Investigation on Lightweight Sandwich Wall Panel Subjected to Axial Load

R. Ramya[1,] Dr.K. Sudha[2]

[1]PG Student, M.E Structural Engineering, Government College of Engineering, Salem.

[2]Professor, Department of Civil Engineering, Government College of Engineering, Salem

Abstract:

The construction industry continually seeks innovative solutions to enhance efficiency, reduce construction time, and improve structural performance. Lightweight sandwich wall panels have emerged as a promising technology addressing these needs. Lightweight wall panels are engineered materials that offer reduced density compared to traditional building components, without compromising strength and durability. These wall panels offer a wide range of benefits, such as ease of installation, reduced transportation costs, and improved thermal performance. Compared to traditional buildings, the density of sandwich wall panels is low. This study focuses on lightweight sandwich wall panels, which consist of two outer layers (face layer) and an inner layer (inner core). The facings can be made from materials such as fiber-reinforced polymer, high-strength concrete, ferrocement or steel, while the core is typically composed of lightweight materials like foam concrete, expanded polystyrene (EPS), or autoclaved aerated concrete (AAC). In this project, the face layer is made up of ferrocement, and the inner core is made up of foam concrete. These panels contribute to energy efficiency by providing insulation and reducing the overall impact on the buildings.
Keywords: Lightweight sandwich wall panels, foam concrete, inner core, face layer, expanded polystyrene (EPS), or autoclaved aerated concrete (AAC).

INTRODUCTION

The development in the construction field all over the world creates a huge demand for construction materials. The wall of the building constructed using masonry systems or normal concrete contributes to the higher dead weight of the structure. Due to the higher dead load, the need for the larger size of the structural member's increases. So the reduction in the size of the wall reduces the need for the larger size of structural members and also contributes to overall capital reduction. To fulfil these reasons, there is a need for an alternative system for wall construction.

Lightweight wall panels are the construction materials designed to be significantly lighter than traditional building systems. These panels typically consist of lightweight materials which contributes to their low density and exceptional strength - weight ratio.

Lightweight sandwich wall panels are panels made by combining different materials to create a single panel. These panels consist of three layers. A lightweight core material is sandwiched between two facing materials. The facing material is generally made up of metal, fiber cement, cement, ferrocement, and oriented strand boards (OSB). The lightweight core materials made up of are polystyrene (PS), expanded polystyrene (EPS), or polyurethane (PUR); and its derivatives, such as polyisocyanurate (PIR). These panels are used as floors, walls, roofs.

APPLICATIONS

Lightweight sandwich wall panels are used in

- Prefabricated buildings
- Recording studio
- Warehouse walls

- Interior partition works
- Exterior walls
- Floors
- Temporary buildings etc.,

ADVANTAGES

The advantages of Lightweight Sandwich wall panels are listed below.

- Weight reduction (up to 80%)
- Excellent sound insulation
- Thermal insulation
- High resistance to fire
- Does not need compaction or vibration
- Deduction in dead load of the whole structure results in overall capital reduction
- Less reinforcing materials
- Smaller size of structural members

DISADVANTAGES

The disadvantages of Lightweight Sandwich wall panels are listed below.

- Expensive
- Limited local availability
- Required skilled installation
- Some types of Lightweight wall panels are sensitive to moisture

OBJECTIVES OF THIS PROJECT

- To produce lightweight wall panels with lower densities compared to traditional methods.
- To investigate the behavior of a lightweight sandwich, wall panel when subjected to axial load.
- To study the properties of lightweight wall panels.
- To determine the economic advantages of using lightweight wall panels over traditional construction materials.

METHODOLOGY

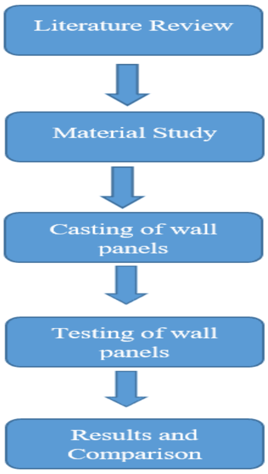

Fig :1 Methodology

MATERIAL USED AND ITS PROPERTIES

Cement

The cement used for this study is 53 grade, Ordinary Portland cement.

S.NO	NAME OF THE TEST	LIMITATIONS AS PER IS CODE	RESULT
1.	Consistency	30-35%	32%
2.	Initial setting time	>30	45 minutes
3.	Final setting time	<600	445 minutes

Table 1: properties of cement

M-Sand

The specific gravity of M-Sand used is 2.46.

Water

Based on ACI 523.3R.93, it is recommended that the water to be used for the foamed concrete be fresh and drinking water. The amount of water that is required in the manufacturing of foam concrete depends on a lot of factors: composition of binder materials, type of filler, and required workability. A low water content generates rigid mixtures and causes the bubbles to break; a high water content provokes thin mixtures that generate segregation of the materials. The W/C ratio varies from 0.4 to 1.25.

Foaming Agent

There are two types of foaming agents. They are synthetic - based foaming agents and protein - based foaming agents. Protein-based foaming agents are substances derived from hydrolysed proteins that are used to create stable foam in various applications. The protein-based foaming agent possesses higher strength and stability as compared to the synthetic foaming agent. The foaming agent used in this project is Soya based protein foaming agent.

Fig :2 Foaming agent

Weld Mesh

Welded mesh, also known as weld mesh or welded wire mesh, is a type of construction material commonly used in various applications, including fencing, concrete reinforcement, and industrial purposes. Weld mesh of 2.5mm diameter is used.

CASTING OF WALL PANELS

A sandwich wall panel of size 915 x 380 x 120 mm is cast with lightweight concrete inner core infill. The thickness of each ferrocement layer is 20 mm and the inner core is 80 mm. The mix ratio for the ferrocement layer is 1:2:0.5. This mix is used for casting both 20 mm thick ferrocement skin layers.

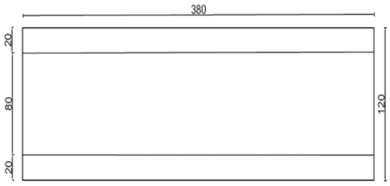

Fig :3 Dimensions of wall panel

The inner core of the concrete is made up of foam concrete. According to ACI, foam concrete is a mixture of cement, water and foam. Foaming agents were introduced to the production process to create a stable foam. Foam is obtained by mixing foaming agent and water. These foam are added to the mortar to make it foam concrete.
The bottom skin concrete layer is first laid, levelled, and maintained uniform skin thickness. The weld mesh is placed over the bottom skin concrete. The foam concrete is prepared in parallel using the driller machine with paint mixer attachment. Foam concrete is poured uniformly over the bottom skin layer. The setting time of foam concrete is 24 hrs. So the prepared panel is kept untouched for a day. After the hardening of foam concrete, top ferrocement layer is cast.

Ferrocement bottom layer **Pouring of foam concrete**

Top ferrocement layer

Fig :4 Casting of lightweight sandwich wall panel

TESTING OF WALL PANELS

After the curing of wall panel, the panel was cleaned, whitewashed and grid lines are marked at 5 cm interval. Then the panel is placed in the loading frame of capacity 1000 kN. Linear variable Displacement Transformer (LVDT) is placed on both faces of the panel at a distance of L/2 and L/3 distances. The total of 6 LVDT (3 at each faces) is placed at the testing specimen to calculate deflection. The load is measured using load cell. The load is applied in increasing steps and the corresponding response of panel is observed. The load and the deflection at different locations were observed using the data logger and the failure pattern is observed

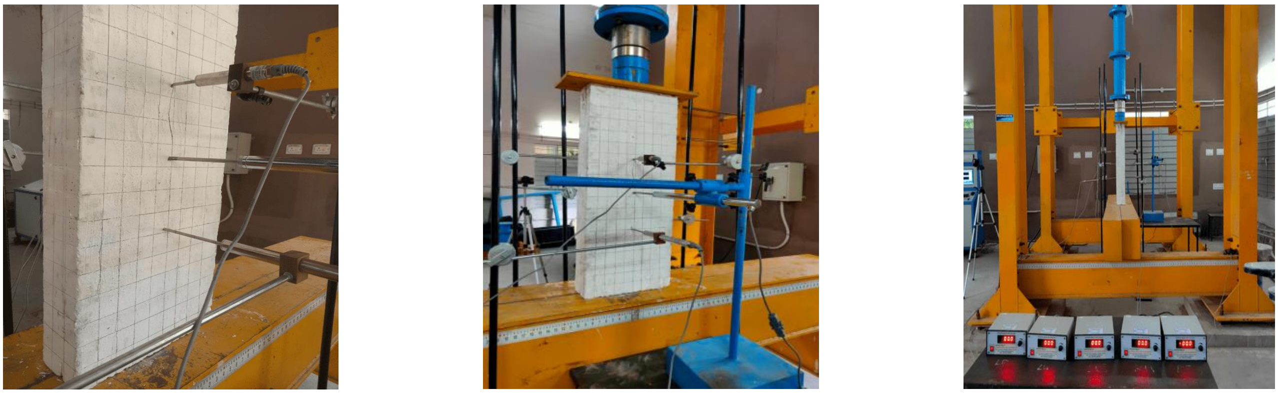

Fig :5 Testing arrangement for wall panel

WALL PANEL TEST RESULTS AND ITS DISCUSSION

The first load drops at 225 kN. The load is further increased, and the panel carries the load steadily. When the wall panel reaches its lower yielding point, the cracks were found to be formed at the edge of the wall panel. Further, when the load is increased, the wall panel reaches its upper yielding point and then moves towards its ultimate load - bearing capacity, at which the increment of these load leads to the enlargement of cracks in the wall panel, and then it is found that the cracks on the vertical side surface are extended and the separation between the outer skins and infill layer occurs. The ultimate load and its corresponding deflection are 437 kN and 2.4 mm respectively. The compressive strength of wall panel is found to be 10.37 N/mm^2. Finally, the wall panel reaches its breaking point where the load starts to drop and observed the crushing and spalling of foam concrete (inner core) from the wall panel.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 07 | July - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

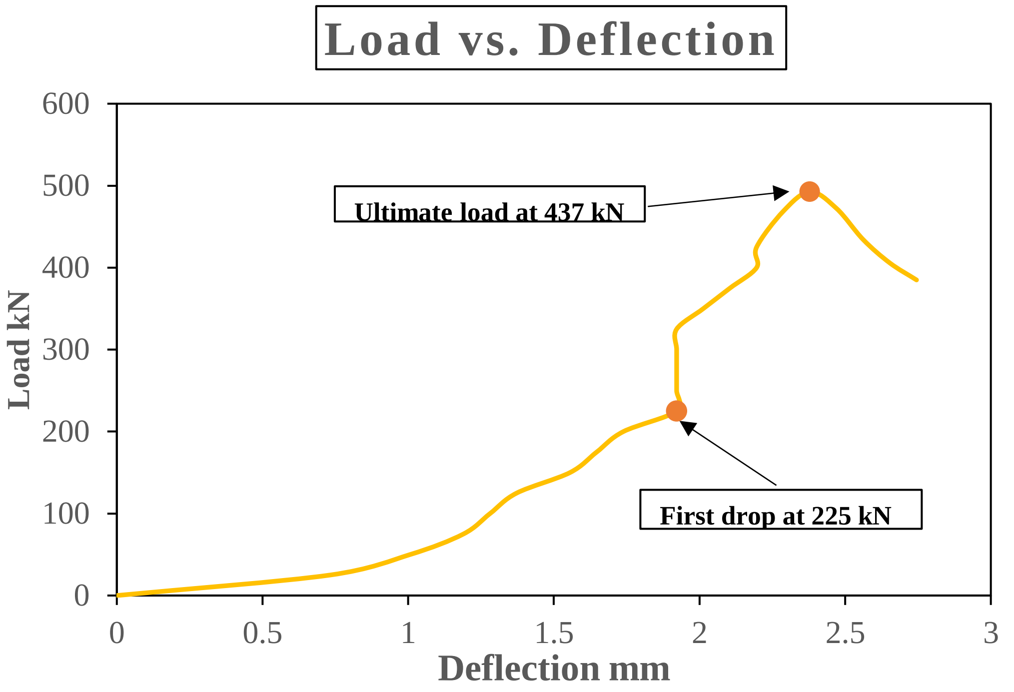

Fig :6 Load vs deflection graph

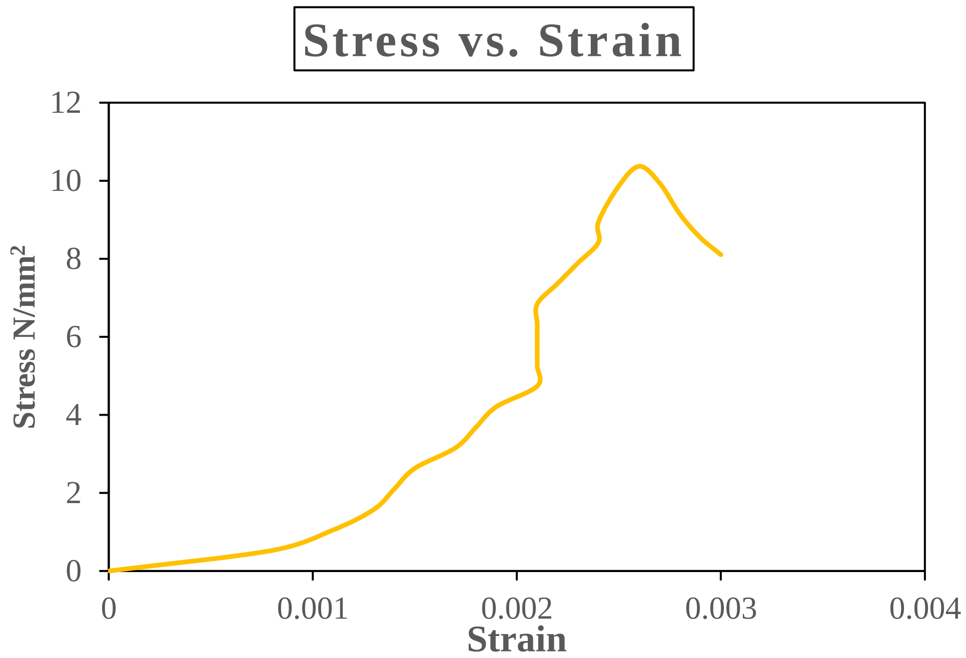

Fig :7 Stress vs Strain graph

Fig :8 Failure pattern of wall panel

CONCLUSIONS

- The density of the foam concrete used in this project is found to be 1185 kg/m³.
- Soya - based foaming agent was cheaper than commercial vegetable protein foaming agents. This foaming agent is used to achieve higher foaming capacity compared to the commercial foaming agent.
- The wall panel behavior was studied under axial load condition; it was observed that the wall panel with lightweight foam concrete infill performed well.
- The ultimate load and its corresponding deflection value are 437 kN and 2.4 mm. The ultimate compressive strength of the panel is found to be about 10.37 N/mm² and the compressive strength at first cracking is 4.45 N/mm². The result confirms the suitability of lightweight concrete infilled panels for the load bearing and non-load bearing walls.
- The failure of the panel is observed due to the crushing of inner core material. This failure is prevented by providing vertical meshes at particular intervals or by providing mesh in the inner core foam layer.

REFERENCES

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.

7. Chunyi Xu, Moncef L. Nehdi, Kaile Wang, Yuyuan Guo, 'Experimental study on Seismic behavior of novel AAC prefabricated panel walls',Journal of building Engineering, Vol 44, 2021.

8. K.G.Vinothan, Dr.G.Baskar, "Effect and Experimental Studies of Lightweight Wall Panels Compared with Normal Wall Panels", International journal of civil engineering research and development.

9. Md Kamrul Hassan, Karanraj Singh, Rohit Kumar, "Experimental Study on Prefabricated Lightweight Composite Wall Panels under Flexural Loading", Journal of Civil Engineering and Construction 2020.

10. K.N.Lakshmikandhan, B.S.Harshavardhan, J.Prabakar, S.Saibabu, "Investigation On Wall Panel Sandwiched with Lightweight Concrete", IOP conference, series: Materials Science and Engineering.

11. S. Grija, P. Sivakumar, K. N. Lakshmikandhan,R. Ravichandran, B. Karthikeyan, "Novel Ferrocement Light Weight Wall Panels", International Journal of Applied Engineering Research.

12. M Kozlovská, D Mokrenko, Z Struková and M Špak, "The potential of lightweight panel systems in building industry", IOP Conference Series: Materials Science and Engineering.