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EVALUATING THE STRENGTH CHARACTERISTICS OF SEA SAND REPLACED CONCRETE

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Abstract-Sand and gravel are mined world-wide and account for the largest volume of solid material extracted globally. Formed by erosive processes over thousands of years, they are now being extracted at a rate far greater than their renewal. Furthermore, the volume being extracted is having a major impact on rivers and deltas, results in loss of land through river, lowering of the water table and decreases in the amount of sediment supply. This emerging problem obliges contemporary material usage to balance the ecology. In this essence the abundant availability of sea sand can be utilized as an effective replacement for natural aggregate which will be beneficial for both circumstances. Hence this research project investigates the use of sea sand in concrete construction. This study proposed with hot water washed sea sand with various replacement in concrete from 10% to 100% with the increment of 10% resulted in higher mechanical properties in all the replacement.

Keywords—Sea sand, Properties, Strength, Test, Chloride.

I. INTRODUCTION

Concrete is the most common material in the construction industry which consumes more than 40 billion tonnes of aggregates in a year. This is twice the time of yearly amount of sedimentation carried by all of the rivers in the world (Milliman and Syvitski, 1992). This large quantity of material cannot be extracted and used without a significant impact on the environment (Sonak et al., 2006, Kondolf, 1994). Extraction has an impact on biodiversity, water turbidity, water table levels, and landscape and on climate through carbon dioxide emissions from transportation. Large scale of exploitation of limited river sand resources as well as imposition of environmental restraints on river sand mining means that river sand supply need to be augmented with alternative resource. In many other countries situation is similar and several have turned to marine aggregate and now concrete specifications allow use of marine aggregate subject to certain controls being imposed on their properties. In the interim, if it is possible to divert sea sand for concrete production, it will be beneficial measure. Hence a study on suitability of sea sand for concrete production has considered as an opportunity for the researcher. Experimental studies about offshore sand extracted from European and American coasts have shown that these materials are suitable as construction materials for the base and sub base pavements (Limeira et al 2011). Also material from marine deposits around the coasts of Great Britain has been used in concrete production for several decades (Newman 1968). Chapman and Roeder (1968) found out in their research that the cylinder-splitting test results for all the mixtures made with sea aggregates fell within the range expected for any given compressive strength. There are indeed no real differences

as regards the mechanical properties of concrete made with sea sand and with river sand, provided of course that the same size fraction is used.

Chloride attack is one of the crucial aspects for consideration when the durability of sea sand replaced concrete is dealt with. The chloride ions present in sea sand, however, make its application potentially threatening to the durability of concrete structures (Huiguang 2011). The consideration of chloride content has drawn the scholarly attention because it is primarily responsible for chloride induced corrosion of reinforcement. Hence the current study was proposed to find an alternative to remove the chloride contents in sea sand. The authors were investigated the strength properties of sea sand replaced concrete where sea sand has been mechanically washed using hot water for the removal of chloride.

II. MATERIALS USED

Intensive material study was carried out and discussed below.

a) Cement

Ordinary Portland Cement (OPC) of 53 grade confirming to IS: 8112:1989, was used in this study. The cement used for the experiment programme was taken from a single lot in order to avoid variations in the properties of cement. The tests were carried out according to IS codes to find out the physical properties and are tabulated in Table 1

b) Fine aggregates

River sand passing through 4.75mm sieve was used. Physical properties of fine aggregate are as per IS: 2386-1997, and specification as per IS: 383-1970 and the results are given in Table 1.

c) Coarse aggregates

Coarse aggregates collected from approved quarry and aggregates having size ranging from 10mm to 20mm are used. The tests are carried out as per IS: 2386-1997 and the results are given in Table 1.

d) Water

Water used for the study is potable water collected from the site of study. The same water was used for mixing and curing of specimens.

e) Sea sand

Sea sand has been collected from Nagoor, Nagapattinam District with proper permission and approval obtained from the district collector of Nagapattinam District. The obtained Sea sand was tested for physical properties as per IS: 2386-1997, and specification as per IS: 383-1970 were tabulated in Table 1 and the results are compared with the river sand which has performed better than the river sand.

Table 1. Properties of Materials used in concrete

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S. No.	Properties	Binder	Fine Aggregate		Coarse Aggregate
		Cement	Sand	sea Sand	
1.	Specific Gravity	3.14	2.63	2.65	2.61
2.	Fineness Modulus	2.80	3.76	2.99	6.40
3.	Water Absorption	-	2.00	2.00	1.00
4.	Bulk Density	1400 kg/m3	1721 kg/m3	kg/m3	1674 kg/m3
5.	Consistency	30%			
6.	Setting Time Initial Setting Final Setting	 30 min. 225 min.			
7.	Compressive Strength 3 Days 7 Days 28 Days	 36.0 MPa 44.5 MPa 60.0 MPa			

The particle size distribution curve (Figure 1) shows that, the Sea sand contain more amount of finer particle than the river sand, it was an indication to get a good binding property and closer matrix in the hardened state of concrete.

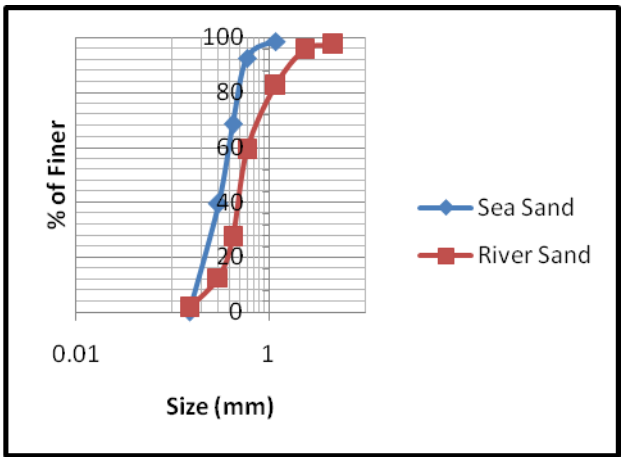

Fig. 1. Particle Size Distributions

The chemical composition of river sand and sea sand has been analyzed using X - Ray diffraction (XRD) method and the results were tabulated in the Table 2. In this we found

0.41% of chloride content which was the only disturbance factor in concrete while using marine sand as aggregate.

Table 2. Comparison of Chemical Properties

Elements	River Sand	Sea Sand
CaCo3	5.03	5.81
SiO2	79.7	75.41
Na	1.09	1.47
MgO	0.42	0.00
Al2O3	7.80	8.12
K	5.05	8.10
Fe	0.91	0.68
Cl	0.00	0.41

2.1 chloride removal by mechanical agitation using boiled temperature

Washing of sea sand was done by mechanical agitation to remove the chloride content. In this test, 600 grams of sea sand was mixed with 1000 ml of water and then the container is heated up to 100ºC. The mixture is vigorously agitated so as to leach out the salts present in the sea sand under the combined action of heat and agitation. The water was heated until the visible appearance of air bubbles. The chloride content in the water was measured before and after mixing with sea sand. The increase in chloride content of the water after washing is due to the salts which have been dissolved from the sea sand and this gives the solubility of chlorides from sea sand which resulted as 1.29%. The most commonly used limit for total chlorides is the 0.4% limit (by weight of cement) specified in BS 5328: Part 1: 1997 for reinforced concrete. Hence this removal makes the acceptable chloride level in concrete.

III. EXPERIMENTAL INVESTIGATION

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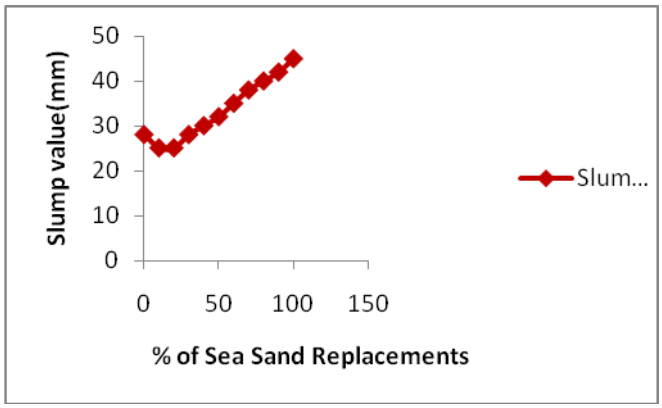
Mechanical properties of Sea sand based concrete were studied using varying percentage of replacement from 0 to 100% by the increment of 10%. M30 grade concrete has been designed as per IS 10262-2009 and super plasticizer CONPLAST SP 430 was used as admixture. Fresh and hardened concrete tests were done accordance with IS 516:1959. After 24 hours of casting, the specimens were de mould and kept in water for curing. The cubes, cylinders and prisms are cast in triple replicates from the same batch of concrete.

IV. RESULTS AND DISCUSSION

a) Slump Cone Test

Fresh concrete tests on workability are found using slump cone for all mixes. The sea sand samples showed acceptable workability in terms of ease of handling, trowelling, placement and finishing. It can be finished to the same standard as the conventional concrete without any difficulties. Figure 2 shows the flow of sea sand replaced concrete which were showing gradual increment in the slump value comparing the behaviour of conventional concrete but the slump factors of sea sand replaced concrete were well within the limit.



a) Compressive Strength

The compressive strength of concrete was determined at 7, 14 and 28 days of curing. Tests were carried out on 150mm x 150mm x 150mm size cubes. A 2000 kN capacity standard compression testing machine was used to conduct the test. The results of the compressive strength were shown in Figure 3. It is clearly visible from the Figure 3 that all the replacements of sea sand performed better than the conventional concrete. Further all the sea sand replacements produce a gradual and strong improvement in compressive strength in line with curing period. The 100% sea sand replacement which shows 26.56% higher compressive strength than conventional concrete. This increase in compressive strength achieved because of the finer particles of the sea sand which acted as a filler of voids in the concrete matrix and increases the compatibility of the concrete.

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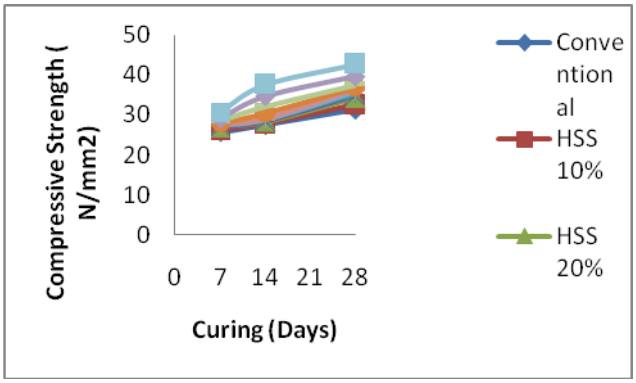
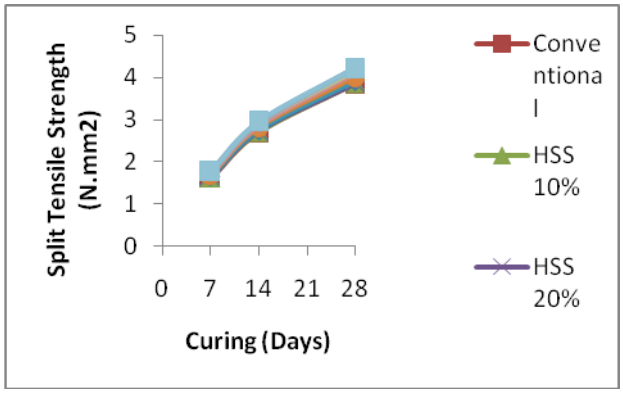


a) Split Tensile Strength

Split tensile strength was determined for 7, 14 and 28 days. The test was carried out on cylindrical specimens of 150 mm diameter and length 300 mm using 2000kN capacity compression testing machine. Figure 4 shows the results of split tensile strength of sea sand replaced concrete. It has been convincingly proved that all the sea sand replacements performance in the tensile strength is better than the conventional concrete. Here also 100% replacement provided 8.57% increase in tensile strength than that of conventional concrete.



d) Flexural Strength

The test was carried out on 100mm x 100mm x 500 mm size prisms using two point loading method. Maximum load applied to break the specimen and appearances of the fractured faces of concrete were noted. Figure 5 provides the result of flexural strength of sea sand based concrete. Here also all the sea sand replacement increases in flexural strength than the conventional concrete specimen.

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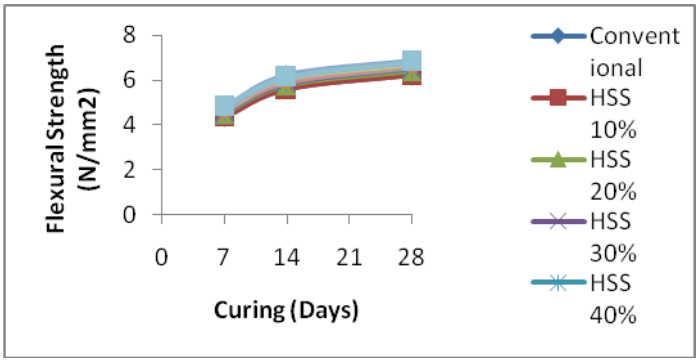

60% sea sand replacement set forth 9.36% higher flexural strength and 100% replacement produces 9.09% increase in flexural strength compared with the conventional concrete.

II. CONCLUSION

The sea sand replaced concrete were tested for various mechanical properties in this study and it was inferred the following:

Chloride content was removed up to 1.29% in the mechanical agitation method using 100ºC which satisfies the Indian Standard requirements.

Since higher percentage of finer particles are observed in the sea sand which promotes higher strength by filling voids of the concrete. Even though fineness has been higher that's not greatly disturbs the slump of the concrete.

Higher mechanical properties were observed in all the replacements of sea sand. Gradual and strong improvement has been identified in properties accordance with curing days.

Sea sand based concrete will be the good alternative for the river sand since 100% replacement of sea sand performed indispensably well in all the strength parameters.

Mining of river sand will be marginally reduced by substantiating sea sand that prevents lowering ground water table and conserves the environment in broad sense.

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