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

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ABSTRACT

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.

This Thesis presents the feasibility of the usage of 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.

The results show that at a dosage 1.3% of super plasticizer by weight of cement the concrete made of quarry stone dust as fine aggregate attained low strengths when compared with other dosages (1% and 1.6%) in compression and flexure.

1.0 INTRODUCTION

A lot of facelift is being is given to roads, footpaths along with roadside. Concrete paving blocks are ideal materials on the footpaths for easy laying, better look and finish. Cement concrete paving blocks are precast solid products made out of cement concrete. The product is made in various sizes and shapes viz. rectangular, square, and round blocks of different dimensions with designs for interlocking of adjacent paving blocks. The raw materials require for manufactures of the product are Portland cement and aggregates which are available locally in every part of the country. Market potential cement concretes paving blocks find applications in pavements, footpaths, gardens, passengers waiting sheds, bus stops, industry and other public places. The product is commonly used in urban areas for the above applications. Hence, the unit may be set up in urban and semi urban areas, near the market.

Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc., 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.

OBJECTIVES:

The main objectives of the present work are:

1. To compare the properties of made of natural river sand and concrete made of quarry stone dust as fine aggregate.
2. To study the effect of super plasticiser on water-cement ratio.
3. To study the behaviour of concretes M25 and M40 grades when exposed to temperature.

2. LITERATURE REVIEW

Investigation on the strength characteristics of mortars and concrete with crusher dust as partial and full replacement of the aggregate are reported by several researchers. The test results indicate that stone crusher dust can be used in mortar and concrete without significant difference in strength and workability compared to mortar and concrete with conventional river sand.

However, **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 as a partial replacement of cement. Further, comprehensive tests on beam models are not reported so far.

Sivakumar.Aet al investigated the influence of 100% replacement of sand with quarry dust. The experimental results showed that the addition of quarry dust for a fine to coarse aggregate ratio of 0.6 was found to enhance the compressive properties as well as elastic modulus.

3. MATERIALS

3.1 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) 90 microns

Ultimate compressive strength of standard mortar cubes

a) At the age of 7-days (MPa) 40.0 & b) At the age of 28-days (MPa) 56.4

3.2Quarry 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/m3)	1720-1810	1813.33
Sieve analysis	Zone II	Zone III

3.3 Fine aggregate (Natural river sand)

River sand having density of 1813.33kg/m3 and fineness Modulus (FM) of 2.015 was used. The specific gravity was found to be 2.5.

3.4 Fine aggregate (Quarry stone dust)

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

The specific gravity of stone dust was 2.63 and

Fineness modulus was 2.67

3.5 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)

3.6 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.

4. EXPERIMENTAL PROGRAMME

4.1 Materials Used

The different materials used in the investigation are:

4.1.1 Cement

Cement used in the investigation was found to be Ordinary Portland Cement(53 grade) confirming to IS : 12269 – 1987.

4.1.2 Fine Aggregate

The fine aggregate used was obtained from a nearby river course. The fine aggregate confirming to zone – II according to Is 383-1970 was used.

4.1.3 Coarse aggregate

The coarse aggregate used is from a local crushing unit having 20mm nominal size. The coarse aggregate confirming to 20mm well-graded according to IS:383-1970 is used in this investigation. Here for standard concrete mix, normal river sand is taken and samples are prepared. These samples are then compared with concrete mix which in which the fine aggregate is replaced with Quarry dust.

4.2 Material tests

4.2.1 Specific gravity (IS:2386)

Specific gravity of Cement-3.07

Specific gravity of Coarse aggregate- 2.8

Specific gravity of fine aggregate-2.66

4.2.2 Bulk density (IS:2386)

Coarse aggregate

Average Bulk Density = Net weight of aggregate in kg / volume of container = ϵ $(W3-W1)v$ = 1650 kg/m3

Fine aggregate:

Average Bulk Density = Net weight of aggregate in kg / volume of container

= ϵ $(W3-W1)$ = 1687 kg/m3

4.3 Moulds and Equipment

4.3.1 Cubes

Standard cube moulds of size 150X150X150mm are made of cast iron were used for obtaining strength and durability properties.

4.3.2 Mixing

It was found that the fresh concrete was dark in colour. The amount of water in the mixture played an important role on the behavior of fresh concrete. When the mixing time was long, mixtures with high water content bleed and segregation of aggregates and the paste occurred. This phenomenon was usually followed by low compressive strength of hardened concrete. The effects of water content in the mixture and the mixing time were critical parameters which decide the concrete should be within five to seven minutes as for the concrete and while mixing the following steps should be followed:

- First mix all dry materials in the pan mixer.
- Add the liquid component of the mixture at the end of dry mixing, and continue the wet mixing for another four minutes.

4.3.3 Casting

The standard moulds were fitted such that there are no gaps between the plates of the moulds. If there are small gaps they were filled with plaster of pairs. The moulds then oiled and kept ready for casting. A pan mixer of having 90 kg capacity was used for mixing concrete and the super plasticizer was used for workability purpose as per the specifications and calculations. This was dispersed in water in required proportion before mixing the water with the ingredients coarse, fine

aggregates, cement. After 24hrs of a casting the moulds were kept under curing for the required number of days before casting.

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

4.4 MIX DESIGN

The method mix design proposed by IS was 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.

Table 4.1 W/C Ratios For M25 Grade

Grade	Superplasticizer 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 4.2 W/C Ratios For M40 Grade

Grade	Superplasticizer 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

4.5 PREPARATION OF TESTING SPECIMEN:

4.5.1 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.

4.5.2 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:

1. M25 grade concrete with OPC+NATURAL SAND
2. M25 grade concrete with OPC + QUARRY STONE DUST
3. M40 grade concrete with OPC+NATURAL SAND
4. M40 grade concrete with OPC + QUARRY STONE DUST

4.5.3 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.

4.5.4 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.

5. 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 ofsuperplasticizerat7daysand28dayswer etabulated.Theresultswerecomparedforc oncretes with natural sand to that of quarry stone dust as fine aggregate.

5.2.1COMPRESSIVESTRENGHTS (M25GRADE):

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-2 shown below

Table 5.1 Strength comparison for M25 Grade cubes

S.No.	Sp %	OPC + SAND		OPC+QUARRYSTONE DUST	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	1.00	14.54	28.33	17.22	28.67
2	1.30	17.74	28.67	18.89	29.89
3	1.60	18.13	29.67	18.77	28.55

M25GRADE-COMPRESSIVESTRENGTHSOFCUBES (N/mm^2)

From the table it is observed that both the concretes are achieving the target strengths at the age of 28days. 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 super plasticizer. The following figures give an idea regarding compressive strength.

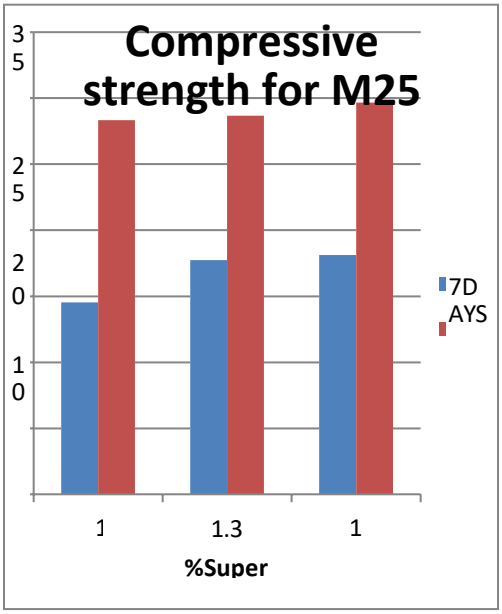


Fig.5.1(a)Compressive strength ofM25gradeconcrete

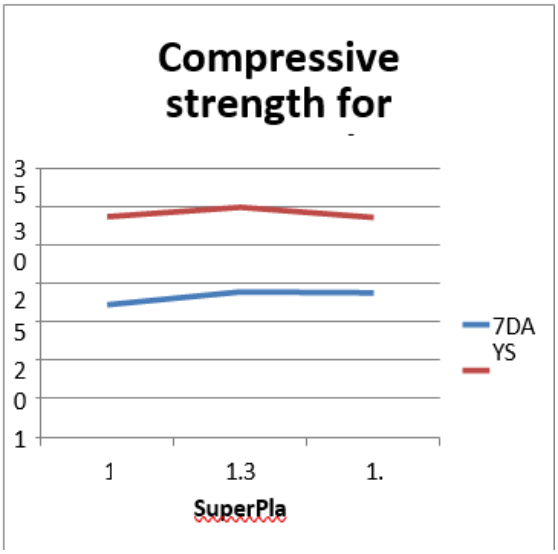


Fig.5.1(b)Compressive strength of M25 grade concrete (OPC+QuarryStoneDust)

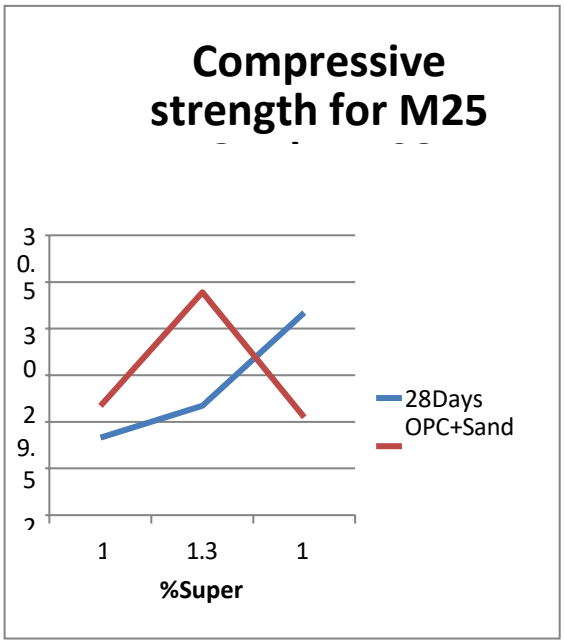


FIG.5.1(d)CompressivestrengthofM25grade concrete at28 days

5.3.1COMPRESSIVE 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+ QUARRYSTONE DUST	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
I	1.00	26.67	44.775	26.75	44.11
2	1.30	27.28	45.333	27.33	45.88
3	1.60	28.55	45.6	29.555	45.67

M40GRADE-COMPRESSIVESTRENGTHSOFCUBES (N/mm^2)

From the table it is observed that both the concretes are achieving the target strengths at the age of 28days.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 super plasticizer. At 1.3% dosage of super plasticizer the strengths were observed to increasing. The following figures show the compressive strengths.

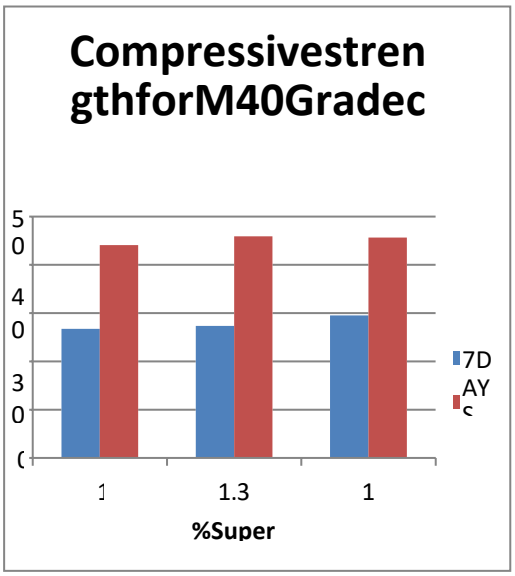
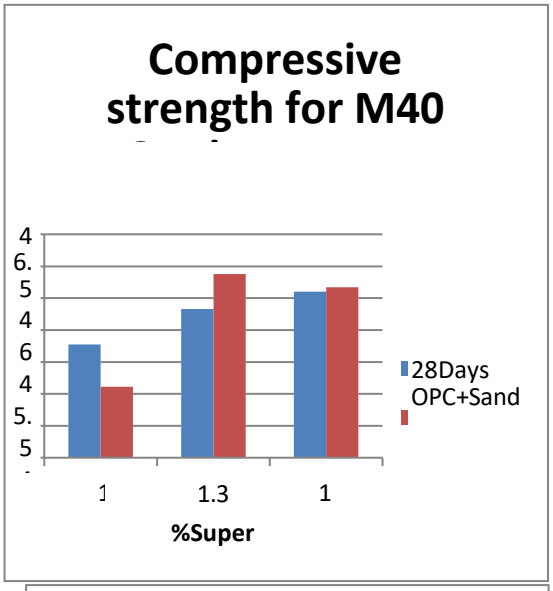


Fig.5.3(a) Compressive strength of M 40gradeconcrete (OPC+ SAND)



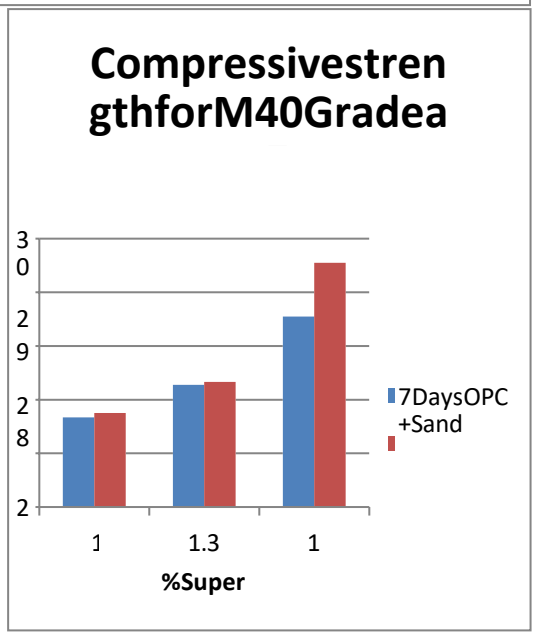


Fig.5.3 (b) Compressive strength of M40grade concrete (OPC+ Quarry Stone dust)

Fig.5.3(c) Compressive strength of M40grade concrete at7 days

Fig.5.3(d) Compressive strength of M40gradeconcrete at28 days

5.3.1 FLEXURAL STRENGTH (M25GRADE):

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

Table5.6-Strength comparison forM25grade beams.

S. No.	Sp %	OPC + SAND		OPC+QUARRY DUST	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	1.00	2.065	3.495	2.26	3.5
2	1.30	2.74	3.67	2.85	3.7
3	1.60	2.84	3.96	2.62	3.615

M25 GRADE-FLEXURALSTRENGTHSOF BEAMS (N/mm^2)

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 Quarry stone dust concrete are slightly higher when compared with normal concrete.

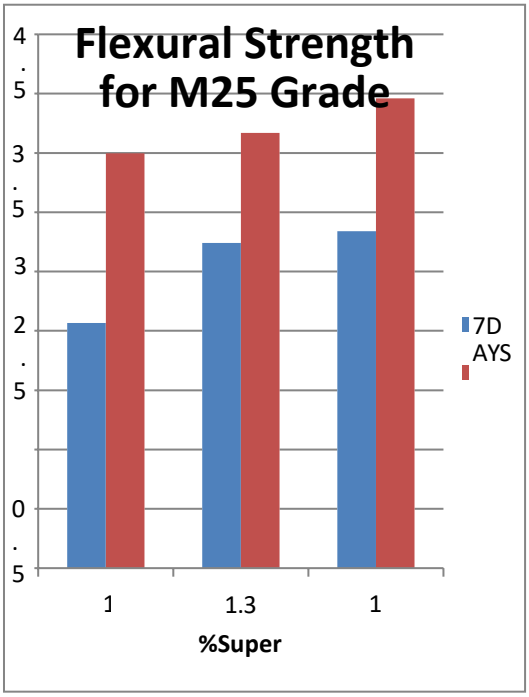


Fig.5.5(a) Flexural strength of M25 grade concrete (OPC+ sand)

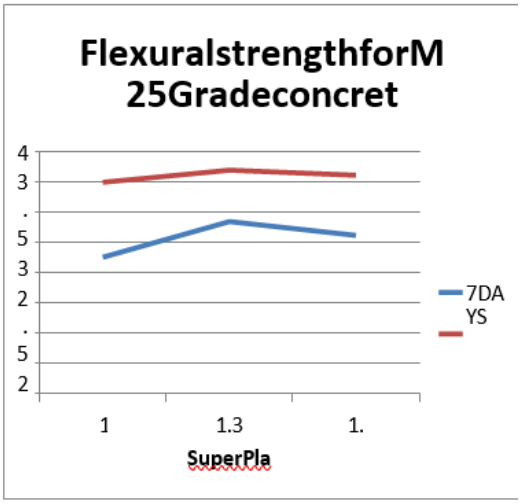


Fig.5.5 (b) Flexural strength of M25grade concrete (OPC+ Quarry Stone Dust)

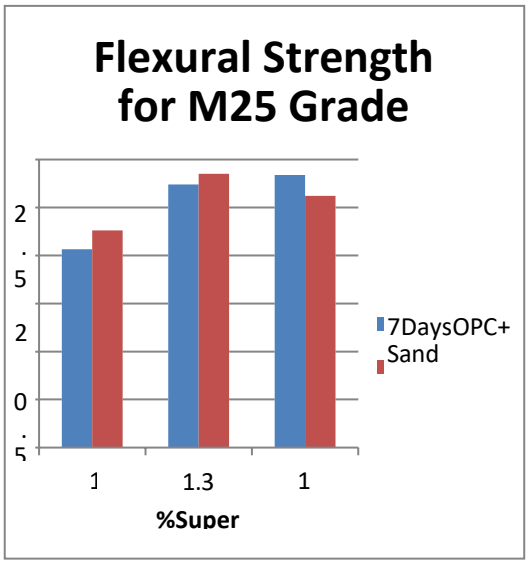


Fig.5.5(c) Flexural strength of M25 grade

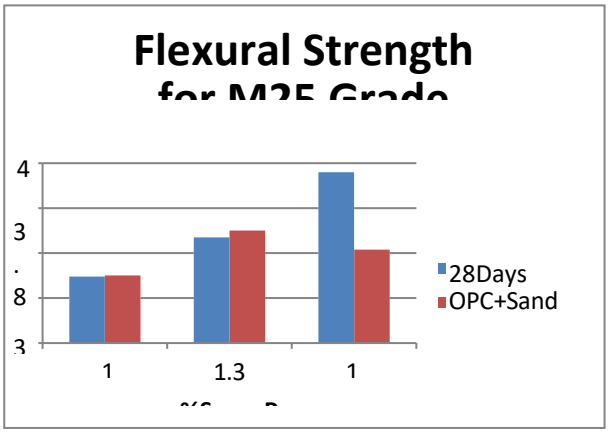


Fig.5.5(d) Flexural strength of M25 grade concrete at 28days

6. CONCLUSIONS

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

1. 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.
2. Thestrengthachievedinconcrete madewithsandasfineaggregatea chievedhighstrengths when compared with Quarry stone dust concrete. However, in both the cases strengths were increasing at a super plasticizer dosage of 1.3% by weight of cement. Similar behavior was also observed in cubes of M40 grade cubes.
3. InM40gradecubesitwasobserve dthatat1.3%dosageofsuperplasti cizerthecompressive strength is increased.
4. Flexural strength of M25 prisms when subjected to two-point loading were approximately neareratvariousdosagesofsuperp lasticizerat7daysand28daysforc onventionalconcrete but whereas in QSD concrete at 1.3% dosage of super plasticizer the strength achieved more at 28 days.
5. At 28 days QSD concrete with a super plasticizer dosage of 1.3% by weight of cement exhibits has high strength compared to other dosages.
6. For M40 grade concrete the

strength gradually increases for 1% to 1.3% super plasticizer whereas in quarry stone dust the strength decreases from 1.6 % to 1.3% super plasticizer.

7. SCOPEFORFUTURE WORK

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

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