BAHAGIAN PENYELIDIKAN & PEMBANGUNAN CANSELORI
UNIVERSITI SAINS MALAYSIA

Laporan Akhir Projek Penyelidikan Jangka Pendek

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2. Pusat Pengajian : PPK Bahan & Sumber Mineral

3. Tajuk Projek : Advanced Manufactured Sand for High Strength Concrete

4. (a) Penemuan Projek / Abstrak

Bahasa Melayu

Pengambilan pasir dari sungai secara berleluasa telah memberi kesan buruk terhadap alam sekitar. Kerajaan Malaysia telah mengharamkan pengambilan pasir sungai di beberapa tempat atas sebab ini. Oleh itu, untuk menggantikan penggunaan aggregat halus (pasir) dalam pembuatan konkrit, satu bahan gentian lain perlu dicari. Dalam hal ini, batuan halus yang berbentuk kubik melepasi saiz 4.75mm digunakan untuk menggantikan pasir sungai. Walaubagaimanapun, partikel ini mempunyai sisi yang tajam dan tekstur permukaan yang kasar, dan penggunaannya dalam konkrit memerlukan bahan tambah lain untuk meningkatkan keplastikan konkrit basah. Ini menunjukkan bahawa mineralogi batuan juga memainkan peranan penting kepada kekuatan dan ciri-ciri lain dalam konkrit.

Dalam projek ini, penghasilan pasir buatan daripada sisa kuari telah dijalankan. Batu hancur adalah hasil daripada proses penghancuran batuan induk bersaiz besar. Beberapa ciri seperti bentuk dan saiz partikel, dan tekstur permukaan batuan hancur tidak dapat dilihat pada batuan induk. Manakala sesetengah ciri-ciri lain boleh berubah ketika proses penghancuran. Sesetengah mesin penghancur menghasilkan pasir hancur yang mempunyai partikel berkeping yang mana boleh menyebabkan kebolehkerjaan konkrit menurun dan memerlukan lebih nisbah air kepada simen. Kesan daripada air yang berlebihan dalam konkrit boleh mengurangkan kekuatan akhir konkrit dengan banyak. Bagi mengelakkan kekurangan ini terjadi, tekstur permukaan pasir perlu sekata dan sisi yang berbentuk bulat. Masalah ini dapat diatasi dengan menggunakan mesin penghancur yang boleh menghasilkan pasir buatan yang hamper sama seperti pasir sungai. Pasir buatan yang dihasilkan dalam kajian ini telah memberikan tekstur permukaan yang lebih baik dan butiran yang berbentuk kubik.

Bahasa Inggeris

Digging of sand from the riverbeds in access quantity is hazardous to environment. The Malaysian Government has banned the quarrying of sand from riverbed in many areas. For this reason, an alternative material must be found to replace the requirement of fine aggregate (sand) in concrete making. Fine cubical particles of stone below 4.75mm are used to replace the river sand. But as these particles have sharp edges and rough surface texture, its use in concrete requires some admixtures to increase the plasticity of the wet concrete mortar. This shows that the mineralogy of the rock plays an important role in the strength and other properties of the concrete.

In this work, a study was carried out to produce manufactured fine aggregate from the quarry waste. Crushed sand is produced by crushing a large parent rock. Some properties such as shape and size of particle and surface texture of crushed sand are not seen in the parent rock. While other properties can change due to the crushing process. Such machines produced sand containing flaky particles, which decrease the workability and requires more water to cement ratio. The effect of high water to cement ratio in concrete reduces its ultimate strength to a substantial amount. To avoid these deficiencies, the surface texture of the sand particles should be smooth and the edges should be rounded. These difficulties could be overcome by using crushing machines that can produce manufactured sand that is similar to river sand. The sand manufactured from this study exhibited good surface texture and particles that were more cubical.

(b) Senarai Kata Kunci Yang Digunakan Di Dalam Abstrak

Sand, fine aggregate, manufactured sand, Barmac crusher

Bahasa Inggeris	**Bahasa Melayu**
Sand	Pasir
Fine Aggregate	Agregat Halus
Manufactured sand	Pasir Buatan
Barmac crusher	Penghancur Barmac
Cubicle particles	Partikel berkubik

5. Laporan Projek

Material

This research used quarry dust obtained from a quarry in Juru. The feed size of the sample was 100% of -10.0mm + 6.3mm particles.

Sample Preparation

The sample of quarry dust was dried before crushing. The Barmac rock-on- rock vertical shaft impact crusher was used in this study. Coning and quartering method was used for sampling to obtain representative samples for the testwork.

RESULTS AND DISCUSSION

Grading is regarded as the main feature of sand (both fine aggregate and manufactured sand). Particle size analysis covers the determination of the particle size distribution of fine aggregate by sieving. Figure 1 shows the results of size distribution curve for the testwork. The size distribution of manufactured sand gave more fines compared to the river/natural sand, especially in the size range -0.60mm to -0.075mm. The fines could give advantage to reduce cement in concrete.

Particle Size Analysis

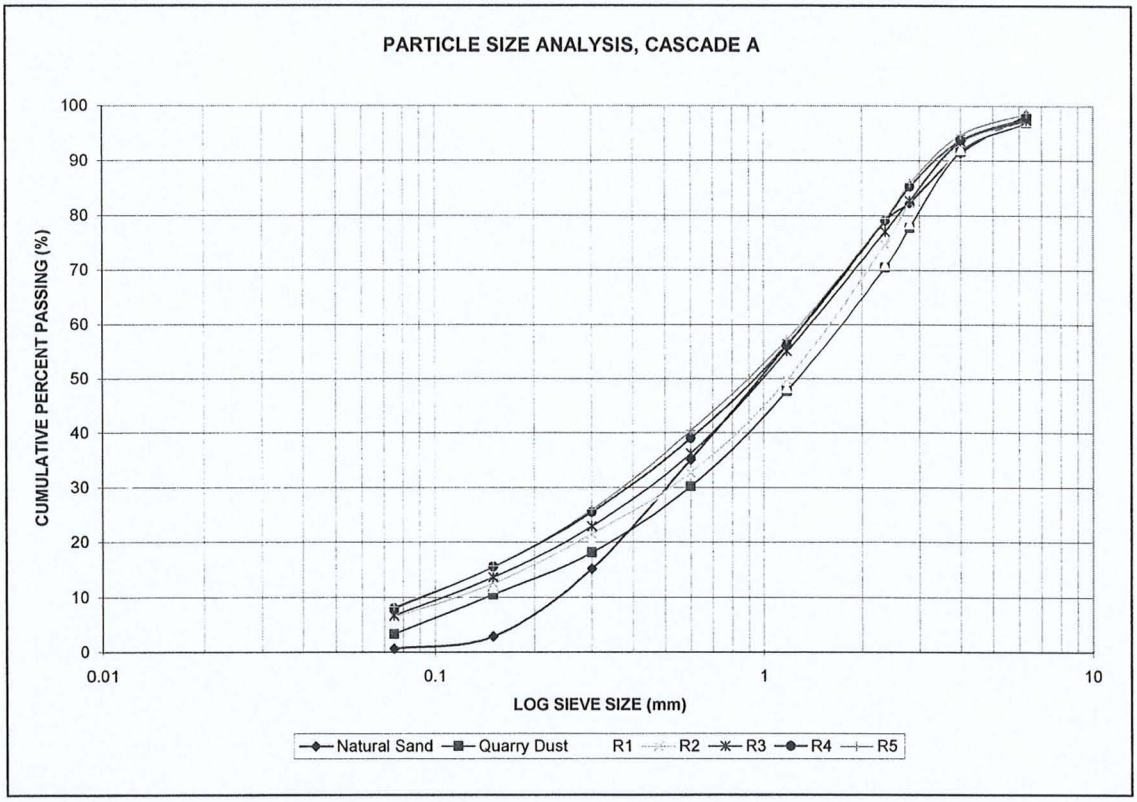

Fig.1: Particle Size Distribution Graph.

Uncompacted Void Content

This test method determined the loose uncompacted void content of a sample of fine aggregate and manufactured sand. Void content provides an indication of the aggregate's angularity, sphericity, and the surface texture compared with other fine aggregates tested in the same grading. But when void content is measured on as received fine aggregate grading, it can be an indicator of the effect of the fine aggregate on the workability of a mixture.

Standard Graded Sample (Test Method A) was the test method used as a standard fine aggregate grading obtained by combining individual sieve size fractions from a typical fine aggregate sieve analysis. Meanwhile, the individual size fractions (Test Method B) was the test method used for each of three fine aggregate size fractions; -2.36-1.18mm,-1.18+0.60mm and -.60+0.30mm respectively. In this method, each size was tested separately. Both test Method A and Test Method B provide percent void content determined under standardized conditions which depend on the particle shape and texture of a fine aggregate.

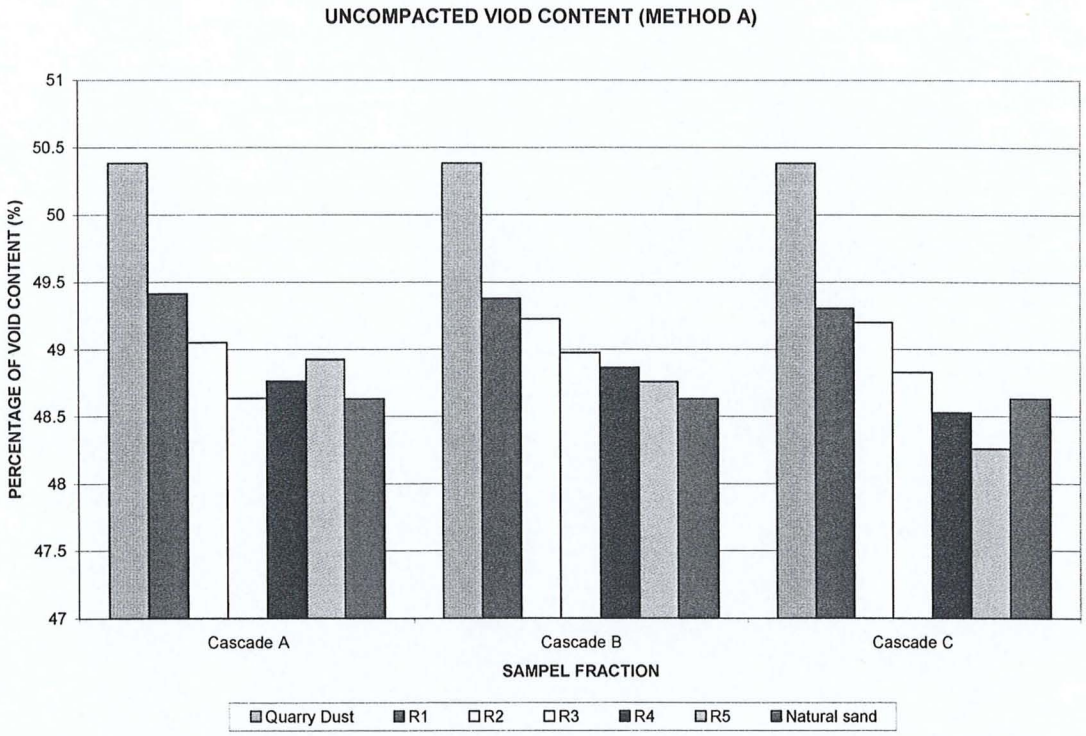

Fig.2: Uncompacted Void Content (Test Method A)

Fig.2 shows that the quarry dust has the highest voids content (50.38%) compared to the products obtained from cascade A, cascade B and cascade C tests. Meanwhile, the natural sand showed the lowest (48.63%) void content, except for the samples which was run during cascade C with the rotor speed of R4 and R5. This shows that the Barmac crusher could produce better fine aggregate (manufactured sand) with lower voids content by increasing the rotor speed. The changed in cascading flow also did not give much difference in the void content value.

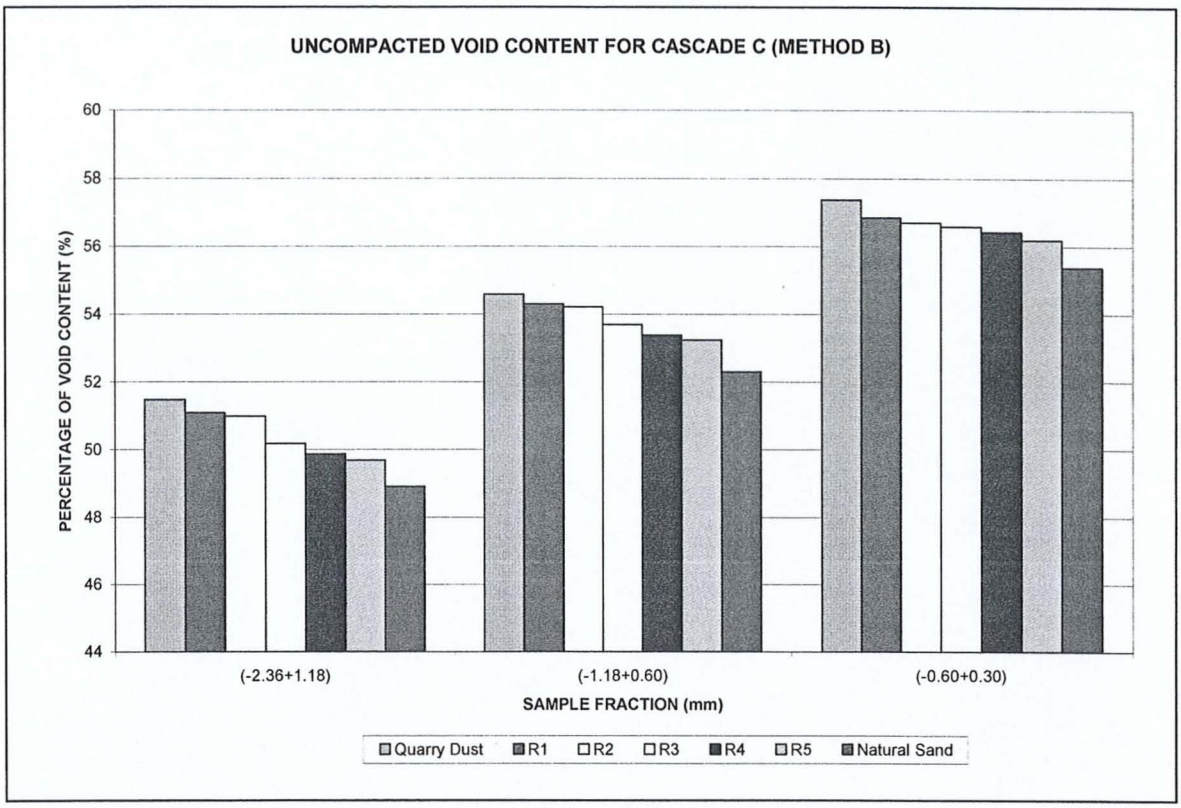

Fig.3: Uncompacted void Content (Test Method B)

The uncompacted void content using Test Method B showed a similar pattern for every size fraction but not the values. From Fig.3, size fraction -2.36+1.18 mm gave the lowest, 48.98% to 51.48% void content for all samples in this fraction. While the fraction of -0.60+0.30 mm gave the highest void content of 55.38% to 57.39%.

An increase in void content by these procedures (test method A or test method B) indicates greater angularity, less sphrecity, or rougher surface texture. A decrease in void content is associated with more rounded, spherical, or smooth-surface fine aggregate. Void content information from both test method would be useful as an indicator propery such as: the mixing water demand of hydraulic cement concrete; flowability, pumpability, or workability factors when formulating grouts or mortars; or in bituminous concrete, the effect of the fine aggregate; or the stability of the fine-aggregate portion of a base course aggregate.

Surface Area, BET

Manufactured sand produced from the Barmac crusher had a higher surface area than quarry dust. From Fig.4, it shows that the manufactured sand which was crushed at lower rotor speed produced higher surface area than the feed (quarry dust).

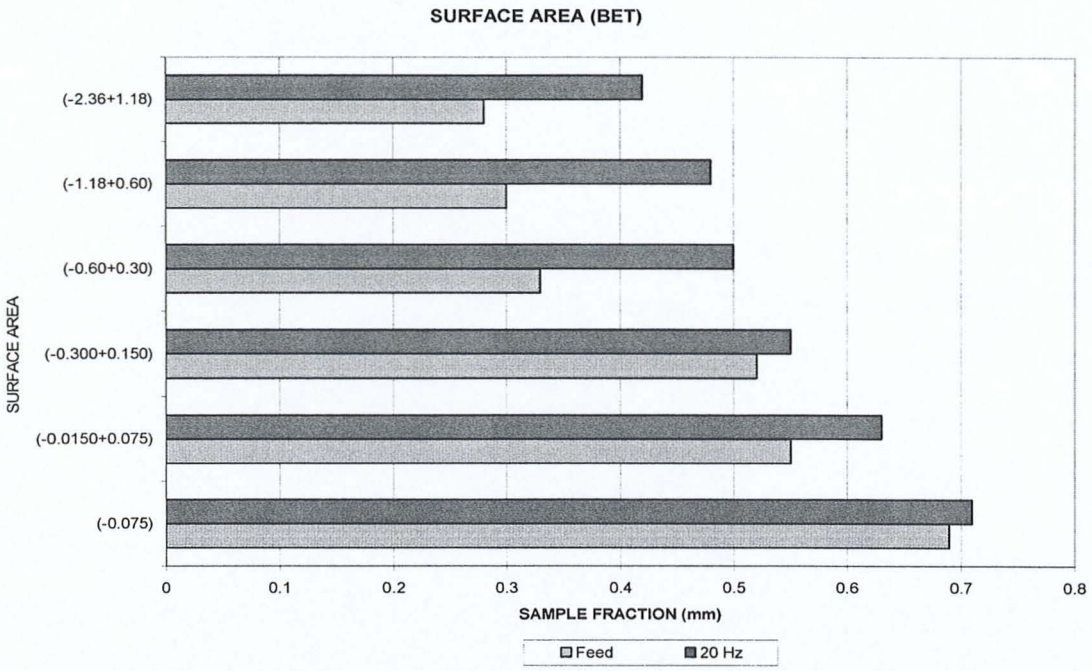

Fig.4: Surface area analysis.

Higher content of fines in the aggregate increased the fineness and total surface area of aggregate particles, where surface area was measured in terms of specific surface, i.e. the ratio of the total surface area of all the particles to their volume. Aggregates with higher specific surface area require more water in the mixture to wet particle surfaces adequately and to maintain a specific workability. Obviously, increasing water content in the mixture will adversely affect the quality of concrete.

Morphological Study and Surface Texture

Determination of surface morphology of manufactured sand at various magnification was carried out for feed and product samples. The effect of bond strength increases with the strength of the concrete. While surface texture plays a significant role, and this will vary from rock type to rock type, the presence of any loose friable material on the surface will reduce bonding. This may be in the form of loose grains of the parent rock or coating of other material such as silt or clay or adhering fines. The strong scrubbing and grinding actions that take place within the Barmac will certainly dislodge any of this loose material, thus ensuring a good bonding surface.

The surface texture of the manufactured sand became smoother with increasing rotor speed. Fig.6 shows that the surface texture of the quarry dust was rougher compared to Fig.8, Fig.10 and Fig.12 which were samples of manufactured sand.

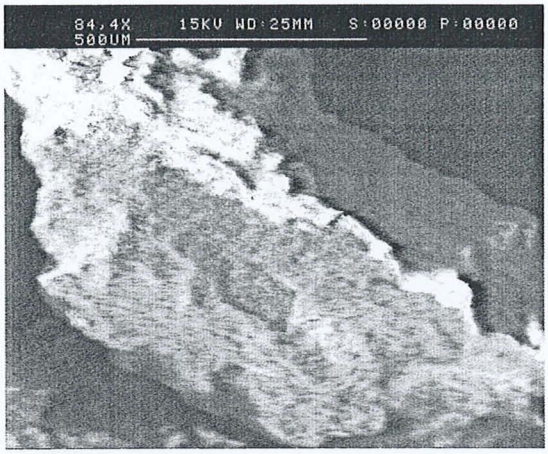

Fig5: Quarry Dust Particles (0.60mm)

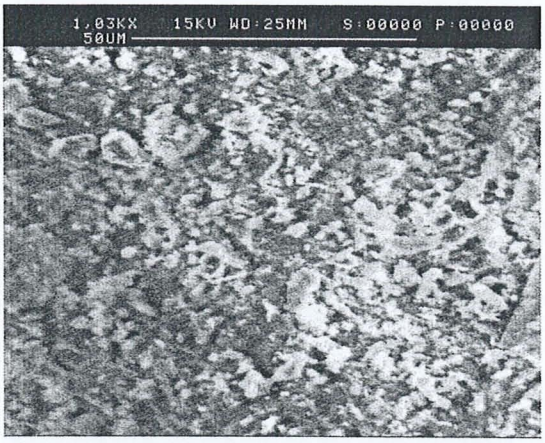

Fig6: Surface Texture of Quarry Dust (0.60mm)

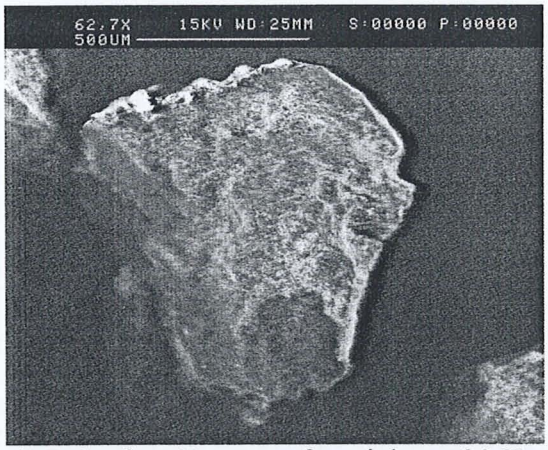

Fig7: Surface Texture of particles at 20 Hz (0.60mm particles)

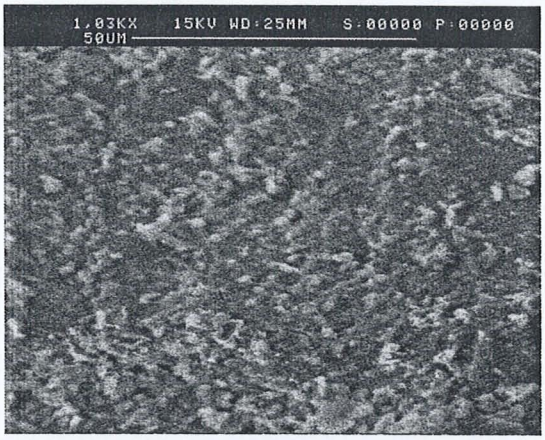

Fig8: Surface Texture of particles at 20Hz (0.60mm)

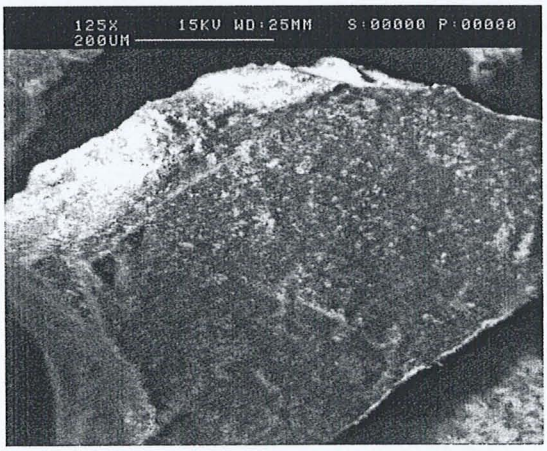

Fig9: Surface Texture of particles at 40Hz (0.60mm)

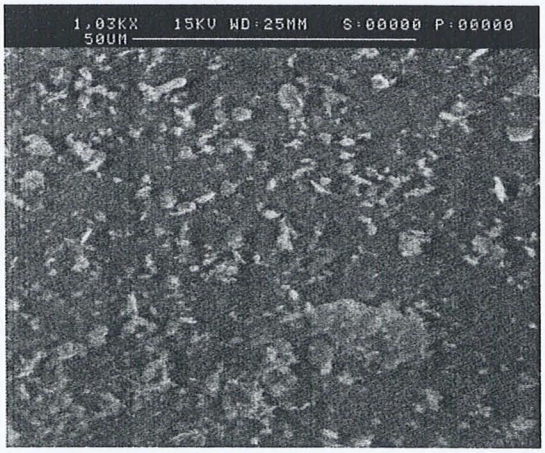

Fig10: Surface Texture of particles at 40Hz (0.60mm)

Fig11: 60Hz (0.60mm particles)

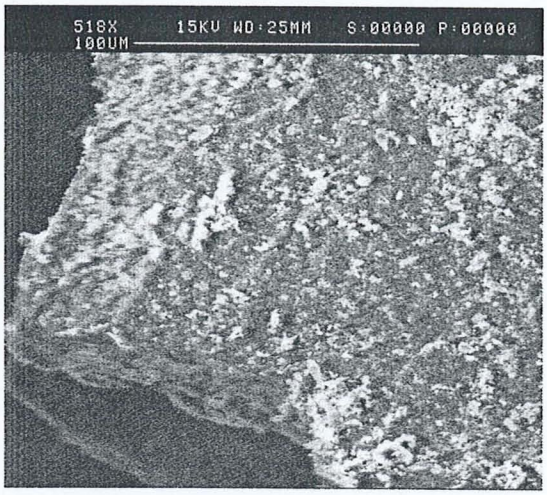

Fig12: Surface Texture of particles at 60Hz (0.60mm)

The Barmac crusher was also capable to reshape the quarry dust particles upon producing manufactured sand. There were less elongated and flaky particles in manufactured sand compared to the feed material. From Fig.7, Fig.9 and Fig.11, the shape of the manufactured sand was more cubical compared to the quarry dust.

CONCLUSION

Sand can successfully be manufactured from rock, and can be used to alleviate the shortage of natural sand. Furthermore, the waste fines from crushing operations, if processed correctly, can be converted into a premium product. The results from the testwork showed that manufactured sand can possibly be used as a substitute for natural sand in concrete thus protecting the exploitation of natural sand to safeguard the environment.

REFERENCES

Anon, (1997): "Enhancing-Manufactured sand ", Quarry Journal, 28-49

Hammer.M.D (1990) "The vertical shaft rock on rock impacted crusher as a producer of quality construction materials", Tidco International, New Zealand

Hudson.B (1997): "Shape Aids Product Performance, vol.5, No.3, p.56

Tahie celik and Khaled Marar (1996): "Effects of Crushed Stone Dust on Some Properties of Concrete", Cement and Concrete Research, vol.26, No.7, p.1121-1130

6. Output dan Faedah Projek

(a) Penerbitan

Khairun Azizi, M. A., Sri Raj Rajeswari, M., Roshazita, C. A., Samayamutthirian, P., Syed Fuad, S. H., Hashim, H., Megat Azmi, M. J. & Metso Minerals (2004). High Quality Shape Aggregates (HIQSA) For Superior Performance In Concrete. *CIRAS'04: Construction Industry Research & Development Achievement Seminar Proceeding.* Construction Industry Development Board, Kuala Lumpur : Malaysia.

Sri Raj Rajeswari, M., Khairun Azizi, M. A., Roshazita, C. A., Samayamutthirian, P., Syed Fuad, S. H., Hashim, H., Megat Azmi, M. J. & Metso Minerals (2004). From Crusher To Higher Quality Or Superior Concrete: An Innovative R&D Approach. Malaysia Quarry Conference & Exhibition (MQC) 2004. Kuala Lumpur : Malaysia.

Roshazita Che Amat and Khairun Azizi M. Azizli (2002). Manufactured Sand As A Substitute For Natural Sand In High Technology Concrete. MAMIP Post Graduate Research Papers 2001/2002. Universiti Sains Malaysia. p. 69-70.

(b) Faedah-faedah Lain Seperti Perkembangan, Produk, Prospek Komersialisasi dan Pendaftaran Paten

Manufactured sand produced from waste material such as quarry dust has been produced from this work.

Manufactured sand can be used as a replacement for natural/river sand in concrete making.

Initial testwork has shown that manufactured sand can produce compatible strength in concrete or in certain cases, higher strength in concrete.

(c) Latihan Gunatenaga Manusia

1. Pelajar MSc : 1 orang
2. Pelajar-Prasiswazah : 3 orang telah menyiapkan tesis tahun akhir

7. Peralatan Yang Telah Dibeli

Tiada. Menggunakan peralatan yang sedia ada di Pusat Pengajian dan yang dipinjamkan oleh Metso Minerals (New Zealand dan Australia).