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DEVELOPMENT OF LIGHTWEIGHT FERROCEMENT SANDWICH PANELS FOR MODULAR HOUSING

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Abstract:
The development and construction of lightweight 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. The study was conducted in two phases. First phase involved the development of high workability and high performance slag-cement based mortar mixto cast proposed ferrocement encasement. The developed mortar was aimed to replace the traditional manual method of plastering the wire mesh by a mechanized casting method. The performance of mortar was investigated in terms of compressive strength, strength development, unit weight, effect of curing regime, and partial replacement of cement by weight with 10%, 15% and 20% of slag.

Keywords: Lightweight, Pre-fabricated, aerated concrete sandwich ferrocement

I. Introduction

II. Sandwich panel is a three-layer element comprising of two thin, flat facing plates of relatively higher strength material and between which a thick core of relativelylower strength and density is encased or it could consists 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 (Mahfuzet al., 2004). Presently, it has gained attention to be used as an effective structural formin the building and construction industries.The development of new construction materials and technology can partly relieve pressures on the existing building material supply and help to arrest the spiraling rise in cost of these materials and also may reduce insitu construction activities.

Objectives :

1. To investigate the minimum flow value (flow table) of cement mortar capable to be poured during the casting of thin ferrocement encasemen.
2. To establish the optimum high workability and high performance mortar with slag and fly Ash.
3. To investigate the behaviour of ferrocement encased lightweight aerated concrete wall elements of relatively large size particularly in compression with additional flexural and ultrasonic pulse velocity (UPV) tests.
4. Compressive strength of high workability slag cement based mortar for ferrocement.

Ultimate load of ferrocement encased aerated concrete sandwich wall elements in compression.

III. Literature

The world is witnessing a revolution in construction practices along with a newphase of development fuelled by the rapid economic growth and the high rate of urbanization. Construction provides the direct means for the development, expansion, improvement and maintenance of urban settlements. The construction industry must keep up with the advanced technology and systems to cope with the modern trends and demands. The growing need for affordable housesis a much discussed subject because due to spiraling construction cost, housing today isnot an affordable proposition for the common people even on the international scene.

Ferrocement

➢ Introduction

"Ferrocement is a type of thin wall reinforced concrete commonly constructedof hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small diameter wire mesh, the mesh may be made of metallic or other suitablematerials".

➢ Constituents of Ferrocement

Ferrocement is defined as being made of cement-based mortar mix and steel wire mesh reinforcement. However, a broader definition of ferrocement includes the use of skeletal steel in addition to the mesh system.

➢ Mortar Mix

The hydraulic cement mortar mix consists of Portland cement(53 grade), slag sand, water and various admixtures (fly ash) as per the 10%, 15%, 20%. The materials should satisfy standards similar to those used for quality reinforced concrete construction, withparticular attention paid to the type of application proposed that the actual mix design should be optimized, whenever possible, with respect to the available local materials and environmental conditions.

➢ Wire Mesh Reinforcement

Steel wire meshes are considered the primary mesh reinforcement. This includethe various typesof the shape; square woven or welded meshes, chicken (hexagonal/aviary) wire mesh, expanded metal mesh lath etc. Except for expanded metal mesh, generally all the meshes are used galvanized. depicts the typical steel wire meshes used in ferrocement applications

RESEARCH METHODOLOGY

Flow Tests: Flow table test in accordance to ASTM C230-03 (2003) was applied in order to determine themortar flow. The flow is defined as the resulting increase in the base diameter of a mortar mass

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expressed as a percentage of the original base diameter after being vibrated on a flow table. First of all the constituents were mixed thoroughly to achieve uniform mix. The mix is filled in the standard mould on the flow table in 2 layers compacted in each layer with 20 numbers of blows with a 25mm diameter mild steel bar. The tamping pressure was just sufficient to ensure uniform filling of the mould.

Compression: Compressive strength is the major test done during this study. Three types of specimens were tested under compression; cubes, blocks and wall elements. The cubes and block specimens were tested using HEICO compressive testing machine of capacity 2000 KN installed in the structures and materials laboratory. The tests were conducted as per the specifications of ASTM C109-02 (2002) and EN 679 (1993) at the prescribed age of the testing. The specimens were withdrawn from the specific curing regime just 15 minutes before the testing and cleaned properly with dry cloth to remove foreign particles if any.

Flexural (Bending) : The bending strength is of value in estimating the load under which cracking

will develop. Flexural strength specimens were in the form prisms 100 x 100 x 500 mm in dimensions, to asses the modulus of rupture. A symmetrical, two point loading (third point / middle third loading) in accordance to ASTM C78- 02 (2002), which produces a constant bending moment between the load points, was used until to failure. Three LVDTs; one at centre and two at load points, were installed at the bottom of the prisms to study the load-deflection behaviour. The load was applied in uniform increments of about 400N/s until failure.

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EXPERIMENTAL RESULTS

(7 DAY COMPRESSIVE TEST READING)

BLOCK NUMBER	PERCENTAGE (%) (Fly Ash added)	LOAD (In KN)
1	0	470
2	0	450
3	0	350
4	10	430
5	10	420
6	10	400
7	15	510
8	15	520
9	15	470
10	20	470
11	20	470
12	20	420

EXPERIMENTAL RESULTS

(28 DAY COMPRESSIVE TEST READING)

BLOCK NUMBER	PERCENTAGE (%) (Fly Ash added)	LOAD (In KN)
1	0	490
2	0	550
3	0	550
4	10	420
5	10	520
6	10	450
7	15	660
8	15	650
9	15	680
10	20	650
11	20	650
12	20	630

EXPERIMENTAL RESULTS
(7 DAY FLEXURAL TEST READING)

BLOCK NUMBER	PERCENTAGE (%) (Fly Ash added)	LOAD (In KN)
1	0	7
2	0	6
3	10	5
4	10	5.5
5	15	3
6	15	2
7	20	5
8	20	5

EXPERIMENTAL RESULTS
(28 DAY FLEXURAL TEST READING)

BLOCK NUMBER	PERCENTAGE (%) (Fly Ash added)	LOAD (In KN)
1	0	9.5
2	0	9
3	10	6
4	10	5.5
5	15	9
6	15	9.2
7	20	10
8	20	9.5

2.1

Conclusion

A brief account of the conclusions drawn, in the context of original objectives, set for this research study, is summarized as follows: (1) To investigate the minimum flow value (flow table) of cement mortar capable to be poured during the casting of thin ferrocement encasement. • Mortar with flow value of 136±3% is adequate to cast 6mm-12mm thick ferrocement encasement. • Flow value should be inversely adjusted by 3% with 2mm variation in the thickness of ferrocement encasement. • Water-binder ratio required to ensure 36±3% mortar flow is adjustable depending on mix proportion and superplasticizer dosage. (2) To establish the optimum high workability and high performance mortar with slag and FLY ASH • High workability mortar of compressive strength ranging between 27MPa and 57MPa were developed 130 • Mortar mix 1:2 with 50% GGBFS and 0.1%, and 0.2% SP were found to be high performance in terms of compressive strength, strength development, water absorption and ISAT (permeability). • Water curing is the suitable curing regime to achieve high performance of high workability . (3) To investigate the behaviour of ferrocement encased lightweight aerated concrete sandwich wall elements of relatively large size in compression with addition flexural and UPV tests. • Slenderness ratio and aspect ratio affect the load carrying capacity of the wall elements. • Lateral and axial deformations of sandwich specimens particularly with wire mesh remained very small and uniform. • Steel bars contributed to the ultimate load of sandwich in compression when embedded inside the wire mesh within the ferrocement encasement. • Sandwich walls exhibited highly composite behaviour up to 90% of their ultimate load and fist crack loading subjected to compression and bending respectively. High degree of material uniformity attained by the sandwich due to method of pouring adopted to cast ferrocement encasement. • Replacement of the conventional labour intensive manual method of ferrocement elements manufacture with the new mechanized method of the pouring the high workability mortar altogether with the partial replacement of cement with industrial by product FLY ASH leads to the cost effectiveness of the final product of sandwich wall elements.

References

1. Bhatacharyya, P., Tan, K.H. and Mansur, M.A. (2003). Flexural Moment Capacity of Ferrocement Hollow Sandwich Panel System. Journal of Ferrocement. 33(3): 183-189.
2. Bave, G. (1980). Aerated Lightweight Concrete-Current Technology. Proceedings of the Second International symposium on Lightweight Concretes. London.
3. Einea, A., Salmon, D.C., Tadros, M.K and Culp, T. (1995). Partially Composite Sandwich Panel Deflection. ASCE Journal of Structural Engineering. 121(4): 778–83.
4. Fabiana, L.D.O. and De Hanai, J.B. (2002). Experimental Analysis of Concrete Block Masonry Walls with Rectangular Openings Strengthened by Ferrocement Overlays. Journal of Ferrocement. 32(3): 179-191.
5. Hago, A.W., Al-Jabri, K.S., Al-Naumi, A.S., Al-Moqbali, H., and Al-Kubaisy, M.A. (2005). Ultimate and Service Behavior of Ferrocement Roof Slab Panels. Construction and Building Materials. 19(1): 31-37.
6. Hossainan, M.Z. and Inoue (2000). A Comparison of the Mechanical Properties of Ferrocement Elements under Compression for Square and Chicken Meshes. Journal of Ferrocement. 30(4): 319-343.
7. Liang, S. and Chen, H.L. (2006). Investigation on the Square Cell Honeycomb Structures under Axial Loading. Composite Structures. 72 (4): 446–454. Liborio, J.B.L. and Hanai, J.B. (1992). Ferrocement Durability: Some Recommendations for Design and Production, Journal of Ferrocement. 22(3): 265-271.