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PERFORMANCE OF CONCRETE PRODUCED WITH SEA SAND AND MICRO SILICA

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ABSTRACT

Sand is a unique raw material for the construction industry, at present, but contractors say that they have to spend more allocations for obtaining bulk loads of sand for their construction work. According to the experts in the global construction trade Sea sand is being used in the construction industry. In this paper an attempt has been made to use the sea sand as partial replacement for fine aggregate. M30 grade of concrete was made with mix proportion of 1:1.22:2.54 and with water cement ratio as 0.42. In this proportion 1.22 parts of fine aggregate is partially replaced with sea sand. Concrete specimens were mould with, 10%, 20%, and 30% of sea sand replacing the fine aggregate. The tests for hardened concrete such as axial compressive strength, split tensile and flexural strength were conducted after 7, 14 and 28 days curing and comparisons were made. The optimum percentage for partial replacement of fine aggregate with sea sand was determined with the usage of micro silica as an admixture to increase the strength.

Keywords— Sea sand-Fine aggregate- Micro silica -strength-Durability.

I. INTRODUCTION

GENERAL

In recent years, it has been taken a growing interest in the shortage of natural fine aggregate having good quality across the world, because of deficient natural sand supplies and increased construction demands. According to the industry sources, the price level of the river sand has skyrocketed. According to the industry figures, the price of the river sand has increased by over 40 per cent after the banning of removing river sand. Due to the government barriers on the removal of river sand, the construction industry faces lots of difficulties to obtain river sand in time.

IMPORTANCE

The main objective of this paper is to study various properties of the materials of concrete, fresh concrete and hardened concrete to design a concrete mix for an increased strength and durability.

II. LITERATURE REVIEW

Over the last few years, lot of research has been focused towards the alternate for fine aggregate and admixtures. The main applications of dredged marine sand (DMS), apart from beach replenishment, are coastal defenses and land reclamations; however, many countries have opted for the use of marine aggregates in specific civil constructions. Experimental studies about DMS extracted from European and American coasts have shown that these materials are suitable as construction material for the base and sub-base of pavements [5–7].

To prevent deterioration and to achieve longer life in concrete structures especially those subjected to extreme exposure conditions engineers are using materials such as Slica fume, Fly ash, Ground granulated blast furnace slag [5]

Davidovits (2008) developed a geopolymer to polymerize the source material such as fly ash [8]. After the development of geopolymer, considerable advancement has been made in fly ash–based geopolymer concrete research. Geopolymer is prepared using alkaline binder, i.e., a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) with sodium silicate (Na2SiO3) or potassium silicate (K2SiO3) [9,10]. However, durability of the concrete in sea environments has not been properly dealt. Replacement of cement by SF for concrete does not indicate any significant change in the durability of concrete [11].

III. MATERIALS AND METHODS

The concrete mix has been designed for M30 grade as per IS 10262-1982. The specified concrete grade involves the economical selection of relative proportion of cement, fine aggregate, coarse aggregate and water. Although compliance with respect to characteristic strength is the main criteria for acceptance it is implicit that concrete must also have desired workability in the fresh state the impermeability and durability in hardened state. Mix design on recommended guide lines is really a process of making an initial guess at optimum combination of ingredients and final mix proportion is obtained only on the basis of further trial mixes.For compressive strength, the following characteristics are chosen from Indian standard (IS-456-2000) for M30 grade concrete

i) Required compressive strength in the field at 28 days - 30N/mm2
ii) Maximum size of aggregate - 20 mm
iii) Degree of quality control - Good
iv) Type of exposure - Mild

The test data determined from the materials are as follows. The specific gravity of cement, fine aggregate (river sand), coarse aggregate and sea sand were 3.15, 2.59, 2.84 and 2.71 respectively. The water absorption of coarse aggregate and fine aggregate are 1% and 0.5% respectively. The mix proportion obtained for M30 grade concrete is 1:1.22:2.54

From the mix design, quantity of cement, fine aggregate, coarse aggregate and water cement ratios are calculated.

Table 1 Mix Proportion

Water	**Cement**	**Fine aggregate**	**Coarse aggregate**
191.141/m^3	456.14 Kg/m^3	555.87 Kg/m^3	1160.2kg/m^3
0.42	1	1.22	2.54

a) Experimental Work

The entire document should be in Times New Roman or Times font. Type 3 fonts must not be used. Other font types may be used if needed for special purposes. The specimens were casted and demould after 24 hours and were cured in a curing pond till the date of testing. The water in the curing pond was changed once in seven days and care was taken not to allow the specimen to dry at time until they were tested. The pond was inside the laboratory where the temperature was not greater than 30ºC. Follwing tests are carried out to establish the properties such as fineness modulus, specific gravity, silt content and water content. The following tests are also carried out to ascertain strengths of concrete: i) Compressive strength (cube strength), ii) Tensile strength (split tensile strength of cylinder) iii) Flexural strength (modulus of rupture).

The specimens used for the test included cubes of size 150mm x 150mm x 150mm for compression test, cylinder of 100mm x 150mm depth for split tensile test and beams of 100mm x 100mm x 500mm for flexural test. Three specimens were tested for the required age and average value was taken. The tests were conducted after 7, 14, and 28 days of curing. The sea sand replacement percentages are 10, 20 and 30.

The usage of Micro Silica (MS) as an admixture for concrete development with the specimens, age of curing and replacement percentage are listed in Table 2.

Table 2 Details of specimens with admixture (MS)

SPECIMENS	**AGE OF CURING IN DAYS**	**PERCENTAGE OF ADMIXTURE (MS) IN CEMENT**			
		5%	**10%**	**15%**	**TOTAL IN NOS**
CUBE	7	3	3	3	9
	14	3	3	3	9
	28	3	3	3	9
CYLINDER	7	3	3	3	9
	14	3	3	3	9
	28	3	3	3	9
BEAM	28	3	3	3	9

IV. STRENGTH ANALYSIS OF CONCRETE

a) Compressive Strength

Compression test was carried out on cube specimens. The size of the specimens is 150mm x 150mm x 150mm. Three specimens were tested for each percentage at 7, 14 and 28 days and average of three was taken. The specimens stored in water were tested immediately after the removal from tank, the specimens were wiped off and the dimensions of the specimens and their weight were recorded before testing.

The bearing surfaces of the testing machine were wiped clean. While placing the cubes in the machine, care was taken such that the load was applied to opposite sides of the cubes as casted and not to the top and bottom. The axis of the specimen was carefully aligned with the centre of thrust of the spherically seated plate. As the Spherical-seated block is to bear on the specimen, the movable portion was rotated gently by hand, so that uniform seating was obtained. The maximum load applied to the specimen was recorded and type of failure was also noted. The compressive strength of the specimen was calculated by using the formula.

$$f = P/A \text{ N/mm}^2$$

Where,

F = Compressive stress in N/mm"
P = Load at which specimen fails in N
A = Area over which the load is applied in mm^2

b) Split Tensile Strength for Cylinder

The cylindrical specimens were tested for split tensile strength after 28 days of curing. The specimen was tested immediately after taking out from the water.

Two packing strips of plywood 3mm thick were provided between the specimen and the plates, one at top and another at bottom. One of the plywood strips was centered along the center of the lower pattern. The specimen was placed on the plywood strip and aligned so that, the central horizontal axis of the specimen is exactly perpendicular to the load applying axis. The second plywood strip was placed length wise on the cylinder and the top plate was brought down till touched the plywood.

The load was applied without shock and increased gradually and continuously until the failure of specimen. The maximum load applied was then recorded. According to IS-5816-1999-Spliting Tensile Strength of Concrete - Method of test, the splitting tensile strength was determined.

The size of the specimen is 10cm diameter and 20cm height.

Tensile strength = $(2P / \Pi DL)$ N/mm^2

Where,

P = load at which specimen fails in N.

L = length of the cylinder in mm.

D = diameter of the cylinder in mm.

c) *Flexural Strength*

The beam specimens were tested for flexural strength after 28 days. The size of specimen was 100mm x 100mm x 500mm. The specimen were submerged in clean fresh water in a curing tank and kept until the test. The specimens are tested immediately on removal from the water whilst they are still in a wet condition. The dimensions of the specimens and their weight were recorded before testing. Three specimens were tested for each percentage at 28 days and average of three was taken.

The value of the modulus of rupture depends on the dimension of the beam and manner of loading. The system of loading used in finding out the flexural tension is two points loading. The bearing surface of the supporting and loading rollers was wiped clean. The specimen was then placed on the rollers in such a way that the load will be applied to the upper most surface. The axis of specimen was carefully aligned with the axis of loading device. The load was applied continuously in increasing manner without any shock. The load was increased until the specimen failed and maximum load applied to the specimen was recorded. According to IS 516-1959- Methods of Tests for Strength of Concrete, the Flexural Strength was determined.

Flexural strength = Pl/bd^2 N/mm^2

Where,

P = Load at which specimen fails in N

1 = Effective span in mm

b = Breadth of the specimen in m

V. EXPERIMENTAL RESULTS AND DISCUSSION

Experiments are conducted on materials, fresh concrete and hardened concrete to study the physical properties and strength properties. The physical properties of cement, fine aggregate (river sand and sea sand), coarse aggregate have been found out. For cement, the physical properties such as normal consistency, initial setting time, Final Setting Time, Specific Gravity, Fineness modulus are determined. The normal consistency is found to be 30 %. The initial setting time and Final Setting Time are 45 minutes and 360 minutes respectively. The specific gravity and fineness modulus are found as 3.14 and 2.01.

River sand and sea sand are used as fine aggregate in this study. The specific gravity, fineness modulus and water absorption are determined for both the fine aggregates and course aggregate. The

specific gravity of river sand, sea sand and course aggregate are determined as 2.59, 2.71 and 2.84 respectively. The fineness modulus values are 2.70, 2,42, 4.39 respectively and the water absorption percentage are 1.2, 1.24 and 0.5 respectively.
The slump cone test has been carried out on fresh concrete to find the workability and slump value. Certain percentage of sea sand is used in this test instead of river sand. The concrete made using river sand yields the slump value of 8 cm. For the partial replacement of sea sand percentage 10, 20 and 30, the slump values are determined as 7.8 cm, 7 cm and 6.5 cm respectively. From the experimental results of slump cone test, it is observed that the workability of the concrete is not affected with the replacement of sea sand up to 30%.
Compressive strength, split tensile and flexural strength tests are conducted on the hardened concrete and the results are discussed.
a) Compressive Strength
The mean compressive strength of 150mm concrete cubes, using sea sand as replacement for fine aggregate were determined after the age of 7, 14 and 28 days in the mix proportion of 1:1.22:2.54 were reported in the Table 3. The nominal compressive strength values for 7, 14 and 28 days of curing of cubes are 27.68, 33.24 and 38.96 respectively. The compressive strength of concrete with sea sand is considerably higher than of the conventional concrete. The compressive strength decreases greatly with 10% replacement of sea sand as fine aggregate in 7, 14 and 28 days. From the Table 3, an addition of sea sand 10% and 20% increases in value but 30% the value of compressive strength decreases with nominal value. So the SF admixture is added with 20% sea sand and compared with nominal value.

Table 3 Compressive strength of Cubes with sea sand

S.No	**Percentage of sea sand**	**Compressive strength of cubes in N/mm^2**		
		7 days	**14 days**	28 **days**
1	**0%**	27.68	33.24	38.96
2	**10%**	27.72	35.4	40.1
3	**20%**	27.7	34.3	39
4	**30%**	25.1	32	36

Table 4 provides the obtained compressive strength values of concrete cubes developed with SF admixture in different ratios and 20% of sea sand. The compressive strength increases with 5% addition of silica fume as admixture in cement for 7, 14 and 28 days. The compressive strength value increases up to 15% of admixture addition, further increase in the SF results in decrease in compressive strength.

Table 3 Compressive strength of Cubes with admixture (MS)

S.No	**Percentage of mica silica and 20% of sea sand**	**Compressive strength of cubes in N/mm^2**		
		7 days	**14 days**	28 **days**
1	0%	25.10	32.00	36.00
2	5%	25.90	32.50	36.30
3	10%	26.70	32.90	37.80
4	15%	28.20	34.30	39.20
5	20%	26.90	32.80	38.40

b) Split Tensile Strength

The mean split tensile strength of concrete cylinder, using sea sand as replacement for fine aggregate were determined at the age of 28 days in the mix proportion of 1:1.22:2.54 were reported in the Table 5. Figure 1 shows the experimental setup for conducting split tensile strength test.

The split tensile strength of concrete with sea sand is considerably higher than the conventional concrete. After 28 days, 10% replacement gives decreased split tensile strength and for more percentage of replacements, the split tensile strength decrease further.

Table 5 Split Tensile Strength for Cylinders

S.No	**Percentage of sea sand**	**Split Tensile Strength of Cylinders in N/mm^2**		
		7 days	**14 days**	**28 days**
1	0%	2.86	3.39	4.43
2	10%	3.10	3.60	4.60
3	20%	3.00	3.50	4.45
4	30%	2.70	3.30	4.10

In above table and graph shows that an addition of sea sand 10% and 20%o increases in value but 30% the value of split tensile strength decreases with nominal value so admixture is added from 30% sea sand and compared with nominal value. The split tensile strength increases with 5% addition of micro silica as admixture in cement for 7, 14 and 28 days.

Table 6 Split Tensile Strength for Cylinders
with admixture Micro Silica (MS)

S.No	**Percentage of micro silica with 30% of sea sand**	**Split Tensile Strength of Cylinders in N/mm^2**		
		7 days	**14 days**	**28 days**
1	0%	2.70	3.30	4.10
2	5%	2.80	3.34	4.20
3	10%	2.80	3.37	4.40
4	15%	3.20	3.41	4.45
	20%	3.00	3.33	4.42

Nominal value	**Split tensile strength of Cylinder in N/mm^2**		
	7 days	**14 days**	**28 days**
	2.86	3.39	4.43

c) Flexural Strength

The mean flexural strength of concrete beams, using sea sand as replacement for fine aggregate were determined at the age of 28 days in the mix proportion of 1:1.22:2.54 were reported in the Table 7. The flexural strength of concrete with sea sand is considerably higher than the conventional concrete. In 28 days, 10% replacement gives a decreased flexural strength and for more amount of replacement produced decrease in strength.

S.No	Percentage of sea sand	Flexural Strength of Beams at 28 days in N/mm^2
1	0%	9.00
2	10%	10.50
3	20%	10.00
4	30%	8.50

VI. CONCLUSION

The following are the conclusions drawn from the experiments done on strength characteristics of concrete using sea sand and admixture Micro Silica (MS). Sea sand can be transformed into fine aggregate. The compressive, split tensile, flexural strength of concrete replaced partially with sea sand in place of river sand is less than the compressive, split tensile, flexural strength of the conventional normal concrete. Micro silica was used in concrete with sea sand, and it results in higher compressive, split tensile, flexural strength than the conventional concrete. In M30 grade of concrete with 15% replacement of micro silica gave more strength than that of conventional concrete. So, we can use sea sand in concrete with micro silica as an admixture for minor and massive structures.

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