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Load Deflection Characteristics of High Performance Light Weight Concrete

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Abstract- **High Performance Light Weight Concrete (HPLWC) could be considered as a combination of high performance concrete and structural lightweight concrete. HPLWC was produced by partially replacing cement in concrete with mineral admixtures, partially replacing light weight aggregates with coarse aggregates . The usage of mineral admixtures leads to the saving of cost, energy and resources conservation. In the present work HPLWC was produced by two ways. One was using air entraining agent and the other was using light weight aggregate (expanded clay). In the former case, air entraining agent was added as additive in different percentages and in the later case the coarse aggregate was partially replaced with different percentages of expanded clay as light weight aggregate. In both the mixes, cement was replaced partially with ground granulated blast furnace slag (GGBFS) and Metakaolin (MK) in two different percentages. In total there were eight different combinations of mixes were studied at three different ages of concrete namely 7, 14 and 28 days of concrete.**

The optimum mix is selected from the 7, 14, 28-days age compressive strengths of different mixes. The beams cast for control and obtained optimum mix were tested to determine the Load – Deflection characteristics and peak load, first crack load, crack and failure pattern were observed. The obtained results are compared with the control mix. . From the results obtained the decrement of compressive strength of 13% and 26% for mix containing AEA and LWA respectively. Whereas the constant Load-Deflection characteristics, Peak load in bending and moment curvature has been observed.

I. INTRODUCTION

Concrete is the most used material for construction in India. Many high raised buildings are evolved in recent years which increase the usage of High Performance concrete (HPC). In general the density of HPC is high which increases the dead load of superstructure. The compressive strength of HPC lies in the range 60 to 100 N/mm2. The density of HPC is in the range of 2500-2700kg/m3. The one or more parameters of concrete are supreme then the concrete is said to be HPC. In order to reduce the density of concrete it is suggested to use High Performance Light Wight Concrete (HPLWC). The HPLWC is the concrete with both high performance and light weight concrete.

HIGH PERFORMANCE CONCRETE

The high performance of concrete can be achieved by replacing partially of cement with mineral admixtures like Metakaolin (Mk), Ground Granulated Blast Furnace Slag (GGBS), Fly Ash (FA), etc. By using these mineral admixtures leads to lowering the global warming.

MINERAL ADMIXTURES

These are finely divided siliceous materials which are added to concrete in the range 20 to 60 percent by mass of the total cementitious material. These are the waste by-products from various industries. These are of two types:

Chemically active mineral admixtures like Metakaolin (MK), Sillica fume (SF).

Micro Filler mineral admixtures like GGBS, and FA

II. EXPERIMENTAL PROGRAM

M15 grade concrete cubes were casted using the following proportions by weight.

Material requirement for M15 grade concrete

Cement	Fine Aggregate	Coarse Aggregate	Water
240 kg/m^3	480 kg/m^3	960 kg/m^3	144 kg/m^3

Cement
OPC of 43 grade conforming to IS: 8122-1989 was used for the present experimental investigation

Fine Aggregate
Natural river sand with fraction passing through 4.75 mm sieve and retained on 600µm sieve confirming to gradation zone –III was used as fine aggregate. The fineness modulus of sand used was 2.81 with a specific gravity of 2.65.

Coarse Aggregate
Crushed granite of size ranging 20mm – 10mm was used and specific gravity was found to be 2.74.

Water
Potable tap water available in the laboratory was used for mixing of concrete and curing.

Super plasticizer
Conplast SP430 was used as a high range water reducing agent complies with IS:9103-1999 having a specific gravity of 1.18.

Metakaolin
Metakaolin was obtained from ASTRRA chemicals, Chennai

GGBS
GGBS was obtained from Akbar Ali chemicals, Salem

Expanded Clay
Expanded Clay was acquired from Future Farms, Chennai having a specific gravity of 0.68

III. MIX PROPORTIONING

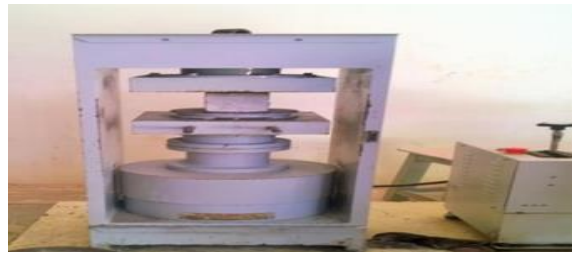
The concrete used is of grade M70 and was designed as per the guidelines of IS 456:2009. The designed mix proportion by weight is 1:1.69:2.03and the water/cement ratio is 0.3. The two different batches of mixes with various proportions of the binder materials like Mk and GGBS were replaced to cement. The AEA is used as weight reducing agent in the set of mixes in table 3.1 specimen of Batch1.

Mix	Cement (%)	Metakaolin (%)	GGBS (%)	AEA added with Respect to cement (%)
A	60	10	30	0.4
B	60	10	30	0.5
C	60	12	28	0.4
D	60	12	28	0.5

Material composition of AEA mixes

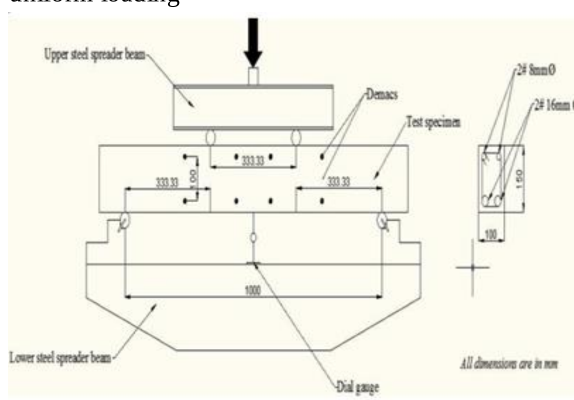
IV. TESTING PROGRAMME

Compressive strength test
The compressive strength test is the most common test conducted because most of the desirable characteristic properties of concrete and the structural design purpose are qualitatively related to compressive strength. The test setup is shown below in Figure



Flexural behaviour test
For finding flexural behaviour, tests were carried on 100 mm x 150 mm x 1200 mm beam prototypes at the age of 28 days using 1000kN capacity flexural strength testing machine. The test setup includes two point loading using a single point loading system by which the loads are transferred equally to the two points using a spreader beam and two rollers. Dial gauges are placed in the bottom of the beam at the mid-point to find the deflection. Demacs are placed on the surface of the beam to find the surface strain which are placed at a distance of 100mm from one another.

The strains at these points are found using a mechanical strain gauge. The crack patterns are noted on both sides of the beams at particular intervals. The gauge length between the loading points are 333.33 mm and 100 mm are left on both sides of the beam at the supports. All the specimens were capped for uniform loading



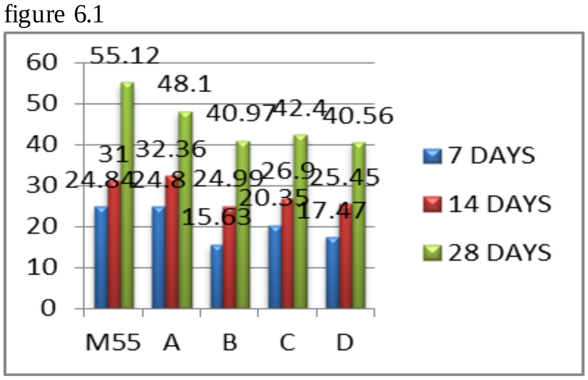
V. OBSERVATIONS AND DISCUSSION OF TEST RESULTS

COMPRESSIVE STRENGTH RESULTS

The cube compressive strength results for various ages with different combinations are presented in Figures6.1 and 6.2.

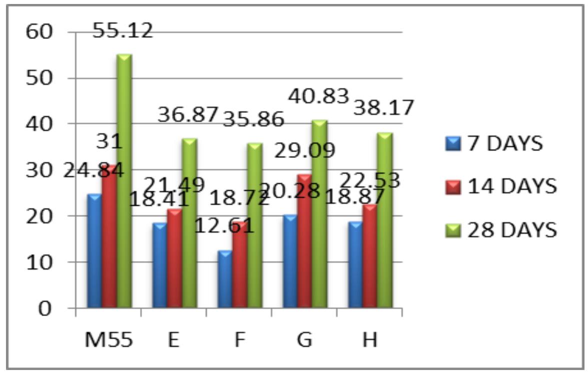
6.3.1 Effect of AEA

The variation of compressive strength due to addition of air entraining agent for different ages of concrete was depicted in Figure 6.1 to understand the effect of age of concrete. Increase in age of concrete increases compressive strength. At the age of 28 days, control concrete yielded 70 MPa. For mixes with 10% MK and 30% GGBFS as replacement for cement with 0.4% AEA gave 61.23 MPa and for concrete with 12% MK and 28% GGBFS with same0.4% AEA was found to be 52.14 MPa. Similar trend was observed for other mixes with increase in AEA of 0.5%. Hence it was understood that increase in AEA beyond 0.4% made further reduction compressive strength of concrete. Around 13% of compressive strength got reduced due to addition of 0.4% AEA, which was very much acceptable if we are going to light weight sections. The rate of reduction of compressive strength increases further for AEA = 0.5 % and increased content of MK from 10 to 12%. The reduction went upto 27% for other cases and hence concrete with 10% MK and 30% GGBFS and AEA with 0.4% was found to be optimum values. In the above case cement was replaced about 40% and hence total cost per unit quantity will be reduced. Effect of AEA on compressive strength is shown in figure 6.1



Effect of Expanded Clay as LWA

The variation of compressive strength due to replacement of coarse aggregate with expanded clay as light weight aggregate for different ages of concrete was depicted in Figure 6.2 to understand the effect of age of concrete. Use of expanded clay as light weight aggregate gave lesser compressive strength at all the ages of concrete irrespective the combination of mix compared to control concrete. Effect of LWA on compressive strength as shown in figure 6.2



VI. CONCLUSION

1. A reduction of compressive strength of 13% only was observed in high performance light weight concrete with air entraining agent with 0.4%. This reduction of 13% was acceptable in the field ensuring the reduction in weight of the concrete. In this mix cement was replaced with MK and GGBFS to an extent of 40%, which will reduce the overall cost of concrete per unit quantity.
2. Higher reduction was observed in compressive strength when light weight aggregate(expanded clay) used as partial substitute to coarse aggregate irrespective of its percentage. Maximum reduction of 35% was observed. Use of 25% of expanded clay as LWA with 12% MK and 28% GGBFS yielded 26% reduction in compressive strength compared to control concrete. Hence when CA to be replaced with LWA, 25% may be permitted.
3. Mix using 4 % AEA by weight of cement have shown an 4.7 % increase in the deflection and mix having 25% LA which replaces CA had 7.6 % decrease in the deflection values when compared with the control specimen.
4. From the results observed, it is found that 25%of Expanded Clay as a replacer for coarse aggregate and usage of 0.4% Air Entraining Agent were to be optimum values to produce High Performance Light Weight Concrete.

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