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An Experimental Study on Silica Fume Blended Cement Concrete with Stone Dust as Fine Aggregate

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ABSTRACT

Construction field requires lot of construction materials like cement, sand, and aggregates etc. In the present days it is very important to reduce the cost of building materials. Cement cost is day to day increasing very high so that only governments and rich people can afford construction. the development of new and cheaper that can fully or partially replace cement in civil engineering construction. In light of a continuous research many pozzalanic materials are introduced. Some of industrial by-product processing pozzalanic properties are paid attention by the researchers. The disposal problem of huge quantites of industrial waste encouraged the interest enthusiastic researchers. The fly ash and condensed silicafume belong to this category. The fly ash is already proved its efficiency as a pozzalanic material. Condensed silicafume a recently introduced a pozzalanic material, gained its importance in construction field with in a short span of time. A lot of research is still being continued in many other countries and CSF is provided to be effective pozzolanic material .

Stone crusher dust is very much is useful as an alternate for river sand. In many areas good quality of stone crusher dust is available is at very low cost form crusher units. Form so many investigations it is provided that use of stone crusher dust in concrete as alternative for sand is good alternate as fine aggregate in concrete construction. 0 to 50% SCS comparative study was taken at age of 7 and 28 days strength viz, compressive, spilt tensile and flexural test.

Keywords :- Condensed silica fume, Compressive strength, W/binder ratio, Workability, Pozzolana, Fine aggregate(Stone dust), Water)

I. INTRODUCTION

1. 1.1 GENERAL

Silica fume, also known as micro silica is an amorphous (non-crystalline) polymorph of silicon dioxide. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production. It is extremely fine with particles size less than 1 micron and with an average diameter of about 0.1 microns, about 100 silicon at temperatures up to 2,000°C produces SiO_2 vapours, which oxidizes and condense in times smaller than average cement particles. Its behaviour is related to the high content of amorphous silica (> 90%). The reduction of high-purity quartz to the low temperature zone to tiny particles consisting of non-crystalline silica.

During the last three decades, great strides have been taken in improving the performance of concrete as a construction material. Particularly Silica Fume (SF) and fly ash individually or in combination are indispensable in production of high strength concrete for practical application. The use of silica fume as a pozzolana has increased worldwide attention over the recent years because when properly used it as certain percent, it can enhance various properties of concrete both in the fresh as well as in hardened states like cohesiveness, strength, permeability and durability. Silica fume concrete may be appropriate in places where high abrasion resistance and low permeability are of utmost importance or where very high cohesive mixes are required to avoid segregation and bleeding.

The objective of this study is to find the effect of partial replacement of Silica fume on the strength characteristics of concrete. Three percentage levels of replacement i.e. 5, 10 and 15 percent are considered for partially replacing cement with silica fume. M30 concrete grade is initially designed without replacement and subsequently cement is partially replaced with silica fume.

1.2 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.

However, though the inclusion of silica fume in concrete gives many benefits, such inclusion causes a significant reduction in early strength due to the relatively slow hydration of silica fume. Nevertheless, fly ash causes an increase in workability of concrete. Quarry dust has been proposed as an alternative to river sand that gives additional benefit to concrete. Quarry dust is known to increase the strength of concrete over concrete made with equal quantities of river sand, but it causes a reduction in the workability of concrete.

1.3 SCOPE OF THE STUDY

•Identification of quarry with different mineralogical composition in and around Nellore region.

•Collection of quarry dust from two different quarries.

•Collection of silica fume from by-product of ferrosilicon alloys or ferrosilicon metals

•Testing of the collected samples for various physical and chemical properties.

•Testing of fresh concrete containing silica fume & quarry dust for workability.

•Identification and usage of chemical admixture super plasticizer of varaplast sp-123 for better workability and strength.

•Testing of hardened concrete cubes & cylinders for strength at different ages.

1.4 NEED FOR THE PARTIAL REPLACEMENT OF SILICA FUME

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 silica fume especially Class F silica fume is very useful as the partial replacement of cement. The silica fume is obtained from the ferrous silicon alloys. Silica fume is a by-product of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable.

The other material that can be used is admixture which is made while in the processing of replacement of cement, The silica fume is used benfits to give High early compressive strength High tensile flexural strength and modulus of elasticity Very low permeability to chloride and water intrusion Enhanced durability Increased toughness Increased abrasion resistance on decks, floors, overlays and marine structures.. Many studies are made with several other admixtures which gave the concrete to be a material made of some other partial replacement admixtures 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 mineral admixtures that are used as a reference for this. Some of the properties are workability, compressive strength are the major one that are considered.

II. MATERIALS USED

In this investigation, the following materials were used:

- Ordinary Portland Cement of 53 Grade cement conforming to IS: 169-1989
- Fine aggregate and coarse aggregate conforming to IS: 2386-1963.
- Mineral admixture
  Silica fume
- Quarry dust
- Chemical admixture(super plasticizer) Varaplast sp 123
- water

2.1.1. CEMENT:

Ordinary Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete.

The physical properties of the cement are listed in Table – 1

Table-1 Properties of cement

S.no	Properties	Test results	IS: 169-1989
1.	Normal consistency	0.32	
2.	Initial setting time	50min	Minimum of 30min
3.	Final setting time	320min	Maximum of 600min
4.	Specific gravity	3.14	
5.	Compressive strength		
	7days strength	44.6 Mpa	Minimum of 40Mpa
	28days strength	56.6 Mpa	Minimum of 53Mpa

2.1.2. FINE AGGREGATES:

River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity in accordance with IS: 2386-1963.The sand was surface dried before use.

Table 2: Properties of Fine Aggregate

S.no	Description Test	Result

1	Sand zone	Zone- III
2	Specific gravity	2.59
3	Free Moisture	1%
4	Bulk density of fine aggregate (poured density) Bulk density of fine aggregate (tapped density)	1385.16 kg/m3 1606.23 kg/m3

2.1.3. COARSE AGGREGATES:

Crushed aggregates of less than 12.5mm size produced from local crushing plants were used. The aggregate exclusively passing through 12.5mm sieve size and retained on 10mm sieve is selected. The aggregates were tested for their physical requirements are given in table.

Table 3: Properties of Coarse Aggregate

S.no	Description	Test Results
1	Nominal size used	20mm
2	Specific gravity	2.9
3	Impact value	10.5
4	Water absorption	0.15%
5	Sieve analysis	20mm
6	Aggregate crushing value	20.19%
7	Bulk density of coarse aggregate (Poured density) Bulk density of coarse aggregate (Tapped density)	1687.31kg/m3 1935.3 kg/m3

2.1.4 MINERAL ADMIXTURE- SILICA FUME

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. Silicon metal and alloys are produced in electric furnaces The raw materials are quartz, coal, and woodchips. The smoke that results from furnace operation is collected and sold as silica fume, rather than being landfilled. Perhaps the most important use of this material is as a mineral admixture in concrete. The individual particles are extremely small, approximately 1/100th the size of an average cement particle. Because of its fine particles, large surface area, and the high SiO2 content, silica fume is a very reactive pozzolan when used in concrete. The quality of silica fume is specified by ASTM C 1240 and AASHTO M 307.

3.2.2.1 PROPERTIES OF SILICA FUME IN STUDY

Silica fume is an ultrafine material with spherical particles less than 1 µm in diameter, the average being about 0.15 µm. This makes it approximately 100 times smaller than the average cement particle.[1] The bulk density of silica fume depends on the degree of densification in the silo and varies from 130 (undensified) to 600 kg/m3. The specific gravity of silica fume is generally in the range of 2.2 to 2.3. The specific surface area of silica fume can be measured with the BET method or nitrogen adsorption method. It typically ranges from 15,000 to 30,000 m2/kg. It is obtained from ferro silicon alloys or ferrosilicon metals.

PROPERTIES	SILICA FUME
Specific Gravity	2.2
Mean Grain Size (µm)	0.15
Specific area (cm^2/gm)	150000-300000
Colour	Light to Dark Grey

2.1.5QUARRY DUST

The crusher plants located in and Nellore is the source for collecting quarry dust used in the study. The crusher plants are equipped with roller or jaw type crushed and the crushed stone metals of different sizes are collected after sieving them through rotary sieves, which are cylindrical in shape and placed in an inclined position. Starting from higher end of the screening unit, they have in general openings of 3.2, 9.5, 12.7, and 25.4mm sizes. The material passing through 3.2mm sieve is known as crusher dust or quarry dust and is collected. Quarry dust is collected from two different crusher locations at the following places.

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

Fig no: 02 Production of Quarry Dust in a Crushing Plant

2.1.6CHEMICAL 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.

USES

♦ VARAPLAST SP 123 can provide self-leveling concrete practically eliminating the need for vibration during placing.

♦ VARAPLAST SP 123 provides excellent workability even at low water/cement ratio.

♦ VARAPLAST SP 123 is especially recommended for use in PPC concrete and high workability concrete and where fast shutter removal is required.

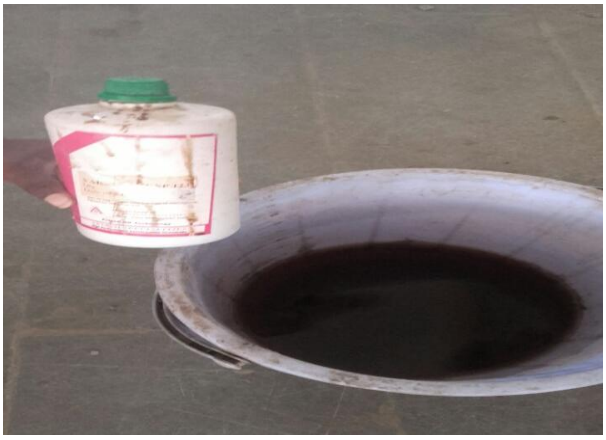
ADVANTAGES

♦ Increased Workability: Reduces placing time, labour and equipment.

♦ High Strength Concrete: Water reduction gives higher strengths without cement increase or workability loss.

♦ Improved Palpability: Line friction is reduced by increasing workability and cohesion.

♦ Chloride Free: Safe in reinforced concrete.



Chemical admixture (SUPERPLASTICIZER)

2.1.4. WATER:

Water plays a vital role in achieving the strength of concrete. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9.

III. MIX DESIGN FOR M30 GRADE CONCRETE

Table 6: Mix design for M30 grade concrete

cement	Fine aggregate	Coarse aggregate	water
394Kg/m3	732Kg/m^3	1139Kg/m3	197Kg/m^3
1	1.85	2.59	o.50

Table 7: Content of materials as per mix design per one cube and one cylinder:

CUBE	**CYLINDER**
Volume = 0.15x0.15x0.15 = 0.00338m^3	Volume = Π/4 x0.15^2 x0.3 =0.00530m^3
Cement = 1.292kg	Cement = 2.029kg
F.A = 1.845kg	F.A = 2.893kg
C.A = 4.015kg 60% 20mm =2.409kg 40% 12mm=1.606kg	C.A = 6.296kg 60% 20mm =3.777kg 40% 12mm=2.518kg
Water =0.647lit	Water = 1.015lit

MIXING:

Mixing of concrete is simply defined as the "complete blending of the materials which are machine mixing, with machine mixing being the most common.

However, no successful mixture can be achieved without the proper batching of all materials. Batching is the "process of weighing or volumetrically measuring and introducing into the mixer the ingredients for a batch of concrete. Quality assurance, suitable arrangement of materials and equipment, and correct weighing of the materials are the essential steps that must be completed before any mixing takes place.

3.1 MOULDS USED FOR CASTING:

Standard cube moulds of 150 x 150 x 150mm made of cast iron used for the cement mortar and concrete specimens for testing of compressive strength.

Cylindrical moulds of 150 mm in diameter and 300 mm height is made for concrete specimens for testing of Split tensile strength.

Fig 3.1: Samples of cube and cylindrical moulds

3.2 CASTING:

The standards moulds were fitted such that there are no gaps between the plates of the moulds. If there is any gap, they were filled with plaster of Paris. The moulds were then oiled and kept ready for casting. Concrete mixes are prepared according to required proportions for the specimens by hand mixing; it is properly placed in the moulds in 3 layers. Each layer is compacted 25 blows with 16 mm diameter bar. After the completion of the casting, the specimens were vibrated on the table vibrator for 2 minutes. At the end of vibration the top surface was made plane using trowel. After 24 hours of a casting the moulds were removed and kept for wet curing for the required number of days before testing.

Fig 3.2: Hand mixing and placing of concrete mix

3.3 CURING:

The test specimens are stored in place free from vibration; specimens are removed from moulds after 24 ± half an hour time of addition of water to dry ingredients. After this period, the specimens are marked and removed from the moulds and unless required for test within 24 hours immediately submerged in clean fresh water and kept there until taken out just prior to test. The water in which the specimens are submerged, are renewed every seven days and are maintained at temperature of 27°±2°C.The specimens are not allowed to become dry at any time until they have been testing. The specimens were put under curing for 28 days.

IV. TESTS CONDUCTED

- Workability
- Compressive strength
- Split tensile strength

4.1 WORKABILITY:

Workability is one of the physical parameters of concrete which affects the strength and durability as well as the cost of labor and appearance of the finished product. Concrete is said to be workable when it is easily placed and compacted homogeneously i.e. without bleeding or Segregation.

In this study, the slump-cone test is carried out to determine the workability of concrete.

WORKABILTY TEST RESULTS

Slump values for M30 grade by addition Quarry Dust as partial replacement of fine aggregates.

S.no	% of replacement	w/c ratio	Slump(mm)
1	0%	0.50	50
2	5%	0.50	53
3	10%	0.50	58
4	15%	0.50	True slump

Fig no: 3.6 Slump Cone Test

4.2 COMPRESSIVE STRENGTH:

A total of 20 cubes of size 150 x 150 x 150mm were casted and tested for 7 days and 28 days testing each specimen after conducting the workability tests. The results are tabulated below:

Fig 4.1: Compression testing of Cube Specimen

Table 10: Compressive strength results of M30 grade of concrete for 7 and 28 days

% of replacement	For 3 days	For7 days	For28 days
0%	13.88 Mpa	19.32 Mpa	38.90 Mpa
5%	22.89 Mpa	26.67 Mpa	50.00 Mpa
10%	23.33 Mpa	28.33 Mpa	50.44 Mpa
15%	42.11 Mpa	44.66 Mpa	54.44 Mpa

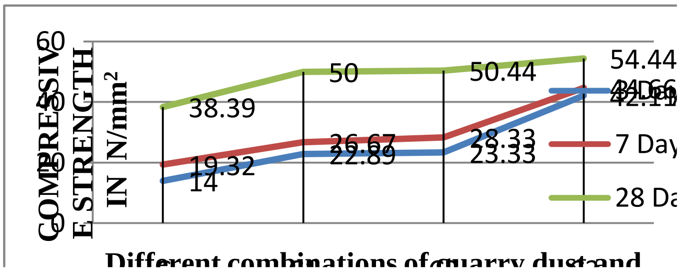


Fig 4.2. Comparison of Compressive strength of M30 at 7 and 28 days

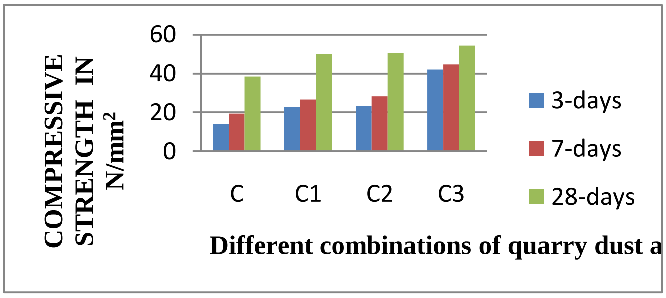


Fig no:5.2 Bar chart showing different combinations of quarry dust and admixture M30 mix compressive strength

4.3 SPLIT TENSILE STRENGTH:

The split tensile strength obtained by testing the cylindrical specimen for M30 grade of concrete to all the mixes designed for various replacements are given below:

Fig 4.3: Split Tensile Testing and Specimen (Cylinders)

Table 11: Split tensile strength results for M30 grade of concrete

% of replacement	For 3 days	For 7 days	For 28 days
0%	6.39Mpa	12.20Mpa	12.44 Mpa
5%	7.07Mpa	8.88Mpa	12.44 Mpa

10%	8.42Mpa	10.20Mpa	14.14 Mpa
15%	9.30Mpa	10.60Mpa	13.29 Mpa

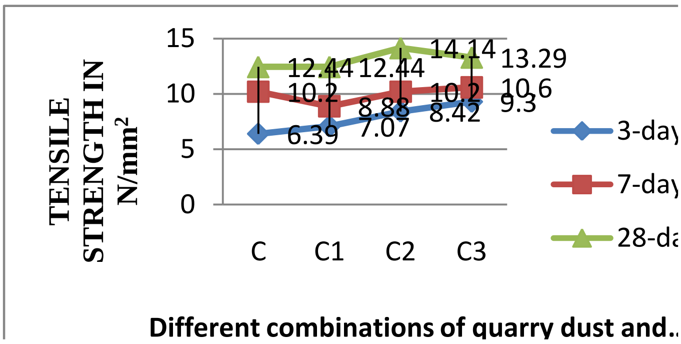


Fig no:5.3 Graph sheet showing different combinations of quarry dust and admixture M30 mix(Tensile strength)

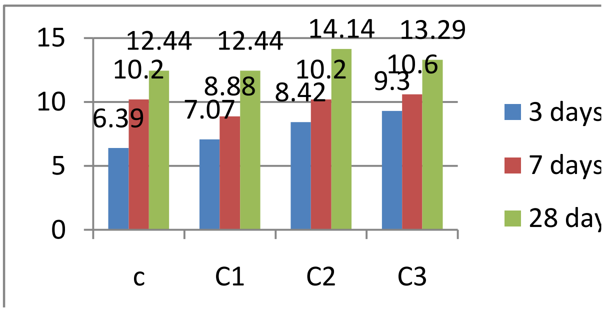


Fig no: 5.4 Bar chart showing different combinations of quarry dust and admixture M30 mix (Tensile strength)

V. RESULTS AND DISCUSSIONS

The test data and results obtained from the tests conducted in the present investigation concrete 60 cubes and 60 cylinders have presented in tables and discuss in this chapter in the test carried out, importance has been given to workability, ultimate compressive strength, cracking and durability. The results of conventional concrete are compared with the quarry dust as a replacement of fine aggregate with individual percentage replacement of admixture of compared between the M30 grade concrete such as workability and compressive strength cracking have been observed and recorded. Graphs of compressive strength Vs compared between the above two grades.

VI. CONCLUSIONS AND SUGGESTIONS

6.1 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 and admixture of concrete can be increased by adding super plasticiser.

•Quarry dust and silica fume admixture of concrete has equal or slightly higher strength than reference concrete for all the two grades of concrete considered in this study M30. This shows that cement partial replacement and quarry dust concrete can be used with confidence as a building material.

•Concrete acquires maximum increase in compressive strength and tensile strength at 5%,10% & 15% silica fume admixture and 100% sand replacement. When compared with concrete with only river sand, the amount of increase in strength is M30

6.2 FOR 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.

6.3 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 M40grade 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.

6.4 Suggestions for the future work

1. It is suggest that the study of concrete for the estimation of concrete durability may be extended.

2. The scope of using concrete in our constructional activities lies large, VIZ., precast, pre stressed bridges, and multi storied buildings, bridges and structures on coastal areas and like. To affect this change we will have to revive the designing to structures by encouraging use of workability of concrete.

3. As soon as micro crack appears, sudden failure is observed in the concrete cubes.

4. The same investigation can be carried out for different water cement ratios for mineral Admixture for M30 grade of concrete.

REFERENCES

[1] Indian standard recommended method of concrete mix design (IS:102622009)

[2] Concrete technology by M.S.shetty.

[3] High performance concrete by V.M.Malhotra.

[4] Design of concrete mixes by N.Krishna raju.

[5] ACI committee 363,(1984),"state of the art report on high strength concrete",ACI journal,proc.V.81 NO.4,PP364-411.

[6] Bureau of Indian standards, specification for casting of specimen IS:102621962.

[7] Ghosh R.K., Ved Prash, "Suitability of manufactured sand for making quality concrete", Road Research paper No.111, Central Road Research Institute (CRRI), New Delhi 1970,pp.21.

[8] Iangovan and Nagamani (2) 2006. Studies on Strength and Behavior of Concrete by using Quarry Dust as Fine aggregate. CE and CR Journal, +New Delhi. October. Pp.40-42.

[9] Nagaraj T.S. 2000. Proportioning Concrete Mix Rock Dust as Fine Aggregate. CE and CR Journal. pp. 27-31.

[10] Nagaraj T.S. and Zahida Banu. 1996. Efficient utilization of rock dust and pebbles as Aggregates in Portland cement concrete. The Indian Concrete Journal..53-56.

[11] Sahu A.k., Sunil Kumar and Sachan A.K. 2003. Quarry stone Waste as Fine aggregate for concrete. The Indian Concrete Journal.pp. 845-848.

[12] B.P.Hudson, Manufactured sand for concrete, The Indian Concrete Journal, May 1997 , pp237-240.

[13] A.K.Sahu, Sunil kumar and A.K.Sachan, Crushed stone waste as fine aggregate for concrete, The Indian Concrete Journal, January 2003 pp845-847.

[14] Selvakoodalingam, B. and Palanikumar, M. " Partial Replacement of Sand in Concrete with Quarry dust", Proceedings of National Symposium, Karunya Institute of Technology, Coimbatore, pp. 41-43, 2002.

[15] Md.Safiuddin, S.N.Raman and M.F.M. Zain, Utilization of Quarry waste fine Aggregate inconcrete mixures, 2007 Journal of Applied sciences research 3(3) : 202-208. 16.Manasseh Joel, "Use of Crushed Granite Fine as Replacement of River Sand in Concrete Production", Leonardo Electronic Journal of Practices and Technologies, Issue 17, pp. 85-96, 2010.

[16] I.R.Mithanthaya, Jayaprakash Narayan, Replacement of Sand by Quarry Dust for Plastering and in the Pavement Design, Proceedings of national Symposium at Karunya Institute of Technology on 20-21,December 2002, pp 9-15.