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Experimental Investigation on Conventional Concrete and Self-Compaction Concrete and Partial and Full Replacement of Fine Aggregate with Quarry Rock Dust

M. Rajendra[1], Y. Vinod kumar[2], K. Venkateswara Rao[3]

[1] PG Student & Civil Department, Gudlavalleru engineering college, Gudlavalleru, Krishna Dist, Andhra Pradesh, India,
[2]Asst. Professor & Civil Department, Gudlavalleru engineering college, Gudlavalleru, Krishna Dist, Andhra Pradesh, India,
[3] Associate. Professor & Civil Department, Gudlavalleru engineering college, Gudlavalleru, Krishna Dist, Andhra Pradesh, India,

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ABSTRACT - *Advanced concrete technology can reduce the consumption of resources and the effect of pollutants on environment. This document describes the feasibility of using the rock dust in production as partial replacement of natural river sand. Quarry rock dust is a byproduct of crushing rocks in quarries. It is formed as waste, so it becomes as a useless material and cause of air pollution. The role of quarry rock dust in concrete very effective, in constructions reducing the demand of natural sand. The experimental study which is investigated the partial replacement of sand by quarry rock dust in both normal concrete and self compaction concrete (M40) mix design in both. Self-compacting concrete (SCC) is a flowing concrete that spreads through congested reinforcement, fills every corner of the formwork, and is compacted under its self weight. SCC requires excellent filling ability, good passing ability, and adequate segregation resistance. In addition of chemical admixture Conplast SP430 as water reducing agent and to obtain, compression, tensile and flexural strength.*

Key Words: *Self-compacting concrete (SCC),* Quarry *rock dust, natural sand, chemical admixture, Conplast SP430*

1. INTRODUCTION

The world wide consumption of fine aggregate in concrete production is very high, and several developing countries have encountered difficulties in meeting the supply of natural river sand as FA in order to satisfy the increasing needs of infrastructural development in recent years. In India attempts have been made to replace river sand with quarry dust. The successful utilization of quarry dust as fine aggregate would turn this waste material that causes disposal problem into a valuable resource. The utilization will also reduce the strain on supply of natural fine aggregate, which will also reduce the cost of concrete. The main objective of the present investigation is to evaluate the possibilities of using quarry dust as a replacement to fine aggregate along with super plasticizer CONPLAST (SP 430) at a dosage of 1 % by weight of Cementitious material. During the present study, 0%, 25%, 50%, 75% and 100% of traditional fine aggregate was replaced with quarry dust. For each mix, 1% of super plasticizer by weight of cement was added. And also in normal concrete the replacement should be done. Compression, tensile and flexural strengths were found after 7, 14, 28, 56 days of curing.

2. LITERATURE REVIEW

General

Extensive research works both at national and international level has been done on the using of various admixtures in mortars and concrete with a common goal.

- To combat the environmental hazards from the industrial waste.
- To modify the properties of traditional concrete to the desired level suitable to the specific circumstances.
- To conserve the natural resources used in the production of construction materials.
- To overcome the stress and demand for natural river sand.

Anil .M.D and Dr V. Ramesh. They carried out an investigation on the replacement natural river sand by quarry rock dust and with the addition of chemical admixture to improve its workability and determining the mechanical properties of concrete.

G. Balamurugan and Dr. P. Perumal. They carried out an investigation on use quarry rock dust to replace natural river sand in concrete. The compressive strength at 50% of sand replacement is effective than normal concrete.

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Devi M. Kannan. K. They carried out an investigation on strength and corrosion resistance behaviour of inhibitors in concrete containing quarry dust as fine aggregate. The incorporation of inhibitors as admixture did not show any adverse effects on the strength properties and there was an increase in strength up to certain percentage. The addition of inhibitors as admixture to concrete was found to lower the permeability and water absorption.

3. MATERIALS AND PROPERTIES

Cement:

Ordinary Portland Cement (53 Grade) with specific gravity of 3.12 was used for this experimental investigation.

Fine Aggregate (Natural River Sand):

Locally available river sand having fineness Modulus (FM) of 1.81 was used. The specific gravity was found to be 2.67. The fine aggregate was found to be confirming to Zone II as per IS 383:1970.

Coarse Aggregate:

Natural granite aggregate having fineness modules (FM) of 9.0 was used. The specific gravity was found to be 2.925 and maximum size of aggregate was 20mm.

Quarry Rock Dust:

Quarry dust is fine rock particles. When boulders are broken into small pieces quarry dust is formed. It is grey in colour and it is like fine aggregate. The physical and chemical properties of quarry rock dust and the fine aggregate are listed respectively. Physical properties of quarry rock dust and natural fine aggregate.

Super Plasticizer: CONPLAST SP 430 is an admixture of Sulphonated naphthalene formaldehyde (SNF). It is used as a super plasticizer and is based on sulphonated naphthalene polymers and supplies as brown liquid instantly dispersible in water. It has been specially formulated to give high water reduction to produce high quality concrete of reduced permeability. Volume of Conplast used in this project is 1% of volume of the cement.

Properties of Conplast SP430

Table-I

Physical property	Values
Specific gravity	1.20 to 1.21 at 30^0 C
Chloride content	Nil. IS:9103-1999 and BS:5075
Air entertainment	Approx. 1.5% additional air over content

Cement properties:

- fineness of Cement : 7%
- normal consistency : 31%
- initial setting time : 37 min
- final setting time : 660 min
- Specific gravity of cement: 3.12

Fine aggregate properties:

- Specific gravity of fine aggregate: 2.67
- Sieve analysis: zone II
- Fineness modules: 2.72

Course aggregate properties:

- Specific gravity of fine aggregate: 2.925
- Sieve analysis: 20 mm (crushed angular)
- Fineness modulus: 7.40

Quarry rock dust properties:

- Specific gravity of fine aggregate: 2.63
- Fineness modulus : 4.04

4. SELF-COMPACTING CONCRETE

Self-Compacting Concrete (SCC) is a type of special concrete that has high workability and self-compacting property, i.e. the compaction occurs due to its high flowing property and the need for external vibrators are not required. The concrete is cohesive enough to avoid bleeding or segregation. For the making of self-compacting concrete for high strength purpose the water cement ration should be kept to the minimum. In order to increase the flow property and high workability, chemical admixtures are used in order to increase the workability of the concrete without compromising on the water cement ratio and strength of the concrete. The following properties shown in Table-II & III should satisfy the SCC.

Tests to determine the workability

Table-II

Property	Test Method
Filling Ability	Slump Flow, T50 cm slump flow, V-Funnel
Passing Ability	L-Box, U-Box
Segregation Resistance	V-Funnel at T5 min

Self-Compacting Concrete should contain some limitation as shown

Table- III

Test method	Property	Permissible range of values	
		Min	Max
Slump flow	Filling Ability	650mm	800mm
T50 cm slump flow	Filling Ability	2sec	5sec
V-Funnel	Filling Ability	8sec	12sec
J-Ring	Passing Ability	0	10mm
L-Box	Passing Ability	0.8	1.0
U-Box	Passing Ability	0	30
V-Funnel at T5 min	Segregation Ability	0	3sec

SCC must meet the required levels of properties filling and passing ability whilst its compaction remains uniform throughout the process of transport and placing. Many tests have been used in successful applications of SCC. However, in all the projects the SCC was produced and placed by an experienced contractor whose staff has been trained and acquired experience with interpretation of a different group of tests. Slump flow test, L – Box test, U – Box test, V funnel test were used to evaluate the fresh concrete properties of SSC.

5. EXPERIMENTAL INVESTIGATION

1. Mix proportioning:

In this study both conventional and SCC mixes of M40 grade is produced as per codes IS 456-2000 and IS 10262-2009 with five different weight percentages of Q.D as replacement of FA to study the effect on compressive, flexural and tensile strength. The experimental investigation consists of making M40 grade conventional concrete and SCC. The required materials were weighed and mixing of concrete was carried out manually. Cube specimens of size 150 mm x 150 mm x 150 mm, cylinder specimens of diameter 150 mm and length 300 mm and prism specimens of size 500 mm x 100 mm x 100 mm were cast. The specimens were de molded after 24 hours of casting and the specimens were cured in tank for 7, 14, 28 and 56 days. The proportions of various ingredients of both conventional and self compacting concrete are (1:1.3:2.4) and (1:1.18:2.1).

Workability tests on fresh concrete (SCC)

Table – IV

S. No	Quarry rock dust %	Slump flow (mm)	Slump T 500 (sec)	L-box	V-box
1	0	786	4.8	0.98	11.5
2	25	778	4.5	0.95	11.2
3	50	771	3.9	0.93	9.4
4	75	768	3.4	0.90	9.4
5	100	762	3.1	0.85	8.6

6. METHODOLOGY

During the present study, 0%, 25%, 50%, 75%, and 100% of traditional fine aggregate was replaced with quarry dust. For each of the mix, super plasticizer of 1% by weight of cement was added. After 28 days of curing, the Specimens were taken out of the curing tank, dried and tested using a compression machine. These Specimens were loaded on their sides during compression testing such that the load was exerted perpendicularly to the direction of casting. The Specimens were placed in the compression testing machine and the loads are applied gradually at a rate of 14 N/mm^2 /min. The average value of the compression strength of three Specimens was taken as the compression strength. Three conventional concrete cubes without super plasticizer and without quarry dust were also cast and tested. Same as flexure and tensile strength tests were conducted. These results are satisfying the normal mix design of M40 without any replacements and below table.

7. RESULTS

a) Test results of conventional concrete without Replacement

Table – V

M40	Compressive Strength (MPA)	Flexural strength (MPA)	Split tensile strength (MPA)
7 Days	32.72	2.26	3.96
14 Days	45.76	2.96	4.33
28 Days	49.58	4.43	6.25
56Days	51.02	5.12	6.97

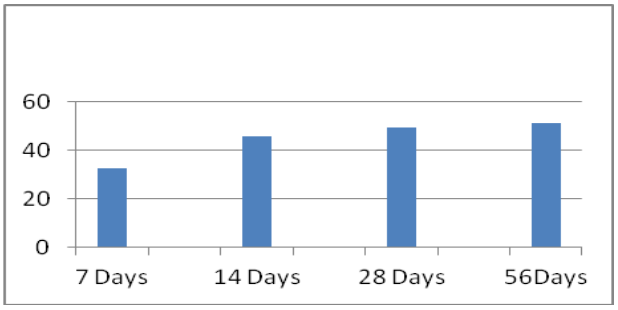

Fig.1.COMPRESSIONSTRENGTH

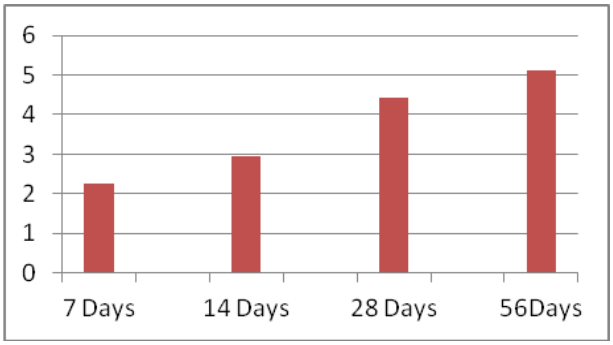

Fig.2. FLEXURAL STRENGTH

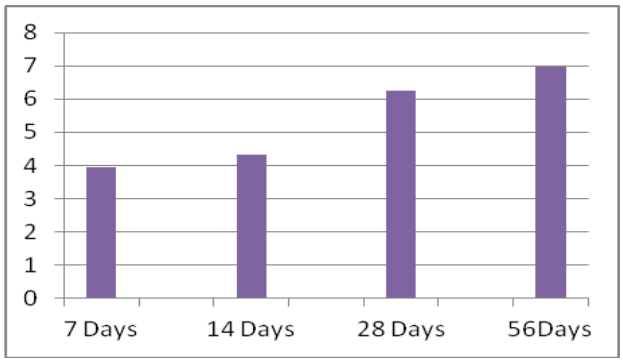

Fig.3. SPLIT - TENSILE STRENGTH

b) Test Results of Conventional Concrete with Replacement of fine aggregate using Quarry dust

Table – VI

S. no	QD (%)	Compressive strength (Mpa)		Flexural strength(Mpa)		Split-tensile strength (Mpa)	
		7 days	28 days	7 days	28 days	7 days	28 days
1	0	32.89	49.58	3.96	6.25	2.26	4.43
2	25	33.56	50.34	4.61	7.31	2.93	5.11
3	50	35.12	52.68	5.46	8.66	3.96	6.81
4	75	32.98	49.47	4.92	7.80	3.12	5.37
5	100	30.75	46.13	3.25	5.15	2.15	3.70

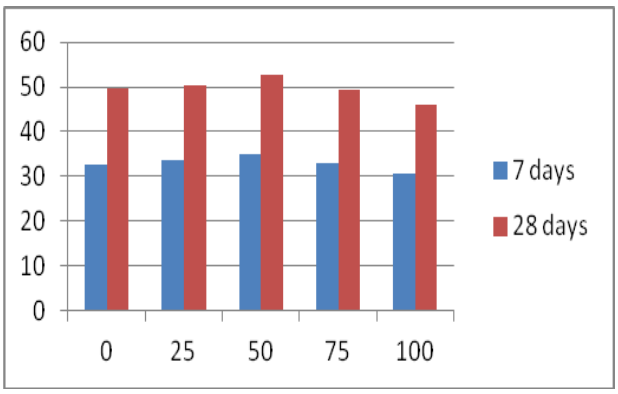

Fig.4. COMPRESSION STRENGTH

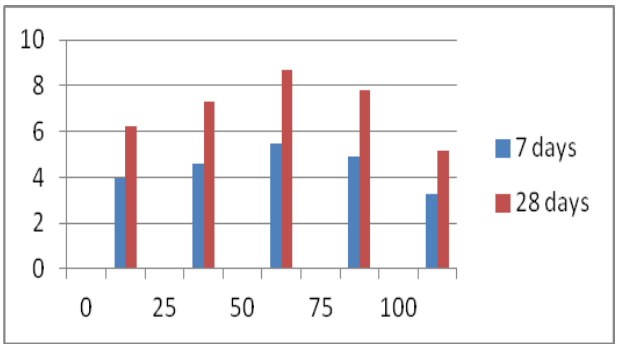

Fig.5. FLEXURAL STRENGTH

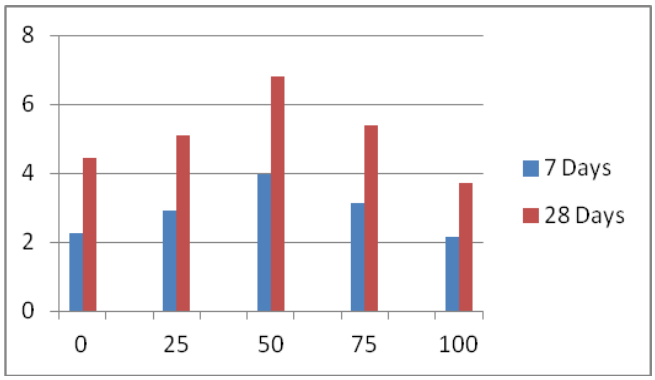

Fig.6. SPLIT - TENSILE STRENGTH

c) Test Results of Self Compacting Concrete with Replacement of fine aggregate using Quarry dust

Table – VII

S. no	QD (%)	Compressive strength (Mpa)		Flexural strength(Mpa)		Split-tensile strength (Mpa)	
		7 days	28 days	7 days	28 days	7 days	28 days
1	0	32.75	49.34	4.38	6.87	1.87	3.41
2	25	34.08	51.13	5.12	7.52	2.12	4.20
3	50	35.06	52.59	6.61	8.53	2.87	4.89
4	75	32.59	45.89	5.18	7.98	2.64	4.72
5	100	32.1	41.5	5.1	7.3	2.52	4.61

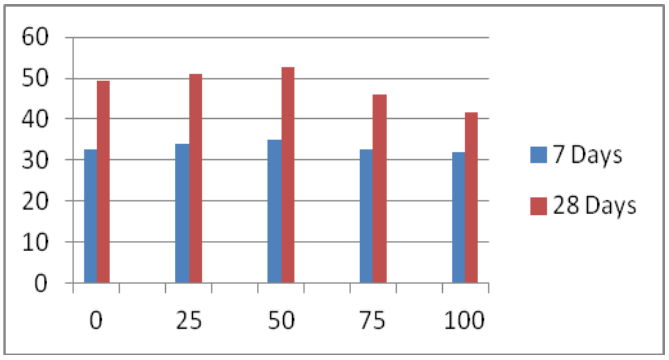

Fig.7. COMPRESSION STRENGTH

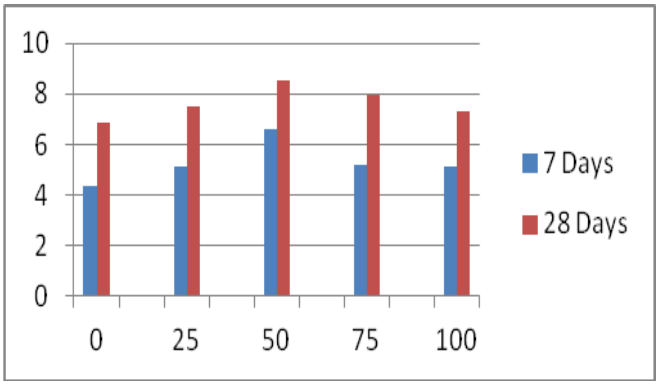

Fig.8. FLEXURAL STRENGTH

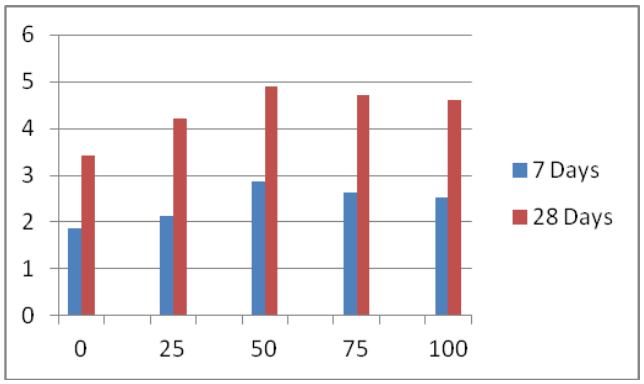

Fig.9. SPLIT - TENSILE STRENGTH

8. CONCLUSIONS

1. Based on this experimental investigation, it is found that quarry dust can be used as an alternative material to the natural river sand.

2. The physical and chemical properties of quarry dust satisfy the requirements of fine aggregate.

3. It is found that quarry dust improves its mechanical property of concrete if used along with super plasticizer.

4. Usage of quarry dust it will also reduce the cost of concrete because it is a waste material from quarries.

5. Use of quarry dust in concrete will also reduce the disposal problem. Economically low compared to sand.

6. When the natural river sand is 50% replaced with quarry dust as fine aggregate the strength concrete is increased and also in SCC 1 % dosage of super plasticizer (SNF) used and increase in the compressive strength slightly.

9. REFERENCES:

1. **Anil M D and Dr V Ramesh**. They carried out an investigation on the replacement natural river sand by quarry rock dust and with the addition of chemical admixture to improve its workability and determining the mechanical properties of concrete.

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