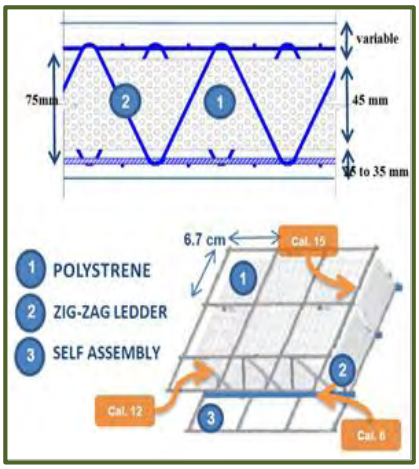
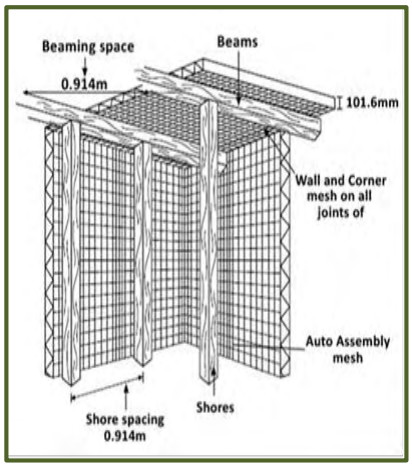
BMTPC
PACS
PERFORMANCE APPRAISAL CERTIFICATION

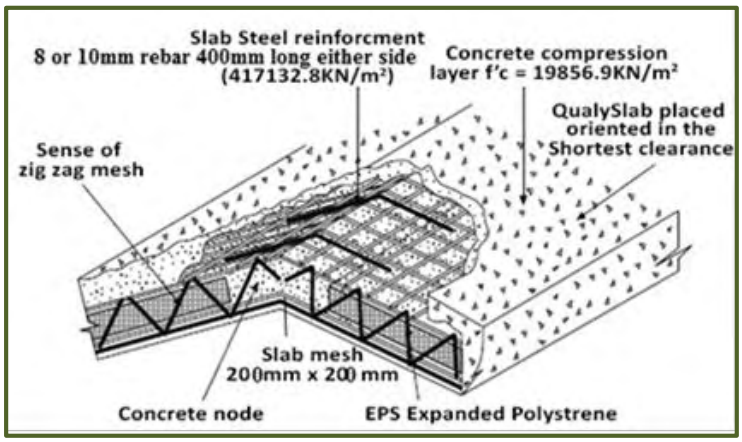
Rapid Panels

User should check the validity of the Certificate by contacting Member Secretary, BMBA at BMTPC or the Holder of this Certificate.

Name and Address of Certificate Holder:	Performance Appraisal Certificate No.
M/s Worldhaus Construction Pvt. Ltd. **No. 102/5, 7th 'A' Main,** **3rd Block, Jayanagar** **Bangalore -- 560011**	PAC No **1026-S/2016** Issue No. **01** Date of Issue: **08.04.2016**







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PERFORMANCE APPRAISAL CERTIFICATE

FOR

RAPID PANEL

ISSUED TO

M/s Worldhaus Construction Pvt. Ltd.

STATUS OF PAC NO. 1026-S/2016

S.No	Issue No.	Date of Issue	Date of renewal	Amendment		Valid up to (Date)	Remarks	Signature of authorized signatory
				No.	Date			
1.	2.	3.	4.	5.	6.	7.	8.	9.
1	01	08-04-2016	08-04-2018	--	--	07-04-2018	--	

CONTENTS

PART 1 CERTIFICATION

1.1 Certificate Holder

Worldhaus Construction Pvt. Ltd.
No. 102/5, 7th 'A' Main, 3rd Block
Jayanagar
Bangaluru -- 560011
Tel: 09740916023, 08050268566
Email: girija@worldhaus.com

1.2 Description of system

1.2.1 Name of the System – Rapid Panel

1.2.2 Brand Name – WorldHaus

1.2.3 Brief Description

The Rapid Panel is a prefabricated assembly of high-strength steel wire forming a panel with a core of expanded polystyrene (EPS). During construction, Rapid Panels are installed as walls and/or slabs. Specified mixtures of mortar or concrete are applied to the surfaces of the panels to complete the structure.

The basic unit of the Rapid Panel is the zig-zag truss. Steel wire is bent into a zig-zag shape to form a continuous chain of web members. This bent wire is then welded to continuous chord wires at every node to form the complete truss. *(See Fig. 1)*

The Rapid panels are manufactured in a fully automated plant.

This technology was initially developed in USA and the Indian firm has a collaboration with WorldHaus, California, USA.

The Rapid panels are manufactured in Mexico and there is no plant in India at present.

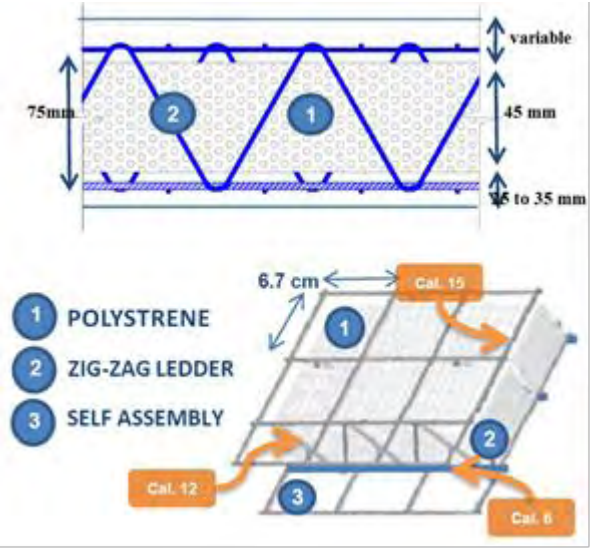


Fig. 1 Rapid Panel

1.3 Design Considerations

1.3.1 Structural design and analysis of Rapid panels shall be based on relevant Indian and International standards. The design loads shall not exceed the values given in Table 1 except where additional load is provided. The panel construction assembly shall be used for free standing walls when designed and anchored as cantilever walls. Panels shall be reinforced and tied at vertical joints to maintain alignment. Additional reinforcement and cement plaster shall be provided as required by the design.

The technology is intended for use where Architectural drawings are available. The Architect and Engineer designer team of the concerned developer/owner (client) is responsible for the drawings and overall building design to comply with the various regulatory requirements applicable to the area.

1.3.2 The design assumptions, detailed calculations, references to necessary and detailed design drawings shall be made available on demand, if required. The structural design calculations should clearly demonstrate structural integrity and stability including connection details. Design calculations should have proper sketches annotated in English.

1.3.3 Foundation shall be specifically designed in accordance with provisions given in IS 1904:2005. All foundations should be designed by structural engineer with appropriate reference.

1.3.4 In addition, any other requirement regarding safety against earthquake need to be ensured by the designer as per prevailing codal requirements.

A typical Design and Structural analysis of G+3 storey building using Rapid panels is attached at Annex IV**.**

1.4 Production Machinery and Equipment

There is no manufacturing plant in India at present. The panels are manufactured in Mexico and are imported as per requirement. The information is based on the papers submitted by the firm.
The machinery (not verified by BMTPC) are:

Truss Machine: The truss machine takes spools of steel wire and welds them into trusses of a specified length and width. It consists of three components:

- Six spools for staging the steel wire fed into the machines (three wires for each truss).
- A machine that pulls wire off the spools and straightens it.
- The truss machine itself.

Assembly Carts: Alternating layers of truss and EPS strips are placed in this cart to assemble the panel in preparation for the panel assembly welder.

Panel Assembly Welder: The panel assembly welder takes the assembled panel on the assembly cart, draws in cross wires from spools, and welds them to the panel. It consists of two components:

- Two spools for staging the steel wire fed into the machine (one wire for either side of the panel).
- The panel assembly welder itself.

Hand Repair Station: The hand repair station is essentially a table and a hand held welder that allows the operator to create the continuous connection part of the panel and repair any incomplete welds from the panel assembly welder.

Support Equipment: This section includes any equipment or services required for manufacture that do not rely on specialized equipment.

1.5 Manufacturing Process

The manufacturing process of the panels shall be as follows:

The shop-fabricated panels shall consist of welded wire zig-zag trusses and a foam plastic core to which structure plaster shall be applied on each side. The panels shall have vertical 75 mm (3 inch) deep 14 gauge (2.03 mm) wire trusses spaced at 50 mm (2 inch) centers with preformed 57 mm (2 ¼ inch) thick expanded polystyrene (EPS) foam strips between. The assembly shall be held together with 14 gauge (2.03 mm) horizontal wires on each face at 50 mm centers electro welded to the truss chords. The horizontal wires and vertical truss chords shall project 10 mm (3/8 inch) approx. beyond each foam plastic face to permit wire embedment within cement and gypsum plaster finish applied to each face after erection on the site.

The panels shall be manufactured in 1.22 m (4 feet) widths and varying heights from 1.52 m to 3.55 m (6 feet to 14 feet) in increments of 100 mm. The nominal thickness of the panel shall be 75 mm resulting in a finished wall thickness, after plastering, of 100 mm or more. The Rapidpanels are manufactured in a fully automated plant.

1.6 Basis of Assessment

1.6.1 Scope of Assessment

Scope of assessment includes conformance of manufactured wall and floor/roof panels to the specified requirements for use in the building construction.

1.6.2 Assessment

Assessment of the suitability of the Rapid Panel is based on:

i) Inspection of the under construction/constructed buildings during visit of some of TAC members and Officers of BMTPC at Bangalore
ii) Test Report of EPS and Galvanized high strength steel bars by Civil-Aid Technoclinic Pvt. Ltd., Bangalore and Shriram Industrial Research Institute, Delhi
iii) Test report of Load tests on Roof Panels by IIT Madras
iv) Test Report on Wall Panel by Civil-Aid Technoclinic Pvt. Ltd., Bangalore
v) Test Report on Steel Bars by Karnataka Test House Pvt. Ltd., Bangalore

vi) Legacy Report by ICC Evaluation Services Inc., USA
vii) Construction Manual by WorldHaus Construction Ltd., USA
viii) Quality Assurance Procedure followed by the Certificate Holder for quality control of the system as per the Quality Assurance Plan enclosed at Annex II.

1.7 Use and Limitations of the Rapid Panels

1.7.1 The panels shall be used for construction of buildings consisting of frame structures, load bearing walls, floors and roof etc. for residential purposes up to G+3 storey.

1.7.2 *Limitations of Use*

i. Panel lengths shall be up to 5 m, simply supported on beams or bearing walls not less than 125 mm in width
ii. Panels shall be installed with min. M20 grade of concrete and 1:3 cement plaster
iii. Total dead load (including panel self-weight) shall not exceed 3.3 kN/m^2
iv. Total imposed load (live load) shall not exceed 3.0 kN/m^2.

1. 8 C**onditions of Certification**

1.8.1 *Technical Conditions*

1.8.1.1 Raw materials and the finished panels shall conform to the requirements of the prescribed specifications.

1.8.1.2 The building to be constructed using the Rapid Panels shall be designed by competent structural engineers in accordance with the specifications, following relevant codal requirements, manufactured as per the details worked out in design and constructed by trained persons only with technical support or supervision by qualified engineers and builders, based on structural designs and seismic evaluation & wind forces as per the details given and this PAC.

The structural engineers and building designers associated with such type of construction should be thoroughly familiar with the various structural aspects. It is also recommended that Architects and Construction Engineers who undertake such building design and construction gain familiarity with the properties and materials, characteristics of Rapid Panels and its applications.

The design assumptions, detailed calculations, references to necessary and detailed design drawings shall be made available on demand, if required. The structural design calculations should clearly demonstrate structural integrity and stability including connection details.

1.8.2 *Setting up of Plant in India*

The Certificate holder shall inform BMTPC as and when any plant is set up in India. The panels from new set up will be allowed to be used for this Certification purpose only after it fulfils the requirements given in this Certification .

1.8.3 *Quality Assurance*

The Certificate Holder shall implement & maintain a quality assurance system in accordance with Scheme of Quality Assurance (SQA) given in the Annex II attached with this Certificate.

1.8.4 D*urability*

The Certificate Holder shall provide necessary structural warranty ensuring durability of the system to the user, on demand.

1.8.5 *Handling of User Complaints*

1.8.5.1 The Certificate holder shall provide quick redressal to consumer/ user complaints proved reasonable & genuine and within the conditions of warranty provided by it to customer/purchaser.

1.8.5.2 The Certificate holder shall implement the procedure included in the SQA. As part of PACS Certification he shall maintain data on such complaints with a view to assess the complaint satisfaction and suitable preventive measures taken.

1.9 Certification

On the basis of assessment given in Part 3 of this Certificate & subject to the conditions of certification, use & limitations set out in this Certificate and if selected, installed & maintained as set out in Part 1 & 2 of this Certificate, the system covered by this Certificate is fit for use set out in the Scope of Assessment.

PART 2 CERTIFICATE HOLDER'S TECHNICAL SPECIFICATIONS

2.1 General

The PAC holder shall manufacture the panels in accordance with the requirements specified.

2.2 S**pecifications of the Rapid Panels**

2.2.1 *Specifications*

Specification for the raw materials and finished panels shall be as per performance criteria when tested in accordance with the company standard & relevant Indian/ International Standards listed in this Certificate.

2.2.2 *Specifications of Raw Materials*

1. *Galvanised high strength steel wire: Fe 500 & Fe 550 as per IS 1786: 2008 having following characteristics:*

(a) For Slab Panel

(i) Dia.
Top wire: 2.65 mm
Top distribution wire: 1.9 mm
Truss wire: 2.65 mm
Bottom wire: 5 mm
Bottom distribution wire: 1.9 mm

(ii) Mechanical characteristics

1.9 mm dia
Yield strength : 680 N/mm^2
UTS : 687 N/mm^2
Elongation : > 4.8 %

2.65 mm dia
Yield strength : 618 N/mm^2
UTS : 632 N/mm^2
Elongation : > 6.1 %

5 mm dia
Yield strength : 670 N/mm^2
UTS : 816 N/mm^2
Elongation : > 14 %

(iii)) *Chemical characteristics*
C % < 0.153, P % < 0.016, S % < 0.015, Mn % < 0.893, Si % < 0.134

a) For wall Panel

(i) Dia
Top wire: 2.65 mm
Top distribution wire: 1.9 mm
Truss wire: 2.65 mm
Bottom wire 2.65 mm
Bottom distribution wire: 1.9 mm

(ii) Mechanical characteristics

1.9 mm dia

Yield strength : 680 N/mm^2
UTS : 687 N/mm^2
Elongation : > 4.8 %

2.65 mm dia

Yield strength : 618 N/mm^2
UTS : 632 N/mm^2
Elongation : > 6.1 %

(iii)) Chemical characteristics

C % < 0.153, P % < 0.016, S % < 0.015, Mn % < 0.893, Si % < 0.134

2. *Expanded Polystyrene (EPS):* Self-extinguishing type EPS shall conform to IS 4671:1984 and shall have following characteristics:

Density: Shall be not less than15 kg/m^3.
Flammability: Non Flammable
Moisture Continent at 50ºC: less than 1.1 %
Thickness: not less than 50 mm
Bead size: shall be > 95% between 0.5 – 1.12 mm as per ASTM C 578
Environmental hazardous Substances:
Lead: <1 ppm, Cd: < 1 ppm, Hg: < 0.01 ppm and Cr: <1 ppm

3. *Ordinary Portland Cement:* 43 grade as per IS 8112:2013.
4. *Fine aggregate* 4.7 mm size for concrete as per IS 383:2016 and plaster of sand 150 micron – 2.36 mm as per IS 1542:1992
5. *Coarse Aggregate* of 20 mm & 40 mm size as per IS 383:2016

6. *Steel reinforcement:* as per IS 1786:2008.

7. *Gypsum Plaster board:* as per IS 2095 (Part 1):2011.

8. *Cast-in-place concrete:* The min. grade of concrete is M20 and slump for walls, floors and roofs shall be as per IS 456:2000.

9. *Cement Plaster* having a minimum 28-day compressive strength as required by design based on testing in accordance with IS 4031(Part 6):1988.

10. *Adhesive:* as per ASTM C 881

11. *Plasticizers:* as per IS 9103:1999

12. *Waterproofing:* as per IS 2645:2003

13. *Fibers: P*olypropylene fiber mesh as per EN 14889-2:2006

14. *Ledger Bolt: C*onsists of 12.7 mm diameter L-shaped bolt with washers and nuts as per ASTM A 307. It shall be fastened to the panel wire sand plastered in accordance with Fig.4. The cement plaster for the panel for use with this connection device shall have a minimum 28-day compressive strength of 25 MPa.

15. *Hartco clips:* Formed from 11.11mm-wide, No. 20 gauge cold-rolled steel and manufactured by Stanley Hartco or Spenax Flex-C-Rings, No. 516G100, manufactured by Stanley Spenax or equal.

2.3 Production

No production is done in India at present. All the panels are imported from Mexico. The process of production as reported is given in Annex III.

2.4 Implementation

2.4.1 *Panel System*

2.4.1.1 *Raft foundation*

For only ground floor and G+1 unit constructions. When the soil surface is strong or when the soil is improved, this is done by using a slab/raft foundation. Construction process of a slab/raft foundation shall be as follows:

(i) A trench of 600 mm in depth and 200 mm in width shall be excavated as per design.

(ii) The trench shall be made waterproof with 400 caliber polyethylene or a comparable product.

(iii) At the bottom of the trench PCC concrete 50 mm thick shall be placed.

(iv) The wall panels shall be placed in groups of 2 or 3.

(v) The inside reinforcing steel shall be tied to that on the next panel.
(vi) The welded wire mesh for the slab shall be placed and tied to the wall panel.
(vii) The wall panels shall be made straight with plumb, holding them with tension wires and metal rules to avoid the panels moving or falling out of plumb.
(viii) The trench shall be filled with concrete after waterproofing and vibrated for correct execution.
(ix) The concrete slab shall be placed according to its specifications. *(See Fig. 2)*

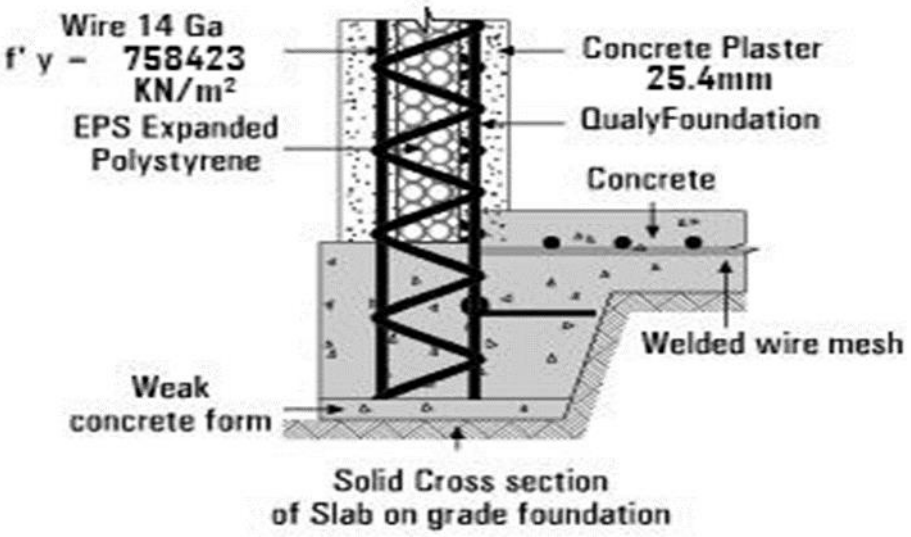


Fig. 2 Foundation Details

2.4.1.2 *Strip foundation*

For only ground floor and G+1 unit constructions. When the surface soil is in a terrain with vegetation or lime, and it is required to locate the foundation in a stronger and deeper layer, this is done by using a strip footing. Construction process of a slab/raft foundation shall be as follows:

(i) A trench of 1000 mm in depth or that which is required and of a width adequate to transfer the load to the soil as per design shall excavated.
(ii) The trench shall be made waterproof with 400 caliber polyethylene or a comparable product.
(iii) A layer of 50 mm PCC concrete shall be laid.
(iv) Thereafter, wall panels shall be placed in groups of 2 or 3.
(v) The inside reinforcing steel shall be tied to that on the next panel.

(vi) The wall panels shall be made straight with plumb, holding them with tension wires and metal rules to avoid the panels moving or falling out of plumb.

(vii) The footing shall be filled with concrete after waterproofing and vibrated for correct execution. *(See Fig. 3)*

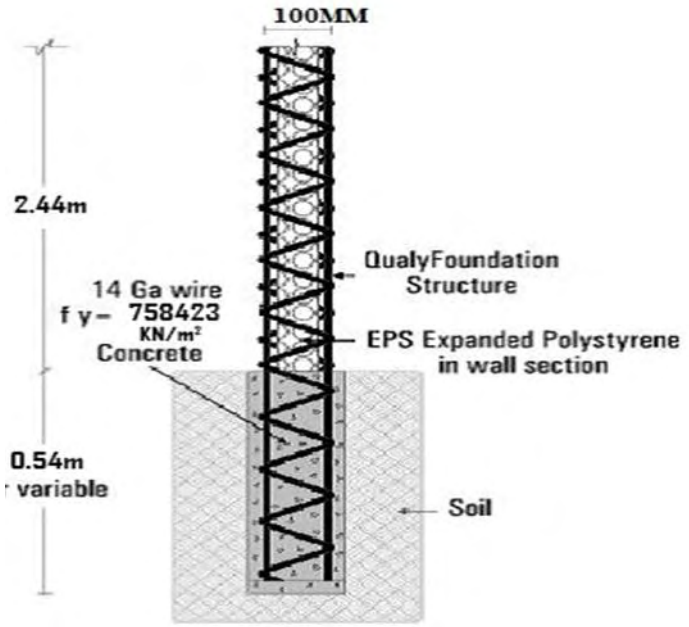


Fig. 3 Implanted Type Foundation

2.4.1.3 *To use the wall panel as a footing*

Steps as given below shall be followed:

(i) A trench of 700 mm to 1000 mm in depth or that which is required and of a depth necessary to carry the load as per design shall be excavated.

(ii) The trench shall be made waterproof with 400 caliber polyethylene or a comparable product.

(iii) At the bottom of the trench PCC concrete 50 mm thick shall be placed.

(iv) The footing which is made from the wall panel with the required steel reinforcement shall be placed, with the steel on the bottom and perpendicular to the wall length, without polystyrene and with the thick steel bars on the bottom.

(v) The wall panels shall be placed in the center of the footing in groups of 2 or 3 pieces, integrating them with the footing with 10mm steel bars ever 300mm.

(vi) The reinforcing steel shall be tied together with wires.

(vii) The wall panels shall be supported with wood props, allowing a covering of 50mm.

(viii) The wall panels shall be made straight with plumb, holding them with tension wires and metal rules to avoid the panels moving or falling out of plumb.

(ix) Concrete having grade M25 shall be placed and vibrated adequately, integrating waterproofing for correct execution. *(See Fig. 4)*

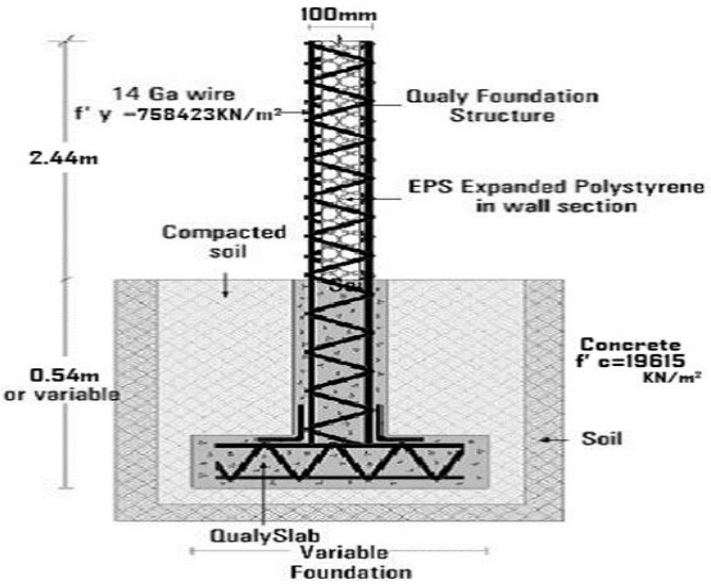


Fig. 4 Foundation Details

2.4.1.4 *Existing foundation*

When a foundation already exists or when something is being constructed over existing construction, steps as given below shall be followed:

(i) Holes of 8 or10 mm dia. of 100 mm depth every 400 mm shall be drilled and lined up with inside of the wall.

(ii) High strength steel bars of 8 or10 mm dia. shall be placed in every hole leaving 400 mm of height above the foundation.

(iii) The wall panel shall be tied with bars of 8 or10 mm dia. on the outside of the mesh with steel wire, with a minimum of 3 ties per bar. *(See Figs. 5 & 6)*

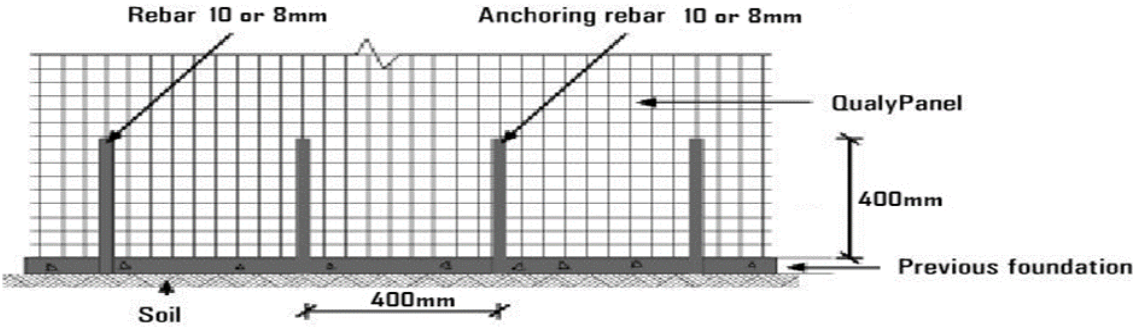


Fig. 5 Panel System Joints to Foundation (Front Elevation)

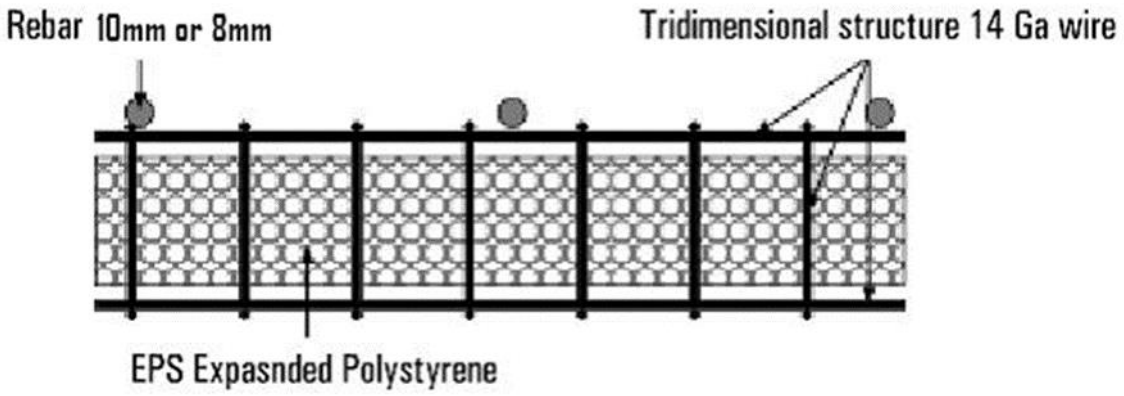


Fig. 6 Panel System Joints to Foundation (Top View)

2.4.2 *Boundary Wall*

Following procedure shall be followed for construction of boundary walls:

(i) Bars of 8 or 10 mm dia shall be placed on top of the foundation, alternating one on the outside of the foundation and the other on the inside every 400 mm.

(ii) The bars that are placed on the inside shall be bent in such a way that they are rooted in the foundation.

(iii) The wall panel shall be located on the soil and plastered on the bordering side. They shall be placed in groups of two or three.

(iv) The mortar layer shall be dried, and the wall panel erected while straightening the interior bars.

(v) Finally, the wall panels shall be tied to the bars on both sides perfectly and plastered on the interior.
(See Fig. 7)

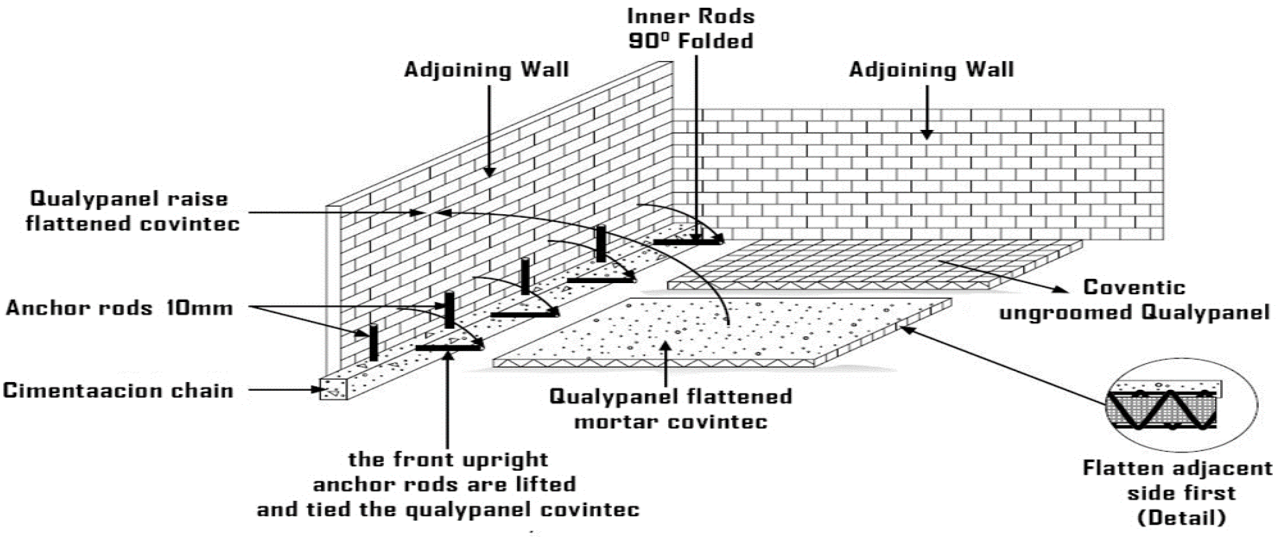


Fig. 7 Boundary Wall

2.4.3 *Wall Panels*

Exterior wall panels shall be set with a minimum 6 mm (1/4 inch) clearance between the concrete slab edge and the panel reinforcement. The slab shall be attached with perimeter foundation with 63 mm-long by 3 mm (2 ½ inch by 1/8 inch) thick steel hold-down connector channels and 13 mm (1/2 inch) diameter foundation bolts placed at a distance of 1.22 m (4 feet) max. centers along width and at each panel end. Panel reinforcement and connector channels shall be attached with 305 mm (1 feet) long, 12 gauge wires extending approximately 45 degrees upward along each panel face from each channel end. The upper end of the diagonal wires shall be attached to the panel reinforcement. As an alternate, shear receivers consisting of 54 mm (2 $_{1/8}$ inch$_{)}$ long channel-shaped 16 gauge (1.63 mm) sheet metal fastened with two Hartco clips each side and anchored with 13 mm-diameter anchor bolts shall be used with the placement as above. These shear receivers shall also be used at panel tops and openings. For details of the shear receiver and anchor connection. *(See Figs 5 and 16).*

Resistance to uplift or overturning forces shall be provided by installing a hold-down device using No. 8 gauge wire loops (See *Fig. 18)*. 26 gauge (0.46 mm) galvanized sheet metal flashing with external and internal lips shall be placed between the floor slab and wall. Vertical foam core edges of exterior wall panels shall be treated with a 6 mm to 10 mm (¼ inch to 3/8 inch) continuous bead of elastomeric sealant prior to butting with adjacent panel cores.

Panels shall be joined along vertical edges with 203mm (8 inch) wide strips of 14 gauge (2.03 mm) 51 square mm (2 inch square) welded wire mesh on each face centered on the panel joint. The mesh shall be attached to the vertical panel wire reinforcement with Hartco clips spaced 305 mm on center at the edge wires and 610 mm (2 feet) on center at interior wire (*See Figure 12)*. Panels shall also be joined on both sides with 14 gauge (2.03 mm) wire trusses (See *Fig. 17).* In addition to the above, butting panel edge wires shall be attached with the clips spaced at 610 mm on center on each panel face. Corner and intersecting walls shall be connected with mesh trusses and clips in a similar manner. Clips installed in accordance with figures when truss strips shall be used as joint mesh.

Interior wall panels shall be set and attached to hold-down connector channels with 12 gauge (2.64 mm) wires in the same manner as exterior panels. Approved powder-actuated anchors shall be used, provided they are adequate for applicable uplift

loads. A nonstructural plaster ground shall be attached at the base of the interior panels if desired.
Lintel sections over openings shall consist of panel sections with truss reinforcement placed horizontally and reinforced *(See Figs 15 and 20).* Allowable loads shall be as per in *Table 1*.

Electrical raceways, switch boxes and outlet boxes shall be installed prior to application of the cement plaster in accordance with local requirements. Outlet boxes shall be placed to minimize the cutting of the wire mesh reinforcement. Where two or more wires in the same direction are cut, they must be replaced with wire of the same gauge and attached with at least two Hartco clips at each end at a sufficient distance beyond the opening to develop continuity.
Plumbing and waste lines shall be limited to extending at right angles through the wall panels and located to minimize the cutting of panel wires.

Detail of a Wall panel is shown in *Fig. 8* below:

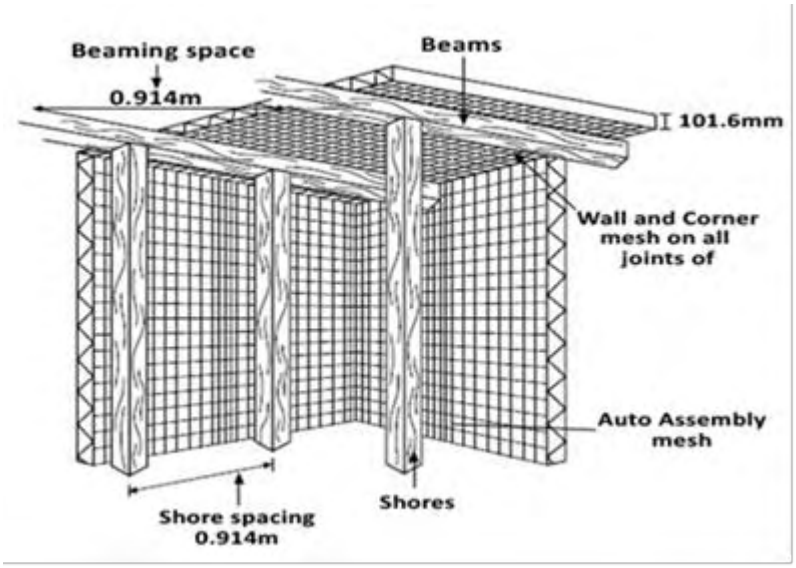


Fig. 8 Wall Panel

2.4.4 *Roof and Floor Panels*

The panels shall not be permitted to bear on wood-frame walls. The connection method of the roof panels to wall panels *(See Figs 4 and 13)* and the allowable loads for the connection are shown in *Table 2*. Horizontal diaphragms shall be permitted the same shear values as vertical racking shear, provided the panels are fastened to each other and to walls as described in this report.

The details of a Roof panel is shown in *Fig. 9* below:

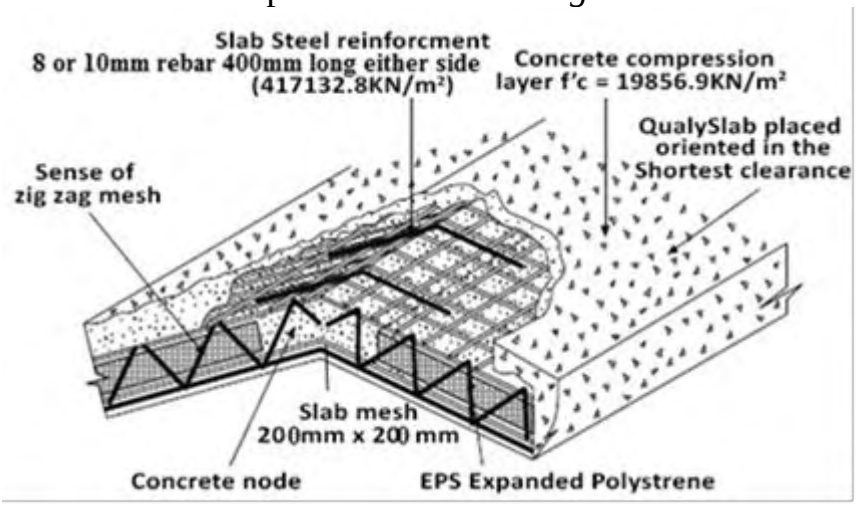


Fig. 9 Roof Panel

Process flow chart is given at Annex I.

Table 1 Allowable Roof, Floor and Wall Panel Loads[1]

Type of loading	Panel height or span[4] (m)	Load		Remarks
		kg/m	kg/m²	
Axial[2]	2.44	4607[5]	--	--
	3.66	4013[5]		
Axial[3]	2.44	4013		
Transverse[2] for wall, roof or floor panels	1.22	--	434	Wind or lateral load applied perpendicular to the face of panel. For superimposed roof or floor loads, no increase for duration of load is permitted.
	1.52		385	
	1.83		273	
	2.13		249	
	2.44		195	
	3.05		122	
	3.66		78	
	4.27		59	
Transverse[3] for wall, roof or floor panels	2.44	--	112	Wind or lateral load applied perpendicular to the face of panel. 3.05 & 3.66 m high panels to be used for interior walls only.
	3.05		63	
	3.66		49	
Racking shear[2] for wall panels	H/D = 0.457 or less	490	--	In continuous panel runs, 12.7 mm dia anchor bolts shall be reqd. at each end and at a max. of 1.22 m centers at intermediate locations. Where panel runs a max. of 1.22 m wide, the anchor bolts shall be placed at each end of the panel.
Racking	H/D = 0.305	409		The lower shear values

shear[3]for wall panels	H/D = 0.457	357	--	should be used where intermediate H/D values encountered
	H/D = 0.610	354		
	H/D = 1.219	253		
Superimposed vertical load on lintel/ beams	1.83	803	--	Lintels shall be constructed as per Fig. 15 or Fig. 20
	2.44	594		

[1] Axial loads and transverse loads due to wind or earthquake shall be combined for wall panels as follows:

$$\frac{P}{P_{all}} + \frac{W}{W_{all}} \leq 1.33$$

Where

P = Axial load at mid height, including tributary wall height

P_{all} = Allowable axial load indicated in Table 1

W = Transverse wind or earthquake load

W_{all} = Allowable transverse load indicated in Table 1

[2] Min. 25.4 mm (1 inch) thick cement plaster on both faces

[3] Min. 25.4 mm thick cement plaster with a min. compressive strength of 703 N/m^2 on one face and 22 mm (7/8 inch) thick gypsum plaster on the opposite (interior) face

[4] H is height of panel and D is width of panel

[5] Normal construction allows plaster to extend approx. 10 mm (4 inch) outside of floor slab. When full bearing of the entire panel (including plaster) the allowable axial load for the 2.44 m (8 feet) and 3.66 m (12 feet) high panels may be increased to 7440 and 6250 kg/m of panel respectively and the racking shear to 632 kg/m of panel.

Table 2 – Allowable Load for Roof Panel to Wall Panel Connection

Connection type	**Direction of load**	**Allowable load[1,3] (kg/m)**
Butterfly Truss	Uplift[2]	223
	Transverse	1085
	Longitudinal	1085
14 gauge wire	Uplift[2]	282
	Transverse	1085
	Longitudinal	1085

[1] Based on details shown in Fig. 10/ Fig. 19

[2] Load due to dead load not included. Comnnections should be designed for vertical downward loads

[3] Cement plaster should have a min. compressive strength of 1406 N/m^2

As per IS 875 (Part 3):1987, Wind load

$Vz = Vb\ K_1\ K_2\ K_3$ m/s

Where

Vb = Basic wind speed m/s

Vz = Design wind speed at any height in m/s

K_1 = Probability factor (Risk coefficient)
K_2 = Terrain height & structure size factor
K_3 = Topography factor
Design wind pressure $Pz = 0.6\ V^2z\ N/m^2$

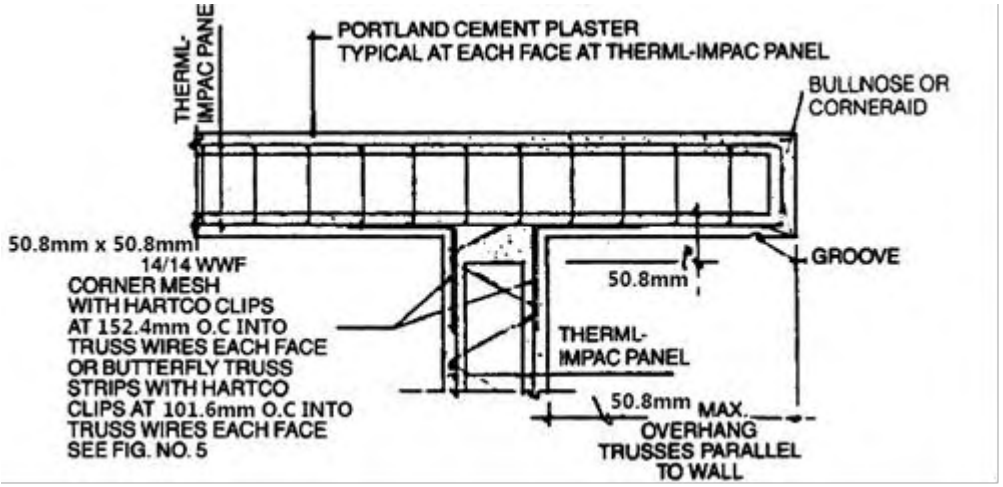


Fig. 10 Typical Overhang Detail

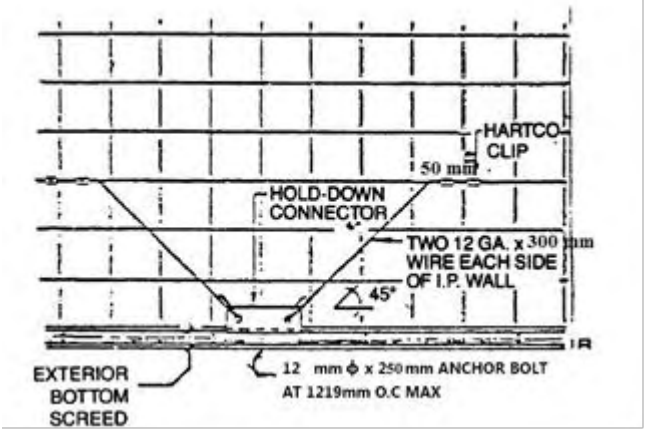


Fig. 11 Panel Shear Connector

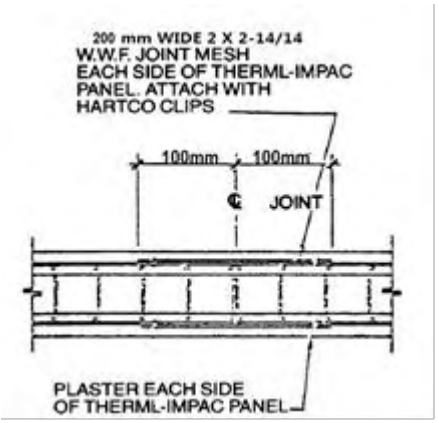


Fig. 12 Wall Panel Joint

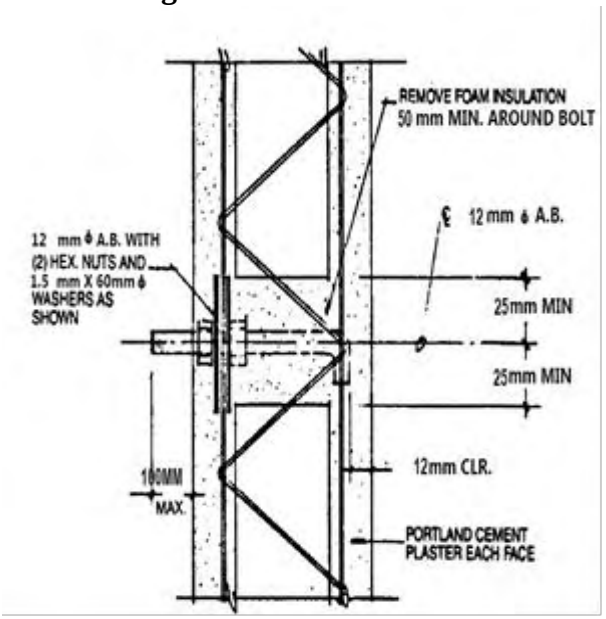


Fig. 13 Ledger Bolts to Panel

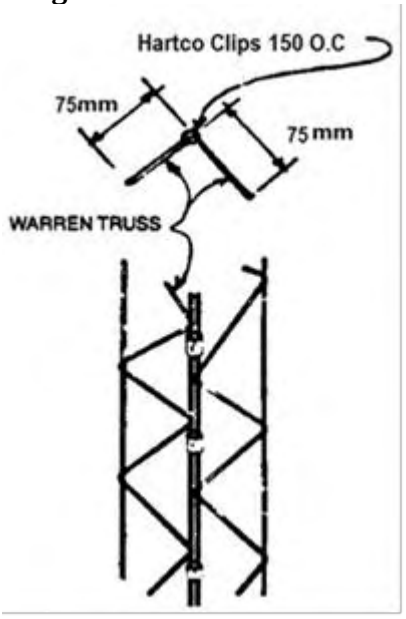


Fig. 14 Butterfly Truss Strip

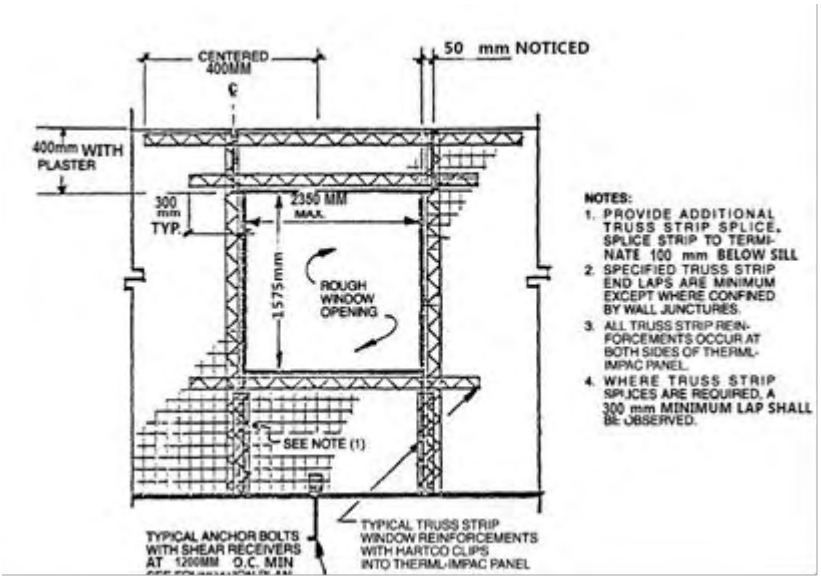


Fig. 15

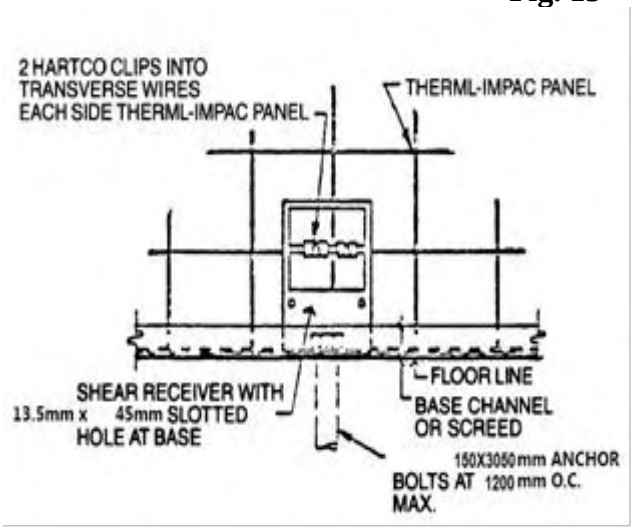


Fig. 16 Shear Receiver

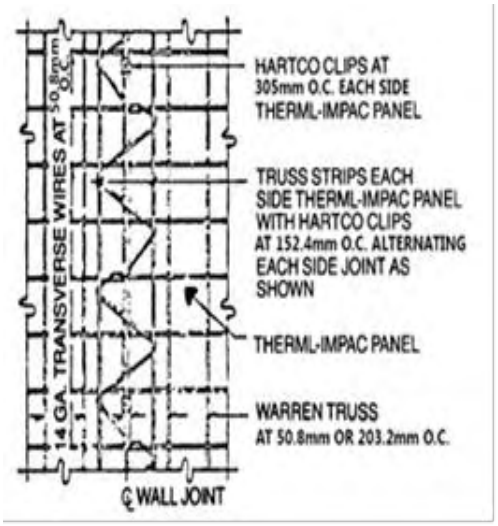


Fig. 17 Truss Strip Connection at Wall Joint

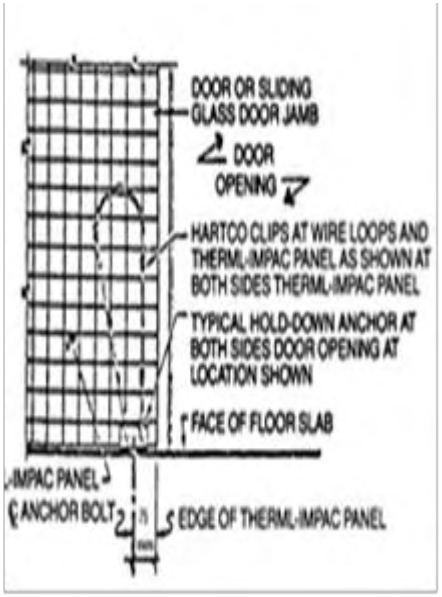


Fig. 18 Hold-down Anchor

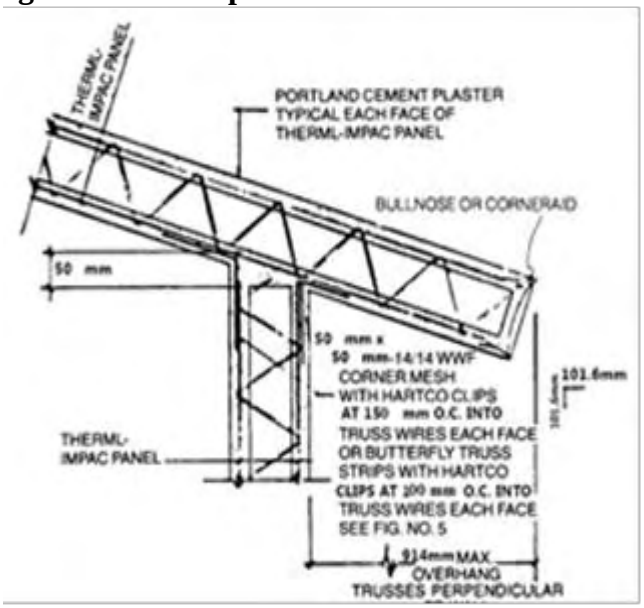


Fig. 19 Typical Eave Detail

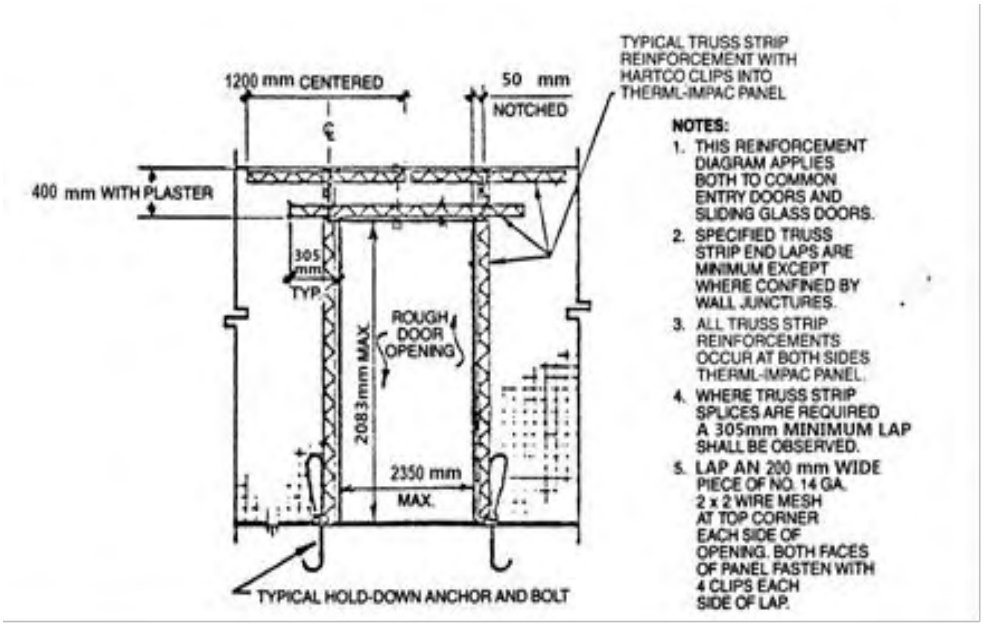


Fig. 20 Typical Door Opening Reinforcement

2.4.5 *Installation of Panels*

The procedure for installing the panels shall be as follows:

1. The panels shall be put in place according to the building plan as follows:
    - It must be ensured that the rebar is on the bottom of the panel
    - Each panel shall have a portion of wire mesh on the end without polystyrene.
    - The adjacent panel shall be inserted into this area thereby locking them together. The overlapping wire mesh should be tied together.
    - The vertical rebar in the wall shall be allowed to go through the polystyrene in the panels.
    - It shall be necessary to cut some of the wire mesh to allow this. The rebar on the bottom of the panel shall not be cut.

2. The polystyrene in the areas directly over the walls shall be removed.

3. The rebar that bends into the panels shall be placed according to the wall reinforcement and this bar shall be tied to the wire

mesh on top of the panel. The vertical rebar shall be extended as necessary.

4. The support props shall be placed beneath the panels as follows:
    - The panels should be supported from below at a spacing of max. 1 m in each direction.
    - Wood beams shall be placed between the panels and the props in the direction opposite the rebar on the bottom of the panel.
    - The middle prop shall be higher than the others as per the building plan. *(See Fig. 21)*
5. The edge molds shall be placed around the perimeter of the panel as follows:
    - Each set of holes in the edge molds shall be tied tightly to the panel
    - It must be ensured that the edge molds are level and straight.
    - It must also be ensured that there is more than 50 mm clearance between the top of panels and top of edge molds.
6. A minimum M20 grade of concrete shall be used.
7. The concrete shall be placed in 50 mm thick layer on top of the panels. It must be ensured that there is a smooth and level surface by using the bubble level.
8. The edge molds shall be removed after 24 hours while the props after 7 days.
9. The surface of the concrete should be kept moist for 28 days and the concrete shall not be allowed to become dry during this period.

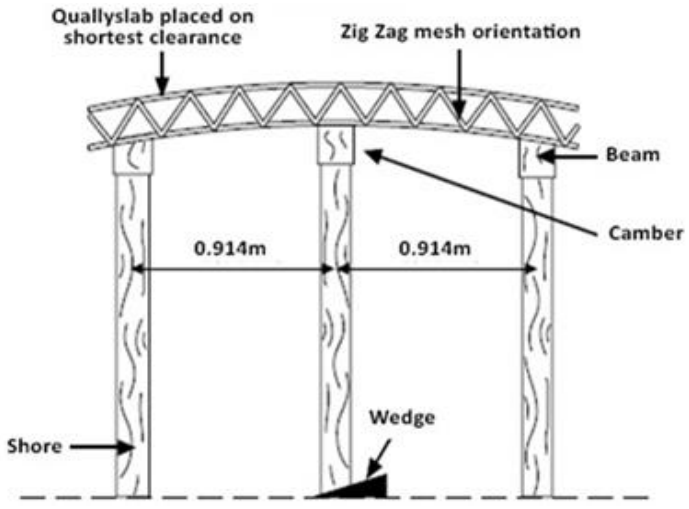


Fig. 21 Counter Shaft

Table 3 Slab Camber at Panel Midspan

Slab clearance (m)	3	4	5
Camber (mm)	30	35	40

2.4.6 *Supports and Cambers*

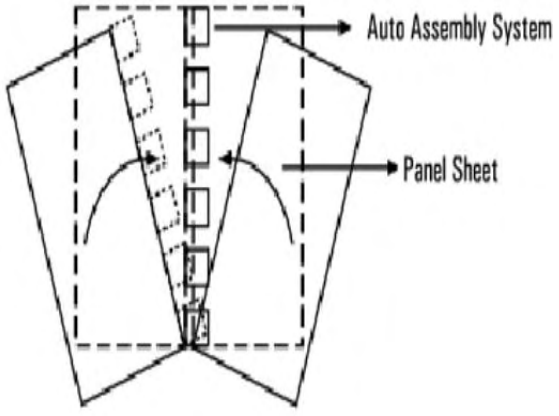
Slabs for roofs and floors shall be made with slab panels and supported during erection with temporary beams with props spaced at 900 mm, leaving a camber (see table below). The support beams shall be located on the bottom of the panel, always perpendicular to the direction of the zigzag trusses in the panel. Most of the supports shall be removed 14 days after concreting, leaving only those supporting the center of the span for 30 days.

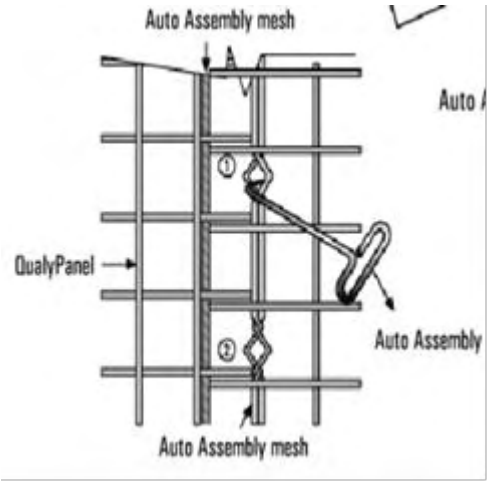
Table 4 Cambers for Floor and Roof

Slab span (m)	2.50	3.25	4.06	4.50	5.00
Slab simply supported on both ends (mm)	10	30	35	35	40
Continuous slab or slab supported on 3 or more ends (mm)	10	15	20	25	30

2.4.7 *Connections*

All the connections for walls and slabs shall use the self-connection system, where the mesh on the end of the panel shall be used to join the panels in different situations. *(See Fig. 22)*





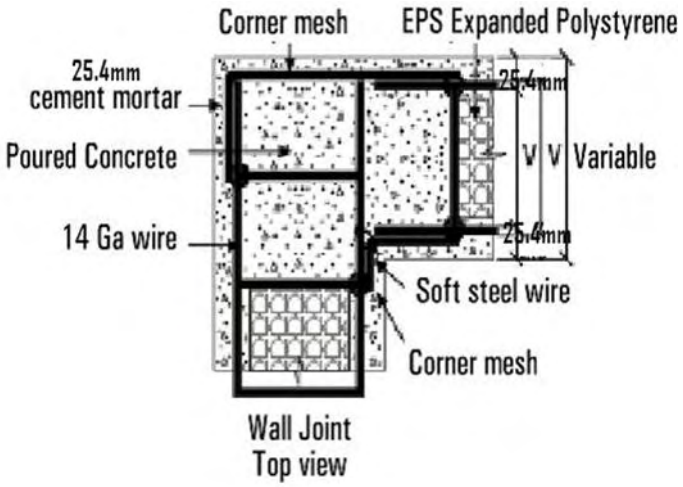


Fig. 22 Connections

2.4.8 *Door and Window*

These shall be made by marking and cutting the mesh of the wall panel with a circular saw, reciprocating saw, or with wire cutters, and reinforcing the edges on both sides with zigzag mesh. The zigzag mesh should extend 300 mm from the edges of the doors and windows. Afterwards, diagonal zigzag mesh shall be installed on every corner of 400 mm.

Where edges and corners are reinforced, the polystyrene along the perimeter of the opening shall be removed and the space is filled with mortar or concrete to form a rigid boundary. In the area on top of the opening, the polystyrene shall be removed and reinforcing steel placed to form a lintel beam. *(See Figs. 23 & 24)*

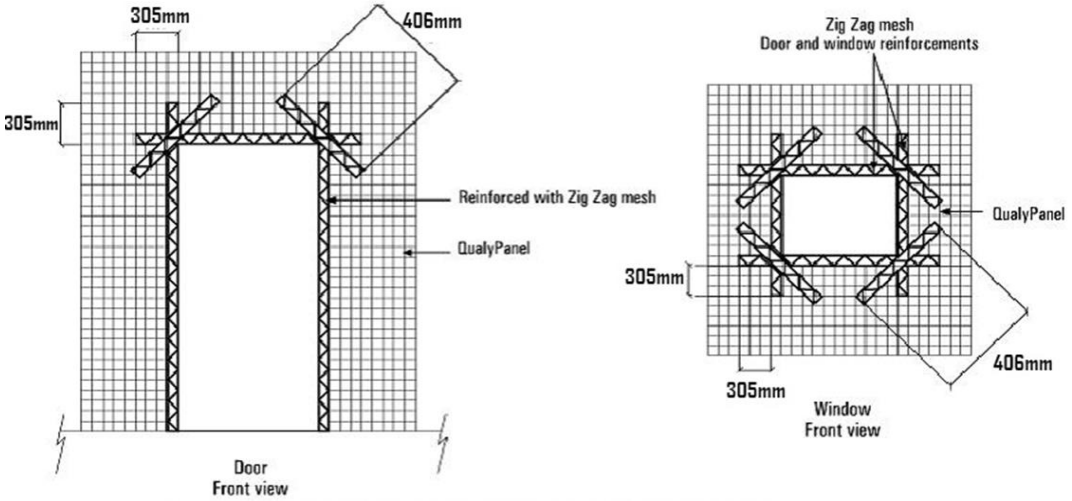


Fig. 23 Door and Window Connection Details

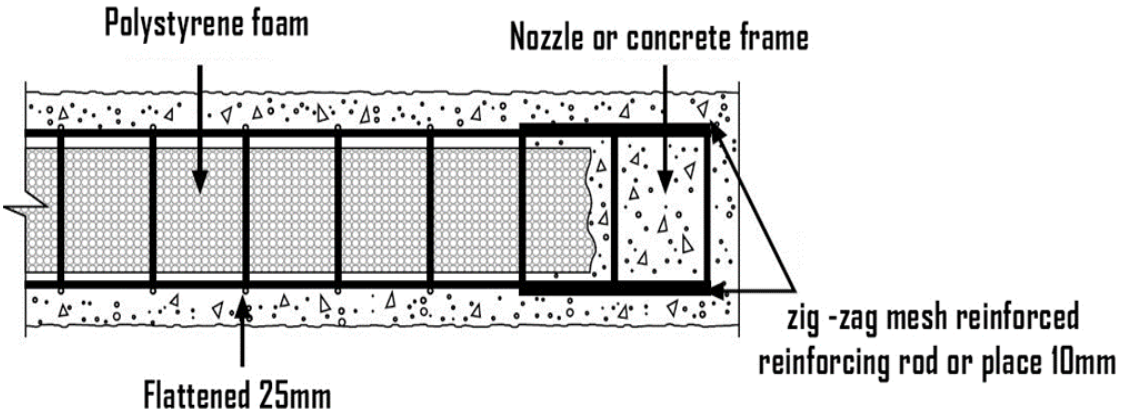


Fig. 24 Door and Window Nozzles (Elevation)

2.4.9 *Plumbing and Electrical Fixtures*

Water pipes and electrical conduits shall be placed within the panels as shown in the building plans. The guidelines for installing pipes and conduits in the panels shall be as follows:

- Polystyrene in the panel shall be removed to accommodate pipe and conduits
- Large pipes shall require cutting wire mesh so as to fit in the panel. The wire mesh on top of the panel shall only be cut.
- The pipe should not be higher than 25 mm above wire mesh on top of the panel.
- Taps, other plumbing fixtures and electrical fittings should be fixed after plastering
- Taps shall be located at floor height other than the sill level. The vertical pipes shall be fixed along the wall surface to provide the taps at the levels above the finished floor level – for toilets at 450 mm, for bathrooms at 750 mm and for kitchen at 900 mm.
- All floor drains should be provided with perforated covers.
- Wires to electrical wall fittings should be fixed from the ceiling panel to the location indicated on the building plans and conduit installed on the wall surface.
- Wall electrical fittings should be located at 1200 mm above the finished floor level. *(See Figs 25 & 26)*

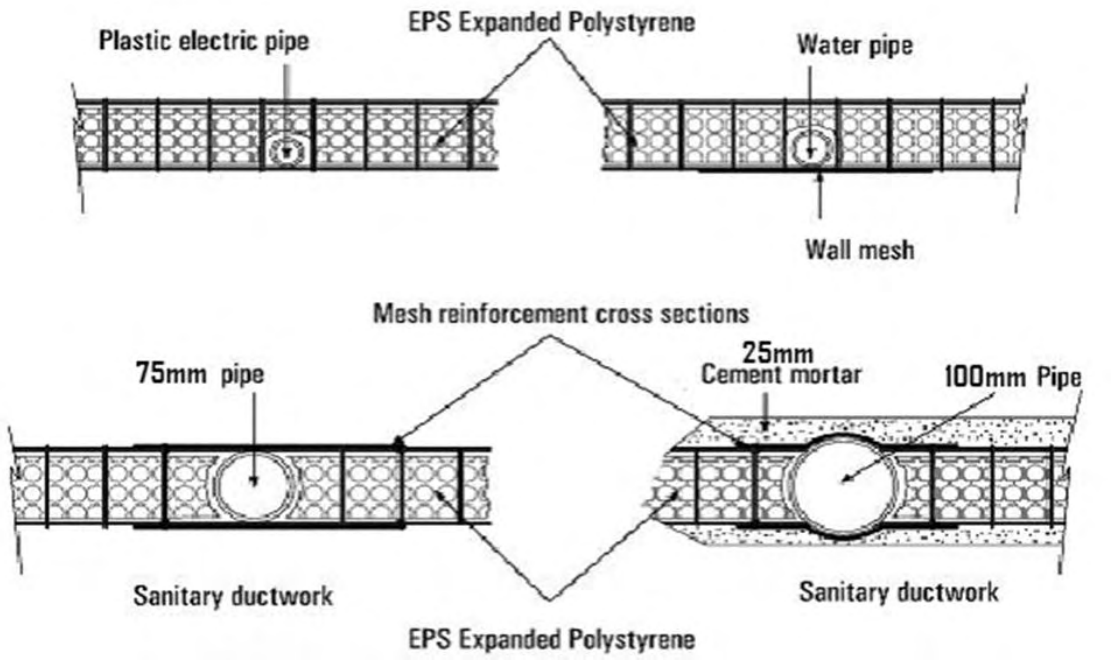


Fig. 25 Duct Work on Panel System (Top View)

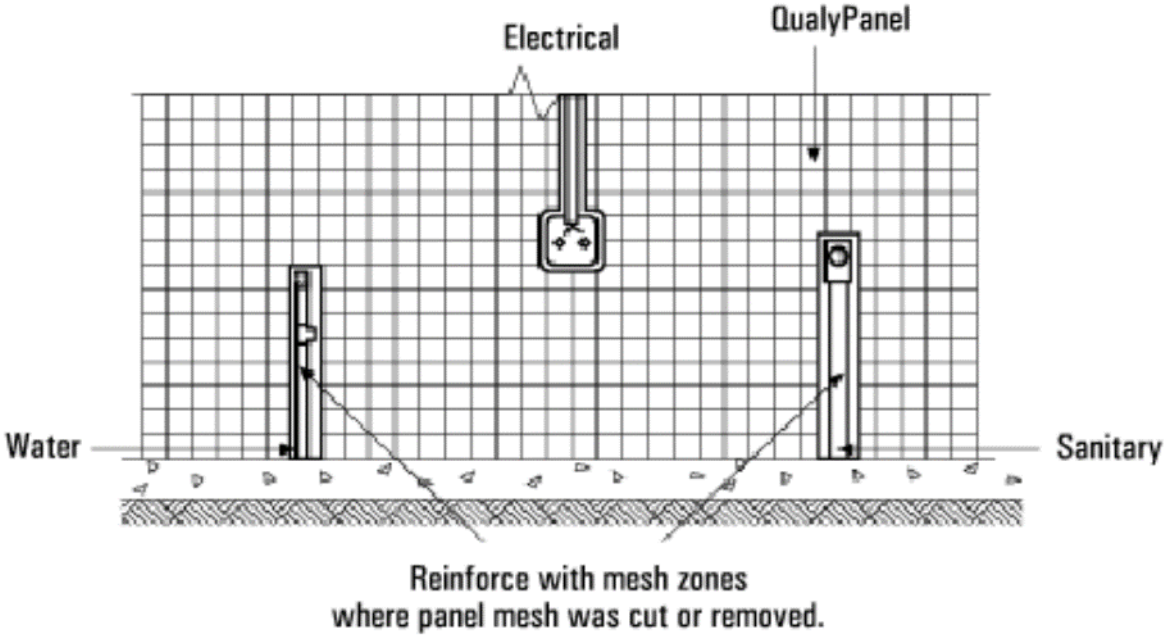


Fig. 26 Installation of Duct Work

2.4.10 *Plumb and Alignment*

It shall be assured that the wall panel is plumb and in line, and to maintain right angles between them, tension wire and metal rulers shall be used. *(See Figs. 27 & 28)*

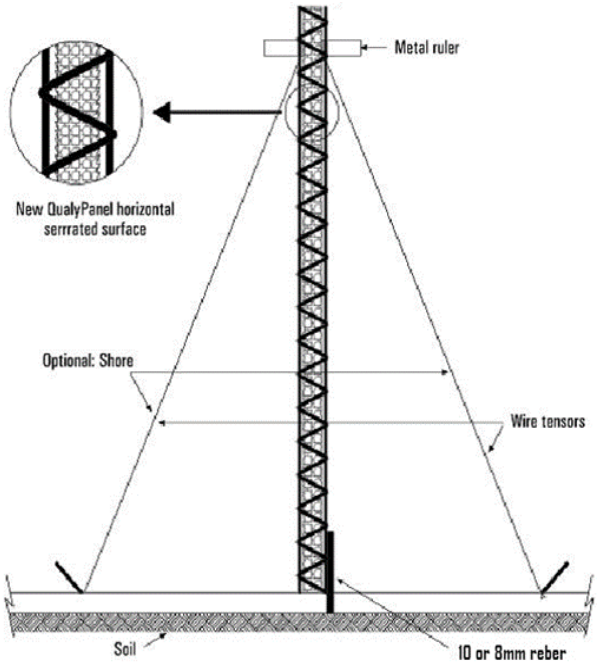


Fig. 27 Plumb and Align – Cross section Panel System

The polystyrene in the center of the panel shall be toothed on the surface to ensure better mortar connection and less wastage.

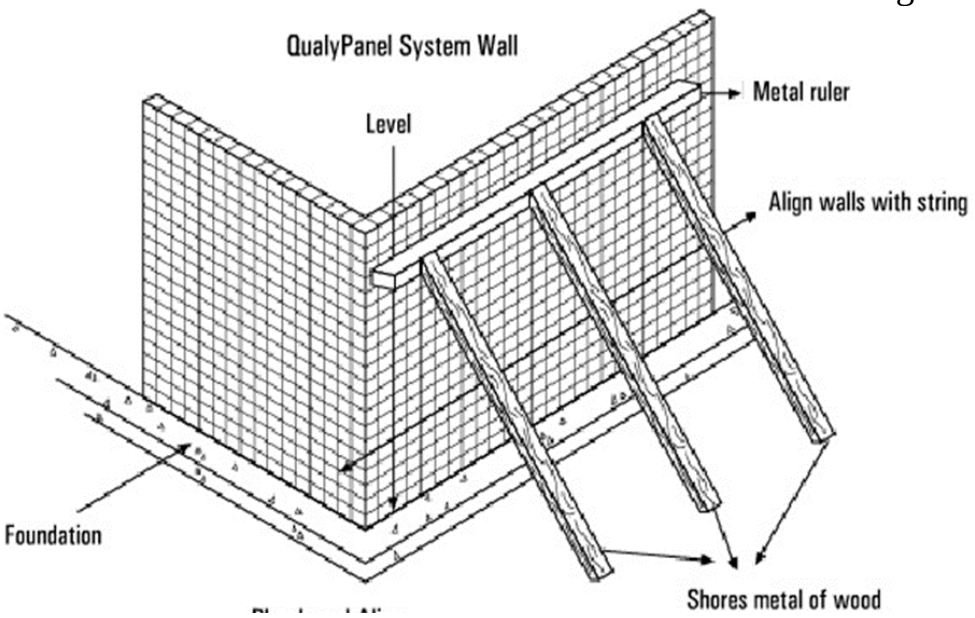


Fig. 28 Plumb and Align (Schematic drawing)

2.4.11 *Finishing*

2.4.11.1 *Floor finishing*

The guidelines for floor finish shall be as follows:

- It must be ensured that the floor area is completely clear of any debris, dust and soil etc.
- It must be ensured that the floor surface is damp prior to finishing and it should be fully moist without any water stagnating on it.
- Cement mortar of mix 1 cement: 3 sand shall be prepared and required quantity of mortar shall be applied to the floor to provide a smooth finish.
- Slope shall be given in the floor as per the building plans. However, if no slope is specified, minimum slope towards the doorway out of the room shall be provided.
- Floor finish should be allowed to be cured for at least 10 days after placement.

2.4.11.2 *Ceiling finishing*

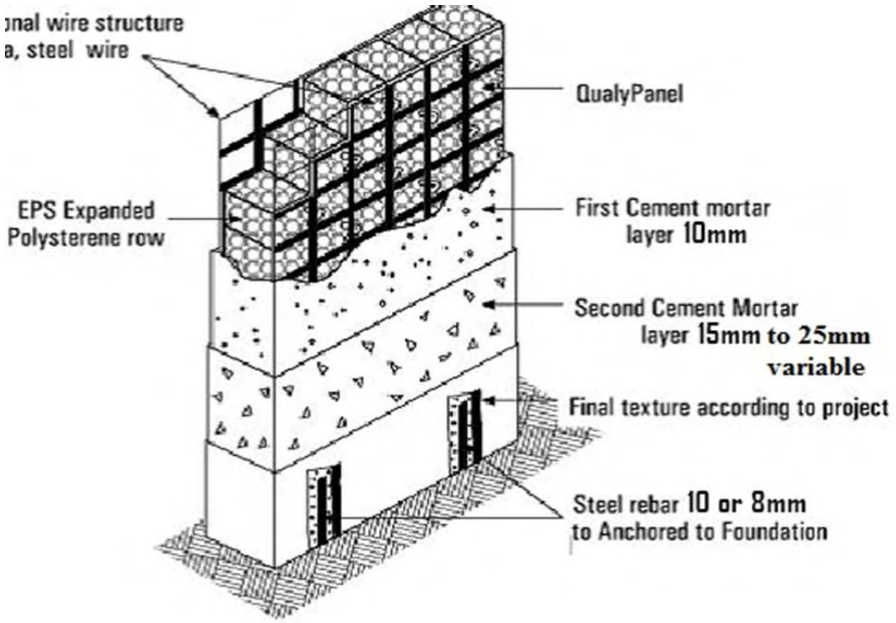
The guidelines for ceiling finish shall be as follows:

- A stiff mix of 1 cement: 3 sand mortar shall be prepared and applied to the ceiling, providing a level but rough surface. This layer should be cured for at least 24 hours before next layer is applied.
- It must be ensured that the first layer of plaster is damp prior to applying the finish layer.
- Cement mortar of mix 1 cement: 4 sand shall be prepared and required quantity of mortar shall be applied to the ceiling to provide a smooth finish.
- The total thickness of the ceiling finish should not exceed 19 mm below the panel wire mesh.
- Ceiling finish should be allowed to be cured for at least 10 days after placement.

2.4.11.3 *Wall finishing*

The guidelines for wall finish shall be as follows:

- It must be ensured that the wall is damp prior to applying plaster.
- Cement mortar of mix 1 cement: 4 sand shall be prepared and 25 mm plaster shall be applied to the wall to give a finish surface.
- Wall plaster should be allowed to be cured for at least 7 days after placement. *(See Fig. 29)*



Fig, 29 Panel System Wall (Schematic Drawing)

2.4.12 *Handling of Panels*

These panels are composed of two layers of steel wire mesh with a layer of polystyrene in the middle. The bottom side of each panel has rebar welded in which provides the strength that allows the panel to be used as a slab. The wire mesh on the top and bottom are connected to each other with a 'zig-zag truss' of wire running between the two meshes, welded at each joint.
The guidelines for handling the panels for ensuring safety shall be as follows:

- Gloves shall always be worn while handling the panels otherwise the hands may be cut with the ends of the wire mesh
- The wire mesh or rebar shall not be bend, deform or broken, except necessary to cut or install the panels.

2.4.13 *Cutting of Panels*

As the panels are manufactured in a few fixed sizes, it shall be necessary to cut the panels to a smaller size. The procedure for cutting of the panels shall be as follows:

- The length of the panel to be cut shall be measured and the measurement extended to the far-side of the nearest cross-wire. This measurement extension shall make the panel size longer and not smaller.

- Bolt cutters shall be used to cut the wires along the measured length on one side of the panel.
- Panels shall be flipped to the other side and bolt cutters used to cut the wires along the measured length on the other side of the panel.
- Panels shall be allowed to stand on its end and bended to 90 to expose the 'zig-zag truss'. The bolt cutter shall be used to cut the exposed wires.
- It shall be necessary to bend the panel to 90^{o} in the other direction also to expose the rest of the 'zig-zag truss' wires and cut them with bolt cutters.

2.5 Transportation, Handling and Storage of Panels

2.5.1 *Transportation*

- The panels shall be shipped using closed body containers on all sea routes.
- On land route, open body trailers may be used to transport more materials.
- In case of open body container, the panels shall be strapped or tied up in an appropriate manner for withstanding the wind and travel velocity.
- Flammable materials should not be stacked along with the panels.

2.5.2 *Handling*

- Panels shall be stacked in an appropriate manner to prevent sliding, spreading, or falling.
- Panels shall be stacked one on one basis with the longest panel at the bottom / side.
- Lagging (sleeve) shall be used when steel is handled by a crane or forklift to aid safe rigging.
- Gloves shall be used while loading or unloading manually.
- The top panel shall be removed from a stack on top of the stock.

2.5.3 *Storage*

- Panels shall be stored in a planned and orderly manner that does not endanger employee safety.
- It must be ensured that stacks are stable and stacked to aid safe handling and loading.
- Panels shall be stored on pallets to discourage rodent.

- Spills and leaks from rodents shall immediately be cleaned up.
- Petrochemical products or flammable products shall not be stored near the panels.

2.5.3.1 *Storing panels in an open yard*

- Combustible materials should be stored at least 5 meters away from a building or structure.
- Stacks shall not be more than 5 meter high.
- Panels shall be covered with high density polythene sheets.
- Driveways between and around panels shall be at least 3 meter wide.
- The stacks shall be kept free from accumulations of material or rubbish.
- A map grid system shall be used for planning driveways in open-yard.
- Panels shall not be stored under power lines or where they may block egress or emergency equipment.
- Portable fire extinguishing equipment shall be provided at accessible marked locations in the yard so that the nearest extinguisher is not more than 15 meter away from the panel.

2.5.3.2 *Storing panels indoors*

- In order to store panels indoors, special attention shall be required to access, fire prevention and protection, floor loading and overhead hazards.
- Panels shall be placed so they do not interfere with access ways, doorways, electrical panels, fire extinguishers etc.
- The access ways or exits shall not be obstructed with accumulations of scrap near Panels.
- Aisles should be wide enough to accommodate forklifts or firefighting equipment.
- Portable fire extinguishing equipment shall be provided at
- accessible marked locations in the yard so that the nearest extinguisher is not more than 15 meter away from the panel.
- Panels shall be placed inside buildings under construction at least 2 meter away from any hoist way or inside floor openings, and 3.50 meter away from an exterior wall that does not extend above the top of the material stored.

2.6 Inspections & Testing

Inspections & testing shall be done at appropriate stages of manufacturing process of all the components. The inspected frames and panels shall be stored & packed to ensure that no damage occurs during transportation. As part of quality assurance, regular in process inspections shall be carried out by the trained personnel of the PAC holder.

2.7 Good Practices for Installation & Maintenance

Good practice as per requirement including Do's & Don'ts of working with Rapid panel System of the manufacturer shall be followed for erection and maintenance of these sections.

2.8 Maintenance Requirements

It is assumed that no special maintenance is required during intended working life. Should repairs prove necessary, it shall ably be carried out by the trained persons using appropriate products and materials.

2.9 Skilled /Training Needed for Installation

Special training shall be required to get necessary skill set for assembly of Rapid panels and their erection. Moreover, workers shall be trained/ oriented on handling and installation of modules, panels etc. and support system with all required safety measures taken including heavy hats, protective shoes etc.

2.10 Guarantees/Warranties Provided by the PAC Holder

PAC holder shall provide necessary guarantees/ warranties of the system to the client.

2.11 Responsibility

- Specific design using Rapid panels technology is the responsibility of the designer with the instructions, supervision and guidance of the PAC holder.
- Quality of installation/construction of the system on site is the responsibility of the trade persons engaged by the manufacturer.
- Quality of maintenance of the building is the responsibility of the building owner.
- Providing necessary facilities and space for movement of cranes and vehicles is the responsibility of the manufacturer.

PART 3 BASIS OF ASSESSMENT AND BRIEF DESCRIPTION OF ASSESSMENT PROCEDURE

3.1 Assessment

3.1.1 The technical assessment was done as per provisions of the Standards listed in Part 5 of this Certificate.

3.2 Site Inspection

Inspection of a complete module assembled at site for construction of a house (G+1) of 110 sqm area approx. by the manufacturer was done by the TAC members and IOs. A (G+2) flat of 60 sqm area approx. constructed in 2015 was also inspected by the TAC members and IOs. The work was found to be satisfactory and the occupants have no complaints.

3.3 Tests Performed

3.3.1 *By Civil-Aid Technoclinic Pvt. Ltd., Bangalore*

1. *Test Report on Galvanised high strength steel bars in January, 2016*

i. Measured dia (mm) : 1.90, 2.65
ii. UTS (N/mm^2) : 687 632
iii. Elongation (%) : 4.8 6.1

2. *Test Report on Wall Panel in February 2014*

The following tests were conducted on the sample of wall panel:

i. Axial Load test
ii. Rebound Hammer test
iii. Nail withdrawal test

i. *Result of Axial Load test*

Dimensions of Sample: 3100 mm x 1220 mm x 115 mm
Maximum load applied: 12.0 tons
Maximum deflection: 5.50 mm

Table 5

Load applied (ton)	Central deflection measured (mm)	Observation
0	0	The wall panel is capable of taking the min. load of 12.0 ton No crack observed on the surface of the wall panel
5.0	2.7	
10.0	5.0	
12.0	5.5	

ii. *Result of Rebound Hammer Test*

Dimensions of Sample: 3100 mm x 1220 mm x 115 mm

Position of Hammer: vertically downwards

Table 6

S. No	**Rebound hammer reading**
1.	14
2.	18
3.	18
4.	14
5.	12
6.	12
7.	12
8.	12
9.	12
10.	10
Average	13.4

iii. *Result of Screw Withdrawal Test*

Dimensions of Sample: 3100 mm x 1220 mm x 115 mm

Details of screw: MS screw of dia. - 3.8 mm, length - 50 mm

Depth inserted - 25 mm, hole dia. – 3.0 mm

Depth – 25 mm

Table 7

S. No	**Pullout force - Max. load (kg)**
1.	208
2.	179
3.	200
Average	196

3.3.2 *Karnataka Test House Pvt. Ltd., Bangalore*

Test Report on Steel Bars in

Nature of Sample: Reinforcement steel 4 mm

Table 8 Tensile Test

Dia (mm)	**4**	**Limits as per IS 1786:2008 (Gr. Fe 415)**	**Limits as per IS 1786:2008 (Gr. Fe 450)**	**Limits as per IS 1786:2008 (Gr. Fe 500 D)**
Weight /unit length (kg/m)	0.139	4 mm – 0.0921 Min		
Yield Stress (N/mm^2)	764.33	415 Min	500 Min	500 Min

Tensile Strength (N/mm^2)	907.64	10% more than actual 0.2% proof stress but not less than 485 N/mm^2	8% more than actual 0.2% proof stress but not less than 545 N/mm^2	10% more than actual 0.2% proof stress but not less than 565 N/mm^2
Elongation (%)	16.0	14.5 Min	12.0 Min	16.0 Min

3.3.3 *By M/s Shriram Institute for Industrial Research, Delhi*

Test Report on EPS i*n January, 2016*

i. Bead size (%) : 96
ii. Environmental Hazardous substances :
   a. Lead content as Pb, (ppm) : < 1
   b. Cadmium content as Cd (ppm) : < 1
   c. Mercury content as Hg (ppm) : < 0.01
   d. Hexavalent chromium content as Cr +6 (ppm): <1

3.3.4 *By IIT Madras, Chennai in November, 2012*

Load tests on prefabricated sandwich roof panels:
Single-point loadings (shear) and two point load (bending).
Based on static tests under gravity loading, IIT Madras has certified that RapidPanel Roofing slab system is found satisfactory for use in buildings, for imposed loads (live loads) defined in IS 875 (Part 2):1987, under the following conditions:

1. Panel lengths up to 5.01 m, with appropriate camber provided, simply supported on beams or bearing walls not less than 125 mm in width
2. Panels installed with M20 grade of concrete and 1:3 cement mortar
3. Total dead load (including panel self-weight) not to exceed 3.3 kN/m^2
4. Total imposed load (live load) not to exceed 3.0 kN/m^2

3.4 Execution of Projects

The manufacturer, as reported, has constructed the buildings as per the details given below: (These have not been inspected by BMTPC)

S. No.	Name & location of the project	Total Area (sqm)approx.	Period of Completion
1.	Construction of Ground floor house at Sarjapura,	200	June 2014

	Bangalore		
2.	Construction of Basement + Ground floor house at Coorg, Bangalore	300	July 2014
3.	Construction of S+2, Nirmithi Kendra at Bangalore	120	July 2014
4.	Construction of S+2+H floor flat at Bangalore	180	October 2014
5.	Construction of S+2 floor flat at Bangalore	120	January 2015
6.	Construction of CSI Church at Hosur, Bangalore	350	May 2015
7.	Construction of G+2 floor flat at Bangalore	120	May 2015
8.	Construction of G+3 flat at Bhubaneswar	200	November 2015

PART 4 STANDARD CONDITIONS

This certificate holder shall satisfy the following conditions:

4.1 The certificate holder shall continue to have the product reviewed by BMBA.

4.2 The product shall be continued to be manufactured according to and in compliance with the manufacturing specifications and quality assurance measures which applied at the time of issue or revalidation of this certificate. The Scheme of Quality Assurance separately approved shall be followed.

4.3 The quality of the product shall be maintained by the certificate holder. Complete testing facilities shall be installed for in-process control.

4.4 The product user should install, use and maintain the product in accordance with the provisions in this Certificate.

4.5 This certificate does not cover uses of the product outside the scope of this appraisal.

4.6 The product is appraised against performance provisions contained in the standards listed in Part-V. Provisions of any subsequent revisions or provisions introduced after the date of the certificate do not apply.

4.7 Where reference is made in this Certificate to any Act of Parliament of India, Rules and Regulations made there under, statutes, specifications, codes of practice, standards etc. of the Bureau of Indian Standards or any other national standards body and the International Organization for Standardization (ISO), manufacturer's company standards, instruction/manual etc., it shall be construed as reference to such publications in the form in which they were in force on the date of grant of this Certificate (and indicated in Part V to this Certificate)

4.8 The certificate holder agrees to inform BMBA of their clients with details of construction on six monthly basis.

4.9 The certificate holder agrees to provide to BMBA feedback on the complaints received, the redressal provided, and the time taken to provide redressal on complaint to complaint basis as soon as redressal is provided. BMBA agrees to provide the certificate holder the user feedback received by it, if any.

4.10 If at any time during the validity period, PACH is unable to fulfill the conditions in his PAC, he should on his own initiative suspend using the PAC and notify Chairman, PAC the date from which he has suspended its use, the reason for suspension and the period by which he will be able to resume. He shall not resume without the prior permission of BMBA. He shall also inform, simultaneously, his agents, licensees, distributors, institutional, government, public sector buyers, other buyers and all those whom he has informed about his holding the PAC. He shall also inform all those who buy his product(s) during the period of suspension. He shall provide to BMBA at the earliest the list of who have been so informed by him.

4.11 In granting this Certificate, BMBA takes no position as to:

(a) The presence or absence of patent or similar rights relating to the product;
(b) The legal right of the Certificate holder to market, install or maintain the product;
(c) The nature of individual installations of the product, including methods of workmanship.

4.12 BMTPC and the Board of Agreement of BMTPC (BMBA) take no position relating to the holder of the Performance Appraisal Certificate (PACH) and the users of the Performance Appraisal Certificate (PAC) respecting the patent rights / copy rights asserted relating to the product / system / design / method of installation etc. covered by this PAC. Considerations relating to patent / copy rights are beyond the scope of the Performance Appraisal Certification Scheme (PACS) under which this PAC has been issued. PACH and users of this PAC are expressly advised that determination of the Claim / validity of any such patent rights / copy rights and the risk of infringement of such rights are entirely the responsibility of PACH on the one hand and that of the users on the other.

4.13 It should be noted that any recommendations relating to the safe use of the product which are contained or referred to in this Certificate are the minimum standards required to be met with when the product is installed, used and maintained. They do not purport in any way to restate or cover all the requirements of related Acts such as the Factory Act, or of any other statutory or Common Law duties of care, or of any duty of care which exist at the date of this Certificate or in the future, nor is conformity with the provisions of this Certificate to be taken as satisfying the requirements of related Acts.

4.14 In granting this Certificate, BMTPC and BMBA does not accept responsibility to any person or body for any loss or damage, including personal injury, arising as a direct or indirect result of the use of this product.

4.15 The certificate holder indemnifies BMBA, its officers and officials involved in this assessment against any consequences of actions taken in good faith including contents of this certificate. The responsibility fully rests with the certificate holder and user of the product.

4.16 The responsibility for conformity to conditions specified in this PAC lies with the manufacturer who is granted this PAC. The Board (BMBA) will only consider requests for modification or withdrawal of the PAC.

4.17 The PAC holder shall not use this certificate for legal defense in cases against him or for legal claims he may make from others.

Place: New Delhi
Date of issue_____

Chairman TAC &
Member Secretary, BMBA

for and on behalf of

PART 5 LIST OF STANDARDS & CODES USED IN ASSESSMENT

5.1 Standards - These Standards are referred for carrying out particular tests only and do not specify the requirement for the whole product as such.

5.1.1 IS 383:2016 – Specifications for fine and coarse aggregates from natural resouces
5.1.2 IS 456:2000 -- Code of practice for plain and reinforced concrete
5.1.3 IS 875 (Part 1):1987 -- Code of Practice for Design Loads (Other Than Earthquake) for Buildings & Structures Part 1 Dead Loads - Unit Weights of Building Material & Stored Materials (Incorporating IS 1911: 1967)
5.1.4 IS 875 (Part 2):1987 -- Imposed Loads
5.1.5 IS 1346:1991 – Code of practice for waterproofing of roofs
5.1.6 IS 1542:1992 – Specifications for sand for plaster
5.1.7 1786:2008 – Specifications for high strength deformed steel bars and wires for concrete reinforcement
5.1.8 IS 1893 (Part 1):2002 -- Criteria for Earthquake Resistant Design of Structure
5.1.9 IS 1904: 2005 – Code of practice for design and construction of foundations in soils: General requirements
5.1.10 IS 2095 (Part 1):2011 – Specifications for gypsum plaster board
5.1.11 IS 2645:2003 – Specifications for integral water proofing compounds for cement, mortar and concrete
5.1.12 IS 4326:1993 -- Code of Practice for Earthquake Resistant Design and Construction of Buildings
5.1.13 IS 4671:1984 -- Specifications for expanded polystyrene for thermal insulation purposes
5.1.14 IS 8112:2013 – Specifications for 43 grade ordinary portland cement
5.1.15 IS 9103:1999 -- Specifications for concrete admixtures
5.1.16 ASTM A 307-14 – Standard specifications for carbon steel bolts and studs
5.1.17 ASTM C 881 -- Standard specifications for epoxy resin based bonding
5.1.18 EN 14889-2:2006 -- Standard specifications for plymers for concrete

Part 5.2 Company Standards of the PAC holder – The branded design & specifications of the raw materials and finished product are as submitted by the manufacturer. The PAC holder has to make available the company standards to the consumers according to which testing have been done.

CERTIFICATION

In the opinion of Building Materials & Technology Promotion Council's Board of Agreement (BMBA), **Rapid Panels** bearing the mark manufactured by M/s Worldhaus Construction Pvt. Ltd. is satisfactory if used as set out above in the text of the Certificate. This Certificate **PAC No. 1026-S/2016** is awarded to **M/s Worldhaus Construction Pvt. Ltd., Bangaluru.**

The period of validity of this Certificate is for a period of two years i.e. from 08-04-2016 to 07-04-2018. This Certificate consists of pages 1 to 51.

Dr. Shailesh Kr. Agarwal
Chairman, TAC
& Member Secretary, BMBA
Building Materials and Technology Promotion Council
Ministry of Housing & Urban Poverty Alleviation, (Govt. of India)
Core 5A, Ist Floor, India Habitat Centre,Lodhi Road,
New Delhi-110 003

Embossing Seal Of BMBA

On behalf of BMTPC Board of Agreement Chairman, Technical Assessment Committee (TAC) of BMBA & Member Secretary, BMTPC Board of Agreement (BMBA) Under Ministry of Housing and Urban Poverty Alleviation, Government of India, New Delhi, India

Place: New Delhi

Date: .....

PART 6 ABBREVIATIONS

Abbreviations

BMBA	Board of Agreement of BMTPC
BMTPC	Building Materials and Technology Promotion Council
CPWD	Central Public Works Department
ED	Executive Director of BMTPC
IO	Inspecting Officer
MS	Member Secretary of BBA
PAC	Performance Appraisal Certificate
PACH	PAC Holder
PACS	Performance Appraisal Certification Scheme
SQA	Scheme of Quality Assurance
TAC	Technical Assessment Committee (of BMBA)

PERFORMANCE APPRAISAL CERTIFICATION SCHEME - A BRIEF

Building Materials & Technology Promotion Council (BMTPC) was set up by the Government of India as a body under the Ministry of Housing &Urban Poverty Alleviation to serve as an apex body to provide inter-disciplinary platform to promote development and use of innovative building materials and technologies laying special emphasis on sustainable growth, environmental friendliness and protection, use of industrial, agricultural, mining and mineral wastes, cost saving, energy saving etc. without diminishing needs of safety, durability and comfort to the occupants of buildings using newly developed materials and technologies.

During the years government, public and private sector organizations independently or under the aegis of BMTPC have developed several new materials and technologies. With liberalization of the economy several such materials and technologies are being imported.

However, benefits of such developments have not been realized in full measure as understandably the ultimate users are reluctant to put them to full use for want of information and data to enable them to make informed choice.

In order to help the user in this regard and derive the envisaged social and economic benefits the Ministry of Housing &Urban Poverty Alleviation has instituted a scheme called Performance Appraisal Certification Scheme (PACS) under which a Performance Appraisal Certificate (PAC) is issued covering new materials and technologies. PAC provides after due investigation, tests and assessments, amongst other things information to the user to make informed choice.

To make the PACS transparent and authentic it is administered through a Technical Assessment Committee
(TAC) and the BMTPC Board of Agreement (BMBA) in which scientific, technological, academic, professional organizations and industry interests are represented.

The Government of India has vested the authority for the operation of the Scheme with BMTPC through Gazette Notification No. 1-16011/5/99 H-II in the Gazette of India No. 49 dated 4th December, 1999.

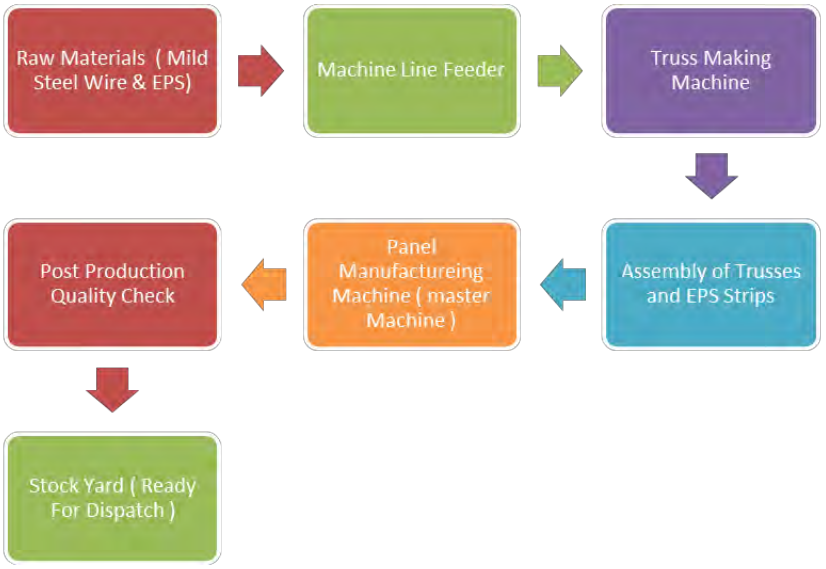
Builders and construction agencies in the Government, public and private sectors can help serve the economic, development and environmental causes for which the people and Government stand committed by giving preference to materials and technologies which have earned Performance Appraisal Certificates.

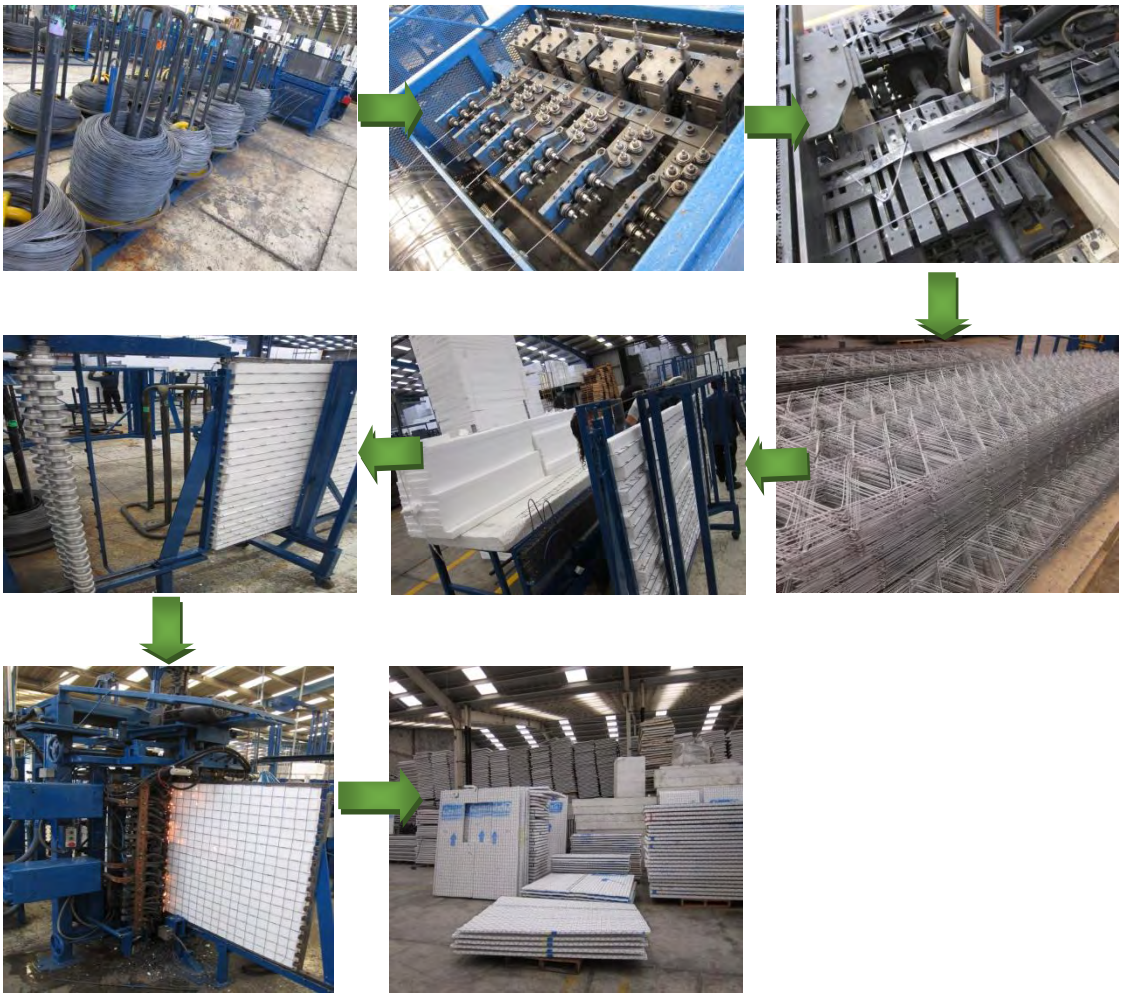
Further information on PACS can be obtained from the website: www.bmtpc.org

ANNEX I

(Clause 1.3.2)

Production Flow Chart





ANNEX II

(Clause 1.6.2)

QUALITY ASSURANCE PLAN FOR RAPID PANELS

S.No	Parameters to be inspected	Requirement Specified	Test Method	Frequency Of Testing
I.	**Raw Material**			
A.	*G I Wire*			
1.	Diameter (mm)	Thickness	As per manufacturer lab	Every fresh procurement
2.	Weight / unit m	0.0921 kg/m for Fe 500	As per manufacturer lab	Every fresh procurement
2.	Chemical composition %	C < 0.153% , Mn < 0.893%, P < 0.016%, S < 0.015%, Si < 0.134%	IS 8811:1998	Every fresh procurement
3.	Yield Stress (N/mm^2)	680 N/mm^2 min	IS 1599:2012 & IS 1786:2008	Every fresh procurement
4.	UTS (N/mm^2)	632-816 (N/mm^2)	IS 1608:2005	Every fresh procurement
5.	Elongation %	14.5 % to 16.0% min	IS 1599:2012 & IS 1786:2008	Every fresh procurement
B.	*Expanded Polystyrene (EPS)*			
1.	Dimensions (mm)	Length, width & thickness –	As per manufacturer lab	Every fresh procurement
2.	Bead size %	>95%	ASTM C 578	Every fresh procurement
3.	Density kg/m^3	15 kg/m^3 min	As per manufacturer lab	Every fresh procurement
5.	Moisture Content (%)	1.1 % max.	As per manufacturer lab	Every fresh procurement
6.	Environmental hazardousness (ppm)	Lead <1, Cadmium <1, Mercury <0.01, Chromium <1	ROHS Directive 2002/95/EC & IEC 62321:2008	Every fresh procurement
II.	**Finished Product**			
1.	Axial Load test	Deflection 5.50 max	Dial gauge	Every Year
2.	Rebound Hammer Test	--	Schimdt Hammer	Every Year
3.	Screw Withdrawal Test	--	Nail withdrawal test	Every Year

ANNEX III

(Clause 2.3)

Production Stages

The production stages as reported are given below:

1. *Raw Material*

The steel wires/ rods and EPS of specified quality shall be procured as per quantity required and stored at the stock yard.

2. *Truss*

The truss machine produces two trusses simultaneously, with length and width programmed by the operator. The steel wire shall be staged on spools and fed into the first machine, which shall straightens six lines of spooled wire. The straightened wires shall feed directly into the truss machine. The center wire on each of the two tracks shall be bent into the zig-zag shape.

The two outer wires on each track shall be drawn parallel to the zig-zag

And welded to its corners. Once the programmed length of truss is produced, the operator places the trusses on a storage rack. The equipment itself does not require any direct operation after it has been programmed, except to start and stop the process.

3. *Assembling Trusses and EPS Strips*

A movable rack specially designed to feed through the panel machine shall be used to assemble the panel and prepare it for welding to the cross wires. A truss shall be placed horizontally on the bottom of the rack, then alternating layers of EPS strips (67 mm thick) and trusses placed until the rack is full (achieving the 1200 mm panel width). A lever shall be closed on the top of the rack to secure the layers in place, and the positions of the EPS strips and trusses adjusted to ensure they are in line. The rack shall then positioned near the panel machine.

4. *Panel*

The rack fits into a track on the panel assembly welder, confining it to only move though the machine. The machine operator feeds the front of the panel into the machine, then starts the machine. The panel automatically moves through the machine in steps of 67mm. Steel cross wires on spools are drawn into the top of the machine and fed onto either side of the panel, perpendicular to the trusses.

The machine welds each intersection of the chord wires and truss wires at once before pushing the panel another 67 mm and doing the same thing. This continues until the end of the panel is reached. The operator manually starts and stops this process at the beginning and end of the panel.

5. *Manual Welding and Repair*

The completed panel is moved to the hand repair station, which is a large table with a hand welder. First, the continuous connection feature is completed by manually welding two more wires along the length (parallel with the truss) where the cross wires extend beyond the EPS. Then the panel is checked for any weld points that the panel assembly welder may have missed, and these points are manually welded.

6. *Post-Production*

Completed panels are stored in a godown for use or sale.

ANNEX IV

(Clause 1.3)

TYPICAL DESIGN OF A BUILDING

The building has been designed for G+3 floors. All elements are designed as per Indian Standards.

1. Design Parameters

- Size of the plot: 12.20 X 12.20 mtr.
- Type of Building: R.C.C Rapid panel Slab and R.C.C Rapid panel Slab wall.
- Number of storey: Ground + 3 floors.
- Safe Bearing capacity of the soil as per the soil investigation report: 1.50 mtr below G.L= 20 T/m^2.
- Type of foundation: Isolated footing.
- Grade of Concrete: M25 min. Cement content shall be as per provisions of IS 456:2000, for moderate environmental exposure condition.
- Grade of Steel (Fe 500): All reinforcement shall be high yield deformed bars of Fe-500, indicated with a prefix # with the appropriate bar diameter in the drawings.
- Environmental exposure condition considered would be ‘moderate’.
- Density of Concrete: 25 kN/m^3
- Density of Rapid panels: 5.5 kN/m^3 (as per test report)

2. Static Loads consideration.

All loads and combinations are as per IS 875:1987 and IS 456:2000.

2.1 Ground floor roof

Dead load of slab: Rapid panel + (75 mm floor finishing) + (25 mm ceiling plastering).

Live load= 2.0 kN/m^2 (As per Table 1, IS 875(Part 2):1987). Residential occupancy.

Wall load: Rapid wall panel load, 5.5 kN/m^3 + 35 mm cement mortar plastering works both face of the wall.

Stair case load: Rapid panel + (75 mm staircase finishing).

2.2 First floor and second floor

Dead load of slab: (Rapid panel + (75 mm floor finishing) + (25 mm ceiling plastering).

Live load: 2.0 kN/m^2. (As per Table 1, IS 875(Part 2):1987). Residential occupancy.

Wall load: Rapid wall panel load, 5.5 kN/ m^2+ 35 mm cement mortar plastering works both face of the wall.

Stair case load: Rapid panel + (75 mm staircase finishing).

2.3 Third floor roof (Terrace)

Dead load of slab: Rapid panel + (75 mm floor finishing) + (25 mm ceiling plastering) + WPC.

Live load: 1.5 kN/m^2 Flat roof with Access. (As per Table 1, IS 875(Part 2):1987). Residential occupancy.

Wall load: Rapid wall panel load, 5.5 kN/ m^2 + 35 mm cement mortar plastering works both face of the wall.

Stair case load: Rapid panel + (75 mm staircase finishing).

3. Seismic load.

Zone II (As per IS 1893:2002 Bangalore region falls under Zone –II. Relevant earthquake parameters as per zone-II are considered in the design).

Importance Factor: Important Building, 1.5.

Response Reduction: Special RC Frame building, 5.0

Type of soil: medium soil

Damping: 5%.

4. Load combination.

Ultimate limit state (partial safety factors as per IS 456:2000, CI 36.4.1)

UL=1.5 (DL+LL)

UL=1.5 (DL+EQL/WL) or (0.9DL+ 1.5 EQL/WL)

UL=1.2 (DL+LL+EQL/WL)

Serviceability limit state

SL=1.0(DL+LL)

UL=1.0DL+ 0.8LL+ 0.8 EQL/WL

UL=1.2(DL +EQL/WL).

5. Foundation analysis.

All the isolated footing is analyzed as per the standard empirical methods.

Design of Panel wall and roofing/flooring system

Slab Panel floor

Dead Load of panel: 5.5 kg/m^2 = 0.055 kN/m^2
Self-weight of concrete 75 mm thick = 1.875 kN/m^2
Ceiling Plaster 20 mm thick = 0.4 kN/m^2
Finished Load = 0.8 kN/m^2
Total Dead Load = 3.075 = **3.13** kN/m^2

Wall Panel

Dead Load of panel: 5.5 kg/m^2 = 0.055 kN/m^2
Plastering external 35mm thick = 0.7 kN/m^2
Plastering internal 35mm thick = 0.7 kN/m^2
Total Dead Load = 1.455 = **1.5** kN/m^2
Live Load as per IS-875 Part-2:1987 for Residential Floor = **2.0** kN/m^2
Live Load as per IS-875 Part-2:1987 for Residential = **1.5** kN/m^2
(Access Terrace).
*Load due to wall per running meter
Height of each floor 3.0 m (Ground floor to first floor)
3.0 m (First floor to second floor)
3.0 m (Second floor to Terrace floor)
1.0 m (Ground level to Foundation)
0.45 m (parapet wall)
Total Height = 10.45m

Wall construction

- All corners and wall joints should be reinforced with right angled wire mesh to the full height of the walls.
- To cut panels to fit for door & window openings, wire should be cut with a wire cutter or angle grinder. Measure and mark the cut lines before starting to cut.
- After the wire mesh has been cut, EPS shall be cut with a hacksaw blade or stiff blade hand saw.
- Added steel mesh reinforcement shall be required around door and window openings to ensure that no plaster cracks form in these areas. Mesh reinforcement strips shall be tied diagonally with wire around openings before plastering.
- Once wall panels are in place and tied together, bracing shall be required to hold them vertical before plastering. This shall be done only on one side of the panels.
- Once the panels are plastered on one side, the wall bracing shall be removed after 24 hours. The panels are now sufficiently stiff so that plastering on other side can be done without bracing.

- Extra Vertical reinforcement should be provided floor to floor junction.

Slab construction

Same as wall construction.

- When connecting a slab to load bearing wall panel, the EPS within the entire joint area should be removed and the joint should be fully concrete. Also, additional steel wire mesh should be tied to all joints.
- If panels need to extended or otherwise joined together, a full concrete section should be provided at the joint with the same strength of the panel itself. Note that the allowable positive moment capacity of the panel is 23 Knm. So any full concrete joint should be designed to have the same capacity.

Load due to wall per running meter = L x B x H x weight per cu meter
=1 m x 10.45 m x 1.5 kN/m^2
= **15.7 kN**

Load due to roofing per running meter load.

Area of roof per running meter = 1m x 5.5 m =5.5 m^2

Floor Load for Ground roof, First roof and second roof
Dead load = 3.13 kN/m^2
Live load = 2.0 kN/m^2
Total dead+ live load = 5.13 kN/m^2x 5.5m^2 =28.2 kN per running meter.
Ground + first + second floor =3 x 25.5Kn = **84.6 kN**

Roof Load for terrace
Dead load = 3.13 kN/m^2
Live load = 1.5 kN/m^2
Total dead + live load = 4.63 kN/m^2 x 5.5 m^2 =**25.5 kN** per running meter.
Terrace load =25.5 kN
Total Load due to roofing per running meter load =**110.1 kN**

- Total wall panel load of all floor + total roofing load per running meter = **126 kN per running meter**.