

Structural Behavior of Ferro cement Composite Wall Panels

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ABSTRACT: In this project the natural resources are replaced by industrial waste for sustainable construction and for economic reasons. The industrial waste are difficult to dispose and the disposal of these materials are costly. Hence, these industrial wastes were used in the construction material for construction purpose. This project reports on experimental investigation of wall panels and slab panels constructed by Ferro-cement techniques using industrial waste like copper slag, fly ash and gypsum. Where fly ash, phosphogypsum and sludge were used as cement replacement. Copper slag and vermiculite was used as sand replacement materials. A trial mix of cement mortar using this fly ash, phosphogypsum, sludge and copper slag were made. Wall and slab panel were cast by using the optimized mixtures. Ferro cement construction is adopted that proved to yield superior properties in terms of cracks control, impact resistance and toughness largely due to the closely spaced and uniform dispersion of reinforcement within the material. G.I mesh and chicken mesh are used. The wall panel is of size 600X600X100 mm in the 100mm thickness the middle 60mm layer is filled with cement vermiculite layer to make it light weight and to obtain insulating properties. Vermiculite concretes are light weight, have good insulating properties and are intrinsically fire resistant.

KEYWORDS: Ferro cement Concrete, Fly Ash, Wall panels, compression strength, Flexural strength.

I. INTRODUCTION

Many countries are observing a rapid growth in the construction industry, which involves the use of natural resources for the development of the infrastructure. This growth, thereby reduces the natural resources. There is a decrease in the natural resources at the same time there is an increase in the industrial wastes. For the sustainable development of the construction industry, we can use this industrial waste. Aggregate are the main constituents of the concrete as they occupy more than 70% by volume of the concrete medium. Consequently, it makes us to explore other sources of high quality and inexpensive aggregates for the production building material. The surge in waste materials and by-products production leads to the problem in disposal of these materials. Thus, we can replace the costly and scarce natural resources with the innovative, cost effective and environmental friendly alternate building materials.

Ferro-cement is a construction material that proved to yield superior properties in terms of cracks control, impact resistance and toughness largely due to the closely spacing and uniform dispersion of reinforcement within the material. Recently, Ferro-cement has increased attention as a building material in developing countries, especially for roofing of housing construction. Unskilled laborers were required for performing this technique. Ferro-cement is an attractive construction method in areas where labor cost is high. When the Ferro-cement method is used in house construction in developing countries, it can provide better resistance to fire, earthquake, and corrosion than the traditional method. The advantages of well-built Ferro-cement construction are the low weight, low maintenance costs and long lifetime. Ferro-cement is an environmental friendly and possess excellent unique properties such as tensile strength, fire resistance to cracking, etc.

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site and transporting complete assemblies to the construction site where the structure to be located. Prefabrication now a day's gain a great importance in the construction of a building as they relatively reduce the time of construction. With the advancement of prefabrication technique, we can go for slender size, structural member, which thereby decreases the quantity of materials required, reducing the construction time and increase the quality because

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they are factory made. Fly ash and copper slag are the materials, which has a promising future as the building material in the construction industry. Fly ash generated during the combustion of coal for energy production, is an industrial by-product, which is an environmental pollutant. Fly ash has the properties similar to the cement, and hence used as a replacement for cement. Copper slag is a by-product obtained during the smelting and refining of copper. Copper slag possesses mechanical and chemical characteristics that qualify the materials as a partial replacement of aggregate. As cement replacement, Phosphogypsum was used which was collected from fertilizer chemical company. The sludge was procured from acetylene chemical factory. The sludge was used as a partial replacement for cement.

The industrial waste are difficult to dispose and the disposal of these materials are costly. Hence, these industrial wastes were used in the construction material for construction purpose. This project reports on structural behavior of Ferro cement wall panels with different types of connection. Structural behavior of wall panels constructed by Ferro-cement techniques using industrial waste like copper slag, fly ash and gypsum. Where fly ash, phosphogypsum and sludge were used as cement replacement and copper slag was used as sand replacement materials. A trial mix of cement mortar with fly ash, phosphogypsum, sludge and copper slag are to be studied. Wall panels are to be cast by using the optimized mixtures and appropriate connections were provided.

II. OBJECTIVE OF THE PROJECT

The objectives of this project are as follows,

1. Collection of literatures related to Ferrocement wall panels and Ferro cement composite wall panels.
2. Identification of sources for industrial wastes suitable for construction.
3. Collection of different types of mixtures, mix proportions and their mechanical and durability related properties for mixes, which contains industrial wastes.
4. Collection of joint details and joint material all ready used for applications.
5. Finalization of wall panels dimensions to be used.

III. LIGHT WEIGHT PANEL

Light weight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as stability and lessened the dead weight. The choice of light weight concrete for the structure has two distinct advantages in terms of temperature effects. First, light weight concrete has lower conductivity of heat and therefore takes longer to reach any steady state of temperature.

VERMICULITE

A group of platy minerals, hydrous silicates of aluminum, magnesium and iron that expand markedly on being heated; used in the expanded state for heat insulation. The exfoliated vermiculite shall be produced by the application of heat to the natural ore at a temperature range of 870°C to 1000°C. It shall not contain any extraneous material.

Properties of Vermiculite:

- i) Heat Conductivity
- ii) Animal Feedstuffs
- iii) Fire Protection
- iv) Friction Linings
- v) Durability
- vi) Electrical Resistance
- Vii) Fire Proof
- viii) Odorless

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IV. EXPERIMENTAL RESULTS

TESTING OF MATERIALS

The selection of the materials have been done based on basic preliminary tests that are conducted and compared to the criteria as stated in their respective codes. The tests that have been performed on the materials and their results are listed below under their respective material chapters. The test procedures are as follows.

MIXTURE PREPARATION

The various mixture designs were prepared to optimize the required mixture proportion. The mixture consists of cement (C), Fly ash (FA), phosphogypsum (PG), sand (S) and copper slag (CS). The cement mortar was taken in the ratio of 1:2. The mixtures were mixed thoroughly to get uniform color and consistency. The workability of mixtures was checked by using the slump cone test. The same procedure was carried out for all the types of mixtures as shown in Table 5.1. A test specimen of size 100X100X100mm cubes (total 9 No's) in each mixture were cast to carry out a compression test at the ages of 7, 14 and 28 days. Three identical specimens were tested in each age for all the types of mixtures.

MIXTURE PROPORTION	W/C RATIO	MIXTURE ID
1:2 (1 Part cement + 2 Part sand)	0.4	A
1:2 (1 Part cement + 2 Part copper slag)	0.4	B
1:2 (1 Part cement + 2 Part vermiculite)	0.8	C

Table 1 – Mix proportion

COMPRESSION LOAD TEST ON TRIAL MIXTURES

Compression test was carried out on 100mm cube specimens in a 1000KN capacity UTM. All the specimen were tested in saturated surface dry condition before conducting compression test all specimens were undergone the ultrasonic pulse velocity test. Table 5.2 gives the load and average compressive strength and Table 5.5 gives UPV values of all the trial mixtures tested at the age of 7, 14, 28 days and density at the age of 28 day

Specimen	No. of days	Load (KN)	Compressive Strength (N/mm ²)	Average Compressive Strength (N/mm ²)
Cement-copper slag	7 th day	376	37.6	34.9
		376	37.6	
		296	29.6	
	14 th day	370	37.0	35.8
		378	37.8	
		328	32.8	
	28 th day	392	39.2	36.6
		357	35.7	
		351	35.1	

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PREPARATION OF SLABS

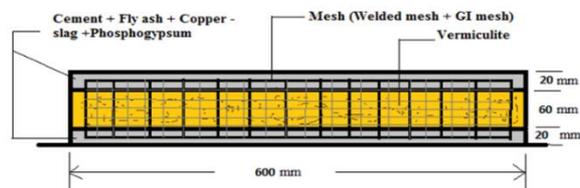
Two different meshes of grid size 60mmX60mm and galvanized meshes of size 12mmX12mm are tied together using binding wires in a box shaped structure, which act as reinforcement. The size of the slab is 600X300X20mm. The size of reinforcement prepared was 560X260 and this kept above 5mm after the concreting is done till 5mm so that the mesh layer is kept and compacted and the top layer can be filled correctly. Two slabs are casted i.e. one slab with cement mortar slab and another one is cement copper slag slab. Care was taken to flow mortar at the sides to form a single box unit. The top surface was smoothly finished. After 24 hours the wooden mould was released and the panels of size 600X300X20mm were cured using gunny bags for 28days.

PANEL PREPARATION

Two different meshes of grid size 60mmX60mm and galvanized meshes of size 12mmX12mm are tied together using binding wires in a box shaped structure, which act as a reinforcement. The panel was bent at the edges to the dimension 560X560X70mm. The cement vermiculite mixture is kept in between the top and bottom layers. The cement mortar was poured up to 20mm in the wooden mould. This mortar was well compacted before placing the meshes reinforcement inside the mould. After placement of the bottom layer in the mould, the cement vermiculite mixture was placed over the bottom layer and top layer reinforcement was kept over the cement vermiculite mixture and the bottom layer mesh and top layer mesh were tied together. Then the mortar mixture was poured on the top and compacted manually. Care was taken to flow mortar at the sides to form a single box unit. The top surface was smoothly finished. After 24 hours the wooden mould was released and the panels of size 600X600X100mm were cured using gunny bags for 28days.



Sectional view of the panel



placing the mesh in position

TESTING OF SLABS AND PANELS

After 28 days of curing, slabs were surface dried and were whitewashed. Marking were drawn to the centre of panels along length and breadth directions and a span of 800mm are marked. Pellets were pasted to the slabs for gauge length of 200mm along the compression zone and tension zone of the thickness of the slabs. Spirit level were used to check the leveling of the slabs. The slabs were tested for centre point bending load in loading frame of 400KN capacity. Rollers were provided at the centre of the panel in full width for loading and at the supports. LVDT and demec gauge are used to measure central deflection and the strain in the panel. Load was applied in the control manner using the load cell of capacity 400KN. Strain values are taken in the compression zone and tension zone of panels at different load intervals. Load was applied till the slab fails.

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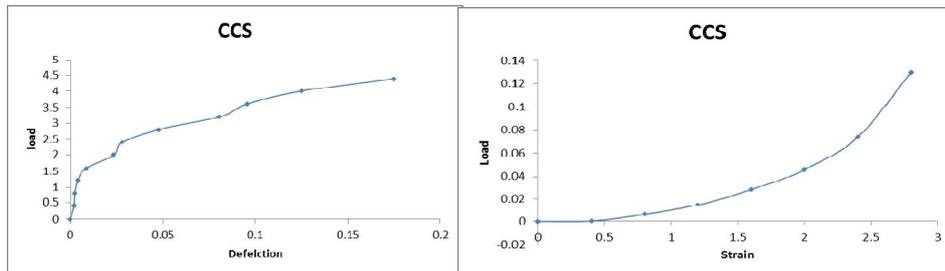
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Load (KN)	Deflection	Demec gauge reading
0	0	0.620
0.4	0	0.694
0.8	0.57	1.834
1.2	1.46	3.49
1.6	2.04	6.22
2.0	2.789	9.76
2.4	4.03	15.37
2.8	4.48	26.56

Tabulation for Flexural test on test specimen with cement-copper slag



Load Vs Deflection for Cement- Mortar Load Vs Strain for Cement – copper slag

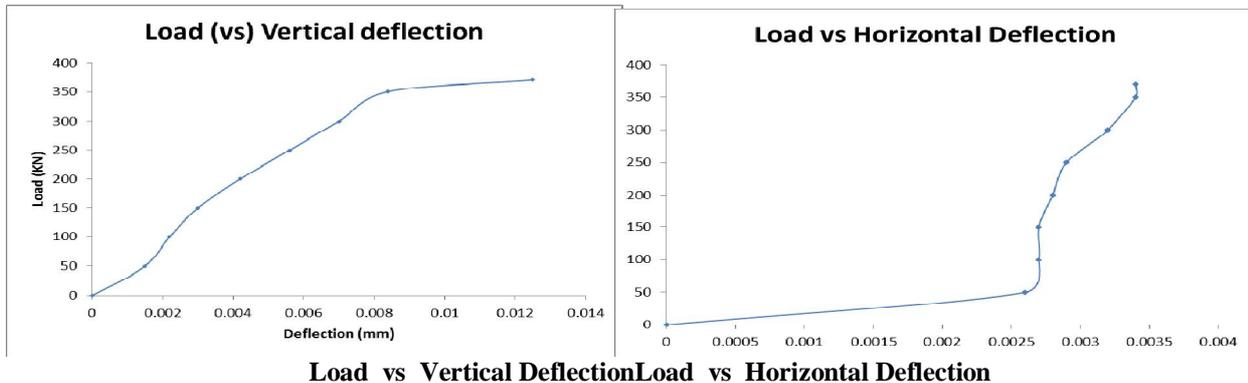
COMPRESSIVE STRENGTH TEST ON PANEL



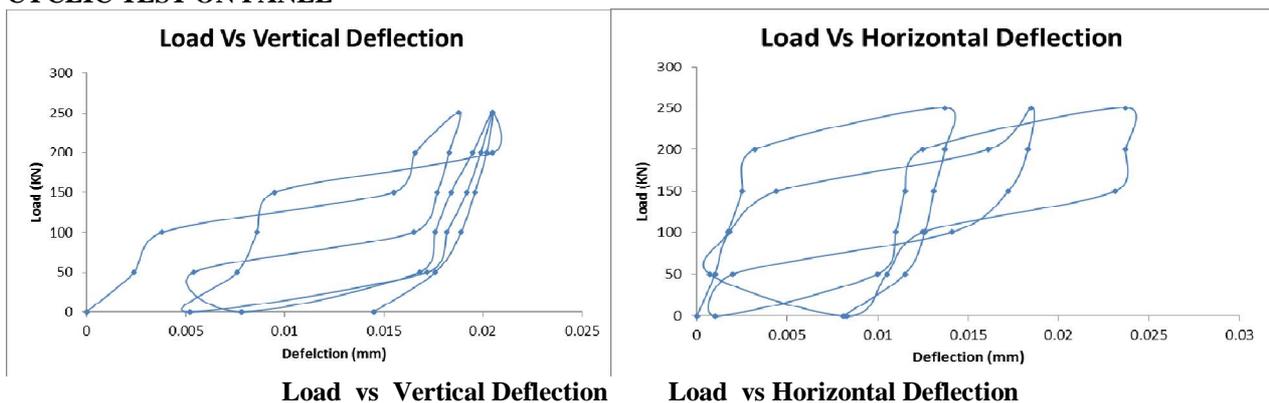
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CYCLIC TEST ON PANEL



V. CONCLUSION

1. Phosphogypsum and sludge can be used as partial replacement for cement.
2. Specific gravity is higher for copper slag compared with the sand. Water absorption of copper slag is less compared to sand. Hence, the water requirement for mixing is less than the conventional cement mortar.
3. Density of copper slag is higher than the density of sand. As the content of copper slag increases density of cement mortar increases.
4. There was an almost 8.1% reduction in water demand at 100% copper slag replacement in comparison with the control mixture with 100% sand at the same workability.
5. By maintaining same workability 100% replacement of sand by copper slag can be made.
6. This overall results demonstrate good performance for the ferrocement panels which can be true construction merits in both developed and developing countries. Therefore, further research work can make it much better.

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