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STUDIES ON UTILIZATION OF QUARRY DUST IN PRODUCTION OF CONCRETE

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Abstract: ***Use of Quarry rock dust as a fine aggregate in concrete draws serious attention of researchers and investigators. Quarry rock dust has very recently gained good attention to be used as an effective filler material instead of fine aggregate. In the present study, the properties of concrete using quarry dust were investigated. This work presents the feasibility of the usage of Quarry Rock Dust as 100% substitutes for Natural Sand in concrete. Mix design has been developed for M40 and M50 grades using design approach IS for both conventional concrete and quarry dust concrete. Tests were conducted on cubes and beams to study the strength of concrete made of Quarry Rock Dust and the results were compared with the Natural Sand Concrete. It is found that the compressive and flexural strength of concrete made of Quarry Rock Dust are nearly 10% more than the conventional concrete. Tests were also conducted on cubes and beams which are exposed to temperatures of 300°C for 1hr, 3hr durations respectively. The results were analysed and discussed.***
Key Words: Quarry stone dust, Admixture, Concrete, Strength, Durability

I. INTRODUCTION

The utilization of Quarry Stone dust 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 undertaken with respect to increasing application of this industrial waste, the level of utilization of Quarry Stone Dust in the industrialized nations like Australia, France, Germany and UK has been reached more than 60% of its total production. The use of manufactured sand in India has not been much, when compared to some advanced countries. This paper presents the feasibility of the usage of Quarry Stone Dust as hundred percent substitutes for Conventional Concrete. Tests were conducted on cubes and beams to study the compressive, flexural strengths of concrete made of Quarry Stone Dust for two different grades of concrete M40 and M50. The investigation on the use of Quarry Stone Dust in concrete as an alternative to sand as fine aggregate are presented in this report. Standard concrete cubes (150x150x150 mm), prisms (100x100x500 mm) were tested. The physical properties of stone dust and its influence on the strength of concrete in the fresh and hardened state, along with a comparative study with the concrete prepared using river sand are also included. The strength in direct compression at 7 days and 28 days, and those in flexure at 7days and 28days were compared. Mix proportions obtained by procedure specified in IS10262:2009 using 20 mm coarse aggregate was adopted in the investigations. Tests were also conducted to evaluate the flexural behavior of beams under two-point loading. Strengths of cubes and beams made with conventional concrete and concrete made with Quarry Stone Dust were tested and compared when exposed to temperature of 300°C for 1hr and 3hr durations. Quarry stone dust has many of the useful properties of the stone that it comes from. It is very heat resistant and contains no plastic chemicals that may be toxic to the surrounding environment over time. The chemical nature of Quarry stone dust is very dependable and largely alkaline which helps manufacturers use it confidently in a variety of materials. It is also durable, strong, and can be easily compressed into tight spaces. The dust is also used to make mortar and other similar materials. Ordinary Portland cement (KCP) of 53 grade confirming to Bureau of Indian Standard is used in the present study. The stone dust is procured from locally available sources. The stone dust is tested for various properties like specific gravity, bulk density etc, in accordance with IS 2386-1968. Super plasticizer by trade name CONPLAST SP-430 was used as water reducing agent to achieve the required workability. The main objectives of the present work are:

1. To compare the properties of natural river sand and concrete made of quarry stone dust as fine aggregate.
2. To study the effect of addition of quarry stone dust as replacement of sand
3. To study the effect of superplssticizer on water-cement ratio.
4. To study the behaviour of concretes M40 and M50 grades when exposed to temperature.

II. MATERIALS AND METHODS

Cement

Ordinary Portland Cement (53 Grade) with 32% normal consistency Conforming to IS: 8112-1989 was used. The properties of cement were given below:

Initial setting time :	118 min.
Final setting time :	242min.
Specific gravity	3.13
Fineness (IS sieve)	2.00

Quarry stone dust

The Quarry Rock Dust obtained from local resource was used in concrete to cast test cubes and beams. The physical properties of Quarry Rock Dust obtained by testing the samples as per Indian Standards are listed in Tables 1

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

Property	Quarry rock dust	Natural sand
Specific gravity	2.54-2.60	2.50
Relative density (kg/m3)	1720-1810	1813.33
Sieve analysis	Zone II	Zone III

Admixture

Super plasticizers are usually highly distinctive in their nature, and they make possible the production of concrete which, in its fresh or hardened state, is substantially different from concrete made using water-reducing admixtures.

Conplast SP430 disperses the fine particles in the concrete mix, enabling the water content of the concrete to perform more effectively. The very high levels of water reduction possible allow major increases in strength to be obtained.

III. EXPERIMENTAL PROGRAMME

The 150 mm size concrete cubes, concrete beams of size 100 mm x 100 mm x 500 mm were used as test specimens to determine the compressive strength and flexural strength respectively. The specimens were cast for M40, and M50 grade and for coarse aggregates of size 20 mm was used. The workability of fresh concrete was measured in terms of slump values. To obtain the required slump value superplasticiser (1.0%, 1.3% and 1.6 % of weight of cement) is added. The ingredients of concrete were thoroughly mixed till uniform consistency was achieved. The cubes and beams were compacted on a vibrating table. Compressive strength and flexural strength were obtained as per IS: 516-1959.

Mix Design for M40-Grade Concrete

Grade Designation: M40
Type of cement: OPC 53 grade KCP
Maximum size of Aggregate: 20mm
Minimum cement content: 250Kg/m3
Maximum Water-Cement ratio: 0.5
Workability: Slump
Type of Exposure: Severe
Degree of Quality Control: Good
Type of Aggregate: ANGULAR aggregate

MIX PROPRTIONS:

Cement = 375kg/m3
Water = 180kg/m3
Coarse aggregate = 1204.466kg/m3
Fine aggregate = 616.503kg/m3
Chemical admixture = 3.75kg/m3
Water-cement ratio = 0.48.

Mix Design for M50-Grade Concrete

Grade Designation: M50
Type of cement: OPC 53 grade KCP
Maximum size of Aggregate: 20mm
Minimum cement content: 250Kg/m3
Maximum Water-Cement ratio: 0.5
Workability: Slump
Type of Exposure: Severe
Degree of Quality Control: Good
Type of Aggregate: ANGULAR aggregate
Max. Cement content: 450Kg/m3
Chemical Admixture type: SP 430 CONPLAST

MIX PROPORTIONS :

Cement = 430kg/m^3
Water = 180kg/m^3
Coarse aggregate = 1181.320kg/m^3
Fine aggregate = 578.685kg/m^3
Chemical admixture = 3.75kg/m^3
Water-cement ratio = 0.43

CASTING OF THE SPECIMENS:

The present experimental work includes casting and testing of specimens to know the compressive strength and flexural strength of cubes and beams. These concrete cubes and beams are casted and tested as per IS 516-1959 specifications.

The specimens are casted for the following:

- M40 grade concrete with OPC+NATURAL SAND
- M40 grade concrete with OPC + QUARRY STONE DUST
- M50 grade concrete with OPC+NATURAL SAND
- M50 grade concrete with OPC + QUARRY STONE DUST

IV. RESULTS AND DISCUSSION

COMPRESSIVE STRENGTHS (M40 GRADE):The compressive strength of M40 grade concrete cubes made with natural sand and those made with quarry stone dust as fine aggregate are tested under compression testing machine and results are tabulated in table-2 shown below

Table 2- Strength comparison for M40 Grade cubes

S.No.	Sp %	OPC + SAND		OPC+ QUARRY STONE DUST	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	1	38.44	46.33	42.284	50.963
2	1.3	38.89	48.67	42.779	53.537
3	1.6	41.33	50.67	45.463	55.737

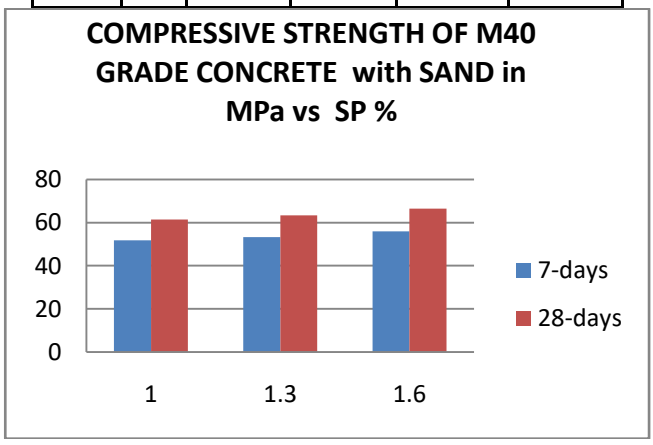

Fig.1

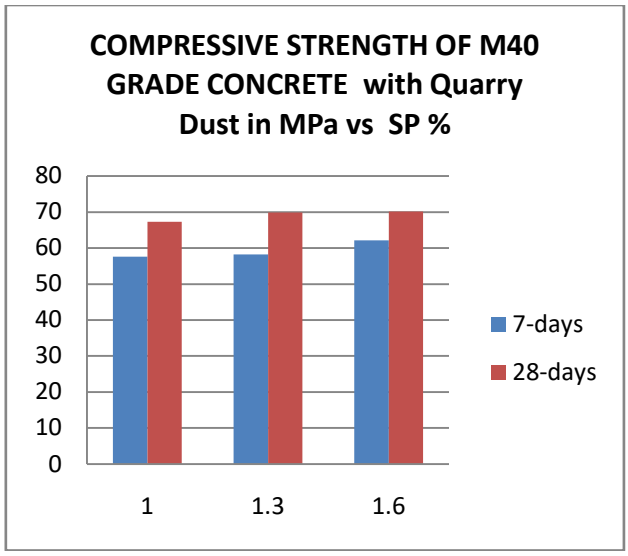

Fig.2

From the table it is observed that both the concretes are achieving the target strengths at the age of 28 days. But the compressive strengths of normal concrete are slightly higher when compared with Quarry stone dust concrete. There is no significant difference in the strengths with variation in dosage of superplasticiser. The following figures give an idea regarding compressive strengths.

TEMPERATURE STUDIES ON M40 CUBES:

The test results of M40 grade cubes(after 28 days, with 1.6% SP) which are exposed to a temperature of 300°C in furnace for 1hour and 3hr durations are tabulated below:

Table 3- TEMPERATURE STUDIES ON M40 CUBES

S. No	Details	Time Duration	% Reduction in weight	Compressive strength (MPa)
1	OPC+SAND	1hr	2.9	53.55
2	OPC+QUARRY STONE DUST	1hr	3.6	54.22
3	OPC+SAND	3hr	3.2	50.22
4	OPC+QUARRY STONE DUST	3hr	3.9	51.77

COMPRESSIVE STRENGTH (M50):

The compressive strength of M50 grade concrete cubes made with natural sand and those made with quarry stone dust as fine aggregate are tested under compression testing machine and results are tabulated in table-4 shown below.

Table 4- Strength comparison for M50 grade cubes

S.No.	Sp %	OPC + SAND		OPC + QUARRY STONE DUST	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
I	1.00	51.775	61.475	57.586	67.248
	1.30	53.333	63.433	58.246	69.872
	1.60	56.025	66.502	62.153	70.162

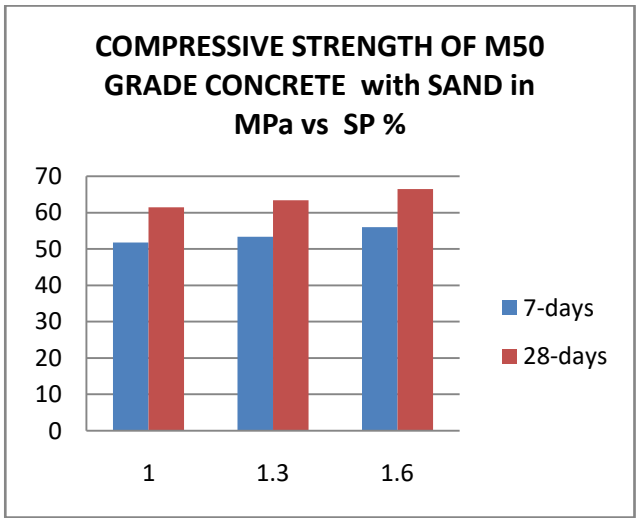

Fig.3

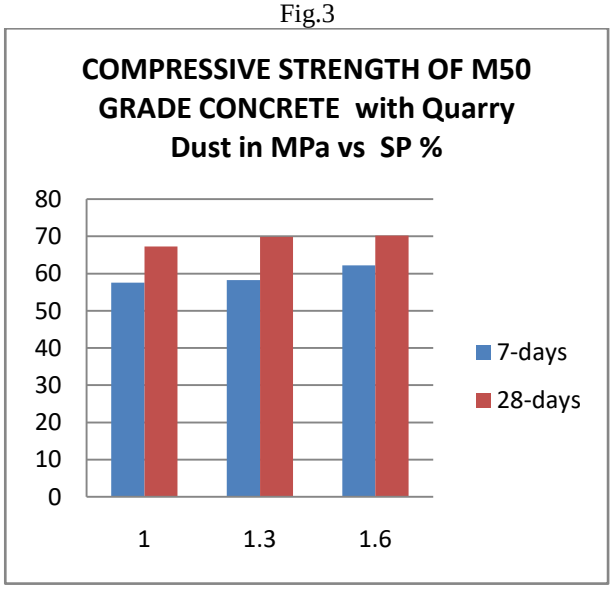

Fig.4

From the table it is observed that both the concretes are achieving the target strengths at the age of 28 days. But the compressive strengths of normal concrete are slightly higher when compared with Quarry stone dust concrete. There is no significant difference in the strengths with variation in dosage of superplasticiser. At 1.3% dosage of superplasticiser the strengths were observed to decreasing. The following figures show the compressive strengths.

TEMPERATURE STUDIES ON M50 CUBES:

The test results of M50 grade cubes (after 28 days, with 1.6% SP) which are exposed to a temperature of 300°C using furnace for 1hour and 3hr durations are tabulated below:

Table 5- TEMPERATURE STUDIES ON M40 CUBES

S. No	Details	Time Duration	% reduction in weight	Compressive strength (MPa)
1	OPC+SAND	1hr	3.8	68.55
2	OPC+QUARRY STONE DUST	1hr	3.4	64.11
3	OPC+SAND	3hr	3.9	63.33
4	OPC+QUARRY STONE DUST	3hr	3.7	60.32

V. CONCLUSIONS

Results were analyzed to derive useful conclusions

From the results tabulated in earlier chapter the following conclusions can be derived:

For the designed mix proportions of M40 and M50 grades of concrete the desired characteristic strengths for cubes are achieved in both conventional concrete and Quarry Stone dust concrete. The strength achieved in concrete cubes made with Quarry stone dust as fine aggregate achieved high strengths when compared with Quarry stone dust concrete. The increase is about 10 % that of concrete with natural sand. This behaviour is observed in both M40 and M50 grade concretes. With the addition of super plasticizer at 1, 1.3, 1.6%, strength values showed an increasing trends. In case of flexural strengths addition of super plasticizer at 1.3% showed lesser values.

Fire resistance:

For M40grade cubes when exposed to 300°C temperature the compressive strength decreases at 3hr when compared to 1hrs duration for OPC+SAND and OPC+QSD but OPC+SAND attains more strength when compared to OPC+QSD.

For M50 grade cubes the similar trend was observed.

For M40 grade prisms the flexural strength decreases at 3hr when compared to 1hrs duration both for OPC+SAND and OPC+QSD. The strength is more for OPC+QSD when compared to OPC+SAND. Similarly for M50 grade concrete the flexural strength decreases at 1hr when compared to 3hrs duration both for OPC+SAND and OPC+QSD.

The strength is more for OPC+QSD when compared to OPC+SAND. The resistance to fire in QSD concrete is more when it is compared with normal concrete.

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