REVIEW ON LIGHTWEIGHT WALL PANELS

N.Harinarayanan[1], Dr.K.Sudha[2]

[1]*PG Scholar, Department of Structural Engineering, Government college of Engineering – Salem-11,Tamilnadu, India*

[2]*Professor, Department of Civil Engineering, Government college of Engineering – Salem-11, Tamilnadu, India*

ABSTRACT

The growing need for sustainable and efficient construction practices has spurred a surge in the development of advanced building materials. Lightweight wall panels have emerged as a promising solution to address the challenges of traditional construction methods. This abstract delves into the design, composition, and benefits of lightweight wall panels, highlighting their contributions to sustainability, energy efficiency, and ease of installation. The lightweight wall panel comprises a combination of materials such as foam cores, composite materials, and reinforcements, carefully engineered to optimize strength while significantly reducing overall weight. This innovative construction material offers various advantages over conventional walls, including enhanced thermal and acoustic insulation properties, increased structural integrity, and improved resistance to fire and moisture. Furthermore, the streamlined manufacturing process of lightweight wall panels minimizes waste generation and reduces the carbon footprint associated with transportation and installation. These panels also facilitate quicker construction timelines, enabling cost-effectiveness and increased flexibility in building design. This abstract discusses the diverse applications of lightweight wall panels across residential, commercial, and industrial sectors, emphasizing their adaptability and versatility in meeting diverse construction requirements. Additionally, it explores ongoing research and developments in the field, aiming to further enhance the performance and sustainability aspects of these panels.

INTRODUCTION

Structural LWC is an advanced concrete material, focused to reduce concrete density. It is essential to minimize dead load of the structure, especially in cases as stair pan fill, roof deck repairs, floor slabs at elevated height on available floor decks. Since LWC are lighter in weight, it offers ease in lifting and transportation which accounts as significant benefit over conventional material. And moreover, it aids in incremental increase in temperature transfer rates than traditional concrete, resulting in better insulation.

WALL PANEL

A wall panel is single piece of material, usually flat and cut into a rectangular shape, that serves as the visible and exposed covering for a wall. Wall panels are functional as well as decorative, providing insulation and soundproofing, combined with uniformity of appearance, along with some measure of durability or ease of replaceability. While there is no set size limit for a piece of material fulfilling these functions, the maximum practical size for wall panels has been suggested to be about
0.6 to 2.4 m (2 to 8 ft), to allow for transportation.

TYPES OF WALL PANELS

Wall panels can be comprised of a variety of shapes, and wall types. Typically, precast concrete wall systems fall into three basic categories: solid, sandwich and thin-shell. These can be panelized and erected in either a horizontal or vertical position and used on all types of structures from residential to commercial, institutional to industrial. Wall panels

can be designed as non-load bearing or load bearing, carrying floor and roof loads, as well as lateral loads.

Typical widths: 1.2m to 4.5m

Typical heights: 3m to 12m

Typical thickness: 120mm to 500mm

SOLID WALL PANELS

Solid wall panel simply refers to walls being made of solid concrete as opposed to including integral insulation. These wall systems require some form of insulation and an interior wall/finishing system to complete the building enclosures.

Finishes: Since wall panels are cast in flat orientation, the form side is typically the side that will be exposed to view in the final construction achieving an off-form class 2 finish. This face can be made with virtually any type of finish. The back face is typically trowelled smooth or may have a light broom finish.

Typically, the interior does not need additional furring and drywall to create the finished surface.

SANDWICH WALL PANELS

Insulated sandwich wall panels can be strictly architectural, strictly structural, or a combination of both. The difference between typical panels and insulated sandwich wall panels is that the latter are cast with rigid insulation "sandwiched" between two layers, or wythes, of concrete. The insulation thickness can vary to create the desired thermal insulating property for the wall. The typical concrete sandwich panel is shown in Fig 1.1.

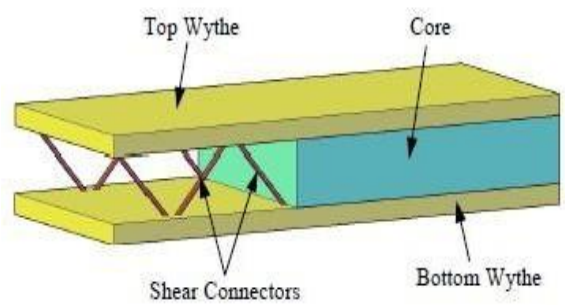

FIG 1.1 TYPICAL CONCRETE SANDWICH PANEL (CSP)

The structural behaviour may be composite, non-composite or semi composite.

COMPOSITE CSP

In composite CSP, the top and bottom wythes act together to resist the applied load. The shear connectors of the composite concrete sandwich panel are capable of transferring the shear forces fully between the top and bottom wythes and 100% composite action is achieved.

NON-COMPOSITE CSP

In non-composite CSP, the top and bottom wythes act independently to resist the applied load. One wythe is considered as a structural wythe and the other wythe is considered as a non-structural wythe. The shear connectors do not transfer the shear forces between the top and bottom wythes. However, the shear connectors act as elements to hold the top and bottom wythes in their position. The load carrying capacity of the non-composite CSP depends on the load carrying capacity of the structural wythe.

SEMI-COMPOSITE CSP

The degree of composite action achieved in semi-composite CSP lies between the composite and non-composite CSP. In practice, semi-composite action of the CSP is considered in the design only to resist the handling stresses during shipping and erection. After erection, the load carrying capacity of the semi-composite CSP is limited based on the non-composite action.

LIGHT WALL PANELS

Light or "lite" walls are shear walls used in parking structures cast with an opening in their center to provide visual continuity and to allow daylight or artificial illumination to penetrate deeper into an interior. The components provide openness and a feeling of security.

As with other types of shear walls, lite walls serve as the lateral force-resisting systems in the structure. They act as cantilever beams, transferring lateral

forces acting parallel to the face of the wall, from the superstructure to the foundation.

MATERIALS

In sandwich structures three types of materials are to be selected. They are face sheet material, core and the type of matrix used to bond the face sheets to the core.

FACE SHEET MATERIALS

Almost any structural material which is available in the form of thin sheet may be used to form the faces of a sandwich panel. Panels for high-efficiency aircraft structures utilize steel, aluminium or other metals, although reinforced plastics are sometimes adopted in special circumstances. In any efficient sandwich structure the faces act principally in direct tension and compression. It is therefore appropriate to determine the modulus of elasticity, ultimate strength and yield or proof stress of the face material in a simple tension test. When the material is thick and it is to be used with a weak core it is desirable to determine its flexural rigidity.

SANDWICH CORE STRUCTURAL CLASSIFICATION

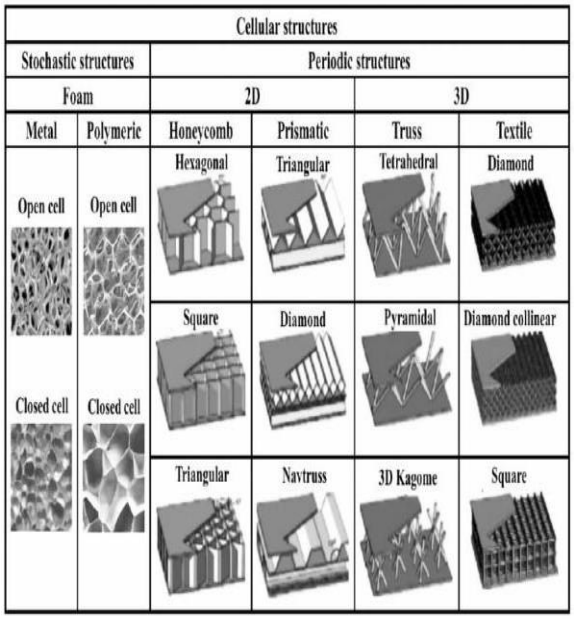

FIG 1.2 CLASSIFICATION OF CELLULAR STRUCTURES ON SANDWICH PANEL BASED ON STOCHASTIC AND PERIODIC STRUCTURES

In order to enhance the mechanical properties of sandwich structures, many types of cellular core structures were proposed and developed, which is generally defined as cellular structures. Cellular structures can be briefly classified as the stochastic cells and periodic cells; and the classification of cellular structures on sandwich structure is summarized in Figure 1.2. For stochastic structures, metal and polymeric foams have been introduced, which provides the open-cell and closed-cell types. For periodic structures, the cell unit is repeated in the array, which can fabricate the two-dimensional (2D) and three-dimensional (3D) core structures. It is indicated that cellular structures have increasingly paid attention to higher dimensional structure, which could provide better other properties.

LIGHTWEIGHT CONCRETE WALL PANELS

Classifications of lightweight concrete wall panels can be based on several criteria, including composition, production method, intended use, structural properties, and specific characteristics. Here are some classifications based on different factors:

Composition-based Classification

1. Foamed Concrete Panels: Created by introducing air bubbles into a cementitious mixture.
2. Autoclaved Aerated Concrete (AAC) Panels: Made by mixing cement, sand, lime, water, and aluminium powder, which reacts to create air bubbles.
3. Fibre-Reinforced Concrete Panels: Incorporate fibres (such as fibreglass, carbon, or steel) to enhance tensile strength and flexibility.
4. Polystyrene Concrete Panels: Combines polystyrene beads with a cementitious mixture to reduce weight and improve insulation properties.
5. Magnesium Oxide (MgO) Panels: Composed of magnesium oxide, fillers, and reinforcements, known for their durability and fire

resistance.

Production-based Classification

1. Precast Lightweight Concrete Panels: Manufactured off-site in controlled conditions, then transported and assembled on-site.
2. Cast-In-Situ Lightweight Concrete Panels: Created and poured directly on-site, allowing for customization and adaptability to various shapes and sizes.

Intended Use-based Classification

1. Interior Wall Panels: Designed for use as interior walls in residential, commercial, or industrial buildings, providing insulation and partitioning.
2. Exterior Wall Panels: Specifically engineered for the exterior facade of buildings, offering weather resistance and insulationproperties.
3. Sound Barrier Panels: Panels designed to mitigate noise pollution, used in highway barriers or industrial settings for sound insulation.

Structural Property-based Classification

1. Low-Density Lightweight Panels: Panels with reduced density, achieved by incorporating materials like expanded aggregates or lightweight fillers.
2. High-Strength Lightweight Panels: Engineered to possess high tensile and compressive strength while maintaining a lower weight compared to traditional concrete.

Specific Characteristic-based Classification

1. Fire-Resistant Panels: Panels specifically designed and tested to offer high resistance to fire and heat.
2. Thermally Insulating Panels: Panels engineered to provide excellent thermal insulation, reducing heat transfer and energy consumption.
3. Acoustically Insulating Panels: Panels designed to minimize sound transmission, providing better acoustic insulation.

LIGHTWEIGHT CONCRETE WALL PANELS SUBJECTED TO AXIAL LOADS

When lightweight concrete wall panels are subjected to axial loads (loads applied along the axis of the panel), depends on various factors including the panel's design, composition, reinforcement, and the magnitude of the load. Here's an overview of how lightweight concrete wall panels may behave under axial loads.

Behaviour under Axial Load

1. Compression Strength: Lightweight concrete wall panels are typically designed to withstand compressive forces. Axial loads primarily induce compressive stresses within the panel.
2. Buckling Resistance: Depending on the panel's slenderness ratio (ratio of height to thickness) and support conditions, it may be susceptible to buckling under high axial loads.
3. Cracking and Deformation: Excessive axial loads can lead to cracking or deformation in the panels, particularly if the load exceeds their capacity or if there are design flaws.

4. Failure Modes: Failure under axial loads can occur due to material crushing, excessive deflection, or buckling, depending on the design, material properties, and support conditions. **Factors Affecting Performance**

1. Material Properties: The properties of the lightweight concrete used in the panels, including compressive strength, density, and modulus of elasticity, influence how well the panel can resist axial loads.
2. Reinforcement: Incorporating steel or other reinforcing materials within the panels can enhance their tensile strength and overall load-bearing capacity, reducing the risk of failure under axial loads.
3. Panel Geometry and Thickness: Thicker panels and appropriate cross-sectional geometry can provide better resistance to axial loads.

4. Support and Boundary Conditions: The way the panel is supported and restrained at its edges can significantly affect its under axial loads. Proper anchoring and support are crucial.

Design Considerations

1. Load Capacity Calculation: Engineers use structural analysis methods to calculate the maximum axial load a lightweight concrete panel can withstand, considering factors such as material properties, dimensions, and intended use.
2. Safety Factors: Designers apply safety factors to ensure that the panel can safely withstand anticipated loads without failure or excessive deformation.
3. Code Compliance: Adherence to building codes and standards ensures that the design and construction of lightweight concrete wall panels meet safety and performance requirements.

ADVANTAGES OF LIGHTWEIGHT CONCRETE WALL PANELS

1. Reduced Weight: As the name suggests, lightweight concrete wall panels are lighter than traditional concrete, making them easier to handle and transport. This can lead to cost savings in labour and transportation.
2. Insulation Properties: Many lightweight concrete panels offer good thermal insulation properties, helping to regulate interior temperatures and potentially reducing energy costs.
3. Fire Resistance: Some types of lightweight concrete panels exhibit excellent fire resistance, which enhances safety in buildings.
4. Acoustic Insulation: These panels can offer decent soundproofing qualities, contributing to a quieter interior environment.
5. Speed of Installation: Due to their lighter weight and pre-fabrication, they often allow for faster installation, thereby reducing construction time.
6. Customization: These panels can be manufactured in various sizes, shapes, and finishes,allowing for design flexibility.

DISADVANTAGES OF LIGHTWEIGHT CONCRETE WALL PANELS

1. Strength Variability: Lightweight concrete panels may have lower structural strength compared to traditional concrete, which could limit their use in certain load-bearing applications.
2. Cost: While they can save on transportation and labour costs, the initial cost of lightweight concrete panels might be higher than some other materials.
3. Moisture Absorption: Some lightweight concrete panels might have higher moisture absorption rates, which could affect their durability in certain environments if not properly treated or sealed.

APPLICATIONS OF LIGHTWEIGHT CONCRETE WALL PANELS

1. Residential Construction: Used for interior and exterior walls, especially in homes where ease of installation and insulation properties are desired.
2. Commercial Buildings: In commercial construction, these panels can be used for partitions, facades, and cladding due to their aesthetic appeal and quick installation.
3. Industrial Structures: Lightweight concrete panels are suitable for warehouses, factories, and other industrial structures that require both insulation and quick installation.
4. Prefabricated Construction: They are often utilized in off-site construction for modular buildings due to their ease of transportation and assembly.
5. Sound Barrier Walls: Due to their acoustic insulation properties, they are useful in constructing sound barrier walls along highways or industrial areas.

CONCLUSION

Lastly, compared with conventional building materials, wall panels are offered an extensive range of advantages and disadvantages. Lightweight wall panels, due to their quick installation and their potential to be manufactured, may be a good choice for projects that prioritise speed and efficiency. The requirements, environmental conditions and budget considerations should be taken into account in deciding on the wall panel type for a project. Energy efficiency, rapid build speed, strength and durability are the main benefits of these panels. Other features of the lightweight wall panels include reduced construction waste and design flexibility. Due to initial costs, limited availability in certain regions and concerns regarding long term durability and fire resistance, there are some problems which must be taken into account.

REFERENCE

1. Mohammad Panjehpour, Abang Abdullah Abang Ali, and Yen Lei Voo, 'Structural Insulated Panels: Past, Present, and Future', Journal of Engineering, Project, and Production Management,2012.
2. G.Deepa, K. Mythili, Venkata Ratnam, 'Cellular Light Weight Concrete Blocks With Different Mix Proportions', International Journal Of Research And Innovation, 2015.
3. Raj Vardhan Singh Chandel, Rashmi Sakale, 'Study of Cellular Light Weight Concrete', International Journal for Scientific Research & Development, Vol. 4, Issue 07, 2016.
4. Lina Chica, Albert Alzate, 'Cellular concrete review: New trends for application in construction', Construction and Building Materials,2018.
5. Aisswarya.R, Jagadesh Kannan.S, Nithila.S, Karthikeyan.M, 'Experimental Study On Eps Shotcreting Panel', International Journal of Pure and Applied Mathematics, Volume 119, No. 14 ,2018.
6. Akshay lad, Nikhil,Shirode,Balaji Shivpuje, Prof. B.R.Waravte, 'Autoclaved Aerated Concrete', International advanced Research Journal in Science, Engineering and Technology, Vol 8, Issue 5, May 2021.