Design and Fabrication of a Spiral Classifier for Off-shore Sand Washing

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Abstract: The rapid growth of construction industry has created a significant demand for sand. Consequently, it has increased the exploitation rate of river sand giving rise to adverse environmental impacts. Therefore, the tendency now is to find alternatives for river sand avoiding massive environmental damages. Among the potential alternatives, offshore sand could be the best alternative, because of particle size distribution and availability. However, the demand on offshore sand is low, due to its soluble Cl^- content which could influence badly on the structural properties of concrete. As a solution, sea sand could be stored in open air until the Cl^- content is decreased to acceptable limits (<0.075% by weight) under the influence of rain water. However, considering the increasing demand and changing weather patterns, the above method appears to be inappropriate to meet the demand. In this research, a spiral classifier was designed and fabricated in order to wash offshore sand from salts and other suspended materials. The separation is done on sea sand by optimizing critical parameters of the spiral classifier such as feed rate, rotational speed of spiral, inclination angle of the spiral and weir height.

Keywords: Acceptable limit, Cl^- content, demand for sand, offshore sand

1. Introduction

Currently Sri Lanka is experiencing a shortage of sand for the construction industry. The sand available is exorbitant in price consequently; the construction industry is facing difficulties. In the recent past, sand for above was obtained from the river beds. As a result, there has been an environmental degradation. Areas which were not inundated previously have now been subjected to flooding causing immense difficulties to the people and the Government financially and socially. The other alternative to the river sand is the sea sand or off shore sand. But the problem lies in its chloride content. However, it may be possible to reduce this to acceptable standard using appropriate technology.

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Currently, sand stock piles are washing with rain water. But considering the increasing demand and changing weather patterns this may not be possible to meet the demand for such a large scale industry. In this conventional stock pile method, we have to wait few months for rain.

Alternatively, sea sand can be effectively washed off from its soluble ingredients, specially chlorides by means of a spiral classifier and river water as once it is pumped from the sea. In this research a prototype spiral classifier has been designed, fabricated and tested in the laboratory.

2. Methodology

2.1 Design and fabrication

Design and fabrication was completed at the work shop. Initially, we had to design the spiral by repeating flights along the Shaft. Flights were mounted on the shaft with a constant pitch and number of revolutions.

Figure 1 - Mounting flights on shaft (Scale - 1:8)

Figure 2 - Fabricated spiral (Scale – 1:20)

Apart form the spiral, other components such as tank, outer casing, weir box, adjustable weir and adjustable stand for the entire system was done with the aid of cutting, grinding, drilling, lathing, nut and bolting, hammering, painting, etc. Apart from arc welding, we had to use gas welding in some special occasions such as assembling parts, cutting metal sheets into required sizes, etc.

Figure 3 - Fabricated spiral classifier (Scale – 1:28)

2.2 Collecting samples and testing procedure

Sea sand was collected along the beach from sample locations as shown in the (Figure. 4) and thereafter it was mixed together.

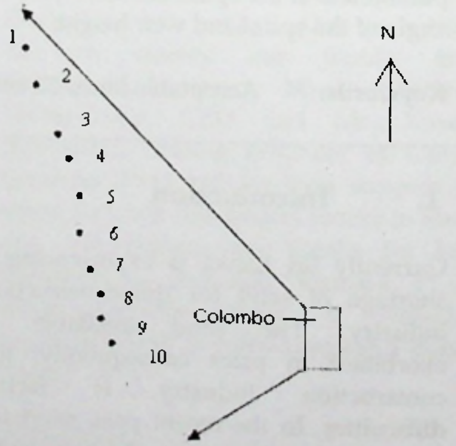

Figure 4 - Sample location points along the beach

The sand was dried in the oven at 110°C for 2 hours to remove water. Then it was sieved through 3.35 mm mesh to remove sea shells and other impurities. Thereafter, soluble chloride content was determined by the silver nitrate titration. The spiral classifier is then positioned.

The method utilized is a counter current washing technique with water where, the flow direction of sand in the spiral is made counter to the direction of water flow.

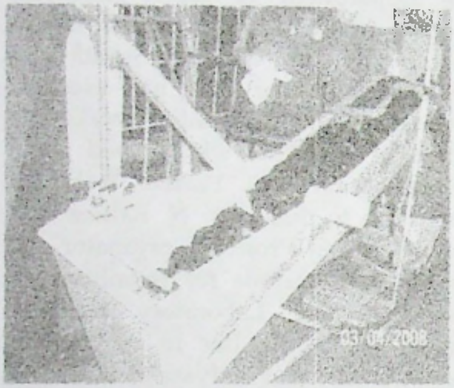

Figure 5 - Washing sea sand using Spiral classifier (Scale – 1:24)

The sand from the feeder (silo) is fed into a point at a distance of about 6 inches down the feed water entry point of the spiral. The water is sprayed uniformly across the breadth of the chamber by fixing a perforated pipe fitting so that there is an even distribution of water in to the chamber. The washed sand is conveyed up the slope of the spiral by rotating the spiral about its axis uniformly. Alternatively, a gear mechanism may be fitted to give a uniform rate of rotation.

2.3 Operating variables

Operating variables are,

1. Feed rates of sand and water
2. The angle of inclination
3. Rate of rotation of the spiral axle
4. Weir height

All these variables have to be adjusted to optimize the washing operation.
After adjusting the above variables to optimum values as indicated in the results, the washed sand was collected at the top discharge point, dried in an oven at 110°C for 2 hours and the soluble chloride content determined by titration.

3. Results

Table 1 - Characteristics of the fabricated model

Optimized Variables	Values
Sand flow rate(g/s)	62.55
Water flow rate (ml/s)	116.75
Angle of inclination of the spiral (°)	20
Rate of rotation of the spiral (rpm)	75
Soluble chloride of the feed (%)	0.192
Soluble chloride of the washed sand (%)	0.0177
Soluble chloride allowed in the standard (%)	0.075

The average Cl⁻ content present in offshore sand is around 0.2% - 0.3%. It should be reduced to the maximum allowable limit of 0.075% by weight of sand. (Dias, W.P.S., Nanayakkara, S.M.A., Seneviratne, G.A.P.S.N., 2002).

The allowable limit of Cl^- content (0.0175%) was obtained by washing sea sand by means of the fabricated spiral classifier.

4. Discussion

During the washing stage, sand particles inside the washing chamber undergo extensive turbulence by the rotating spiral and the flowing water. Due to the turbulence it was noted that individual sand particles undergo rotation, fluidization and sedimentation at different intervals. (Wills, B.A., 1992).

When the washing is optimized there should not be water discharging with the washed sand at the top discharge and also no sand discharge from the overflow weir at the bottom discharge. This situation was accomplished very effectively in this research. Finally, the washed sand is found to be within the specification of the standards for construction industry. Note: the flow chart in Fig. 6.

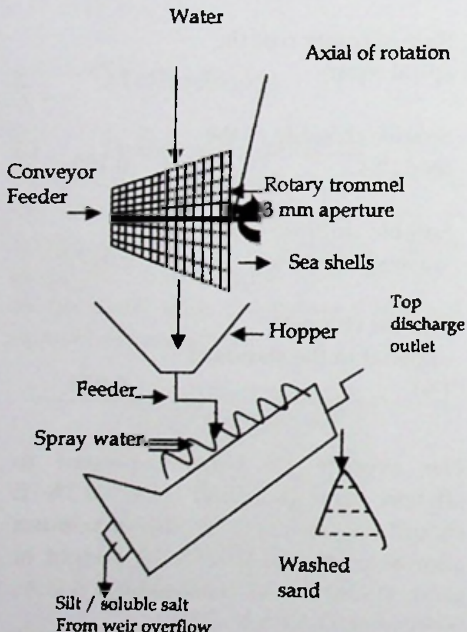

Figure 6 - Flow chart for the washing process

5. Conclusion

The fabricated prototype model showed that it is an ideal unit to wash off off-shore sand from its soluble chloride impurities. This model can wash one tractor load of off-shore sand within a period of 10 hours, if run continuously.

By scaling up these units and also by installing several units of the scaled up version at suitable locations, higher productions can be achieved.

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