Possibility of Producing Manufactured Sand from Quartzite Rocks at Rajawaka off Balangoda

Priyankara WMD, Pavithra P, Suwimal WMW and *Weerawarnakula S

Department of Earth Resources Engineering, University of Moratuwa, Sri Lanka

*Corresponding author – sarath89@hotmail.com

Abstract

Demand for construction sand rapidly increases due to speedy development projects going on all over the country. Until the recent past the sand requirement was fulfilled mainly by river sand. However due to scarcity of river sand and restriction of river sand mining due to negative environment effects, increased attention was received to find suitable alternatives. In addition to sea sand mining possibility of producing manufacture sand from suitable rocks, recycled aggregates and crush waste glass were carried out by many research groups.This study was carried out to find the suitability of large scale quartzite rocks occur at Rajawaka off Balangoda area for producing manufactured sand in the industrial scale. Sieve analysis, cube tests and slump tests carried out showed that manufactured sand produced from quartzite rocks of the area reach required strength for concrete.

Keywords: Concrete, Cube test, Digital Elevation Model, Sand

1. Introduction

Demand for the raw materials of concretes is increased day by day because of the speedy development projects going on all over the country. A good quality concrete is produced by careful mixing of cement, fine and coarse aggregates, water and admixtures as needed to obtain an optimum quality and economy[6]. Until the recent past, requirement of construction sand (fine aggregates) was fulfilled by river sand which is no more viable to extract because it is becoming a scarce material[5]. Sand mining from rivers has reached a stage where it is destroying our rivers, so it is being discouraged by environmental authorities.

The river sand remains the main source of sand for construction industry in Sri Lanka[3]. The main cause of concern is the nonrenewable nature of natural sand and the corresponding increasing demand of construction industry. As a result, it has been noticed the over exploitation of river sand causing serious environmental problems.

Sri Lanka consists of various kind of mineral resources which can be used as an alternative for river sand[2]. The effort to find such new economic mineral deposits or ore bodies is essential for the development of construction industry[4].

A systematic study to analyze the viability of these deposits for a manufactured sand project will be benefited economically and environmentally to the country.

This study is carried out to analyze the viability of using Quartzite as manufactured sand which is found in large quantities at Rajawaka off Balangoda area which are currently not used for any production. Preliminary studies in the area around Rajawaka show larger deposits of quartzite located around the area. Analysis of this study was mainly based on field work followed by several laboratory testing.

2. Methodology

2.1 Preliminary Planning

Overall study was planned to carry out in two main steps;

- Quantifying the Quartzite deposit located at Rajawaka off Balangoda area.
- Analyzing the suitability of Quartzite rock for manufactured sand found at Rajawaka off Balangoda Area.

Figure 1 – Sampling location map

2.2 Site Selection and Fieldwork

A reconnaissance geological survey of Rajawaka off Balangoda area was carried out to locate the quartzite deposits. Sampling locations were selected around the study area considering the extent of the quartzite deposit and accessibility.

Ten representative samples of approximately 5kg each were collected from the area of interest. Global Positioning System (GPS) was used to locate and determine co-ordinates of sample locations.

Table 1- Coordinates of sampling points

Location	Easting (m)	Northing (m)
L1	202309	156846
L2	202331	156887
L3	202347	156896
L4	202355	156899
L5	202376	156908
L6	202392	156915
L7	202545	156925
L8	202490	156582
L9	203048	156914
L10	203059	156912
L11	203067	156911
L12	203081	156908
L13	203099	156912
L14	203110	156911
L15	199403	157866
L16	199459	157813
L17	199485	154822
L18	199470	157789
L19	199149	157580
L20	199169	157580
L21	199194	157547

2.3 Sample Preparation

Samples were cleaned prior to crushing process to remove impurities present at their edges. Then samples were crushed and ground using laboratory Jaw Crusher. Samples that doesn't satisfy the particle size criteria by crushing using Jaw Crusher were introduced to Cone Crusher to check whether it can be crushed to the range using Cone Crusher.

2.4 Sample Analysis

2.4.1 Determination of Particle Size Distribution of Crushed Sand

Particle size distribution of crushed sand was measured using standard size sives, and later compared with the ASTM C33 standard.

2.4.2 Preparation of Manufactured Sand with Suitable Particle Distribution

Different particle sizes were collected separately from the sieving and they were added according to the required ratio. Then sample was mixed in the Ball Mill for better mixing. Finally, two sieve analysis were carried out to confirm whether the standard size distribution was achieved.

2.4.3 Preparation of Mix Design for Concrete Casting

For the purpose of making concrete, we selected grade as M20 which has ratio between cement, fine and coarse aggregates as 1:2:4. For higher accuracy volume ratio was converted to weight and weights were taken. Required water ratio was taken from the testing standards.

2.4.4 Determination of the Strength of the Concretes Casted using Manufactured Sand

This step was carried out to find the strength of concrete cubes casted using manufactured sand by performing the cube test. It was consisted by two main steps; casting of concrete cubes and

testing of cubes. Manufactured and mixed sand prepared in laboratory earlier was used in casting concrete cubes. Then, those casted cubes were tested after 7,14 and 28 days.

2.4.5 Determining the Workability of Concrete (Slump Test)

Slump Test is giving an idea about the workability of concrete thus here we used it for the determining the workability and followability of concrete made with manufactured sand. It was carried out according to ASTM C143 standard.

2.4.6 Quantifying the Available Quartzite Deposit at Rajawaka off Balangoda Area

This was carried out to roughly estimate the available quantity of Quartzite at Rajawaka area by developing a digital model using available contour maps. For locating quartzite deposits, 1:10000 geological maps were used and shape files developed using that were overlapped with contour maps inorder to develop Digital Elevation Model.

3. Results and Discussion

3.1 Determination of Particle Size Distribution of Crushed Sand

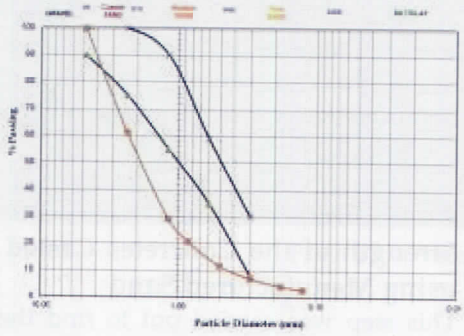

Figure 2 - Particle size analysis of sample 1

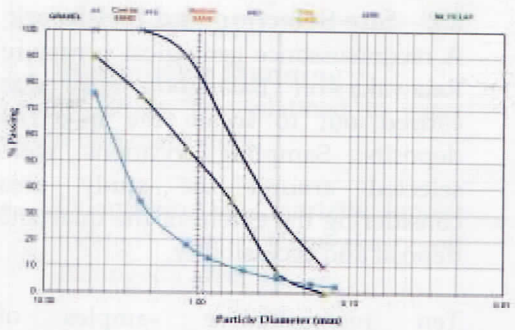

Figure 3 - Particle size analysis of sample 2

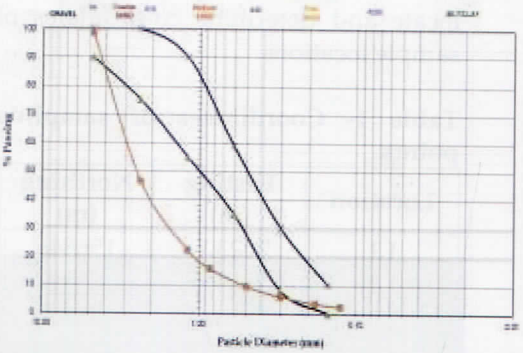

Figure 4 - Particle size analysis of sample 3

Available laboratory instruments were used to grind Quartzite samples which were taken from Rajawaka area to achieve suitable particle size range for concrete mixtures. However, as the available instruments couldn't produce required range of particles, two options were considered;

- Adding required size river sand to manufactured sand, and achieve particle size distribution
- Collect different particle sizes separately and mixing them in correct proportions

First one was rejected as calculations showed that requirement of large amount of river sand for mixing which makes the samples not representative as samples won't exhibit actual properties of manufactured sand.

3.2 Preparation of Manufactured Sand with Suitable Particle Distribution

Different particle sizes were separated and mixed in required ratios to achieve suitable particle size distribution for concretes. Sieve analysis was done for two mixed sand particles in order to confirm whether they are within required particle size range.

Table 2- Weights of different particle sizes

Particle Size (mm)	Weight (g)
4.75	1150.2
2.36	4025.9
1.18	8051.8
0.6	7239
0.3	4888.5
0.15	2895

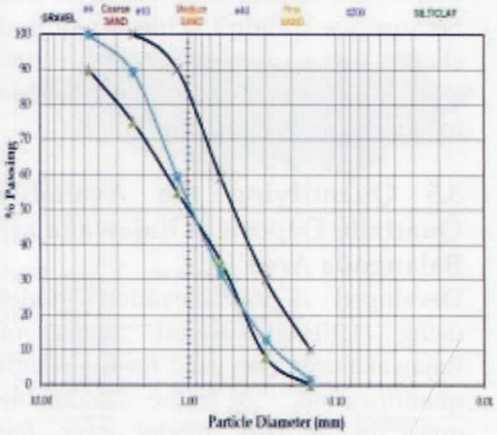

Figure 5 - Mixed sand, sample 1

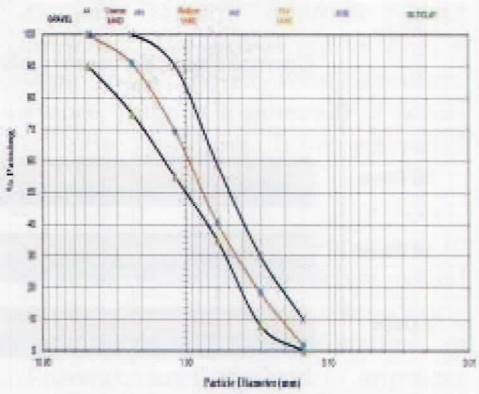

Figure 6 - Mixed sand, Sample 2 Mixed sand exhibit the required particle size distribution for concrete manufacturing.

3.3 Determination of the Strength of the Concrete Cubes Casted using Manufactured Sand

Table 2 - Results of cube test

Time	Sample	Weight (kg)	Force (KN)	Strength (Nmm^{-2})	Average strength (MPa)
7 Day	ER 5	8.2	315.4	14.01	15.3
	ER 6	8.3	296.2	13.16	
	ER 7	8.3	427.5	19	
	ER 8	8.3	343.6	15.27	
14 Day	ER 9	8.25	371.2	16.4	16.1
	ER 10	8.15	369.7	16.43	
	ER 11	8.3	346.7	15.4	
	ER 12	8.1	372.9	16.5	
28 Day	ER 1	8.2	389.5	17.3	17.6
	ER 2	8.3	430.1	19.1	
	ER 3	8.15	383	17.02	
	ER 4	8.3	385	17.11	

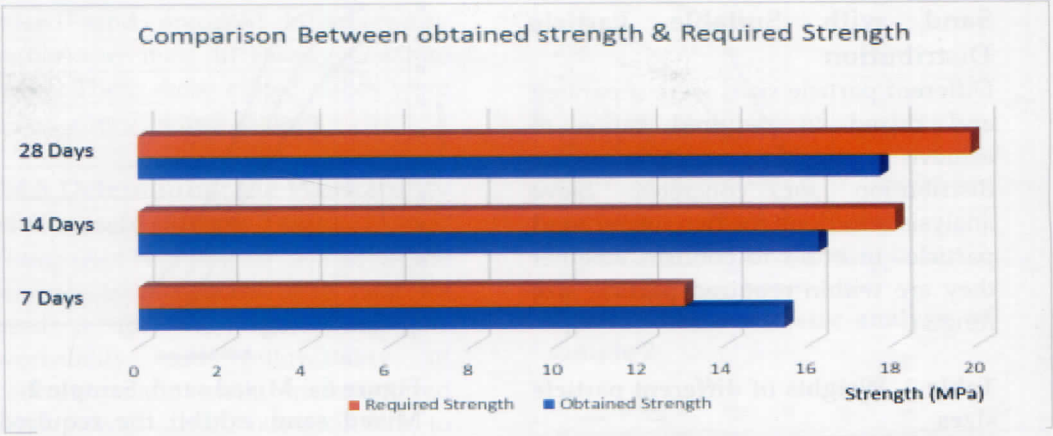

Figure 7 - Comparison between obtained strength and required strength

Compared to above standard casted cubes in the study obtained required strength within 7 days, however not up to the mark within other two durations. Following reasons were considered as root causes;

•Improper compaction due to ungrounded edges of sand particles.

•Change in inherent properties quartzite during crushing due to compression compared to inherent properties of river sand. Expertise prefer Vertical Shaft Impact Crusher than Jaw Crusher for this purpose.

•Less efficiency of used mixing machine which led to improper mixing.

3.4 Determining the Workability of Concrete (Slump Test)

Table 3 - Slump test results

Sample No	Height of the cone (mm)	Average (mm)
1	182	178
2	175	
3	177	
4	190	186.67
5	183	
6	187	

Results of the slump test shows workability (ease to flow) of made concrete is bit lesser than the required values according to the ASTM C143 standard. Literature show that size and shape of the aggregates make impacts on the workability of concrete; that would be the major reason for this because we couldn't achieve required shape using available instruments. Also, improper mixing of the available machine can lead for this.

3.5 Quantifying the Available Quartzite Deposit at Rajawaka off Balangoda Area

Developed digital elevation model using 1:10,000 digital maps of Rajawaka area was used for the rough quantification of the available quartzite. Initially model gave the volume by keeping the baseline to the sea level then it was changed to the base line to the elevation of Rajawaka area 503m for calculation.

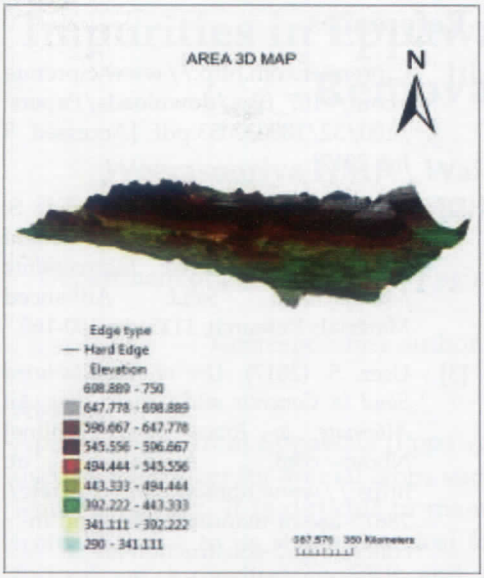

Figure 8 - DEM developed for Rajawaka off Balangoda

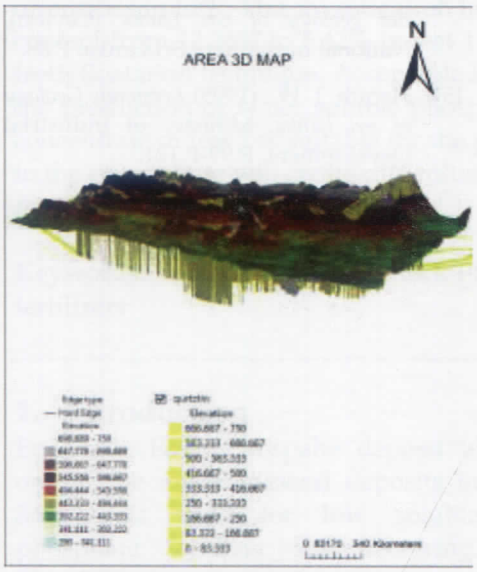

Figure 9 - Quantified DEM

Approximate volume of quartzite presence at Rajawaka off Balangoda area is 847,854,954 m^3.

However, this was only a rough estimation with few draw backs which are discussed below.

- Though software take the quartzite body as a vertical prism shape element, actual quartzite layer present at the area is not vertical, it dips in to north west direction. Hence, there is a potential of actual quantity differing from estimated value.

- Borehole logging is important to accurately measure the actual extend of the deposit whereas considering the extent up to elevation of Rajawaka area can lead to improper estimation.

4. Conclusions

The study is focused on the Rajawaka off Balangoda area that is situated in Rathnapura district at Sabaragamuwa province. Eventhough the sieve analysis of sand made from Quartzite does not lie within required range, the qualitative analysis of the deposits shows that compressive strength and workability of concrete made by manufactured sand is quite sufficient for construction purposes. Low impurity level and less dust generation implies the user-friendly production process. Quantitative analysis shows that there is enough quartzite present for economical extraction. Locating quarry in such rural condition can be expected to result in lesser issues as quartz plants are identified as one of industries with serious issue in populated zones, so mining license can be approved with lesser effort. Labor intensity of the area can be an advantage for the startup of a manufacturing process. All these characteristics make the deposit suitable for manufacturing sand for construction industry.

5. Recommendations

- Further studies are required to analyze the distribution of Quartzite body with higher accuracy.
- Vertical shaft impellor can be used as powerful instrument for lab sample preparations which will drive particles to be in required shape.
- Further studies should be carried out to determine the strengths of cubes using other mixing designs; M15, M25, M30.
- Analysis should be done to find out the impurity level and effects from those impurities to the strength of the concrete casted using manufactured sand.

Acknowledgements

The authors are thankful to Dr. H.M.R. Premasiri; Head of the Dept.of Earth Resources Engineering for facilitating the project, Dr. G.V.I. Samaradiwakara coordinating the research projects and all academic and non-academic staff members of the Department of Earth Resources Engineering for their cooperation given to make their project a success.

References

[1] Cipremier.com.http://www.cipremier.com/e107_files/downloads/Papers/100/32/100032053.pdf [Accessed 9 Jul. 2017].

[2] Ali, M., Nordin, M. and Saad, S. (2015). *Physical and Mechanical Properties of Concrete Incorporating Manufactured Sand.* Advanced Materials Research, 1115, pp.160-165.

[3] User, S. (2017). *Use of Manufactured Sand in Concrete and Construction An Alternate to River Sand.* [online] Nbmcw.com. Available at: https://www.nbmcw.com/concrete/28675-use-of-manufactured-sand-in-concrete-and-construction-an-alternate-to-river-sand.html [Accessed 9 Jul. 2017].

[4] Cooray P.G., (1984) *An introduction to the geology of Sri Lanka* (Ceylon), National museum of Sri Lanka, P.88.

[5] Herath, J. W., (1995) *Economic Geology of Sri Lanka,* Ministry of Industrial Development, P.99-P.121.