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Utilization and Experimental Investigation on Metakaolin in Concrete as Partial Replacement of Cement

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***Abstract* - Concrete is a basic material for the construction industry. Due to infrastructure development in the developing countries, consumption of concrete is very high. The consumption of cement is also very high to meet the requirements. So, there is a need to look after the supplementary / alternative materials for the cement, fine aggregate, and coarse aggregate. By using the Metakaolin it reduces the cost of cement being one of the most expensive components of concrete production and to also improve sustainability in the construction industry. In these trial examination work concrete cubes, cylinders and beams of M-60 grade were casted and tested to inspect different properties of concrete like workability, compressive strength, flexural strength, and split tensile strength test. Metakaolin was replaced with cement at 0, 5, 10,15 and 20 % by weight of concrete in cement and testing after 7, 21 and 28 days curing.**

***Index Terms* - Cement, Metakaolin, Concrete, Mechanical properties, Durability, compressive strength, flexural, strength and split tensile strength.**

I.INTRODUCTION

Concrete is the most widely used construction material in India with annual consumption exceeding 100 million cubic meters. It is well known that conventional concrete designated on the basis of compressive strength does not meet many functional requirements such as impermeability, resistance to frost, thermal cracking adequately.

Metakaolin

Metakaolin is a pozzolan, probably the most effective pozzolanic material for use in concrete. It is a product that is manufactured for use rather than a by-product and is formed when china clay, the mineral kaolin, is heated to a temperature between 600 and 800ºC. Its quality is controlled during manufacture, resulting in a much less variable material than industrial pozzolans that are by-products. First used in the 1960s for the construction of a number of large dams in Brazil, metakaolin was successfully incorporated into the concrete with the original intention of suppressing any damage due to alkali-silica reaction.

Metakaolin

II.LITERATURE REVIEW

Many works have been carried out to explore the benefits of using various waste materials such as Metakaolin, granite dust, marble dust, stone dust and glass powder in making and enhancing the properties of concrete. This chapter also presents the brief review of literatures refer to Metakaolin concrete in terms of strength and durability aspects.

Terrence Ramlochana et al. Observed from his experiment work that metakaolin is highly effective in controlling the alkali silica reaction, expansion. Approximately 10 to 15% of metakaolin was required to limit the expansion within the range of 0.04% at the end of 2 years, the limit being strongly dependent on the usage of type of aggregates.

G. Batis, et al. have studied that studies in the his experimental work that if metakaolin is added for the purpose of corrosion resistance properties of mortar , there is no significant change in 1 day strength but 2 days and 28 days strength were greatly increased to up to a maximum value.

Jibing Bai and Albinas Gailius explained development of a multivariate statistical model for consistency parameter prediction including slump, compacting factor and vebe time for concrete incorporating FA and MK is described. The models constructed provide an efficient, quantitative, and rapid means for obtaining optimal solutions to consistency prediction for concrete mixes using PC-FA-MK blends as binder.

III. OBJECTIVE

The objectives of the present work are listed below

- To investigate the effect of Metakaolin as a partial replacement of Cement on strength properties of M60 grade of concrete.
- To find the optimum value for replacement of cement by Metakaolin concrete mix.
- To study the durability characteristics of Metakaolin concrete
- To investigate the strength properties of the concrete with Metakaolin

IV. EXPERIMENTAL INVESTIGATIONS

Materials Used

The following are the materials used in the investigation.

Cement (OPC 53 grade)

Metakaolin

Fine Aggregates

Coarse Aggregates

Super plasticizer

Ordinary portl and cement (OPC)

Materials used for the preparation of concrete in the present investigation are shown below. Ordinary Portland Cement (OPC) of 53 grade was used in this research. Cement was purchased from the same source throughout the investigation. While storing cement, care was taken to avoid contact with moisture.

Metakaolin

The raw material in the manufacture of Metakaolin is kaolin clay. Kaolin is a fine, white, clay mineral that has been traditionally used in the manufacture of porcelain. Metakaolin is neither the by-product of an industrial process nor is it entirely natural. It is derived from naturally occurring mineral and is manufactured specially for cementing applications

Metakaolin

River Sand

This sand is obtained from banks or beds of rivers. The river sand consists of fine founded grains probably due to mutual attrition under the action of water current. The colour of river sand is almost white.

Coarse Aggregates

The broken stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. For this slabs and walls, the maximum size of coarse aggregate should be limited to one-third the thickness of the concrete section.

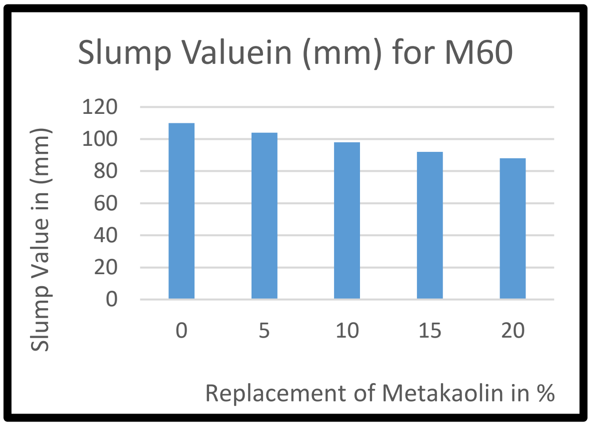
Retained Coarse Aggregate

Super Plasticizer

Super Plasticizers to be added to cement concrete at the time of mixing so as to achieve the desired property in concrete, in the plastic or hardened state. Poly-carboxylate Ether Super plasticizer obtained from Chemcon tech SYS was used. It conforms to IS: 9103 – 1999 and its specific gravity was 1.2.

V. EXPERIMENTAL RESULT & DISCUSSION

Slump Cone Test Results

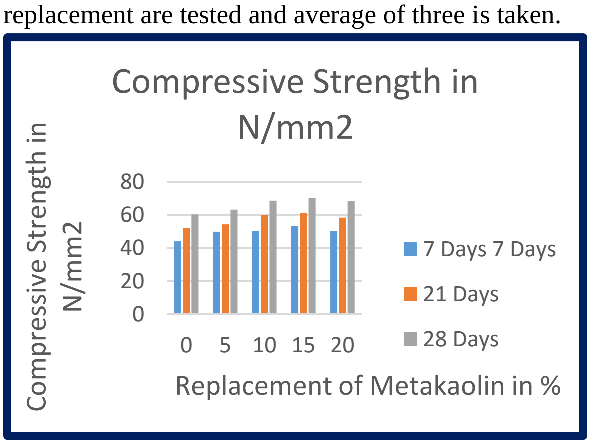


Variation of Slump Value at different percentage of Metakaolin

From the Experimental result it was found that Slump value decreases when increase the percentage of Metakaolin.

Compressive strength test results

The Compressive strength test performed on specimen made during the work containing different percentage of Metakaolin powder after curing period of 7, 21 and 28 days. There are three samples of each percentage replacement are tested and average of three is taken.

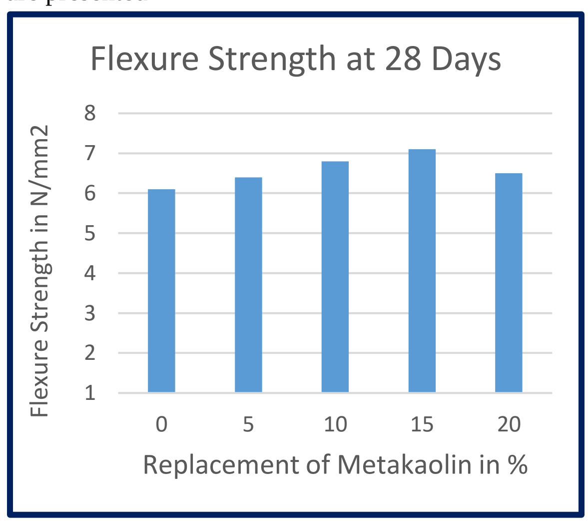


Variation of Compressive Strength at Different percentage of Metakaolin at 7,21 and 28 days

The Compressive Strength compared to control specimen with various percentages of Metakaolin. Compressive Strength results of specimens presented in Table 5.2. The seven-day Compressive Strength varied between 44 and 53.25 N/mm2 and for 21 days it varies from 52.1 to 61.2 N/mm2. The 28-day strength varied between 60.25 and 70.21 N/mm2. The 15% replacement MK mixture have higher strengths comparatively than the other MK percentages. All the concrete s including the control achieved their target strength of 60 N/mm2 at 28 days and all the concretes achieved strength of more than 70MPa. Fig. 5.1 presents the relation between Compressive Strength and MK percentages at 7,21 and 28 days. The highest value of strength achive at MK15 mixtures is 70.21 N/mm2 at 28days. This clearly shows the replacement level of 15% was the optimum Compressive Strength is concerned.

Flexural Strength

The prism specimens were placed in the machine in such a manner that the load was applied to the uppermost surface as cast in the mould, along two lines spaced 13.33cm apart. The axis of the specimen was carefully aligned with the axis of the loading device. The load was applied through two similar steel rollers, 38mm in diameter, mounted at the third points of the supporting span that is spaced at 13.33cm center to centre. The load was applied without shock and increased continuously at a rate of 180 kg/min until the specimen failed. The test results for Flexural strength are presented

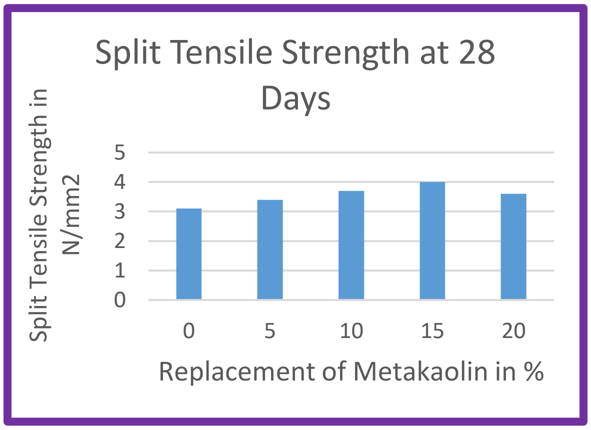


Variation of Flexural Strength at Different percentage of Metakaolin at 28 days

From the test results it can be observed that the Flexural strength of concrete containing Metakaolin powder in proportion of 5%, 10% ,15% and 20% is higher than the control mix .The highest Flexural strength achieved by 15 % replacement level of Metakaolin which was found about 7.1 N/mm² as compared with 6.1 N/mm² for the control mix after 28 days of curing period. At 15 % of MK concrete achieve high strength which is 16.39 % more than the normal concrete.

Split tensile strength

For split tensile strength, the load was applied without shock and increased continuously at a nominal rate within the range 1.2 N/mm2/min to 2.4 N/mm2/min until failure of the specimen. The test results for split tensile strength are presented



Variation of Split Tensile Strength at Different percentage of Metakaolin at 28 days

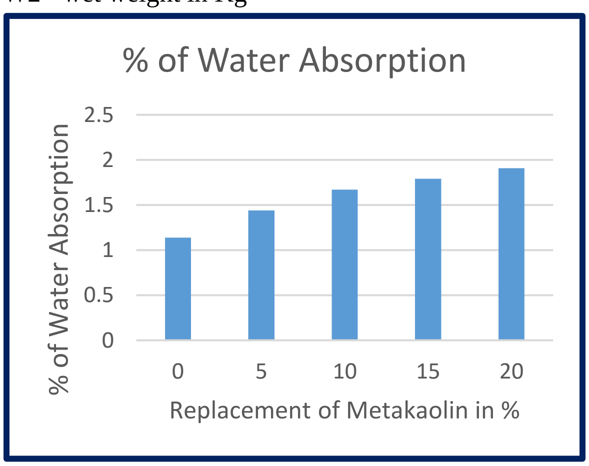
From the test results it can be observed that the Split Tensile strength of concrete containing Metakaolin powder in proportion of 5%, 10% ,15% and 20% is higher than the control mix .The highest Split Tensile strength achieved by 15 % replacement level of Metakaolin which was found about 4 N/mm² as compared with 3.1 N/mm² for the control mix after 28 days of curing period. At 15 % of MK concrete achieve high strength which is 29.03 % more than the normal concrete.

WATER ABSORPTION FOR METAKAOLIN

Formula used is Water absorption = [W2 – W1)/W1] x 100%.

Where W1= dry weight in Kg

W2= wet weight in Kg



Variation of water Absorption at Different percentage of Metakaolin

From the above figure We observe that maximum value of Water absorption of M60 is 1.91 % Table 5.5 shows that the MK content is increased from 0% to 20%, the water absorption increases. But according to IS 15658: 2006 the water absorption for concrete is 3%. The water absorption values of the samples are calculated for different mixing ratios and the effect of the MK content produced on the water absorption is shown in figure .From the test results it can be deduced that the water absorption values for all samples of mixing ratios were lower than 3 % according to IS: 15658-2006 specifications. It was also found that, for specimens without MK, the water absorption values are relatively lower compared to those of specimens.

VI. CONCLUSION

Metakaolin can be recommended as useful replacement to enhance the durability of concrete in aggressive environment consisting of sulphates. Cement replacement upto 15% with metakaolin leads to increase in compressive strength, for M60 grade of concrete. The seven day Compressive Strength varied between 44 and 53.25 N/mm^2 and for 21 days it varies from 52.1 to 61.2 N/mm^2. The 28 day strength varied between 60.25 and 70.21 N/mm^2.

The highest Flexural strength achieved by 15 % replacement level of Metakaolin which was found about 7.1 N/mm² as compared with 6.1 N/mm² for the control mix after 28 days of curing period. The highest Split Tensile strength achieved by 15 % replacement level of Metakaolin which was found about 4 N/mm² as compared with 3.1 N/mm² for the control mix after 28 days of curing period.

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