Procedings of Technical Sesions, 37 (2021) 24-30
Institute of Physics- SriLanka

Analysis of material properties of offshore-sand sludge in Muthurajawela: A case study

C. Niroshan[1], S.A.D.A.S. Suraweera[2], S.S.K Muthurathna[2], P.K.D.D.P. Pitigala[1,3]

[1] *Department of Physics, University of Sri Jayewardenepura, Sri Lanka*

[2] *Materials Research and testing Division, National Building Research Organization, Sri Lanka*

[3] *Center for Advance Material Research, University of Sri Jayewardenepura, Sri Lanka.*

charithniroshanwathukara@gmail.com

ABSTRACT

The over extraction of river sand has an adverse environmental impact, and the offshore-sand was introduced as an alternative. The processing of offshore-sand gives sludge as a byproduct which also giving rise to a deferent environmental impact. Hence it is a requirement to study other alternative uses for these offshore sands sludge (OSS). Since chemical and physical properties directly effects the properties of the post produced value-added product as well as in determining and accurate identification of physical and chemical properties of offshore sand sludge, it carries lot of importance. This research conducts ahead to analyze the mineralogical composition and physical properties of OSS its compliance for value added product. The sludge samples from the sand dump were characterized using an XRF, Sieve Analysis, Loss of Ignition and Organic Impurities tests to determine the elemental composition and other physical properties. It revealed that the predominant compounds in the OSS were SiO2 (49.5%) and CaO (32.6%). Loss of Ignition test results showed that OSS had a 0.485% of low value and it was determined according to BS 1377 standard. Sludge Particle size range were determined as per ASTM, BSEN standards and a predominant number of fine particles less than 0.125 mm. According to the BS 1377 standards test organic matter (0.01%) water soluble sulfate (0.03%) and chloride (0.07%) content were identified.

1. INTRODUCTION

River sand, used as a raw material in construction industry, is being over extracted in Sri Lanka and this has progressed into adverse environmental impact. Therefore, as a solution to this burning issue, the offshore-sand was introduced as an alternative to river-sand by the Sri Lanka land development corporation (SLLDC) in 2002.[1] Daily ~600 cubes of offshore sand were produced in Muthurajawela Redco and Asset sand washing plants. During the processing of offshore sand, the OSS is produced as a byproduct which amount accumulated to be ~150 cubes per month. Currently, the sludge is used either as land filling or are been dumped haphazardly at different locations. Landfill disposal of the offshore sands sludge (OSS) is also not economically viable because it drains the

Procedings of Technical Sesions, 37 (2021) 24-30
Institute of Physics- SriLanka

volume capacity of the land. Therefore, it is important to study the alternative uses of OSS, to get it utilized as an economical and environmentally friendly feasible option, due to the similar mineralogical composition of offshore sand. This study is focused on identifying the material properties of the OSS, in order to identify the possibilities of utilizing of OSS as a raw material suitable in secondary applications of the construction industry apart from use as a land filling material.

2. METHODOLOGY AND CHARACTERIZATION OF OFFSHORE SAND SLUDGE

OSS samples were collected from different places in sand dumping places in Muthurajawela using the sampling spear as per given in the EN 932-1: 1996 standard.[2] Then dried samples were characterized using an XRF test to determine the chemical composition and other methods to identify the size distribution and other physical properties.

2.1. Particle size distribution

Particle size distribution is a measurement to identify the size distribution of individual particles in a sample of aggregates. The main features of particle size distribution are the dispersion of soil aggregates into discreet units by mechanical means and the separation of particle according to size limits using sieving.
Soil particles which are smaller than 2000µm are generally divided into four major size groups; rocks, sands, silts and clays. These groups are sometimes called soil separates and can be subdivided into smaller size classes namely coarse, medium and fine particles.[3]
Particle size analysis data is used to determine the cumulative percentage passing distribution curve. Sieve analysis and hydrometer test are used to investigate the particle size distribution of soil.

2.1.1. Sieve analysis

This test was done according to the BSEN 13139:2002 and ASTM C144-99 standards for analyze a particle size distribution and its sieve size ranges are 2.00mm to 0.063mm, 4.75mm to 0.063mm respectively. Here, the offshore sand sludge sample was washed with water and kept in an oven allowing drying. Then the dried sample was weighted. Sieve was assembled according to the above standards and dried sludge sample carefully added into the top sieve. It was shaken using mechanical shaker and finally retained mass in each sieve was taken out and separately weighted. The cumulative percentage passing of each sieve was calculated by using equations.

2.2. XRF test

X-ray fluorescence or XRF test was done in order to find out the chemical composition of off- shore sand sludge sample. Which was carried out at Sri Lanka Institute of Nanotechnology (SLINTEC). HORIBA Scientific XGT- 5200 X-ray Analytical Microscope capable of detecting elements from 11Na to 92U.Six different spots per sample were analyzed.

Procedings of Technical Sesions, 37 (2021) 24-30
Institute of Physics- SriLanka

2.3. Loss of ignition

Loss of ignition was used to analyze the weight of living organism, water, carbonates, carbon, containing materials, decomposing matter and other volatile substances in the sand sludge, through the weight change percentage caused by heating the sample to high temperature. The test was done according to BS1377-3:1999 standard at 440 °C. [4]

Loss of ignition refers to different in weight in a sample of offshore sand sludge. It is measured by weighting a sample before heating and subtracting the weight of the sand sample after it has been heated to 440 °C temperature. Then calculate the LOI percentage using difference of weight is divided by the original weight. According to LOI value determine the composed things in offshore sand sludge.

3. RESULTS AND DISCUSSION

3.1. Sieve analysis

The table 01 show the comparison of the results achieved from sieve analysis of off-shore sand sludge with the specified requirements for fine aggregates according to BSEN and ASTM respectively. As can be seen in Table 01, even though the OSS are way differ to the requirements of BSEN standards for aggregate of mortar, but they are well within the ASTM standards for manufactured sand for use in masonry mortar except for the high percentage of small grains (<0.3).

Table 01: Comparison of passing percentage of off-shore sand sludge with BSEN standard and ASTM standard.

Sieve Size (mm)	**4.75**	**2.36**	**2.00**	**1.18**	**0.60**	**0.30**	**0.15**	**0.125**	**0.075**	**0.063**	**pan**
Cumulative percentage passing%	100	100	99.82	99.64	97.54	82.73	24.58	17.53	7.93	2.17	0
BSEN standard for aggregates of mortar	-	-	100	-	-	-	-	85 to 100	-	70 to 100	-
ASTM standard of manufactured sand for use in masonry mortar.	100	95 to 100	-	70 to 100	40 to 75	10 to 35	2 to 15	-	0 to 5	-	-

Figure 01 also show a graphical representation of the passing percentage of offshore sand sludge in sieve analysis is lower than the specific limits of BSEN standards and passing percentage of offshore sand sludge is higher than the ASTM specific limits. Since the sieve analysis results confirm that this off-shore sand sludge is fine graded sand

Procedings of Technical Sesions, 37 (2021) 24-30
Institute of Physics- SriLanka

according to the ASTM standard. The as of the data shown in table 3.1 the retaining percentage of sand sludge in sieves below 0.3 mm particle diameter is very high (~ 82%); hence can clearly conclude the particle diameter of majority (~60%) offshore sand sludge is within the 0.3mm and 0. 075mm.This means fine sand percentage of off-shore sand sludge sample is much higher than the gravel percentage of this sand sludge. Furthermore, the aggregate particle size is a very important parameter affecting the strength of construction materials. According to sieve analysis test results that offshore sand sludge has low grain size, hence the sand sludge has suitable grain size to be used as a fine aggregate to be used in construction purposes, such as aggregate for cement mortar and tile adhesive.

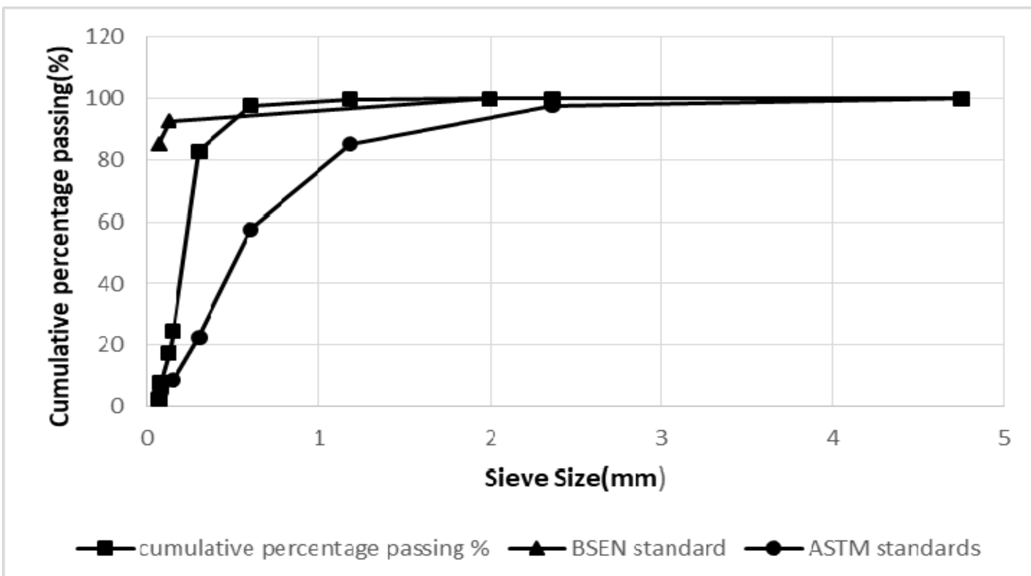

Figure 01: Comparison of sieve analysis, cumulative percentage passing vs. sieve size curve and grading curves for fine aggregate according to BSEN and ASTM standards cumulative percentage passing vs sieve size.

The sieve analysis revealed the existence in fine sand in our specimens, therefore organic impurity test, chloride content, and sulfate content test should be carried out to offshore sand sludge. The chloride content, and sulfate content test have shown the presence of water-soluble chloride and sulfate content in OSS is 0.01(w/w %) and 0.03(w/w %) respectively, the test determined in accordance with BS 1377: part 3:1990. The chloride and sulfate in the OSS can corrode the reinforcement metals and create expansive disruptions in mortar respectively, in a concrete. But the above values imply the respective chloride and sulfate contents are below the maximum allowed levels as stated in BSEN 998-2 standards.

Procedings of Technical Sesions, 37 (2021) 24-30
Institute of Physics- SriLanka

3.2. XRF test analysis

As of the XRF results shown in the Table 02, the collected off-shore sand sludge sample consisted of major SiO_2 and CaO, where the average mass percentage of silicon dioxide is ~49.5% and calcium oxide is ~32.56%, It is a very high amount compared to the average mass percentage of other oxides in the sample.

Table 02: Chemical composition of offshore sand sludge in oxide form

Compound	SiO_2	CaO	Al_2O_3	Fe_2O_3	TiO_2	MgO	SO_3	K_2O	SrO_2	Zro_2	Yb_2O_3	WO_3	MnO_2	Cr_2O_3
% (in OSS)	49.51	32.56	7.75	4.34	2.02	1.97	0.98	0.97	0.14	0.13	0.08	0.08	0.05	0.03

Both in sea sand and river sand, the silica content is very high because of its chemical inertness, considerable hardness and weather resistant. But the existence of large percentage of calcium oxide in OSS compared to what that of in river sand and comparatively high CaO: SiO2 ratio (~ 3:5) should be affect to the fine aggregate of the properties of the final product. This SiO2: CaO ratio generally affect to the pull-out strength of tile adhesive, it determined accordance with EN 12004 European standard for dry, wet, hot and thaw test.[5] Highest pull-out strength was obtained on sample those aggregate have high content of SiO2 and small amount of CaO in dry and wet conditions. Freeze and thawing condition which aggregate sample in tile adhesive has high amount of CaO, it gave high pull-out strength. Therefore, the presence of CaO in the composition makes it most suitable for the cold climate tile adhesive applications.[5]

3.3. Loss of ignition (LOI)

Table 03: Loss of ignition test results

LOI test 01	**0.58%**
LOI test 02	**0.39%**
Total LOI value	**0.485%**

To increase the accuracy of the LOI test, two simultaneous tests were conducted in two individual crucibles. LOI 01 and LOI 02 are the weight loss percentage, 0.58 and 0.39 respectively, of each specimen after heating to extreme temperature. The mean LOI of these two results is 0.485. It was noted the difference between two LOI values of two crucibles is quite higher, but it is within the BSEN 13139-2002 standard. According to

Procedings of Technical Sesions, 37 (2021) 24-30
Institute of Physics- SriLanka

the BSEN 13139-2002 standard LOI value shall not exceed 3%.[6] The Total LOI number is lower than the limits of standard and major mass loss are related to the organic content of OSS. The difference in LOI 1 and LOI 2 can be a result of uneven distribution of the organic impurities in the OSS dump. Additional factors unrelated to organic contents in OSS could also be responsible for the mass loss on ignition. Therefore, according to the results variation in the distribution of the quantity of organic substances and other volatile matters in the sand sludge is high. This high variation of LOI have a negative impact on the quality of OSS, but it is to be noted the total LOI is within the standers, therefore this high variation in LOI will not have a major impact.

3.4. Organic impurities test

This test method covers standard color solution procedure for an approximate determination of the presence of injurious organic impurities in offshore sand sludge and test should be carried out according to ASTM C 40-90 standard.[7] OSS mixed with sodium hydroxide solution and after 24 hours, determined the supernatant liquid color using five glass standard color chart.

In reagent bottle OSS supernatant liquid color is darker than to the standard color solution (Figure 02). Therefore, OSS under test shall be possibly containing injurious organic impurities. Furthermore, this OSS is advisable to perform further test before approving the aggregate for use in masonry product, But Some inorganic compound which discolors the supernatant liquid in the sodium hydroxide test too. This test produces no numerical values; therefore, determination of the precision and bias is not possible. Other advance chemical analysis methods are requires identifying the type and the quantity of the organic impurities.

Figure 02: Reagent bottle supernatant liquid color is darker than the standard color

4. CONCLUTION

The offshore sand sludge was analyzed to determine the physical and chemical properties of offshore sand sludge. This sludge samples were collected from different places in the sand dump and characterized using an XRF and other tests to determine the elemental

Procedings of Technical Sesions, 37 (2021) 24-30
Institute of Physics- SriLanka

composition and other physical properties. It revealed that the predominant compounds in the OSS were SiO2 (49.5%) and CaO (32.6%). Loss of Ignition test results showed that OSS had a 0.485% of low value and it was determined according to BS 1377. Sludge Particle size range were determined as per ASTM, BSEN standards and a predominant number of fine particles less than 0.125 mm. According to the BS 1377 standards organic matter (0.01%) water soluble sulfate (0.03%) and chloride (0.07%) content were determined. As revealed by the testing, most of the chemical composition properties of the OSS are within the acceptable limit of standards defined for building materials, one of the major drawbacks is the grain size and low SiO2 composition in OSS. Due to the finest particular sizethe sand sludge is not suitablefor constructional purposes. Since the sand sludge is containing impurities, it also may affect on the properties of the other value-added product the OSS used as a raw material. Therefore, a special process may need to remove the organic and inorganic impurities of OSS before using this by product as a raw material in other products.

REFERANCES

[1]. D.A.R Dolage, M.G.S. Dias, C.T Ariyawansa, *Offshore sand as a Fine aggregate for concrete production*, British journal of applied science and technology 3(4):2013. (15th May 2013). 813-825 Available from: https://doi.org/10.9734/BJAST/2013/3290 [Accessed 3rd September 2020].

[2]. Tests for general properties of aggregates, part 1, methods for sampling, British Standard European Norm 932-1: 1997.

[3]. Dane, Jacob H. [SSSA Book Series*] Methods of Soil Analysis: Part 4 Physical Methods// 2.4 Particle- Size Analysis*., American Society of Agronomy (2002). 256 Available from: https://doi.org/10.2136/sssabookser5.4.c12 [Accessed 2nd October 2020].

[4]. Methods of test for Soils for civil engineering purposes, part 3, chemical and electrochemical tests, British Standards 1377: Part 3: 1990.

[5]. H.T. Ozkahraman, E.C. Isik, *The effect of chemical and mineralogical composition of aggregates on tensile adhesion strength of tiles*. ELSEVIER (28. Aug 2004). 252-255 Available from: https://doi.org/10.1016/j.conbuildmat.2004.07.016 [Accessed 20th October 2020].

[6]. Aggregates for mortar, British Standard European Norm 13139:2002.

[7]. ASTM C40 / C40M-20, Standard Test Method for Organic Impurities in Fine Aggregates for Concrete, American Society for Testing and Materials International, West Conshohocken, PA, 1996.