Experimental Study on Lightweight Polystyrene Sandwich Blocks for Replacement of Bricks

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Abstract – **An Experimental study was conducted to investigate the compressive strength of lightweight polystyrene sandwich blocks since the weight of common building bricks is more or less same weight of concrete blocks. Eight specimen blocks of size 400mm X 200mm X 100mm were prepared using combination of cement, sand, wire mesh and thermocol with and without different shear connectors. They are Single mesh thermocol (SM),Single mesh thermocol with M pin (SMM), Single mesh thermocol with V pin (SMV), Single mesh thermocol with U pin (SMU), Three web mesh (individually and collectively enclosed with wire mesh) (WM), Three web mesh with M pin (WMM), Three web mesh with V pin (WMV) and Three web mesh with U pin (WMU) and subjected to compressive strength after 28 days of curing**

The test results are compared with each other and found that the lightweight polystyrene sandwich concrete blocks offered higher compressive strength of 4.12 MPa at 28 days. The density is found 1200 kg/m^3. Hence there is a reduction of dead load, faster building rates in construction and lower haulage and handling costs.

Keywords –**Lightweight Polystyrene, Sandwich Blocks, Replacement for bricks, Thermocol as a core**

I.INTRODUCTION

In Devotions upon emergent Occasions, the seventeenth century English metaphysical poet John Donne wrote "No man is an Island, entire of itself". Through this statement, Donne asserted that we all share a common humanity. In today's increasingly complex and interrelated world, not only is no man an island but, similarly, no building stands alone. Every building exists within an environmental context upon which it not only acts but which also has an impact upon the building. Due to today's increased complexity and inter-relatedness, no building can be considered as microcosm. The people in charge of every building project must consider the impact it will have on the environment into which it will be placed locally and globally.

Sustainability is a social concept in that it considers the need of the unborn. It is an environmental concept in that it addresses the effect of pollution and resource management. The term sustainability, once rare to find in dictionary, has in last few years begun to appear with more regularity. The term green has also become part of our working vocabulary. Simply stated, a green building is one that is located and constructed in sustainable manner and that is designed to allow its occupants to live, work in a sustainable manner.

Lightweight pre-fabricated sandwich structural elements in building construction is a growing trend in construction all over the world due to its high strength-to-weight ratio, reduced weight and good thermal insulation characteristics. Sandwich construction element consists of encasement of high performance material and a thick lightweight and low strength material as core. Ferro cement is regarded as highly versatile thin material possessing superior properties.

Sandwich composite structure possesses excellent flexural and shear properties. Their inherent lightweight characteristics make them ideal structural components where weight reduction is desirable. Thus structural sandwich blocks are becoming important elements in modern lightweight construction. In concrete construction, self-weight of structure it represents a very large proportion of the total load on the structures thus, reduction in the self-weight of the structures by adopting an appropriate approach results in the reduction of element cross-section, size of foundation and supporting elements there by reduced overall cost of the project.

The lightweight structural elements can be applied for construction of the buildings on soils with lower load-bearing capacity. Reduced self-weight of the structures using lightweight concrete reduces the risk of earthquake damages to the structures because the earth quake forces that will influence the civil engineering structures and buildings are proportional to the mass of the structures and building. Thus reducing the mass of the structure or building is of utmost importance to reduce their risk due to earthquake acceleration. Among the other advantages, its good thermal insulation due to the cellular thick core makes it an ideal external construction component. Some recent investigations suggest their excellent energy-absorbing characteristics under high-velocity impact loading conditions.

It been regarded as highly versatile construction material possessing unique properties of strength and serviceability. Its advantageous properties such as strength, toughness, water tightness, lightness, durability, fire

resistance, and environmental stability cannot be matched by any other thin construction material.

As an alternative construction material, Ferro cement has not gained widespread acceptance in both developed countries in general and developing countries in particular. Its acceptance is hindered mainly due to its small thickness and labor intensive method of production. In order to cope with the problem of thickness, one of the options currently suggested is to develop Ferro cement sandwich elements. This technique provides not only the thickness but makes the sandwich element lightweight and good heat insulating. Sandwich block is a three-layer element comprising of two thin, flat facing plates of relatively higher strength material and between which a thick core of relatively lower strength and density is encased or it could consist of thin skin box of relatively higher strength material in-filled with relatively weaker and lower density material known as core. These have been used in the aerospace industry for many years and more recently they are being used as load bearing members in naval structures. Presently, it has gained attention to be used as an effective structural form in the building and construction industries.

Aerated concrete refers to concrete having excessive amounts of air voids. These air bubbles are created to reduce the density of the concrete and to make it lightweight, which provides good thermo-acoustic insulation too. However, aerated concrete, which is a porous material and classified as cellular construction material exhibits low compressive strength and high rate of water absorption. It can be used as a potential material for core in sandwich composite because of its relatively more compressive strength compared to the traditional lightweight core materials like foam. Attention has not been paid in order to investigate its suitability as core material. Most recently, its application as core material in FRP-AAC sandwich block has been reported so far. However, the literature is silent about its application as core in cement-based sandwich composite structural blocks.

Green building material can be classified in different ways. One of the ways is to classify them according to their use in the building. Depending on their functional use in the building, they can be classified as follows:

- Structural/ Partition Materials
- Ventilation/ Thermal Insulation Materials
- Finishing Materials/ Paints
- Materials for Furniture.
- Miscellaneous Materials.

II. REVIEW OF THE LITERATURE

T. Chandra Sekhar Rao et al., [2012] have an experimental study on the strength and behavioral aspects of cored Ferro cement box-beams for precast purposes. As these beams are lighter in weight, they find their place in seismic resistant design of structures.SalihuddinRadinSumadi et al., [2008] have developed two mathematical models to predict compressive strength of high workability slag-cement based mortars and the ultimate load of Ferro cement encased aerated concrete sandwich wall elements. The values predicted from the mathematical models were 95%-100% accurate to the experimental results.Ade S. Wahyuni et al., [2012] have an investigation of new lightweight sandwich reinforced concrete (LSRC) section using prefabricated autoclaved aerated concrete (AAC) blocks as infill in the section where concrete is considered ineffective under bending. T. Chandra Sekhar Rao et al., [2012] have an experimental study on the strength and behavioral aspects of cored Ferro cement box-beams for precast purposes. Have proposed an empirical formula based on the layers of wire mesh for the ultimate moment capacity of box-beam.Jalal A. Saeed et al., [1997]have experimentally studying on the behavior and flexural strength of Ferro cement one way slabs with square openings under two point loads taking into consideration number of wire mesh layers and size of the openings as variables.

III. METHODOLOGY

Ferro cement is a construction material composed of reinforced concrete and various layers of steel wire mesh, either electro-welded or hexagonal, distributed uniformly around Thermocol. Normally a mortar rich of cement, sand and water is used. This material is thin (10–35 mm thick) and with high resistance and flexibility besides of being a low cost material. Ferro cement constructions present weight reduction compared to traditional building materials.

Eight specimen blocks prepared and tested in this study and the Compressive strength measured and compared to different types of shear connectors given below

Sl.No.	Specimen Details	Specimen Index
1	Single Core with Single Mesh	SM
2	Single Core Single Mesh With “M” Pin	SMM
3	Single Core Single Mesh With “V” Pin	SMV
4	Single Core Single MeshWith “U” Pin	SMU
5	Three Core with Single Mesh	WM
6	Three Core Single meshWith “M” Pin	WMM
7	Three Core Single mesh With “V” Pin	WMV
8	Three Core Single mesh With “U” Pin	WMU

Specimen details

Steps in methodology

1. Allocation of raw materials like cement (IS 1489 Part (I):1991), Sand,Mesh (0.77 kg/m^2), Water proofing admixture (As per IS: 2645-1975) and Thermocol measuring as per requirements.
2. Cover 12mm.
3. Preparation of mortar is done with water cement ration of 0.45
4. The mould of size 400 x 200x 100 mm is made.
5. Thermocol is arranged for each type.
6. Casting of Blocks were done and kept for 1 day mould
7. Curing of blocks in water is done after removing from mould
8. Checking compressive strength for particular 28th day.

Formulation of mix design

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of required strength, quantity, durability and workability as economically as possible, is termed as concrete mix design. Since there are no standards for mix proportioning of foam concrete, this project is carried out with the formulation of the design procedure.

In normal concrete, water content in kg/m3 is used, which indirectly gives the values of cement content through use of graph. This method is not suitable for foam concrete, because such graphs do not exist for foam concrete. So a rational proportioning method based on solid volume calculation is adopted to determine the cement content.

Mix proportion of mortar for encasement (Ferro cement)

Binder: Cement	1:2
PPC	100% of total binder by weight
Sand	Passing through sieve size 1.18
Water cement ratio	0.45
Waterproofing admixture	0.4

Amount of encasement material used in each block

S.NO	Material	Quantities in Kg/m^3	Proportion
1	Cement	350	1
2	Fine aggregate	700	2
3	Water-cement ratio	143.2	0.45

Manufacturing details

a) Preparing the reinforced wire meshes with the required block dimensions.
b) Preparing the steel mesh reinforcement for web
c) Arrange the rib shear connectors and attaching or fixing with the one side wire meshes.
d) The designed concrete is poured in the mold for the first layer. Placing the Thermocol or filler blocks material in place and above the first concrete layer.
e) The designed concrete is poured in the mold to full fill the mold and make the concrete cover with the required thickness.

IV. RESULTS AND DISCUSSION

Compressive strength of Polystyrene Sandwich blocks with various types of connectors with is determined on the 28th day in the compressive strength testing machine of each sample. There were two samples for each test and the results would be taken as the average of these two.

Compressive strength of sandwich blocks

S.NO	Details	Load(KN)	Compressive strength of concrete N/mm^2 28 days
1	Single Core with Single Mesh(SM)	225	5.625
2	Single Core Single Mesh With “M” Pin(SMM)	267	6.675
3	Single Core Single Mesh With “V” Pin(SMV)	250	6.250
4	Single Core Single Mesh With “U” Pin(SMU)	255	6.375
5	Three Core with Single Mesh(WM)	290	7.250
6	Three Core Single mesh With “M” Pin(WMM)	340	8.500
7	Three Core Single mesh With “V” Pin(WMV)	300	7.500
8	Three Core Single mesh With “U” Pin(WMU)	310	7.750

Discussions

- The sandwich blocks are weight less and can used in construction as partition wall

- The Single Core Single Mesh with "M" Pinis 1.19 times more compressive strength than Single Core with Single Mesh (SM).
- The Single Core Single Mesh with "V" Pin (SMV)is 1.11 times more compressive strength than Single Core with Single Mesh (SM).
- The Single Core Single Mesh with "U" Pin (SMU)is 1.13 times more compressive strength than Single Core with Single Mesh (SM).
- Three Core with Single Mesh (WM)is 1.29 times more compressive strength than Single Core with Single Mesh (SM).
- Three Core Single Meshwith "M" Pin (WMM)is 1.51 times more compressive strength than Single Core with Single Mesh (SM).
- Three Core Single Meshwith "V" Pin (WMV)is 1.33 times more compressive strength than Single Core with Single Mesh (SM).
- Three Core Single Meshwith "U" Pin (WMU)is 1.38 times more compressive strengththan Single Core with Single Mesh (SM).

V. CONCLUSION

- In order to make use of these building materials more efficiently and make people aware of its benefits, an organized technique is required to promote them. It is very important that people are aware of the benefits of using the substitutes for construction materials.
- According to various experts related to the real estate sector, the best environment friendly construction can be acquired through the usage of manufactured sand from stone quarries and brick substitutes. This will also avoid over-exploitation of natural resources like river sand and clay.
- Sandwich Blocks these days are being used in incredible projects taken up by business tycoons and real estate builders. It is also necessary that the government should start promoting these environment friendly construction substitutes to boost market acceptance.
- The government authorities have put a stop to the mining of sand due to environmental concerns but the manual operations in the sand mining have increased its prices. The sand prices have increased since the last few months and so are the brick prices due to climatic changes. Owing to all these reasons it is better that the usage of the Sandwich should be adopted.

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REFERENCE

[1]. Carmichael, J (1986). Pumice Concrete Blocks. Concrete International. 8(11): 31–32.
[2]. Ergul, Y., Cengiz, D.A., Aleaettin, K. and Hassan, G. (2003). Strength and Properties ofLightweight Concrete Made with Basaltic Pumice and Fly Ash. Materials Letters.57 (15): 2267-2270.
[3]. Bottcher, M. and Lange, J. (2006). Sandwich Blocks with Openings. CompositeConstruction in Steel and Concrete, 186(14):137-46.
[4]. Villanueva, GR and Cantwell, W.J. (2004). The High Velocity Impact Response ofComposite and FML-Reinforced Sandwich Structures. Composite Science andTechnology 64(1): 35-54.
[5]. Naaman, AE. (2000). Ferrocement and Laminated Cementitious Composites. AnnArbor, Michigan, USA: Techno Press.
[6]. Abang, A.A.A. (1995). Application of Ferro cement as a Low Cost ConstructionMaterial in Malaysia. Journal of Ferrocement. 25(2):123-128.
[7]. SalihuddinRadinSumadi, MahyuddinRamli [2008] "Development of Lightweight Ferro cement Sandwich Blocks for Modular Housing and Industrialized Building System". Research Vote No: 73311 University Technology Malaysia.
[8]. Ade S. Wahyuni, VanissornVimonsatit and Hamid Nikraz [2012] "Shear Behavior of Lightweight Sandwich Reinforced Concrete Slabs ". Advances in Structural Engineering: An International Journal. 15 (10): pp.1705-1715.
[9]. T.Chandrasekhar Rao, T.D.Gunneswara Rao and N.V.Ramana Rao [2008]" An Experimental Study on Ferro Cement Channel Units under Flexural Loading". International Journal of Mechanics and Solids ISSN 0973-1881 Volume 3 Number 2 (2008) pp. 195–203.
[10]. Jalal A. Saeed, Payman H. Mohammad and lbrahim H. Aziz [1997] "Behavior and Flexural Strength of Ferro cement One Way Slabs with Square Openings". Journal of ZankoySulaimoni, No.1, Vol.1.