International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

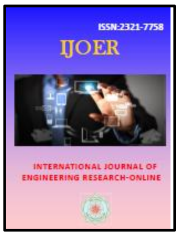
Vol.5., Issue.4, 2017
July-August

RESEARCH ARTICLE

ISSN: 2321-7758

LOAD-DEFLECTION CHARACTERISTICS OF HIGH PERFORMANCE LIGHT WEIGHT CONCRETE

K.JYOTHIPRASAD[1], R.ARUN[2], N.SIVASHANKAR REDDY[3]
[1]M.Tech Structural Engineering & Sir vishveshwaraiah Institute of science technology, AP
[2]Assistant Professor, Dept. of Civil Engineering, sir vishveshwaraiah Institute of science & Technology Technology, AP
[3]Associate Professor, Dept. of Civil Engineering, sir vishveshwaraiah Institute of science& technology Technology,AP



ABSTRACT

High Performance Lightweight Concrete (HPLWC) could be considered as combination of high performance concrete and structural lightweight concrete. HPLC was produced by partially replacing cement in concrete with mineral admixtures and 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 are compressive strengths of different mixes. The beams cast for control and obtained optimum mix werw 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 AER and LWA respectively.

Key Words: HPLWC, HPLC, GGBFS, AER & LWA.

1. 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 - 100MPa.and 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.

International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com
Vol.5., Issue.4, 2017
July-August

1.1. Light Weight Concrete: When lightweight concrete first came into being, usage of lightweight aggregates was the only way to achieve lesser density. The bond between light weight aggregates and the matrix is stronger than in conventional concrete. This is because the cement paste can penetrate inside the aggregates due to their porous nature. Nearly all lightweight aggregates are fire-resistant.

1.2. Cellular Light Weight Concrete: Concrete produced with the addition of an air- entraining agent to the mix is called cellular lightweight concrete. It has also been referred to as lightweight aerated concrete, variable density concrete, foamed concrete or ultra-lightweight concrete. This variable density can go as low as 300 kg/m3. However, concrete with this density would have no structural integrity. The strength is reduced while the thermal insulation and acoustic insulation is increased.

1.3. Objective of Present Work: The primary objective of the study is to obtain the effect of replacement of coarse aggregate with lightweight aggregate and cement with mineral ad- mixtures on compressive strength To study load- deflection characteristics and cracking pattern of admixed concrete beam To compare the results of admixed concrete beam with control specimen.

2. LITERATURE SURVEY

Shannag (2011) [1] investigates the properties of fresh and hardened concretes containing locally available natural lightweight aggregates, and mineral admixtures. Test results indicated that replacing cement in the structural lightweight concrete developed, with 5–15% silica fume on weight basis, caused up to 57% and 14% increase in compressive strength and modulus of elasticity, respectively, compared to mixes without silica fume. But, adding up to 10% fly ash, as partial cement replacement by weight, to the same mixes, caused about 18% decrease in compressive strength, with no change in modulus of elasticity, compared to mixes without fly ash.

Bogasetal(2014) [2] was carried out on the shrinkage behavior of structural expanded clay light weight aggregate concrete (LWC), taking into a account different compositions.

Hubertova et al (2013) [3] describes a development and use of lightweight concrete and lightweight self-compacting concrete using artificial Lightweight aggregates based on expanded clay for ready mix concrete and precast elements.

Huang et al. (2004) [4] made an investigation on the strength and durability properties of light weight concrete. Two light weight aggregate concretes were compared the total light weight aggregate (LWC) concrete and the sand light weight concrete (SLWC).

Huang et al. (2003) [4] carried an experimental work on the effect of aggregate properties like compressive strengths and elastic moduli on the strength and stiffness of lightweight concrete.

3. EXPERIMENTAL PROGRAM

3.1. Fine aggregate cement: OPC of 43 grade conforming to IS: 8122-1989 was used for the present experimental investigation. 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.

Fig -1: Physical apperance of Mk and GGBS

3.2. GGBS: GGBS was obtained from Akbar Ali chemicals, Salem and its physical and chemical properties Expanded Clay was acquired from Future Farms, Chennai having a specific gravity of 0.68.

Fig -2: Appearance of Expanded clay

3.2. MIX PROPORTIONING: The concrete used is of grade M70 and was designed as per the guidelines of ACI 211-1. The designed mix proportion by weight is :1.69:2.03 and 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.

Table -1: Material Composition of AEA mixes

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

Table -2: Material Composition of LWA mixes

Mix	Cement (%)	Metakaolin (%)	GGBS (%)	AEA added with respect to cement
E	60	10	30	25
F	60	10	30	20
G	60	12	28	25
H	60	12	28	20

3.3. SPECIMEN CASTING & CURING: To examine the consequence of addition of MK and GGBS combination (as partial replacement of cement) and additional usage of AEA and partial replacement of CA with LWA, 100mm cubes were cast for reference and additional mixes comprising different mix combinations of MK and GGBS. Chemical admixture is added in all the mixes as it gives better results and good workability. Based on the test results of compressive and tensile strength, 100mm × 150mm × 1200mm size beam specimens were cast for optimum mix proportion obtained for both M70 and M50 grade of concrete.

3.4. 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.3.

Fig -3: Compressive strength test setup

The test was conducted in compression testing machine of 3000kN capacity for different ages of concrete viz.7 and 28 days as per the specifications given in IS 516: 1959 under normal room temperature.

3.5. FDLEXURAL STRENGTH 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.

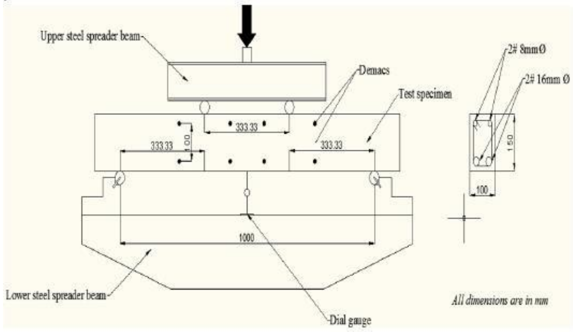


Fig -4: Flexural strength test setup

4. CONCRETE MIX DESIGN

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative quantities with the object of producing as economically as possible concrete minimum properties notable consistent strength and durability. Mix design is done based on the guidelines of ACI 211-1.

4.1. DESIGN STIPULATIONS OF M70 GRADE

Table -3: Specific gravity of Various Materials

SI.	Mater	Specific gravity
1	Cement	3.10
2	Fine aggregate	2.65
3	Coarse Aggregate	2.70
4	Slag	2.80
5	Metakaolin	2.50
6	Expanded clay	0.68

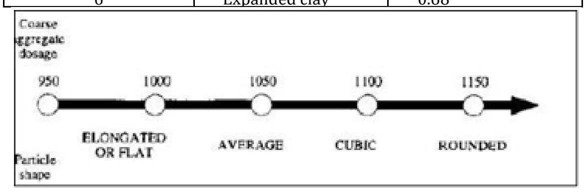


Fig -5: Course Aggregate dosage

5. BEAM DESIGN

Length = 1200mm,Width = 100mm,Depth = 150mm

5.1. BEAM DESIGN DETAILS

Ast required = 346 mm2,Ast provided = 402 mm2

fck = 70 Mpa,fy = 500 Mpa

Ultimate moment = 16.84 kN-m Reinforcement details:

Beam type: Doubly reinforced beam

Longitudinal reinforcement (tension zone) = 2 nos. of 16mm dia.

Longitudinal reinforcement (compression zone) = 2nos. of 8mm dia.

Transverse reinforcement = 8mm dia. @ 125mm spacing at supports and

increasing towards centre.

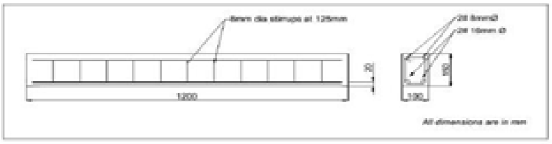


Fig -6: Reinforcement details of M70 grade Beam

6. CONCRETE MIX DESIGN

The chemical composition was obtained by X-Ray Fluorescence test using XRF-analyzer of model Tiger 88 to determine major and trace elements in solids. Table 6.1 shows the main elements (expressed as oxides) present in cement, GGBFS and MK. Cao and Silica (SiO_2) constituted 75 percentages and were the major components in slag, followed by Al_2O_3 and MgO with 12 and 10% respectively.

6.1. FLEXURAL STRENGTH TEST

The mass of the control specimen (without AEA and expanded clay as light weight aggregate) was found to be 2.538 kg and gets reduced due to the addition of AEA. When AEA was added with 0.4% in the concrete with 10% MK and 30% GGBFS was found to be 2.174 kg and about 14% reduction with control concrete. The mass of concrete was about 2.183 kg for AEA with 0.5% addition and was slightly more than the earlier case.

6.2. COMPRESSIVE STRENGTH RESULTS 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 same.

6.3. 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.

6.4. FIRST CRACK LOAD

The first crack load for beams cast with AEA and EC are given in Table 6.3. It can be seen that optimum mix i.e. A and G and control mix beam exhibits similar first crack load.

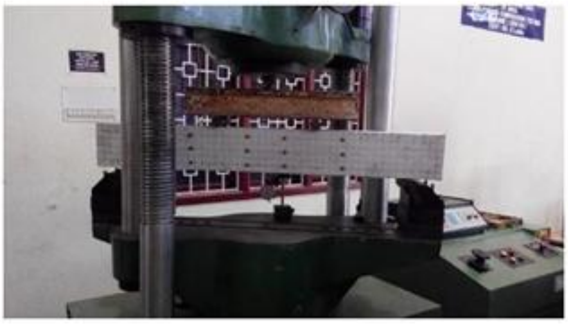


Fig -7: Flexural Load setup

6.5. FIRST CRACK LOAD

Fig -8: Crack pattern for control beam

Fig -9: Crack pattern for optimum

7. CONCLUSION

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

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.

From the results, the beams with control mix and optimal mixes using .4 %AEA by weight of cement and 25% LA replacing CA have shown similar ultimate and first crack loads.

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.

REFERENCES

[1]. AlaettinKilic, Cengiz Duran Atis, ErgulYasar, Fatih Ozcan. 2003. High-strength lightweight concrete made with scoria aggregate containing mineral admixtures. Cement and Concrete Research, 33, 1595–1599.

[2]. American Concrete Institute (ACI). 1991. Standard practice for selecting portions for normal, heavyweight and mass concrete. ACI 211-91, Farmington

[3]. BS 1881. British Standard Testing concrete Part 122. 1983. Method for determination of water absorption, British Standards Institution, 2 Park Street London