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Effect of Replacement of Natural Sand by Quarry Dust on Mechanical Properties

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ABSTRACT
Green concrete is a concept of thinking environment into concrete considering every aspect from raw materials manufacture over mixture design to structural design, construction and service life. Quarry dust is a byproduct of the crushing process during quarrying activities. The Quarry dust is one of the best alternative materials for the replacement of cement to produce Environmental Friendly Green Concrete. The paper reports the experimental study undertaken to investigatesome properties of quarry dust and discusses the suitability of those properties to enable quarry dust to be used as partial replacement material for sand in concrete Physical and chemical properties of quarry dust have satisfied the requirements of the codal provisions. For the purpose of experimentation M30 grade concrete is designed for 10, 20 and 30% replacement of natural sand by quarry dust.

Keywords
Natural sand, Quarry dust, Concrete.

[1] INTRODUCTION
Green concrete is defined as a concrete which uses waste material as at least one of its components; or its production process does not lead to environmental destruction. Green concrete improves the three pillars of sustainability: environmental, economic, and social impacts. In other words, green concrete is an environment friendly concrete. Green concrete is a revolutionary topic in the history of concrete industry. This was first invested in Denmark in the year 1998. Green concrete has nothing to dowith colour. It is a concept of thinking environment into concrete considering every aspect from raw materials manufacture over mixture design to structural design, construction and service life. Green concrete is very often also cheap to produce because for example waste products are used as a partial substitute for cement, charges for the disposal of waste are avoided, energy consumption in production is lower, and durability is greater.

In the recent past good attempts have been made for the successful utilization of various industrial by products (such as fly ash, silica fume, rice husk ash, foundry waste) to save environmental pollution. In addition to this, an alternative source for the potential replacement of material in concrete has gained good attention. Cement and concrete production consumes enormous amounts of natural resources and aggregates, thereby causing substantial energy and environmental losses. This production also contributes significantly to the emission of carbon dioxide, a naturally occurring greenhouse gas. Adjustments and improvements to the present concrete making methods are essential in order to address these environmental and economic issues. This has encouraged researchers in the area of concrete engineering and technology to investigate and identify supplementary by-product materials that can be used as substitutes for constituent materials in concrete production. The beneficial effects of some of these materials on the properties of concrete have further enhanced these efforts. Silica fume is one of the most preferred cement replacements, especially when the engineering properties and durability of the hardened concrete were the primary concern. The major

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advantages of silica fume are its high SiO2 content, in most instances above 90 %, as well as its ultrafine particles. However, the extensive use of silica fume in concrete production, especially in developing economies, is usually prohibited by its high cost. In view of this, several other pozzolanic materials are being investigated for similar applications.

QUARRY DUST

Quarry dust is a byproduct of the crushing process during quarrying activities. Quarry dust have been used for different activities in the construction industry, such as road construction, and manufacture of building materials, such as lightweight aggregates, bricks, tiles and autoclave blocks. Quarry Rock Dust can be defined as residue, tailing or other non-voluble waste material after the extraction and processing of rocks to form fine particles Quarry dust is fine rock particles. When boulders are broken into small pieces quarry dust is formed. It is gray in color and it is like fine aggregate. Quarry dusts are produced during the extraction and processing of aggregates.

Figure 1 Quarry Dust

AVAILABILITY OF QUARRY DUST

Quarry Rock Dust can be defined as extraction, tailing or other non-voluble waste material after the extraction and processing of rocks to form fine particles less than 4.75mm. it is abundantly available to an extent of 200 million tonnes per annum which has land fill disposal problems, health hazard and Environmental problems. Usually, Quarry Rock Dust is used in large scale in the transportation for a highway as a surface finishing material and also used for manufacturing of hollow blocks and lightweight concrete prefabricated Elements. The utilization of Quarry rock dust which can be called as manufactured sand has been accepted as a building material in the industrially advanced countries of the west for the past three decades. As a result of sustained research and developmental works under-taken with respect to growing application of this industrial waste. The level of utilization of Quarry Rock Dust in the industrialized nations like Australia, France, Germany and UK has been reached more than 60% of its total production.Many quarry stones such as marble, granite, limestone, and sandstone are cut into larger slabs and removed from the quarry. The surfaces are polished and finished with varying degrees of sheen or luster. Polished slabs are often cut into tiles or countertops and installed in many kinds of residential and commercial properties. Natural stone quarried from the earth is often considered a luxury and tends to be a highly durable surface, thus highly desirable.

APPLICATIONS OF QUARRY DUST

Quarry dust are used various activities in the construction industry such as transportation engineering and manufacture of building materials such as light weight aggregates, bricks, and tiles. The use of quarry dust in concrete is desirable because of its benefits such as useful disposal of byproducts, reduction of river sand consumption as well as increasing the strength parameters and increasing the workability of concrete. Use of

quarry rock dust as a fine aggregate in concrete give serious direction to researchers and investigators for investigate.

1. The quarry dust is widely used in construction industry
2. Quarry dust is used as a fine aggregate in Concrete for paving blocks of good permeability capacity and high grade concrete productions.
3. Quarry dust gives better workability and strength when it is mixed with the ingredients like fly ash, in concrete.
4. It is being used as surface dressing in highway work.
5. It is also used in the manufacturing of building material, such as lightweight aggregates, bricks, tiles and autoclave blocks.
6. Fiber-reinforced pre-cast units are also made up of this.
7. It is used in synthetic rock and kerbs.

LITERATURE REVIEW

Charles K. Kankam, Bismark K. Meisuh, Gnida Sossou and Thomas K. Buabin (2017) They present paper on concrete using quarry dust to replace sand at levels of 0%, 25%, and 100% by weight. Design mixes were prepared for concrete grade C25, C30, C35, C40, C45. The results of the study showed that for all concrete grades, 25% sand replacement level gave higher (7.9%) modulus of elasticity (MoE) while 100% sand replacement level gave lower (8.6%) MoE relative to 0% sand replacement level.

Bruce Roy Thulane Vilane, Thandeka Lucia Dlamini (2016) Their study on the manufactured of Concrete Quarry Dust Block. Various companies in Matsapha, Swaziland manufactured CQDB. The results reflected that CM concrete, N, D, Roots, Toepfer and Sons as well as Santos produced CQDB with compressive strengths of 5.55 N/mm^2, 3.39 N/mm^2, 1.68 N/mm^2, 1.24 N/mm^2, 3.02 N/mm^2, and 1.92 N/mm^2, respectively. Only CM concrete manufactured CQDB that met the standard 4.0 N/mm^2 mean compressive strength of 5 units. The CQDB manufactured by the other five companies were even below the standard 3.0 N/mm^2 unit block compressive strength.

K. Shyam Prakash, Ch. Hanumantha Rao (2016) They are discussed about quarry dust can be used as a replacement for fine aggregate. As the quantity of water increases, the compressive strength decreases when replaced with quarry dust. This is due to the water absorption property of quarry dust. It is found that 40% replacement of sand by quarry dust gives maximum result in strength compared to normal concrete and then decreases from 50%.

K. Sai Kumar, S. Sameer Kumar and Dr. M.L.V. Prasad (2014) They Discuss about the Quarry Rock Dust (QRD). Quarry Rock Dust is a by-product from crushing process during quarrying activities is one of the substitute materials for the natural river sand is one of the best alternative materials for the replacement of Sand to produce Environmental Friendly Concrete. With the help of 50% marble sludge powder and Quarry Rock Dust we solve the problems of workability.

Neethu Joseph, Harilal B., Mathews M Paul, Job Thomas (2013) They investigates on the mechanical properties of quarry dust aggregate concrete subjected to high temperature. Concrete cubes are prepared and tested at an age of 28 days. Cubes are heated to elevated temperatures of 200°C, 400°C, 600°C for different durations. According to result quarry dust which is waste materials can be used for the manufacture of cold bonded artificial coarse aggregate. It also indicates that it can withstand a temperature up to 400°C and the designers can adopt the correct quantity of steel for strengthening.

S. N. Raman, M. F. M. Zain, H. B. Mahmud, K. S. Tan (2005) They gave reports on the experimental study undertaken to investigate some properties of quarry dust that were determined are aggregate crushing value, flakiness index, pH value, soundness, specific gravity, absorption and fineness modulus. Aggregate Crushing Value (ACV) of quarry dust used in this study is in the range of 47.70% to 50.28 %, with an average value of 49.38 %. When compared to the ACV of river sand used in this study which has a value of 18.0 %, it can be deduced that the river sand is a stronger and harder aggregate compared to the quarry dust. The Flakiness Index of quarry dust used in this study ranged between 48.86 % and 61.70 % with an average value of 54.58

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%. This result implies that half of the quarry dust used in this study is flaky. aggregates with flaky particle shape tends to be oriented in one plane, with air voids and bleeding water forming underneath, which may result in adverse effects to the compressive strength and durability of concrete. The average pH value for quarry dust was 8.38 and compared to the river sand used in this study which exhibited a pH value of 6.20, it can be deduced that river sand is more inclined to neutral condition compared to the quarry dust.

S. N. Raman, M. F. M. Zain, H. B. Mahmud, K. S. Tan (2005) These people present experimental study undertaken to investigate the influence of partial replacement of sand with quarry dust, and cement with fly ash on the concrete compressive strength development. Two types of replacement proportion of sand with quarry dust, 20 % and 40 % were practiced in the concrete mixes. The result is measured on the 7^{t} , 28^{t} , 56^{t} and 91^{t} Day. Six types of concrete, OPC0QD, OPC20QD, OPC40QD, FA0QD, FA20QD and FA40QD, each with two water-binder ratios of 0.35 and 0.50 were produced in this study. The 91st day compressive strengths of concretes with water-binder ratio of 0.35 ranged between 61.2 MPa and 70.9 MPa. For the case of concretes with water-binder ratio of 0.50, the 91st day compressive strengths ranged between 37.6 MPa and 51.8 MPa. The quarry dust used in this study recorded a flakiness index of 54.58 % which implies substantial amount of flaky particles in the quarry dust sample. Concrete containing fly ash has recorded higher compressive strength than the quarry dust concrete under all conditions.

[2] EXPERIMENTAL PROCEDURE

MATERIAL

Locally available quarry dust was the primary material used in this study. Besides that, for concrete mixing purpose. Type I concrete include Quarry dust 4.75 mm passed in sieve analysis. Type II concrete include Quarry dust 50% of dust 4.75 mm passed and 50% of dust is 600 µ passed quarry dust.

PHYSICAL AND CHEMICAL PROPERTIES OF QUARRY DUST

Table 1 Sieve Analysis of Quarry Dust

Sieve Size	Mass Retained, gm	Cumulative Mass Retained, gm	Cumulative % Mass Retained	% of Passing
10.0 mm	0	0	0	100.0
4.75	0	0	0	100.0
2.36	0	0	0	100.0
1.18	0	0	0	100.0
600	233	233	47	53.4
300	79	312	62	37.6
150	162	474	95	5.2
75	23	467	99	0.6

Table 2 Physical Properties of Quarry Dust

	Quarry Dust	Natural Sand
Specific Gravity	2.783	2.60
Water Absorption %	0.87	2.12
Bulk Density, kg/lit	1.458	1.460

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Table 2 Chemical Properties of Quarry Dust

Sr. No	Test	Quarry Dust
1	Silica, %	7.45
2	Aluminum & Iron Oxide, %	44.18
3	Calcium Oxide, %	1.80
4	Magnesium Oxide, %	0.36
5	Loss of Ignition, %	1.48

CONCRETE MIX DESIGN AND PREPARATION OF CONCRETE SPECIMENS

A total 42 cubes, 42 cylinders and 42 beams concrete specimens were prepared for this study. The concrete mix design was determined by using IS Code 10286. M30 grade of concrete are used for this study. The mix M100-0 represents 100% natural sand 0% quarry dust. Similarly, M90-10 represents 90% sand and 10% quarry dust, M80-20 represents 80% sand and 20% quarry dust, M70-30 represents 70% sand and 30% quarry dust. The specimens were cured in water for 7 and 28 days.

RESULTS AND DISCUSSION

COMPRESSIVE STRENGTH

The compressive strength of M30 concrete has been tasted for 7 and 28 days curing.The variation of compressive strength with 0,10,20 and 30 replacement of natural sand have been shown in Table 2.

Table 2 Compressive Strength for M30

M30 Combination	7 days Avg N/mm^2	14 days Avg N/mm^2
M100-0	27.34	40.23
M90-10 Type I	29.28	42.30
M80-20 Type I	30.23	43.33
M70-30Type I	30.95	44.29
M90-10 Type II	28.03	40.21
M80-20 Type II	28.25	41.21
M70-30 Type II	27.02	40.25

SPLIT TENSILE STRENGTH

The split tensile strength of M30 concrete has been tasted for 7 and 28 days curing. The variation of split tensile strength with 0,10,20 and 30 replacement of natural sand have been shown in Table 3.

Table 3 Split Tensile Strength for M30

M30 Combination	7 days Avg N/mm^2	14 days Avg N/mm^2
M100-0	2.53	4.57
M90-10 Type I	3.97	6.03
M80-20 Type I	4.14	6.47
M70-30Type I	4.67	6.89
M90-10 Type II	3.15	5.39
M80-20 Type II	3.98	5.83
M70-30 Type II	3.89	5.29

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FLEXURE STRENGTH

The flexure strength of M30 concrete has been tasted for 7 and 28 days curing. The variation of flexure strength with 0,10,20 and 30 replacement of natural sand have been shown in Table 4.

Table 3 Flexure Strength for M30

M30 Combination	7 days Avg N/mm^2	14 days Avg N/mm^2
M100-0	3.08	6.18
M90-10 Type I	3.61	6.98
M80-20 Type I	3.82	7.25
M70-30Type I	4.03	7.45
M90-10 Type II	3.42	6.36
M80-20 Type II	2.98	5.95
M70-30 Type II	2.60	5.05

Chart 1 Compressive Strength of M30 Concrete at different ages

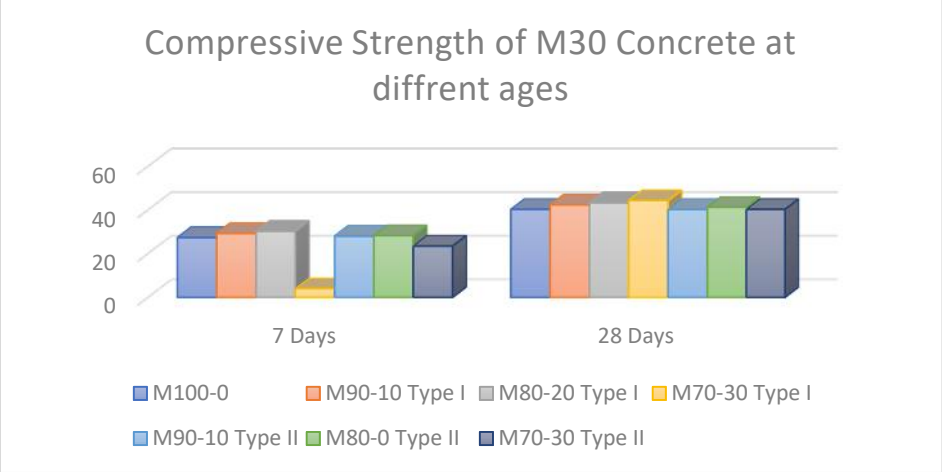


Chart 2Split Tensile Strength of M30 Concrete at different ages

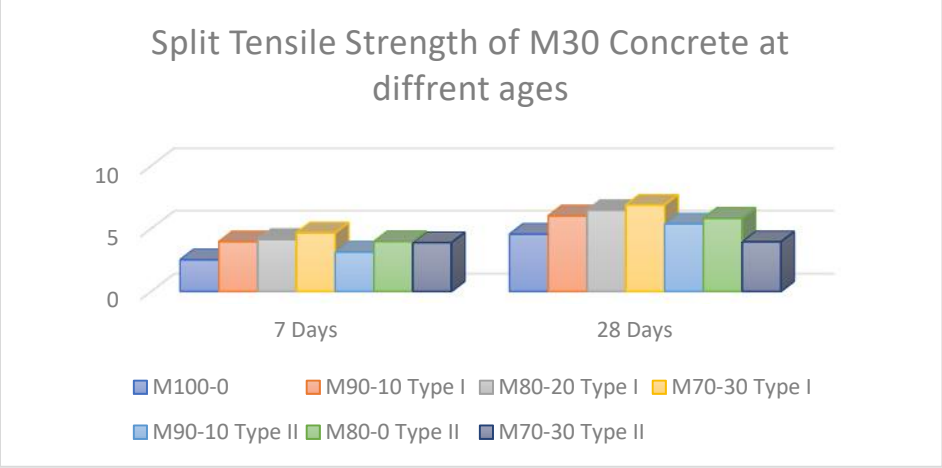
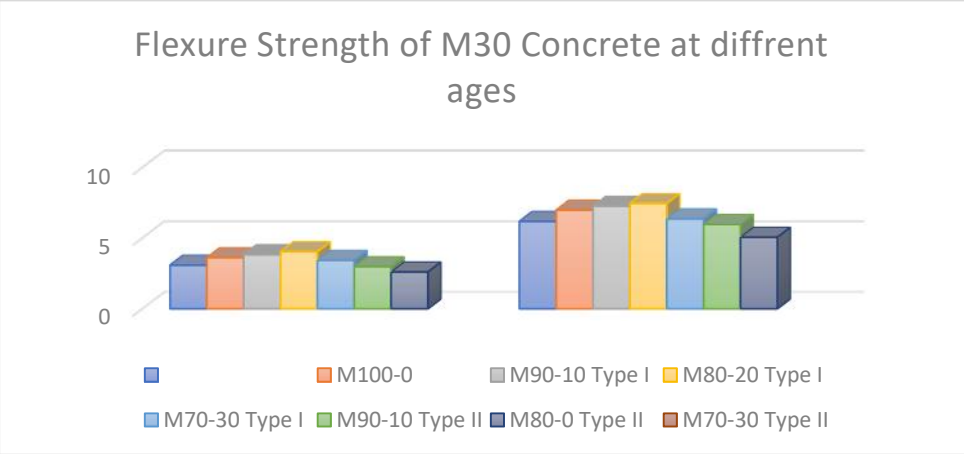


Chart 3Flexure Strength of M30 Concrete at different ages



CONSCLUSION

The Concept of replacement of natural fine aggregate by quarry dust highlighted in the present investigation improve the utilization of generated quarry dust.

1. The physical and chemical properties of quarry dust have satisfied the requirements of a code provision in properties studies.
2. The optimum replacement for natural sand by quarry dust is 60%.
3. It has been observed that the compressive strength increasesup to 30% replacement for natural sand by quarry dust. But after using Type II quarry dust it has been decreased when the replacement proportion was increased.
4. Similarly, split tensile and flexure strength of concrete was increased when proportion was increased. But then after using Type II quarry dust it was decreased with increased of proportion replacement.

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