QUARTZITE MINING AND SAND MANUFACTURING

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ABSTRACT

Manufactured sand is considered as an alternative to match the rising demand of river sand in the construction industry. The basic concept is to crush Quartzite, the source rock to produce sand. This report focuses on sand manufacturing from a quartzite deposit at Dampellessa in Kurunegala district in Sri Lanka. The deposit has to be mined in multiple benches of 10m height and 80° of maximum working angle. Blasting for rock loosening and subsequent ripping with dozers, excavators and hydraulic hammers is recommended as a mining method. The manufacturing process involves crushing of the aggregates after which grinding and milling is simultaneously done by a specially designed perforated ball mill. Product is made on for customer specifications and suitable for concerting, plastering and as mortar.

KEYWORDS

Manufactured sand, Mining method, Processing, Quartzite

INTRODUCTON

Growing construction industry as well as natural catastrophes like Tsunami has contributed to sand demand and has increased in an exponential rate. Although sand extraction from river basins have already reached the break even point, sand suppliers are striving to fulfill the demand with some undesirable manners and trying to grab the market opportunities. In a time period where more emphasis is on sustainable development, these illegal and unethical sand extractions from river basins and river banks have already accounted massive damages to the environment. Ma Oya, Deduru Oya, Kalu Ganga and Kelani Ganga have been affected by sand mining. During the last half decade there has been rise in the tendency to mine land based sand from flood plains. People employing mechanized sand mining with dozers, loaders or specially designed equipments have turned the surrounding areas in to total chaotic situation. Government and the respective authorities had to impose new rules and regulations to protect the enviornment. Within a context that sand mining along Ma Oya and Deduru Oya, being banned by the Supreme Court a sand crisis was created in the country. Now sand has become a scarce resource and price of it has become unbearable to the average consumer. The situation desperately demands alternatives to overcome this crisis.

Alternatives for River Sand

- Dune sand
- Offshore sand
- Land based sand
- Quarry dust
- Manufactured sand (from quartzite)

Although some alternatives are economically feasible they suffer from many adverse environmental impacts. Within this context manufacturing sand from Quartzsite rock seem to be undoubtedly one of the best possible solutions to address the sand crisis. This paper describes a mining method for Dampellesse quartzite deposit in Kurunegala district and subsequent processing to produce sand.

Suitability of Quartzite

Quartzite is a high grade metamorphic rock which is made of (over 80%) crystalline silica. It is available in ample quantities in almost all around the country. The economical benefit rendered by low grade quartzite has not been notable to date. Normally Due to its mineralogical formation Quartzsite rock consists of fractures and cracks. This facilitates mining of quartzite by ripping and subsequent processing to make sand. Though quartzite is subjected to physical weathering its free of clay.

Merits of Manufactured Sand (Quartz Sand)

- Specific sizes for particular applications can be obtained by process itself
- Polished texture Increases the workability of the concrete mix and residual surface roughness increase the flexural strength
- Post sieving is not needed
- Binding qualities with cement is better than sea sand and even river sand due to irregular shape
- Absence of impurities such as mica

METHODOLOGY

The area to be mined was evaluated for possible environmental impacts. Rock samples from the area were collected for laboratory experiments. Following tests were carried out to determine the properties of quartzite and its suitability to use as feed material to produce sand

- Density
- Swelling factor
- Uniaxial compressive strength
- Measurement of angle of repose of crushed quartzite
- Microscopic analysis of manufactured sand

A series of trials were done with lab scale instruments to determine the most appropriate processing method to make sand.

Size reduced quartzite boulders were crushed in the lab scale jaw crusher and put in to the Teema mill for 30 seconds. These particles were fed in to the ball mill for further processing and particle size distribution was tested pre and post to milling. Several test runs were carried out under wet and dry systems while changing milling duration (2,4,6,8 and 10 minutes) and quantity of grinding media(2*feed and 4*feed). Particle size distributions were plotted in graphs and compared with river sand particle size distribution. Graphs which were closely followed the river sand distribution is again plotted in a graph as a summery, given as figure 4.

The research team developed a small scale prototype of a perforated ball mill to make sand having particle size of 2-5mm, 0.75-2 mm and <0.75mm.

LABORATORY TEST RESULTS

- Bulk Density of quartzite 2516.2 Kg/m^3.
- Swelling factor=1:1.62
- The UCS value of the specimen varied from 1.87x107 to 2.51x107.
- Repose angle of crushed quartzite=37°

Mining Method

The Figure 1 illustrates a 3D view of the surface topography of mining area and a sketch of the mine plan developed using the contour data of the Dampellesa quartzite deposit. The Quartzite rock is exposed from the earth surface which elevates about 50m from Allawwa Dampellessa road. Hence, open cast mining with multiple benches would be the most appropriate mining method.

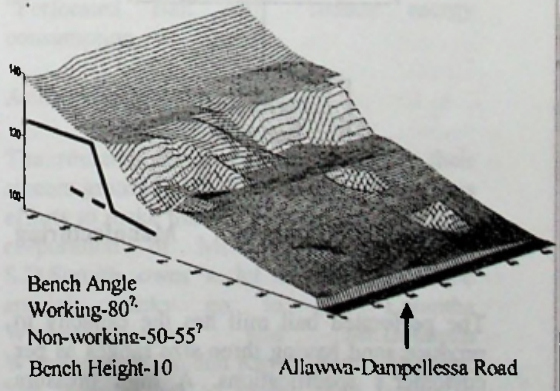

Figure 1: Mine Plan

As per the designed production of 250cubes/day, blasting would be ideal to mine the deposit .The purpose of blasting is to loosen the material which could be ripped using rippers, excavators or back dozer. Gelignite with electric detonators should be used for blasting.

Fragmentation of Quartzsite to suit feed material is an important to be considered which allows direct feeding to the primary crusher.

Since fine quartzite dust is highly carcinogenic wet processing is recommended. Four different processes were considered and finally below given method (Figure 2) was selected as the most suitable method. With this newly designed perforated ball mill, milling and sieving could be done simultaneously

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The actual production capacity is 250cubes/day.Folowing table shows the recommended crusher specifications

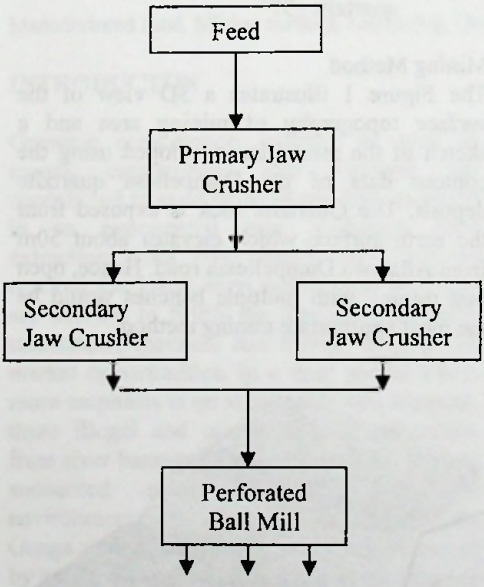

Figure2: Quartzite Manufacturing Process

The perforated ball mill has the capacity to produce sand having three size ranges as per customer's specifications. A high pressure water jet would be introduced in the milling chamber to suppress dust generation as well as to improve textural properties of sand.

Table 1:Crusher Specifications

Crusher	Size of Feeder Opening (mm)	Maximum Feeding Size(mm)	Capacity (tons)	Motor Power (HP)
Primary	900x600	480	45-110	75
Secondary	1200x250	210	28-60	37

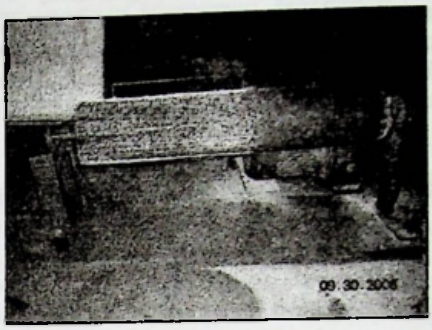

Figure 3: Perforated Ball Mill

Table 2: Percentage of Fines in at Different Ball Mill Parameters

No	Feed (g)	Feed Size (mm)	Milling Time (Minutes)	Ball Charge (g)	Fine Fraction %
1	300	<10	10	600	0.71
2	300	<10	10	1200	0.77
3	500	<10	10	1000	0.04
4	500	<10	8	2000	0.99

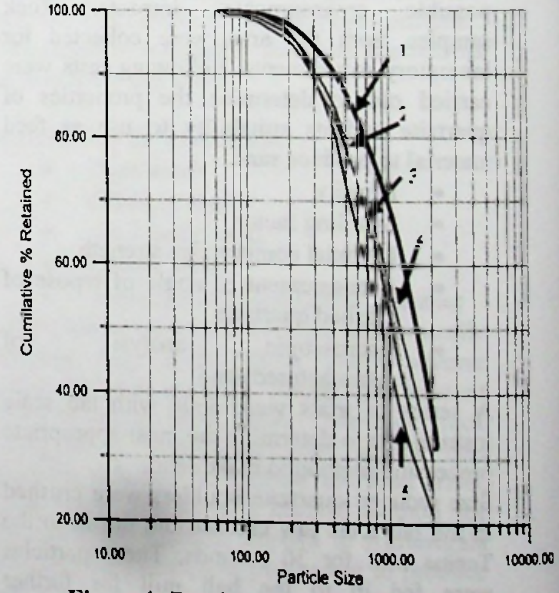

Figure4: Particle Size Distribution

1: 300g sample wet milling for 10 minutes with ball Charge of 2 times feed ——

2:300g sample wet milling for 10 minutes With ball charge of 4 times feed .....

3:500g sample dry milling for 10 minutes with ball Charge of 2 times feed ——

4:500g sample dry milling for 8 minutes with ball Charge of 4 times feed ——

5:500g river sand sample ——

DISCUSSION

Dampellessa Quartzsite deposit is an outcropping deposit where open pit mining with multiple benches would be more economical. Engineering and geological properties of quartzite rock does not permit the use of ANFO and only gelignite is recommended with electric detonators for blasting. UCS values were determined in order to decide safe bench heights and bench angles .Quartzite samples at the surface were heavily weathered and observed UCS values were below the expected theoretical values. It could expect competent rock at depth

The application of computer aided quarry planning and simulation will be of great use in proactive decision making

Quartzite fine dust being highly carcinogenic wet process is recommended which will remove fines and trap them in a silt pond. Dust generation in mining, loading and hauling activities could be minimized by water sprinkles and construction of wind barriers.

Particles less than 0.75mm are considered as fine dust which falls out of sand range. Laboratory test results conclude no 3 experiment (Table2) yields the minimum percentage of fines.

The work carried out resulted in developing a "Perforated Ball Mill" where milling and sieving could be done simultaneously and this may reduce the power consumption, in an effective manner .Power requirement was not quantified as it was beyond the scope of this research. Quartz pebbles could be used as the grinding media which are available in ample quantities. Further more quartzite pebbles charge will eliminate any possible addition of impurities. Due to the simplicity of sand manufacturing process these units can be easily moved from one place to another and re-assembled.

Comparing textural properties of manufactured sand and river sand by Microscopic analysis confirms that wet milling is the most appropriate for sand manufacturing.

A sound and object oriented post mining rehabilitation programme need to be implemented .Native and typical trees relating to the area must be planted as a part of the rehabilitation process. An attractive awareness program must be launched to educate neighboring residents on the positive outcomes of the project

CONCLUSION

Quartzite is a suitable alternative for river sand. Open pit mining method should be used to extract quartzite outcrop. Gelignite with electric detonators could be used for loosening and mechanical mining by ripping to mine the deposit is recommended .Wet processing is recommended to minimize the dust emission. The results obtained in laboratory scale testing concluded that 10 minutes grinding with four times ball charge as the best suited for laboratory scale sand production. Simultaneous sieving and milling in the "Perforated Ball Mill" reduce energy consumption

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