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A REVIEW ON EXPANDED POLYSTYRENE MONOLYTIC PANELS – EPS

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ABSTRACT

The need for hours is a requirement for sustainability in the construction industry. Urbanization is accelerating in India, resulting in increased housing demand as well as a slew of issues such as pollution and unsustainable construction techniques. Traditional construction methods, which require a significant amount of time, materials, and energy, can achieve the same results. Natural resources and energy are also in short supply on a global scale. As a result, for better natural resource optimization, construction approaches and materials that reduce construction costs, CO2 emissions, and construction time while using the least amount of energy are required. A wide variety of environmentally friendly building materials are now available. Structural Insulated Panels, Plastic Composite Lumber, Vacuum Insulation Panels, Recycled Steel, Insulating Concrete Forms, Plant-based Polyurethane Foam, Straw Bales, Structural Insulated Panels, Plastic Composite Lumber, Vacuum Insulation Panels, Recycled Steel, Insulating Concrete Forms, Plant-based Polyurethane Foam, Straw Bales, Structural Insulated Panels, Plastic Composite Lumber, Vacuum In recent years, research has been carried out all over the world to address specific challenges, and numerous innovative materials and technologies have been developed. One such building technology is expanded polystyrene sheet, or EPS. This research paper aims to investigate the material aspects that contribute to sustainability, with a focus on various parameters such as structural safety, cost effectiveness, and ease of construction and maintenance, as well as indoor comfort, using some real-time case studies and simulation techniques.

***Keywords**: Sustainable material; Expanded polystyrene sheet; Cost effective; Thermal Performance*

1. MAIN TEXT

The use of Expanded Polystyrene Panels (EPS) in the construction of reinforced concrete buildings introduces a ready-made technology. The EPS core Panel system is a modern, efficient, safe, and cost-effective building solution. These panels can be load-bearing as well as non-load-bearing components. [11].

The EPS core panel is a three-dimensional panel composed of a welded wire space frame with a truss concept for stress transfer and rigidity and a polystyrene insulation core. The panel is in place, with shotcrete on both sides [9]. In terms of the management aspect of sustainability, project managers and decision makers will benefit from prioritising their management and maintenance processes based on importance, availability of funds, and so on[10]. Shotcrete is applied to the panels assembled on the job site, which gives the structure its bearing capacity. A growing gap in supply and demand for various materials has been identified in a study conducted by the Material Consumption Patterns in India in 2016 [7]. The EPS panel is made up of welded reinforcing meshes of high-strength wire, diagonal wire, and self-extinguishing expanded polystyrene uncoated concrete that are manufactured in the factory, and shotcrete is applied to the assembled panel at the construction site, which gives the structure its bearing capacity [2].

Furthermore, [9] stated that construction projects and buildings are designed and developed to meet the expectations of clients and professionals. A single panel structure may have up to four floors, whereas a double panel structure may have up to fifteen floors [6]. The finished panels are put together on-site. In this context, [3] revealed that inefficient handling and supervision of materials, as well as their storage, can cause construction delays. Unlike traditional building processes that require multiple employees to set up a wall using masonry stone and plaster, a single operator can lift and arrange the panels at their respective design positions, resulting in labour savings. [11]

The EPS panel is a versatile structural component that can be used for floors, walls, partitions, roofs, and staircases. The standard EPS panel is 1200 mm wide, 3000 mm long, and has a thickness range of 80-230 mm. The panels are finished on the job site with a minimum 30 mm thick shotcreting of cement and coarse sand in a 1:4 ratio applied under pressure. The shotcreting coat encases the EPS Core with steel welded wire mesh in the centre.

Advantages

• Construction Time Reduction • Lightness, Handling, and Transportability • Seismic Resistance	• Integration with other systems • Fire Resistance • Thermal Insulation and Sound Insulation	• Cyclone Resistance

2. LITERATURE REVIEW

Various literatures have been studied for experimental studies on EPS shortcreting panels and their behaviour. This chapter discusses the overview and comparison of results from various literatures. In North America, precast concrete sandwich panel (PCSP) technology has advanced gradually over the last four decades. The first non-composite prefabricated panels were made up of thick structural leaves, a layer of insulation, and non-structural leaves (Seeber et al., 1997). PCSP feature all of the desirable properties of a traditional precast concrete panel, such as durability, economy, fire resistance, vast vertical intervals between supports, and possible use as shear walls, bearing walls, and retaining walls. Furthermore, PCSP may be shifted to allow for building expansion. The panel's firm surface on both the interior and exterior provides resistance to harm and a completed product that requires no additional treatment.

The combined materials may be formed into composite panels, allowing for optimal design for a variety of applications. Individual materials' desirable qualities can be blended, while their poor ones can be removed. It achieves better strength-to-weight ratios by combining the shear strength of a lighter core material with the high compressive and tensile strength of dense leaves. The core material isolates and stabilises the outer facings during edgewise compression, torsion, or bending. The leaves are typically constructed of high-strength material and bear the principal loads. They withstand stress and compression to prevent buckling, tension failure, and impact deformation.

Pre-cast concrete sandwich panels (PCSP) are classified into three categories based on the degree of composite action accomplished (Shutt, 1997). A noncomposite sandwich panel has concrete leaves that operate independently to resist bending. Plane section behaviour is attained in each leaf, but not throughout the whole depth of the panel. A completely composite sandwich panel is one in which the two concrete leaves work together to prevent bending, allowing the panel to function as a single unit. A completely composite panel, in principle, displays plane section behaviour over its whole depth and at all places along its span. By allowing for adequate horizontal shear transmission between the leaves, full composite behaviour is accomplished. The steel mesh in the concrete leaves was linked with shear connections. The connections transfer load from the outside to the inner concrete leaves.

A partially composite sandwich panel is one in which concrete leaves work together to prevent bending at least partially. As a result, a partly composite panel resists bending to the same extent as a fully composite panel and a non-composite panel. The degree of composite action displayed by a panel may alter during the course of the panel's loading history.

Panels have received a lot of attention in the engineering world as an useful structural element. It has been employed in naval constructions as load-bearing elements (Aicher and Hofflin, 1999). However, in the building and construction business, the majority of sandwich panel research is focused to the investigation of the nonload bearing non-composite kind of PCSP (Jokela et al., 1981, Olin et al., 1984, Hopp et al., 1986 and Bush, 1998). The section will be divided into several sub-sections that will discuss the various materials used as the leaves and core, the shear connectors' influences on panel behaviour, and the structural behaviour of panels under various loadings that have been done on this type of panel, particularly in the context of their applications.

3. REVIEW OF PAST STUDIES ON PANEL

"Mechanical characteristics of EPS wall panels under shear and flexural loads," Mohammad Z. Kabir [1] worked on. EPS wall panels are utilised in the construction of external and interior load-bearing and non-load-bearing walls and floors in all types of buildings. The current study looks at the mechanical properties of EPS wall panels under static shear and bending stresses in order to gain a better understanding of their structural components. The numerical model is loaded in increments to reproduce the tests and enable for failure detection in flexural testing for vertical and horizontal bearing panels, as well as direct shear. The load displacement curves produced by finite element analysis are extremely comparable to the specimens tested. Maximum loads in flexural testing are equivalent to experimental ultimate loads for both wall and floor panels. Tension failure in the bottom leaf of concrete initiates the failure mechanism after migrating from the elastic zone at the load stage of 700 kg. The break then spreads to the top layer with a weight of 1200 kg. The bottom mesh is relinquished, and lastly, the crushing of concrete generates system instability. The maximum load is stated to be 2200 kg. The panel acts as a cantilever deep beam in direct shear analysis. EPS wall panels are utilised in the construction of external and interior load-bearing and non-load-bearing walls and floors in all types of buildings. The current study looks at the mechanical properties of EPS wall panels under static shear and bending stresses in order to gain a better understanding of their structural components. The numerical model is loaded in increments to reproduce the tests and enable for failure detection in flexural testing for vertical and horizontal bearing panels, as well as direct shear. The load displacement curves produced by finite element analysis are extremely comparable to the specimens tested. Maximum loads in flexural testing are equivalent to experimental ultimate loads for both wall and floor panels. Tension failure in lower leaves of concrete initiates the failure mechanism after migrating from the elastic zone at the load stage of 700 kg. The break then spreads to the top layer with a weight of 1200 kg. The bottom mesh is relinquished, and lastly, the crushing of concrete generates system instability. The maximum load is stated to be 2200 kg.

G. Carbonari [2] "Experimental and analytical research of the compressive behaviour of EPS sandwich panels" was completed. This study provides a thorough analysis of the behaviour of EPS sandwich panels subjected to typical load while accounting for a number of factors. Two experimental programmes were carried out for this purpose, which resulted in the suggestion of an analytical formulation to estimate the maximum load resisted. The results indicate how the height of the panel, the material qualities, the location and configuration of the reinforcement, and the position and configuration of the reinforcement may all effect panel resistance. The eccentric location of the reinforcement should be given special consideration since it might significantly lower the maximum load resisted. Some recommendations for the best location of the reinforcement are made.

Waiel MOURTAJA [3] "EPS Behavior of Shotcreted Light Weight Panel Buildings" was worked on. To build the skeleton section of an EPS construction, specially constructed two layers of reinforcement grids are employed, which are connected by zig zag form continuous cross bars. Because a layer of foam sheet has been inserted between the two sides of the reinforcing cages, shotcrete application from either side is almost effortless during the building phase. In the laboratory, a 1/2 scale model of a one-story specimen was created utilising this material and building technique and evaluated for lateral stresses. The low weight panels decrease the overall weight of the construction in half. Furthermore, the monotonic lateral loading suggests that the ultimate load obtained may be ten times greater than the design load, with all relative displacement criteria properly met.

Omid Rezaifar [4] "Nonlinear dynamic behaviour of structural frames produced with EPS wall panels with Vertical Irregular arrangement" was the project on which I worked. In this work, the hysteresis behaviour of integrated systems, RC frames, and pre-cast EPS wall sandwich panels in non-linear material characteristics is investigated. The seismic behaviour of a structure made with EPS wall panels is investigated for energy absorption and dissipation with material nonlinearities. The results compare standard bending RC frames to full box type shotcrete sandwich panel systems and demonstrate the variations in hysteresis behaviour for each system as well as any scenarios with irregularity in vertical stiffness such as soft story. Material nonlinearity was simulated using the Drucker-Prager failure criteria in this investigation. The behaviour of the FEM model was confirmed by the experimental results. Seventy-three frames were evaluated, and the results were researched and compared. A comparison of energy dissipation for stories and the effects of soft stories is offered.

M.Z.Kabir [5] worked on the project "Structural Performance of EPS Sandwich Panels Under Shear and Flexural Loading." In all forms of construction, EPS wall panels are utilised to build external and interior load bearing and non load bearing walls and floors. The purpose of this research is to better understand the structural components of EPS wall panels by investigating their mechanical properties under static shear and bending stresses. The numerical model is loaded in increments to reproduce the tests and provide failure detection in flexural testing for vertical and horizontal bearing panels, as well as direct shear. The load versus displacement curves produced by finite element analysis are extremely comparable to the specimens tested. Maximum loads in flexural testing are equivalent to experimental ultimate loads for both wall and floor panels. Tension failure in the lower Leaves of the concrete initiates the failure mechanism after migrating from the elastic zone at the load stage of 700 kg. The break then spreads to the top layer with a weight of 1200 kg. The bottom mesh is relinquished, and eventually, the system becomes unstable due to the crushing of concrete. The maximum load is stated to be 2200 kg. The panel acts as a cantilever deep beam in direct shear analysis.

Dr. Jasim M. AL-Khafaji [6] worked on the project "Structural Behavior of Normal and High Strength Concrete Wall Panels Subjected to Axial Eccentric Uniformly Distributed Loading." Concrete wall panels are subjected to axial eccentric distributed loads in this study; as a result of this form of loading, concrete wall panels react and fail in some way. There are several variables that influence the structural behaviour of concrete wall panels. This study presents an experimental investigation of the structural behaviour of concrete wall panels subjected to axial eccentric distributed loading; it also assesses the effect of parameters such as slenderness ratio (H/t), aspect ratio (H/L), and concrete strength on the behaviour of concrete wall panels. The experimental programme includes testing fifteen concrete wall panels hinged at the top and bottom with free sides by applying the load axially with eccentricity equal to (t/6); these panels are divided into five groups, each group consists of three panels with slenderness ratio (H/t) equal to (20, 25, 30) for each panel, three groups of normal concrete strength with aspect ratio (H/L) equal to (1.0, 1.5, 2.0) for each group, and the other two groups are of high strength. Concrete wall panel deflections are determined by the slenderness ratio (H/t), aspect ratio (H/L), and concrete strength. The aspect ratio (H/L) has a large influence on the failure mode of concrete wall panels; panels with a low aspect ratio prefer to crush, whereas panels with a high aspect ratio tend to buckle.

Nathan Koekoek [7] Sandwich panel technology and Easy panel provide a lot of benefits over traditional onsite production, as demonstrated in this research. Easy Panel was created to take use of the benefits of sandwich panel technology - strength combined with low weight - in line with the unique demands of property building. Aside from the general benefits, Easy panel construction streamlines the production process and supply chain, allowing for the greatest utilisation of both onsite and offshore production advantages. This results in increased efficiency and speed. Fewer resources are wasted, and projects are completed faster, providing for a faster return on investment. Society benefits from these advantages as well, because they have a lower environmental effect as a result of more efficient production and greater insulation. Furthermore, the Easy panel franchising model of turn-key delivery enables the ability to immediately join a local market when demand is identified, reducing possible shipping bottlenecks. All of this suggests that the negative implications of prefab offsite manufacture may be mitigated – or perhaps eliminated.

Tarek K. Hassan and Sami H. Rizkalla [8] Three different precast concrete sandwich wall panels, reinforced with carbon-fiber-reinforced-polymer shear grid and constructed using two different types of foam, expanded polystyrene (EPS) and extruded polystyrene (XPS), were selected from the literature to validate the proposed approach. The study findings showed that the proposed technique is compatible with the actual behaviour of the panels since the projected stresses compared well with the observed values at all load levels for the individual panels. Aside from that, the method is useful for determining the degree of composite interaction at various load levels for different panels at any given curvature. To compute the nominal moment capacity of EPS or XPS wall panels as a function of the maximum shear force created at the contact, a simple design chart is supplied. To compute the nominal moment capacity of EPS and XPS foam-core panels at various degrees of composite interaction, a simpler design chart is presented. The chart is solely valid for the present study's panel arrangement, shape, materials, and reinforcement. It may, however, be simply made for other panels. The graph depicts the impact of composite interaction on induced curvature.

Bernard A. Frankl et.al. [9] Six precast, prestressed concrete sandwich wall panels were developed and tested for flexural response under combined vertical and lateral stresses. The panels in the research were made with two distinct types of insulation: expanded polystyrene (EPS) insulation and extruded polystyrene (XPS) insulation. The chosen EPS insulation had a nominal density of 16 kg/m3 and a notional compressive strength of 90 KN, according to the manufacturer. The XPS insulation used had a nominal density of 29 kg/m3 and a nominal compressive strength of 170 KN. The panels measured 6.1 m 3.7 m, were 200 mm thick, and were made up of three layers. The flexural properties of six full-scale insulated precast, prestressed concrete sandwich wall panels were studied. To imitate gravity and wind pressure stresses, the panels were exposed to monotonic axial and reversecyclic lateral forcing. According to the findings of this study, the kind and design of the shear transfer mechanism has a considerable impact on panel stiffness and deflections. The kind of foam also influences panel rigidity.

4. CONCLUSION

A clear notion about EPS shortcreting panel and their behaviour has been gathered from numerous literatures. The needs for future housing systems continue to rise, but the pressure to keep costs low rises. To fulfill these objectives, structural designers must develop new materials and technologies that are both high in quality and low in cost. Because of its various advantages, including high sustainability, precast lightweight sandwich technology is one of the solutions accessible as both non-structural and structural parts. Foamed concrete is a form of cellular lightweight concrete that has been employed in lightweight PCSP, particularly as the core layer, due to its superior insulation, as observed by Rice et al. [13] in their study. When, however, Because the thickness of the core is generally bigger than the thickness of the leaves in a typical sandwich panel, the cost will rise substantially. The lack of strength of foamed concrete as a face material is primarily responsible for its reluctance to be used. Finite element analysis is used to validate and supplement experimental findings. Based on the findings of the experiment and finite element analysis, a semi-empirical equation will be produced. It is intended that the results of this research would be transmitted to industry by offering a quick and low-cost method of constructing a low- to medium-rise residential structure.

REFERENCES

[1] Salmon, D. C., And Einea A. " Partially Composite Sandwich Panel Deflections", ASCE, Journal Of Structural Engineering, Vol. 121, No. 4, 1995;778- 783

[2] Moehle, J.P.," Seismic Analysis of R/C FrameWall Structures", ASCE, Journal of Structural Engineering, Vol. 110, No. 11, 1984;

[3] Moehle, J.P. "Seismic Response of Vertically Irregular Structures", ASCE Journal of Structural

[4] Engineering, Vol. 110, No. 9, 1984;

[5] Lu, Yong," Comparative Study of Seismic Behavior of Multistory Reinforced Concrete

[6] Framed Structures", ASCE, Vol. 128, No. 2 2002;

[7] Wood Sharon L, "Seismic Response Of RC Frames With Irregular Profiles", Journal Of

[8] Structural Engineering. Vol.118, No. 2, 1992,

[9] Jahanpoor, A.R.," An Estimate Of Ductility Behavior Of 3D Wall Panels Subjected To Cyclic Shear Loads" , M.Sc. Dissertation , Amirkabir University Of Technology ,March 2003

[10] Rezaifar, Omid, "Nonlinear Dynamic Behavior of Combined System (3Dwall Panel +Frame) Under Cyclic Loading", M.Sc. Thesis, Amirkabir University Of Technology, September 2003.

[11] M. Z. Kabir, Omid RezaiFar And M. R. Rahbar, " Non-Linear Dynamic Behavior Of Combined System On RC Frame Pre-cast 3d Wall Panels With Irregularities In Vertical Stiffness",13th World Conference On Earthquake Engineering, Vancouver, B.C., Canada, August 1-6, 2004.