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Experimental Study on Strength and Durability of M60 mix with Metakaolin as an Admixture in Brine Solution

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Abstract— *Concrete is the most extensively used construction material in the world. The addition of mineral admixture in cement has dramatically increased along with the development of concrete industry, due to the consideration of cost saving, energy saving, environmental protection and conservation of resources. However, environmental concerns both in terms of damage caused by the extraction of raw material and carbon dioxide emission during cement manufacture have brought pressures to reduce cement consumption by the use of supplementary materials. An experimental study on the brine solution (3.5 % Nacl) on the hardness properties of M60 with metakaolin. This study includes fresh and hardened properties such as compressive strength at 3,7,28 days and split tensile strength and flexural strength at 7, 28 days of control mix and optimum percentage. This study helps to find out the optimum percentage of metakaolin in brine solution. This study also includes durability of concrete at 56 days and 90 days.*

Keywords— *Metakaolin, brine solution, compressive strength, durability, split tensile strength, flexural strength, high strength concrete.*

I. INTRODUCTION

Concrete is the most widely used construction material in the world and second to water as the most utilized substance on the planet. It is obtained by mixing cementitious materials, water and aggregates in required proportions. The mixture when placed in forms and allowed to cure, hardens into a rock- like mass known as concrete. It is difficult to find out alternate material for construction which is as suitable as that of such material form durability and economic point of view. The hardening is caused by chemical reaction between water and cement and is continues for a long time, and consequently the concrete grows stronger with age. The strength, durability and other characteristics of concrete depend upon the properties of its ingredients, on the proportions of mix, the method of compaction and other controls during placing, compaction and curing. So far, numerous types of concrete have been developed. Concrete is designated as “high-strength concrete” on the basis of its compressive strength measured at a given age. Any concrete mixtures that showed 40 MPa or more compressive strength at 28-days are designed as high-strength concrete. High strength concrete mixtures are commercially developed and used in the construction of high-rise buildings and long-span bridges, marine structures, embankment walls, in many parts of the world. With natural aggregates, it is possible to make concretes of high compressive strength by improving the strength of the cement paste, which is controlled through the choice of cement ratio and type and dosage of admixtures. However, with the recent advancement in concrete technology and the availability of various types of mineral and chemical admixtures, and special super plasticizer, improve to choose for mixing and curing than the pure water.

II. MATERIALS UESD

The materials used in the project are listed below

A. Cement

Ordinary Portland cement of 53 grade is used.

TABLE 1. Physical properties of cement.

Test conducted	**Values obtained**
Standard consistency	35 %
Specific gravity	3.15
Fineness	5 %
Initial setting time	240 min

B. Fine aggregate

M- Sand is used as fine aggregate. Aggregates mainly passing through 4.75 mm IS sieve and retained on 75 microns IS sieve is permitted for fine aggregates

TABLE 2. Physical properties of fine aggregate.

Test conducted	**Values obtained**
Specific gravity	2.7
Grading zone	zone II
Fineness	3.19
Water absorption	1.5 %

C. Coarse Aggregate

The crushed stone aggregate was collected from the local quarry. The coarse aggregate was used in the experimentation were about 20 mm and 12.5 mm size aggregate.

TABLE 3. Physical properties of coarse aggregate.

Test conducted	**Values obtained**
Specific gravity	2.7
Fineness	3.09
Water absorption	0.8%

D. Sea water

Sea water taken from Alappuzha

TABLE 4. Properties of sea water.

salinity of water	3.5%
ph	8
chloride	< 500 ppm
sulphate	< 1000 ppm

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E. Super plasticizer

Master Glenium SKY 8233 is the sp.

TABLE 5. Properties of super plasticizer.

Test	Values
Aspect	light brown liquid
Relative density	1.08 ± 0.01 at 25°c
PH	>6
Specific gravity	1.08

F. Metakaolin

Values given by "ARSAN BUSINESS PRIVATE LIMITED"

TABLE 6. Properties of metakaolin.

Test	Values
Appearance	Off-white powder
PH	5
Specific gravity	2.5

III. METHODOLOGY

The methodology adopted for the present experimental investigation is as follows:

a) Collection of materials: According to the literature review, collect the suitable materials. First of all doing the material characterisation and check it out with standard.

b) Prepare the mix design for the current study.

c) Preparation of specimens: Standard cube moulds of size 150x150x150 mm were used for preparation of cubes, beam moulds of size,100x100x500 mm and cylinder moulds of size,150x300 mm. The mixed materials were placed in the moulds and was compacted properly by rod. Excess material were trowel finished. The moulds were filled in three layers and each layer was compacted properly.

d) Method of Curing: The cubes, cylinders and beams were taken out from the moulds after 24 hours. After removal from the moulds the specimens were kept in brine water, and curing for 7, 14 and 28 days. After curing, testing were done.

e) The durability of cubes was investigated by curing these cubes in the aggressive environments of sulphate solution and alkali environment. Durability at 56 and 90 days were determined.

IV. RESULTS

A. Compressive Strength of Control Mix

TABLE 7. Compressive strength of control mix.

Curing (days)	Cube 1	Cube 2	Cube 3	Avg. strength (N/mm^2)
3 days	40.00	40.22	40.26	40.16
7 days	53.33	53.77	53.88	53.66
28 days	68.34	68.44	68.53	68.44

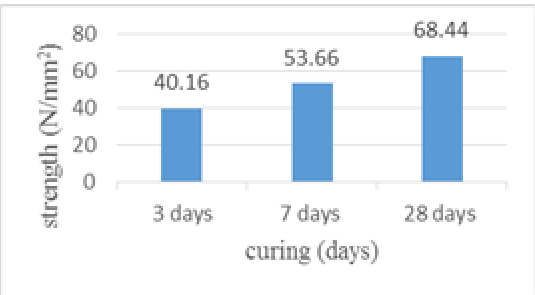

Fig. 1. Graphical representation of compressive strength of control mix.

B. Split Tensile Strength of Control Mix

TABLE 8. Split tensile strength of control mix.

Curing (days)	Average strength (N/mm^2)
7 days	2.81
28 days	3.85

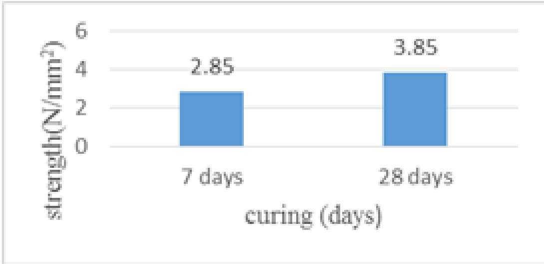

Fig. 2. Graphical representation of split tensile strength of control mix.

C. Flexural Strength of Control Mix

TABLE 9. Flexural strength of control mix.

Curing (days)	Average strength (N/mm^2)
7 days	7.5
28 days	10.6

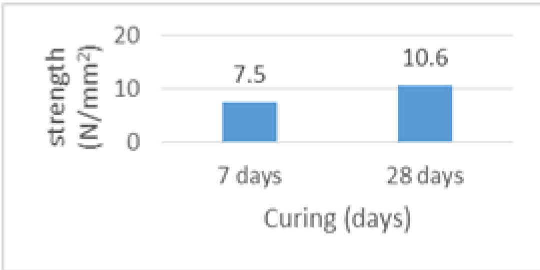

Fig. 3. Graphical representation of flexural strength of control mix.

D. Compressive Strength of Various Percentage of Metakaolin in Sea Water

TABLE 10. Compressive strength of various percentage of metakaolin in sea water.

Percentage	7 days	28 days
5 %	47.64	71.47
10 %	50.39	75.58
15 %	52.11	77.05
20 %	49.49	74.24

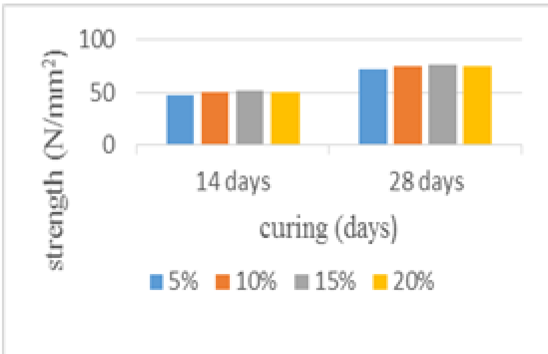

Fig. 4. Graphical representation of compressive strength of various percentage of metakaolin.

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E. Split Tensile Strength of Optimum Percentage of Metakaolin (15%)

TABLE 11. Split tensile strength of optimum percentage of metakaolin (15%).

Curing (days)	Average strength (N/mm^2)
7 days	3.35
28 days	4.87

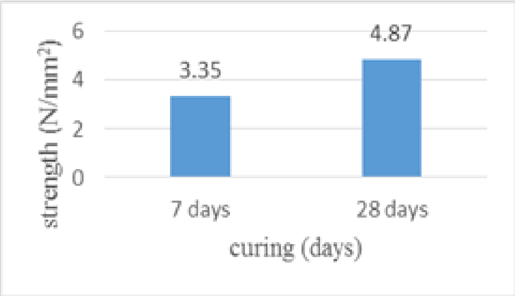

Fig. 5. Graphical representation of split tensile strength of optimum percentage of metakaolin.

F. Flexural Strength of Optimum Percentage of Metakaolin (15%)

TABLE 12: flexural Strength of optimum percentage of metakaolin (15%)

Curing (days)	Average strength(N/mm^2)
7 days	8.02
28 days	11.95

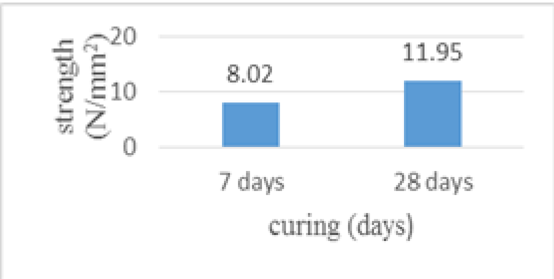

Fig. 6. Graphical representation of flexural strength of optimum percentage of metakaolin.

G. Duradility Tests

i) Specimen exposed to Magnesium sulphate Solution

TABLE 13. Specimen exposed to magnesium sulphate solution.

Solution	Avg .compressive strength (N/mm^2)	
	56 days	90 days
0 % $MgSO_4$	73.39	72.98
5 % $MgSO_4$	71.26	70.35

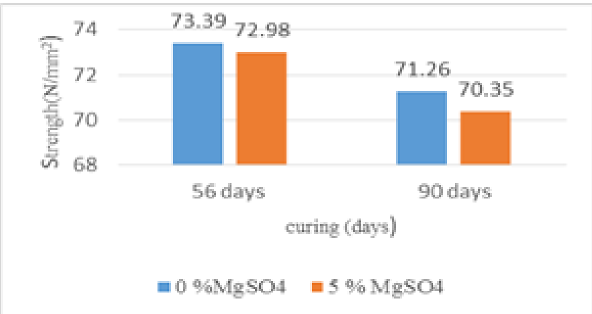

Fig. 7. Graphical representation of specimen exposed to magnesium sulphate solution.

ii) Specimen exposed to NaOH Solution

TABLE 14. Specimen exposed to NaOH solution.

Solution	56 days	90 days
0 % NaOH	73.25	72.25
5 % NaOH	71.41	71.01

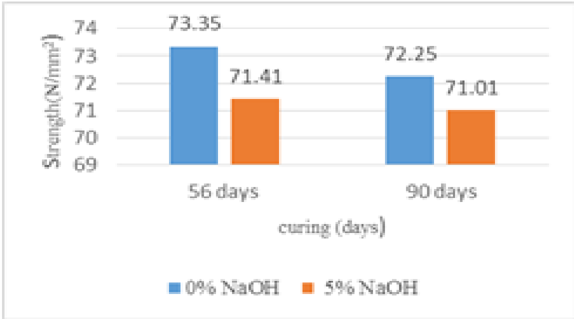

Fig. 8. Graphical representation of specimen exposed to NaOH solution.

V. CONCLUSION

- The workability of concrete decreased with the increase in metakaolin content.
- The optimum percentage of metakaolin in M60 mix in brine solution is 15% by replacing the cement.
- Compressive strength values at 3,7,28 days of control mix increased
- Split tensile strength and flexural strength of control mix at 7, 28 days also increased.
- Compressive strength of various percentage are obtained, the values increases from 5% to 15% and gradually decreased.
- The compressive strength of 15% metakaolin cubes gives 12.58% increment than the compressive strength of control mix
- The split tensile strength of 15% metakaolin cylinders gives 26.49% increment than the split tensile strength of control mix
- The flexural strength of 15% metakaolin cylinders gives 12.73% increment than the flexural strength of control mix
- The specimens made and cured in brine solution gives better strength.
- Specimens for durability tests, the compressive strength values decreased from 56 to 90 days.
- When the specimen is exposed to MgSO4, loss of strength is observed due to sulphate attack
- To compare the compressive strength of cubes without MgSO4and with 5% MgSO4, loss of strength of 3.6 % at 90 days
- When the specimen is exposed to NaOH, loss of strength is observed due to the hydroxide ions
- To compare the compressive strength of cubes without NaOH and with 5% NaOH, loss of strength of 0.56 % at 90 days

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