Load-Deflection Characteristics of High Performance Light Weight Concrete

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ABSTRACT:

High Performance Lightweight Concrete (HPLWC) could be considered as a 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 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 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. Whereas the constant Load-Deflection characteristics, Peak load in bending and moment curvature has been observe

Keywords: High Performance Light Wight Concrete (HPLWC), High Performance Concrete (HPC), Ground Granulated Impact Heater Slag (GGBS),Fly Ash(FA), LWC.

INTRODUCTION Concrete is the most used material for construction in India. Numerous high brought structures are advanced up lately which is expands the utilization of High

Performance concrete (HPC). When all is said in done the thickness of HPC is high which is builds the dead heap of the superstructure. The compressive quality of HPC lies in the range 60 - 100MPa.and the thickness of HPC is in the scope of 2500-2700kg/m3. The at least one parameters of cement are preeminent then the solid was said to be HPC. With a specific end goal to lessen the thickness of the solid it was proposed to utilize High Performance Light Wight Concrete (HPLWC). The HPLWC is the solid with both superior and light weight concrete.

A. High performance concrete The elite of cement can be accomplished by supplanting incompletely of bond with mineral admixtures like Metakaolin (Mk), Ground Granulated Blast Furnace Slag (GGBS), Fly Ash (FA), and so on utilizing these mineral admixtures prompts to bringing down the a dangerous atmospheric devation.

B. Light Weight Concrete Lightweight cement is in effect progressively utilized as a part of the development of different basic components, for example, parapet dividers, divider boards, brick work squares and floor decks. The sorts of lightweight cement presently utilized as a part of development are:

- Lightweight total solid, where an extent of the coarse or fine total is supplanted by some lightweight total.

- Cellular lightweight solid, where an air entraining admixture is added to the solid to decrease its thickness.

2.LITERATURE REVIEW:

A brief review of literature on influence of mineral admixtures on the fresh and hardened concrete, strength and durability aspects are reported and discussed. The literature review of behaviour of structural member beam is also presented. The selection of available documents that are published on the topic, which contains information, ideas, data and evidence written from a particular standard point to fulfil certain aims or express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research being proposed.

2.1.STUDY ON LIGHT WEIGHT CONCRETE

Shannag (2011) 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. Adding 10% or more of silica fume, and 5% or more fly ash to lightweight concrete mixes perform better, in terms of strength and stiffness, compared to individual mixes prepared using same contents of either silica fume or fly ash. The mixes developed had a compressive strength range of 22.5–43 MPa; an air dry density of 1935–1995 kg/m3 and a high degree of workability. Replacing cement with 5–15% silica fume on weight basis for LWC, caused up to 57% and 14% increase in compressive strength and modulus of elasticity respectively compared to mixes without silica fume.

Bogas et al (2014) was carried out on the shrinkage behaviour of structural expanded clay lightweight aggregate concrete (LWC), taking into account different compositions, types and initial wetting conditions of lightweight aggregat

(LWA). The influence of different compositional parameters on shrinkage, such as the type and volume of aggregate, the w/c ratio, the binder content and the partial replacement of normal aggregates by LWA was analysed. The shrinkage of LWC depends on how the volume of LWA varies. The influence of different pozzolanic materials was also studied, namely, silica fume, nanosilica and fly ash. Depending on the type, content and reactivity of the pozzolanic additions, the shrinkage was higher or lower than that of LWC without admixtures. The initial wetting condition of LWA had little influence on the long-term shrinkage. The LWC with the most porous aggregates is more affected by the cross-section geometry of concrete in that it is more susceptible to differential shrinkage. Current standard expressions did not properly predict the shrinkage behaviour of LWC. Multiplier coefficients of about 1.3 for the most co mmon structural LWA and about 1.6 for more porous LWA are suggested, to take into account the higher long-term shrinkage of LWC.

Hubertova et al (2013) 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. The objective of this research was to evaluate the lightweight concrete on durability of concretes placed in chemically aggressive liquid and gaseous environment like high concentrations of sulphate, chloride ions, automative gas oil and gaseous CO2 and SO2 environments. Using porous aggregates for high strength concrete. Lightweight aggregate is porous and has rather low strength.

Huang et al. (2003) carried an experimental work on the effect of aggregate properties like compressive strengths and elastic moduli on the strength and stiffness of lightweight concrete. Three types of cold-bonded pelletized lightweight aggregates were made of different ratios of cement to fly ash. Three different type of concrete mixtures with various water/binder ratios were designed. The properties of concrete is mainly controlled by the water cement ratio. The compressive strengths and elastic moduli of the concrete are independent on the type of aggregate when the aggregate volume ratio is 18%.

Haque et al. (2004) made an investigation on the strength and durability properties of lightweight concrete. Two lightweight aggregate concretes were compared,i.e. the total lightweight aggregate (LWC) concrete and the sand light weight concrete (SLWC). The curing of specimens were done for 1 day and 7 days and then the specimens were exposed to the worst condition of the climate for two different ages of 28 days and 12 months. The attained strength of the SLWC is similar for the both 1 day and 7 days of curing for age 28days and when compared to the age of 365 days there is increase in strength upto 32%. By replacing the lightweight fine aggregates with normal sand, the concrete which is produced is more durable even the water penetration and the carbonation takes place. The strength of LWC were exhibited the best strength development the concrete for both ages of 28 days and 365 days. The water permeability and the carbonation of SLWC is less when compared to LWC.

Erhan Güneyisi et al. (2012) investigates the effectiveness of metakaolin (MK) and silica fume (SF) on the mechanical properties, shrinkage, and permeability related to durability of high performance concretes. Mechanical properties and permeation characteristics like compressive and splitting tensile strength, water sorptivity and gas permeability tests were carried out to find out the concretes were incorporated with MK and SF. Two series of control mixtures with w/cm ratios of 0.25 (Series 1) and 0.35 (Series 2) were designed. In order to develop the metakaolin and silica fume modified concrete mixtures, the Portland cement was partially replaced with 5% and 15% mineral admixture (by weight) for both series. The compression test was carried out on the cube specimens by means of a 3000 kN capacity testing machine. The SF and MK concretes had consistently higher compressive strength than the control concretes. The 28 day compressive strength of the concrete with w/cm ratios of 0.25 and 0.35 were ranged between 75.4–85.8 MPa and 61.8–73.3 MPa, respectively, without depending on the type of the mineral admixture and replacement level. With the increasing the amounts of MK and SF resulted in sharp decrease of 52% in apparent gas permeability coefficient of concretes for both w/cm ratios. The crack widths of MK concretes were relatively less than that of control concrete and the utilization of SF delayed the crack initiation and propagation.

3.EXPERIMENTAL PROGRAM

Here the details of experimental investigations carried out on the test specimens to study the strength characteristics of concrete using metakaolin and GGBS as partial cement replacement materials in different combinations. .

A.Materials Cement: OPC of 43 grade conforming to IS: 8122-1989 is 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 is 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 is used and specific gravity was found to be 2.74.

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

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

Metakaolin: Metakaolin is obtained from ASTRRA chemicals, Chennai and its physical and chemical properties are shown.

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


Fig1.


Fig2.

3.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 1:1.69:2.03and 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.

Table 3.1 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

Whereas in Batch 2 the Expanded Clay is used as LWA in concrete which were tabulated in table 3.2

Table 3.2 Material composition of LWA mixes

Mix	Cement (%)	Metakaolin (%)	GGBS (%)	LWA replaced with coarse aggregates (%)
E	60	10	30	25
F	60	10	30	20
G	60	12	28	25
H	60	12	28	20

3.1 SPECIMEN CASTING AND 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. Concrete were placed in the well lubricated mould and compacted and the specimens were left at room temperature for 24hrs and after that specimens were placed in curing tank till their testing ages

4.RESULTS:

CHEMICAL COMPOSITION OF MATERIALS

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 4.1 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. All the other components constituted only 3%. In the case of MK, composition dominated by SiO_2 and Al_2O_3 with 94.5% and remaining components was found to be only 5.5%. CaO and MgO were found to be very less in MK.

Table 4.1 Chemical composition of Cement, MK and GGBS

Description	OPC	MK	GGBS
Color	Grey	Off white	Light grey
Specific gravity	3.1	2.7	2.81
CaO (%)	62.8	0.8	40
SiO2 (%)	20.3	53.7	0.2

Al2O3 (%)	5.4	40.8	12
Fe2O3 (%)	3.9	1.6	35
MgO (%)	2.7	0.3	0.1
Na2O (%)	0.14	0.18	10
K2O (%)	0.53	0.11	0.11

DENSITY COMPARISION

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. Similar trend was observed for concrete with 12% MK and 28% GGBFS. The mass of concrete with cement replacement with GGBFS + MK and coarse aggregate replacement with expanded clay ranges from 10 to 12% reduction compared to control concrete. Comparing mass of control concrete with HPLWC, AEA was effective in reducing the mass and give better results in terms of compressive strength of concrete.

CONCLUSIONS

From the experimental results presented in this study, the following conclusions can be drawn:

- 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 ag-gregate (expanded clay) used as partial substitute to coarse aggregate irrespec-tive 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% re-duction 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 ulti-mate 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.

- 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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