BEHAVIOR OF CONCRETE ON REPLACEMENT OF SAND WITH QUARRY STONE DUST AS FINE AGGREGATE

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Abstract: River sand is most commonly used fine aggregate in the production of concrete Quarry stone dust has many of the useful properties of the stone that it comes from. It is very heat resistant and poses the problem of acute shortage in many areas. Quarry rock dust can be an economic alternative to the river sand. Quarry Rock Dust as 100% substitutes for Natural Sand in concrete. Mix design has been developed for M25 and M40 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.
KEYWORDS: Quarry Rock Dust, M25 and M40 grades, **Sand Concrete, flexural strength etc.,**

I. INTRODUCTION

GENERAL

To meet the requirements of globalization, in the construction of buildings and other structures concrete plays the rightful role and a large quantum of concrete is being utilized. River sand, which is one of the constituents used in the production of conventional concrete, has become highly expensive and also scarce. In the backdrop of such a bleak atmosphere, there is large demand for alternative materials from industrial waste. The investigation on the use of Quarry Stone Dust in concrete as an alternative to sand as fine aggregate are presented in this report. report. Standard concrete cubes(150x150x150 mm), prisms (100x100x500 mm) were tested. 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 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 contains no plastic chemicals that may be toxic to the surrounding environment over time. 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 located at Madhurawada, Visakhapatnam and Andhra Pradesh, India. The stone dust is tested for various properties like specific gravity, bulk density etc, in accordance with IS 2386-1968.Machine crushed angular metal from single source from available crusher located in village near Anakapalli , Visakhapatnam district is used as coarse aggregate. Super plasticizer by trade name Conplast SP-430 was used as water reducing agent to achieve the required workability.

II. LITERATURE REVIEW

GENERAL

Sahu et al investigated the use of crusher dust only as a partial replacement of fine aggregates, and not as complete replacement, while Jaffar et al investigated the performance of high strength concrete with silica stone dust was a partial replacement of cement. Further, comprehensive tests on beam models are not reported so far.

Devi. M et al dealt with the strength and corrosion resistance behavior of various integral type corrosion inhibitors namely triethanolamine, diethanolamine, diethyl amine, calcium nitrite and sodium nitrate at the dosage of 1%, 2%, 3% and 4% by weight of cement in concrete containing quarry dust as fine aggregate is carried out. Results herein revealed that replacement of sand by quarry dust increases the strength of the concrete; with addition of inhibitor it offers lower permeability and greater density which enable it to provide better resistance corrosion and durability in adverse environmental.

Priyanka Jadhav A. et al investigated the effect of water cement ratio on fresh and hardened properties of concrete with partial replacement of natural sand by manufactured sand. Concrete mix design of M20 (2900 psi) grade was done according to Indian Standard code (IS: 10262). Concrete cube, beam and cylindrical specimens were tested for evaluation of compressive, flexural and split tensile strength respectively. Workability was measured in terms of slump and compacting factor. The concrete exhibits excellent strength with 60% replacement of natural sand, so it can be used in concrete as viable alternative to natural sand. This paper puts forward the applications of manufactured sand as an attempt towards sustainable development in India. It will help to find viable solution to the declining availability of natural sand to make eco- balance.

RAO.P.N et al focused on investigating characteristics of M30 concrete with partial replacement of cement with Ground Granulated Blast furnace Slag (GGBS) and sand

with the ROBO sand (crusher dust). The cubes and cylinders are tested for both compressive and tensile strengths. It is found that by the partial replacement of cement with GGBS and sand with ROBO sand helped in improving the strength of the concrete substantially compared to normal mix concrete.

III. MATERIALS

Cement: In modern cement plant cement is manufactured by semi – dry process in which lime stone and shale are crushed to powder form and blended in correct proportions. This is then mixed in dry form by means of compressed air.

This mixture then behaves like a fluid and is sieved and sent to the calciner which converts it into clinker which is ground to cement. The main constituents in cement that give cementing properties are C_2S, C_3S, C_3A, C_4AF.

Quarry Stone dust: It is obtained from the screenings left from the crushed stone. It is a byproduct in Quarry stone crusher plants. Nowadays, this is being used as fine aggregate because of the difficulty in getting natural sand. Special crushers are introduced in India for making fine aggregate from rocks. In the present work QSD from existing crushers which is a byproduct was used.

Sand: Sand belonging to Zone II and III are recommended for structural works. Very Coarse sand shows more difficulties in surface finishing. In most of the cases, concrete mix can be designed to fit the available sand and coarse aggregate.

Super Plasticiser: These are chemicals which decrease the water requirement for a given workability more than plasticizers, by more than 15%. They can reduce water requirement even up to 30%. In all high strength concrete production, super plasticisers have to be used water-cement ratio. These are generally used in ready-mixed concrete plants. Reduction in W/C ratio enables increases in density and impermeability thus enhancing durability of concrete.

Water: Water is the most essential material for construction. IS456-2000 specified the requirements of water to be used for construction. The pH of water should not be less than 6. Chlorides content exceeding 400mg/lit in water cannot be used for R.C works. Sea water or brackish should not be allowed for making or curing of R.C. Works.

Coarse Aggregate: Coarse aggregate is obtained by crushing quarry rock to required size. The pieces of crushed stone varying from 5mm to 80mm size can be called coarse aggregates. The size of the aggregate that is to be used depends on the type of work. Most of the times 20mm to 40mm size aggregates are used in R.C Works.

IV. EXPERIMENTAL INVESTIGATION

Quarry rock dust:

The Quarry Rock Dust obtained from local resource Sri Kanaka Durga Fal-G Brick products, Visakhapatnam 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 - 3.1. 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/	1720-1810	1813.33
Sieve analysis	Zone II	Zone III

Fine aggregate (Natural river sand):

River sand having of 1813.33 kg/m^3 and fineness modulus of 2.015 was used. The specific gravity was found to be 2.5.

Table - 3.2. Sieve analysis for sand

IS SIEVE SIZE (mm)	WEIGHT RETAIN -ED (Kgs)	CUMMU -LATIVE WEIGHT RETAINED (Kgs)	CUMMU -LATIVE % RETAINED	CUMMU -LATIVE % PASSING
10	0.005	0.005	0.5	99.5
4.75	0.005	0.010	1	99
2.36	0.01	0.02	2	98
1.18	0.075	0.095	9.5	90.5
0.6	0.16	0.255	25.5	74.5
0.3	0.43	0.685	68.5	31.5
0.15	0.260	0.945	94.5	5.5

Fine aggregate (Quarry stone dust):

Quarry Stone dust used in the laboratory investigations was procured from a local crushing plant.

Table - 3.3. Sieve analysis for quarry stone dust

IS SIEVE SIZE (mm)	WEIGHT RE (Kgs)	CUMMU -LATIVE WEIGHT RETAINED (Kgs)	CUMMULA -TIVE % RETAINED	CUMMUL -ATIVE % PASSING
10	0	0	0	100
4.75	0	0	0	100
2.36	0.25	0.25	25	75
1.18	0.215	0.465	46.5	53.5
0.6	0.095	0.56	56	44
0.3	0.175	0.735	73.5	26.5
0.15	0.235	0.97	97	3

The specific gravity of stone dust was 2.63 and Fineness modulus was 2.67

Coarse aggregate: Natural granite aggregate having density of 2700kg/m^3 and fineness modules (FM) of 7.26 was used. The specific gravity was found to be 2.60. (Conforming to IS 2386-1963).

Natural granite aggregate having density of 2700kg/m3 and fineness modules (FM) of 7.26 was used. The specific gravity was found to be 2.60. (Conforming to IS 2386-1963)

Table - 3.4. Sieve analysis for coarse aggregate

IS SIEVE SIZE (mm)	WEIGHT RETAIN -ED (Kgs)	CUMMU -LATIVE WEIGHT RETAIN ED (Kgs)	CUMMU -LATIVE % RETAINED	CUMMU -LATIVE % PASSING
80	0	0	0	100
40	0	0	0	100
20	1.37	1.37	27.4	72.6
10	3.545	4.915	98.3	1.7
4.75	0.085	5.0	100	0
2.36	-	-	100	0
1.18	-	-	100	0
0.6	-	-	100	0
0.3	-	-	100	0
0.15	-	-	100	0

TEST SPECIMENS PREPARATION

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 M25, and M40 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 super plasticiser (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.

Mix Design for M25-Grade Concrete
Grade Designation : M25
Type of cement : OPC 53 grade KCP
Maximum size of Aggregate : 20mm
Minimum cement content : 250Kg/m^3
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/m^3
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/m^3
Chemical Admixture type: SP 430 CONPLAST Specific Gravity of Coarse Aggregate: 2.7 Specific Gravity of Fine Aggregate : 2.5

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/m^3
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/m^3
Chemical Admixture type : SP 430 CONPLAST
Specific Gravity of Coarse Aggregate: 2.7
Specific Gravity of Fine Aggregate : 2.5

The above mix designs are used for casting concrete specimens. The water-cement ratio changes for different dosages of super plasticiser. Usage of super plasticiser reduces the water requirement and new w/c ratios are obtained. The following tables show the details of w/c ratios obtained at various dosages of super plasticiser for M25 and M40 concrete.

TABLE: W/C RATIOS FOR M25 GRADE

GRADE	SUPER PLASTICISER DOSAGE (%)	ACTUAL W/C RATIO	W/C RATIO
M25	1	0.48	0.456
	1.3	0.48	0.4557
	1.6	0.48	0.384

TABLE: W/C RATIOS FOR M25 GRADE

GRADE	SUPER PLASTICISER DOSAGE (%)	ACTUAL W/C RATIO	W/C RATIO
M40	1	0.43	0.408
	1.3	0.43	0.387
	1.6	0.43	0.366

PREPARATION OF TESTING SPECIMEN:

MIXING:

The individual mix ingredients are weighed with their proportions exactly and then the materials are placed on pan. The materials are thoroughly mixed in their dry condition before water is added. The prepared mix was then immediately used for testing workability of fresh mix.

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:

- M25 grade concrete with OPC+NATURAL SAND
- M25 grade concrete with OPC + QUARRY STONE DUST
- M40 grade concrete with OPC+NATURAL SAND
- M40 grade concrete with OPC + QUARRY STONE DUST

COMPACTION OF CONCRETE:

Compaction of concrete is the process adopted for expelling the entrapped air from the concrete. In the process of placing and mixing of concrete, air is likely to get entrapped in the concrete. If air is not removed fully, the concrete loses strength considerably. In order to achieve full compaction and maximum density Table vibrator is used in this experiment.

CURING OF TEST SPECIMENS:

After casting, the moulded specimens are stored in laboratory at room temperature for 24 hours. After these periods the specimens were removed from the moulds and immediately submerged in clean, fresh water curing tank. The specimens are cured for 7 days and 28 days.

V. RESULTS

In order to study the strength behavior and fire resistance of the concrete made with full replacement of sand with Quarry stone dust the tests are conducted. Results so obtained for the tests conducted on cubes and prisms for M25 and M40 grades of concrete with various dosages of super plasticiser at 7days and 28 days were tabulated. The results were compared for concretes with natural sand to that of quarry stone dust as fine aggregate.

COMPRESSIVE STRENGHTS (M25 GRADE):

The compressive strength of M25 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 shown below

Table 5.1- Strength comparison for M25 Grade cubes

S.No.	Sp %	OPC + SAND		OPC + QUARRY STONE DUST	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	1.00	38.44	49.33	28.22	38.67
2	1.30	38.89	42.67	26.89	34.89
3	1.60	41.33	50.67	25.77	31.55

M25GRADE - COMPRESSIVE STRENGTHS OF CUBES (MPA)

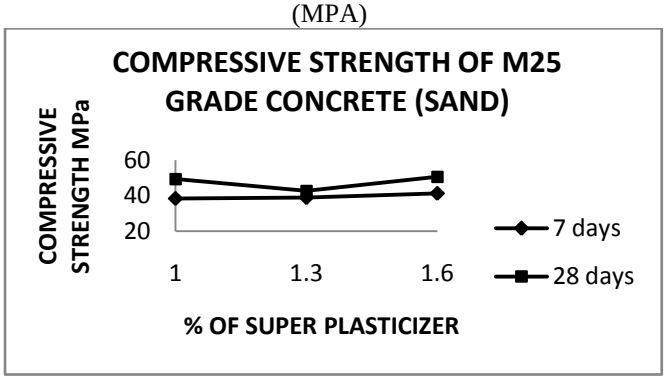

Fig. 5.1(a)

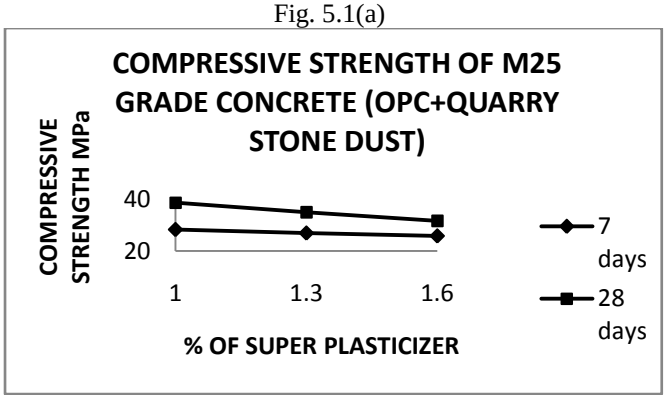

Fig. 5.1(b)

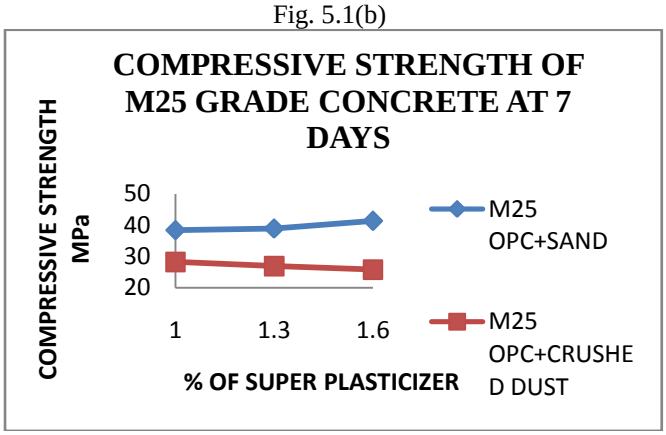

Fig. 5.1(c)

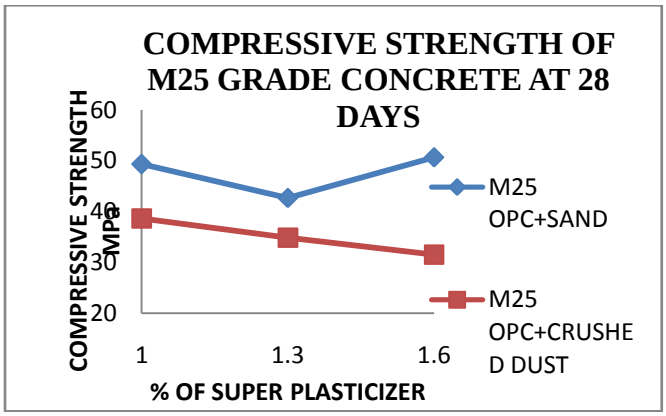

FIG. 5.1(d)

5.2.3 COMPRESSIVE STRENGTH (M40):
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-4 shown below

Table 5.3- Strength comparison for M40 grade cubes

S.No.	Sp %	OPC + SAND		OPC + QUARRY STONE DUST	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	1.00	46.67	51.775	34.445	51.11
2	1.30	32.28	53.333	33.335	48.88
3	1.60	47.55	56	31.555	49.77

M40 GRADE - COMPRESSIVE STRENGTHS OF CUBES(MPA)

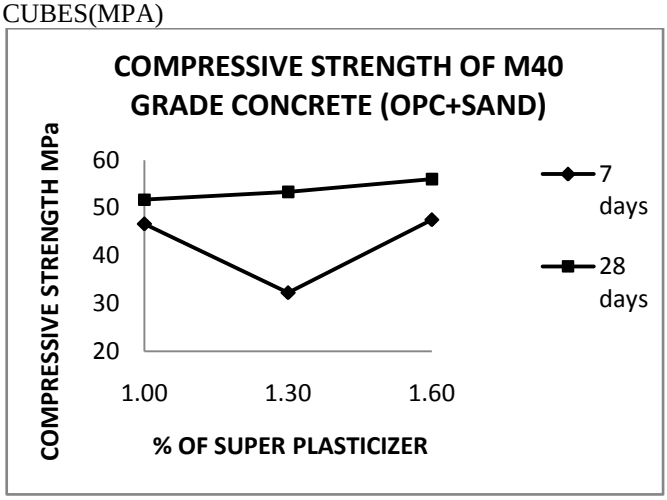

Fig.5.3 (a)

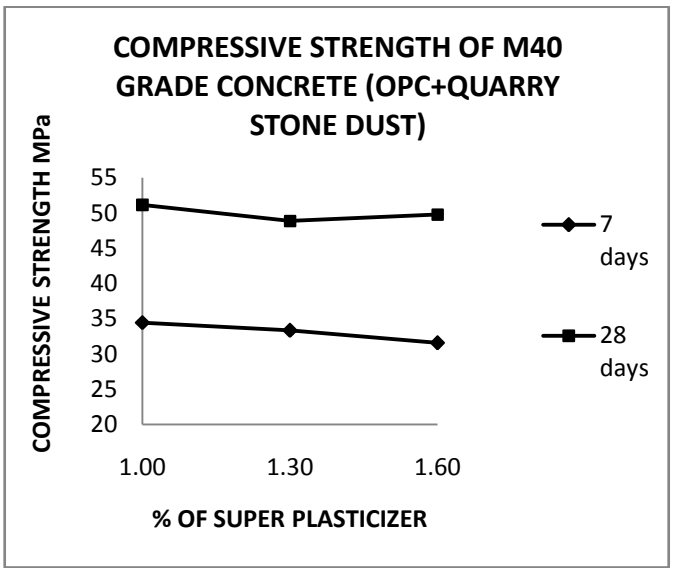

Fig.5.3 (b)

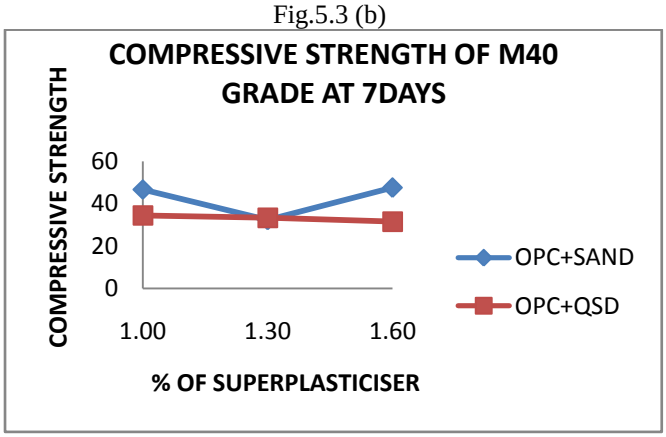

Fig.5.3(c)

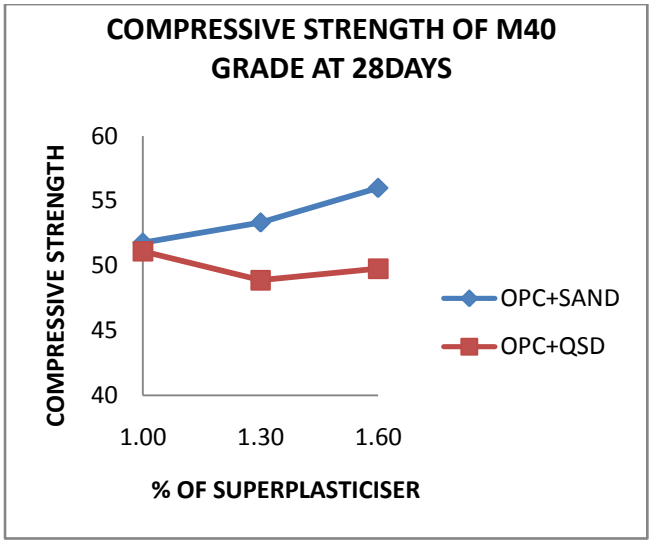

Fig.5.3 (d)

5.3.1 FLEXURAL STRENGTH (M25 GRADE):
The flexural strength of M25 grade concrete beams made with natural sand and those made with quarry stone dust as fine aggregate are tested under universal testing machine and results are tabulated below:

Table 5.6- Strength comparison for M25 grade beams

S.No.	Sp %	OPC + SAND		OPC+CRUSHR DUST	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	1.00	5.065	5.495	4.2	5.22
2	1.30	5.02	5.53	4.085	4.905
3	1.60	5.06	5.375	4.32	5.415

M25 GRADE- FLEXURAL STRENGTH OF CUBES (MPA)

From the table it is observed that both the concretes are achieving the target strengths at the age of 28 days. But the strengths of normal concrete are slightly higher when compared with Quarry stone dust concrete. The flexural strengths did not show much variation with change in dosage of super plasticiser in normal concrete.

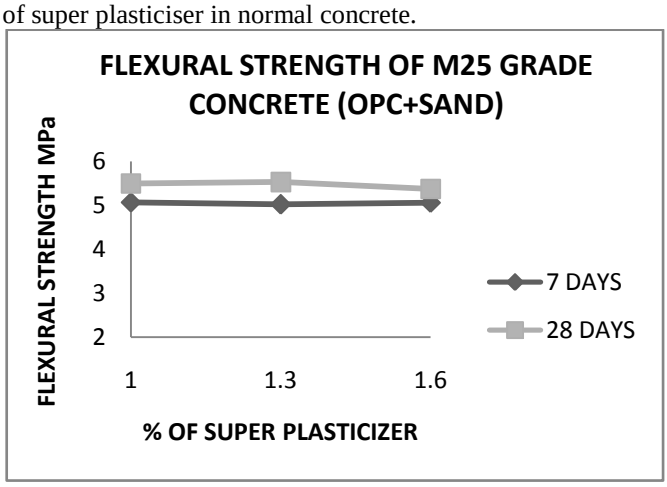

Fig. 5.5(a)

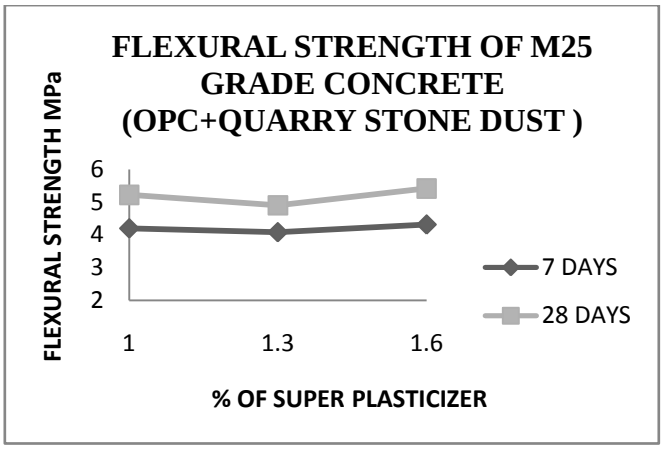

Fig. 5.5(b)

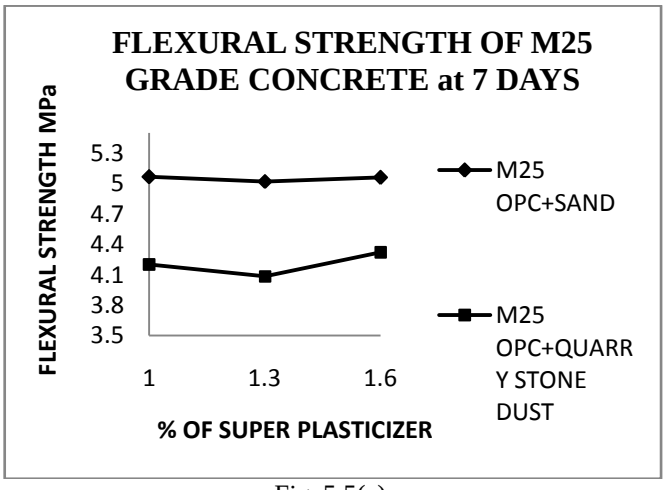

Fig. 5.5(c)

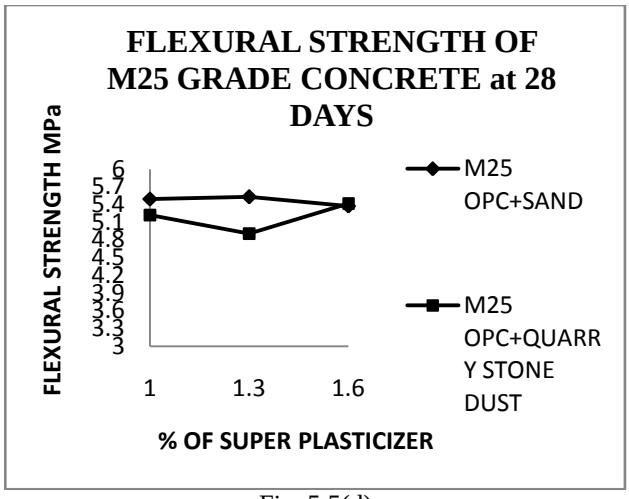

Fig. 5.5(d)

5.4.1 FLEXURAL STRENGTH (M40 GRADE):

The flexural strength of M40 grade concrete beams made with natural sand and those made with quarry stone dust as fine aggregate are tested under universal testing machine and results are tabulated below:

Table 5.7- STRENGTH COMPARISON FOR M40 GRADE BEAMS

S.No.	Sp %	OPC + SAND		OPC+CRUSHR DUST	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
I	1.00	5.027	6.16	5.415	5.77
	1.30	3.295	6.38	5.455	5.455
	1.60	5.14	6.635	4.825	5.81

M40 GRADE - FLEXURAL STRENGTHS OF BEAMS (MPa)

From the table it is observed that both the concretes are achieving the target strengths at the age of 28 days. But the strengths of normal concrete are slightly higher when compared with Quarry stone dust concrete.

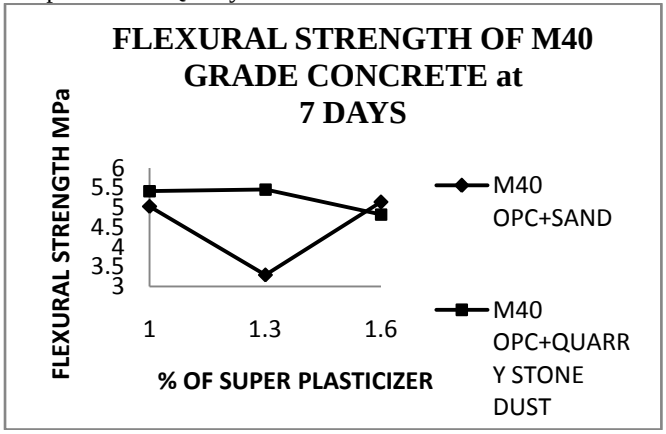

Fig. 5.7(a)

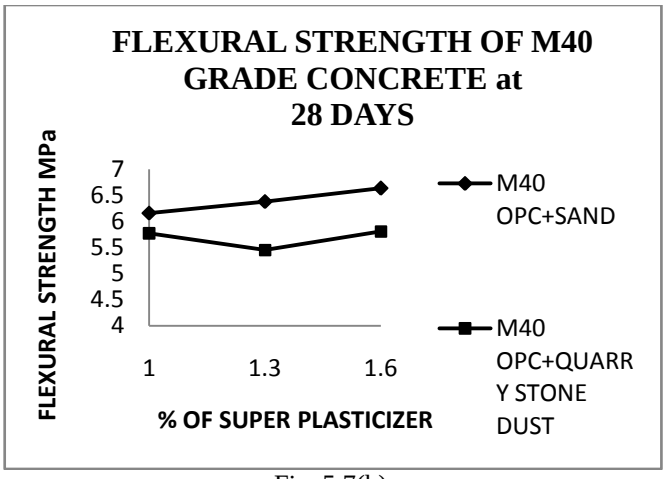

Fig. 5.7(b)

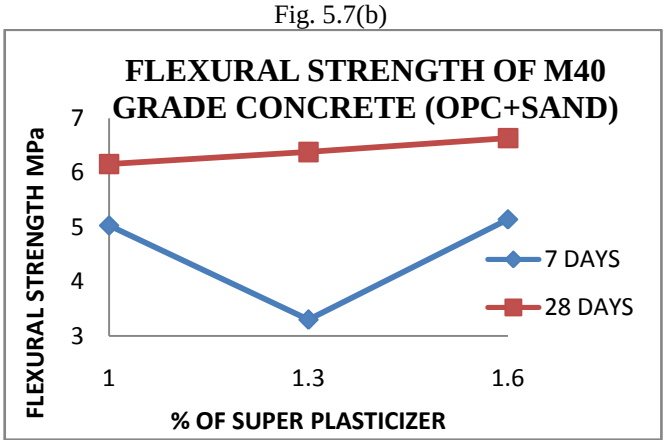

Fig. 5.7(c)

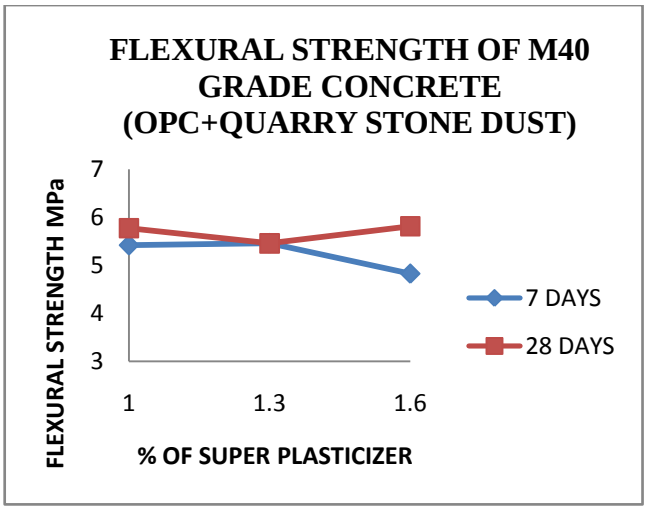

Fig.5.7(d)

VI. CONCLUSION

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

- For the designed mix proportions of M25 and M40 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 made with sand as fine aggregate achieved high strengths when compared with Quarry stone dust concrete. However, in both the cases strengths were falling at a super plasticiser dosage of 1.3% by weight of cement. Similar behavior was also observed in cubes of M40 grade cubes.
- In M40 grade cubes it was observed that at 1.3% dosage of super plasticizer the compressive strength is decreased.
- Flexural strength of M25 prisms when subjected to two-point loading were approximately nearer at various dosages of super plasticiser at 7 days and 28 days for conventional concrete but whereas in QSD concrete at1% dosage of super plasticiser the strength achieved more at 7 days.
- At 28 days QSD concrete with a super plasticiser dosage of 1.3% by weight of cement exhibits has low strength compared to other dosages.
- For M40 grade concrete the strength gradually increases for 1% to 1.6% super plasticizer whereas in quarry stone dust the strength decreases from 1% to 1.3% super plasticizer and then increase at 1.6% super plasticiser.

Fire resistance:

- For M25grade cubes when exposed to 300°C temperature the compressive strength decreases at 1hr when compared to 3hrs duration for OPC+SAND and OPC+QSD OPC+SAND attains more strength when compared to OPC+QSD.
- For M40 grade cubes the compressive strength increases at 1hr when compared to 3hr duration both for OPC+SAND and OPC+QSD. Whereas at 1hr the OPC+QSD strength is higher and for 3hrs OPC+SAND strength is higher.
- For M25 grade prisms the flexural strength increases at 1hr and 3hrs duration both for OPC+SAND and OPC+QSD. The strength is more for OPC+QSD when compared to OPC+SAND. Similarly for M40 grade concrete the flexural strength decreases at 1hr when compared to 3hours duration 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.

SCOPE FOR FUTURE WORK:

- The same work can be carried out by blending the quarry stone dust from one or more sources.
- Alternative materials other than quarry stone dust such as artificial sand, rob sand, waste copper slag, marble sludge powder can be used for replacement.
- Super Plasticiser of different type can be used and water reduction can be determined.

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