Experimental Study of Pre-Engineered Wall Panel

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Abstract – The aim of pre-engineered wall panel is high bending stiffness at low densities due to minimal compressive and flexural strength, thermocol or polystyrene is a filler material in structural member. Thus we aim to prove that by using reinforced thermocol as an alternative building material we can achieve an easy, fast and cheap method of construction. Steel industry is growing rapidly in almost all the parts of the world. The use of steel structure is not only economical but also ecofriendly at the time when there is a threat of global warming. Time being the most important aspect, of structures is build in very short period and one such example is pre-engineered building (PEB).Result show that these structures are economic, reduces construction cost and time, energy efficient and flexibility of expansion.

Index Terms – PEB- pre-engineered building polystyrene, global warming

1. INTRODUCTION

1.1 General

The wall constructed with conventional masonry system contributes higher dead weight of the structure. The reduction in the weight of the wall will significantly reduce the dead weight of the structure which result in overall reduction in size of structural component. Furthermore, the improved technologies are to manage shortfall in the availability of natural aggregate material, there is a need for a alternative system of fulfil the construction demand environmental friendly. The wall panel system consists of assembly of modular wall panel made of shaped polystyrene panel that are contained between two sheets of galvanized welded wire meshes. The above wire are bound to each other by the mesh horizontal wire and the joints are machine welded. The concrete sandwich panels are such system, which is more suitable for wall construction. The concrete sandwich panel consists of lightweight expanded polystyrene (ESP) plate with skin concrete on both sides. The EPS core panel system may be designed using the appropriate design software. The buildings constructed in EPS core system shall be studied and designed as reinforced concrete structure since the parameters required for their design are the same as needed for traditional reinforced concrete. In the calculation model, the building shall be designed as a structure composed of load bearing walls with a bow-like structure the system is intended for use where Architectural drawings are available and satisfy the various requirements. The Architect and engineer team of the concerned developer (client)is responsible for the drawings and overall building design to comply with the various regulatory requirements applicable to the area. Foundation shall be specifically designed in accordance with provision given in IS 1904:1986. The design concept is same that of the conventional building design. The safe bearing capacity and soil properties (soil investigation report) shall be provided from the site after soil investigations. Foundation shall be designed based on the soil investigation report. Both single and double panels should have starter bars for either foundation or ground floor slab. All foundation should be designed by experience engineer with appropriate reference the design assumptions, detailed calculations, references to necessary and detailed design drawing shall be made available on demand, if required. The structural design calculation should clearly demanstate structural integrity and stability including connection details In addition, any other requirement regarding against earthquake need to be ensured by the designer as prevailing codal requirements. In engineering, the best way to solve the rising housing deficit is to be considering cheaper and better way so building that will reduce 65 and 30 per cent of overall costs brought about by building material and labour respectively. Materials represent the major expense in the overall cost of a construction project. Construction using prefabricated materials to get buildings up fast is a relatively new method in India.

1.2 DESCRIPTION

Name of system – Reinforced EPS core panel system

Brand Name – `Reinforced EPS wall panel

Brief Description – Expanded polystyrene core panel system is a factory produced panel system for the construction of own rise buildings up to G+1 and as filler walls in high rise RCC and steel frame buildings. In this technique a core of undulated polystyrene is covered with reinforcement and shortcrete concrete.

1.3 MAIN COMPONENTS

Vertical structural wall

Horizontal structural element

Cladding element

1.4 TYPES OF WALL PANEL

1.4.1 Load bearing wall

Mesh

Width : 1235 mm

Longitudinal wires :Ø 2.5/3.0mm @ 80mm c/c (max)

Transverse wires : Ø 2.5/3.0 mm @ 75 mm c/c (max)
Connectors & cross wire : Ø3.0 mm @ 150 mm c/c

EPS

Density : ≤ 15 kg/m³

Thickness : 50 mm to 160 mm

Waves Depth : 15 mm

1.4.2 Non load bearing wall

Mesh

Width : 1235 mm

Longitudinal wires : Ø2.5/3.0mm @ 80mm c/c (max)

Transverse wires : Ø2.5/3.0mm @ 75/150mm c/c (max)

Connectors & cross wires : Ø3.0mm @ 150 mm c/c

EPS

Density : 12 to 15 kg/m³

Thickness : 40 mm to 280 mm

Wave depth : 5 mm

1.5 TECHNICAL CONDITIONS

Raw materials and the finished panels shall conform to the requirements of the prescribed specifications.The building to be constructed using EPS core panels shall be in accordance with the specifications and manufacturing & construction process prescribed by the manufacturer and designed by competent structural Engineering,Plumbing and Electrical services are not a part of this certificate. It shall be governed by the provision of relevant Indian Standard and details provided by the manufacture. It shall be governed by the provisions and details given by the manufacturer.EPS Core panel system should be erected only with technical support or supervision by qualified engineers and builders, based on structural designs complying with prevailing standards and specification; this is applicable even for low-rise and affordable mass housing to provide safety of structures.It is strongly recommended that structural engineers and building designers associated with EPS core panel construction should get themselves thoroughly familiar with the various structural aspects. It is also recommended that architects and construction engineers who undertake EPS core panel building design and construction with EPS core panel system gain familiarity with the properties of material, characteristics of EPS core panels and its application and construction.For construction of load bearing structure of G+3 & above in seismic active area of zone III, IV &V as per IS 1893 (Pt. 1):2002, the certificate holder hall submit evidence of performance analytically or exprimentally against earthquake forces by IIT / NIT before taking the job.

1.6 USE OF PANEL

The panels shall be used as:

- As load bearing walling in buildings.
- As non-load bearing wall panels.
- As partition infill wall in multistorey framed buildings.
- As road construction and bridge.
- As swimming pools.
- As retaining wall.
- As basement construction.
- As soundproof rooms constructed.

2. LITERATURE REVIEW

S.Doroudianii,H. Omidian,@March 2009 Decorative tiles and mouldings made of polymeric foams are getting more popular in buildings. There are health, safety and environmental concerns on these products and their use in the buildings. In this paper, we report the results of the study and discuss about concerns of decorative mouldings made of expanded polystyrene (EPS). Physical damage to the structure of the buildings, potential harms to residents and health hazards were found as main concerns in this regard. The use of decoractive mouldings made of EPS in the buildings in the subject to some considerations. The climate conditions play siginificant role in the feasibility of usage of decoractive mouldings in the buildings. Although these products may add some aesthetic effects to the buildings exterior view, the observations and results of the study do not support the use of the products in the buildings. Decoractive mouldings bring significant safety and health risks and it is recommended that for usage in buildings, particularly residential ones, the decoractive moulding to be made of nonflammable light-weight materials or to be completely excluded from the buildings.

Syed Firoz, Sarath, Chandra Kumar @ 2012, Thepre-engineered steel building system construction has great advantages to the single storey buildings, practical efficient alternative to conventional buildings, the system representing one central model within multiple disciplines. A large steel structures being built are only single storey buildings for industrial purpose. Secondary structural members span the distance between the primary building frames of metal building systems.

Thomas Tamut. Rajendra Prabh,@Feb 2014 With the increase in demand for construction materials, there is a strong need to utilize alternative materials for sustainable development. The main objective of this investigation is to study the properties. normal concrete i.e., without EPS beads. EPS beads are used as partial replacement to coarse aggregates. The results showed that the amount of polystyrene beads incorporated in concrete influences the properties of hardened concrete. At 28 days, it was found that compressive strength of 5%,10% ,15% ,20% ,25% and 30% EPS incorporated concrete strengths were 91% ,77% ,71% ,63%, 57%, and 45%, respectively when compared to concrete with no EPS case.

Rohana Mamat, Jamilah, @June 2015 This study used steel fiber as reinforcement while enhancing the EPS-LWC strength. In line with architechural demand and ventilation requirements, opening with in wall panel was also taken into account. Experimental tests were conducted for reinforced and unreinforced EPS-LWC wall panel. Two samples with size of 1500mm (hight) x 100 mm (length) 75 mm (thickness) for the each group of wall panel were prepared. Samples in each group had opening size of 600 mm (hight) x 400 mm (length) located at 350 mm and 550 mm from upper end respectively. EPS-LWC wall panel had fcu of 20.87 N/mm2 and a density of 1900 kg/m3. The loading capacity, displacement profiles and crack pattern of each sample was analyzed and discussed.

3. SPECIFICATION

3.1 Technical specification

3.1.1Raw material

Reinforced thermocol is made from styrene, a by-product of crude oil extraction.it also found in the natural starch contained in many fruit such as strawberries and food products such as wine coffee beans and cinnamon.Reinforced thermocol is a polymerization process which produces translucent spherical beads of polystyrene with size ranging from 0.5 to 1.3mm in diameter. During this process a low boiling point hydrocarbon usually pentane gas, is impregnated to the material.Pentane has a Global Warmming potential (GWP) of zero. The European union does not register pentane as substance hazardous to human health or the environment.

3.2 Manufacturing process

Manufacturing process of expanded polystyrene is carried out in three stages:

3.2.1. First states pre-expansion

The raw material (beads) are heated in special machines called pre-expanders with steam induced to the vessel at temperatures of approximately 100c.the steam causes the pentane to released from the beads. During the process of pre-expansion peads swell up to almost 50 times their original size. Once the desired volume has been rachead , the expanded beads are released into a ded dryer and all condensed steam moisture is dried from the surface. This process takes approximately 3min to finish.

3.2.2. Second stage-Intermediate maturing

Once the expanded beads have been dried, they are blown into large open silos or mesh bags for the aging process. this is because on cooling, the expanded beads from a vacuum in their interior which must be equalized to atmospheric pressure to prevent collapse or implosion of the beads. Hence this process allows the beads to fill back up with air. This process can take from 12 hours to 48 hours in order to achieve a greater mechanical elasticity and improve expansion capacity of the beads and also depends on the desired expanded density required of the beads.

3.2.3. Third – Final moulding

In this stage, the pre-expanded beads are transported to moulds where they are further subjected to steam so that as the beads are compressed, they bind together to form a block “block moulding” – that are later cut into panels and shaped or products are moulded in their final finished shape “shape moulding”

3.3.Material specification

3.3.1.Roof slab panel

SI. No.	Sample Design ation	Dimensions (mm) (b X l X t)	Effective Span (mm)
1.	RF-001	1220X 1055 X 85	1020
2.	RF-002	1230X 1050 X 130	850
3.	RF-003	1230X 1460 X 170	1260
4.	RF-004	1240X 1460 X 160	1260

4. INSTALLATION PROCESS

The PAC holder shell manufacture the panels in accordance with the requirements specified in this certificate. In addition it shall follow the company standard specifying requirements of various materials used and not listed in the certificate.The EPS core panel system consists of assembly of modular wall panel, roof panel made of shaped polystyrene panel that are contained between two sheet of galvanized welded wire meshes. The above wire are bound to each other by the mesh horizontal wire and found orthogonally by the links which keep the mesh together. All the joints are machine welded.

4.1 Foundation

Foundations for the EPS panel system whether strip or raft are conventional. If strip foundations are used, they should be level and stepped as this makes panel positioning easier.For EPS

core panels, parallel sided timber or metal template of the width of panel shall be required to mark the position of the wall panels on the foundation and the spacing of the starter bar holes.

4.2 Wall start up

Line wall positions shall be marked and profiled.A timber or metal template of the exact width of panel (from wire to wire) shall be used to mark the position of the panels with chalk or pencil line .On the panel lines position shall be marked to drill the starter bar holes. These should be in zig zag pattern at 600mm centres on each side of panels. starter bars should be at all panel joints and on the opposite side in mid panel plus at all corners and joints.Starter bar should be either 6mm or 8mm dia. 500mm long with 100mm drilled into the foundations and 400mm above.Drill bits shall be used to give a tight fit with the starter bars.Once starter bars are in position, place the EPS core panels between the starter bar starting from a corner. Starter bars shall be wire-tied to the panel mesh and the panels to each other on the overlapping mesh.

4.3 Wall construction

All corners and wall joints shall be reinforced with right angled wire mesh to the full height of the walls.To cut panel to fit for door & window openings, wire should be cut with a wire cutter or angle grinder. measure and cut mark lines before starting to the 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 opening 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. Plastering on other side can be done without bracing.

4.4 Door and window fittings

4.4.1 First method

Fix a metal angle iron or hollow tube sub frame into the openings before plastering. Fix and plaster these in place and then secure the frames to the sub frame.In order to secure heavy door/window frames, the EPS where the bolts are to be fixed to the wall shall be burnt or cut and this space shall be filled with mortar or concrete to hold the bolts.

4.4.2 second method

Before plastering metal ‘cliscoe’ type window and door frames (which should be sized to the width of the panels) may be fitted into the pre-cut panels.Metal ‘coliscoe’ type window frame fitted into future house panel before plastering.Metal lung s from the back of metal frames shall be wire tied to the panel mesh to keep the frames in position.

4.5 Floor/Roof panel

After the vertical panels are assembled, verticality of the walls shall be checked and the bending meshes positioned on all the corners. Thereafter, horizontal bending meshes shall be placed to connect the floor/roof to the vertical panels. The bending meshes shall be fixed throughout the perimeter of floor/roof, at the level of intrados.When the horizontal bending meshes are fixed and checked, floor/roof panel shall be placed on these. The lower mesh of the panel shall be fixed by steel wire to the bending meshes.Between the edges of floor/roof panel and vertical panel, gap of 35mm should be left to ensure structural continuity. the plaster applied on the walls shall be continued from one level to another level.Placing of the EPS core panel elements for the floor and/or roof should be done before the application of the external layer of plaster on the walls. casting on concrete on the floor/roof panels(after placing the additional reinforcing bars, if required) should be done after the walls are plastered and a number of props shall be put to limit the deformation of the panel.

4.6 plastering

Plastering shall be done by machine or hand . the indicative quantity of each material per cum. Should conform to relevant Indian standards shall be:

Cement : 350kg

Sand with mixed granulometry : 1600kg. sand should be without clay or any organic substance and totally washed.

Water – 160litres. The quality of water may be different according to the natural sand humidity. The parameters that should be constant are: W/C=0.52 and I/C=4.50.Any problem of workability should be solved without adding water. the retraction cracks formation may be avoided by adding polypropylene fibers in the mix ($1kg/m^3$).In order to control the final plaster thickness, some guides should be used. These shall be removed as soon as the plaster ‘sets up’ and the spaces are filled and are sets dry smoother before the plaster dry.Spray application should be done in two steps with a first layer covering the mesh applied on both the sides of the wall and the finishing layer as soon as the first layer gets dry.

4.7 plumbing and electrical fittings

Plumbing and electrical conduits shall be behind the panel wire mesh before plastering.The space behind the wire mesh shall be opened up by using a blow torch to partially melt the EPS along the lines of the conduits. As the EPS used in the panes is fire retardant, it will melt under the flame but not burn.The wire mesh shall be cut with wire clippers to make space for DB boards, switches and plug boxes.

4.8 connection

The reinforced EPS wall system is composed by panels consisting of a polystyrene sheet assembled together with welded wire mesh.Various connections are detailed in figs of which may be referred.There are several techniques available for connecting EPS wall components; the wall system is composed by panels consisting of a polystyrene sheet assembled together with welded wire mesh. The panels are finished on site by spraying concrete to realize the different elements of the system.

4.8.1 Connection elements

Vertical structural walls;

Horizontal structural elements;

Cladding elements;

Internal wall.

4.8.2 type of connection

Panel connection;

Inside corner connection;

Outside corner connection

5. TESTING

5.1. Material type

The following types of the EPS were tested:

1.EPS 70 - density of 15 kg/m3

2.EPS 100 -density of 20 kg/m3

3.EPS 150 - density of 25 kg/m3

4.EPS 200 - density of 30 kg/m3

5.EPS 250 - density of 35 kg/m3

5.2. Tests

5.2.1. compressive strength

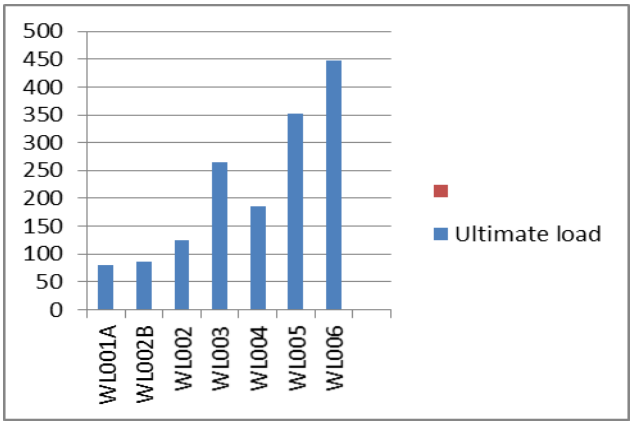
The most important property of a structural material which will be covered with concrete is the compressive strength which is determined by loading as dictated by the standards.

5.2.2. Flexural strength

Tensile strength is commonly defined in one of the three ways: direct tensile strength, tensile splitting strength or flexural strength. The flexural strength is about 1.5 times the tensile stress determined by splitting test Flexural strength may be determined by using the two methods:-Test method 1 – A loading system utilizing centre loading on a simply supported beam, supported at both ends.Test method 2 – A loading system utilizing two symmetric load points equally spaced from their djacent support joints at each end with a distance between load points.

6. RESULT ON TESTING

SAMPIE DESIGNATION	ULTIMATE LOAD KN/m	REMARKS
WL001A	76.940	Vertical faces Unconfined
WL001B	85.930	Vertical faces Unconfined
WL002	125.50	Vertical faces Unconfined
WL003	264.70	Vertical faces Unconfined
WL004	186.32	Vertical faces Unconfined
WL005	352.70	Vertical faces Unconfined
WL006	447.33	Vertical faces Unconfined



7. ADVANTAGES OF PEB

Reduced Construction Time

Building are typically delivered in just a few weeks after approval of drawings. Foundation and anchor bolts are cast parallel with finished, ready for the site bolting. PEB will reduces total construction time of the project by at least 50%. This also allows faster occupancy.

Lower cost

There is a significant saving in design, manufacturing and on site erection cost. The secondary members and cladding nest together reducing transportation cost.

Flexibility of expansion

Buildings can be easily expanded in length by adding additional bays. Also expansion in width and height is possible by pre designing for future expansion.

Large clear spans

Buildings can be supplied to around 80m clear span.

Quality control

As buildings are manufactured completely in the factory under controlled conditions the quality is assured.

Low maintenance

Buildings are supplied with high quality paint systems for cladding and steel to suit ambient conditions at the site, which results in long durability and low maintenance coats.

Sustainability

Steel is 100% recyclable and the most recycled material in world, Thus each ton of recycled steel saves 2500 pounds of iron ore and approximately 1000 pounds of coals.

Single source responsibility

As the complete building package is supplied by a single vendor, compatibility of all the building components and accessories is assured. This is one of the major benefits of the pre engineered building systems.

8. CONCLUSION

The first task of the field study was to determine the suitability of using Reinforced Thermocol technology in construction. The second task of the field study involved evaluating the cost of using Reinforced Thermocol as a construction material.

Based on the present work, the following conclusions were made:

The tests for the compressive and flexural strength, as well as use of Reinforced Thermocol as a filler material proved that that technology can be used for structural purposes. A comparison was made between the prices of using Reinforced Thermocol technology and using the conventional stone and mortar method. The evaluation mainly concentrated on the material cost as well as labour cost as aspects that greatly influence the total cost of construction.

The cost of materials while using the Reinforced Thermocol technology proved to be more expensive than using the conventional stone and mortar for wall construction. But since the conventional method of construction is more labour intensive, labour proved to be more costly than using Reinforced Thermocol technology. Reinforced Thermocol thus proved to be a cheaper method of construction. The hypothesis has thus been proven showing that Reinforced Thermocol technology can provide a low cost solution to the national housing deficit in the country.

REFERENCES

[1] C.M. Meera (June 2013) Pre engineered building design of an industrial warehouse. International journal of engineering sciences and emerging technologies. Volume 5 Issue 2.

[2] Aijaz Ahmad ZENDE, Prof A.V. Kulkarni, Aslam Hutagi (Feb 2013). Comparative study of analysis and design of Pre engineered buildings and conventional frames. IOSR journal of Mechanical and Civil Engineering, Volume 5.

[3] Jatin D. Thakar Prof P.G. Patel comparative study of pre engineered steel structure by varing width of structure .International journal of advanced engineering technology, Volume 4.

[4] Syed Firoz, Sarath Chandra kumar design concept of pre engineered building. International journal of pre engineering research and application, Volume 2.

[5] S.D. Charkhal and Latesh (June 2014) Economizing steel Building using pre-engineered steel sections. International of research in Civil engineering, architecture and design, Volume 2.