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A COMPARATIVE STUDY ON STRENGTH PROPERTIES OF CONCRETE BY PARTIAL REPLACEMENT OF FINE AGGREGATES WITH QUARRY DUST

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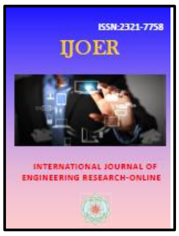

ABSTRACT

This experimental study presents the variation in the strength of concrete when replacing sand by quarry dust from 0% to 100% in steps of 20%. M30 and M40 grades of concrete were taken for study keeping a constant slump of 60mm.

In such a situation the quarry dust can be an economic alternative to the river sand. Quarry dust can be defined as residue, tailing or other non-voluble waste material after the extraction and processing of rocks to form fine particles less than 4.75mm. Usually, dust is used in large scale in the highways as a surface finishing material and also used for manufacturing of follow blocks and lightweight concrete draws serious attention of researchers and investigators.

From test results it was found that the maximum compressive strength is obtained only at 40% replacement at room temperature and net strength after loss due to hike in temperature was above the recommended strength value due to 40% replacement itself. We are using the M30 and M40 grade concrete by adding 20% and 40% quarry dust used was designed by a modified IS method were casted and compression, split tensile strengths conducted for the age 3days of 7 and 28 days were obtained at room temperature.

The quarry dust as a partial replacement of fine aggregate with super plaster (VARA PLASTER SP 123) to obtained high workability and high strength as a chemical mixture. This result gives a clear that quarry dust can be utilized in concrete mixtures as a good substitute for natural river sand giving higher strength at 50% replacement.

Key Words: Concrete, quarry dust, river sand, super plaster, compressive strength split tensile strength.

1. INTRODUCTION

Common river sand is expensive due to 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 s 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 problem with respect to its availability, cost and environmental impact. The increasing demand is also leading to hike in its price and large excavations in river beds. It is in turn posing a problem to the existing water bodies.In such a situation the quarry rock dust can be an economic alternative to the river sand. Quarry rock dust can be defined as residue, tailing or other non-voluble waste material after the extraction and processing of rocks to from fine particles less than 4.75mm. Usually, quarry rock dust is used in large scale in the highways as a surface finishing material and also used for manufacturing of hollow blocks and lightweight concrete prefabricated elements. Use of quarry rock dust as a fine aggregate n concrete draws serious attention of researchers and investigation.

1.1 IMPORTANCE OF THE STUDY: The objective of our project to find a substitute for fine aggregate which is more economical and durable without reducing the strength of the concrete. Such a substitute should comply with the existing standards stipulated for fine aggregate. It also should be available at cheaper rates in abundant quantities.

1.3 NEED FOR THE REPLACEMENT OF SAND: Large scale efforts are required for reducing the usage of the raw material that is present, so that large replacement is done using the various by-product materials that are available in the present day. Materials like fly ash especially Class F fly ash is very useful as the fine aggregates. The fly ash is obtained from the thermal power plants which is a by-product formed during the burning of the coal.

The other material that can be used is quarry dust which is made while in the processing of the Granite stone into aggregates, this is formed as a fine dust in the crushers that process the coarse aggregates, which is used a earthwork filling material in the road formations majorly. Many studies are made with several other materials which gave the concrete to be a material made of recycled material but the parameters that are primary for the material was not satisfied. The properties of concrete in fresh and hardened state are studied in the various papers that are used as a reference for this. Some of the properties are workability, compressive strength are the major one that are considered.

1.4 QUARRY DUST

1.4.1 Origin of Quarry Dust: The quarry dust is the by-product which is formed in the processing of the granite stones which broken downs into the coarse aggregates of different sizes.

1.4.2 Physical and chemical Properties: The physical and chemical properties of quarry dust obtained by testing the sample as per the Indian Standards are listed in the below table.

Table 1: showing the Physical properties of quarry dust and natural sand

Property	Quarry Dust	Natural Sand	Test method
Specific gravity	2.54 - 2.60	2.6	IS2386(Part III)-1963
Bulk density (kg/m3)	1720-1810	1460	IS2386(Part III)-1963
Absorption (%)	1.20-1.50	Nil	IS2386(Part III)-1963
Moisture Content (%)	Nil	1.5	IS2386(Part III)-1963
Fine particles less than 0.075 mm (%)	15-Dec	6	IS2386(Part III)-1963
Sieve analysis	Zone-II	Zone-II	IS 383- 1970

Table 2: showing the typical chemical properties of quarry dust and natural sand

Constituents	Quarry Dust (%)	Natural Sand (%)	Test method
SiO2	62.48	80.78	IS 4032- 1968
Al2O3	18.72	10.52	
Fe2O3	6.54	1.75	
Cao	4.83	3.21	
MgO	2.56	0.77	
Na2O	Nil	1.37	
K2O	3.18	1.23	
TiO2	1.21	Nil	
Loss of ignition	0.48	0.37	

1.5 PRODUCTION OF QUARRY DUST

The Aggregate Crushing plant includes vibrating feeder, impact crusher, jaw crusher or cone crusher, vibrating screen, belt conveyor and centrally electric controlling system, etc. The big materials are fed to the jaw crusher evenly and gradually by vibrating feeder through a hopper for the primary crushing. After first crushing, the material will transferred to impact crusher or cone

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crusher by belt conveyor for secondary crush; the crushed materials will then transferred to vibrating screen for separating. After being separated, the parts that can meet standard will be taken away as final products, while the other parts will be returned to impact crusher, thus forming a closed circuit. Size of final products can be combined and graded according to customer's specific requirement. We can also equip dust catcher system to protect environment.

Fig 1: Production of Quarry Dust in a Crushing Plant
(source: Budawada, Chimakurthy, Prakasam District)

1.5.1 BEHAVIOUR OF QUARRY DUST:

Quarry dust produced by crushed rock pieces are often made up of particles having rough and angular surfaces. When this quality is coupled with flattened elongated shapes, it will produce a concrete mix that is harsh and not as concrete containing quarry dust can be increased by adding super plasticizer. Quarry dust, because of their angularity and toughness, produce greater concrete compressive strength for cement even with higher water content than natural sand. However, quarry dust produced with modern equipments behaves almost the same as natural sand.

1.5.2 Advantages of Quarry Dust:

The Specific gravity depends on the nature of the rock from which it is processed and the variation is less.

1.5.3 Disadvantages of Quarry Dust:

Shrinkage is more in when compared to that of the natural river sand. Water absorption is present so that increase the water addition to the dry mix.

1.6 TYPICAL PROPERTIES SUPERPLASTICIZER

- Calcium Chloride Content: Nil
- Specific Gravity: 1.22 at 25° C.
- Air Entrainment: Less than 1% additional air is entrained.
- Setting Time: No retardation at normal dosage.
- Chloride Content: Nil to BS 5075.
- Cement Compatibility: Compatible with sulphate resisting and other Portland cements, high alumina cements and cement replacement materials such as PFA, GGBFS and Micro silica.
- Durability: Water reduction gives increase in density and water impermeability which improves durability.

Fig 2: Super Plasticizer VARA PLAST SP 123

2. SCOPE OF THE STUDY

- Identification of quarry with different mineralogical composition in and around Nellore region.
- Collection of quarry dust from two different quarries.
- Testing of the collected samples for various physical and chemical properties.
- Testing of fresh concrete containing quarry dust for workability.
- Identification and usage of admixtures for better workability and strength.
- Testing of hardened concrete cubes for strength at different ages.

3. MATERIALS & THEIR PROPERTIES

3.1 MATERIALS USED: The different materials used in this investigation are:

- Cement
- Fine Aggregates
- Coarse Aggregates
- Quarry Dust
- Chemical Admixture-super plasticizer
- Water

3.1.1 CEMENT: Cement is a binding materials called calcareous and argillaceous materials. K.C.P-53 grade ordinary Portland cement conforming to IS: 12269 was used. There are about 70 varieties of cement and available in powder, paste and liquid form but we are only concerned here with constructional cement commonly known as Portland

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cement. (Portland is the town in South England where cement was originally made)

Fig 3: Collection of Cement

Table 4: Properties of Ordinary Portland cement

S.No	Properties	Results	IS : 12269-1987
1	Specific gravity	3.15	-
2	Normal consistency	32%	-
3	Initial setting time	60 Min	Minimum of 30min
4	Final setting time	350 Min	Maximum of 600min
5	Fineness	8%	<10%
6	Compressive strength A. 3 days strength B. 7 days strength C. 28days strength		Minimum of 27 Mpa Minimum of 40Mpa Minimum of 53Mpa

3.1.2 FINE AGGREGATE

The standard sand used in this investigation was obtained from PENNA River in NELLORE. The standard sand shall be of quartz, light grey or whitish variety and shall be free from silt. The sand grains shall be angular; the shape of the grains approximating to the spherical form elongated and flattened grains being present only in very small or negligible quantities. The standard sand shall (100 percent) pass through 2-mm IS sieve and shall be (100 percent) retained on 90-micron IS Sieve and the sieves shall conform to IS 460 (Part: 1): 1985.

Fig 5: Collecting PENNA RIVER SAND

Table no: 05 Particle Size

Particle Size	Grade	Percent
Smaller than 2 mm and greater than 1 mm	I	33.33
Smaller than 1 mm and greater than 500 microns	II	33.33
Below 500 microns but greater than 90 microns	III	33.33

Table 6: Properties of Fine aggregate

Colour	Light yellow
Specific gravity	2.67
Shape of grains	Rounded

3.1.3 COARSE AGGREGATES: According to IS 383: 1970, coarse aggregate may be described as crushed gravel or stone when it results from crushing of gravel or hard stone. The coarse aggregate procured from quarry was sieved through the sieved of sizes 20 mm and 10 mm respectively. The aggregate passing through 20 mm IS sieve and retained on 10 mm IS sieve was taken. Specific gravity of the coarse aggregate is 2.76.

Table 7: Properties of Coarse aggregate

Colour	Greyish
Specific gravity	2.8
Shape of grains	Angular

Table 8: GRADING OF FINE AND COURSE AGGREGATE

Sieve size(mm)	20mm	Natural sand
40	100	100
20	90.2	100
10	7.6	100
4.75	1.2	96
2.36	-	81.52

1.18	-	59.1
0.6	-	4.7
0.3	-	3.95
0.15	-	2.01
0.075	-	1.08

From the above sieve analysis the fine aggregate is falls under **ZONE- III.**

3.1.4 QUARRY DUST

Quarry dust is collected from two different crusher locations at the following places.

1. Chimakurthy, prakasam district (TPA 412).
2. Kanuparthipadu, Nellore district.

3.1.5 Gradation and fineness modulus of sample 1

Quarry dust obtained from the two source are sieved are sieved in set of sieves to determine the FM under the condition namely, using the set of sieves as presented in the IS code for fine aggregates i.e. from 4.75mm to 75micron. The result of sieve analysis for two samples are give in table 3.4 and 3.5. The variation in the gradation under the above two conditions are brought out clearly in the gradation curve shown in fig 3.1

Fig no: 3.1 06 Set of Sieves

Table 9: Sieve analysis of sample from prakasam

Sieve size	Weight Retained	% Retained	Cumulative Retained %	Total Passing %
4.75	0.001	0.2	0.2	99.8
2.36	0.004	0.81	1.01	98.99
1.18	0.081	16.33	17.34	82.66
0.6	0.112	22.58	39.92	60.08
0.3	0.043	8.67	48.59	51.41
0.15	0.138	28.02	76.61	23.39
0.075	0.087	17.34	93.95	6.05

Fineness modulus=1.8

Table 10: Result of sieve analysis of sample from Nellore

Sieve Size	Weight Retained	% retained	Cumulative Retained %	Total Passing %
4.75	0.005	1.01	1.02	99.1
2.36	0.002	0.41	1.42	98.58
1.18	0.084	17.07	18.5	81.5
0.6	0.085	17.28	35.77	64.23
0.3	0.003	6.71	42.48	57.52
0.15	0.165	33.54	76.02	23.98
0.075	0.09	18.29	94.31	5.69

Fineness modulus=1.7

3.1.6 Specific gravity

The specific gravity of two samples of quarry dust is determined based on procedure given in IS: 2386(part III)-1963

Table 11 Specific gravity of the quarry dust samples

Sample	Specific gravity
Prakasham sample I	2.5
Nellore sample II	2.4

3.1.7 WATER

Portable water was used in the experimental work for both preparing and curing. The pH value of water taken is not less than 6. The allowable limits of physical and chemical impurities and the test methods of their evolution are compiled. The limits of impurities as per Indian, Australian, American and British standard sarepresented. From the literature it is seen that, the reaction between water and cement affect the setting time, compressive strength and also lead to softening of concrete. All the impurities may not have adverse effect on the properties of concrete. The use of impure water for concrete mixing is seen to favorable for strength development at early ages and reduction in long term strength.

3.1.8 CHEMICAL ADMIXTURE (SUPERPLASTICIZER)

Admixture used in this study is VARAPLAST SP123. It is based on Sulphonated Naphthalene polymers. VARAPLAST SP 123 is a chloride free, Superplasticising admixture based on selected synthetic polymers. It is supplied as a brown solution which is instantly dispersible in water. VARAPLAST SP 123 can provide very high level of water reduction and hence major increase in strength can be obtained coupled with good retention of workability to aid placement.

Table 12: Properties of super plasticizer

Specific gravity	1.22 at 25° C
Air entrainment	Less than 1% additional air is entrained.
Setting Time	No retardation at normal dosage
Cement Compatibility	Compatible with sulphate resisting and other Portland cements, high alumina cements and cement replacement materials such as PFA, GGBFS and Micro silica.
Durability	Water reduction gives increase in density and water impermeability which improves durability.

4. CONCRETE MIX PROPORTION

After conducting the procedure of Mix Design the following are the proportions obtained.

4.1 MIX PROPORTION FOR M30

Table 13 M30 Mix proportion

Cement	Fine aggregate	Coarse aggregate	Water
422 Kg/m^3	1048 Kg/m^3	1087 Kg/m^3	198 Kg/m^3
1	2.48	2.525	0.47

4.2 MIX PROPORTION FOR M40

Table 14 M40 Mix proportion

Cement	Fine aggregate	Coarse aggregate	Water
528 Kg/m^3	716Kg/m^3	1063 Kg/m^3	197 Kg/m^3
1	1.35	2.01	0.375

5. TESTS & RESULTS

5.1 COMPRESSIVE STRENGTH TEST

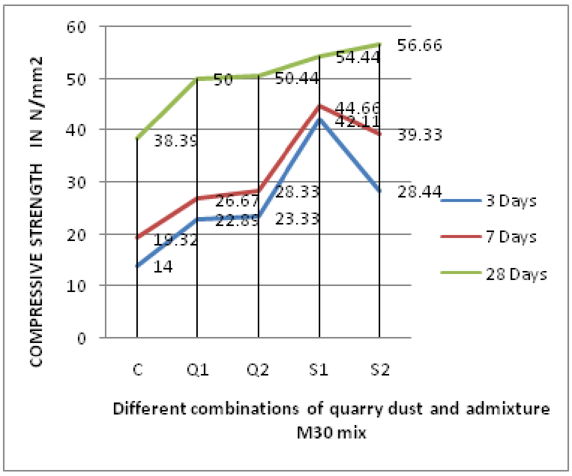
To determine the compressive strength (cube and cylinder) of both grades of concrete, 150mm cubes and 100mm dia* 200mm ht. Cylindrical specimens are cured for 3days , 7days and 28 days. At the end of above curing period, the specimens are tested in a compression testing machine 100 T capacity under a uniform rate of loading (at 140 kg/cm^2/min) and compressive strength is calculated as per IS 516-1959.

Compressive strength = $\frac{load}{area} = \frac{P}{A}$

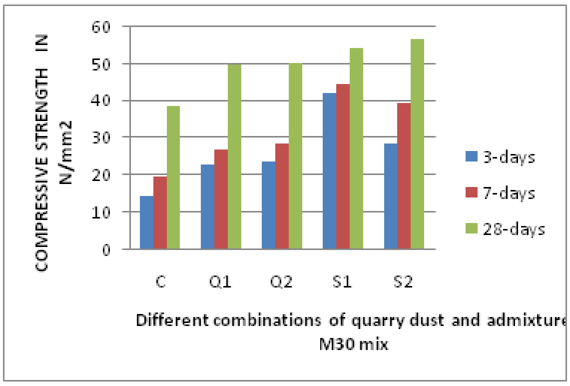
Fig 12 Compression Testing Machine

TABLE 5.1: Compressive strength test values for M30 grade by addition Quarry Dust as partial replacement of fine aggregates.

Codings	Compressive strength for 3 days(MPa)			Compressive strength for 7 days(MPa)			Compressive strength for 28 days(MPa)		
	Cube no			Cube no			Cube no		
	1	2	Avg	1	2	Avg	1	2	Avg
C	13.8	14	13.88	18.9	19.8	19.32	37.8	40	38.9
Q1	23.6	22.2	22.89	25.8	27.6	26.67	44.4	55.6	50
Q2	22.2	22.4	23.33	26.7	30	28.33	52	48.9	50.44
S1	42	42.2	42.11	44.9	44.4	44.66	55.6	53.3	54.44
S2	28.9	28	28.44	41.3	37.3	39.33	57.8	55.6	56.66



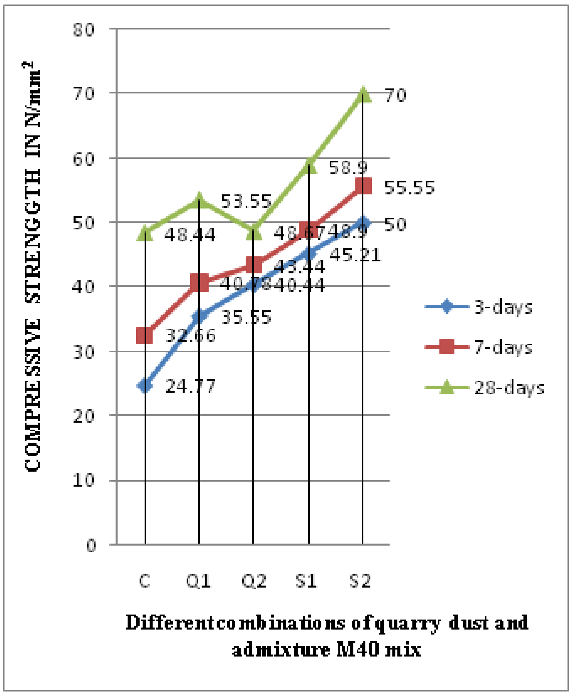
Graph 1: showing different combinations of quarry dust and admixture M30 mix (compressive strength)



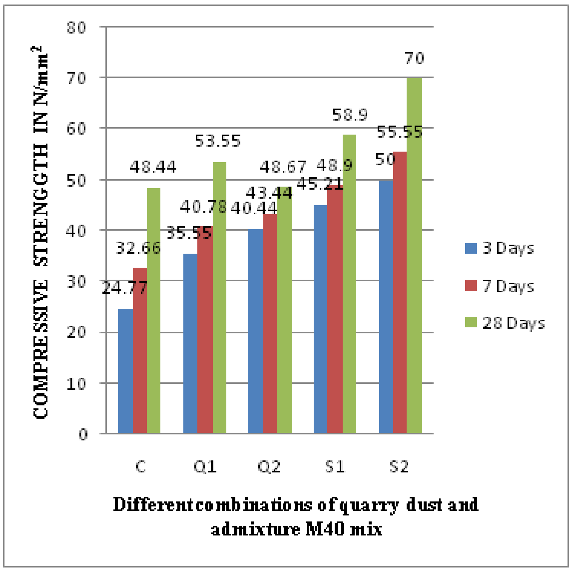
Graph 2: showing different combinations of quarry dust and admixture M30 mix compressive strength

TABLE 5.2: Compressive strength test values for M40 grade by addition Quarry Dust as partial replacement of fine aggregates.

Codings	Compressive strength for 3 days(MPa)			Compressive strength for 7 days(MPa)			Compressive strength for 28 days(MPa)		
	Cube no			Cube no			Cube no		
	1	2	Avg	1	2	Avg	1	2	Avg
C	24.66	24.88	24.77	33.3	32	32.7	48	48.9	48.4
Q1	36	35.11	35.55	40.4	41.1	40.8	53.3	53.8	53.6
Q2	41.33	39.55	40.44	43.6	43.3	43.4	51.1	46.2	48.7
S1	46.88	43.55	45.21	47.3	50.4	48.9	57.8	60	58.9
S2	44.88	47.11	50	57.8	53.3	55.6	68.9	71.1	70



Graph 3 showing different combinations of quarry dust and admixture M40 mix (Compressive strength)



Graph no:4 showing different combinations of quarry dust and admixture M30 mix (Compressive strength)

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5.2 TENSILE STRENGTH TEST

To determine the tensile (direct) strength of concrete cylinder specimens of size 100mm dia * 200mm ht. are cast and after 28 days of moist curing tested in a compression testing machine by loading it on the longitudinal direction and keeping cardboard strips just above and below the specimen. The split tensile strength corresponding to failure of the specimen is calculated using the formula of $\frac{2P}{\rho LD}$

Where P= compressive load on cylinder,

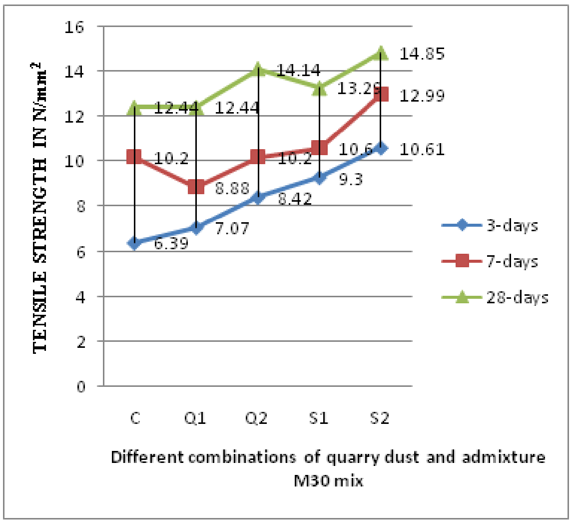
L= length of cylinder,

D= diameter of cylinder

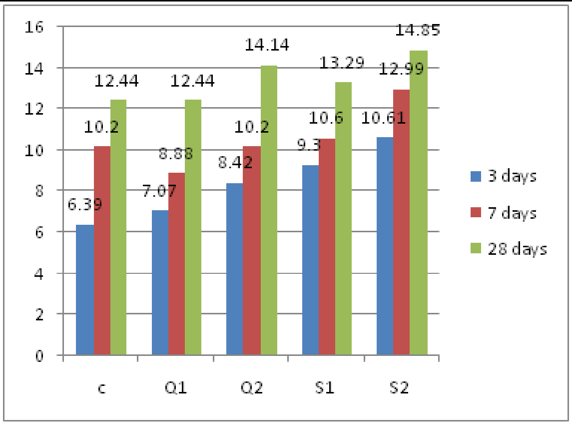
Fig 13 Split tube tensile Testing Machine

TABLE NO.18 TENSILE STRENGTH FOR M30 GRADE CONCRETE

codings	Tensile strength for 3 days(MPa)			Tensile strength for 7 days(MPa)			Tensile strength for 28 days(MPa)		
	Cylinder no			Cylinder no			Cylinder no		
	1	2	Avg	1	2	Avg	1	2	Avg
C	6	6.79	6.39	10	10.4	10.2	11.3	13.6	12.4
Q1	7.35	6.76	7.07	8.7	9.05	8.88	11.3	13.6	12.4
Q2	8.71	8.14	8.42	9.62	10.8	10.2	13.6	14.7	14.1
S1	8.49	10.2	9.3	10.5	10.8	10.6	13	13.6	13.3
S2	10.5	10.8	10.6	12.4	13.6	13	14.7	15	14.9



Graph 5: showing different combinations of quarry dust and admixture M30 mix(Tensile strength)



Graph 6: showing different combinations of quarry dust and admixture M30 mix (Tensile strength)

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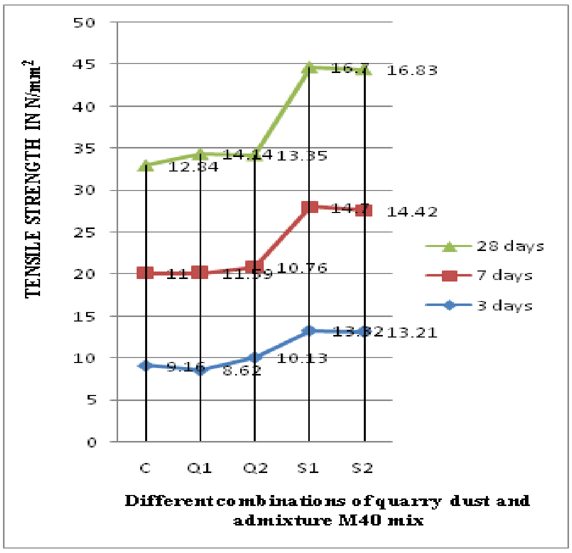
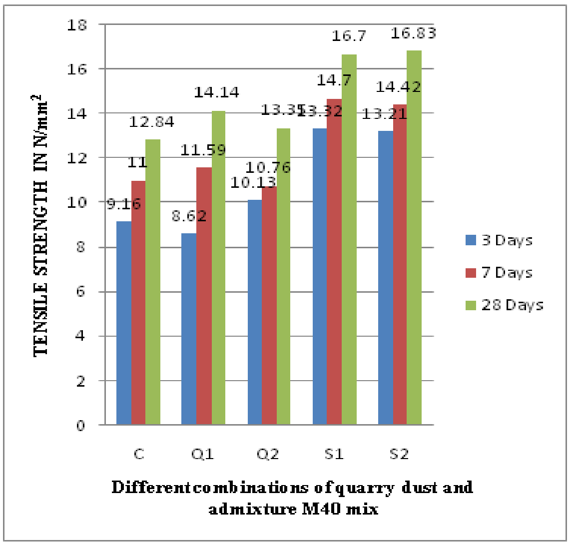
TABLE: 20 Tensile strength test values for M40 grade by addition Quarry Dust as partial replacement of fine aggregates

codings	Tensile strength for 3 days(MPa)			Tensile strength for 7 days(MPa)			Tensile strength for 28 days(MPa)		
	Cylinder no			Cylinder no			Cylinder no		
	1	2	Avg	1	2	Avg	1	2	Avg
C	9	9.33	9.16	10.8	11.2	11	12.7	13	12.8
Q1	7.92	9.33	8.62	10.8	12.4	11.6	13.6	14.7	14.1
Q2	10	10.2	10.1	10.2	11.3	10.8	12.6	14.1	13.4
S1	12.8	13.9	13.3	14.1	15.3	14.7	17.5	15.8	16.7
S2	12.6	13.9	13.2	14.7	14.1	14.4	16.7	17	16.8



Graph 7 showing different combinations of quarry dust and admixture M40 mix(Tensile strength)



Graph 8: showing different combinations of quarry dust and admixture M40 mix (Tensile strength)

6. CONCLUSIONS

The following conclusions are arrived at based on the experiment investigation carried out in the study:

Quarry dust obtained from various sources in and around Nellore and Prakasam

Districts satisfies the requirement as specified in IS standards.

- The workability of the quarry dust concrete can be increased by adding super plasticizer.
- Quarry dust concrete has equal or slightly higher strength than reference concrete for all the two grades of concrete considered in this study (M30, M40). This shows that quarry dust concrete can be used with confidence as a building material.
- Concrete acquires maximum increase in compressive strength and tensile strength at 20% and 40% sand replacement. When compared with concrete with only river sand, the amount of increase in strength is M30 and for M40.

6.1FOR COMPRESSIVE STRENGTH:

- When compared to conventional concrete 20% of the quarry dust is increased by 11.1% as per M30 grade concrete.
- When compared to conventional concrete 40% of the quarry dust is increased by 11.54 % as per M30 grade concrete.
- When compared to conventional concrete 20% of the quarry dust + 0.6 % super plasticizer is increased by 15.54 % as per M30 grade concrete.

- When compared to conventional concrete 40% of the quarry dust + 0.6 % super plasticizer is increased by 13.76 % as per M30 grade concrete.
- As compared to above conventional concrete the maximum value is 20% of the quarry dust + 0.6 % super plasticizer is 15.54 % as per M30 grade concrete of compressive strength.
- When compared to conventional concrete 20% of the quarry dust is increased by 5.11 % as per M40 grade concrete.
- When compared to conventional concrete 40% of the quarry dust is increased by 0.23 % as per M40 grade concrete.
- When compared to conventional concrete 20% of the quarry dust + 0.8 % super plasticizer is increased by 10.46 % as per M40 grade concrete.
- When compared to conventional concrete 40% of the quarry dust + 0.8 % super plasticizer is increased by 21.56 % as per M40 grade concrete.
- As compared to above conventional concrete the maximum value is 20% of the quarry dust + 0.8 % super plasticizer is 21.56 % as per M40 grade concrete of compressive strength.

6.2 FOR TENSILE STRENTH

- When compared to conventional concrete 20% of the quarry dust is increased by 0% as per M30 grade concrete.
- When compared to conventional concrete 40% of the quarry dust is increased by 1.7 % as per M30 grade concrete.
- When compared to conventional concrete 20% of the quarry dust + 0.6 % super plasticizer is increased by 0.85 % as per M30 grade concrete.
- When compared to conventional concrete 40% of the quarry dust + 0.6 % super plasticizer is increased 2.41 % as per M30 grade concrete.
- As compared to above conventional concrete the maximum value is 40% of the quarry dust + 0.6 % super plasticizer is 2.41 % as per M30 grade concrete of Tensile strength.
- When compared to conventional concrete 20% of the quarry dust is increased by 1.3% as per M40 grade concrete.
- When compared to conventional concrete 40% of the quarry dust is increased by 0.51 % as per M40 grade concrete.
- When compared to conventional concrete 20% of the quarry dust + 0.8 % super plasticizer is increased by 3.86% as per M40 grade concrete.
- When compared to conventional concrete 40% of the quarry dust + 0.8 % super plasticizer is increased by 3.99 % as per M40 grade concrete.
- As compared to above conventional concrete the maximum value is 40% of the quarry dust + 0.8 % super plasticizer is3.99 % as per M40 grade concrete of Tensile strength.

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