OPTIMUM UTILIZATION OF QUARRY DUST AS PARTIAL REPLACEMENT OF SAND IN GREEN CONCRETE

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In the Name of Allah, the Beneficent, the merciful,

I dedicate this thesis to Allah S.W.T who has endowed me with the capacity to

Increase

In knowledge and wisdom and has guided my path this far.

This thesis is also dedicated to my beloved husband and my parents,

For their endless love, understanding, support and encouragement.

And not forgotten to

All my family members, lecturers and friends.

ABSTRACT

The reduction in the source of natural sand and the requirement for reduction in the cost of concrete production has resulted poor quality sand sources supplied and thus increased need to identify substitute material to sand as fine aggregates in the production especially in concrete. To overcome from this crisis, partial replacement of sand with quarry dust can be economical alternative. Quarry dust, a by-product from the crushing process during the quarrying activities is one of such materials. In the Peninsular of Malaysia there were also been many attempts to use quarry dust as partial replacement but only up to 50% on the lower grades concrete with different construction purposes. This paper present mix design of higher grade 60 that develop with a replacement of 0% (100% of natural sand), 50% and up to a maximum of 70% of quarry dust usage. Tests were conducted on cubes to determine the properties and strength of concrete made of quarry dust and the results were compared with natural sand concrete. An attempt has also been made to conduct the slump test to determine the fresh concrete workability and also to obtain the compressive strength (cubes), spilt tensile strength, flexural strength and water absorption of hardened concrete for laboratory analysis.

ABSTRAK

Pengurangan sumber pasir semulajadi dan keperluan bagi pengurangan dalam kos pengeluaran konkrit telah menyebabkan sumber pasir berkualiti rendah dibekalkan dan dengan itu secara tidak langsung telah meningkatkan keperluan untuk mengenal pasti bahan pengganti pasir sebagai agregat halus dalam pengeluaran bahan binaan terutamanya dalam penggunaan bancuhan konkrit. Bagi mengatasi krisis ini, penggantian sebahagian pasir dengan debu kuari boleh menjadi alternatif yang menjimatkan. Debu kuari, yang yang merupakan produk bahan terbuang atau sekunder daripada proses penghancuran semasa aktiviti kuari adalah salah satu daripada bahan-bahan tersebut. Di Semenanjung Malaysia terdapat juga banyak percubaan untuk menggunakan debu kuari sebagai pengganti separa tetapi hanya sehingga 50% ke atas gred konkrit yang lebih rendah kekuatannya dengan tujuan pembinaan dan rekabentuk struktur bangunan yang berbeza. Penghasilan reka bentuk bancuhan konkrit yang bergred lebih tinggi seperti gred 60 dengan penggantian 0% (100% pasir semula jadi), 50% dan sehingga maksimum 70% daripada debu kuari dimanfaatkan. Ujian dijalankan ke atas kiub untuk menentukan sifat-sifat dan kekuatan konkrit yang diperbuat daripada debu kuari dan kemudian keputusan tersebut dibandingkan dengan bancuhan konkrit yang menggunakan pasir semula jadi. Percubaan juga dibuat untuk menjalankan ujian kemerosotan untuk menentukan kebolehkerjaan konkrit segar dan juga untuk mendapatkan kekuatan mampatan (kiub), kekuatan tegangan, kekuatan lenturan dan penyerapan air konkrit untuk penganalisaan data-data makmal.

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LIST OF SYMBOLS

CaO	-	Lime
SiO_2	-	Silicate
Al_2O_3	-	Aluminate
Fe_2O_3	-	Iron Oxide
$Ca(OH)_2$	-	Calcium Hydroxide
(C-S-H gel)	-	Calcium Silicate Hydrate
R	-	Flexural Strength, MPA
P	-	Maximum Applied Load, N
L	-	Span Length , mm
b	-	Average Width of Specimen, m
d	-	Average Depth of the Specimen, m
Fct	-	Tensile Splitting Strength (N/mm^2)
F	-	Ultimate Load at Failure (N)
D	-	Diameter of the Specimen (mm)
π	-	3.14
F	-	Shape Factor
q	-	Elongation Ratio
n	-	Coefficient (exponent)
GGBS	-	Ground Granulated Blast Furnace Slag

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CHAPTER 1

INTRODUCTION

1.1 Background

As part of the normal production of crushed aggregate up to 30% (rock dependant) of the material recovered from the quarry is reduced to a size that is not suitable as coarse aggregate. Typically, this material will pass the 4.75mm screen.

As the supplies of suitable natural sand near the point of consumption are becoming exhausted, the cost of this sand is increasing. A replacement material was sought and the fines from crushing operations were identified as a possible substitute material. Early attempts by the quarry industry to market this material as manufactured sand resulted in failure. This was due to the material having been produced as a waste product; no thought having been given to the properties that are crucial to its performance in concrete. The manufactured sand also failed due to noncompliance with the existing sand specifications. Criteria such as misshapen particles increasing the water demand, gradation not falling within the prescribed envelope, micro fines (material passing a 75micron sieve) content too high, sands equivalent and fineness modulus out of specifications; to name but a few, have limited the general acceptance of manufactured sand. Attempts to modify the

properties of the manufactured sand to conform to the specifications brought with them new problem such as increased production costs and disposal of the waste micro fines from the washing process.

These problems were recognised by the aggregate and concrete industries and together with the specifying authorities, revised the sand specifications to include manufactured sand as a construction material in its own right. However, since manufactured sand is so different to natural sand, new testing and proportioning methods need to be developed. In 1997, a report was commissioned to quantify the status of the fitness produced by aggregate quarrying operations in the USA. The report identified that, although 80% of the fitness produced are used for constructions and agricultural purpose, there is in excess of 300 million tons of minus 9.5mm and 400 million tons of minus 75micron material already stockpiled. This amount is increasing by 180 million tons per year. The balance of the material is stockpiled, creating a financial and environmental drain on the quarry industry. One of the main causes is the limit being placed on the amount of minus 75micron material allowed in the aggregates and sand.

Concrete is the most popular building material in the world. However, the production of cement has diminished the limestone reserve in the world and requires a great consumption of energy. River sand has been the most popular choice for the fine aggregate component of concrete in the past, but overuse of the material has led to environmental concerns the depleting of securable river sand deposits and a concomitant price increase in the material. Therefore, it is desirable to obtain cheap, environmentally friendly substitutes for cement and river sand that are preferably by products. GGBS (pulverized GGBS) is used extensively as a partial replacement of cement. However, though the inclusion of GGBS in concrete gives many benefits, such inclusion causes a significant reduction in early strength due to the relatively slow hydration of GGBS. Nevertheless, GGBS causes an increase in workability of concrete.

Quarry dust has been proposed as an alternative to river sand that gives additional benefit to concrete. Quarry dust is known to increase the strength of concrete over concrete made with equal quantities of river sand, but is causes a reduction in the workability of concrete. When examining the above qualities of GGBS and quarry dust it becomes apparent that if both are used together, the loss in early strength due to one may be alleviated by the gain in strength due to the other and the loss of workability due to the one maybe partially negated by the improvement in workability caused by the inclusion of the other.

The use of GGBS in concrete is desirable because of benefits such as useful disposal of a by-product, increased workability, reduction of cement consumption, increase sulphate resistance, increased resistance to alkali-silica reaction and decreased permeability. However the use of GGBS leads to a reduction in early strength of concrete. Therefore the concurrent use of quarry dust and GGBS in concrete will lead to the benefits of using such materials being added and some of the undesirable effects being negated. The concurrent use of the two by-products will lead to arrange of economics and environmental benefits.

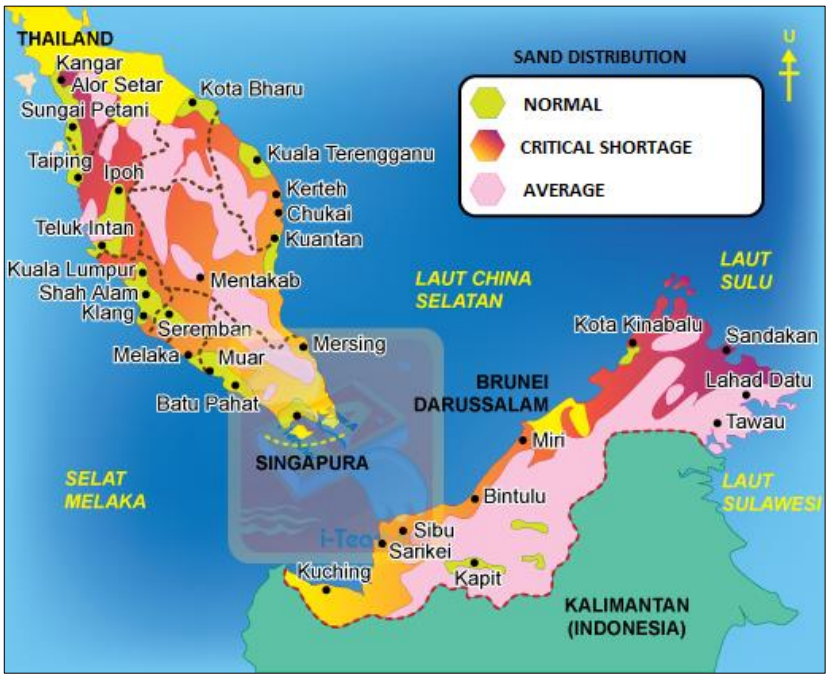

Figure 1.1: Sand Distribution and Location Map

1.2 Problem Statement

The construction industry in Peninsular of Malaysia facing a serious shortage of sand and expected worst in future due to over exploitation of natural river sand. River sand has been used as the major building material component. Hence, the entire construction industry will be paralyzed if there are no alternative sources instead of river sand.

The depleting of securable river sand deposit has causes the rapid price increase in the material. Higher demand may cause the price increase up to the maximum and unreasonable costing and thus benefits the bigger domain. Besides manipulating the pricing, the inconsistency of the sand river quality was neglected thus causing failures in achieving the higher strength in concrete. Common river sand is expensive due to excessive cost transportation from natural sources. Also large scale depletion of these sources creates environmental problems. As environmental transportation and over constraints make the availability and use of the river sand less attractive, an environmentally friendly substitutes or replacement product for concrete industry needs to be found.

1.3 Objective of the Study

The objective of this research is related to a set of aims or targets to be achieved through the completion of the research. The objective of the study comprises of the following:

(i) To design high strength and performance green concrete of Grade 60 with higher percentage of quarry dust as partial replacement of sand.

(ii) To determine the effect of different percentages of quarry dust as partial replacement of sand by 0 %, 50 % and 70 % on concrete strength and performance.

(iii) To determine the properties of quarry dust in concrete.

1.4 Scope of the Study

The scope of work covers the mechanical and physical properties of high strength concrete incorporates with high percentage of quarry dust replacement. The high strength and performance green concrete of grade 60 will be design by incorporating with quarry dust. The application of the Department of Environment in designing the mix concrete are referring to the ASTM C94-86, Standard Specification for Ready Mixed Concrete, BS 146 and BS 4246.

The scope of this study is to incorporate with high percentage of quarry dust replacement. The fresh and harden concrete properties of the high strength concrete will be tested with specific ranging of 0%, 50% and 70% quarry dust as partial replacement of sand. The fresh properties of the concrete are determine through the slump test only whereas the mechanical properties of the harden concrete are tested through the few tests such as compressive strength test with cubes (150x150x150) mm, tensile strength test with cylinders (diameter, 100xlong, 200) mm, flexural test with beams (100x100x500) mm and water absorption test at the age mature of 7 days, 14 days, 28 days and 56 days after the wet curing process at the tank. These tests were conducted on 3 samples for every individual age of curing period for the earlier of trial mix and 50 sets of samplings. Data of the results collected will be reviewed and evaluated.

1.5 Significance of the Study

In the construction industry, river sand is used as important building material and world consumption of sand in concrete generation alone is around 1000 million tonnes per year, making it scarce and limited. Further, it has caused environmental degradation and affecting flora and fauna.

The significance of this study is to ensure the current focus of construction industry should be to partially replace natural sand in concrete by waste material or by-product without comprising the quality of the end product. Besides to ensure the partial replacement for the sand will protect the natural sources and friendly environmental to be utilized. Quarry dust was used and availability almost free of cost, hence this study may significantly show reducing of the usage of river sand in the concrete design and also will cut down the cost of construction with economical concrete production.

The choice of quarry dust as replacement for sand has been supported in the previous study and obtained the positive results. Therefore, with the application of 70% quarry dust as partial replacement as sand in higher grade of 60 green concrete, the results of the strength will be predicted showing positive and optimum results.

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