TECHNOLOGY PROFILE
OF
EXPANDED POLYSTYRENE
CORE PANEL SYSTEM

Building Materials & Technology Promotion Council
Ministry of Housing & Urban Poverty Alleviation
Government of India
New Delhi

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System in Brief

It is a factory made system based on expanded polystyrene panels (corrugated) reinforced with double mesh of galvanized cold steel wires, interconnected to each other (Branded as Technopor).

To form the walls, the mesh is covered with a coat of shortcrete (1:4) applied under pressure using a pneumatic system.

The support walls of a building are constructed by horizontally connecting the panels overlapping the mesh part; the walls are vertically connected to the concrete structure and to the floor of the upper level by means of deformed steel dowels.

The panels used to form the ceiling are similar to the ones used for the walls, except with thicker wire forming the links.

In framed structures the panels are used as infill walls.

Materials Used	**Zinc Coated Galvanized Steel Wire**	**Self Extinguishing Expanded sintered polystyrene**	**Shortcreting**
Whether Indian Standard available	Yes	Yes IS 4671:1984	Yes IS 9012: 1978
Whether the specification is as per Indian Standard	No	EN 13163:2013 EPS 80	Follow their own specification spraying is done using special plaster spraying equipment.
What is the specification if Indian Standard is not followed.	**<u>Chemical Requirement</u>** % C : < 0.24 % P : < 0.055 % S : < 0.055 % Ceq : < 0.52	Density ≥ 15 Kg/m^3 Compression – 80 kpa strength	Structural Plaster (1:4) used with minimum grade of M-25 for an average thickness of 35 mm on both sides.

	Mechanical Requirements Yield stress: > 600 N/mm^2 Breaking stress:>680 N/mm^2 Zinc Coating - 60 gm/m^2 $\pm$ 5 gm/m^2
Other Requirements Structural Evaluation of joints & system. Against Vertical	**INDIVIDUAL ROOF PANEL:** a) Load test as per IS 456:2000 done by Civil Aid Technoclinic Pvt. Ltd., Bangalore. The deflection recovery was observed to be 95% on removal of test load after 24 h. of unloading. b) By Department of Engineering, University of Peru • Vertical load test • Bending test on slab In terms of the fissuring process, the three panels tested for bending behaved in pretty the same manner. Firstly, fissures appeared on the central area, running along the entire width of the panel. As load increased, new fissures appeared. At all times, including great deflection, in which maximum load was obtained, fissures were thin, limited by the lower electro-welded mesh; nonetheless no slides were detected in the concrete-technopor-mortar interface although it is possible that slides were simply not detectable or technopor deformed due to shearing force. No rupture was detected on the supports nor compression rupture on the upper concrete.
	WALLS Tested by Laboratory of Earthquake Structure, Pontificia Universidad Catolica del Peru. **AXIAL COMPRESSION TEST** 3 wall panels of dimension including shortcrete as 119 mm / 2440 mm (ht) x 100 mm. tested for monotonically crescent lateral load presented a bending crack, with sight crumbling of the compressed heels. No overlapping problem were noticed between the dowels and the mesh

	and no separation occurred between technopor and concrete layers. **ECCENTRIC COMPRESSION TEST ON WALLS** Three walls were tested for eccentric axial compression at a speed of vertical displacement of 0.8 mm / min. None of the three walls showed crack due to buckling nor separation of the mortar layers from the technopor. The three walls were very inclined with relation to vertical axis, rotating at the base as a rigid solid. **SHEARING TESTS ON WALLS** Three walls tested for a monotonically crescent lateral load at a speed of lateral displacement of 1 mm/min. One of the walls presented fissures due to setting contraction. **PARTITION WALLS** Walls of EMMEDUE System, acting as partition wall dividing the rooms in vaulted building, in natural scale, tested with seismic load transversal to their surface with an aim to determine their seismic behavior and the effectiveness of their connection to the vault. The partition wall behaved as rigid solid, presenting fissure only on the column- partition wall interfaces, which increased in size as the earthquake increased in intensity. No fissures occurred on the beam partition walls interface or on the foundation partition wall area. **HOUSING UNIT** By Civil Aid Technoclinic Pvt. Ltd. Bangalore : Load test conducted on roof slab under live load, as per IS 456:2000. The deflection was within permissible limit and recovery was 100% on removal of test load within 24 h of unloading. **VERTICAL LOAD TEST ON THE MODULE** By Department of Engineering University of Peru, Ceiling without shortcrete was tested for vertical load by applying sand

	bags. The 1st level was gradually loaded before the second level and unloading was gradually done in reverse order. Report: Satisfactory.
Seismic Test	**i) Department of Engineering, University of Peru.** On two storey module. First floor on natural scale, while the free ht reduced from 227 to 145 cm in 2nd floor to accommodate the structure. size 3000mm x 3000 mm. When faced with light earthquake (Acceleration on hard ground 0.1g), two vertical fissures occurred on the area where the dowels connecting the wall panel to the foundation were located. These fissures did not increase during the experiment neither in thickness nor in length. It is reported that fissures were possibly due to the insufficient coverage of the dowels in those areas. The final crack which formed on module was due to a slide at the base, which started during a severe earthquake (acceleration on hard ground 0.4 g), reducing the resistance by 25% during catastrophic earthquake (ground acceleration 0.5g). At the end of the test the module was quite stable. The Report mentions that it passed the seismic test. **ii) Report from Research & Technology Laboratory Anti – Seismic Structures & Materials, University Di Peruficia** Prototype built with generic architectural and geometric characteristic on a full scale two storey building with lateral demission of 4.20 x 3.50 and a ht. greater than 5.6 m was tested. ***1st Series*** The mechanical exciter was positioned at ht of 1st slab (h-3m) and forced to the structure a maximum acceleration of 5 m /s^2, transferring a load of 2000 daN (approx 2 tons) which is the maximum load of its capability, for a period of 80 seconds maximum displacement recorded, equals 0.13 mm.

	2nd Series Exciter was placed at roof level corresponding to the higher point of it (h=6 m approx). The Specific load configuration associated to the application of instrument; maximum force of 2000 daN, achieved to force an acceleration of 9m/s^2, with resulting maximum displacement of 0,4 mm. Considering that from the base to the top of the building acceleration is amplified by factor 1.5, it was considered as if acceleration at base was = 9/1.5 = 6m/s^2 ***3rd Series*** The mechanical exciter was positioned at the gutter, maximum acceleration recorded 10m/s^2 and the displacement approx 0,3 mm. The structure suffered no damage, not even superficially. The Report satisfied the requirement for 1st Class earthquake, the maximum seismic event anticipated by Italian regulation. Wall–wall splice, wall-wall T junction, foundation slab-ground floor slab connection at floor level are critical to ensure internal behavior. Report for the behavior of joints against seismic load for more than two storey is not available. Before taking such project in seismic active area, this may need to be verified and if necessary additional strengthening measures may be taken. Each project of more than two floor be designed by qualified structural engineer based on load requirement as per Indian Standard.
Durability	Durability will depend on the grade of plaster and thickness of cover. Durability requirements of IS 456: 2000 need to be followed for different exposure conditions.
Fire Resistant Property	a) Civil Aid Technoclinic Pvt. Ltd. has performed the test by

	placing fire wood inside the building (away from the joineries) and burning with all door and window closed. The temp. upto 163^{o}C was measured. No distress/ distortion of panel was observed in any part of the building except for breaking of window glazing. b) Ignitability of building product subjected to direct impingement of flame as per EN ISO 11925 :2002 for EPS 80 Grade was satisfactory at LAPI LABORATURO PREVENZIONF SPA c) Fire Classification of EPS at 80 LAPI LABORATURO PREVENZIONF SPA Test. The product is classified as E as per EN 13501–1- 2009.
Thermal Behaviour	i) Civil Aid Technoclinic Bangalore verified inside and outside temperatures. Variation upto 5.8^{o}C inside was observed. ii) Thermal resistance by means of guarded hot plate and heat flow meter method as per EN 12667:2002 by LAPI LABORATURO PREVENZIONF SPA on sample of EPS 80 Density 15 Kg/m^3 was 1.30 m^{2}k/W
Acoustic Comfort Test	Civil Aid Technoclinic Pvt Ltd. Bangalore performed Acoustic Comfort Test by using sound source and sound level meters. The result showed reduction of sound level by 35 db indicating good acoustic comfort.
Ease of Fixing Services (Electricity & Plumping)	Fixing of service lines are easy by using a jet of hot air.
Impact Resistance Test	Missile Test done by Texas University. Wind Science and Engineering Research at Texas Tech University carried out tests to determine debris impact resistance of insulated cementitious panels. EMMEDUE Building System of Fano, Italy. Tests were consistent with the requirements of three separate protocols. The results of the protocols are as follows: • *Protocol* 1 – 4 kg, 50.8 mm x 101.6 mm wood

<table>
<tr><td></td><td>missile propelled at 55 km/h as required by the South Florida Building Code for hurricane envelope protection.

• Protocol 2 – 6 kg, 50.8 mm x 101.6 mm wood missile propelled at 105.6 km/h as recommended for hurricane shelters.

• Protocol 3 – 6 kg, 50.8 mm x 101.6 mm wood missile propelled at 166 km/h as recommended by the guidelines of FEMA 320/361 for tornado shelters.
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<table><tr><th>Series</th><th>Protocol 1</th><th>Protocol 2</th><th>Protocol 3</th></tr><tr><td>Series 1 PSME80</td><td>Passed</td><td>Not tested</td><td>Not tested</td></tr><tr><td>Series 1 PSM80HP</td><td>Not tested</td><td>Passed</td><td>Not tested</td></tr><tr><td>Series 1 PDME80</td><td>Not tested</td><td>Not tested</td><td>Passed</td></tr></table></td></tr>
<tr><td>Availability of Plant & machineries</td><td>EMMEDUE is in the process of setting up plant in India in West or South or both. Setting up of plant is necessary for transfer of technology to field level application at mass scale.

It is important for the implementing agency, to verify the quality of raw materials and finished product produced in India vis-à-vis requirements specified, before accepting the product and system for use.

This is valid for other agencies also using the same technology.</td></tr>
<tr><td>Scale of Economy</td><td>The costs of the panels vary according to the utilization of the machinery.

As informed Complete production plant has got capacity of 1600 m^2 (17,200 ft^2) in a 8 h shift.

A minimum of three years pay back is recommended by the agency for economy.</td></tr>
<tr><td>Project in India</td><td>No Project in India so far except. Projects in Argentina,</td></tr>
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	Mexico, Venezuela, Chili, Costa Rica, Saudi Arabia, Ecuador and Spain.

Standards/Guidelines referred:

IS 456:2000	-	Code of Practice for plain and reinforced concrete.
IS 1786:2008	-	High strength deformed steel bars and wires for concrete reinforcement-
IS 2185 (Pt.3):1984	-	Concrete masonry units - Part 3 Autoclaved cellular Aerated concrete blocks
IS 6073 : 2006	-	Autoclaved reinforced cellular concrete floor and roof slabs
EN 13163: 2012	-	Thermal Insulation products of buildings – Factory made expanded polystyrene (EPS) products – Specification.
EN 11925 -2 : 2002	-	Reaction of fire tests ignitability of products subjected to direct impingement of flame part 2 single flame source
EN 12667: 2002	-	Thermal performance of building materials and products – Determination of thermal resistance by means of guarded hot plate and heat flow meter method – products of high & medium thermal resistance.
EN 13501 – 1 – 2009	-	Fire Classification of construction products and buildings elements Part 1 – Classification using data from reaction to fire tests.