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Preliminary Study on the Development of Concrete with Sea Sandas Fine Aggregate

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Abstract

Background/Objectives: In this study, the construction industries expect a serious shortage of sand in the near future due to over exploitation of river sand. This paper deals with the use of sea sand as substitute for conventional river sand. **Methods/Statistical Analysis:** M20 concrete mix was designed with sea sand as fine aggregate and the workability, strength in compression and split tension and water absorption characteristics are determined and compared with conventional concrete. **Findings:** The sea sand, as available, is inferior to conventional river sand but proper washing for two times make it feasible for making concrete. For M20 grade concrete, two times washed sea sand can be used as fine aggregate totally replacing river sand as the workability and strength characteristics reach within the limits of acceptable level. Sea sand utilization is cost effective in coastal line construction.

Keywords: Alternative to River Sand,Sea Sand, Sea Sand Concrete, Strength

1. Introduction

The human settlements are always around the water streams like river, lake, waterfalls and sea shore. The free open sand mine, vast space and the fishing related activities make the communities settle close to sea. Actually two-thirds of the world's populations, at present, survive in the close proximity to **shorelines and l**ikely, 10% of the world's population (about 600 million people) lives in the vulnerable areas of the coastal line. India has a coastline of about 5400km of mainland and nearly a quarter of the country's population lives within 50km of the coast[1]. A wide range of coastal ecosystems such as mangroves, sea grass beds, coral reefs, tidal flats, estuaries, lagoons, sand dunes and salt marshes are found along the coast. The escalation of material cost brought much more problems in constructions and all the construction materials are to be transported from inland to the coastal site of construction. Therefore, many countries tried to use sea based sand instead of river sand for making concrete in coastal construction activities. Sand dunes can supply aggregate sand for use as fine aggregate in concrete.

The Villupuram, Cuddalore and Nagapattinam districts of Tamil Nadu in India has about 245km coastal line which has experienced comparable loss of lives and properties during the Indian Ocean Tsunami of December 2004. The government and the NGOs have tried for recovery and made rehabilitation measures to the affected coastal community. Construction activities are also critical in the coastal regions. However, the identified problem of construction activities is the scarcity of construction materials particularly the river sand[2].

2. Alternatives to River Sand

Investigations were carried out[3] to establish the feasibility of making concrete using soil as fine aggregate in place of river sand and reported that for M25 concrete, the compressive strength of soil concrete is 21% lower, split tensile strength of cylinder is 33.8 % lower and flexural

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strength of beam with soil concrete is 14 % higher than sand concrete. It was concluded that the properties of local soil were as good as the regular river sand and proved that it can as well be used as fine aggregate in the production of concrete in lieu river sand.

After a thorough study on the chloride content of offshore sand in Sri Lanka[4] reported that offshore sand saturated with sea water has Cl- content around 0.3%, where as if the seawater is gravity drained; it reduced to around the acceptable 0.075% and concluded that an average rain fall would be enough to reduce the Cl- contents below the acceptable levels. The relevant properties of offshore sand obtained soon after dredging are tested and reported[5] that washing of offshore sand is not required particularly to remove organic matter and other contaminates, the grading of the offshore sand is within the limits specified in BS882:1992 and the compressive strength of M25 grade concrete is also with the acceptable limits**.** Experimental study was conducted to consider suitability of local sea sands of Sri Lanka for concrete production from the perspective respect of aggregate and concrete properties for efflorescence, durability and strength development[6]**.** It is concluded that most local sea sand is suitable for concrete production, normal or water retaining and site locations can be identified where sea sand mined can be used directly without washing also, most sea sands can be used after washing to remove salt contaminates. High density and hard concrete using sea water and unwashed sea sand was developed[7] and reported that the internal organizations were denser compared with normal concrete and the water tightness, early strength and long term strength also were increased.

Survey has been made of sand dunes of Indian coastal line[8] and found that coastal dunes of the Chennai region are wide and dunes of the Pondicherry and Portonovo regions are narrower and high up to 10m. The popular tourist centre of Tamil Nadu, Pichavaram has ancient stabilized dunes and they are peculiarly shaped due to the water occupying interdunal depressions or swales. Sand dunes can supply aggregate sand for use as fine aggregate in concrete.

The properties of sea water and unwashed sea sand concrete (concrete and mortar made using a combination of sea water, unwashed sea sand, fly ash, silica fume, and calcium nitrate) were investigated and observed[9] that the early strength of sea water and unwashed sea sand concrete (total chloride ion content: 4.5 kg/m^3) is high, and long-term strength is retained at a higher level. The literature survey made on the utilization of sea sand and sea water are realized that chloride content is the main problem and established that,

- Most sea sand can be used after washing to remove salt contaminates.
- Locations can be identified where sea sand mining can be directly without washing.
- Chloride levels of offshore sand found to lower when fresh water drained to simulate average monthly rainfalls
- For an isolated island, the use of sea water and unwashed sea sand contributes to production for local consumption, reduces the construction and material transportation cost, and reduces the CO_2 emissions.
- If non-metallic reinforcements are used, there may not be durability problem of corrosion.

Coastal countries have initiated the research for using sea sand and off shore sand instead of conventional river sand for concrete constructions. But the feasibility of using available sea sand is not fully recommended due to solid contents and saline nature. Further, there are lot of variations in the properties like specific gravity, fineness, etc., for different countries and locations. Therefore, there is a need to conduct investigation on the utilization of sea sand as fine aggregate in concrete. As the problem is somewhat a localized investigations have to be made then and there. If the sea sand use is made feasible and viable, it shall be great contribution to the concrete industries.

3. Experimentation

The test program consists of casting and testing of concrete specimens of cube (100mm) and cylinder (100×200mm) to determine the compressive and tensile strength respectively. The specimens are cast using M20 grade concrete for four different types of sand (river sand and sea sands). Using IS method, Portland pozzolana cement (43 grade Chetty Nadu brand), sea sand, natural river sand and the crushed maximum size 12.5mm coarse aggregate are used. The determination of material properties of the constituent materials is made as per the relevant IS Standards[10,11].

The sea sand is collected from three different locations along the east coast in Nagai district. About 10 gm from every sample is taken in a bowl and 400 ml of water is

added and kept for 18 hours. After 18 hours of immersion as first washing, the water sample is tested for its pH value, saline and sulphate contents, hardness and Total Dissolved Solids (TDS). The sample is again washed and tested in a similar manner. The results of repeated washing are shown in Table 1. The details of the constituents are given in Table 2 and the mix proportions are given in Table 3. Concrete is prepared for the four different mix proportions namely one River Sand Concrete (RSC) and three different sea sand concrete (SSC1, SSC2 and SSC3) and tested for workability, strength[12–14] and water absorption characteristics. The test results are compared as given in Table 4. The compressive strength of the various concrete is compared in Figure 1.

4. Discussion

The washing of sea sand is effective and in two washings, the requirements have reached the safer limits as presented in Table 1. As the particle size is finer compared to river

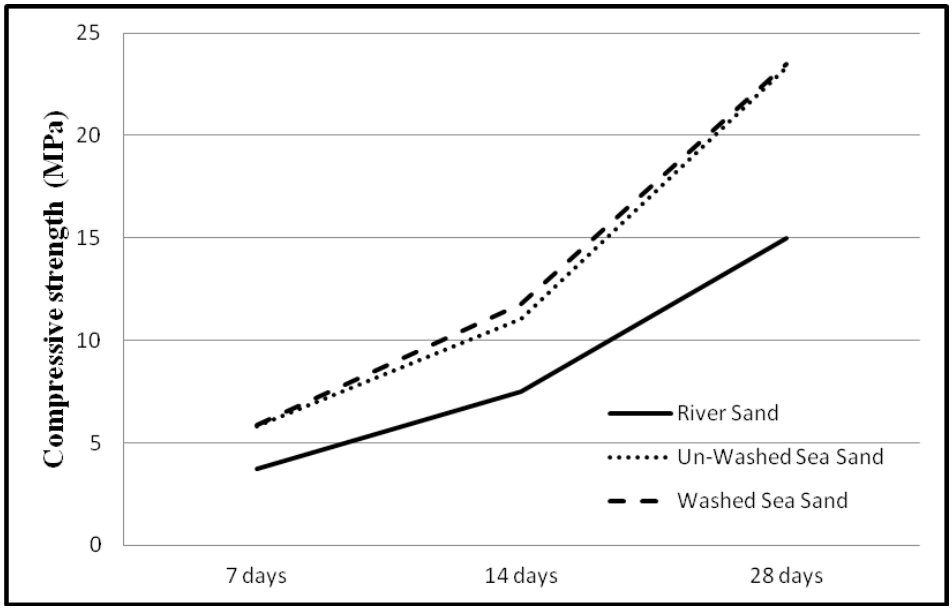

Figure 1. Block diagram of the proposed algorithm.

Table 1. Test results for Sea sand in washing

Sample	No. of Washing	pH value	Sulphat mg/l	Chloride Content mg/l	Hardness mg/l	TDS*
1	First	7.29	69	1312	415	1401
	Second	7.32	24	86	34	123
2	First	7.38	46	1099	590	1648
	Second	7.51	19	98	67	169
3	First	7.43	28	970	623	1307
	Second	7.35	07	76	109	53
Limiting value		>7	<400	<1000	<600	<2000

*TDS Limit For Drinking is <500 and <2000 for mortar and concrete making

Table 2. Properties of concrete constituents

Parameters	Cement	River sand	Sea sand samples			Coarse aggregate
			1	2	3	
Grade	43	-	-	-	-	-
Fineness		-	-	-	-	-
Specific gravity	3.15	2.67	2.63	2.60	2.61	2.70
Unit weight kg	-					
Fineness modulus	-	3.27	2.32	2.27	2.30	6.50
Water absorption %	-	0.41	0.64	0.63	0.60	
Crushing/impact value	-	-	-	-	-	6.1%/6.3%

Table 3. Mix proportions and quantities of constituents

No	Details	Trial Mix(1:2:4)			
		RSC	SSC1	SSC 2	SSC 3
1	Cement kg/m^3	320	325	350	375
2	Sand kg/m^3	761.60	793.00	857.50	926.25
3	Jelly kg/m^3	1523.20	1586.00	1715.00	1852.50
4	Water added kg/m^3	497	425	373	331
5	Admixture %	1	1.2	1.4	1.6

Table 4. Test results of concrete

No	Concrete type	Trial Mix	Slump mm	Compressive strength* MPa			Tensile strength* MPa	Water absorption %
				Target	7days	28 days		
1	Conventional	RSC	51	25.94	19.4	27.6	2.56	0.194
2	Sea sand based	SSC1	64	26.10	17.3 (11%)	23.6 (14.5%)	2.33	0.171
3		SSC2	57	26.20	16.7 (14%)	25.3 (8%)	2.51	0.165
4		SSC3	60	26.60	17.8 (8%)	24.2 (12%)	2.43	0.181

*Average of three

sand, the sea sand concrete is more workable. However, as sea sand is fine, the mix proportions vary compared with river sand. The conventional river sand concrete RSC reached the target strength but the SSCs did not. The compressive strength of sea sand concrete is 8-14% less when compared to conventional concrete. However, the characteristic strength is reached in all cases.

5. Conclusion

- The sea sand as available is inferior to conventional river sand but proper washing for two times make it feasible for making concrete.
- For plain concrete, sea sand without washing can be used.
- In fact, being very fine in quality, workability is very good when sea sand is used in concrete.
- Mix design process, casting techniques, curing methods are similar to conventional concrete.
- For M20 grade concrete, two times washed sea sand can be used as fine aggregate totally replacing river sand as the workability and strength characteristics are acceptable within limits.
- Sea sand utilization is cost effective in coastal line construction.
- However, the study of corrosion resistance like durability characteristics and possibilities of using sea sand for higher grades of concrete in both reinforced and prestressed concrete should be carried out.

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