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Study on Effect of Induced Combined Index of Coarse Aggregate on Characteristic Strength of Concrete using Manufactured Sand

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***Abstract*—The investigation is aimed to study the effect of induced combined index of coarse aggregate on characteristic strength of concrete using manufactured sand as fine aggregate. The experimental program consists of basic laboratory testing of all materials required, separating flaky and elongated aggregate, testing of fresh concrete, casting of cubes (15x15x15 cm) and beams (50x10x10 cm) and critical study on test results. Total 42 cubes and 21 beams were casted out of which 36 cubes and 18 beams were casted using manufactured sand with variation of combined index of coarse aggregate 0% (normal aggregate) 0% (rounded aggregate), 10%, 20%, 30% and 40%. Remaining 6 cubes and 3 beams were casted using natural sand as fine aggregate for comparison. To study the characteristic strength of concrete all cubes and beams were tested after 28 days curing. For each 10% increase in combined index compressive strength is increasing by 4 % till 30% combined index. In case of beams for each 10 % increase in combined index the flexural strength is increasing by 2- 8% till 30% combined index. For concrete made with manufactured sand with normal (procured) aggregate, the compressive and flexural strength was found to be 8% and 17% higher that the concrete made with natural sand.**

Index Terms— combined index, coarse aggregate, manufactured sand and natural strength, workability, compressive and flexural strength

I. Introduction

Concrete can be defined as a mixture of water, cement, sand i.e. fine aggregate and coarse aggregate. In accordance with the volume terms, the aggregate volumes to 60-80 % of the volume of concrete and is, therefore, proved to be the major constituent of the concrete. They provide body to the concrete, decrease shrinkage and effects the economy. To improve the quality of fresh and hardened concrete we should always be concerned about the coarse aggregate sizes and shape as well. As coarse aggregate characteristics are very important to the performance of the both fresh and hardened concrete mixes. In general, the flaky and elongated aggregate are usually removed for making valuable and worthy concrete. Increase in percentage of flaky and elongated aggregates further than the certain limits increases the degradation of the concrete mixes. More percentages of flaky and elongated aggregate makes the mix the harsh and hard to handle while working. The fine aggregates i.e. sand used is usually collected from natural sources like river bank sites. At present due to limitless sand removal from the natural sources, natural sand is running down terrifyingly. Sand removal from river bank sites are causing several environmental problems. Due to those various environmental problems, Government has started taking action against the removal of sand from rivers. This has steered to an insufficiency and major growth in the rate of natural sand. So there has been a crucial need to find a substitute for river sand. The only replacement can be found is manufactured sand as there could not be any better substitute for natural sand.

II. Objectives

The main objective of the project work is to study the effect of induced combined index on characteristics strength of concrete replacing natural sand by manufactured sand.

- To determine the corresponding workability associated with the aggregate sizes using manufactured sand as fine aggregate.
- Characteristics study of concrete with fine aggregates (M sand) i.e. workability, with variation of combined index of coarse aggregate.
- To determine the effects of aggregate sizes on the flexural strength as well as compressive strength of concrete mixtures with manufactured sand as fine aggregate.
- Primary objective to know that a manufactured sand can be made to replace by natural sand.
- To study the influence of manufactured sand on the compressive and flexural strength of concrete and compare the result with that of concrete produced using selected river sand and stone crushed aggregate.

III. Material

Ordinary Portland cement of 53 grade conforming to IS 1489 – 1991 was used. Maximum size of coarse aggregate was 25 mm. Locally available manufactured sand and river sand were used. The basic laboratory test results are shown in the Table-I.

IV. Methodology

The study will be carried out to evaluate the characteristics strength of concrete o cubes and beams of M25 grade of concrete mix with flaky and elongated aggregate (10 mm and 25 mm down) and normal aggregates having fur type mix conditions including nominal mix and three types of special mix conditions.

1. Mix 1: water + cement + fine aggregate (m sand) +coarse aggregate(Procured aggregate) - Control mix
2. Mix 2: water + cement +fine aggregate (m sand) +coarse aggregate (10% combined index)
3. Mix 3: water + cement + fine aggregate (m sand) + coarse aggregate (20% combined index)
4. Mix 4: water + cement + fine aggregate (m sand) + coarse aggregate (30% combined index)
5. Mix 5: water + cement + fine aggregate (m sand) + coarse aggregate (40% combined index)
6. Mix 6: water + cement + fine aggregate (m sand) + coarse aggregate (Rounded aggregate).
7. Mix 7: Water + cement + fine aggregate (natural sand) + coarse aggregate (Procured aggregate) (For comparison)

For each trial mix no of cubes are 6, whereas no of beams are 3.Therefore total number of

Cubes= 6*6= 36, size= 150*150*150 mm^3

Beams=6*3= 18, size= 500*100*100 mm^3

The combined index was induced by separating the flaky and elongated aggregate from the aggregate sample bags and then multiplying the percentage of combined index with the total weight of coarse aggregate for each individual mix.

TABLE I
Material Properties

Materials		Test	Values obtained
Cement		Specific gravity	3.135
Fine aggregate	**Manufactured sand**	Specific gravity	2.665
		Water absorption	2.2%
		Sieve analysis	2.918
	Natural sand	Specific Gravity	2.58
		Sieve analysis	2.1
Coarse aggregate		Specific gravity	2.642
		Water absorption	0.19 %
		Sieve analysis	8.1
		Flakiness Index	13.3 %
		Elongation Index	21.1 %

V. Results and Discussions

A. Results

To find the physical and mechanical properties of concrete mix following test has been carried out.

1. Test conducted on Fresh concrete
   - Slump test
   - Compaction Factor test
   - Vee Bee test

TABLE II
Test Results on Fresh Concrete

Mix Sample	Slump (mm)	Compaction Factor	Vee bee time (sec)
M sand + Natural aggregate	89.50	0.87	6.17
M sand + 10% combined Index	86	0.84	5.96
M sand + 20% combined index	83.50	0.82	6.1
M sand + 30% combined index	81.50	0.80	5.94
M sand + 40% combined index	81.50	0.79	6.1
M sand + rounded(0% combined index) aggregate	91.50	0.865	4.75
Natural sand + Natural aggregate	107	0.93	2.9

2. Test Conducted on Hardened Concrete
   - Compressive Strength of Cubes
   - Flexural Strength of Beams

TABLE III
Test Results on Hardened Concrete

Mix Sample	Compressive strength (Mpa)	Flexural Strength (Mpa)
M sand + Natural aggregate	26.74	4.41
M sand + 10% combined Index	27.49	4.65
M sand + 20% combined index	28.12	5.02
M sand + 30% combined index	29.00	5.28
M sand + 40% combined index	28.19	4.98
M sand + rounded aggregate	26.74	4.59
Natural sand + Natural aggregate	25.37	3.63

B. Discussions

From the test result it can be seen very clearly that both fresh and hardened concrete is affected by the change of combined index and also if comparison are made it can be observed that the same thing happens with full replacement of manufactured sand by natural sand.

1. Fresh Concrete

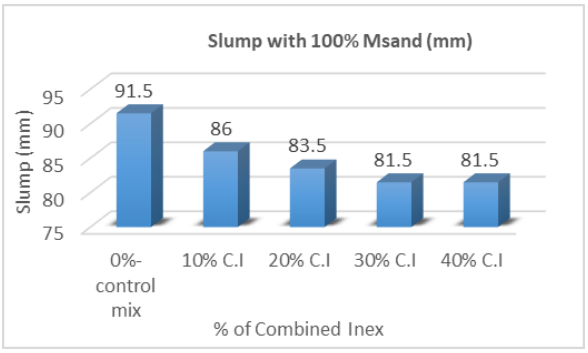

Fig. 1. Slump with % variation of C.I using M sand

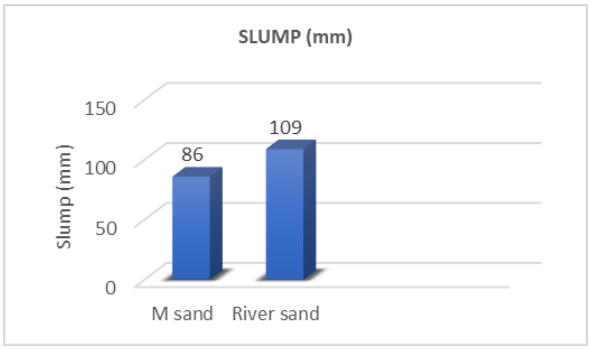

Fig. 2. Slump with M sand and river sand

From the Fig. 2, it can be observed that the slump values are decreasing with the increase in percentage of combined index.

From Fig. 2, it can be observed that the concrete with river sand gives higher value of slump as compared to concrete with M sand.

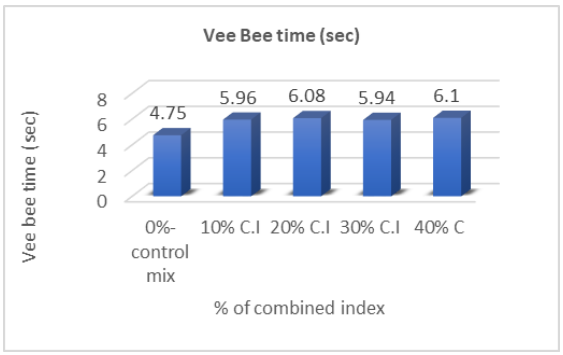

Fig. 3. Vee bee time with % variation in combined index using M sand

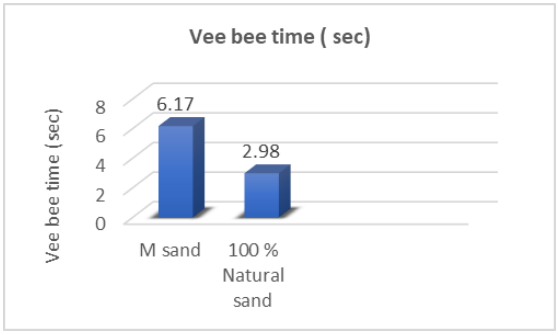

Fig. 4. Difference of vee bee time with M sand and river sand

From Fig. 3, it can be observed that with the increase in % of combined index the vee bee time increase.

From the Fig. 4, it can be observed that concrete with river sand is having lesser vee bee time as compared to concrete with M sand.

2. Hardened Concrete

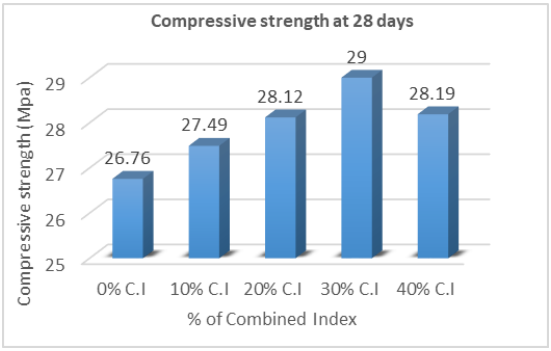

Fig. 5. Change in compressive strength with % variation of combined index

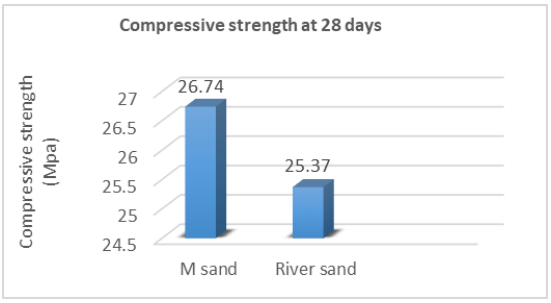

Fig. 6. Difference in compressive strength of cubes with M sand and river sand

From the Fig. 5, it can be seen that the compressive strength of cubes at 28 days increases with the increase in % of combined index.

From the Fig. 6, it can be observed that concrete with M sand possess higher strength, about 6% extra, as compared to concrete with river sand.

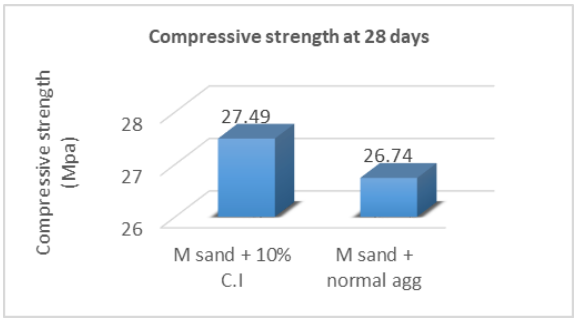

Fig. 7. Difference in compressive strength of cubes with 10% C.I, M sand and with only river sand

From Fig. 8, it is clear that combined index of coarse aggregate increase the flexural strength of beams. From Fig. 9, it can be observed that concrete beam with M sand possess higher flexural strength as compared to beams with river sand.

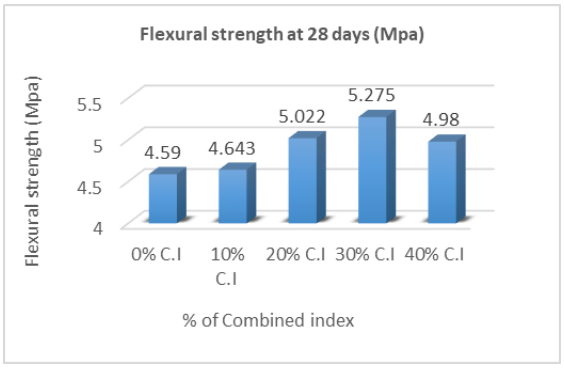

Fig. 8. Increase in flexural strength with the increasing % of combined index

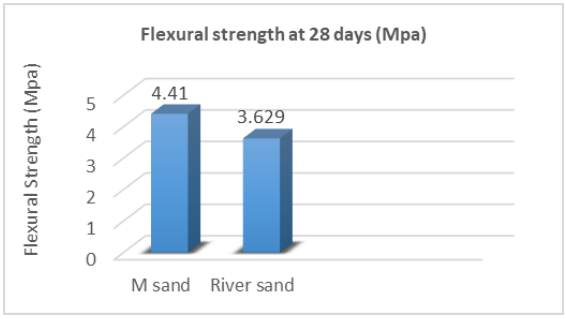

Fig. 9. Difference in flexural strength of beams at 28 days with M sand and with river sand

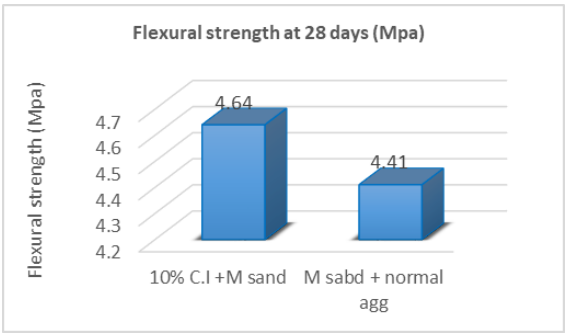

Fig. 10. Change in flexural strength of beams with M sand + 10% C.I and with only river sand

From Fig. 8, it is clear that combined index of coarse aggregate increase the flexural strength of beams.

From Fig. 9, it can be observed that concrete beam with M sand possess higher flexural strength as compared to beams with river sand.

VI. Conclusion

Physical and Mechanical properties of concrete were studied by conducting various laboratory test. On the basis of these test conducted as per IS standards and as per analysis of the result, the following conclusion can be made.

1. The physical properties of fresh concrete were studied which shows that the workability of fresh concrete made with manufactured sand is decreasing when combined index of coarse aggregate is induced.
2. From the test result on fresh concrete using manufactured sand and without any induced combined index of coarse aggregate, it can be observed that the workability is slightly lesser compared to the concrete with natural sand.
3. Concrete with only rounded aggregate showing proper degree of workability.
4. Mechanical behavior of concrete cubes and beams were also studied for compressive and flexural strength test with curing time of 28 days which shows increase in its strength behavior.
5. It can be noticed that up to 30% replacement of normal aggregate with flaky and elongated (combined index) aggregate showing increment in compressive about 3 – 5%. At 40% replacement of normal coarse aggregate by flaky and elongated aggregate it can be noticed that there is a marginal decrease in compressive strength about 3%.
6. It can be noticed that the 5th point is also valid for flexural strength of beams. In case of flexural strength the increment is 5 – 8 %. At 40% combined index the flexural strength is decreasing about 8 %.
7. With the presence of only manufactured sand, the concrete cubes and beams are showing higher strength compared to concrete made with only river sand about compared to concrete made with only river sand about 6% and 20% respectively.
8. If comparison are made for concrete made with only manufactured sand and concrete with induced combined index of 10%, also made with manufactured sand, it can be concluded that compressive and flexural strength of concrete increases marginally by 3% and 1% respectively, but the slump value decreases.
9. Concrete made with 30% replacement of coarse aggregate by combined flaky and elongated aggregate has proved to be equally good as concrete made up with normal aggregate.
10. From the above study it can be concluded that strength requirement is very important for any concrete work and river sand is not available, introduction of combined index by the total weight of coarse aggregate and manufactured sand can be the perfect alternative.
11. When requirement of higher degree workability is an important issue, replacement of coarse aggregate by combined flaky and elongated aggregate would not be an accurate choice.

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