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Experimental Evaluation of thermal Insulated Light Weight Precast Wall Panels

R. Rajeshwaran[1], D. Ajith kumar[2], S. Paramesh[3], V. Arun[4]
Assistant Professor[1], Student[2, 3, 4]
Department of Civil Engineering
Vel Tech, Chennai, TamilNadu, India

Abstract:
There is a huge growing requirement of building materials in India due to the existing housing shortage of 46.3 million units, mainly for the low-income groups in urban India. Estimated urban housing shortage in 2015 was 56.43 million, while the housing shortage of rural India in 2015 was 62 million units. Thus, total estimated housing shortage for Urban & rural India in 2015 was 128.43 million units. To fulfill this basic need of urban habitat; India requires innovative, energy efficient building materials for strong and durable housing in fast track method of construction at affordable cost. All these concerns have lead to develop an energy efficient and economical material. Lightweight pre-fabricated Sandwich wall Panel which provides rapid or faster construction and contributes to environmental protection, can provide a solution to many of the above issues and concerns. The development and construction of lightweight pre-fabricated sandwich structural elements in building construction is a growing trend in construction industry all over the world due to its high strength-to-weight ratio, reduced weight, and good thermal insulation characteristics. Sandwich construction element consists of thin face sheets or encasement of high performance material and a thick, lightweight and low strength material as core. Masonry walls are the major component in the housing sector and it has brittle characteristics and exhibit poor performance against the uncertain loads. Further, the structure requires heavier sections for carrying the dead weight of masonry walls. The present investigations are carried out to develop a simple, lightweight and cost effective technology for replacing the existing wall systems. The lightweight concrete is developed for the construction of sandwich wall panel. High density polystyrene (HDP) is used as inner core material. An experimental analysis of wall panel is done and results are observed.

Key words: sandwich wall panel, High density polystyrene, pre-fabricated sandwich structure.

1. INTRODUCTION

1.1 GENERAL

The conventional concrete is strong but high in self weight. This factor effects the ease of construction which will lengthen the construction period. More construction workers are needed to accelerate the progress of the construction workDue to increase of workers, the cost will also increase. The traditional labor-intensive practices which includes the three problems; namely, dirty, difficult and dangerous have always been associated with the construction industry. The construction industry suffers from low productivity, safety and quality control due to this syndrome. Therefore, the use of precast lightweight concrete to substitute the conventional concrete has become vital because of its advantages and environmental friendly. Precast light weight concrete sandwich panel is an alternative solution to the conventional construction method due to its ease of construction. Air-conditioning system plays a significant role in providing users a thermally comfortable indoor environment, which is a necessity in modern buildings. To save the vast energy consumed by air-conditioning system, the building envelopes in envelope load dominated buildings should be well designed such that the unwanted heat gain and loss with environment can be minimized. The construction sector consumes vast amount of natural resources and produces significant quantity of construction and demolition waste (CDW). A proper CDW use leads to efficient and effective use of natural resources and helps mitigate the environmental impacts to the Planet. The Waste Framework Directive requires Member States to take necessary measures to achieve a minimum target of 70% (by weight) of recycling CDW by 2020. The fact that in most European countries disappointingly small percentage of CDW is being reused, illustrates the possibility of expanding a construction market in Europe by reusing CDW for new ‘’green’’ materials. Concrete, as one of the most used construction materials, can be used to produce energy and resource efficient products. Thus, the wall panel can reduce the demolition waste and can be reused.

1.2 SANDWICH PANEL

Precast concrete sandwich panel mainly consists of two layers of high strength skins or Wythe and are separated by a lower strength core layer. The wythes are relatively thin while the core is relatively thick but lighter in weight. The common materials used for wythes are steel, aluminum, wood, fiber reinforced plastic or concrete while the materials used for the cores are balsa wood, rubber, solid plastic material or polyethylene, rigid foam material (polyurethane, polystyrene, phenolic foam), or from honeycombs of metal or paper.

1.3 BENEFITS OF PRECAST WALL PANELS

a. Reduce the load on the super structure by reducing their cross-sectional area. (i.e. by using light weight precast wall panels)
b. reduce power consumption by using insulating material.
c. increase speed of construction andcost effective
d. Reduces demolition waste
e. Easy handling and replacement
f. Eco friendly

2. MATERIALS USED AND TEST RESULTS

Ordinary Portland Cement (OPC) of grade 53, Locally available river sand and coarse aggregate, Tap water, High density poly styrene (1.04 g/cm^3).

2.1CEMENT

PHYSICAL PROPERTIES OF CEMENT:

1. Specific gravity – 3.09
2. Consistency – 27.5%
3. Initial setting time – 37 min
4. Final setting time – 562 min
5. Fineness – 2.75

2.2 FINE AGGREGATE

PHYSICAL PROPERTIES OF FINE AGGREGATE:

1. Specific gravity – 2.55
2. Fineness modulus – 2.71
3. Grading zone – I

2.3 COARSE AGGREGATE

PHYSICAL PROPERTIES OF FINE AGGREGATE:

1. Specific gravity – 2.69
2. Fineness modulus – 6.65
3. Water absorption – 0.69

3. MIX PROPORTION

The concrete is designed for M_{30} grade as per IS 10262: 2009

a. Cement = 450 kg/m^3
b. Water = 220.48 kg/m^3
c. Fine aggregate = 889.04 kg/m^3
d. Coarse aggregate = 767.36 kg/m^3
e. Water-cement ratio = 0.45

MIX RATIO = 1: 1.97: 1.70

4. INITIAL ASSEMBLY AND SPECIMEN DETAILS

Initially the steel plates are cut and welded for required specimen size. Then the polystyrene is cut for the required length and thickness. The reinforcement bars are prepared as per requirements. Polystyrene is bind between the reinforcements and placed inside the wall panel during casting.
Mould size = 750 mm x 750 mm x 100 mm
WALL 1 = 6 mm diameter with 300 mm spacing (specimen 1 and specimen 2)
WALL 2 = 6 mm diameter with 150 mm spacing (specimen 1 and specimen 2)
Insulation material = 700 mm x 700 mm x 40 mm

Reinforcement bar details:

Dimensions: 6 mm diameter, 700 mm length, 10 mm fillet,
a. 12 bars for 300 mm spacing
b. 20 bars for 150 mm spacing

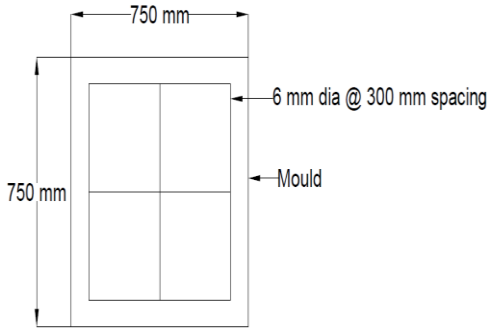


Figure.1. Wall 1 detailing

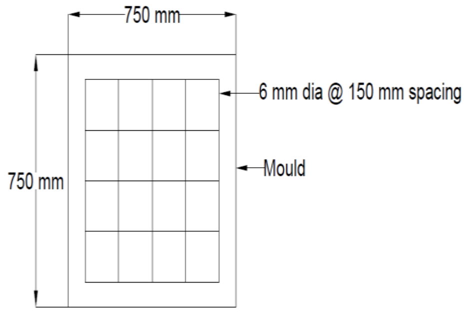


Figure.2. Wall 2 detailing

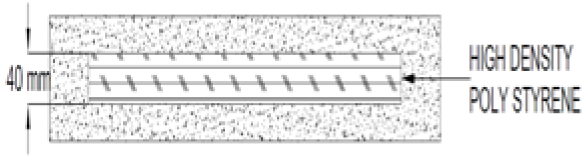


Figure.3. Cross section of wall panel

Figure.4. polystyrene tied between reinforcement bars

Figure.5. concrete pouring

5. EXPERIMENTAL TEST SETUP

The wall panels are tested in the Universal Testing Machine (UTM). The wall is placed vertically over two steel plates for proper load distribution. The load is applied gradually at the rate of 25 kN/m^3. Then the dial gauge is place on the vertical wall surface to find the deflection or buckling details of the wall.

Figure.1. Load setup

Figure.2. load patterns

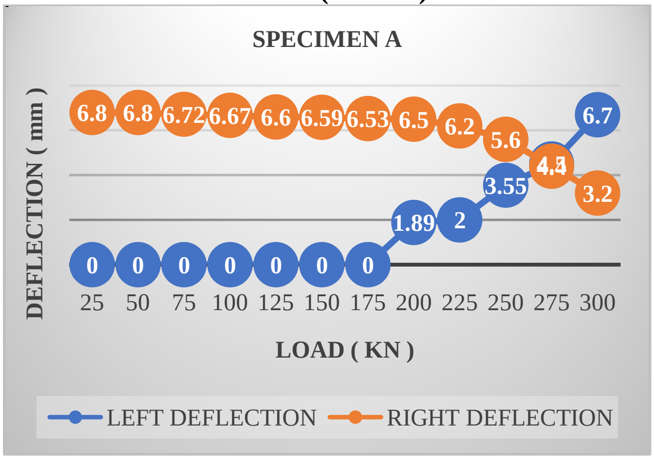
6. LOAD AND BUCKLING DETAILS

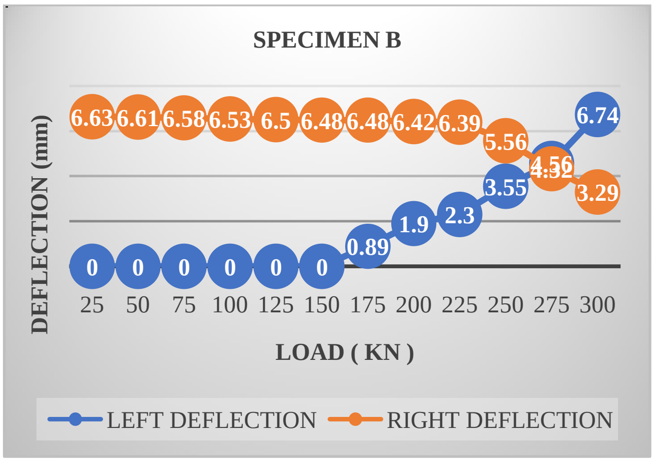
6.1 LOAD

Table 1

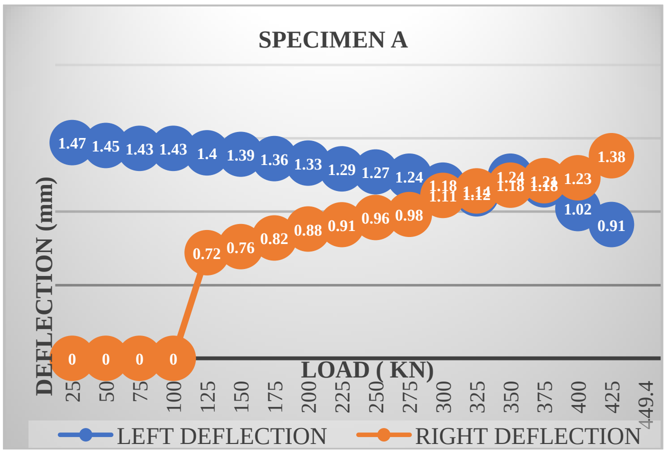
WALL		LOAD (KN)	AVERAGE LOAD (KN)
WALL 1	SPECIMEN A	312	317
	SPECIMEN B	322	
WALL 2	SPECIMEN A	445	449
	SPECIMEN B	453	

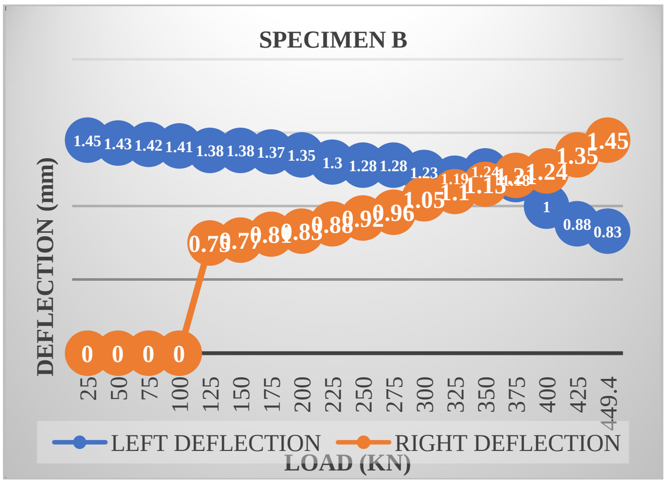
6.2 BUCKLING DETAILS (300 mm)





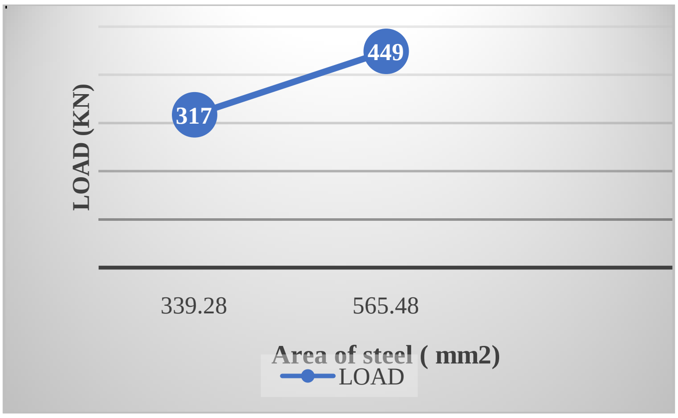
6.3 BUCKLING DETAILS (150mm)





7. DESIGN FOR REINFORCEMENT

For the future design of this wall panel, the required reinforcement is obtained from the graph plotted between ultimate load and area of reinforcement.



From the graph, we formulated an equation

$$P = 0.58A_{st} + 120.2$$

P – Load (KN)

A_{st} - Area of steel (mm^2)

a. Maximum reinforcement provided = 4% of cross sectional area

b. Depends on grade and height of wall, thickness is determined

8. WEIGHT AND COST ANALYSIS

SELF WEIGHT (KN/m3)	
WALL PANEL	0.916
BRICK WALL	1.125
CONCRETE WALL	1.40
COST (RS)	
WALL PANEL	3375
BRICK WALL	4500
CONCRETE WALL	6000

9. RESULT

- For 300 mm spacing (minimum spacing), the ultimate load is 317 kN
- For 150 mm spacing, the ultimate load is 449 kN
- Self-weight obtained is 0.916 KN/m^3
- Buckling length for 300 mm spacing is 6.8 mm
- Buckling length for 150 mm is spacing is 1.45 mm

10. CONCLUSION

- Thus, the self-weight of the wall panel is reduced, so that the cross section of structural elements is reduced.
- Less cost required for construction.
- Thus, we can design the wall panel for required load, so that we can reduce the minimum requirements required for shear wall.
- Hence, we get a satisfactory result, we can also study by varying the insulation material thickness by keeping reinforcement as constant.

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