Exploring the Innovative use of Dredged Material in Construction

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Abstract* - In present times, a large quantity of marine sediments is dredged from harbours and seaports for construction of the marine structures and for maintenance of the shipping channels. The dredged soil requires large area for its disposal. It is recognized that the offshore dumping of dredged soil causes disruption to the aquatic environment. This project addresses use of the dredged marine soil as a sustainable material for the construction activities, with main focus on "dredged material in partial replacement of fine aggregate in concrete" and "soil stabilization". These may thus minimise the area of land required for disposal impoundments and also meet part of the growing demand for increasingly scarce geo resources. For this study, the dredged sand was collected from Neendakara port, Kollam. The study on partial replacement of fine aggregate in concrete involves determination of physical properties of constituent materials, compressive strength test, flexural strength test, water absorption test, alkalinity test and durability test on M30 mix concrete with fine aggregate replaced in proportions of 0%, 10%, 20%, 30%. For the analysis of soil stabilisation using dredged material, weak soil was collected from marshy land in Omalloor ,Pathanamthitta. Sieve analysis, hydrometer tests, specific gravity and Atterberg limits determination were performed for the classification of the soils. Standard Proctor tests were performed to understand the compressibility behaviour of the soils and finally, unconfined compression tests are performed for the determination of the effective dredged sand proportioning in stabilization process.

Keywords: Dredged sand, partial replacement, Compressive Strength, Flexural Strength, Tensile strength, Water Absorption, Alkalinity, Compressibility, soil stabilization

I. INTRODUCTION

To meet the ever rising demand for fine aggregate in the construction industry, river sand has been exploited unconditionally in various parts of our country. This has led to various environmental issues. Hence we have to restrict river sand mining, mainly from rivers in which water level is decreasing. As a remedial measure, the government has imposed various restrictions on the extraction, but all of these leads to instability of the construction industry and has led to researches in developing alternate materials.

Worldwide millions cubic metres of material are removed each year from ports, harbours and waterways in order to optimise navigation, remediation and flood management. The disposal of this dredged material is often one of the greatest challenges facing a dredging project. Over the last few decades, however, research and experience have shown that dredged material can be reused and is not inevitably a waste to be disposed. Dredged material can be used beneficially, for instance, for environmental improvements, raw material in construction industry and for stabilisation purpose. When a use purpose is not an option, disposal alternatives must be considered and their destination on land or at sea may become controversial. Since 90 percent of dredged material is clean, use options can usually be found proper treatment and studies during the planning of the project.

This paper focuses on the extent of study of using off shore sand "as a partial replacement of the fine aggregate in concrete" (Analysis - 1) and for "the stabilization of subgrade soil"(Analysis - 2).

II. OBJECTIVES

- Carry out studies for utilization of dredged sand to reduce net expenditure on maintenance dredging.
- Conduct analysis for utilization of dredged sand as a partial replacement of the fine aggregate in concrete.
- Conduct analysis for utilization of dredged sand for the stabilization of subgrade soil.

III. MATERIALS AND METHODS

A .Raw Materials

Dredged sand, M sand, Ordinary Portland cement and aggregates (fine and coarse aggregates) are the materials used. The offshore dredged sand for this study was collected from Neendakara Port, Kerala, which was dredged from the sea bed around 2 Km of the shore. The cement used is Ordinary Portland cement of Grade 53. The collection of M sand and course aggregate of size 20mm was from Pathanamthitta.

The properties of all materials including cement, coarse aggregate, fine aggregate, dredged sand and normal soil were tested. For the Analysis - 1,the following properties as shown in the table 1 are found out.T he specific gravity of cement was obtained using Le- Chatliers flask and the value obtained was 3.06. The gradation of Coarse aggregate, Fine aggregate and Dredged Sand was determined using Sieve Analysis. The Coarse and Fine

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aggregate was found to be well graded while dredged sand was gap graded. The gradation curves is as shown in the figures 1,2,3. Bulking test for both fine aggregate and dredged sand was conducted. Graphs were plotted percentage of water added and percentage of bulking. In both the cases standard curves as shown in figures 4 and 5 were obtained. From the bulking graph maximum bulking occurred at 4% addition of water. The analysis of individual material properties help us to understand its behavior in concrete.

Table 1 Material Properties

Property	Coarse Aggregate	Fine Aggregate	Dredged Sand
Bulk Density	1500 kg/m^3	1810kg/m^3	1628 kg/m^3
Void Ratio	0.86	0.207	0.45
Porosity	46.3 %	17 %	31.08%
Specific Gravity	2.77	2.59	2.53

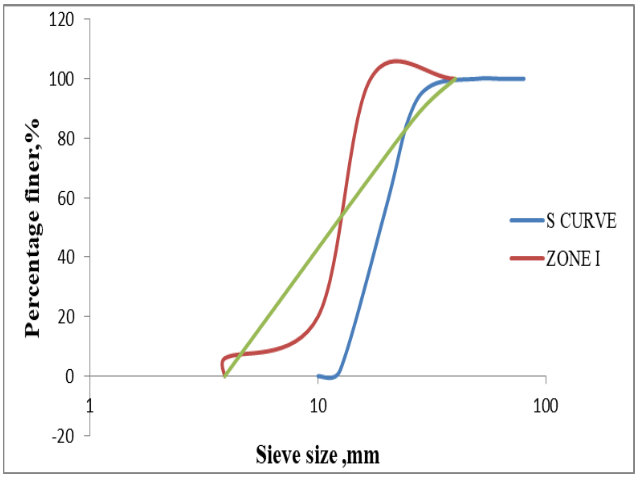

Fig.1 Gradation of Coarse aggregate

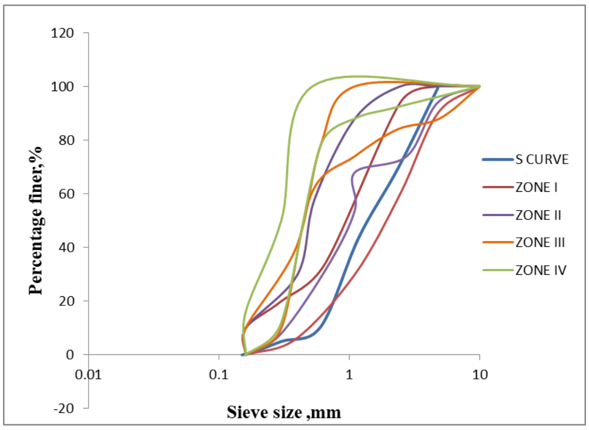

Fig.2 Gradation of Fine aggregate

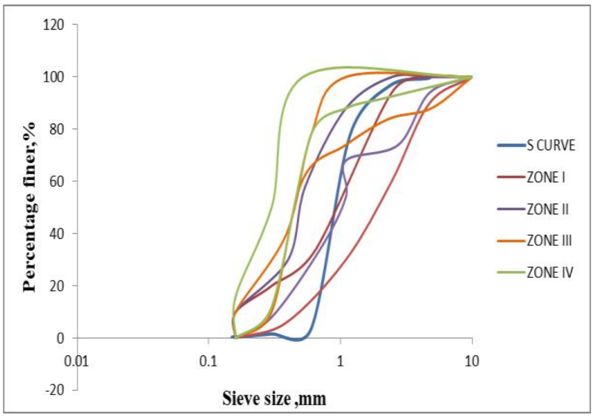

Fig.3 Gradation of Dredged sand

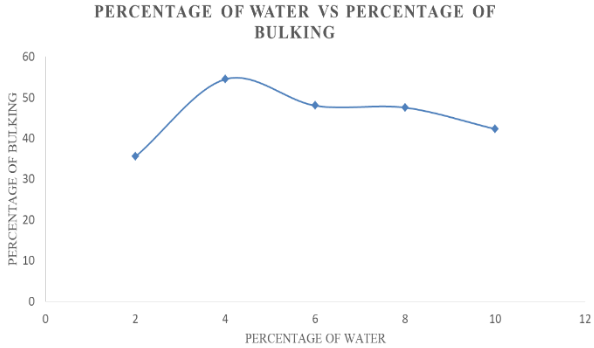

Fig.4 Bulking of Fine aggregate

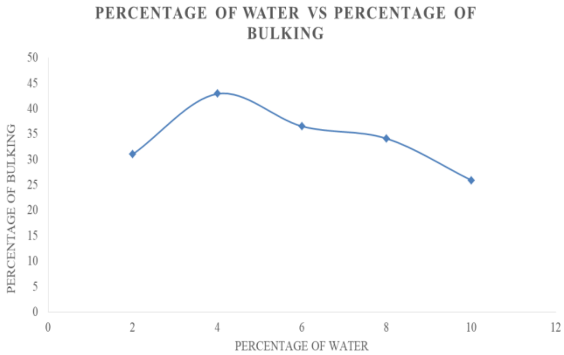

Fig.5 Bulking of Dredged Sand

The chloride content of dredged sand was tested. Maximum chloride content of 0.075% by weight of sand could be deemed acceptable for all reinforced concrete work using a 20 mm maximum aggregate size and Portland cements. The obtained chloride content was 32.49 mg/l and this is within the permissible limit**.**

The study of soil stabilization using dredged sand (Analysis – 2) involved collection of weak soil from marshy land in Omalloor, Pathanamthitta. It is brought to the lab and is dried in oven for 24 hours in large pans. This soil due to loss of water formed big lumps which is broken to smaller pieces or even fine powder and is sieved according to the needs of different experiments.

For Analysis – 2,the experimental programmes conducted are particle size analysis, Atterbergs limits and

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compaction. The physical properties of natural soil and dredged sand were tested and are shown in table 2.

Table 2 Soil Properties

Sl. No.	Particulars	Natural soil	Dredged sand
1.	Specific gravity	2.34	2.53
2.	Liquid limit	51 %	44%
3.	Plastic limit	32.04 %	-
4.	OMC	22.1 %	28.57%
5.	Maximum dry density	1.654 g/cc	1.462 cc

B. Methodology

In the Analysis - 1,the M sand was partially replaced by the proportions of dredged sand shown in the table 3.

Table 3 Specimen Details

Sl.No	Specimen Id	Specimen Details
1.	100 – MS	Normal concrete using M Sand
2.	10 – DS	10 % replacement of MS by DS
3.	20 – DS	20 % replacement of MS by DS
4.	30 – DS	30 % replacement of MS by DS

The concrete mix used was M30 designed according to IS 10262-2009. Water cement ratio was 0.45. Identification details are given in Table 3.

From the experiments conducted in Analysis – 2, the effective dredged sand proportioning in stabilization process was find out. The different mixes are presented on table 4.

Table 4 Soil Proportions

Sl.No	Mix	% of soil	% of dredged sand
1.	S_1	100	0
2.	D_1	100	0
3.	SD_{10}	90	10
4.	SD_{20}	80	20
5.	SD_{30}	70	30
6.	SD_{40}	60	40

IV . RESULTS AND DISCUSSIONS

A. Compressive Strength ,split tensile strength and flexural tensile strength

The cube specimens of normal concrete and cubes with 10%, 20%, 30% replacement of fine aggregate were casted. The specimens were made using 53 grade OPC cement, M sand Dredged sand, 20mm coarse aggregate. From the results obtained, it was observed that the compressive strength of concrete using DSS as partial replacement is satisfactory up to 30% replacement.

In case of split tensile strength and flexural strength the results were satisfactory in all proportions. The results of various tests are shown in Table 5 and graphical representation of compressive strength is shown in figure 6.

Table 5 Test Results

Mix	Compressive Strength (N/mm^2)	Split tensile Strength (N/mm^2)	Flexural Strength (N/mm^2)
100 - MS	39	3.11	6.37
10 - DS	44	5.7	6.79
20 - DS	46.55	6.31	7.41
30 -DS	42.21	5.18	5.95

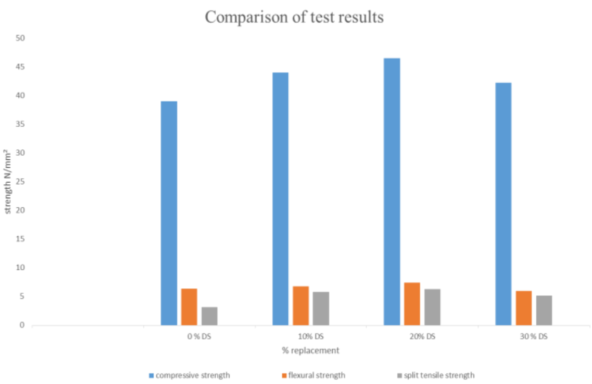

Fig.6 Comparison Graph

B. Water absorption test on cubes

The percentage of water absorbed by various specimens was determined and the results are shown in Table 6.

Table 6 Water Absorption Results

Mix	Water absorption
10% replacement of fine aggregate	1.88%
20% replacement of fine aggregate	2.3%
30% replacement of fine aggregate	2.59%

C. Alkalinity test

Alkalinity of water is a measure of its capacity to neutralize acids. The alkalinity of different samples was calculated. Table 7 below shows the alkalinity test result of concrete samples after 28 days of curing. The samples with cement mortar and water for kept aside to settle and the pH of the supernatant was found out. This gives the alkalinity values. The alkalinity of concrete must be within the range of 9 to 12 as per ASTM D 4262. All the obtained values found to be within the permissible limit.

Table 7 Alkalinity results

Mix	Alkalinity in pH for concrete
10% replacement of fine aggregate	10.69
20% replacement of fine aggregate	10.45
30% replacement of fine aggregate	11.34

D. Durability of Concrete

The Compressive strength of cube specimens after immersing in HCl solution for 56 days. There is a decrease in weight and compressive strength of concrete specimens after immersing in HCl solution. But the variation is under permissible limit and so it can be considered durable.

Table 8 Durability results

Mix	Weight(kg)	Loss Weight (kg)	Compressive Strength (N/mm^2)
10% replacement	8.73	8.620	42.66
20% replacement	8.78	8.610	44.88
30% replacement	8.70	8.50	32.88

E. Test result of Analysis -2

The results of various tests conducted on soil specimens are given below in Table 9.

Table 9 Soil Test Results

Sl. No	**Particulars**	SD_{10}	SD_{20}	SD_{30}	SD_{40}
1.	Liquid limit (%)	54	42	20	4
2.	Plastic limit (%)	29.58	31.50	33.33	34.18
3.	OMC (%)	22.22	22.15	25	16.66
4.	Maximum dry density (g/cc)	1.448	1.68	1.612	1.868

F. UCC Test Results

UCC test gives the compressive strength of soil. In this test the specimen with 20% replacement gave the best results. All the values are given in table 10. The comparison graph is given in figure 7.The results of UCC test gives an idea about variation in the strength of soil with and without addition of dredged sand.

Table 10 UCC Test Results

Sl. No	**Particulars**	**Unconfined Compressive Strength (N/mm^2)**
1	Soil	12.17×10^{-3}
2	Soil with 10% DS	32.3×10^{-3}
3	Soil with 20% DS	44.65×10^{-3}
4	Soil with 30% DS	30.28×10^{-3}
5	Soil with 40% DS	30.09×10^{-3}

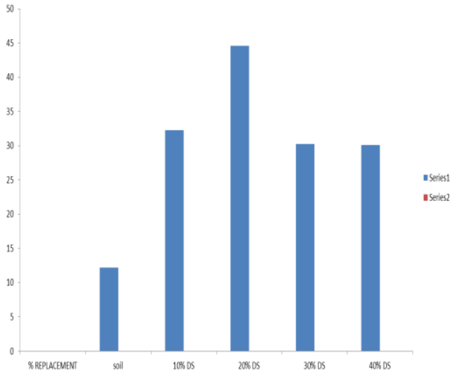

Fig 7 Comparison graph of UCC results

V. CONCLUSION

- Partial replacement of fine aggregate in concrete with dredged sand showed increase in compressive strength, flexural strength and split tensile strength.
- 20% replacement showed peak values among other proportions.
- Water absorption increased with increasing percentage of dredged sand.
- Alkalinity was within the permissible limit for all proportions.
- Effectiveness of replacement can be found out by carrying out durability test.
- For soil stablisation, 20% replacement showed considerable increase in unconfined compression strength.

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