panels
  - *Prefabricated Fibre Reinforced Sandwich Panels (Aerocon Panels)*
  - *Rising EPS (Beads) Cement Panels*
  - *Plasmolite – fibre Cement board as outer & inner skin filled with foam concrete*
  - *Flyash EPS Cement Sandwich Panel (Bhargav Infrastructure)*
  - *Pir Dry-Wall Prefab Panel System (Covestro)*
  - *Nano Living System Technology (Mgo Board as inner &*

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outer skin with core of PUF)
- *Continous PUF Sandwich Panels*

Light Gauge Steel Structural Systems
- *Light Gauge Steel Framed Structure (LGSFS)*
- *Light Gauge Steel Framed Structure with Infill Concrete Panels (LGSFS-ICP)*

Steel Structural Systems
- *Factory Made Fast Track Building System*
- *Speed Floor System*

Precast Concrete Construction Systems
- *Waffle-Crete Building System*
- *Precast Large Concrete Panel System*
- *Industrialized RCC Precast 3-S system using RCC precast with or without shear walls, columns, beams, Cellular Light Weight Concrete Slabs/ Semi-Precast Solid Slab*
- *Pre-stressed Precast Prefab Technology Using Hollow Core Slab, Beams, Columns, Solid Walls, Stairs, etc.*
- *Moducast systems*
- *3D monolithic Volumetric construction*
- *Walltech Hollowcore Concrete Panel*
- *Robomatic Hollowcore Concrete Wall Panels*

Metal Structural Systems
- *Aluminium framing structures - infinium*

These systems are being used world over successfully and now most of the states along with govt. agencies & departments, construction agencies, development authorities & housing boards have shown interest & are willing to adopt them. About 9 lakhs houses

are being constructed with emerging construction systems in India under PMAY-U and other state-run schemes. Nevertheless, these systems are subjected to various kinds of evaluations, queries and apprehensions and through this article, the author wishes to dispel the misconceptions about greenness of these technologies. These systems are actually green, if seen in a broader perspective of sustainability and have potential to replace conventional methods of construction. These are futuristic systems for construction industry and, therefore, it is required to make all the stakeholders aware and sensitize about the green aspects so that they qualify as sustainable/green construction technologies.

What is Green Construction?

Green construction or sustainable buildings employ practices or technologies which are environmentally-responsible and resource-efficient throughout the life span of building involving all cradle-to-grave processes i.e. from planning to design, extraction of raw materials through materials processing, manufacture, distribution, construction, use, operation, repair & maintenance, renovation, demolition & disposal and recycling. The practice of sustainable buildings complements classical building design, concerns of economy, utility, durability & comfort. It also embodies environmental, social and economic concerns. In addition to above, the global

warming potential, air pollution, water pollution, and waste are also part of assessment of green construction.

Green building brings together a vast array of practices, techniques, and skills to reduce and ultimately eliminate the impacts of buildings on the environment and human health. While the practices or technologies employed in sustainable construction are constantly evolving and differ from expert to expert, fundamental principles persist from which the method is derived: siting and structure design efficiency, energy efficiency, water efficiency, materials efficiency, indoor environmental quality enhancement, operations and maintenance optimization and waste and toxics reduction.

On the aesthetic side of green construction is the philosophy of designing a building that is in harmony with the natural features and resources surrounding the site. There are several key steps in designing sustainable buildings: specify 'green' building materials from local sources, reduce loads, optimize systems, and generate on-site renewable energy.

Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective of green buildings is to reduce the overall impact of the built environment on human health and the natural environment by:

- *Efficiently using energy, water, and other resources*
- *Protecting occupant health and improving employee productivity*
- *Reducing waste, pollution and environmental degradation*
- *Reducing environmental impact*

Globally, buildings are responsible for a huge share of energy, electricity, water and materials consumption. The building sector has the greatest potential to deliver significant cuts in emissions at little or no cost. Buildings account for 18% of global emissions today, or the equivalent of 9 billion tonnes of CO_2 annually. If emerging technologies in construction are not adopted during this time of rapid growth, emissions could double by 2050, according to UNEP report.

There are number of agencies world over working in assessment of green buildings and have evolved their own rating systems. Leadership in Energy and Environmental Design (LEED) is a set of rating systems for the design, construction, operation, and maintenance of green buildings which was Developed by the U.S. Green Building Council. Other certificates system that confirms the sustainability of buildings is the British BREEAM (Building Research Establishment Environmental Assessment Method) for buildings and large-scale developments. Currently, World Green Building Council is conducting research on the effects of green buildings on the health and productivity of their users and is working with World Bank to promote Green Buildings in Emerging Markets through EDGE (Excellence in Design for Greater Efficiencies) Market Transformation Program and certification. There are also other tools such as Green Star in Australia and the Green Building Index (GBI) predominantly used in Malaysia.

Green building rating systems such as BREEAM (United Kingdom), LEED (United States and Canada), DGNB (Germany), CASBEE (Japan), and VERDEGBCe (Spain) help consumers determine a structure's level of environmental performance. They award credits for optional building features that support green design in categories such as location and maintenance of building site, conservation of water, energy, and building materials, and occupant comfort and health. The number of credits generally determines the level of achievement.

In India, there are predominantly three rating systems – Leadership in Energy and Environmental Design (LEED), the rating systems from Indian Green Building Council (IGBC) and the Green Rating for Integrated Habitat Assessment (GRIHA). In addition, there is also the Energy Consumption Building Code (ECBC) and the National Building Code (NBC), which provide guidelines on energy consumption. All buildings in India need to comply with these prescribed guidelines.

Emerging Housing Technologies for Sustainable Buildings

The construction industry poses a major challenge to the environment. As per UNEP, more than 30% of global greenhouse gas emissions are building related and emissions could double by 2050 on a Business as Usual scenario. As per report of GRIHA, Globally, buildings consume about 40% of energy, 25% of water and 40% of resources. In addition, building activities contribute an estimated 50% of the worlds air pollution, 42% of its greenhouse gases, 50% of all water pollution,

48% of all solid wastes and 50% of all CFCs (chlorofluorocarbons) to the environment.

However, construction of sustainable buildings would lead to 35% reduction in GHG emissions, 30-50% reduction in energy use, 40% reduction in water use and 70% reduction in waste outputs.

India is running ambitious Pradhan Mantri Awas Yojna-Urban (PMAY-U) which targets housing for all by 2022 envisaging around 10 million houses to be constructed. The overall impact of creating such a housing stock with brick & mortar and cast-in-situ brick & pillar approach will do no good as far as our commitment to climate change mitigation & reduction of CO_2 emissions is concerned. The most optimal housing technologies which are resource efficient and environmental-responsible need to be employed and BMTPC under Technology Sub Mission of PMAY-U has been tirelessly pursuing identification and certification of these systems for large scale adoption in India by public and private agencies including state govts. Out of 5.5 million houses sanctioned as on date, more than 6 lakhs houses are constructed with emerging technologies whereas in other schemes, about 3 lakh houses are being constructed with these. This does not include the housing stock being created by private developers who have also been using emerging housing technologies. The interaction with the agencies involved in construction with these new construction systems corroborates the fact that the use of technologies helps in faster construction with less pollution, optimal use of water and other resources, low maintenance, minimum life-cycle cost and at the same time material efficiency, water efficiency, energy efficiency, structural design efficiency, disaster resilience, indoor environmental quality enhancement, operation & maintenance optimization, waste reduction etc. are in-built with these emerging housing technologies. These are goals of green construction and therefore, the emerging construction systems need to be termed as green construction or sustainable construction.

Green Aspects of Emerging Housing Technologies

Cost & Payoff

The most criticized issue about emerging construction systems is the price. The stigma is between the knowledge of up-front cost vis-à-vis life cycle cost. The cost of a building is defined as follows:

Total Cost = Initial construction cost + Running cost during life of building + disposal cost

This is also known as life-cycle cost.

Most of the time, the criterion in selection of technology is cost per m^2 which is initial cost and can be incongruous, if green aspects are to be considered. The buildings with emerging systems may cost 10-15% higher as of now (*It can also be questioned as today these systems require initial push but once mainstreamed the initial cost will also be equivalent to cost of conventional construction*) but yield couple of times as much over the entire life of the building. During life span of building, the financial payback will exceed the additional initial cost of using emerging systems several times. And broader benefits, such as reductions in greenhouse gases (GHGs) and other pollutants have large positive impacts on surrounding communities and on the planet.

Resource Efficiency

A conventional building tends to focus on the use of basic materials namely cement, bricks, sand, aggregates, steel which are based on natural resources. These natural resources are finite and cannot be replenish quickly. Also, their extraction and manufacturing have direct and indirect consequences on environment & energy requirements and also pose danger to our planet in terms of greenhouse gas emissions, land & air pollution etc. Therefore, natural resources are to be used efficiently which is one of the key features of emerging construction systems as they employ industrial techniques to produces building components and use cement, steel and other aggregates optimally. The other feature of emerging construction systems is to make use of renewable resources.

Structural Design Efficiency

The emerging systems follow the path of optimization. Right from the concept & design stage, the building components including structural configuration is designed in a manner to optimize the performance. The performance-based design instead of prescriptive design philosophy is the key for design efficiency while dealing with these emerging construction systems.

Disaster Resilience

The emerging construction systems designed to be resilient

in terms of natural hazards as it entails performance-based design of buildings.

Energy Efficiency

Emerging construction systems often include measures to reduce energy consumption i.e. the embodied energy required to extract, process, transport and install building materials and the operating energy to provide services such as heating and power for equipment. The buildings with emerging systems use less operating energy, embodied energy. These buildings will have a lower embodied energy than those built primarily with brick, mortar, concrete, or steel.

The other aspects to reduce operating energy use is to employ details that reduce air leakage through the building envelope.

Water Efficiency

The conventional construction systems primarily are cast-in-situ reinforced concrete systems which require large quantity of potable water for curing and most of the time, the water of curing go waste. The new systems employ better techniques of curing such as pressurized curing, chemical curing etc. which help in conserving the water during construction.

Material Efficiency

Building materials typically considered to be sustainable, if they are based on renewable/waste resources and can be reusable and recyclable. Most of the emerging construction systems either make use of industrial waste, renewable resources, energy efficient building materials or optimizes the use of basic raw materials i.e. cement, sand, aggregates, steel consumption. For example, The GFRG panels makes use of phospho-gypsum which is a by-product of fertilizer plant, sandwich panels make use of EPS beads which are energy efficient.

Indoor Environmental Quality Enhancement

The Indoor Environmental Quality refers to provide comfort, well-being, and productivity of occupants. Indoor Air Quality seeks to reduce volatile organic compounds, or VOCs, and other air impurities such as microbial contaminants. The emerging systems employ construction materials and interior finish products with zero or low VOC emissions during the design and construction process which enhance indoor air quality. Also, well-insulated and tightly sealed envelope reduce moisture problems which often leads to dampness.

The use of thermally efficient materials in construction systems coupled with a properly designed building envelope aid in increasing a building's thermal quality.

Operation & Maintenance Optimization

The construction systems identified are based on factory made building components which are manufactured with high precision under strict quality control and therefore, more durable requiring no or minimum maintenance. The emerging technologies are industrial products having SOPs for building's O & M.

Waste Reduction

Emerging construction systems not only seeks to reduce waste of energy, water and materials used during construction but also generate less construction & demolition waste after completion of the building. Well-designed buildings also help reduce the amount of waste generated by the occupants.

When buildings reach the end of their useful life, they are typically demolished and disposed to landfills. In case of emerging systems, most of the deconstructed components can be reclaimed into useful building materials.

Epilogue

It is often debated that emerging construction systems are industrial systems and are not sustainable systems. However, a broader outlook on different aspects of these emerging systems help in establishing the fact that the buildings constructed with these identified systems conserve natural resources, optimize energy efficiency, use less water, generate less waste, minimize air & land pollution and provide improved indoor environment for occupants, as compared to a conventional cast-in-place conventional construction. Therefore, these systems fall under green construction and can be considered future of Indian construction industry in light of climate change mitigation.

While presenting the above views, the author has referred various websites of green building councils across globe, LEED, IGBC, GRIHA and many other documents. Some of the viewpoints are directly taken from these reports and gratefully acknowledged.

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नई एवं उभरती प्रौद्योगिकियों के उपयोग से
प्रदर्शन आवास परियोजनाएं

परिषद ने प्रौद्योगिकियों के पहचान, मूल्यांकन, मानकीकरण, प्रमाणन, क्षमता निर्माण एवं प्रशिक्षण एवं जमीनी स्तर के उपयोग के माध्यम से देश के विभिन्न क्षेत्रों में प्रमाणित एवं उभरती भवन निर्माण सामग्रियों एवं प्रौद्योगिकियों को बढ़ावा दिया है। हाल के समय के दौरान परिषद् ने देश के विभिन्न हिस्सों में कई प्रदर्शन आवासों का निर्माण किया है। परिषद् के प्रयासों ने सार्वज. निक एवं निजी निर्माण एजेंसियों, पेशेवरों आदि में प्रमाणित एवं उभरते प्रौद्योगिकियों के विश्वास निर्माण और स्वीकार्यता में सहायता की है। एक नई पहल के रूप में, बीएमटीपीसी प्रधानमंत्री आवास योजना (शहरी)–सबके लिए आवास मिशन के अंतर्गत राज्यों में नई प्रौद्योगिकियों के बारे में जागरूकता फैलाने एवं विशेष तकनीकी जानकारी के प्रसार के उद्देश्य के साथ उभरती प्रौद्योगिकियों के उपयोग से भारत के विभिन्न हिस्सों में प्रदर्शन आवास परियोजनाओं का निर्माण कर रही है।

बीएमटीपीसी ने आंध्र प्रदेश, ओडिशा, तेलंगाना, बिहार और उत्तर प्रदेश में मॉडल प्रदर्शन आवास परियोजनाओं का निर्माण शुरू किया है। इन परियोजनाओं का उद्देश्य पूरे भारत में नई उभरती हुई प्रणाली के बारे में जागरूकता फैलाना और प्रसारण करना है। नेल्लोर, आंध्र प्रदेश और भुवनेश्वर, ओडिशा में प्रदर्शन आवास परियोजनाएं पूरी की जा चुकी हैं। परियोजनाओं का विवरण नीचे दिया गया है:

(क) नेल्लौर, आंध्र प्रदेश में प्रदर्शन आवास परियोजना

बीएमटीपीसी ने सरस्वती नगर, चौटापेलम गांव, वेंकटचलम मंडल, एसपीएस नेल्लौर, आंध्र प्रदेश में जीएफआरजी पैनल प्रौद्योगिकी के उपयोग से 36 प्रदर्शन आवास (जी1) एवं वैकल्पिक प्रौद्योगिकियों नामतः उड़नराख ईंट, फिलर स्लैब आदि के उपयोग से एक सामुदायिक भवन का निर्माण पूरा किया है। इस प्रदर्शन आवास परियोजना को आईआईटी मद्रास द्वारा डिजाइन किया गया था जिन्होंने बडै पैमाने पर आवास हेतु जीएफआरजी प्रौद्योगिकी को प्रमाणित किया है। आंध्र प्रदेश सरकार ने निर्माण हेतु 1.85 एकड़ जमीन आबंटित की थी। इस परियोजना का कार्यान्वयन आईआईटी चेन्नैई, एफआरबीएल, कोच्चि एवं एपीएसएचसीएल के साथ साझेदारी में बीएमटीपीसी द्वारा किया गया। परियोजना का ब्यौरा निम्नानुसार है:

ifj;kstuk ikQkby

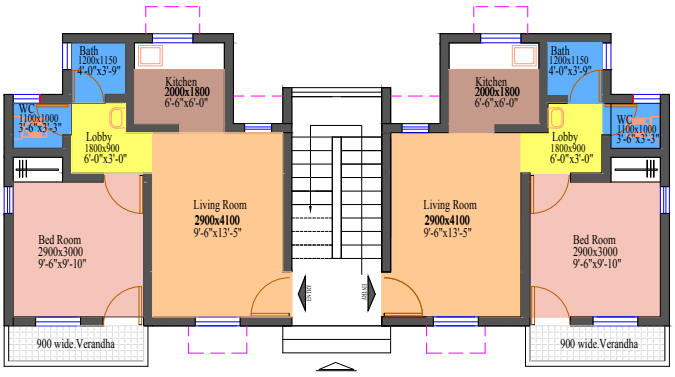
- मकानों की सं.: 36 (जी–1)
- प्रत्येक इकाई का निर्माण क्षेत्रः 450 वर्ग मीटर
- प्रत्येक इकाई में एक लिविंग रूम, एक बेडरूम, किचन, एक अलग से बाथरूम एवं डब्ल्यूसी है।
- 6900 वर्ग फीट के क्षेत्र में एक सामुदायिक भवन
- भूकंप रोधी विशेषताओं सहित

(ख) भुवनेश्वर, ओड़िशा में प्रदर्शन आवास परियोजना

आवास एवं शहरी विकास विभाग, ओड़िशा सरकार ने चंद्रशेखरपुर, भुवनेश्वर, ओड़िशा में एक्स्पेंडेड पॉलीस्ट्रीन कोर पैनल सिस्टम (ईपीएस) प्रौद्योगिकी से प्रदर्शन आवासों के निर्माण हेतु 0.43 एकड़ भूमि आबंटित की थी भुवनेश्वर विकास प्राधिकरण (बीडीए) के आधिकारियों के साथ, प्रदर्शन आवास परियोजना की योजना, सेक्शन, लेआउट प्लान को अंतिम रूप दिया गया। प्रदर्शन आवास योजना में जी–3 विन्यास में 32 इकाई वाले आवास का एक ब्लाक है। इकाई का कार्पेट एरिया 23.97 वर्गमीटर है जिसमें लिविंग रूम, खाना बनाने की जगह, शयन कक्ष, बाथरूम एवं डब्ल्यू.सी. शामिल है। कॉमन सीढ़ी के क्षेत्र के साथ आवास इकाई का निर्माण क्षेत्र 34.10 वर्गमीटर है और परियोजना का कुल निर्माण क्षेत्र 11,782 वर्ग फीट है। इस परियोजना में ऑन–साइट अवसंरचना जैसे कि फुटपाथ, चाहरदीवारी का निर्माण, जलापूर्ति कार्य, बागवानी, जलनिकासी एवं निपटान तथा सौर पैनल के उपयोग से बाहरी विद्युतीकरण आदि भी शामिल है। प्रधान मंत्री आवास योजना (शहरी) के अलावा, परियोजना में अन्य साझेदारी और वित्त पोषण एजेंसियां, अंतर्राष्ट्रीय विकास विभाग (डीएफआईडी) और नेशनल हाउसिंग बैंक (एनएचबी) हैं। परियोजना को पूरा कर लिया गया है और राज्य स्थानीय निकाय को सौंप दिया गया है।

(ग) बिहारशरीफ, बिहार में प्रदर्शन आवास परियोजना

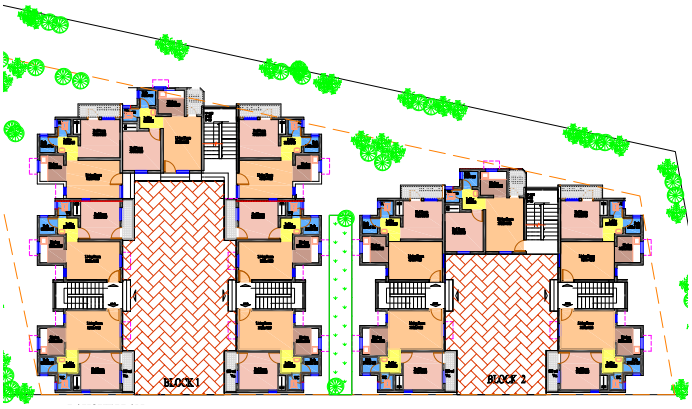
आवासन और शहरी कार्य मंत्रालय, भारत सरकार की प्रधान मंत्री आवास योजना (शहरी) के अंतर्गत बीएमटीपीसी ने उभरती एवं आपदारोधी प्रौद्योगिकी को प्रदर्शित करने के क्रम मे प्रदर्शन आवासों के निर्माण की एक योजना बिहार राज्य में सोहन कुआं, मौजा चाकियाहजान, बिहारशरीफ में कार्यान्वित की है। प्रदर्शन आवासो के निर्माण हेतु एक एकड भूमि नगर निगम, बिहारशरीफ, बिहार द्वारा उपलब्ध कराई गई है। इस परियोजना का निर्माण करने का ध्येय इस क्षेत्र में उभरती हुई प्रौद्योगिकियों को लोकप्रिय बनाना है, जोकि प्रौद्योगिकी उप–मिशन के तहत प्रधान मंत्री आवास योजना (शहरी) का अधिदेश (मैन्डेट) है। परियोजना पूर्ण होने के अंतिम चरण में है।



भूतल नक्शा

ifj;kstuk dh izeq[k fof'k"Vrk,a

- इस परियोजना में स्ट्रैचरल स्टे इन प्लेस सीआर स्टील स्पेशियली डिजाइन्ड फोर्मवर्क सिस्टम (कॉफर) तकनीक का प्रयोग किया गया है ।
- मकानों की संख्या 36 (भूतल+2 मंजिल)
- प्रत्येक भवन का फ़र्शी क्षेत्रफल 29.67 वर्ग मी.
- प्रत्येक भवन का निर्मित क्षेत्रफल 45.54 वर्ग मी.
- प्रत्येक आवासीय इकाई में एक बहुउद्देश्यीय कमरा, एक बेडरूम, रसोईघर, अलग बाथरूम और डब्ल्यूसी शामिल हैं
- बाहरी विकास
  - क्षेत्र का समतलीकरण
  - इंटरलॉकिंग टाइल की पगडंडी (पेवमेंटस)
  - भूदृश्य अनुकुलता



परियोजना नक्शा

- जल आपूर्ति की लाइने
- ट्यूब वैल का निर्माण
- जल–मल निष्पादन
- बरसाती पानी की निकास नालियां
- बाहरी विद्युतीकरण

- मकानों में भूकंप प्रतिरोधन क्षमता है।

bLrseky dh xbZ çk|kfxfd;k

यह परियोजना उभरती हुई एवं आपदारोधी प्रौद्योगिकियों के प्रभावी इस्तेमाल की सजीव उदाहरण है । इसमे निम्नलिखित प्रोद्योगिकियाँ इस्तेमाल की गई है :

uhao

- आरसीसी कॉलम की नींव

nhokj @ Lyc @ Nr

- स्ट्रैचरल स्टे इन प्लेस सीआर स्टील स्पेशियली डिजान्ड फोर्मवर्क सिस्टम (कॉफर) वॉल पैनल
- आरसीसी स्लैब के साथ

njokts dk Ýse

- लकड़ी के स्थान पर प्रेस्ड स्टील दरवाजे के फ्रेम
- दरवाजों के लिए लकड़ी का विकल्प फ्लश शटर्स
- शौचालय के दरवाजे में पीवीसी के फ्रेम और शटर

f[kMdh dh Ýse

- गार्ड रेल और स्टील ग्लैज्ड शटर्स के साथ एमएस सेक्शन विंडो फ्रेम

Q'k

- कमरे, डब्ल्यूसी और बाथ में सिरेमिक टाइल फर्श
- सार्वजनिक मार्ग में कोटा स्टोन

jlksbZ dkmVj

- संगमरमर के साथ आरसीसी काउंटर टाप

lh<h;k

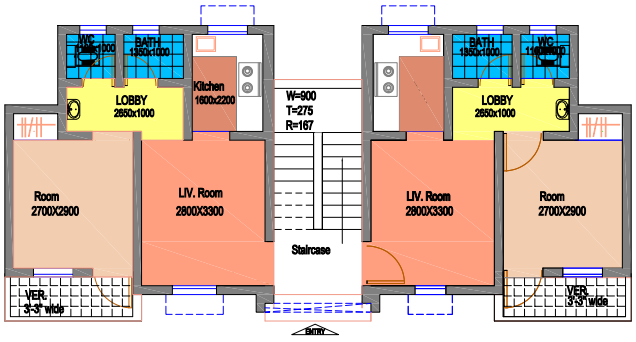
- कोटा स्टोन फर्श के साथ आरसीसी सीढ़ी

nhokj dh lrg

- आंतरिक दीवार सतह पर एक्रिलिक डिस्टेंपर
- बाहरी दीवार सतह पर मौसम प्रतिरोधी पेंट

(घ) औरंगाबाद जागीर, लखनऊ में प्रदर्शन आवास परियोजना

बीएमटीपीसी ने उभरती एवं आपदारोधी प्रौद्योगिकी को प्रदर्शित करने के क्रम मे प्रदर्शन आवासों के निर्माण की एक योजना उत्तर प्रदेश में औरंगाबाद जागीर, तहसील सरोजनी नगर, लखनऊ में कार्यान्वित की है। प्रदर्शन आवासो के निर्माण हेतु 0.38 हैक्टेयर भूमि राज्य नगरीय विकास अभिकरण (सूडा), उत्तर प्रदेश द्वारा उपलब्ध कराई गई है। परियोजना पूर्ण होने के अंतिम चरण में है।



भूतल नक्शा

ifj;kstuk dh izeq[k fof'k"Vrk,a

- इस परियोजना में स्टे इन प्लेस डबल वाल ईपीएस पैनल तकनीक का प्रयोग किया गया है ।
- मकानों की संख्या 40 (भूतल+1 मंजिल)
- प्रत्येक भवन का फ़र्शी क्षेत्रफल 26.40 वर्ग मी.
- प्रत्येक भवन का निर्मित क्षेत्रफल 40.31 वर्ग मी.
- प्रत्येक आवासीय इकाई में एक बेडरूम, बहुउद्देश्यीय कमरा, रसोईघर, अलग डब्ल्यूसी और बाथरूम शामिल हैं
- बाहरी विकास
  - क्षेत्र का समतलीकरण
  - इंटरलॉकिंग टाइल की पगडंडी (पेवमेंटस)
  - बाउंड्रीवाल (चारदीवारी)
  - भूदृश्य अनुकुलता
  - जल आपूर्ति की लाइने
  - ट्यूब वैल का निर्माण
  - जल–मल निष्पादन
  - बरसाती पानी की निकास नालियां
  - बाहरी विद्युतीकरण
- मकानों में भूकंप प्रतिरोधन क्षमता है।

bLrseky dh xbZ çkS|ksfxfd;k¡

यह परियोजना उभरती हुई एवं आपदारोधी प्रौद्योगिकियों के प्रभावी इस्तेमाल की सजीव उदाहरण है । इसमे निम्नलिखित प्रोद्योगिकियाँ इस्तेमाल की गई है :

uhao
- आरसीसी दीवार की नींव

nhokj @ Lyc @ Nr
- स्टे इन प्लेस डबल वाल ईपीएस पैनल तकनीक

njokt+ksa dk Ýse
- लकड़ी के स्थान पर प्रेस्ड स्टील दरवाजे के फ्रेम
- दरवाजों के लिए लकड़ी का विकल्प फ्लश शटर्स
- शौचालय के दरवाजे में पीवीसी के फ्रेम और शटर

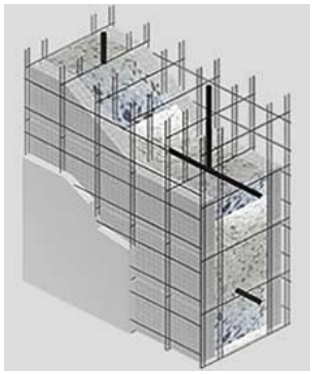
f[kM+dh dk Ýse
- गार्ड रेल और स्टील ग्लैज्ड शटर्स के साथ एमएस सेक्शन विंडो फ्रेम

Q'k
- कमरे, डब्ल्यूसी और बाथ में सिरेमिक टाइल फर्श
- सार्वजनिक मार्ग में कोटा स्टोन

jlksbZ dkmaVj
- संगमरमर के साथ आरसीसी काउंटर टाप

lh<h;k¡
- कोटा स्टोन फर्श के साथ आरसीसी सीढ़ी

nhokj dh lrg
- आंतरिक दीवार सतह पर एक्रिलिक डिस्टेंपर
- बाहरी दीवार सतह पर मौसम प्रतिरोधी पेंट



(ङ) हैदराबाद, तेलंगाना में प्रदर्शन आवास परियोजना

उभरती एवं आपदारोधी प्रौद्योगिकी को प्रदर्शित करने के क्रम मे प्रदर्शन आवासों के निर्माण की एक योजना तेलनगांना राज्य में निर्मती केन्द्र, गॉचीबावली, हैदराबाद में कार्यान्वित की है। प्रदर्शन आवासो के निर्माण हेतु 1085 वर्ग मीटर तेंलनगांना स्टेट हॉउसिंग कॉरर्पेशन लिमिटेड, हैदराबाद द्वारा उपलब्ध कराई गई है।

विभिन्न उभरती प्रौद्योगिकियों के प्रदर्शन के क्रम में, परिषद ने दो भिन्न प्रौद्योगिकियों अर्थात (i) संरचनात्मक स्टे–इन–प्लेस सीआर स्टील से बने और विशेषतौर पर डिजाइन किया गया फॉर्मवर्क सिस्टम वाली मॉनोलिथिक संरचना (16 आवास) एवं (ii) हल्के गेज वाले स्टील फ्रेम संरचना (16 आवास) के उपयोग से 32 प्रदर्शन आवासों (जी–3) हेतु दो ब्लाकों का निर्माण कर रहा है। परियोजना पूर्ण होने के अंतिम चरण में है।

ifj;kstuk dh izeq[k fof'k"Vrk,a

- इस परियोजना में दो तकनीको का उपयोग किया गया है:
  - स्ट्रैचरल इन प्लेस सीआर स्टील स्पेशियली डिजान्ड फोर्मवर्क सिस्टम (कॉफर) तकनीक
  - लाईट गेज स्टील फ्रेमन्ड स्ट्रैक्चर (एल.जी.एस.एफ. एस.) वॉल तकनीक
- मकानों की संख्या 32 (भूतल+3 मंजिल)
- प्रत्येक भवन का फ़र्शी क्षेत्रफल 38.74 वर्ग मी.
- प्रत्येक भवन का निर्मित क्षेत्रफल 53.18 वर्ग मी.
- प्रत्येक आवासीय इकाई में एक बहुउद्देश्यीय कमरा, दो बेडरूम, रसोईघर, दो शौचालय डब्ल्यूसी सहित शामिल हैं
- बाहरी विकास
  - क्षेत्र का समतलीकरण
  - इंटरलॉकिंग टाइल की पगडंडी (पेवमेंटस)
  - जल आपूर्ति की लाइने
  - ट्यूब वैल का निर्माण
  - जल–मल निष्पादन
  - बरसाती पानी की निकास नालियां
  - बाहरी विद्युतीकरण
- मकानों में भूकंप प्रतिरोधन क्षमता है।

भूतल नक्शा

bLrseky dh xbZ çk|kfxfd;k¡

यह परियोजना उभरती हुई एवं आपदारोधी प्रौद्योगिकियों के प्रभावी इस्तेमाल की सजीव उदाहरण है । इसमे निम्नलिखित प्रोद्योगिकियाँ इस्तेमाल की गई है :

uhao

- आरसीसी कॉलम / कॉफर वॉल की नींव

nhokj @ Lyc @ Nr

- स्ट्रैचरल इन प्लेस सीआर स्टील स्पेशियली डिजान्ड फोर्मवर्क सिस्टम (कॉफर) वॉल पैनल
- सिमेन्ट बोर्ड फिक्सड ऑन लाईट गेज स्टील फ्रेमन्ड स्ट्रैक्चर (एल.जी.एस.एफ.एस.) वॉल
- बीम आधारित आरसीसी / एल.जी.एस.एफ.एस. स्लैव

njokt+k d; Ýse

- लकड़ी के स्थान पर प्रेस्ड स्टील दरवाजे के फ्रेम
- दरवाजों के लिए लकड़ी का विकल्प फ्लश शटर्स
- शौचालय के दरवाजे में पीवीसी के फ्रेम और शटर

f[kM+dh dh Ýse

- गार्ड रेल और स्टील ग्लैज्ड शटर्स के साथ एमएस सेक्शन विंडो फ्रेम

Q’k

- कमरे, डब्ल्यूसी और बाथ में सिरेमिक टाइल फर्श
- सार्वजनिक मार्ग में कोटा स्टोन

jlkbZ dkmVj

- संगमरमर के साथ आरसीसी काउंटर टाप

lh<h;k¡

- कोटा स्टोन फर्श के साथ आरसीसी सीढ़ी

nhokj dh lrg

- आंतरिक दीवार सतह पर एक्रिलिक डिस्टेंपर
- बाहरी दीवार सतह पर मौसम प्रतिरोधी पेंट

Concept Note

Improving Municipal Solid Waste Management is critical for sustainable urban development

OCTOBER 1 World Habitat Day MUNICIPAL SOLID WASTE MANAGEMENT

World Habitat Day, which is celebrated on the first Monday of October, brings attention to UN-Habitat's mandate to promote sustainable urban development policies that ensure adequate shelter for all.

This year's theme is Municipal Solid Waste Management. In 2010 it was estimated that every day 0.8 kilograms of waste is produced by every person in the world. And the amount of total waste generated is expected to triple to 5.9 billion tons a year by 2025, due to increased consumption and ineffective management strategies.

Cities often spend a large proportion of their budget on Municipal Solid Waste Management which should be at the top of the agenda for cities, their inhabitants and governments at national and local levels. Cities should aim to become 'Waste-Wise Cities'.

The Sustainable Development Goals (SDGs), the Paris Agreement and the New Urban Agenda, address the key issue of solid waste management. The target of SDG11.6 is to reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management with indicator 11.6.1 being the proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated by cities. SDG 12 on "Sustainable Production and Consumption" targets among other things, environmentally sound management of all waste through prevention, reduction, recycling, reuse and the reduction of food waste.

The New Urban Agenda makes a commitment to "the environmentally sound management and minimization of all waste". Under the Paris Agreement, Nationally Determined Commitments (NDCs) of many countries, include action on waste management to reduce greenhouse gas emissions. Translating the national government commitments to practical and sustainable actions at the local level, needs the support of a network of actors with local authorities taking the lead to maximise partnership opportunities.

Expected yearly waste generation by 2025

5.9 billion tons

This is due to increased consumption and ineffective management strategies

11 SUSTAINABLE CITIES AND COMMUNITIES

UN-HABITAT FOR A BETTER URBAN FUTURE

Source: https://unhabitat.org/whd-2018/

The Problem

Developing countries often have inadequate waste management systems due to lack of financing, poor awareness, poor governance systems and sometimes inappropriate applications of technological solutions. Poor collection and disposal of municipal solid waste causes local flooding and water pollution and accumulated waste provides a breeding ground for rodents and insects which spread disease. Marine litter and erosion of coastal dumpsites contribute to marine pollution.

Uncontrolled waste-burning adds to air pollution while poorly maintained waste transportation vehicles and landfills contribute to greenhouse gas emissions.

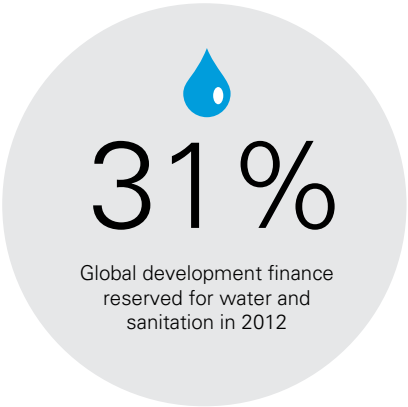
High-income countries generate more waste per-capita than low- income countries. In rapidly-urbanizing areas, suitable sites for sanitary landfills is becoming scarce due to the increasing price of land and objections from the community.

Wider use of electronic goods and their built-in obsolescence leads to "waste trafficking" with e-waste produced in developed countries ending up in dump-sites in developing countries with lower environmental standards and labour costs.

Poorly managed landfills pose many health hazards particularly for informal waste pickers. These include air pollution, injuries and landfill collapses. In 2017 alone more than 130 people, most of them women, died in landfill collapses in Africa. Children are also frequently employed in this dangerous occupation and are deprived of educational opportunities.

The trans-boundary movement of municipal solid is an inexpensive way to circumvent local environmental laws related to disposal but must be discouraged. Although appropriate recycling industries may not be available locally, every effort should be made to establish such facilities.

Municipalities often spend up to 70% of their budget on waste management, including on street sweeping etc. Aside from high investment costs for equipment, a sizeable number of staff are also required. The quality of a city's waste management system is often used as a guide to the overall effectiveness of municipal management. However, government investment in solid waste management is low compared to other sectors such as water and sanitation. The main difficulty lies in providing an equitable charging system. In addition, solid waste management is a low priority for development finance institutions. In 2012, only 0.32% of global development finance went to solid waste management while water and sanitation received 31%. Africa, compared to the Latin America, Caribbean and Asia regions received the least investment.



Source: https://unhabitat.org/whd-2018/

Towards Solutions

Trends in consumption and production, manufacturing product cycles, public attitudes, municipal governance systems, capacity of city managers and innovative financing for solutions are all part of the solution to solid waste management. In addition, transparent and rules-based engagement of all stake-holders including waste producers, the waste recycling industry and waste workers is key. Integrating the informal waste recycling sector in the organized economy, with adequate health and safety provisions for workers can change the current informal and dangerous jobs of waste collectors. Developing a market for innovative and attractive products made from waste material can help to integrate the informal waste sector in the economy.

Greenhouse gas emissions from solid waste accounts for about 3% of the global total (IPCC 2010) but the potential contribution of better waste and resource management to climate change mitigation is much higher.

Recognising that municipal waste management needs and approaches varies from city to city, UN-Habitat recommends that solutions are built on respective cities' assets and strengths either in the formal waste management system or in the informal or micro enterprise sectors. Developing a network to share experiences and good practices will allow cities to learn from each other.

UN-Habitat thus promotes an "Integrated Solid Waste Management Framework" which envisages: good waste collection services; environmental protection through proper treatment, disposal and resource management; cost-effective, affordable, and inclusive solutions which also recognize the role of informal and micro-enterprise sectors in achieving high rates of recycling.

Cities need to explore how increasing land values can be channeled towards better waste management. For example, cities could examine the real cost of providing waste collection services to high-income, low-density neighborhoods, taking into account the quantity of landfill space required to accommodate such waste and charge residents according to the volume of waste. In some cities, reclamation of land through treatment of landfill sites and the use of disused quarries as landfills have been tried and can be studied for potential replication.

Education and awareness activities have a key role to play and local governments can engage with civil society and advocacy groups to raise public awareness with schools as a possible focus. UN-Habitat's field experience has shown the efficacy of child to parent teaching of better hygiene practices and this could be replicated with municipal waste. Incentives to change public behavior such as paying for the return of used plastic bottles can be effective. Manufacturers need to improve packaging to reduce waste or by making packaging waste more easily recyclable.

Source: https://unhabitat.org/whd-2018/

The is no doubt that sharing of knowledge and experience between countries and cities has added valued. Some examples are described below:

The African Clean Cities Platform and the Urban Pathways Project

The African Clean Cities Platform (ACCP) is a platform to share knowledge and promote the Sustainable Development Goals (SDGs) on waste management in Africa with the aim of African countries realizing clean and healthy cities. It was established in April 2017 with the Ministry of the Environment of Japan, the Japan International Cooperation Agency (JICA), the United Nations Environment Programme (UN-Environment), the United Nations Human Settlements Programme (UN-Habitat) and City of Yokohama, and currently 60 cities in 31 countries in Africa are participating.

At the first annual meeting of the ACCP held in Morocco in June 2018, 32 countries and 48 cities presented their municipal waste management issues and discussed solution strategies and potential projects. The African Development Bank and the Japan Bank for International Cooperation participated.

UN-Habitat supported by the German Government's International Climate Initiative is implementing the "Urban Pathways: Low Carbon Basic Services in the context of the New Urban Agenda". This project will assist countries in making progress against the SDGs and the Paris agreement. Capacity building of city managers and city-city exchange of good practices are expected to lead to the development of bankable projects including on Solid Waste Management and resource recovery.

Call to action – become a 'Waste-Wise City'.

- Urbanisation and economic growth are creating a potential "time-bomb" of poor solid waste management. If not addressed, aside from huge costs, the significant impact on human health and the environment will be felt by nations at all levels of development;
- All cities regardless of their size and financial capacity can improve upon the current state of solid waste management to become 'Waste-Wise Cities'. Reducing operational cost while at the same time minimizing negative impacts on health and environment;
- Cities and national government should empower and work with civil society and NGOs;
- Cities should learn from examples from other cities and should carefully examine technological solutions implemented elsewhere;
- Cities should make long-term strategic plans for urbanisation which fully consider solid waste generation, treatment (including recycling) and identify adequate space for future sanitary land-fill sites;
- Cities and national governments should design financial and other incentives that will promote a transition to a more circular economy, built around resource use and efficient recycling and reuse as outlined in SDG12.5 on reducing waste generation through prevention, reduction, recycling and reuse;
- Moving forward, UN-Habitat will continue its dialogue on solid waste management beyond World Habitat Day with cities, industries and the private sector. It will explore how to work with other UN agencies in creating a joint platform on urban waste management to better inform Governments through policy dialogue and focused technical assistance through specific projects. Cities that improve their solid waste management and reduce their expenditure on waste management should be publicly recognized as "Waste-Wise Cities". UN-Habitat looks forward to hearing about innovative practices to achieve "Waste-Wise Cities"

Source: https://unhabitat.org/whd-2018/

Purview of C&D Waste Management Practices in Indian Construction Companies



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Introduction:

Construction sector has always played a pivotal role in shaping Indian economy. By 2030, it will become third largest in the world with 15% contribution to India's total GDP [1]. But one of the key challenges associated with such "construction boom" is effective management of the tremendous amount of waste generated during the course of construction works. According to TIFAC (Technology Information Forecasting and Assessment Council) approximately 40-60 kg of waste is generated per sqm of new construction/ repair work whereas 300-500 kg of waste is generated during demolition of building and other civil structures [2]. As per the estimates of Ministry of Environment and Forest, Govt. of India, approximately 10-12 million tonnes of construction and demolition waste is generated every year. [2]

Essentially, construction and demolition waste is bulky, heavy, inert and heterogeneous in nature. It is comprised of building materials, debris and rubble generated from construction, re-modelling/ renovations, repair and demolition of civil structures like buildings, roads bridges etc [2]. It often contains excavated materials (like soil, sand gravel) concrete, bricks, wood, metals, gypsum, plastic and other salvaged building materials. Thus the characteristics and composition of C&D waste makes it difficult to handle. However, there are many other factors which affect the efficacy of C&D waste management system, like market for recycled construction materials, quantum and pace of C&D waste generation, awareness among various stakeholders, usage of low-waste materials and technologies, availability of an effective C&D waste management policy etc.

2. Literature Review

The challenge associated with effective management of C&D waste is more profound in developing countries like India "which are entering or already entered in construction boom era" and thus produces more quantum of C&D wastes demanding immediate attention [3]. Recent investigation by many researchers reveal that primary reasons behind an ineffective waste management system in India is either lack of enforcement of statutory norms [4] or space constraints, deployment of multiple stakeholders etc. affecting efficacy of construction waste management systems [5]. A need for treating C&D waste management in distinct from municipal solid waste management has also been raised [6]. There is a dire need to deal with the existing ambiguity of available data on the composition and quantum of C&D waste generated along with rationalizing the process of quantification of C&D waste data. The lack of accurate data is also an inhibitor on nation-wide capacity building for handling C&D wastes [3]. This paper tries to explore the extent to which these issues affect the efficacy of C&D waste management system, especially after the publication of "C&D waste management rules, 2016". A monitoring of construction projects those have started

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after this will give a more realistic understanding on the efficacy of the current system of C&D waste management in the country. The authors acknowledge the importance of the linkage between project demographics and C&D waste management practices which seems to be currently lacking in most of the previous researches.

3. Objectives

The overarching objective of this research work is to investigate the current practices of C&D waste management from perspective of construction contractors. For accomplishing this broad objective, following sub-objectives are designed for the purpose of this research:

- To develop a thorough understanding of applicable C&D waste-management policy and regulations from the perspective of construction contractors.
- To investigate the present situation of C&D waste management in building construction projects.
- To identify the critical challenges in implementing an effective C&D waste management systems from the perspective of construction contractors and suggest policy implications for the same.

4. Scope

Management and generation of C&D waste depends on the type of project as well as the construction materials and technologies used. Implementation of off-shore construction techniques (like prefab construction) or other emerging construction technologies can significantly reduce the generation of construction wastes. But in spite of the recent advances in innovative and alternate construction materials/ technologies, Indian construction industry is still primarily dominated by the traditional methods of construction [3]. The scope of the research is limited to C&D waste management practices in building construction projects which use traditional cast-in-situ methods of construction.

5. Research methodology

The study started with an exhaustive literature review of the present situation of the C&D waste management in India and the related statutory norms followed by case-studies of construction-projects across the country for an in-depth understanding. The case studies selected from the National Capital Region (NCR), Kharagpur (Sub-urban area in West Bengal) and Bhubaneshwar (State-capital of Odisha) reflect a wide spectrum of project dynamics, range of variations in terms of project-size and the type of Construction Company. The first case-study, which is a mega-construction project being developed by one of the leading construction companies of India demonstrates usage of state-of-the-art construction management tools like Building Information Modelling (BIM-5D). The second and third case studies are medium scale construction projects being developed medium and small construction enterprises respectively. This paper presents a comparative analysis of these projects conducted in order to identify the critical challenges of C&D waste management practices and assesses the variation of the same with demographic conditions. To further validate these findings, the identified challenges were presented to industry experts through semi-structured interviews. Total five industry experts with 5 to 20 years of experience were interviewed for this purpose. The ensuing discussion with the industry experts were helpful to identify the root-causes of the waste-management problems observed in the case studies.

5.1 Review of Construction and Demolition Waste Management Guidelines for Construction Contractors

In India, statutory regulations regarding management of C&D wastes are primarily governed by MOEF at the national level and provided as a part of Municipal Solid Wastes Management Rules. The latest policy guidelines on C&D waste management can be found from *The Construction and Demolition Waste Management Rules, 2016* which has been published in 29th March 2016 and superseded the provisions given in the previous policies on the same.

These rules are applicable to construction contractors producing more than 20 tons of waste in one day or more than 300 tons per project per month who would be responsible for collection, segregation, storage and disposal of construction and demolition waste generated, as directed by the concerned local authority. They are also required to submit a waste management plan to the local authorities and ensure that there is no littering or illegal disposition of the wastes.

5.2 Review of the Existing Practices of C&D Waste-Management: Discussions on the Case-studies

Case-study 1: This is a large scale

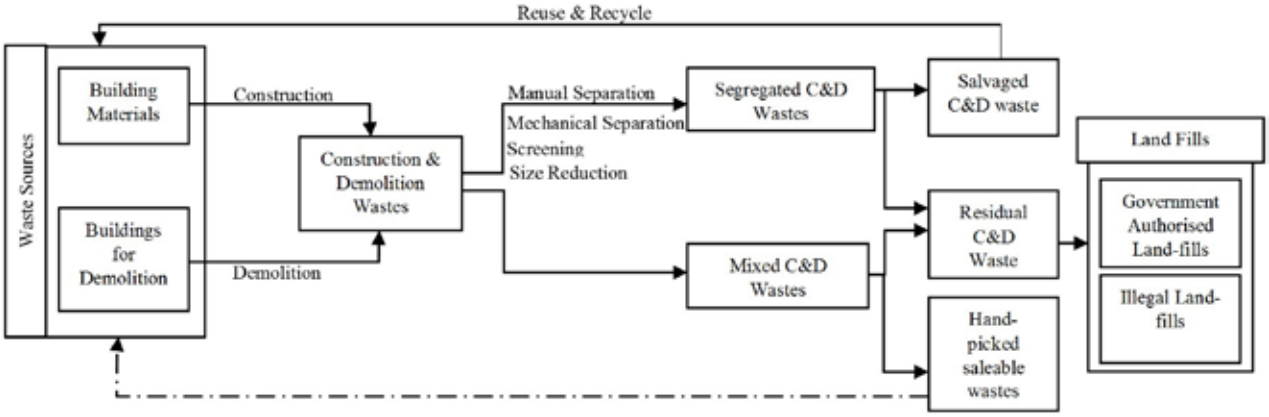

Figure 1: C&D waste management process in India

commercial building with a total built up area of 900,000 sqm over a plot size of 250 acres and an estimated cost of INR 2500 Cr. The project is being constructed by one of the leading construction companies of the country as a design & build project who handles this issue at two levels.

At the organization level, the concerned construction company demonstrates a well-structured system for waste-management which includes maintaining database of the registered vendors for disposing the waste materials at authorized government land-fills. This reduces significantly the chances of malpractices regarding illegal waste disposition although it might not be possible to track the individual trucks sent by these vendors. The company has also established an e-tendering system for selling of salvaged C&D wastes and created online stock record which can be used for centrally monitoring project stocks and issue of construction materials to the subcontractors.

At the individual project level, the waste management plan includes:

- Estimate at the inset of project various types of expected wastes during the course of the project, their quantities and potential sources.
- Set maximum permissible percentage of wastage for the major construction materials like, steel, cement, sand, coarse aggregates, bricks, tiles in consensus with the statutory provisions and contractual obligations by client. Incorporation of these calculations in project direct cost makes the project cost estimates realistic.
- Prepare consolidated reconciliation statements periodically for major construction materials and check the wastage percentages against the set limits.
- Draft standard norms for segregation and storage of various wastes in compliance with statutory requirements and the organizational policy on environmental management.
- Prepare detailed site-waste management plan with necessary budgetary provisions. This clearly defines the demarcated areas for various types of construction wastes.
- Provide strategic recommendation for the possible reuse of wastes and guidelines on other aspects of waste management like the standard procedure Equipment required for on-site recycling of C&D and other solid wastes, like composters, sedimentation tanks etc. are also identified at the very beginning of the project and incorporated in the project budget as an indirect cost.

Segregated cement bags

Mixed steel scraps stored in demarcate waste storage yard

Excavation wastes stored for backfilling

Table 1: Material Reuse Strategies-Case study 1

Materials	*Description of Reuse*
Concrete Debris	Crushed at site & used for backfilling below the plinth level in the structure itself, Waste of higher grade concrete are used in making pathway roads to labour hutment.
Solid CC Blocks	Used in filling & area development in steel yard service road at site
Reinforcement Steel Scrap	Moderate size cut pieces used in external drain cover slab, cable trench & other ancillary jobs like entrance canopy, pedestal for relaying of fire pipe line, air purification unit at terrace floor etc. and rest is sold to the external scrap vendor for recycling.
Structural Steel Scrap	Used for miscellaneous works at site & balance sold to external agency and used for recycling.
Plywood Waste	Moderate size cut pieces were used as temporary office file racks, shelf & miscellaneous site purposes and balance sold to external agency and used for recycling.

- Create waste-consciousness among the stakeholders through celebration of the best practices of C&D waste management (by subcontractors) at a quarterly interval. Other initiatives in this regard include poster competitions, workshops, drills and cultural programmes conducted on occasions like world environment day.

However, according to one of the senior planning engineers of the project, despite taking all these initiatives, challenges like rework, poor workmanship and frequent changes in design specification continue plaguing the waste management system of the project.

Case-study 2*:* This is a live construction project involving construction of 66 staff quarters with a total built-up-area of 8250 sqm, located within the campus of a Technical Institute in a medium sized town of West Bengal. The project having scope is construction of buildings and development of allied infrastructure (like roadways and other landscape works) with an estimated cost of INR 17.5 crores was awarded to a local, small scale constructor.

It was found that the second case-study project lacked in development of a systematic approach since there did not exist any mandate imposed by the local authorities. The authors on interviewing the site manager identified the following limitations in the system:

- Non availability of data on the quantity of waste generated in the project.
- No system of making periodic reconciliation of material usage or stock monitoring and materials are usually procured on "as-and-when-required" basis.
- Use of inferior quality of materials in the temporary structure and improper material handling/ storage like keeping formwork materials exposed to weather are significant contributors towards waste generation. This practice significantly reduces their service life and the average number of repetitions.
- Improper storage of materials like bricks, sand, etc to reduce labour-payments on items like material-shifting.
- Absence of well-defined system

Temporary access ways made by waste steel shuttering

Excavation waste stored for backfilling

Timber shuttering stored in open areas during monsoon

Mixed construction wastes

to segregate materials based on composition or hazardous nature of the wastes.

- Current practice of segregation depends on potential reuses of the wastes.
- Absence of demarcated area for waste storage.

However during the course of interview, the authors observed a few good practices on waste reduction and reuse as outlined below but these initiatives are more driven by financial concerns than environmental considerations.

- There is a general consciousness among the project engineers regarding the need for waste reduction and reuse.
- The excavated soil is stored for potential use in landscaping and backfilling work.
- Broken clay-bricks are mostly reused in plinth-protection and laying water-proofing course on terraces.
- Fresh concrete is put in sedimentation tanks for salvaging and reusing coarse aggregates.
- Timber wastes (primarily from formwork) are used as fuels for cooking in labour camps.

Case-study 3: This is a leisure building with built-up-area of 4,50,000 sqm at Bhubaneshwar (Odhisa) with an estimated project cost of INR 350 Cr being developed by a medium construction company. The primary cause of wastage in this project is rework like a clash encountered during installation of two escalators eventually led to demolition slabs/beams and subsequent rework. Also faulty design and frequent design changes are often causes of rework. The wastage of major materials like concrete, shuttering, reinforcement and bricks have been noted to be 12%, 1%, 9% and 7.5% as against respective permissible limits of 4%, 1% 5% and 5%

The authors noted the following points about this project:

- Prepare of a site-waste-management plan at the onset of the project in accordance to the organizational policies and statutory requirements.
- Define the maximum permissible limits of wastage for the major construction materials.
- Demarcate areas for scrap storage.
- Presence of a system of reconciliation of material usage which is irregular due to inadequacy of management emphasis in this regard.
- Absence of a system for maintaining online/ digital records of project stocks and material in the initial stages. This has led to eventual ambiguity in monitoring material usage.
- Presence of a system to enhance the productivity and skills of labour-force since they are permanent employees to reduce chances of rework.

The table 2 presents a comparative assessment of the three case studies.

6. Challenges in Effective C&D Waste Management: Analysis and Discussion on Contractor's Perspectives

On reviewing the site-waste management plans of the three cases studies in general and aspects like identification of potential sources of wastes, periodic monitoring, compliance to standard protocols for segregation, storage, collection and disposal of wastes as well as strategies for reducing/ reusing and on-site recycling of the same ,the authors compile the following challenges to be addressed.

Technological Challenges:

- ***Lack of adoption of low-waste construction technologies:*** Technological interventions like offshore construction can effectively reduce the generation of C&D waste but usage of these emerging construction technologies still remains low. The primary reasons behind this can be attributed to factors like unawareness and inability to assess potential benefits, fears regarding low end-user acceptability, lack of standards and guidelines, poor supply chain reliability and unavailability of skilled labours.
- ***Design inefficiencies:*** Lack of knowledge and awareness on waste generation and waste utilization aspects of building design, frequent design changes, communication gap between various project-stakeholders, lack of adequate consideration at design-phase of the project.

Organizational Challenges:

- ***Lack of management support:*** In most of the cases construction waste management plan is considered just as a statutory compliance and protection of environment gets less importance as compared to other project management objectives like time, cost quality and safety.
- ***Inadequate planning & lack of***

Table 2: Comparison of Waste Management Practices of the Case-study Projects

Parameters	*case-study 1*	*case-study 2*	*case-study 3*
Location	Delhi/ NCR (Metropolitan city)	Kharagpur (Suburban area)	Bhubaneshwar (State-capital)
Project Value	2500 Cr	17.5 Cr.	350 Cr
Total Construction Area	9 L sqm	8250 sqm	4.5 L sqm
Contractor Type	Large International Construction Company	Small/ Medium Local Construction Contractor	Large International Construction Company
Waste Management Plan	Yes	No	Yes
Waste storage	In demarcated areas	No dedicated area for storage of wastes	In demarcated areas
Waste segregation	Yes (based on composition and hazards associated)	Partial (based on potential reuse)	Yes (based on composition)
Wastage quantity	Within permissible limits	Not quantified	High, beyond permissible limits
Wastage monitoring system	Through reconciliation of materials and site inspections	None	Through reconciliation of materials and site inspections
Periodicity of waste monitoring	Monthly/ Regular	NA	On "as required" basis/ irregular
Major waste	Reinforcement and sand	Sand	Concrete
Major reasons of wastage	Lack of design considerations and poor workmanship	Inefficacy of material handling and storage, inferior quality material, poor workmanship	Rework due to design changes and inefficacy of material issuing system
Wastes reused	Concrete debris, steel scrap, ply wood, bricks, excavated soil	Plywood, steel formwork panels, clay bricks, excavated soil	Excavated soil, steel scrap
On-site recycling of wastes	Sedimentation tank and composter	Sedimentation tank	None

organizational standards/policies on waste management: In absence of organizational standards and policies on waste management, the efficacy of SWMP becomes subjective to the individual expertise of project managers and it becomes difficult to monitor them. It is often observed that construction companies largely rely on the "temporary arrangements" for waste management [7]. Other factors that need to be addressed in this regard include unavailability of dedicate resources and budgetary provisions for waste management, inadequacy of the time for planning of waste reduction/reuse/ recycling strategies and lack of coordination among various project participants.

- ***Incorrect perceptions regarding waste management costs:*** The major costs associated with C&D waste management are cost of collection, segregation, storage, transportation and disposal of wastes generated including costs associated with on-site recycling of wastes. Whereas the potential economic benefits associated with proper management are savings of the penalty charges levied on account of non-compliance with statutory provisions, revenue generated from selling C&D wastes, savings from reusing salvaged building materials from C&D wastes, incentives for using recycled construction materials. However, in absence of a standard framework for cost-benefit analysis of C&D waste management, a general perception prevails among construction contractors that C&D waste management is cost intensive.
- ***Inadequate training to supervisors/ labours:*** Inadequate on-job training provided by construction companies creates a pool of semi-skilled and inexperienced work-force leading to rework and subsequent generation of high amount of C&D wastes. Almost no formal training is given to construction workers on waste handling and management which further aggravates the inefficiency of the overall process of waste management.

Environmental Challenges:

- ***Lack of awareness on C&D waste management:*** This includes lack of awareness and education on the importance and also benefit of C&D waste management as well as standard procedures for the same.

- ***Poor implementation of C&D waste management regulations:*** In spite of policy regulations, malpractices like illegal dumping of wastes prevail in India [2] which is more prominent in sub-urban areas and small towns.
- ***Lack of market for recycled building materials and poor supply chain reliability:*** Out of the total waste generated in India, only 5% is recycled [2] whereas the developed countries typically recycle 80-85% of the total waste generated. High cost of recycled products and unavailability of appropriate wastes due to illegal dumping are important reasons [8].

7. Conclusion and Policy Implications

From the findings of the case-study and literature review it can be safely concluded that the waste management initiatives of Indian construction companies are primarily driven by the mandate of fulfilling the statutory requirements and financial concerns related to high material wastage. Most of the construction contractors focus on potential opportunities of reducing and reusing wastes generated with a view to alleviate the wastage-costs. Wastes that cannot be reused at site, are typically disposed to land-fills or sold at scrap value without considering the possibilities of recycling. However, it has been observed that in general waste management practices are better in large metropolitan cities where enforcement of C&D waste management regulations are more stringent. In sub-urban areas the situation of C&D waste management deteriorates primarily because of lack of implementation of the government policies. Thus more focus should be given towards enforcement of C&D waste management rules across the country and especially in the rural and suburban areas. Also to create a general consciousness about this issue among the construction practitioners, incorporation of construction waste management education should be mandated in disciplines like architecture, civil engineering and construction project management. In addition to this, policy interventions towards augmenting digitalization of the construction industry, implementation of innovative construction technologies, low-waste materials and effective project management tools like building information modelling can be instrumental for reducing waste generation significantly. In fact, the problem of C&D waste management is multi-disciplinary in nature. So an isolated policy on C&D waste-management might not be able to address all the dimensions of this problem effectively. Only through an array of well-structured and inter-related policies, the required regulatory framework can be developed for effective management of C&D wastes.

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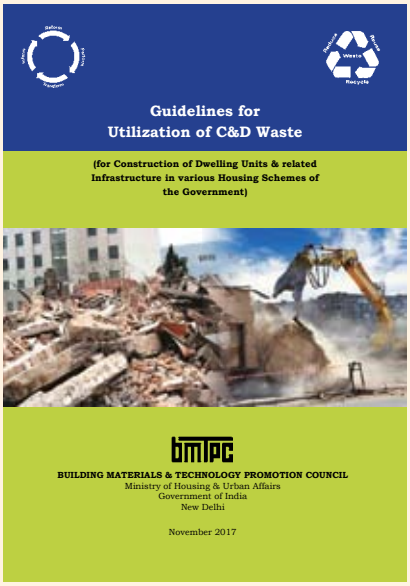
Guidelines for Utilization of C&D Waste

(for Construction of Dwelling Units & related Infrastructure in various Housing Schemes of the Government)



THE GUIDELINES

The Guidelines are developed to facilitate use of construction and demolition (C&D) waste in housing, especially low income housing. This is not only to promote sustainable development, environmental protection and optimum use of natural resources but also to combat the problems arising at urban centers for management of C&D waste. The Guidelines would provide citizens, developers, designers, practitioners, contractors, sub-contractors and concerned authorities for a framework to take forward the gainful utilization of C&D waste in construction of low cost urban housing and allied structures.

In India, the legislation governing C&D waste management has just been enacted. The plants that have came up at New Delhi and Ahmedabad for recycling of C&D waste are the result of proactive action of the concerned two civic bodies.

Subsequent to finalisation of Guidelines by BMTPC, Central Pollution Control Board, Ministry of Environment, Forest & Climate Change, Govt. of India has also brought out "Guidelines on Environmental Management of C&D Waste" in compliance of Rule 10 sub-rule 1(a) of the C&D Waste Management Rules 2016. This Guideline addresses issues pertaining to abatement of adverse environmental impacts specifically arising from C&D waste management activities, not covered by BMTPC Guidelines.

A set of guidelines that can go a long way to facilitate large scale utilization of C&D waste are:

I. Legislative and Statutory

(i) The Government of India and State Governments may take appropriate action for speedy implementation of the "C&D Waste Management" legislation. C&D Waste Management Rules, 2016 have been notified vide G.S.R. no. 317(E) dated 29th March, 2016.

(ii) Each of the State government may re-affirm the implementation of the Central act as it is or with further details as may be applicable to the respective State.

(iii) The Civic bodies of mega cities and million plus cities may bring out the guidelines incorporating the norms and practices to be followed in their respective jurisdictions. Civic bodies of other urban centers of population less than 1 million may also initiate the similar actions. The timelines for these actions by civic bodies may be specified by the State governments.

(iv) The Statutory bodies responsible for bringing out Standards & Specifications such as BIS, IRC, etc. may bring out the required documents on priority with in a defined timeline.

(v) CPWD, PWD, Indian Railways, Military Engineering Services (MES) and all other Government/ Quasi Government agencies may incorporate use of C&D waste and products derived out of that, as applicable to each one of them in their respective schedule of approved materials and rates. This may also be reflected appropriately in their respective departmental guidelines, manuals and tender documents, etc.

II. Implementation actions by State government/ Civic bodies

(i) Site for setting up for recycling of C&D waste may be identified, allotted and approved. The Civic bodies wherein current waste generation is more than 2000 tpd, may set up more than one plant for recycling of C&D waste.

(ii) Collection centers may be notified wherein small quantity generators of C&D waste can deliver the C&D debris. The system and arrangements for collection and supply of C&D waste to recycling plants may be worked out and defined in an unambiguous manner.

(iii) The guidelines/ terms & conditions for the concessionaire/ vendors to set up C&D waste recycling plants may be published.

(iv) The training programs be initiated for builders, architects, contractors, demolitioners, etc. to recover maximum of items for re-use and also for segregation of C&D waste as well as for building the confidence in the products manufactured from C&D waste.

III. Product quality Assurance

(i) Central and State Governments may sponsor projects with IITs, NITs, Engineering Colleges and renowned private/ in-house engineering R&D agencies/ facilities to develop/ improve technologies and or processes for production of consistent quality products from C&D waste at affordable cost and also to provide required technical guidance and help to the C&D waste recycling plants.

(ii) Laboratories/ common testing facilities may be designated for quality test and certification.

IV. Statutory clearances and availability of finance

(i) The site selection and finalization for setting of C&D waste recycling plant may be done by State government with all required approvals, clearances, consent, etc. of different wings of the Government regarding forest clearances, environment clearance or any other such requirements so that the concessionaire/ vendor is not required to spend time and energy for such clearances.

(ii) While implementing the project on C&D, cognizance of CPCB Guidelines should also be taken into account.

(ii) As the proposed activity is to reduce the load on the environment as well as natural resources, the C&D waste recycling plants may be provided all concessions and incentives as applicable to clean energy technologies, such as:

(a) Finances on concessional rate of interest.

(b) Interest holiday for 10 years

(c) Income tax holiday for 10 years.

(d) The recycled C&D waste products should be free of any taxes/ levies such as VAT, excise duty, sale tax, municipal/ panchayat tax, any state tax or inter state movement tax.

(iii) The agreement of concessionaire with Municipal Corporation/ government agencies should be at least for a period of 20 years and not for 7-8 years as is being proposed by some of the municipal corporations. This is to provide sustainability.

V. Utilization of recycled C&D waste products

(i) All Government constructions may be mandated to use at least 20 per cent of recycled C&D waste products.

(ii) All renovation projects involving demolition, even in private sector, may be mandated to use at least 20 per cent of recycled C&D waste products. These projects can take recycled C&D waste products from recycling plant on return trip of their debris delivery vehicle.

(iii) The tipping fee for delivery of C&D waste to the recycling plant, terms & conditions of civic body with the concessionaire may be designed to keep the price of C&D waste recycled products about 20 per cent lower than the corresponding conventional products. This would be an attraction to the end users of these products.

(iv) The use of recycled C&D waste products may not be confined to building construction only. Some of the products like coarse aggregates including big size aggregates, mixed debris and waste fines can be used in construction of roads, filling of low lying areas, plinth filling and landscaping, etc.

(Excerpts from the Guidlines for Utilization of C&D Waste brought out by BMTPC in November 2017)

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Solid Waste Management

*Ar. Anupam Mittal**

"50 meter high Ghazipur garbage pile dumps many into the road side canal"

September 1, 2017 may not have been registered in our minds as one of the very important dates but the same date has become the most important date for the families of those who have lost their dear ones and for those who could somehow escaped from the death. It may be probably the first incident of its kind when our own trash, created by ourselves, collected randomly and dumped brainlessly by the group of intellectuals, sitting at a high position in the government and could not foresee any such thing in spite of having all kind of data, standards and knowledge with them.

Apparently, as per reports in September 2018 the pile could now be just 8 meters short in height than the Qutub Minar, the tallest monument in New Delhi which

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is 73-meters-high. The unsegregated pile at Ghazipur is largely solid waste collected from all over Delhi is increasing by 10,000 metric tonnes each day, a question to be answered

"What our ancestors provided us and what we will be leaving for future generations?"

There were alarms earlier too but we have ignored all of them. Whenever there is normal or excess of rains, our cities get flooded for hours and days, mostly due to chocked drains and drains are chocked due to solid waste which has been never collected or dumped otherwise. The house hold waste, electronic waste, scrap, cottage industries waste and day to day solid waste can be found scattered throughout the lanes, streets and city roads in most of our cities in India. The absence of any organized waste segregation and dumping system, even the segregation at household level does not help much.

Mumbai Flood 2017

None of the state government or even the central government has come up with a policy to curb the existing system and create a long term solution, may be with small steps at grassroots level.

The solid waste management can be taken in consideration from both the ends together, the user and the final disposal. One thoughtful policy by the governing bodies like Municipal corporations of cities, one decision of stopping

Colored Garbage Collection System

Mechanical Waste Segregation

Reuse of used tyres as landscape elements

Kitchen Waste Recycling

production of plastic bags, the biggest culprit and one strong step of implementing those polices and decisions by enforcement may do wonders. Though the polices and enforcement will take its own time to show results, public awareness though social media, print and electronic media and workshops at grass root level will definitely help the system to be built as a long term solution.

Even if we go back to The days of "kabadiwala" or the scrap guy, who used to roam around the lanes to collect scraps in exchange of little money, can be taken an example of small steps of reuse and recycling of many items which otherwise become the part of solid waste, get mixed with the other house hold garbage and create those toxic, artificial and dangerous pileups in and around the cites, ready to take lives of many by poisoning the ground water and sweeping the lives instantly once that becomes bigger.

Singapore, Japan and countries like Norway and Finland have planned the household garbage collection and the disposal very effectively. They have created a system which allows them to recycle and reuse most of the part of garbage collected because the solid waste was collected in three to seven parts right at the user level itself. For glass, plastics, metals, paper, electronic items, rubbers and kitchen waste are the maximum number of collection boxes generally kept on the streets for the first level collection for the municipal solid waste. The collected metals, plastics, papers and glass like recyclable materials are then taken to the large collection areas near the city outskirts or designated fields and the same is been mechanically segregated as per the desired scrap which is later auctioned to the scrap dealers or transferred to the designated government agencies for recycling purpose.

Kitchen waste is no longer a waste but converts into fertilizer after composting. There are many ways of using 100% of kitchen waste as fertilizer even at the kitchen garden level and the same can be done in larger level to manage the waste by putting put such composting plants at municipalities level. Electronic waste, may be the biggest and the most dangerous solid waste of the recent times. The size of which is increasing day by day and we are still to find the right way to manage the same. Electronic waste is not only inflammable but also spreads toxic gases which harm the environment in the worst possible way. Though few of the manufacturers of electronic goods have started buy back or started giving discounts against the deposit of unusable or old electronic products under their "corporate social responsibility" programs. This helps in reducing the dumping of electronic waste and may help the manufacturing companies in producing little cheaper items for the masses as well.

Rubber, again inflatable and toxic in nature with one of the worst solid waste for which we are still struggling to find ways to recycle it to save it from creating more of toxic gases in the future. Though few social organizations and individuals are trying to make use of used tyres in some innovative way such as creating underground septic tanks, making base of mechanical equipments and in similar long lasting tanks which can save time and money in addition of using the waste but we still to find bigger and better use of the used rubbers to save the environment from its dumping in due course of time.

Ultimately, only dumping or landfill will not be a long term solution for the municipal solid waste even if it is able to create some land parcels in water logged area but we need to do into the depth of it by creating innovative ways to recycle it as much as possible and reducing the quantum of solid waste to nil in the future to save the environment for our own future generations.

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BMTPC's Role in Implementation of the Pradhan Mantri Awas Yojana (Urban)

A. Site Scrutiny along with DPR Desk Scrutiny of projects under BLC vertical of PMAY

BMTPC has been designated appraisal and monitoring agency under Pradhan Mantri Awas Yojana - Housing for All (Urban) Mission for projects in various states/UTs falling in Earthquake Zone IV and Zone V. The following project has been scrutinized & visited during 2018-19:

1. DPR for beneficiary led Construction (1558 DUs) at Naharlagun Arunachal Pradesh
2. DPR for construction of 191 Enhancement DUs under beneficiary led Construction at Kathua Town, Jammu & Kashmir
3. DPR for construction of 1200 New DUs under beneficiary led Construction at Sopore Town, Jammu & Kashmir
4. DPR for construction of 431 DUs (419 New DUs & 12 DUs Enhancement) under beneficiary led Construction at Jawali, Himachal Pradesh
5. Site Scrutiny along with DPR Desk Scrutiny of project of OF New Construction – 5361 DUs In Aizawl City, Mizoram, Under BLC vertical of PMAY (U)
6. DPR for construction of 1794 New DUs under beneficiary led Construction at Tuensang Town, Nagaland
7. DPR for Construction of 1146 Enhancement DUs under Beneficiary Led Construction at Wokha Town Nagaland
8. DPR for 270 DUs under Beneficiary led Construction at Chinyalisaur, Uttarakhand
9. DPR for 1093DUs under Beneficiary led Construction at Srinagar, Jammu & Kashmir
10. DPR for 92 DUs under Beneficiary led Construction at Jammu, Jammu & Kashmir
11. DPR for construction of New DUs under beneficiary led Construction at 64 Town, Arunachal Pradesh
12. DPR for construction of 4224 New DUs under beneficiary led Construction at Agartala Town, Tripura

Shri Durga Shanker Mishra, Secretary, MoHUA, inspecting the Demonstration Housing Project being constructed by BMTPC using emerging Technologies under PMAY(U) at Biharshariff, Bihar

B. Random Quality check/ Monitoring of project under Rajiv Awas Yojana (RAY)

(As per the direction of Ministry)

1. Construction of 576 Rental Houses & infrastructure at Chimpu village, Itanagar (Arunachal Pradesh)
2. Construction of 320 Houses & infrastructure at Dirang (Arunachal Pradesh)
3. Construction of 384 Houses & infrastructure at Bomdila (Arunachal Pradesh)
4. In-situ redevelopment of Sakharnagar slum for construction of 1448 DUs in Akoda Tandaja area ,Vadodara (Gujarat)
5. In-situ redevelopment, construction of 1448 DUs near Mansarover lake area, north Palanpur (Gujarat)
6. Construction of 960 DUs in Surendranagar City Mansarover lake area, north Palanpur (Gujarat)
7. Affordable Housing in Partnership (AHP) for EWS (1652 DUs) & LIG (812 DUs) at 4 locations in AUDA area, Ahmedabad (Gujarat)

C. Other activity under HFA

1. Interactive Session on New Construction Technology for Housing held on 18th January, 2018 at New Delhi.

Performance Appraisal Certification Scheme (PACS)

Introduction

Performance Appraisal Certification Scheme (PACS) is a third party operated voluntary scheme for providing Performance Appraisal Certificate (PAC) to a manufacturer/supplier/installer of a product/ system which includes building materials, elements of construction, assemblies, technologies etc. after due assessment. The process encompasses:

- Establishing criteria of performance
- Verifying that the product/ system conforms to the requirements for satisfactory performance, durability and safety
- Operation of a Quality Assurance Scheme by the manufacturer/supplier/installer
- Issue of PAC providing, amongst other things, necessary data to designers and users.

The Govt. of India, the then Ministry of Urban Development and Poverty Alleviation authorized BMTPC through Gazette Notification dated 4th December, 1999 to operate PACS.

PACS operation is fully transparent and in order to ensure transparency and objectivity, it is administered by a tier of committees of experts, the structure consists of:

1) BMTPC Board of Agreement (BMBA) with a senior technical expert as its President and nominees from Professional Bodies, major Govt. bodies like CSIR, Central & State PWDs, BIS, DGS&D, Industry Associations, eminent individuals etc.
2) Technical Assessment Committee (TAC) with a senior technical expert as its Chairman and members from R & D Institution, BIS, user departments and other concerned agencies/ experts.

The Committee is assisted in the assessment of products/ systems by individual experts in the related fields and well established laboratories.

II. Need for PACS

As a part of its mandate, BMTPC has lent its support in the development of a number of non-traditional building materials/ components and systems and machinery for their manufacture. These newly developed products are user friendly and eco-friendly. In the absence of data regarding design and use of these products, these have not become popular/ are not being used as widely as they should have been. National standards do not exist for some of these products or existing standards do not specifically cover the special aspects for these products. Therefore, a need was felt for a system which provides the necessary information to remove the inhibitions and doubts in the minds of designers and users.

III. PAC helps in formulating National Standards and Schedule of Rates

- PACS is designed to create necessary data and documents which are required for formulation of a standard
- While processing for PAC, criteria are fixed for performance of a product/ system
- Where test methods are not available, these are developed for specific product/system
- Laboratory, factory and field test verify performance
- The Certificate contains details required for framing Specifications and Code of Practice
- Certificates are forwarded to BIS and CPWD for formulation/review of relevant Indian Standard and Schedule of Rates (SoR) respectively.
- Ministry of H&UA has decided that CPWD, DDA & NBCC may adopt the technologies which have been validated by BMTPC

in all their projects irrespective of location and project cost. Further, in future, new emerging technologies as validated by BMTPC, DG, CPWD will issue the SoR and will also be included in the list.

IV. PACs Approved and Issued Till Date

Within the framework of Power and Functions of Technical Assessment Committee (TAC), Applications for appraisal of new building materials and construction technologies were received by BMTPC. Performance Criteria, based on National & International practices were framed in consultation with other members.

So far 14 meetings of TAC have been held and 56 PACs have been issued till now.

V. Progress Report of Performance Appraisal Certification Scheme (PACS)

The details of activities carried out under Performance Appraisal Certification Scheme (PACS) during 2018 are highlighted below:

Approval of PACs

PAC for the following 11 systems/products approved in the TAC's 13th & 14th meetings held on 16th February, 2018 and 10th August, 2018 were approved and issued to the respective manufacturers:

1. Structural Stay-in-place Formwork System
2. Monolithic Insulated Concrete System (MICS)
3. Lost-in-place Formwork System - Plasmolite Wall Panels
4. Lost-in-place Formwork System - Plaswall Panel System
5. Resin Bonded (Plastic Waste) Tiles
6. Continuous Sandwich (PUF) Panels with Steel Structure
7. Nano Living System Technology
8. PIR Dry Wall Pre-fab Panel System
9. Flyash EPS Cement Sandwich Panels
10. Robomatic Hollowcore Concrete Wall Panels
11. BauPanel System

Brief about these technologies are given hereunder:

1. Structural Stay-in-place Formwork System

The system consists of an integrated formwork, with draining facing panels, self-bracing with relation to the thrust from the fresh concrete. The formwork consists of two panels with vertical stiffening frame work of press-formed steel sheet sections and skin of expanded metal, connected to each other by metal connectors. The panels are manufactured and assembled in the factory.

2 Monolithic Insulated Concrete System (MICS)

Monolithic Insulated Concrete System (MICS) is a system of formwork for reinforced concrete made with a rigid thermal insulation that stays in place as a permanent interior and exterior substrate for walls, floors and roofs. Monolithic Insulated Concrete System (MICS) results in cast-in-place concrete walls that are sandwiched between two layers of modules i.e. *Expandable Polystyrene* (EPS) separated by hard plastic ties. The modules are interlocking modular units that are dry stacked (without mortar) and filled with concrete once laid out. The units lock together and create a form for the structural walls or floors of a building.

3. Lost-in-Place Formwork system – Plasmolite Wall Panels

Plasmolite Panels are lost in place formwork system where two fibre cement boards (FCB) of 6 mm thickness and High Impact Molded Inserts (HIMI) (spacers) bonded between two sheets of FCB in situ and 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 for pre-engineered buildings. This technology may be used as non-load bearing walls for external and internal applications.

4. Lost-in-Place Formwork System – Plaswall Panels

Plaswall Panels are lost in place formwork system, 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

5. Resin Bonded (Plastic Waste) Tiles

Resin Bonded Tiles are manufactured from plastic waste and white sand. The plastic waste is taken from city waste collection centre, dried, segregated, crushed, grinded, separated from metals and formed into plastic chips. Plastic chips are then mixed with sand granules for further processing for production of tiles. These tiles may be used for walls, flooring and roofing depending upon the

thickness. The tiles are eco-friendly as these are made by eliminating plastic waste. These tiles are available in attractive designs and colours as per the requirement of customers.

6. Continuous Sandwich (PUF) Panels with Steel Structure

Continuous sandwich panels are single piece, prefabricated, modular, factory made units which consist of an insulating layer of rigid polyurethane foam between two layers of metal sheets. 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.

7. Nano Living System Technology

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.

8. PIR Dry Wall Pre-Fab Panel 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.

9. Flyash EPS Cement Sandwich Panels

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.

10. Robomatic Hollowcore Concrete Wall Panels

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. 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.

11. BauPanel 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.

PACs for Approval of Renewal

PACs for the following 9 systems/products approved for renewal in the TAC's 13th & 14th meetings held on 16th February, 2018 and 10th August, 2018 were approved and issued to the respective manufacturers:

1 Polyethylene Underground Septic Tank
2 Continuous Sandwich Panel
3 Marshal Door
4 FRP Manhole
5 Bamboowood Flooring and Decking
6 QuikBuild 3D Panels
7 Precast Large Concrete Panel System
8 Light Gauge Steel Framed Structure with Infill Concrete Panel Technology
9 Rising EPS (beads) Cement Panels

Receipt of Applications for PACs

Applications for the following new products/systems have been received from the manufacturers for processing further for issue of PACs:

1 Precast Hollowcore Wall Panels
2 Plaster Aggregate
3 Limestone Calcined Clay Cement (LC^3).
4 V-Infill Wall
5 Expanded Clay Aggregate (ECA).

6 Precast Concrete Technology

The above applications are being processed on the basis of data furnished by the firms, information available on their web sites, inspection of manufacturing plants at site of works and testing of samples of the products/systems etc. before preparation of Performance Appraisal Certificates (PACs).

Inspection of Works

Inspection of Works of the following new systems and renewal of PACs has been carried out by the officers of BMTPC and TAC members:

- Resin Bonded (Plastic Waste) Tiles, Surat
- Monolithic Insulated Concrete System (MICS), Khammam (Telangana)
- Lost-in-Place Formwork system – Plasmolite Panels, Mumbai
- Lost-in-Place Formwork system – Plaswall Panels, Mumbai
- Prefabricated Large Concrete Panel System, Bangalore
- QuikBuild Panels, Chennai
- Continuous Sandwich (PUF) Panels with Steel structure, Baddi (HP) & Neemrana (Raj.)
- Bamboowod Flooring and Wall Cladding, Agartala
- Polyethylene Underground Septic Tank, Kalol (Gujarat)
- Continuous Sandwich Panel, Kalol (Gujarat)
- Marshal Door, Kalol (Gujarat)
- FRP Manhole, Kalol (Gujarat)

- PIR Dry Wall Prefab Panels, Kalol (Gujarat) & Jaipur
- Robomatic Concrete Hollowcore Wall Panels, Hyderabad
- BauPanel System, Bangalore
- LGSFS-ICP Technology, Bangalore
- Flyash EPS (Beads) Cement Sandwich Panels, Surat

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National Seminar on Emerging Building Materials & Construction Technologies

In order to take stock of the recent development in the area of building materials & construction technologies, BMTPC, Ministry of Housing & Urban Affairs, as part of its endeavour to identify and promote cost effective, environment friendly and disaster resistant building materials and construction processes, organized the National Seminar on Emerging Building Materials & Construction Technologies on February 22-23, 2018 at New Delhi so as to bring all stakeholders at one platform to share their knowledge and experience.

The National Seminar was inaugurated by Shri Hardeep Singh Puri, Hon'ble Minister of State (I/C) for Housing & Urban Affairs, Government of India. Hon'ble Minister in his inaugural speech said that considering the present housing shortage in urban areas, more than 1 crore houses in urban areas with necessary infrastructure are required to be constructed. To achieve this, appropriate actions are required at all fronts. This necessarily includes, among other measures, identification and selection of appropriate building materials and technologies to bring not only economy but also quality, durability, speed with due care for safety and environment concern of the country.

Besides Academic, R&D Institutions, known experts of the country; agencies involved in bringing technologies from other countries also participated with their technical presentation and showcasing of products and systems. The representatives of Govt. agencies, faculty & students of technical institutions also participated in the event. More than 350 delegates participated in the Seminar.

On this occasion a publication titled "Building Materials and Housing Technologies for Sustainable Development" and a Mobile App on "Bamboo Housing & Construction" was released by the Hon'ble Minister. The Publication contains 38 papers covering various subjects on the theme of the National Seminar.

Exhibition on Emerging Building Materials & Construction Technologies

To coincide with the National Seminar on Emerging Building Materials & Construction Technologies, an Exhibition on Emerging Building Materials and Construction Technologies showcasing various building products and construction technologies was also organized on February 22-23, 2018 at New Delhi.

Twenty firms/companies displayed following products, technologies and systems for two days:

- EPS Cement Panels
- Structural Stay in Place Formwork System
- Double Walled EPS Panel System
- LGSF System
- Lost in Place Formwork System
- Insulated Sandwich Panels, PUF Panels
- Formwork System for Rapid RCC Construction
- Aluminum Formwork for Monolithic Concrete Construction
- Concrewall Panel System
- Bamboo Based Products
- Cement Bonded Particle Board
- Interlocking Compressed Earth Blocks
- Moducast System
- Insulated Concrete Formwork System
- EPS, Flyash Cement Sandwich Wall panels
- Skim Coat for surface finish and Infragreen Cement
- White Cement & Super Cemen
- Coatings & Adhesives
- Bio-digester Toilet
- Cement Fibre Boards
- Pre Engineered Buildings
- Polyurethane based coating
- Precast Composite Technologies

Sensitization Programmes on "Good Construction Practices including Emerging Technologies for Housing" under PMAY(U)

BMTPC organizes capacity building programmes on regular basis in various states to enhance the capacity of engineers & architects in the area of quality control and good construction practices and also to introduce them with the emerging technologies in housing sector for construction of houses under PMAY (Urban) and other schemes of the state/central Government. During the year, three programmes were organised as detailed below.

Lucknow, Uttar Pradesh

A Sensitization Programme on Emerging Technologies for housing in implementation of PMAY (U) was held on 2nd June 2018 in Lucknow. The programme was organized by BMTPC, MoHUA jointly with SUDA Uttar Pradesh which is the State Level Nodal Agency (SLNA) of Pradhan Mantri Awas Yojana (Urban). More than 150 Participants from various ULBs and engineers working in city level technical cell of various cities of Uttar Pradesh attended the Programme.

During the inaugural session, Hon'ble Minister, Department of Employment & Urban Poverty Alleviation Programme),Vice Chairman, Lucknow Development Authority, Director, SUDA, Govt. of Uttar Pradesh, Addl. Director SUDA, Executive Director, BMTPC, Dy.Chief (TDE&IC) and Dy. Chief (I&D), BMTPC were present.

The Hon'ble Minister released a Pocket Book on Emerging Building and Technologies and Pen Drive containing the Films on technologies and other documents related to PMAY(U).

Sensitization Programme on Emerging Technologies for housing on 2nd June 2018 in Lucknow, Uttar Pradesh

A number of Technology providers from made presentations on Precast concrete Industrialized 3S System; Plaswall System for walling; Precast concrete Technology & Monolithic concrete construction Technology; EPS, Fly ash, Cement Sandwich Wall Panels Continuous Sandwich (PUF) Panels; Precast Concrete technology; EPS Based Panel System; presentation on Monolithic Concrete Construction; Stay in place Formwork System, etc.

A site visit to the DHP being implemented by BMTPC using technology Double Walled EPS Panel based System was organized for the participants of the programme to make them understand the new technology through live project and explain about the advantages of the technology.

Bhopal, Madhya Pradesh

A workshop on Emerging Technologies for housing in implementation of PMAY (U) in Bhopal, Madhya Pradesh was held on 27th June 2018. The workshop was organized by BMTPC, MoHUA jointly with Urban Admn. & Development Department, Govt. of Madhya Pradesh which is the State Level Nodal Agency (SLNA) of Pradhan Mantri Awas Yojana (Urban). More than 150 Participants from various ULBs of Madhya Pradesh attended the workshop.

During the inaugural session, Principal Secretary (UADD), Govt. of Madhya Pradesh, Commissioner (UADD), Commissioner M.P. Housing Board, Engineer-in Chief (UADD), Chief Engineer (UADD), GoMP and Dy. Chief (I&D), BMTPC were present.

The State is interested in adopting new technologies in PMAY

Sensitization Programme on Emerging Technologies for housing at Bhopal, Madhya Pradesh on June 27, 2018

projects, however, the cost of local raw materials and labour is reasonable in the state which makes conventional construction quite competitive. Still, the state is ready to explore the possibilities of adopting new technologies.

Presentation from the State was made on current progress of AHP projects. Technology providers from various companies were invited to make presentation and interact with the participants and made presentations on Precast concrete Industrialized 3S System; Reinforced EPS Core Panel System; Plaswall System for walling; Precast concrete Technology & Monolithic concrete construction Technology; Light Gauge Steel Framing System; Stay in place Formwork System; Sandwich Puf Panel Technology, etc. Dy. Chief (I&D), BMTPC made presentation highlighting the need of new technologies, overview of all certified technologies.

Field visit was organized in Ujjain to see the ongoing projects of AHP and BLC under PMAY. Some houses constructed under BLC were also visited at two locations i.e. Bapu Nagar and Shankar Pur Jagipura.

Jodhpur, Rajasthan

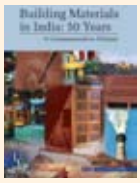
A two days Capacity Building Programme on "Good Construction Practices including Emerging Technologies for Housing" Jodhpur, Rajasthan on August 30-31, 2018. The programme was organized by BMTPC, MoHUA jointly with RAJREDCO Jaipur. Around 80 Participants from Jodhpur Development Authority and state Govt. departments of Rajasthan attended the Programme.

During the inaugural session, Sh. Arun Purohit, Secretary, Jodhpur Development Authority (JDA), Govt. of Rajasthan, Sh. Durgesh Kumar Bissa, Commissioner (JDA), Sh. Anil Kumar Poonia, Dy. Commissioner (JDA),Sh. Ashok Patni, State Convener & Vice Chairman (RAJREDCO), Sh. Sukhram Chaudhry Sr. Engineer, Sh. J.S. Monga, Department of Urban Development, Govt. of Rajasthan, Sh. Pankaj Gupta, Dy. Chief (I&D), BMTPC were present.

Technology providers from various companies made presentations on Cement Sandwich Wall Panels; Monolithic Concrete Construction; Concrete wall System; Bison Panels; Precast Concrete; Stay in Place Formwork System and Rising EPS (Beads) Cement Panels.

Sensitization Programme on Emerging Technologies for housing at Jodhpur, Rajasthan on August 30-31, 2018

Priced Publications of BMTPC



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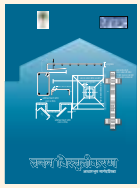

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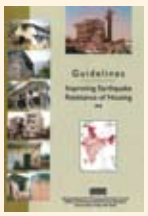

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