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Study on Performance of Quarry Dust as Partial Replacement of Fine Aggregate in Concrete

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***Abstract*: The concept of replacement of natural fine aggregate by quarry dust which is highlighted in the study could boost the consumption of quarry dust generated from quarries. By replacement of quarry dust, the requirement of land fill area can be reduced and can also solve the problem of natural sand scarcity. The availability of sand at low cost as a fine aggregate in concrete is not suitable and that is the reason to search for an alternative material. Quarry dust satisfies the reason behind the alternative material as a substitute for sand at very low cost. It even causes burden to dump the crusher dust at one place which causes environmental pollution. Aggregates normally accounts 70% to 80% of the entire volume of concrete, while water and cement account 20% to 30%. These percentages affect the mechanical properties of concrete. So, replacing of any material by industrial waste can create a positive impact on environment and reduces the intensive use of energy and natural resources (aggregate mining). There are plenty of industrial wastes that can be used in concrete as either replacement of fine aggregate. This project has focused on evaluating the opportunity of using of waste materials which is the quarry dust as a replacement of fine aggregate.M40 grade concrete was prepared with 0%, 10%, 20%, 30%, 40% partial replacement of sand with quarry dust. Mechanical and fresh properties of concrete were carried out at 3, 7 and 28 days respectively.**

***Keywords*: Quarry Dust, Concrete, Quarry Dust Concrete, Crusher Dust Concrete.**

1. Introduction

Continuous research efforts have established concrete as a versatile material. Concrete required for extensive construction activity can be made available since all the ingredients of concrete are of geological origin. The most widely used construction material is concrete, commonly made by mixing Portland cement with sand, crushed rock and water. The world consumption of concrete is estimated at ten billion tones every year or one ton for every human being. In concrete 30-40% of the volume is occupied by fine aggregate. Aggregate passes through 9.5 mm sieve and almost passes through the4.75 mm sieve and predominantly retains on the 75-micron sieve. Most of the fine aggregate passes 4.75 mm IS sieve and contains a huge number of coarser materials. Fine aggregate is generally considered to have a lower size limit of0.07 mm or 0.06 mm. originally, all-natural aggregate particles are a part of larger mass. This may have been fragmented by natural process of weathering and abrasion or artificially by crushing. Thus, many properties of the fine aggregate depend entirely on the properties of the parent rock. Properties of fine aggregate may have a considerable influence on the quality of the concrete, either fresh or hardened.

1) Substitutes of Fine Aggregate

Several challenging issues present themselves in the future. These issues will require sustained attention to research, development and appropriate usage of concrete aggregates. Possibly the most important issue is the environmental impact of aggregate production. Large scale of sand quarrying from riverbeds creates environmental problems such as shortage of ground water and changing watercourses. Farmers' organizations, environmental managers and the public have expressed concern over the indiscriminate quarrying in violation against the river environmental conservation principles. Riverbeds, which supply water to cities and villages, suffer extensive damage owing to excessive sand mining. River sand acts as excellent filter system to ground water. The infrastructure developments such as express highway projects, power projects and industrial developments have started now. Natural sand is getting depleted resulting in high cost of sand. Initially, all-natural aggregate particles are a part of larger mass. This may have been fragmented by natural process of weathering and abrasion or artificially by crushing. Thus, many properties of the fine aggregate depend entirely on the properties of the parent rock. Properties of fine aggregate may have a considerable influence on the quality of the concrete, either fresh or hardened. Fine aggregate is obtained from natural rivers, crushing stone sand and industrial waste. Other substitutes are obtained from coal ash, foundry sand, ponded fly ash and quarry rock dust, etc.

2) Quarry Dust

Quarry rock dust is an industrial by-product. It is formed by screening products of secondary and subsequent stages of crushing igneous rocks, sedimentary rocks or gravel. It can be classified by the size of the particles as 0 to 4.75 mm. presently a large amount of quarry rock dust is generated in natural stone processing plants. Sources of granular deposit are becoming

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depleted, particularly in high demand areas such as urban areas. Hence, alternative sources of aggregates must be found. One of the sources is hard rock, which is quarried and crushed. It is possible to produce both coarse and fine aggregates from hard rock quarries. Rock crushing methods and techniques together with the nature of rock itself govern the quality and properties of the product.

Fig. 1. Quarry dust

2. Literature Review

Ilangovan et al., (2008) have conducted tests to study the feasibility of the usage of quarry rock dust as hundred percent substitute for natural sand in concrete. Mix design has developed for M20, M30 and M40 grades for both conventional concrete and quarry dust concrete. Tests were conducted on cubes and beams to study the strength and durability of concrete made of quarry rock dust and the results were compared with natural sand concrete. Feasibility of the usage of artificial sand obtained by crushing basalt over natural sand considering technical, environmental and commercial factors (Chitlange et al.,2008) For the purpose of experimentation concrete mixes using OPC were designed as M20, M30and M40 grades by 100% replacement of natural sand to artificial sand with water cement ratio 0.5. Compressive and flexural tests were conducted to study the strength of concrete at 7 and 28 days using artificial sand and the results were compared with that of natural sand concrete. Nagabhushana and Sharada bai (2011) have conducted experiments on concrete using crushed rock powder as a partial replacement material for natural sand. The percentage of replacement was 20, 30 and 40. Three grades of concrete of M20, M30 and M40 were taken for study using53 grade OPC. Tests were conducted on compressive, flexural and split tensile strength at the age of 7 and 28 days. The w/c ratio was fixed as 0.5, 0.39 and 0.31 for M20, M30 and M40 mixes respectively.

3. Materials

The cement used was Ordinary Portland Cement (ULTRATECH 53 grade). The cement procedure was tested for physical requirements in accordance with IS: 12269-1987. Fine aggregate used are of Natural River sand and quarry dust are obtained from nearest supplier in Gudivada. The maximum size of coarse aggregates of 20 mm are used. The coarse aggregates are of crushed granite aggregates obtained from nearest crusher unit. The Fine aggregate is confirming to Zone – II. The Super Plasticizer used is CONPLAST SP 430 and is of PCE Based Chemical Admixture. Properties of materials are shown below in Table 1

Table 1
Properties of Materials

Material	Specific gravity	Fineness modulus
Cement	3.12	294 m^2/kg
Sand	2.58	2.44
Quarry Dust	2.57	2.41
Coarse aggregate	2.70	7.25

4. Experimental Programme

The mix design is prepared according to the guidelines in the code IS 10262 - 2019. The W/C ratio for M40 grade was taken as 0.40. Several trail mixes have been done to finalize the mix ratios for M 40 Grade Concrete.

The final mix proportion quantities are given in the Table. 2

Table.2
Mix proportion details

Component	Value
Cement	380 kg/m^3
Fine Aggregate	674 kg/m^3
Coarse Aggregate	1209 kg/m^3
Water	152 kg/m^3
Super Plasticizer	1% by Weight of Cement

The main objective of the present investigation was to study the performance quarry dust concretes in terms of strength and transport properties with normal water curing and with no chemical admixtures in the mixes. Performance of the concretes was assessed by Workability, compressive strength, split tensile strength. The specimens were tested for Workability compression and split tensile strengths 3, 7and 28 days. For calculating the compressive strength, cube specimens are casted of size 150mm x 150mm x 150mm. For split tensile strength cylindrical specimens are of size 300mm height and 150mm diameter are used. For testing fresh concrete workability is the main property of concrete. Workability of concrete is calculated by Slump Cone method. The strengths were obtained by considering the average of three replicate specimens. The trail mixes finalized are shown below in Table.3

Table 3
Trail mix details

S.NO	Mix	Cement (Kg/m3)	Quarry dust (Kg/m3)	Fine aggregate (Kg/m3)	Coarse aggregate (Kg/m3)
1	C.C	380	0	675	1210
2	10% Q. D	380	67.5	307	1210
3	20% Q. D	380	135	540	1210
4	30% Q. D	380	202.5	472.5	1210
5	40% Q. D	380	270	405	1210

Table 4
Slump Cone Results

Mix	Slump (mm)
C.C	98
10% Q. D	94
20% Q. D	91
30% Q. D	88
40% Q. D	85

1) *Workability of Concrete*

The workability of concrete is observed by the Slump Cone method and range of slump was selected as 25-100mm.

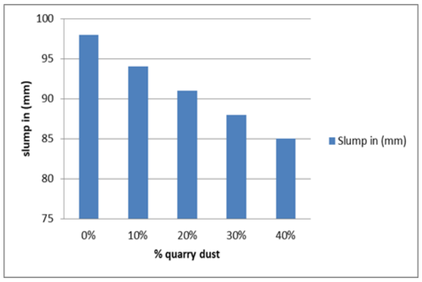

Fig. 2. Workability of concrete

2) *Compressive Strength*

Compressive strength is obtained by applying crushing load on the cube surface. So it is also called as Crushing strength. Compressive strength of concrete is calculated by casting 150mm x 150mm x 150mm cubes. 9 number of cubes were casted for each trail. The test results are presented here for the Compressive strength of 3,7 days and 28 days of testing. An Average value of 3 cubes were taken to determine the Compressive Strength of Concret.

Table 5
Compressive Strength

Compressive Strength (Mpa)				
Trial Mix	% Quarry dust	3 Days	7 Days	28 Days
C.C	0%	21.65	34.94	49.21
10% Q. D	10%	21.86	35.06	51.22
20% Q. D	20%	22.1	36.01	54
30% Q. D	30%	21.26	35.02	49.35
40% Q. D	40%	20	35	49.02

Table 6
Split Tensile Strength

Split Tensile Strength (Mpa)				
Trial Mix	% Quarry dust	3 Days	7 Days	28 Days
C.C	0%	2.59	3.02	5.4
10% Q. D	10%	2.83	3.38	6
20% Q. D	20%	2.92	3.54	7.2
30% Q. D	30%	2.86	3.42	6.9
40% Q. D	40%	2.45	3.3	4

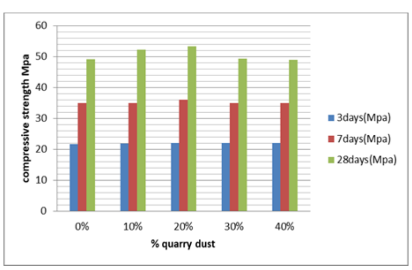

Fig. 3. Compressive strength

3) *Split Tensile Strength*

Three cylinders each having diameter 150 mm and height 300 mm were cured for 3,7and 28 days and tested to determine the average split tensile strength. The trend for split tensile strength was similar to that obtained in the compressive strength.

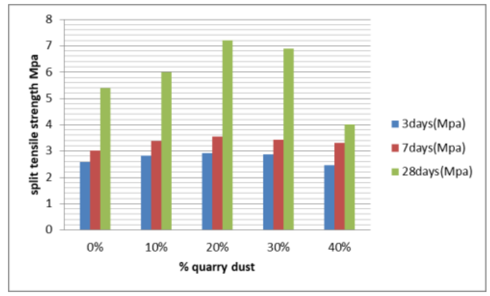

Fig. 4. Split tensile strength

5. Conclusion

- Workability of concrete mixes are increased with the addition of mineral admixtures compared to conventional mix
- Remarkable development in strength is observed in concrete mix with the use of quarry dust of 20% respectively as fine aggregate.
- Increase in compressive, were as 10% of about 4.08% is observed and if 20% added they show promising results of compressive strength is increased 9.7%in replacement of quarry dust concrete compared to conventional Concrete.
- Where as in split tensile strength were as10% is 11.11% and 20% is 30% increased.

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