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. The 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
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/m³       | 1810 kg/m³     | 1628 kg/m³   |
| Void Ratio      | 0.86             | 0.207          | 0.45         |
| Porosity        | 46.3 %           | 17 %           | 31.08 %      |
| Specific Gravity| 2.77             | 2.59           | 2.53         |

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
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 density | dry          | 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**

| SLNo  | 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**

| SLNo | Mix | % of soil | % of dredged sand |
|------|-----|-----------|-------------------|
| 1    | S1  | 100       | 0                 |
| 2    | D1  | 100       | 0                 |
| 3    | SD20| 90        | 10                |
| 4    | SD30| 80        | 20                |
| 5    | SD40| 70        | 30                |
| 6    | SD50| 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/mm²) | Split tensile Strength (N/mm²) | Flexural Strength (N/mm²) |
|-----------|-------------------------------|--------------------------------|---------------------------|
| 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                      |

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/mm²) |
|-----------------------------------|------------|------------------|------------------------------|
| 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 | SD10 | SD20 | SD30 | SD40 |
|--------|-------------|------|------|------|------|
| 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/mm²) |
|--------|-------------|----------------------------------------|
| 1      | Soil        | 12.17 x 10³                             |
| 2      | Soil with 10% DS | 32.3 x 10³                             |

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 stabilisation, 20% replacement showed considerable increase in unconfined compression strength.

REFERENCES

[1]. ATHIRA SS, NEETHU S (2016) “Strength and Durability of Concrete using Dredged sand as partial replacement of M sand” International Research Journal of Engineering and Technology, e-ISSN: 2395 -0056, Volume: 03 Issue: 09, pg 1072-1075
[2]. GIRISH C. G, TENSING D AND PRIYA K. L (2015) “Dredged Offshore sand as a replacement for Fine aggregate in Concrete” International Journal of Engineering Sciences & Emerging Technologies,. ISSN: 22316604 Volume 8, Issue 3, pp: 88-95 ©IJESET 88
[3]. DR. M. B. VARMA, S. B. MAGARE (2015) “Comparative study of self compacting Concrete using artificial crushed sand with conventional concrete without using artificial crushed sand” Journal Of Information, Knowledge And Research In Civil Engineering ISSN: 0975 – 674 | Volume 3, Issue 2 Page 164
[4]. LINDSAY A. MURRAY (2015) “Dredged material as a resource” PIANC Working Group , Pg 3-10
[5]. LIMEIRA J, ETXEBERRIA M, AGULLO L, MOLINA D. (2011), “Mechanical and durability properties of concrete made with dredged marine sand” Journal of Construction and Building Materials. ; 25:4165-4174.
[6]. EWMAN K (1968). “Aspects of workability, strength, shrinkage and creep, sea dredged aggregates for concrete”, Proceedings of a Symposium, Sand and Gravel Association of Great Britain, Buckinghamshire.

[7]. TAJAMUL ISLAM, ER. SUHAIB FIRDOUS, ER. IRTIQA (2018) “Alteration of Dredged material from Jhelum flood spill channel using cement and lime as binder for its potential application in sub-grade”ISSN: 2455-2631 © IJSR | Volume 3, Issue 5 IJISDR1805087 International Journal of Scientific Development and Research (IJSDR) www.ijsdr.org 577