https://doi.org/10.65646/3rc20dmw1t0389

EVALUATING THE EFFECTIVENESS OF USING DREDGING MATERIAL FROM OLIYAMULLA RETENTION POND AS A LANDFILLING MATERIAL IN COLOMBO, SRI LANKA

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The Sri Lanka Land Development Corporation (SLLDC) has developed the Oliyamulla Storm Water Drainage & Environment Improvement Project, aiming to control flooding in the Wattala, Peliyagoda, Kelaniya, Wanawasala, and Kiribathgoda areas by dredging the Oliyamulla retention pond. However, the project faces challenges in space, storage, and disposal. This study observes quarry dust as a cost-effective, eco-friendly substitute for stabilization of soil in landfilling, which is an answer to the prohibitive cost of cement in environmental operations. And assesses the environmental value of dredged material as a disposal site for wastes and demonstrates it to be pH neutral, of low electroconductivity, chlorides, organic matter, minimal heavy metals, and free from harmful toxins. Also, the use of quarry dust as a low-cost and environmentally friendly stabilizing agent for weak and soft soils. Laboratory tests for particle size distribution, Atterberg's limits, and proctor compaction on Oliyamulla retention pond dredged soil showed that mixing quarry dust with soil showed good soil improvement with acceptable landfilling limits. The cost breakdown also established that quarry dust usage is economical compared to other methods of disposal, thus making it an efficient and environmentally friendly method of ground improvement. And research evaluates the feasibility of using quarry dust to enhance the physical properties of dredged soil for landfilling. While the dredged soil is chemically acceptable, it lacks desirable natural physical properties for direct use without treatment. Experimental findings show that a 40% quarry dust and 60% dredged soil mixture enhances some significant physical properties like density, particle size distribution, and plasticity index significantly in favour of landfilling.

Keywords: weak soil improvement, landfilling, Oliyamulla retention pond

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INTRODUCTION

The Sri Lanka Land Development Corporation, which falls under the Ministry of Urban Development, is implementing the Oliyamulla Storm Water Drainage & Environment Improvement Project aimed at addressing the problem of flooding that occurs in the Oliyamulla Basin and improving the overall urban environment in Colombo. In the process, large quantities of dredged materials are generated from lakes and canals without proper avenues for disposal. This study examines the physical and chemical properties of dredged materials as well as quarry dust to determine an ideal ratio for mixing that complies with ICTAD landfill standards while considering the cost as well as making recommendations for the usage of a landfill area.(Sri Lanka Land Development Corporation, 2024).

LITERATURE REVIEW

Literature review indicates that even though cement, quarry dust, and fly ash are commonly used in the treatment of soils, cement is not suitable for landfill. This indicates that quarry dust is a cost-effective and sustainable alternative to improve soft soils, based on which the research has been carried out.

Dredging refers to the excavation of sediment from water bodies with the assistance of specialized equipment that creates a vacuum to remove unnecessary waste (What Is Dredging—How It Works, Advantages, Process & More,2024). Quarry dust is inexpensive and widely used for stabilizing soil, improving the engineering parameters of the soil and reducing cohesion. Its sharp, rough, and angular particles provide strength and interlocking in expansive soil (Tepordei, 1992). Engineering properties of soil are improved considerably with the addition of quarry dust, having lower liquid limit, plasticity, higher dry density, and lower Optimum Moisture Content (OMC), thus, it is appropriate for embankment, backfill, and sub-base materials (Soosan, 2006). The study examines the geophysical application of quarry dust in soil stabilization and modification and demonstrates its potential to improve the strength and engineering behaviours of soils (Onyelowe, 2012).

METHODOLOGY

The soil and quarry dust were sundried to remove the moisture. Mix them in variable proportion to prepare six samples.

Table 3.1: Proportions of the Samples

Dredge Material Percentage %	Quarry dust Percentage %
100	0
80	20
60	40
50	50
40	60
20	80

Table 3.1 above shows that the selected percentages cover the whole range from 100% dredge material to 100% quarry dust. This allows the identification of important limits among the ratios of the mixture and the measured properties. A very small range (for example, only mixtures between 95% and 100% dredge material) would not provide sufficient information to understand the full behavior of the mixtures. The selected ratios are simple to mix accurately in the lab. Extremely low percentages (for example, 0.5% or 5%) can be difficult to measure and mix homogeneously with the bulk of the remaining material, resulting in variation in the samples.

Quarry dust and dredged materials are tested for suitability in landfills. Chemical tests such as pH values, electroconductivity, chlorides, organic matter, and heavy metals were carried out, followed by physical tests such as sieve analysis, Atterberg limits, and compaction. The optimum mix was determined based on the maximum values of dry density. A cost comparison with the traditional method of landfills was carried out, and method statements/recommendations were prepared in line with SLLDC and ICTAD guidelines.

RESULTS AND DISCUSSION

Table 4.1: Observation of the Chemical Test for the Soil Sample

Chemical Tests	Dredged Material Results	Requirement
Soil pH at 25°C	7.2	6.5 - 8.5
Electroconductivity at 25°C (dSm^-1)	0.84	4 dSm^-1, max
Water Soluble Chloride (% by mass)	<0.01	
Organic Compounds (% by mass)	6.0	20 dry mass, min
Chromium (mg/Kg)	104.78	150 mg/kg dry mass, max
Iron (g/Kg)	77.82	
Nickel (mg/Kg)	69.11	80 mg/kg dry mass, max
Cadmium (mg/Kg)	0.05	3 mg/kg dry mass, max

Mercury (mg/Kg)	0.06	2 mg/kg dry mass, max
Lead (mg/Kg)	23.38	150 mg/kg dry mass, max

The chemical tests (Table 4.1) confirmed that dredged material, even in its pure state as received, meets the chemical specifications for use in landfill. The evidence that the <0.01 mentioned material's low water-soluble chloride content is below 0.01% indicates that the material is not toxic and does not pose a high environmental risk on a chemical basis.

Results from the chemical testing reveal that the dredged materials have met critical environmental conditions for landfilling purposes. The material's pH level (7.2) and low electroconductivity rating (0.84 dSm^{-1}) are good conditions with low salinity intensity. The chloride and organic levels are low; more importantly, the amount of heavy metals, such as chromium and lead, are within permissible limits. The dredged material meets conditions for landfilling, though environmental hazards have to be managed.

Table 4.2: The Summary of Results for Physical Properties

Parameter	Percentage of Quarry dust added						
	Soil 0%	20%	40%	50%	60%	80%	100%
Gravel and Sand size%	69%	73%	78%				91%
Silt & clay size %	31%	27%	28%				9%
LL %	32.5%	25.80%	16.2%				
PL%	19.52%	15.48%	12.0%				
PI%	12.98%	10.32%	4.19%				
MDDg/cm3	1.652	1.760	1.860	1.878	1.898	1.936	
OMC%	18.80	16.10	13.30	11.90	11.50	9.60	

The missing data in Table 4.2, the physical property data for the 50%, 60%, 80%, and 100% quarry dust mixtures, is generally significant of the fact that the 40% quarry dust mixture was found to satisfy ICTAD Clause 11.9 (SCA/3/3) (Institute for Construction Training and Development) and CONTECH requirements as landfill fill. Following this establishment of the requirements, further testing on higher percentage mixtures was considered less critical in light of the objective limitations of the study. ICTAD and CONTECH requirements are mentioned below.

Table 4.3 ICTAD Publication Requirements for Landfilling Materials

Tests	Clause	Requirements
Sieve analysis and hydrometer analysis	11.9	Gravel and Sand not less than 70%
Atterberg's Limits	-	-
Proctor compaction	11.9	Minimum Dry Density is 1.760g/cm^3
In-situ moisture content	11.10	Appropriate moisture content shall be maintained

Table 4.4 CONTECH Recommends Specifying the Landfilling Material

Tests	Clause	Requirements
Liquid Limits	Table - 2	40 max
Plasticity Index	Table - 2	10 max
Usual Type of Significant Constituent Materials	Table - 2	Gravel or Sand with silt or clay

Weak soils cannot be used in landfills or constructions; with quarry dust stabilization, weak soils can be strengthened cost-effectively. From sieve analysis, 100% dredged material completely fails the requirements for landfilling, as the proportion of gravel and sand is below 70%. However, adding 20% and 40% quarry dust increases the result to 73% and 78%, respectively, making it suitable for landfilling purposes. The mixture containing 20% quarry dust recorded a highest dry density of 1.76 g/cm^3, as well as a 10.32% plasticity index, which cannot meet the requirements of ICTAD and CONTECH for landfilling purposes. With 40% quarry dust, cohesion is significantly reduced, with the soil properties meeting the requirements, such as a liquid limit of 16.20% and a 4.19% plasticity index.

- Cost analysis for if disposal to Muthurajawela = Rs 226.5 Mn
- Cost analysis for dredge material additive quarry dust = Rs 28 Mn
- Cost analysis for traditional landfill material = Rs 37.2 Mn

It costs about Rs. 226.5 Mn to transport weak soil to the Muthurajawela dump. In contrast, the cost of improving soil with 40% quarry dust is about Rs. 28 Mn and traditional landfilling costs Rs. 37.2 Mn. Thus, quarry dust stabilization is the most viable in terms of economics.

CONCLUSION

The dredged material meets the chemical criteria but is physically unsuitable for landfilling. The blending of 60% dredged material with 40% quarry dust significantly enhances its density, particle size, and plasticity, thus making it suitable for landfilling purposes. This technique is cost-effective, feasible, and environmentally viable as it reduces project costs compared to classic landfilling or waste transportation.

RECOMMENDATIONS

The machine mixing method is recommended for large-scale soil stabilization. Soil and quarry dust are laid by excavation depth, then excavation, crushing, and mixture using a long-arm excavator are carried out. The thickness of every layer would affect the mixing quality. Cost analysis is highly needed, besides proper curing to avoid rapid water loss from sun exposure after filling.

REFERENCES

Onyelowe Ken C, Okafor F.O (2012). Geophysical use of quarry dust (as admixture) as applied to soil stabilization and modification. *ARPN Journal of Earth* , Vol 1, No. 1.

Soosan, T. G. (2006, may 24). *Geotechnical and Geological Engineering*. Retrieved from Shear strength studies on soil-quarry dust mixtures.: https://doi.org/10.1007/s10706-005-1216-9

Sri Lanka Land Development Corporation. (2024, November 10). Retrieved from https://www.srilankalaw.lk/revised-statutes/volume-vii/1190-sri-lanka-land-reclamation-and-development-corporation-act.html

Tepordei, V. V. (1992). *Crushed Stone and Sand and Gravel Production.* U.S: Bureau of Mines.

What Is Dredging—How It Works, Advantages, Process & More. (n.d.). (2024, December 11). Retrieved from GeoForm International: https://geoforminternational.com/sediment-removal-101/