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A Study on Stabilization of Marine Dredged Soil Using Quarry Dust

Anjana Prakash[1], Anju Paul[2]

[1]PG Student, Department of Civil Engineering, Toc H Institute of Science and Technology, Arakkunnam, Ernakulam, Kerala, India
[2]Faculty, Department of Civil Engineering, Toc H Institute of Science and Technology, Arakkunnam, Ernakulam, Kerala, India

Abstract: ***In India large quantity of marine sediments is dredged from harbors 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. The marine dredge soil cannot be used in the valuable construction process because it exhibits properties such as low shear strength, high natural water content and high compressibility. This paper aims to reuse the dredged marine soil as a sustainable material which is economical for the construction activities. Attempts were made to stabilize the dredged soil for the different applications such as embankment construction, road construction and for landfill. This study investigates the potential reuse of the dredged soil for the road construction. This paper describes a study to solidify the dredged marine sediment by using quarry dust. Quarry dust is a waste product generated from the aggregate production could replace some proportion of soil for the improvement of geophysical properties of the soil. This project made an attempt to evaluate the effectiveness of using quarry dust in modifying the properties of marine sediments, by the means of laboratory tests to assess the compatibility of modifying the marine dredge soil as a construction material for the road construction.***

Keywords: Dredged marine soil, Quarry dust, Stabilization, Unconfined Compressive Strength, California Bearing Ratio

1. Introduction

Dredging is an activity of removing the sediments from the bottom portion of the rivers, lakes and sea beds. Dredging process is necessary for the development activities of the coastal region. Dredging is an activity carried out for the purpose of the construction of the port facilities and for the maintenance of existing shipping channels by removing the sediments from the bottom of the sea, lake and river. Due the dredging operation large amount of sediments are generated , which cannot be used for the construction activities because of its poor geophysical properties such as high water content, presence of organic matter and salt. The offshore dumping of the drudged marine soil causes many negative impacts on the marine ecosystem and the environment. Such open dumping also causes the long term damaging pollution due to the contamination of the heavy metals such as hydrocarbons which release the contaminants to the surrounding environment. For the improvement of mechanical and geophysical properties of dredged soil, stabilization technology can be adopted. If the dredged soil is used for any beneficial reuse then the environmental impact due to the open disposal of the dredged soil can be avoided. The typical characteristics of the dredged soil are fine grained soil type and they generally consist of clay and silt sized particles. Due to the properties such as high compressibility and low bearing capacity, it cannot be used for any civil engineering applications such as road construction and back filling activities. So some attempts have been made to the modification of the properties of the dredged marine clay with quarry dust, it seen that it reduces compressibility and increases shear strength. As the treated material has improved strength, it is suitable for used in various civil engineering applications. The focus of this study is to examine the suitability of quarry dust in the stabilization of marine dredge soil.

1.1. Literature Review

Dredged marine soils are treated with Portland cement results the increase in the strength properties. The cement addition to the dredge sediments increases the CBR value. The cement stabilized sediments can be used for different applications especially for the road sub grade construction. The addition of 20% cement results in the increase in strength of the dredged soil suitable for the engineering applications [1]. The addition of 6% of cement to the marine dredge soil is suitable for the construction of foundation and base layer of road construction [2]. The CBR value found to be increasing when the marine dredged sediment treated with fly ash and cement [3].

Steel slag addition to the marine dredge soil found to be increases the unconfined compressive strength by three times than that of the untreated soils. The compressive strength and shear strength are found to be increasing when treated with the activated steel slag in different mix proportions [4], [5]. Quarry dust addition to the expansive soil results in the increase in strength of soil due to its better interlocking properties. Quarry fine addition of 30% to the laterite soil increases its strength so as to use in the road base construction [6], [7]. The improvement of clay using the addition of quarry dust results in the suitability of use in flexible pavements. The addition of quarry dust increases the California bearing ratio which reduces the thickness of pavement and also arrests the swelling nature of the soil [8]. The quarry dust addition causes the increase in MDD and decrease in OMC in the expansive soil. By the addition of quarry dust to the expansive soil results in the increase in the angle of internal friction and decrease in the cohesion [9].

1.2 Methodology

In the first phase of the project the literatures about stabilization of marine dredge soil were studied. In this phase the journals related to the stabilization using the quarry dust

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in different soils and the applications of marine dredge sediments were studied. From the reviewed literatures and studies, the objectives were selected considering the scope of the project. In the second stage of the project the samples were collected and different mix proportions are selected such that the percentage of quarry dust varying from 0% to 60%. In the third phase of the project different laboratory tests were conducted on the selected quarry dust - dredge soil mixes. In the fourth phase results obtained from the tests were interpreted and the final mix was selected.

2. Materials and Methods

The marine sediments studied in this research were dredged from vallarpadam, Ernakulam. The dredging was carried out at a depth of 5-8 m below the sea water level. The samples collected from this depth were greenish black in colour, presence of organic matter like sea shells and undesirable smell. The quarry dust is selected from the nearest source as raw materials without any processing of the dust from the quarry. The quarry dust is the by-product which is formed in the processing of the granite stones which broken downs into the coarse aggregates of different sizes. The Specific gravity of the quarry dust depends on the nature of the rock from which it is processed and the variation of specific gravity is less.

The experimental programme consists of particle size analysis, atterbergs limits and compaction. The tests were conducted for determining the properties of natural soil and the results are shown in table number 1.The physical properties of quarry dust were tested and are shown in table number 2. The California bearing ratio test and unconfined compressive strength tests were conducted on the natural and stabilized soil specimens. Samples are collected and then air dried prior to the tests. Soil mixes were prepared by adding 10% to 60% quarry dust by the weight of soil.

Table 1: Properties of marine dredged soil

Property	*Value*
Natural water content	62%
Specific gravity	2.53
Liquid limit	70%
Plastic limit	28%
Plasticity Index`	56%
% of Clay size particles	56%
% of Silt size particles	44%
Unconfined Compressive Strength	18.5kN/m^2

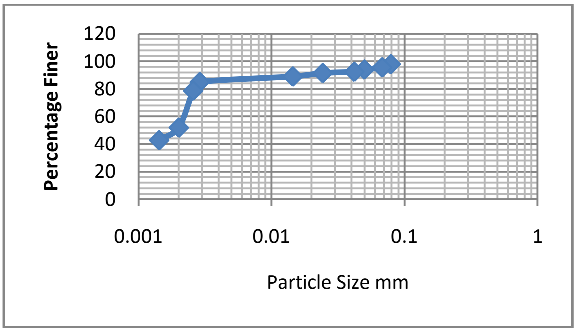

Figure 1: Grain size distribution curve of drudge marine clay

Table 2: Properties of marine quarry dust

Property	*Value*
Specific gravity	2.63
Gravel	1%
Sand	93%
(i)Coarse Sand	30%
(ii)Medium sand	50%
(iii)Fine Sand	13%
Silt and Clay	6%
Soil Classification as per IS	Medium sand

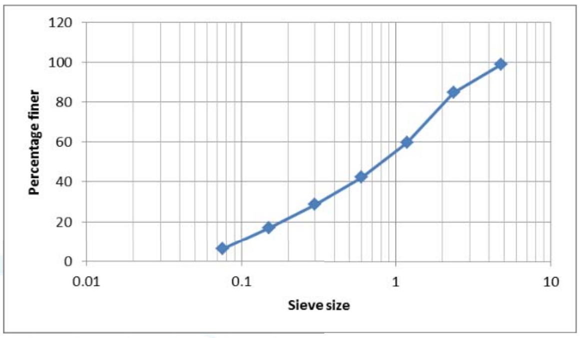

Figure 2: Grain size distribution curve of drudge quarry dust

Different mixes were selected by adding quarry dust in proportions of 0% to 60% by weight of the soil. The different mixes are presented on table number 3.

Table 3: Selected mixes

Sl no	*Mix*	*% of Sand*	*% of Quarry dust*
1	S_1	100	0
2	SQ_{10}	90	10
3	SQ_{20}	80	20
4	SQ_{30}	70	30
5	SQ_{40}	60	40
6	SQ_{50}	50	50
7	SQ_{60}	40	60

3. Result and Discussion

3.1 Determination of Liquid Limit, Plastic Limit and Plasticity Index

Table 4: Liquid Limit, Plastic Limit and Plasticity Index

Mix	*Liquid limit(%)*	*Plastic limit (%)*	*Plasticity Index (%)*
S_1	70	28	42
SQ_{10}	67	27	40
SQ_{20}	62	25	37
SQ_{30}	56	25	31
SQ_{40}	51	23	26
SQ_{50}	47	21	26
SQ_{60}	44	20	24

Addition of quarry dust to the dredged marine soil results in the decrease in the consistency limits and the plasticity index of the soil. The addition of quarry dust increases the coarse sized particles thereby decreasing the clay proportion needed for the bonding of resulting particle.

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3.2 Optimum Moisture Content and Maximum Dry Density

Table 5: Optimum moisture content and maximum dry density

Mix	*OMC (%)*	*MDD g/cm³ Kg/cm³*
S_1	23.2	1.49
SQ_{10}	21.2	1.66
SQ_{20}	18.9	1.83
SQ_{30}	17.2	1.9
SQ_{40}	13.2	1.99
SQ_{50}	11.4	2.11
SQ_{60}	11	2.05

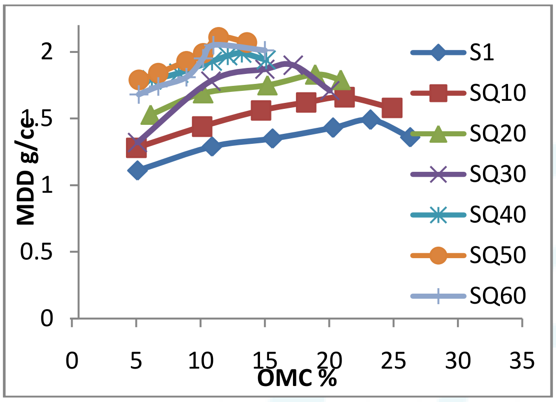

Figure 3: OMC versus MDD graph for different mixes

The data from the test indicates that the optimum moisture content of the stabilized sediments are less than that of raw sediments. Quarry dust added to the raw sample in different mix proportions such as 0%, 10%, 20%, 30%, 40%, 50% and 60%. .Addition of quarry dust leads to the increase in the maximum dry density and decrease in the optimum moisture content. The optimum moisture content decreases from 23.2 % at 0% quarry dust to 11.4% at 50% quarry dust addition. The maximum dry density increases from 1.09 kg/cm³ to 2.11 kg/cm³ by the addition of quarry dust from 0% to 50%.

3.3 Unconfined Compressive Strength

In this test, a cylindrical soil specimen usually 3.8 cm in diameter is subject to an axial compression without any lateral confining pressure. The unconfined compressive strength q_u is defined as the compressive load per unit area at the time of failure of soil sample.

Table 6: Unconfined compressive strength

Mix	*Unconfined Compressive Strength kg/cm²*	*Cohesion kg/cm²*
S_1	0.184	0.092
SQ_{10}	0.268	0.134
SQ_{20}	0.371	0.186
SQ_{30}	0.416	0.208
SQ_{40}	0.498	0.249
SQ_{50}	0.59	0.295
SQ_{60}	0.52	0.26

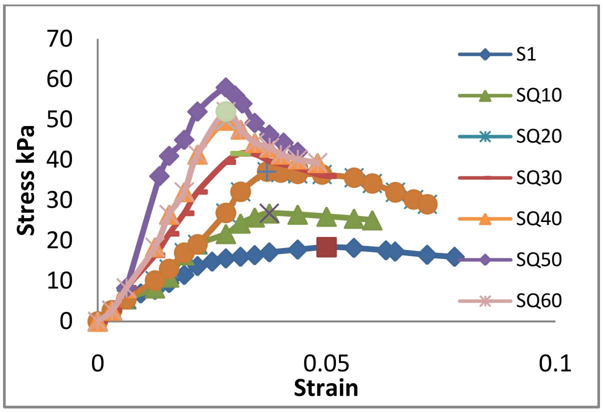

Figure 4: Stress- Strain graph

The UCS values for different samples are graphically represented in figure 4. The UCS value increased from 0.184 kg/cm² at 0% quarry dust, that is for the raw sample to 0.59 kg/cm² at 50% quarry dust addition .The quarry dust addition improves the strength performance of dredged sediments. From the test results it is seen that the UCS value increases significantly with the quarry dust addition. This shows that the quantity of quarry dust increases, the clay fraction bonding the fragments together weakens as the clay fraction is reduced.

3.4 California Bearing Ratio

Laboratory CBR testing carried out directly using a CBR test device. The CBR testing conducted for the raw and treated sediments.

Table 7: California bearing ratio

Mix	*CBR at 2.5mm Penetration*	*CBR at 5mm Penetration*	*CBR Value*
S_1	2.97	2.57	2.97
SQ_{10}	3.8	3.49	3.8
SQ_{20}	4.12	3.83	4.12
SQ_{30}	4.4	4.04	4.4
SQ_{40}	4.7	4.4	4.7
SQ_{50}	5.92	4.9	5.92
SQ_{60}	5.86	4.6	5.86

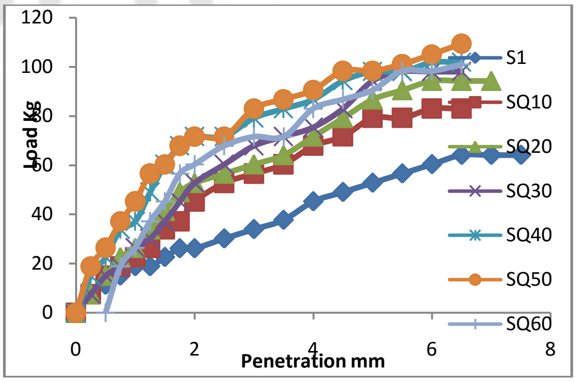

Figure 5: Load – Penetration graph of different Quarry dust content

The California bearing ratio (CBR) increases with the addition of quarry dust. The dredged marine soil have CBR value 2.97 .So it is seen that the raw sediment have poor sub grade strength. The soils stabilized with 50% of quarry dust have CBR value 5.92. This indicates that the CBR value improves from poor standard to the normal standard. The

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increase in the CBR strength of soil mixes is due to the combined effect of improved gradation of the soil caused by increase in the percentage of coarser particles.

4. Conclusion

The addition of quarry dust improves the properties of dredged marine soil. The maximum dry density improved by addition of each 10% of quarry dust. Addition of quarry dust leads to the increase in the maximum dry density and decrease in the optimum moisture content. The UCS value increased from 0.184 kg/cm^2 at 0% quarry dust to 0.59 kg/cm^2 at 50% quarry dust addition. The increase in the UCS value shows the increment in strength properties. Compared to untreated soil the CBR value found to be increased by the addition of quarry dust. The addition of quarry dust increases the CBR value from 2.97 to 5.92. The increase in CBR value shows the suitability to use as a pavement material. According to IRC 37-2001, sub grade should have a minimum CBR value of 5.9% to provide a pavement of total thickness 615mm.

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