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Crisis On River Sand Needed For Construction Work – Remedial Solutions

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Abstract—*Construction activity in a country is a key factor that reflects the extent of development, and sand is a vital commodity needed for this activity. It has been estimated that the sand consumption for the construction industry (based on annual cement consumption) for the year 2000 was 4.9 million cubic metres with the rate increasing at nearly two million metre cubes per year. The Western Province alone utilises about 40% of this entire quantity.*

In Sri Lanka, we have been over-dependent on river sand for construction and other needs. Kelani Ganga and the Maha Oya have been mined for river sand far beyond capacity and the Deduru Oya is now faced with the same threat. The damage caused to land and property as well as to the environment is beyond repair. The stark fact is that there is virtually no sand to mine now in the rivers. Unless an alternative is made available without delay, the serious crisis which is now facing the construction industry will be a severe setback to the economy as a whole.

Keywords: River Sand, Off Shore Sand, Dune Sand, Alternatives, Construction, Conservation

1 Background

1.1 Over two decades ago, extraction of sand from the rivers was carried out manually. With the increase in demand for river sand (as a result of increased construction activity), mechanized systems of sand mining were introduced. The rate of sand mining far exceeded the rate of natural replenishment of sand in the rivers. The consequences of this imbalance resulted in coastal erosion and many other environmental problems. With the realization of the impending damage of excessive river sand mining, the National Sand Study was initiated. The Central Environmental Authority carried out phase 1 of this study, with the assistance of the Government of the Netherlands [1].

1.2 The report on this Study issued in 1992 gave a clear warning signal on the need to curtail the rate of river sand mining and the need to introduce alternatives to river sand.

Phase II of this Study (which was not concluded) was expected to examine alternative materials and propose remedial measure and legislation required to implement such measures. In lieu of Phase II of this Study a team from the University of Moratuwa carried out a study culminating in a workshop on 1997. Its report titled "Alternatives for river sand identified as alternatives, offshore sand, dune sand, crushed rock and land based sand, for use in construction". However, this report was based on a limited number of samples and tests carried out.

The presidential Task Force which also examined the effects of sand mining in the Maha Oya and the Deduru Oya and the mitigatory measures that should be taken to avert such effects also suggested the use of alternative materials for river sand. It also identified NBRO (National Building Research Organisation) as one of the agencies, which should undertake studies on alternative materials. However, the report of this task force was not published (according to the information received by the author).

Some geological studies that have been carried out on dunes and on off shore sand do not shed much light on their properties in relation to their use in construction work.

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However, the NARA study gives useful information on the types of offshore sand available and their locations [2].

2 NBRO Study on the Feasibility of Alternatives to River Sand

2.1 Realising the urgent need for alternative sands and the fact that the information available was hardly sufficient to effect a switch over to alternative sands in preference to river sand, the NBRO in 1999, embarked on an ambitious research programme (totally funded by the Government) on alternative sands. The objective was to provide convincing evidence and information to engineers, architects and others, on the feasibility of using sand taken from the dunes, or offshore or crushed rock in all construction applications (concrete, mortars, plasters, etc.) and thereby avert further damage from the mining of river sand.

Towards the latter part of this Study (Year 2000) a Coast Conservation Study was undertaken by the Coast Conservation Dept. with experts from Moratuwa University and an ADB consultant from Australia. This Study based on offshore sand utilising samples from the sand stockpiled for the Colombo-Katunayake expressway supplemented the NBRO research and recommended further measures to be adopted in utilizing this material as an alternative to river sand for construction work.
The NBRO study was focused on two main areas:

a) the present scenario on river sand mining and the adverse environmental effects caused, and
b) the alternative materials, their availability and their engineering properties.

2.2 Present Scenario

Disaster caused to the environment by the mining of river sand was clearly seen on visiting the areas mined. It was observed that:

1) The lower reaches of Kelani Ganga and Maha Oya were mined to the rock bottom.
2) River banks were mined beyond limits.
3) Much valuable land and property including trees and houses were damaged.
4) Severe erosion has caused potential danger to roads, railway lines etc. and the piers of the Maha Oya bridge main were on the verge of collapse.

The extent of excessive river sand extraction was so much that the Kelani river bed was found to be below sea level. The actual levels determined relative to mean sea level were,

- under the deck of the Hanwella bridge: -3.65 to -1.89 metres
- under the deck of the Kaduwela bridge: -4.92 to - 1.93 metres
- under the deck of the Peliyagoda bridge: - 5.58 to - 2.98 metres

(The negative sign indicates that the level of river bed at the above locations was below the sea level). Thus there will be sea water intrusion causing increased salinity levels in the water. This in turn, will cause pollution of the drinking water supply to the City and in turn, will harm living organisms in the river and plants in the vicinity.

2.3 Suggested Alternatives

The NBRO study was a comprehensive study on offshore sand, dune sand and crushed rock fines using a wide range of samples. It included laboratory investigations, field surveys and trials on the use of these materials in actual construction applications and manufacture of precast items. The major activities undertaken are given below:

1. As mentioned above, based on sample surveys carried out on each material. The Study included laboratory investigations and field applications aimed at evaluating their suitability for construction work.

2. Mapping of all the sand dunes in the NWP using GPS (Geographic Positioning System) extending from Daluwa to Kalpitiya, with a detailed borehole survey of the Daluwa dune. In this study, the quantity of sand which could be extracted was estimated and the areas already subjected to human settlements and cultivation were identified.

3. Offshore samples of sand were drawn from 15 locations extending from Kalpitiya to Hambantota to an overall depth of up to 35 m (and at least 2 m depth in the sand layer).

4. Investigations were carried out on samples drawn from one company where manufactured sand was produced from crushed rock. Samples were also studied from four other quarries in which the rock fines were considered to be suitable for concrete production. (Quarry dust is different to crushed rock sand. The latter has a very high fine content and is not suitable for use in concrete)
5. Samples of different types and locations were subjected to laboratory analysis and evaluation as well as trials on actual construction applications.

3 The outcome of the Study is summarised here:

1. Properties of the samples analysed in the laboratory are given in the Table I.

2. A GPS study of the sand dunes indicated that if sand were to be extracted down to ground level and leaving out the fore dunes (for environmental reasons) the total yield will be almost 15 million cubic metres which is nearly three years' sand requirement for the entire country at current rates of consumption.

3. The off shore sand belt from Colombo to Kalpitiya would yield good quality sand with acceptable levels of chlorides and shell content

4. Off shore sand in the southern area has a high percentage of calcareous material (shelly material and calcareous mud) but there are several areas where the shell content is low

5. Only a few quarries produce crushed rock material suitable for use as fine aggregate in concrete.

4 Inferences

The Sample Survey and the studies carried out clearly show that alternative materials could be used for all applications where river sand is presently used. However, an examination of the properties of these materials (table I) shows that proper care should be exercised in their selection and processing.

Off-shore sand: This is one material which could perhaps be used, as a direct substitute for river sand. The sample study shows that it would be best to exploit the North-Western deposits (North of Colombo to Kalpitiya) for the following reasons:

- content of chlorides and shelly material is relatively low compared to deposits in the Southern area

-it is relatively easy to find storage/ processing locations

- it facilitates transportation to Colombo and suburbs where the demand will be high

Sand stockpiled in sufficient quantity could be left exposed to rain (before being issued for use), so that the salts/ chlorides are washed off. Since the chloride content in these deposits is relatively low, it may not be required to install mechanical washing plants. However, sieving may be required to remove shells (or pebbles) larger than 5 mm in diameter. The presence of smaller shell fragments will not be harmful. However, in areas where the shell content is very high, sieving and processing of material may be uneconomical.

If offshore deposits in the South are to be extracted, sufficient care should be exercised in the selection and processing because of the high chloride and shell content observed in samples in many locations (table I)

Dune sand is ideal for plaster/mortar mixes. However it could be used in concrete when mixed with an equal proportion of crushed rock sand, so that, each material complements the other in improving workability and strength gain.

Crushed rock sand should be processed to remove excess fines (dust/clay sized particles) and preferably to produce more rounded particles. It should be noted that this material has been used successfully in the construction of Victoria and Uda-Walawe Dams.

Crusher dust normally referred to as quarry dust which is a natural by-product of the stone crushing industry is not suitable for use as fine aggregate in concrete (but used in the production of cement blocks and other pre-cast items even at present). Crushed rock fines should be processed by washing, sieving, etc., to produce a sand suitable for concrete.

Getting Started

Engineers have always shown reluctance in using any new material, (and justifiably so) unless it has been proved to be satisfactory and its use is permitted by internationally acceptable standards and national standards. Both these conditions are satisfied in the case of proposed alternative sands. The results of studies carried out in the laboratories and in the field give sufficient information on their selection and application.

There is yet another danger in continuing to use river sand in whatever quality and quantity available. It is a known fact that sand is being extracted from river banks (well into the adjoining land) and from the deposits across the river mouth. Thus, the presence of organic impurities and chlorides will be inevitable, and the levels of these deleterious materials may well exceed permissible limits. Since there is no quality assurance in the 'river sand' supplied, it is all the more important to switch-over to alternative sands. It would therefore, be imperative to establish the infrastructure to extract and supply off-shore sand and dune sand with an assurance of quality. (The manufacture of sand from crushed rock is already being carried out by Lanka Quarries Ltd. at Talagala, but the output is very limited).

Dune sand could be exploited (with necessary controls) as a quick solution to the problem. As a long term solution offshore sand mining should be planned and executed in a scientific manner. Large investments would not be required for this operation, because it would be possible to hire the services of overseas companies possessing suitable vessels which could extract sea sand down to a depth of 40 metres from the sea surface. The following project implementation stages may be envisaged :

1) Allocation of land by the Government, close to the shore, to dump sand.

2) Hiring the services of overseas companies to extract, about two million metre cubes of sand within a period of 6 to 8 weeks each Season between monsoons (such vessels already operate in the South Asian region serving other countries such as Malaysia and Hong Kong).

3) Providing a pipeline (to the sand stockpile from a point close to the shoreline) to deliver the dredged sand. The dredging vessel will have its own system to feed this pipeline. If the stockpiling area is very close to the shoreline then the use of the rainbow projection technique or use of small barges may be considered as alternative methods of delivering sand to the stockpile.

4) Entrusting in the marketing of sand to a local company with the required quality assurance being maintained by the company and monitored by the relevant authorities.

6 Project Implementation

6.1 Dune Sand

Several discussions were held with Provincial Council authorities in the NWP and the NBRO and the methodology to be adopted in extraction and issue of dune sand was worked out. One of the tasks to be carried out is an environmental impact assessment (EIA). It is reliably understood that it is the cause of delay in utilizing this material for the benefit of the construction industry as well as for those interested in carrying out development work/cultivation in these areas.

6.2 Off-shore Sand

i. Information was collected from overseas companies having the capacity and interest to extract sand. This information (gathered by NBRO) together with queries (of non-technical nature) raised by such companies were transmitted to the Board of Investment to enable potential investors to embark on a sand mining project.

ii. Based on the research findings of the NBRO and the University of Moratuwa, the

Ministry of Fisheries and Ocean Resources decided to initiate a pilot project on off shore sand mining and constituted a committee for this purpose. This committee recommended:

- the setting up of company to manage the pilot project for the mining, processing and marketing of off shore sand and

- the enforcement of regulatory measures in support of the use of off shore sand.

With regard to the latter, several activities were identified to be carried out; the important activities being the amendment of specifications, formulation of standards, provision of testing facilities, issue of compliance test reports and provision of training to home builders and contractors. Some of these activities have already commenced.
According to the project implementation schedule the marketing of off-shore sand should have commenced by now. However, a company to manage the project has not yet been set up or identified, although several agencies have shown an interest.

Conclusion

The Construction Industry is faced with a crisis situation with respect to the supply of river sand. It is therefore, important in ensuring better co-ordination and a more effective dialogue with all stakeholders so that an urgent and effective solution is found to avert the crisis.

References

[1] *National Sand Study of Sri Lanka, Phase One, Vols. 1&2, Netherlands Economic Inst. & Dept. Hydraulics, Colombo, April 1992.*

[2] *Report on R/v "Samudra Maru" Cruise SM – 10&11 : NARA, Feb. 1987.*

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Born on 14th February 1925. Eng. Withana is now functioning as Chairman and Managing Director of Land & Marine Engineering, Ltd., a construction company owned by him and his family.

He entered the Public Service in 1951 as a junior assistant engineer in the Colombo Port Commission. He proceeded to UK on a scholarship to study advance design on pre-stress concrete and design of thin cylindrical shells. He rose to the position of Deputy Chief Engineer in the Port.

In 1970 on the invitation of the Minister in charge he assumed duties as vice-chairman & General Manager in Ceylon Petroleum Corporation. He was released from Public Service in 1975 and took up full time appointment as Managing Director of Ceylon Petroleum Corporation, which position he held until he resigned in 1977.

During his tenure of service in the Public and Corporation Services from 1951 to 1975 he also held the following positions from time to-time. Competent Authority Gas Company; Member of the Ceylon Electricity Board; Chairman, Land Reclamation & Development Corporation and finally as Director-General, National Building Research Organisation.

N B M RANATUNGE, B.Sc (Cey). commenced his career in 1971 as a Standards Officer at the Sri Lanka Standards Institution. He rose to the position of Asst. Director in 1980 and was in-charge of standardisation of civil engineering materials. In 1987 he joined the National Building Research Organisation as a scientist attached to the Building Materials Division. In Year 2000 he was appointed as the Head of the Building Materials Division. There, he carried out extensive research on building materials. This Paper is based on research carried out by his team.

	Off-shore sand	Dune sand	Manufactured/ (Crushed rock) sand
1. Particle size	Coarse to medium (but with exceptions)	Fine and contained within narrow grading envelope	Medium
2. Particle shape	Similar to river sand	Similar to river sand	Elongated and irregular
3. Content of fines (dust/ clay sized particles)	unless calcareous mud[1] is present 0.2% to 1.5%, (i.e. within permissible limit of 4%)	0.2% to 0.4% (well within permissible limit of 4%)	2% to 11% on material processed by washing/ sieving to remove excess fines (permissible limit : 16%)
4. Composition (material other than sand)	May contain shells[2], shell fragments or some times calcareous mud (see Note)	Small percentage of heavy minerals	Same composition as in coarse aggregate
5. Properties of cement/ sand or concrete mites Workability	Similar to river sand	Good, especially in plaster/ mortar mixes May need more cement or mixing with other types of sand	Poor workability due to particle shape, but both strength and workability improved by blending with fine sand such as dune sand
Strength gain	- do -		
6. Deleterious material/ chemicals			
- chlorides	0.01% to 0.2% (overall) but less than 0.05% in samples[3] in North-Western coastal shelf	Less than 0.02%	not applicable
- sulphates	Less than 0.3% (within acceptable limits)	Insignificant	- do -
- organic matter	insignificant	Very low (as confirmed by qualitative analysis)	- do -

Table 1 : Comparison of properties of alternatives suggested.

Note : 1. Calcareous mud may be found in a narrow strip of sea shelf from Mt. Lavinia to Panadura and from Beruwela to Matara

2. Shell content in the Southern region is rather high – Some samples of off-shore sand (Hambantota and Nilaveli) contained over 90% shell and shell fragments
If the sizes of shells are less than 5 mm there is no limit specified for shell content in fine aggregate (i.e. sand used in concrete)

3. Permissible limits of chlorides will depend on the type of concrete and the cement used, but the chloride level sand in North Western Province would be acceptable for use in reinforced concrete (not pre-stressed concrete) with ordinary portland cement