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Comparative Study of Lightweight and Normal Weight Concrete in Flexure

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ABSTRACT

This investigation represents a comparative study of the flexural behavior of lightweight and normal weight concrete. Both theoretical and experimental characteristics of the tested specimens were used to study the flexural behavior. Lightweight 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 liability and lessened the dead weight. It is lighter than the conventional concrete. The main specialties of lightweight concrete are its low density and thermal conductivity. Its advantages are that there is a reduction of dead load, faster building rates in construction and lower haulage and handling costs. Lightweight concrete maintains its large voids and not forming laitance layers or cement films when placed on the wall. This research was based on the performance of aerated lightweight concrete. However, sufficient water cement ratio is vital to produce adequate cohesion between cement and water. Insufficient water can cause lack of cohesion between particles, thus loss in strength of concrete. Likewise, too much water can cause cement to run off aggregate to form laitance layers, subsequently weakens in strength. Therefore, this fundamental research report is prepared to show activities and progress of the lightweight concrete. Focused were on the performance of aerated lightweight concrete such as compressive strength tests, water absorption and density and supplementary tests and comparisons made with other types of lightweight concrete.

Key words: Lightweight concrete, normal weight concrete, flexural behavior, compressive strength.

INTRODUCTION

Concrete plays a vital role in building construction and industry. The preeminent properties of strength, durability, workability and the ability of concrete to be formed in various structural shapes make it the material of choice for various uses in the construction industry. It is used more than all other construction materials put together and attractive in many applications, including buildings, roads, concrete bridges, tunnels, tanks, infrastructures and sewerage systems. Nevertheless, the premature deterioration of concrete structures in aggressive environments has led to the development of high-performance concrete. The production of high-performance concrete involves appropriate selection and proportioning of the constituents to produce a composite mainly characterized by its developed strength, low porosity and fine pore structure.

However, practices for manufacturing concrete play a significant role in all aspects of modern environmental life, as they bring about increased atmospheric concentrations of carbon dioxide. Consequently, cement production is responsible for 5% of global ambient carbon dioxide (CO_2) emissions and 7% of industrial energy resources consumption

Cement

OPC of 53 Grade confirming to IS:12269- 1987 was used in the investigation. The specific gravity of cement was 3.10

Coarse Aggregate

Crushed stone metal with a maximum size of 20 mm from a local source having the specific gravity of 2.7 conforming IS383-1970 was used.

Fine Aggregate

Locally available river sand passing through 4.75mm IS sieve conforming to grading zone-II of IS383-1970 was used. The specific gravity of fine aggregate was 2.54.

Metakaolin

Metakaolin is not a by-product. It is obtained by the calcinations of pure or refined Kaolinite clay at a temperature between 6500 C and 8500 C, followed by grinding to achieve a finesse of 700-900 m2 /kg. It is a high quality pozzolonic material, which is blended with cement in order to improve the durability of concrete. When used in concrete it will fill the void space between cement particles resulting in a more impermeable concrete. Metakaolin is a relatively new material in the concrete industry, is effective in increasing strength, reducing sulphate attack and improving airvoid network. Pozzolanic reactions change the microstructure of concrete and chemistry of hydration products by consuming the released calcium hydroxide (CH) and production of additional calcium silicate hydrate (C-S-H), resulting in an increased strength and reduced porosity and therefore improved durability. The formation and properties of Metakaolin are shown in below. The specimen kept immerse in water for 7 and 28 days.

Mix Proportions

All concrete mixes had cement (including metakaolin additive): sand: gravel proportion of 1:1.5:3. The metakaolin replacement for cement was 0, 10, 15, 20, 30 and 40% of the total weight of the cement used for the control mix, respectively. The added polymer to cement ratio was 0, 2.5, 5 and 7.5%, respectively. The two components of the polymer admixture, i.e., SBR and PVA, had proportions of 0, 20, 40, 60, 80, and 100%, of the total polymer to cement percent respectively. Fibre reinforcements were 5% of the total weight of cement used for the splitting and flexural strength tests. Five water/cement ratios, 0.35, 0.38, 0.40, 0.45 and 0.50, and three curing methods (wet curing, dry curing, and moist curing) were investigated.

Table-1 the proportions of the trial mixtures

Mix No.	MK/cement (%)	Polymer / Cement (%)	Water / Cementratios	Fibre / Cement (%)
1	0	0, 2.5, 5, 7.5	0.35, 0.38, 0.40, 0.45, 0.50	0, 5
2	10			
3	15			
4	20			
5	30			
6	40			

EXPERIMENTAL PROGRAM

Casting of Specimens

The test program considered the cast and testing of concrete specimens of cube (150mm) and (150x300mm). The specimen was cast M60 grade concrete using OPC, Natural River sand and crushed stone (20mm 4.75mm) with Metakaolin. Each three numbers of specimens made to take the average value. The Specimens demoulded after 24hrs.The specimens were allowed to the curing periods.

Testing of Specimen

The Compressive Strength, Split Tensile Strength and Flexure Strength of test values were presented in table 3, 4, and 5.

Compressive Strength

For each mix, twenty-four number of cubes of size 150mm were cast (7days and 28days) and tested using Compression Testing Machine (CTM). The specimen placed on the platform of the CTM. The load applied gradually until the failure stage. The ultimate load noted and calculated the compressive strength of corresponding specimen.

Split Tensile Strength

For each mix, twelve numbers of cylinders of size 300x600mm cast and tested in CTM. The specimen placed perpendicular to normal axis on the platform of the CTM. The load applied gradually until the failure stage.

Flexural Strength

For each mix, totally twelve number of prism of size 100x100x500mm cast and tested in Flexural Testing Machine (FTM). The specimen of prism placed horizontally on the platform of the FTM. The ultimate load noted and calculated the flexural strength of corresponding specimen.

RESULTS AND DISCUSSION

The test results of concrete specimen discussed as below:

Compressive Strength

The Compressive Strength compared to control specimen with various percentages of Metakaolin. Compressive Strength results of specimens presented in Table 2. The seven day Compressive Strength varied between 45 and 55MPa. The 28 day strength varied between 61 and 73MPa. The 20% replacement MK mixture exhibited lower strengths comparatively than the other MK percentages. All the concretes including the control achieved their target strength of 60MPa at 28 days and all the concretes achieved strength of more than 70MPa. Fig.1 presents the relation between Compressive Strength and MK percentages at 7 and 28 days. The highest for the MK15 mixtures achieving strength of 72.7MPa at 28days. This clearly shows the replacement level of 15% was the optimum Compressive Strength is concerned.

After 28 days the compressive strength for MK 5% increases in 4.36%, [(64.6/61.9x100)-100] when compared to control specimen. The compressive strength for 10%, 15% and 20% increases in 13.73%, 17.45% and 12.44% respectively. MK 15% increases in higher strength, when compared to all other mixes. But MK 20% decreases in 4.26% from MK 15%. So MK 15% is the best proportion for add in cement.

Table-2 Compressive Strength in MPa

Age of test	Pure OPC			5% Metakaoline			10% Metakaoline			15% Metakaoline			20% Metakaoline		
7 day cube strength	43.9	47.4	44.0	50.2	51.5	50.9	52.9	52.3	50.4	52.8	56.8	54.9	52.1	51.9	50.2
	45.1			50.9			51.9			54.8			51.4		
28 day cube strength	63.1	61.1	61.6	63.5	67.5	62.6	67.5	72.4	71.4	72.8	71.1	74.2	67.2	70.2	71.6
	61.9			64.6			70.4			**72.7**			69.6		
% of Increasing from MK 0%	-			4.36%			13.73%			**17.45%**			12.44%		

Fig. 1 Compression testing

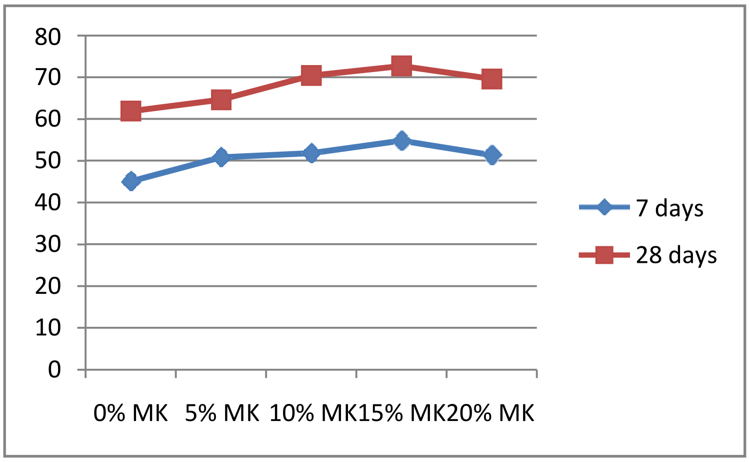

Fig. 2 Variation of Compressive Strength

Split Tensile Strength

From the results Split Tensile Strength also exhibited the highest strength at MK15 mixture. The Split Tensile strength for MK 5% increases in 8.82%, when compared to control specimen. The Split Tensile strength for MK 10%, 15% and 20% increases in 14.70%, 20.56% and 11.76% respectively. MK 15% increases in higher strength, when compared to all other mixes. But MK 20% decreases in 7.31% from MK15%. So MK 15% is the best proportion for add in cement. The split tensile strength and various mix concrete test values are presents in Table 3 and variation of split tensile strength shown in Fig. 4.

Table-3 Split Tensile Strength in Mpa

Age oftest	**0% Metakaoline**			**5% Metakaoline**			**10% Metakaoline**			**15% Metakaoline**			**20% Metakaoline**		
28 day split tensile strength	3.3	3.2	3.6	3.5	3.8	3.7	4.0	3.7	4.0	4.0	4.3	4.2	3.9	3.6	4.0
	3.4			3.7			3.9			4.1			3.8		
% of Increasing from MK0%	-			8.82%			14.7%			20.56%			11.76%		

Fig. 3 Split Tensile Testing

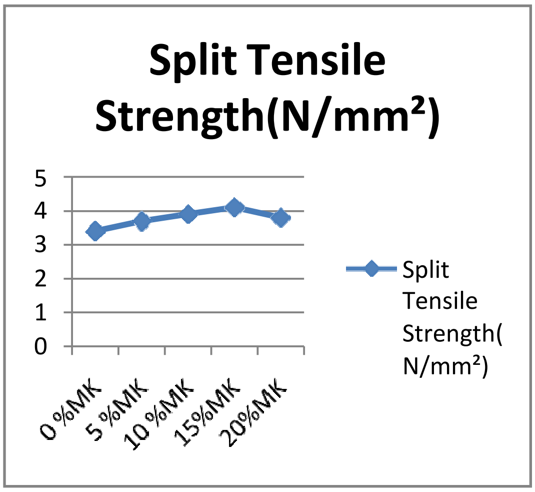

Fig. 4 Variation of Split Tensile Strength

Flexural Strength

The Flexural strength compared to control specimen with various percentages of Metakaolin. When compared to control specimen the Flexural strength for MK5% increases 4.76%. The Flexural strength for MK 10%, 15% and 20% increases 11.11%, 14.28% and 7.94% respectively. MK 15% gave high flexural strength. But 20% of MK decreases in 5.55% from MK15%. So MK 15% is the best proportion for add in cement. The Flexural strength and various mix concrete test values are presents in Table 4 and variation of Flexural strength shown in Fig. 6.

Table-4 Flexural Strength in MPa

Age oftest	Pure OPC			5% Metakaoline			10% Metakaoline			15% Metakaoline			20% Metakaoline		
28 days Flexural Strength	6.4	5.9	6.6	6.5	6.6	6.7	6.8	7.2	7.2	7.0	7.2	7.3	6.7	6.9	6.8
	6.3			6.6			7.0			7.2			6.8		
% of Increasing from MK0%	-			6.6%			11.11%			7.2%			6.8%		

Fig. 5 Flexural Strength testing

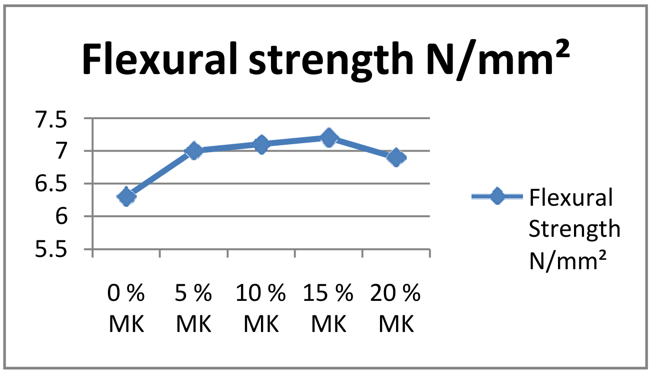

Fig. 6 Variation of Flexural Strength Strength

CONCLUSIONS

From the present investigation on the effect of partial replacement of cement with Metakaolin in concrete, the following conclusions were drawn;

- The strength of all Metakaolin concrete mixes over shoot the strength of OPC.
- 15% cement replacement by Metakaolin is superior to all other mixes.
- The increase in Metakaolin content improves the compressive strength and split tensile strength up to 15% cement replacement.
- The results encourage the use of Metakaolin, as a pozzolanic material for partial replacement in producing high performance concrete.

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