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An experiment on capillary suction water absorption of concrete with metakaolin

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ABSTRACT

Sustainable resources management and development have been at the forefront of an important issue concerning the construction industry for the past several years a study has been carried out to look into the performance of Metakaolin as cement alternative material in concrete. Nowadays availability of natural coarse aggregate is a big constraint, so alternative material called Recycled Coarse Aggregate (RCA) is using in the concrete mix; it has mostly similar properties as Natural Coarse Aggregate (NCA. In this present study, the experimental using RCA is 20%, 40%, 60%, 80%, and 100%, replacement with natural coarse aggregate and constant weight replacement of metakaolin with the weight of the binder. The Finally obtained results to increasing compressive strength as well as tensile strength mix. 20%RCA+10%MK than the percentage of recycled aggregate increasing with decreasing both compressive and tensile strength. The Further study use in RCA in concrete with MK to replacement in a certain limit. Find the surface absorption test in minimum for mix M1and M2 with an increasing percentage of RCA with MK than increasing capillary section values.

Keywords— *Metakaolin, Admixture, Workability, Capillary Suction Absorption Test (CSAT Test)*

1. INTRODUCTION

The present-day world is witnessing the construction of very challenging and difficult civil engineering structures. Quite often, concrete is the most important and widely used material is called upon to possess very high strength and sufficient workability properties. Efforts are being made in the field of concrete technology to develop such concretes with special characteristics. Researchers all over the world are attempting to develop high performance concretes by using metakaolin in concrete up to certain proportions. By replacing cement with MK increases the strength and durability and reduces the porosity in the concrete and reduces the permeability also. Natural Coarse Aggregate is one of the most important constituent materials as far as characteristic strength of concrete is concerned. Increase in demand and a decrease in natural sources of natural coarse aggregate for the production of concrete has resulted in the need to identify the new sources of coarse aggregate. Now a day due to the increasing cost and unavailability of Natural Coarse Aggregate, there is a necessity of rethink about the alternative sources for the NCA. In Europe and some countries in Asia, instead of NCA utilization of the recycled waste material in the form of recycled coarse aggregate (RCA) is increasing. RCA is the most emerging replacement for NCA in the production of the concrete.

2. MATERIALS USED

2.1 Cement

Use Ordinary Portland cement (OPC) from a single lot was used throughout the course of the investigation. Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture. The specific gravity 3.15 and initiation and final setting time are 62 and 270 minutes respectively.

2.2 Course aggregate

Crushed angular granite metal from a local source was used as coarse aggregate. The specific gravity was 2.67; the coarse aggregate is defined as that retained on 4.75 mm IS sieve. To increase the density of the resulting concrete mix, the coarse aggregate is frequently used in 20mm sizes.

2.3 Fine Aggregate

IS 383-1970 defines the fine aggregate, as the one passing 4.75 mm IS sieve. The fine aggregate is often termed as a sand size aggregate. Locally available riverbed sand was used in the present study. The sand conforms to grading Zone – III as per IS 383 – 1970 respectively. The specific gravity was 1.78

2.4 Recycled Coarse Aggregate

Recycled aggregate is collected from concrete technology laboratory of the civil engineering department. The specific gravity was 2.82; the coarse aggregate is defined as that retained on 4.75 mm IS sieve. The water absorption capacity of RCA is more as compare to natural aggregate and performed all test before using recycled aggregate.

2.5 Metakaolin

Metakaolin is highly reactive metastable clay that is an anhydrous aluminosilicate obtained from calcining kaolin to around 650–700^{0}C. Metakaolin was used as the secondary aluminosilicate source material because it is widely used as aluminosilicate source in geopolymeric systems as well as a mineral admixture in Portland cement. Metakaolin is much finer than the flash. This increases its particle surface area and hence influence properties of the concrete made from it.

2.6 Admixtures

Water-reducing and set-retarding admixtures are permitted in order to increase the workability of the concrete. Superplasticizer Gelenium hky 8765 was used for the workability.

3. RESULT AND DISCUSSION ON EXPERIMENTAL TESTS

3.1 Workability of concrete mixes

Table 1: Workability & slump values for different concrete mixes

Mix no.	Description	Super plasticizer (%) by weight of binder	Slump (mm)
M1	100%NA+10%MK	1.00	115
M2	80%NA+20%RA+10%MK	1.00	112
M3	60%NA+40%RA+10%MK	1.00	105
M4	40%NA+60%RA+10%MK	1.00	100
M5	20%NA+80%RA+10%MK	1.00	95
M6	0%NA+100%RA+10%MK	1..25	90

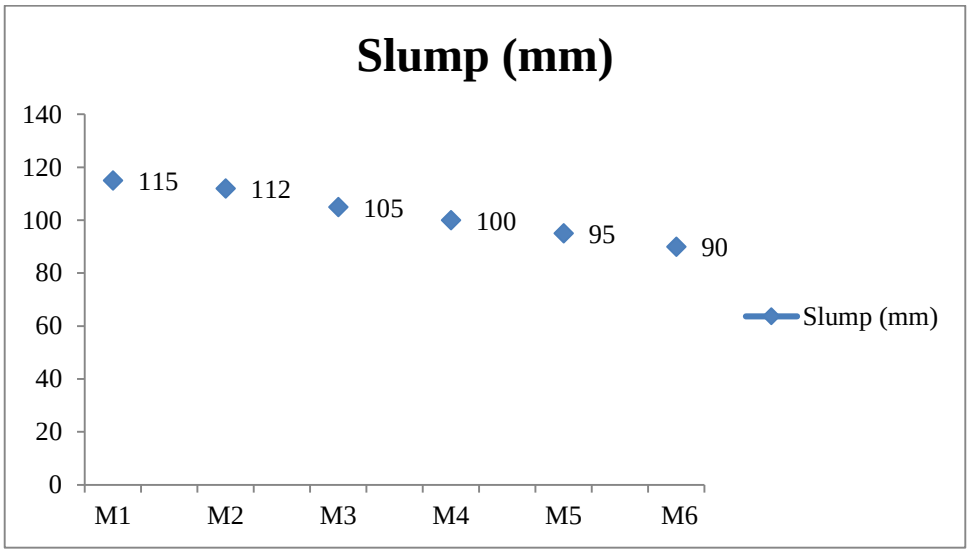

Fig. 1: Slump values in (mm)

From Table 2, it can be seen that the slump value is decreasing with an increase in the recycled concrete percentage in the mix. This is because the recycled aggregates absorb more water than the normal aggregates because of the presence of dust and the mortar on the surface of recycled aggregates. All slump values were maintained between 90-115mm by varying the dosage of superplasticizer.

3.2 Compressive Strength

Three cubes of 150 mm dimension are cast and cured for 7, 14, 28, 56, and 90 days to evaluate the compressive strength of concrete made with RCA with MK. The cubes are tested on the 200T capacity compression testing machine as shown in figure 2.

Table 2: Cube compressive strength at different days

Mix Name	Mix Description	Compressive Strength (MPa)				
		7 day	14 Days	28 Days	56 Days	90 days
M1	100% NA+10% MK	16.27	18.00	25.28	28.00	34.40
M2	80% NA+20% RA+10% MK	16.25	17.27	24.60	29.21	33.67
M3	60% NA+40% RA+10% MK	16.00	16.86	23.70	27.40	31.80
M4	40% NA+60% RA+10% MK	15.02	15.50	21.63	25.12	30.20
M5	20% NA+80% RA+10% MK	14.50	14.80	21.50	23.80	28.30
M6	0% NA+100% RA+10% MK	12.20	13.10	20.68	22.12	27.50

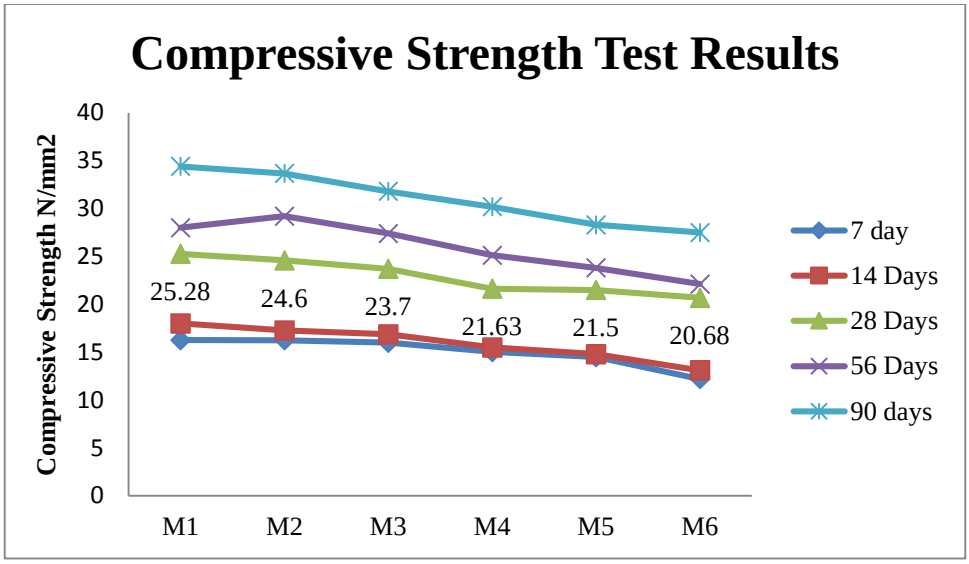

Fig. 2: Variation of compressive strength

Table 2 shows that with an increase in replacement ratio of coarse Recycled Aggregate in the natural aggregate mix there is a decrease in the compressive strength. Compressive strength increasing as replacement of RCA with MK as certain limits up to 20-40%. Maximum compressive strength results in 24.60 Mpa in 28 days with mix 80%NA+20%RA+10%MK and minimum compressive strength is obtained 20.68 in same mix M2. Finally, we obtained the replacement of RCA with MK suitable result obtained to the replacement ratio or percentage is taken 20-40% respectively.

3.3 Split tensile strength test results

Two cylindrical specimens of 100 mm diameter and 200 mm height are cast and cured for 7, 14, 28, 56, and 90 days to evaluate the split tensile strength of concrete made RCA with MK. The cylindrical specimens are tested on the 200T capacity compression testing machine as shown in figure 3.

Table 3: Split Tensile Strength at different days

Mix Name	Mix Description	Compressive Strength (MPa)				
		7 day	14 Days	28 Days	56 Days	90 days
M1	100%NA+10%MK	2.20	2.50	2.71	3.01	4.12
M2	80%NA+20%RA+10%MK	2.19	2.41	2.77	3.12	3.81
M3	60%NA+40%RA+10%MK	2.01	2.25	2.81	2.99	3.77
M4	40%NA+60%RA+10%MK	1.99	2.22	2.75	2.81	3.64
M5	20%NA+80%RA+10%MK	1.85	1.89	2.40	2.75	3.54
M6	0%NA+100%RA+10%MK	1.67	1.74	2.20	2.74	3.21

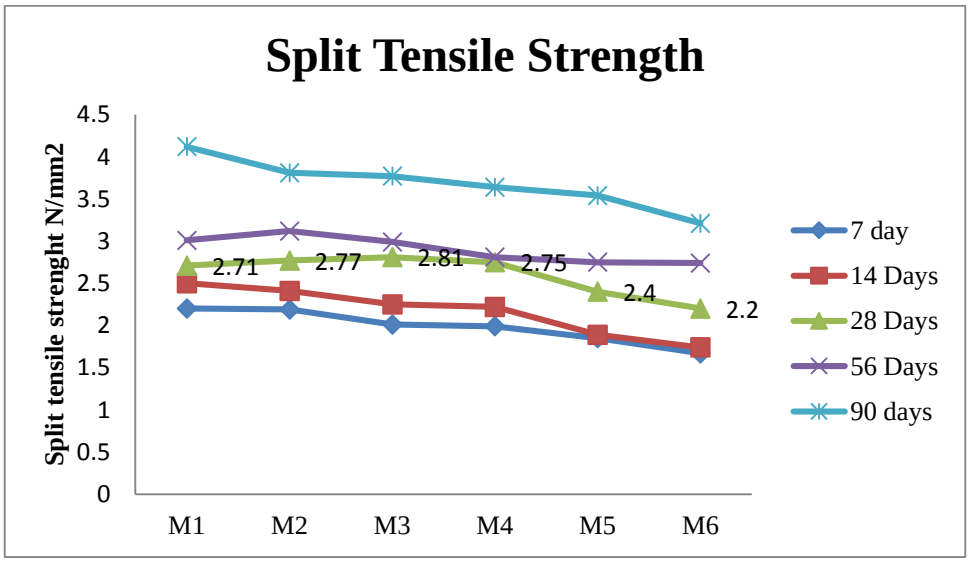

Fig. 3: Variation of Split tensile strength

Figure 3 shows the variation of tensile strength with different replacement ratio. It is clear from the graph that as compare to compressive strength, split tensile strength of RAC is very less affected by the presence of recycled aggregates in the mix. The maximum tensile strength obtained from mix no. M2 and M3 after increasing replacement ratio of RCA with decreasing tensile strength of concrete made with metakaolin winder materials. The maximum strength obtained in 28 days is 2.81 N/mm2 at mix60%NA+40%RA+10%MK. The results show that the tensile strength of the RAC is comparable to the natural concrete. This

improvement in the result is due to the increased absorption of the attached mortar and effective interfacial transition zone which indicate a good bond between aggregate and mortar matrix.

4. CAPILLARY SUCTION (SORPTIVITY) TEST RESULTS

Table 4: Average IRA (mm/Sec$^{1/2}$) at 56 and 90 days of curing

Mix no.	Description	Average IRA (mm/Sec$^{1/2}$)	
		56 days	90 days
1	100%NA+10%MK	0.0189	0.0177
2	80%NA+20%RA+10%MK	0.0182	0.0170
3	60%NA+40%RA+10%MK	0.0187	0.0157
4	40%NA+60%RA+10%MK	0.0202	0.0168
5	20%NA+80%RA+10%MK	0.0214	0.0180
6	0%NA+100%RA+10%MK	0.0243	0.0208

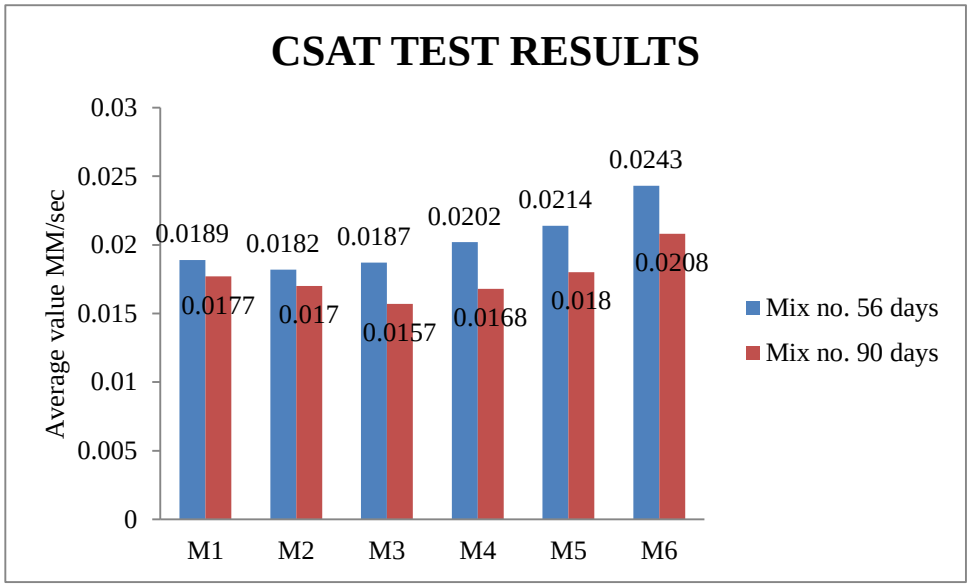

Fig. 4: Average IRA (mm/Sec$^{1/2}$) at 56 and 90 days of curing

Figure 4 shows the variation in the IRA value of concrete mixes at different curing ages. The lowest IRA value was obtained with a mix containing 80%NA+20%RA+10%MK for all curing ages, whereas mix containing 0%NA+100%RA+10%MK give the maximum value at all curing ages. This is because of the high absorption capacity of recycled concrete aggregate. Mix 80%NA+20%RA+10%MK show less absorption value out of all and the mixes and mix with 0%NA+100%RA+10%MK show high absorption value at both 56 and 90 days. The lowest values of absorption (mm) observed with mix 80%NA+20%RA+10%MK was 6.6 mm and 2 mm at curing period of 56 and 90 days whereas, the highest values of absorption (mm) observed with mix 0%NA+100%RA+10%MK was 12mm and 3.1mm at 56 and 90 days of curing. Finally, the result shows the water absorption capacity is increasing with increasing recycled concrete aggregate and the minimum value in MM/cec$^{1/2}$is 0.0182 and 0.0170 at 56 days and 90 days respectively.

5. CONCLUSIONS

- It was observed than efficiently used to produce good quality concrete with a satisfactory slump. The workability of concrete decreasing with increasing recycled concrete with metakaolin.
- Under certain conditions, replacement of natural aggregate with a recycled concrete aggregate of appears to increase the compressive strength of concrete at 28 value of maximum obtained is 24.60 MPa and the minimum value same mix is 20.38 MPa respectively.
- It was observed that tensile strength is maximum at the mix. 60%NA+40%RA+10%MK is 2.81MPa at 28 days and minimum at same days for mix 0%NA+100%RA+10%MK is 2.20MPa.
- It was observed that increasing percentage of recycled aggregate and metakaolin with decreasing compressive strength as well as tensile strength respectively.
- It is clear that the result shows the water absorption capacity is increasing with increasing recycled concrete aggregate and the minimum value in MM/cec$^{1/2}$is 0.0182 and 0.0170 at 56 days and 90 days respectively.
- It was observed that the water absorption capacity increases with increasing percentage recycled concrete aggregate minimum water absorption in this research at the mix. 80%NA+200%RA+10% and maximum at mix no. M6 respectively.

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