IMPLEMENTATION AND ANALYSIS OF STRENGTH CHARACTERISTICS OF CONCRETE USING CRUSHED STONE DUST AS FINE AGGREGATE

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ABSTRACT

Crushed stone or angular rock is a form of construction aggregate, typically produced by mining a suitable rock deposit and breaking the removed rock down to the desired size using crushers. It is distinct from gravel which is produced by natural processes of weathering and erosion, and typically has a more rounded shape. The purpose of this study was to investigate the possibility of using crushed stone dust as fine aggregate partially or fully with different grades of concrete composites. Angular crushed stone is the key material for macadam road construction which depends on the interlocking of the individual stones' angular faces for its strength.[1] Crushed natural stone is also used similarly without a binder for riprap, railroad track ballast, and filter stone. It may also be used with a binder in a composite material such as concrete, tarmac, or asphalt concrete.[2]The suitability of crushed stone dust waste as fine aggregate for concrete has been assessed by comparing its basic properties with that of conventional concrete. Two basic mixes were selected for natural sand to achieve M25 and M30 grade concrete. The equivalent mixes were obtained by replacing natural sand by stone dust partially and fully. The test result indicates that crushed stone dust waste can be used effectively used to replace natural sand in concrete. In the experimental study of strength characteristics of concrete using crushed stone dust as fine aggregate it is found that there is increase in compressive strength , flexural strength and tensile strength of concrete.

***Key words**: concrete, strength, fine aggregate, crushed stone dust, concrete, mix.*

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INTRODUCTION

Crushed stone is one of the most accessible natural resources, and is a major basic raw material used by construction, agriculture, and other industries. Despite the low value of its basic products, the crushed stone industry is a major contributor to and an indicator of the economic well-being of a nation.[3] The demand for crushed stone is determined mostly by the level of construction activity, and, therefore, the demand for construction materials.[4]

Stone resources of the world are very large. High-purity limestone and dolomite suitable for specialty uses are limited in many geographic areas. Crushed stone substitutes for roadbuilding include sand and gravel, and slag. Substitutes for crushed stone used as construction aggregates include sand and gravel, iron and steel slag, sintered or expanded clay or shale, and perlite or vermiculite.[5]

Concrete is a composite material composed mainly of water, aggregate, and cement. Usually there are additives and reinforcements included to achieve the desired physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that is easily molded into shape. Over time, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with many uses.Crushed stone is a high-volume, low-value commodity. The industry is highly competitive and is characterized by many operations serving local or regional markets. Production costs are determined mainly by the cost of labor, equipment, energy, and water, in addition to the costs of compliance with environmental and safety regulations. These costs vary depending on geographic location, the nature of the deposit, and the number and type of products produced. Crushed stone has one of the lowest average by weight values of all mineral commodities. The average unit price increased from US$1.58 per metric ton, f.o.b. plant, in 1970 to US$4.39 in 1990. However, the unit price in constant 1982 dollars fluctuated between US$3.48 and US$3.91 per metric ton for the same period. Increased productivity achieved through increased use of automation and more efficient equipment was mainly responsible for maintaining the prices at this level.[4]

Construction aggregate, or simply "*aggregate*", is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are the most mined materials in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as

reinforcement to add strength to the overall composite material. Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains. Aggregates are also used as base material under foundations, roads, and railroads. In other words, aggregates are used as a stable foundation or road/rail base with predictable, uniform properties (e.g. to help prevent differential settling under the road or building), or as a low-cost extender that binds with more expensive cement or asphalt to form concrete.

Conventionally concrete is mixture of cement, sand and aggregate. Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river or pit sand. Fine and coarse aggregate constitute about 75% of total volume. It is therefore, important to obtain right type and good quality aggregate at site, because the aggregate form the main matrix of concrete or mortar.

The global consumption of natural sand is very high, due to the extensive use of concrete. In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructural growth, in this situation developing country like India facing shortage in good quality natural sand. Particularly in India, natural sand deposits are being depleted and causing serious threat to environment as well as the society. Increasing extraction of natural sand from river beds causing many problems, loosing water retaining sand strata, deepening of the river courses and causing bank slides, loss of vegetation on the bank of rivers, exposing the intake well of water supply schemes, disturbs the aquatic life as well as affecting agriculture due to lowering the underground water table etc are few examples.

Transportation is a major factor in the delivered price of crushed stone. The cost of moving crushed stone from the plant to the market often equals or exceeds the sale price of the product at the plant. Because of the high cost of transportation and the large quantities of bulk material that have to be shipped, crushed stone is usually marketed locally. The high cost of transportation is responsible for the wide dispersion of quarries, usually located near highly populated areas. However, increasing land values combined with local environmental concerns are moving crushed stone quarries farther from the end-use locations, increasing the price of delivered material. Economies of scale, which might be realized if fewer, larger operations served larger marketing areas, would probably not offset the increased transportation costs.[4]

In past decade variable cost of natural sand used as fine aggregate in concrete increased the cost of construction. In this situation research began for inexpensive and easily available alternative material to natural sand. Some alternatives materials have already been used as a part of natural sand e.g. flyash, slag limestone and siliceous stone powder were used in concrete mixtures as a partial replacement of natural sand. However, scarcity in required quality is the major limitation in some of the above materials. Now a day's sustainable infrastructural growth demands the alternative material that should satisfy technical requisites of fine aggregate as well as it should be available abundantly. As a mineral mulch its benefits include erosion control, water conservation, weed suppression, and aesthetic qualities. It is often seen used in rock gardens and cactus gardens.[6][7]

LITERATURE REVIEW

Common river sand is expensive due to excessive cost of transportation from natural sources. Also large-scale depletion of these sources creates environmental problems. As environmental transportation and other constraints make the availability and use of river sand less attractive, a substitute or replacement product for concrete industry needs to be found. River sand is most commonly used fine aggregate in the production of concrete poses the problem of acute shortage in many areas. Whose continued use has started posing serious problems with respect to its availability, cost and environmental impact?

MATERIALS AND METHODS

Cement

Ordinary Portland Cement (43 Grade) with 28 percent normal consistency Conforming to IS: 8112-1989 [3] was used.

Quarry rock dust

The Quarry Rock Dust obtained from local resource AMC Crushers (P) Ltd., Dindigul was used in concrete to cast test cubes and beams. The physical and chemical properties of Quarry Rock Dust obtained by testing the samples as per Indian Standards are listed in Tables 1 and 2, respectively.

Table-1. Physical properties of quarry rock dust and natural sand.

Property	Quarry rock dust	Natural sand	Test method
Specific gravity	2.54-2.60	2.60	[5] IS 2386 (Part III) 1963
Bulk relative density (kg/m^3)	1720-1810	1460	IS 2386 (Part III) 1963
Absorption (%)	1.20-1.50	Nil	IS 2386 (Part III) 1963
Moisture content (%)	Nil	1.50	IS 2386 (Part III) 1963
Fine particles less than 0.075mm (%)	12-15	06	[5] IS 2386 (Part I) 1963
Sieve analysis	Zone II	Zone II	[4]IS 383 - 1970

Table-2. Typical chemical composition of quarry rock dust and natural sand.

Constituent	Quarry rock dust (%)	Natural sand (%)	Test method
SiO_2	62.48	80.78	[10]IS: 4032-1968
Al_2O_3	18.72	10.52	
Fe_2O_3	06.54	01.75	
CaO	04.83	03.21	
MgO	02.56	00.77	
Na_2O	Nil	01.37	
K_2O	03.18	01.23	
TiO_2	01.21	Nil	
Loss of ignition	00.48	00.37	

Fine aggregate (Natural river sand)

River sand having density of 1460 kg/m^3 and fineness Modulus (FM) of 2.51 was used. The specific gravity was found to be 2.6.

Coarse aggregate

Natural granite aggregate having density of 2700kg/m^3 and fineness modules (FM) of 6.80 was used. The specific gravity was found to be 2.60 and water absorption as 0.45%.

Admixture

Commercially available Super-plasticiser has been used to enhance the workability of fresh concrete for selected proportions of ingredients.

Thorough mixing is essential for the production of uniform, high-quality concrete. For this reason equipment and methods should be capable of effectively mixing concrete materials containing the largest specified aggregate to produce *uniform mixtures* of the lowest slump practical for the work.

Separate paste mixing has shown that the mixing of cement and water into a paste before combining these materials with aggregates can increase the compressive strength of the resulting concrete

MIX DESIGN

Since there is No standard method of designing concrete mixes incorporating Quarry Rock Dust as fine Aggregate. The method mix design proposed by IS, ACI, USBR, RN No.4, BS were first employed to design the Conventional Concrete mixes and finally natural sand was fully replaced by Quarry Rock Dust to obtain Quarry Rock Dust concrete mixes. The purpose of mix proportioning is to produce the required properties in both plastic and hardened concrete by working out a combination of available materials, with various economic and practical standards.

I. RESEARCH SIGNIFICANCE

Based on the above discussions, following conclusions are drawn:

(a) The Physical and chemical properties of quarry rock dust is satisfied the requirements of code provision in properties studies Natural river sand, if replaced by hundred percent Quarry Rock Dust from quarries, may sometimes give equal or better than the reference concrete made with Natural Sand, in terms of compressive and flexural strength studies

(b) Studies reported here and elsewhere have shown that the strength of Quarry Rock Dust concrete is comparatively 10-12 percent more than that of similar mix of Conventional Concrete. Also the result of this investigation shows that drying shrinkage strains of Quarry Rock Dust concrete are quite large to the shrinkage strain of Conventional Concrete. However, at the later age, they have shown equal strain than Conventional Concrete. The Durability of Quarry Rock Dust concrete under sulphate and acid action is higher inferior to the Conventional. Permeability Test results clearly demonstrates that the permeability of Quarry Rock Dust concrete is less compared to that of conventional concrete. The water absorption of Quarry Rock Dust concrete is slightly higher than Conventional Concrete. Therefore, the results of this study provide a strong support for the use of Quarry Rock Dust as fine aggregate in Concrete Manufacturing.

IV. CONCLUSION

Crushed stone or 'road metal' is used in landscape design and gardening for gardens, parks, and municipal and private projects as a mulch, walkway, path, and driveway pavement, and cell infill for modular permeable paving units. Concrete has relatively high compressive strength, but much lower tensile strength. For this reason it is usually reinforced with materials that are strong

in tension (often steel). The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develops. Concrete has a very low coefficient of thermal expansion and shrinks as it matures. All concrete structures crack to some extent, due to shrinkage and tension. Concrete that is subjected to long-duration forces is prone to creep. Experiments and mathematical models show that more of a given volume can be filled with hard spheres if it is first filled with large spheres, then the spaces between (interstices) are filled with smaller spheres, and the new interstices filled with still smaller spheres as many times as possible. For this reason, control of *particle size distribution* can be quite important in the choice of aggregate; appropriate simulations or experiments are necessary to determine the optimal proportions of different-sized particles.

Tests can be performed to ensure that the properties of concrete correspond to specifications for the application.Different mixes of concrete ingredients produce different strengths, which are measured in psi or MPa. Different strengths of concrete are used for different purposes. Very low-strength (2000 psi or less) concrete may be used when the concrete must be lightweight

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