Assessing different methods of salt removal techniques from Offshore Sand

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Abstract: Usage of offshore sand as an alternative to inland river sand is beneficial due to the various environmental impacts of river sand mining in Sri Lanka. However, higher amount of chloride ions in the sea sand can corrode the reinforcements of the concrete. Therefore it's necessary to identify suitable, low cost and efficient method to remove cl^- ions from the sea sand. In this study, three different salt removal techniques; mechanical washing, natural washing and recently introduced grain to grain collision were evaluated using samples from beach sand, river sand, offshore sand and old stock piled offshore sand. Relative salt content and absolute cl^- content were measured using conductivity measurements and titration, respectively. Mean grain size and other textural parameters were calculated using sieve analysis. Results indicate 100g of sand soaked in 200ml of water, required approximately 10 minuets to remove salt from sea sand. Natural removal of chloride by rainwater shows one year of Monsoon rain is more than sufficient to remove salt from even 10 m thick piles of sea sand. However, grain to grain collision does not show significant capacity to remove salt.

Key Words: chloride, concrete, muturajawela, river sand, salt content

1. Introduction

Sand is a valuable commodity used extensively in every construction industry. Sri Lanka requires more than 9 million cubic meters of sand for its annual construction requirements. Tsunami disaster has further increased the annual sand demand due to increased constructions in the damaged areas. As a country having many rivers, inland sand resources were the main source of constructions so far. However due to the increased demand for sand and lack of supply, the sand suppliers have carried out illegal sand mining activities which have caused huge environmental impacts to the river banks and whole of the river eco system.

Therefore, as an alternative to the river sand and to support the existing demand for sand, offshore sand can be utilized as the best existing source. Exclusive economic zone that belongs

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to Sri Lanka is more than eight times of the land areas and provides enough resources. Also sea sand results less environmental impacts. However, offshore sand cannot be used directly for construction purposes due to high Cl^- content which causes to erode the reinforcements in concrete. Therefore, maximum allowable Cl^- ion content in sand is 0.075% by the weight of sand according to the construction standards.

Prior to using offshore sand for constructions, the salt content should be reduced to an acceptable limit and this can be performed by

i. Natural washing by rainwater
ii. Mechanical washing
iii. Grain to grain collision.

This study focuses on assessing these methods and to check suitability to Sri Lanka.

2. Methodology

2.1. Sampling

Samples were collected from old stock piles of sea sand deposits from Muthrajawela. These stock piles were approximately 9m in height and samples were collected from 2m intervals from 6 locations that were pumped at different time periods (Table 1). In addition, offshore sand samples were used from offshore sea survey of Kaluthara and river sand samples were taken from Maha Oya, Polgahawela. Beach samples were also collected at Moratuwa for comparison.

2.2. Determination of Cl^- content

Absolute Cl^- content was determined by water extraction method (BS 1377: part3: 1990) using NH_4SCN, $AgNO_3$, HNO_3 acid and ferric alum indicator, and results were expressed as a percentage weight of the offshore sand.

2.3. Determination of minimal time required for complete removal of salt

100g of sand was dissolved in 200ml of distilled water and the conductivity was determined at every 5 minutes while mechanically stirring, by ACTEON 3000-PONSEL conductivity meter. Same method was repeated while manual stirring and without stirring. Then the volume of water was increased by 50ml steps up to 450ml for the same sample and conductivity was determined to identify salt content.

2.4. Quality checking for suitability of sea sand as construction aggregate

Determination of absolute Cl^- content using a titration method at the laboratory is time consuming and therefore, to overcome that and also to find the offshore sand with allowable Cl^- content, a conductivity scale was prepared to suit on site usage. Standard solutions with Cl^- content 0.050% by weight to 0.100% by weight with 0.005 intervals were prepared at the laboratory and conductivity was measured. Cl^- content (% by weight) was plotted against conductivity and permissible Cl^- content and suitable conductivity for that Cl^- content were marked in the graph to show the permissible area with respect to the Cl^- content and conductivity. An offshore sand sample of 100g stirred 10 minutes with 200ml of distilled water can be used to determine conductivity and asses the sand sample with respect to the conductivity values instead of the Cl^- content.

3. Results

Conductivity variation (ms/cm) with respect to time was plotted according to the results of the conductivity determination test for mechanical stirring sample, manual stirring sample and no stirring sample. (Fig 1)

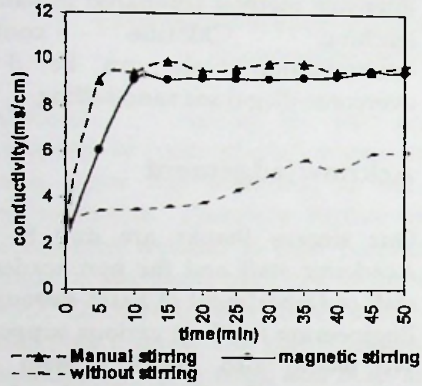

Figure 1 – Variation of conductivity with time in offshore sand

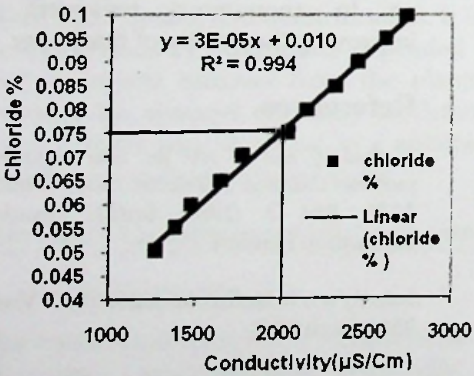

Figure 2 - Quality checking of offshore sand at site

Chloride content determination scale (Fig. 2) was plotted by conductivity values measured respect to the standard chloride solutions. Results of chloride content for offshore sand samples taken from the Muthurajawela using the titration method are provided in Table 1.

Table 1- Cl^- content at different levels of stock piles at Muthurajawela

Location	Time period	Cl- (% wt of sand)
A-Base	2001Sep.	0.004255
A- 2m from base	-	0.001481
A- 4m from base	2002 May	0.001418
A- 2m from top		0.004318
A- top		0.004998
B- Base	2001 Sep.	0.001469
B- 2m from base	-	0.002258
B- 2m from top	2002 May	0.001515
B- top		0.010590
C- Base	2006 July	0.003472
C- 2m from base		0.002780
C- 4m from base		0.001728
C- 6m from base		0.002791
C- 8m from base		0.002678
C- 10m from base		0.001974
C- top		0.002678
D- Base	2006 June	0.003444
D- 2m from base		0.002094
D- 4m from base		0.032705
D- 6m from base		0.001271
D- 8m from base		0.002054
D- top		0.002808
E- Base	2006	0.002678
E- 2m from horizontal surface downward	Nov. - 2007	0.001944
E- horizontal surface	March	0.002763
E- 2m from horizontal surface upward		0.001271
E- 4m from horizontal surface upward		0.004267
E- top		0.008306
F- Surface 1	2007 May	0.002962
F- Surface 2		0.002905
F- Surface 3		0.002145

Note: A, B, C, D, E and F are six offshore sand stock piles which were pumped at different time periods at Muthrajawela. Samples were collected from bottom to top at 2m intervals from each stock pile.

4. Discussion

Magnetic stirring is equivalent to the mechanism of offshore sand washing plant and conductivity of offshore sand sample was approximately constant after 10 minutes. It is clear that, 10 minutes washing time with twice the volume of water is enough to remove the salt ions coated with sand in a mechanical washing plant.

All the samples taken from **A, B, C, D, E** and **F** stock piles have tolerable amount of chloride, which is less than 0.075% by weight of sand. Maximum and minimum chloride content of **A, B** stock piles are 1/7 and 1/53 of permissible chloride content. Presently, Land Reclamation and Development Co-operation is selling the offshore sand from stock piles **A** and **B.** Average rainfall around Muthurajawela is 2000mm, and the number of rainy days had been around 100days/yr. During raining water draining through the sand grains has facilitated in reducing the chloride content of sand grains. The sand deposits pumped in early and mid 2007 (F) also had reduced down to the permissible chloride content.

Chloride content via the titration method is time consuming and fairly difficult. The conductivity meter (ACTEON 3000-PONSEL) can be used on site to determine the conductivity of sea sand sample instead of chloride content. 100g of dry sea sand sample with 200ml of water, after stirring for 10 minutes can be used to determine the conductivity. Using this conductivity value chloride content can be determined.

5. Conclusion

When assessing different methods of offshore sand washing processes, natural chloride removal from the offshore sand by rain is an economical process compared with other techniques of offshore sand washing. But this will take a particular time period to obtain the sand product with reduced chloride content and also require a large space. Mechanical washing method is suitable to reduce chloride content. However it is a cost intensive method compared to natural leaching. Chloride content determination scale can be d to overcome illegal sea sand selling.

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