International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 5, May-2018

An Experimental Investigation on Usage of Quarry Dust as a Partial Replacement of Sand in Concrete

Guru Prasad Sharma[1], Dinchen Theingh[2], Meerak Hang Subba[3], Sanyam Mittal[4]
1Assistant Professor, Department of Civil Engineering, Sikkim Manipal Institute of Technology, Majitar, India
2Undergradutae Student, Department of Civil Engineering, Sikkim Manipal Institute of Technology, Majitar, India
3Undergradutae Student, Department of Civil Engineering, Sikkim Manipal Institute of Technology, Majitar, India
4Undergradutae Student, Department of Civil Engineering, Sikkim Manipal Institute of Technology, Majitar, India

Abstract— The use of concrete in the field of construction has been increased to its highest level. This sharp rise in the use of former has led to reduction in the sources of natural sand. So, in order to cope up with this rising problem the need for use of alternative materials is necessary. For instance, quarry dust, crumb rubber powder, etc. This experimental study presents the use of quarry dust as a partial replacement of sand. The attempts have been made to study the variation in the strength of concrete when replacement of sand is done by quarry dust from 0% to 50% in terms of 10% interval. The concrete cubes of M25 grade has been casted and taken under study. The mix proportioning has been done as per IS 10262:2009, keeping constant water-cement ratio of 0.40. The tests for compressive strength of cubes have been done at the ages of 7 and 28 days and were obtained at room temperature. The experimental study have shown that there is considerable increase in 28 days compressive strength marked for 50% replacement of sand by quarry dust and also for 20% replacement. The workability of the concrete tends to decrease with the rise in percentage replacement of sand as a result of increase in water absorption rate of quarry dust. The height of slump constant remains constant at 300mm for all mixes with same water-cement ratio i.e. workability in terms of slump marked as 0mm. The conclusion can be made that the use of quarry dust as an alternative to river sand can be done in the concrete mixes suitably.

Keywords— Concrete, quarry dust, natural sand, compressive strength, water-cement ratio, mix proportioning.

I. INTRODUCTION

The concrete is a composite material that consists essentially of a binding medium, such as a mixture of Portland cement and water, within which are embedded particles or fragments of aggregate, usually a combination of fine and coarse aggregate. It is by far the most versatile and most widely used construction material worldwide. The rise in the use of concrete in the field of construction has been very steep and rapid in nature as per the present scenario, owing to which there is a reduction in the sources of natural sand and also as an outcome this has led to the rise in cost of concrete production, which again has resulted in the increase in need of finding a solution or an alternative to the use of fine aggregate as a sand.

Concrete as a composite material is made up of various constituents. The properties and characteristics of the composite are functions of the properties of constituent materials as well as the various mix proportions. The study should be made before selecting each of the material in order to improve the quality and standard of concrete and the role played by each of these ingredients of same cannot be underrated. Each of the materials and their nature plays their respective role and affects the mechanism.

The fine aggregate helps in providing uniformity and required workability to concrete mix. So, mostly the use of river sand is done as a fine aggregate, but as a result of large scale use of the material, destruction and depletion of river sand deposits has occurred and owing to this the price of the material are increasing day by day, affecting the overall cost of concrete production. The search for an alternative material has been done over a period of time and their effect on properties of concrete are studied such as by use of crumb rubber powder, saw dust, quarry dust etc. as a partial replacement of sand. The desirability of the alternative materials should be cheap and environmentally friendly.

Quarry dust, which is a by-product from the crushing process during quarrying activities, has been proposed as a substitute material to sand. It is said to increase the concrete strength over concrete made from equivalent amount of river sand, but also tends to decrease the workability of concrete mix [1].

The focus has to be made on the use of quarry dust and Portland Pozzolana cement (Fly ash based) as easily available, so that the decrease in early strength due to one may be compensated by the gain of strength due to other, and the reduction in workability of mix due to one can also be compensated by the other, without sacrificing the strength and workability in overall amount. The concurrent use of both by-products (Fly ash blended with cement i.e. PPC and quarry dust) will lead to provide large range of economic and environmental benefits [1].

II. **CONCRETE MATERIALS USED**

A. Cement: Cement is the "glue" that binds the concrete ingredients together and is instrumental for the strength of the composite. Portland Pozzolana Cement (Fly ash based) conforming to IS 1489 (Part 1):1991 is used for the casting of cube specimens. The required quantity is procured as single batch, stored in airtight bags and used for the experimental programme.

B. Coarse aggregates: Coarse Aggregate is the strongest and least porous component in concrete. It reduces drying shrinkage and other dimensional changes due to moisture. For optimum compressive strength with high cement and lower water cement ratio, size of coarse aggregate must be used [2]. Coarse aggregates of 20 mm maximum nominal size is used for the study programme. The samples from the local stone crushers were collected and sieved. The particles passing through 20 mm IS sieve and retained on 10 mm IS sieve is obtained for the study.

C. Fine aggregates: The river sand as a fine aggregate were collected and sieved for the analysis. The sample analysed for the study programme conforms to Zone II and of medium coarse in nature.

D. Quarry Dust: Quarry dust is a waste material obtained from stone quarries while crushing stones, stone crusher dust, which is available abundantly from crusher units at a low cost in many areas, provides a viable alternative for river sand in concrete. Earlier investigation indicates that stone crusher dust has a good potential as fine aggregate in concrete construction. Crusher dust not only reduces the cost of construction but also helps to reduce the impact on environment by consuming the material generally considered as a waste product with few applications. Crusher dust has potential as fine aggregate in concrete structure with a reduction in cost of concrete by about 20 percent compared to conventional concrete [2]. The quarry dust sample was collected from the locally available stone crushing plant. The particles analysis of the sample is done and all the particles passing through 4.75 mm sieve are considered for the study in dry condition.

E. Water: Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since, it helps to form the strength giving cement gel, the quantity and quality should be taken under consideration carefully. Potable water was used for casting concrete specimens.

TABLE I

PROPERTIES OF CONCRETE MATERIALS

Material description	Material Properties	
Portland Pozzolana Cement (Fly ash based)	Specific gravity	2.9
	Normal consistency	29 %
	Initial setting time	140 minutes
	Final setting time	256 minutes
	Fineness	3.6 %
Fine aggregate (River sand)	Fineness modulus	3.24
	Water absorption	1.4 %
	Specific gravity	2.51
Quarry dust	Fineness modulus	2.64
	Specific gravity	2.61
Coarse aggregate	Fineness modulus	4.39
	Water absorption	0.81 %
	Specific gravity	2.65
	Maximum nominal size	20 mm

III. EXPERIMENTAL INVESTIGATION

A. Mix proportioning: The mix proportioning was done as per guidelines provided as per IS 10262:2009 (First and Second Revision). The concrete mix of M25 (1:1.175:2.22, derived as per design calculation) grade was designed and taken for the study purpose. The water-cement ratio was taken constant as 0.40 for every casting trials. For this concrete mix, quarry dust was added as a partial replacement of sand from 0% to 50% in the interval or step of 10%.

B. Casting of concrete specimen: The test specimens were casted in cast-iron steel moulds of size 150 mm × 150 mm × 150 mm. The inside of the moulds was applied with grease for easy demoulding. The solid ingredients were weighed on a digital balance and placed in pan mixer machine for mixing in dry condition. It was ensured that a uniform colour of the mix was obtained before adding water. Water is added for correct quantity using measuring jar. The 24 nos. of specimens were casted, tested at the age of 7 and 28 days after curing, under normal temperature conditions.

IV. METHODOLOGY

The following are the list of various tests conducted on concrete materials:

i. Particle size analysis of aggregate samples:

The particle size analysis of the aggregate sample helps to determine the gradation of aggregate sample, which helps to derive the size and shape of the same. The test is done as per guidelines provided in IS 2386 (Part I) - 1963. The outcome of the test i.e. gradation is used to obtain the fineness modulus of sample. In this test, initially the IS sieves of different sizes(such as 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ, 90µ and pan) are arranged from top to bottom in a descending order i.e. larger sieve sizes at top. About 2000g of sample of fine aggregate is taken and place at top most sieve. The sieving is done using sieve shaker for about 10 minutes and then note down the weight retained on each of the IS sieve. The fineness modulus is derived from the result. The nature of sample is determined based on the value of fineness modulus. A semi-log graph is plotted with IS sieve size in x-axis and Percentage finer in y-axis, with the use of excel software or any other means. The zoning is also done with reference to IS 383-1970.

The procedure followed for the analysis of quarry dust is same. The sieve sizes are changed for the testing of coarse aggregate and all the other steps are same as that of for fine aggregate. The gradation curve or particle size distribution curve (PSD) is plotted. The nature of sample i.e. well graded, poorly graded or uniformly graded is determined from the graph.

ii. Specific gravity:

The specific gravity of cement is tested as per guidelines provided in IS 2720 (Part 3), using Le Chatelier flask or specific gravity bottle. In this test, a clean and dry Le Chatelier Flask or Specific Gravity Bottle with its stopper is taken and weight is measured. A sample of cement is placed upto half of the flask (about 50gm) and weight with its stopper is taken. Then add kerosene to cement in flask till it is about half full. Then mix thoroughly with glass rod to remove entrapped air and continue stirring and more kerosene till it is flush with graduated mark. The weight is taken after drying the flask from outside and lastly empty the flask clean it and refill with kerosene till the graduated mark, wipe dry the outside and again take its weight. The specific gravity of aggregates is done as per guidelines provided in IS 2386 (Part 3) – 1963, using Pycnometer. In this test, the empty weight of the Pycnometer is measured and then filled with the sample upto a mark and the weight is measured. Then Pycnometer is filled with water (along with the sample inside) and the weight is taken. Then weight of the Pycnometer with only water is taken and recorded. The specific gravity is now calculated.

The same procedure is followed for the calculation of specific gravity of quarry dust (as that for aggregates).

iii. Workability test:

The workability is one of the most important properties of freshly mixed concrete, which controls the strength and durability and also the appearance of finished surface. The workability and its degree is directly related with water-cement ratio used and also on the type of aggregate (its shape and size). The test for workability is done as per guidelines provided in IS 1199-1959. The slump cone is used for measuring the workability in this study in which the height of fall of the concrete cone is measured with respect to w/c ratio of 0.40 (taken constant throughout) for ordinary mix. The same procedure is followed for partially replaced samples.

iv. Compressive strength:

The compressive strength of the cube samples (including ordinary mix and partially replaced mix) were tested at the end of 7 days and 28 days under normal temperature conditions. The samples were tested after the surface of the samples fully in dry condition. The load was applied without shock and increased continuously until the sample fails. The peak load withstand by the samples is noted and compressive strength is determined.

V. TEST RESULTS

A. Specific gravity:

The specific gravity of the cement sample is determined as 2.9. The specific gravity of fine aggregates is obtained as 2.51 and that of coarse aggregate is 2.65. The specific gravity of quarry dust is determined as 2.61.

B. Particle size analysis:

The particle size analysis is summarised and depicted with the help of following gradation charts.

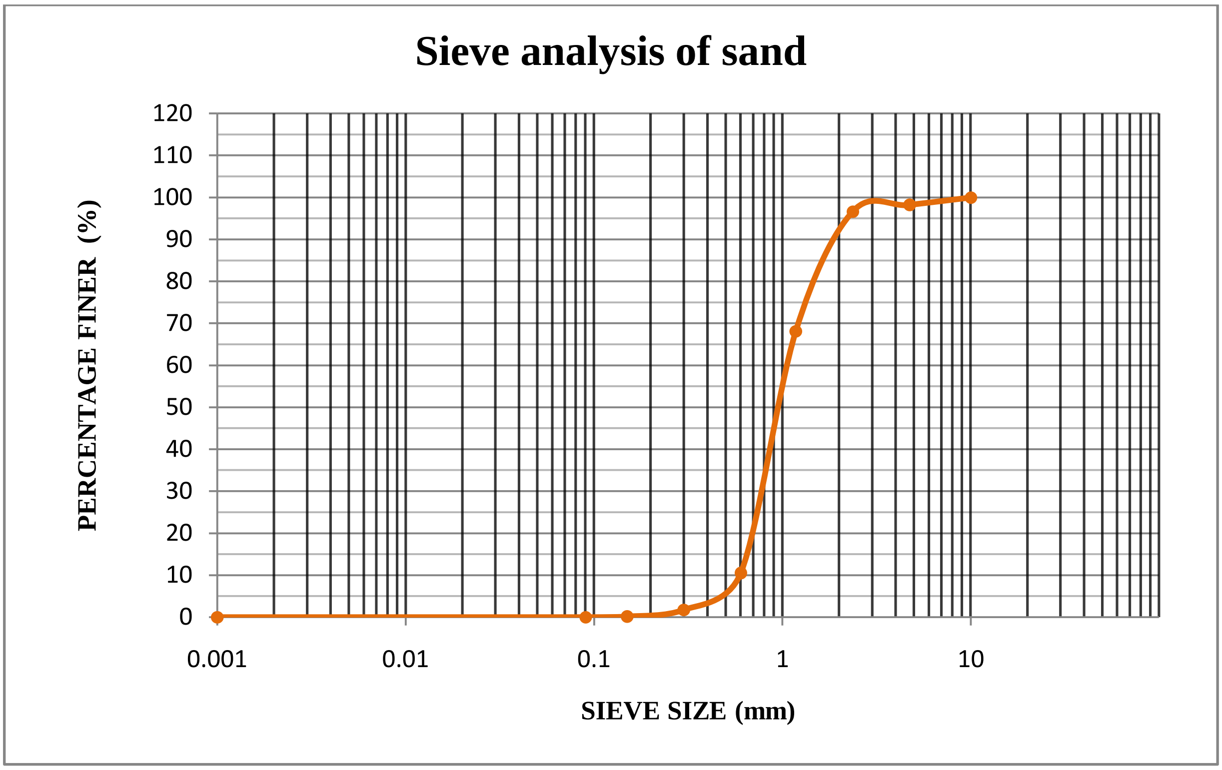

Fig. 1: Chart showing particle size distribution of sand

The value of fineness modulus of fine aggregate (sand) is 3.24 and as per the given ranging values for different types of F.A, the given sample is coarse sand. Also, it can be concluded from Table 4 IS 383-1970, the sample is conforming to zone II. The graph (Fig. 1) also shows the uniform gradation of sample.

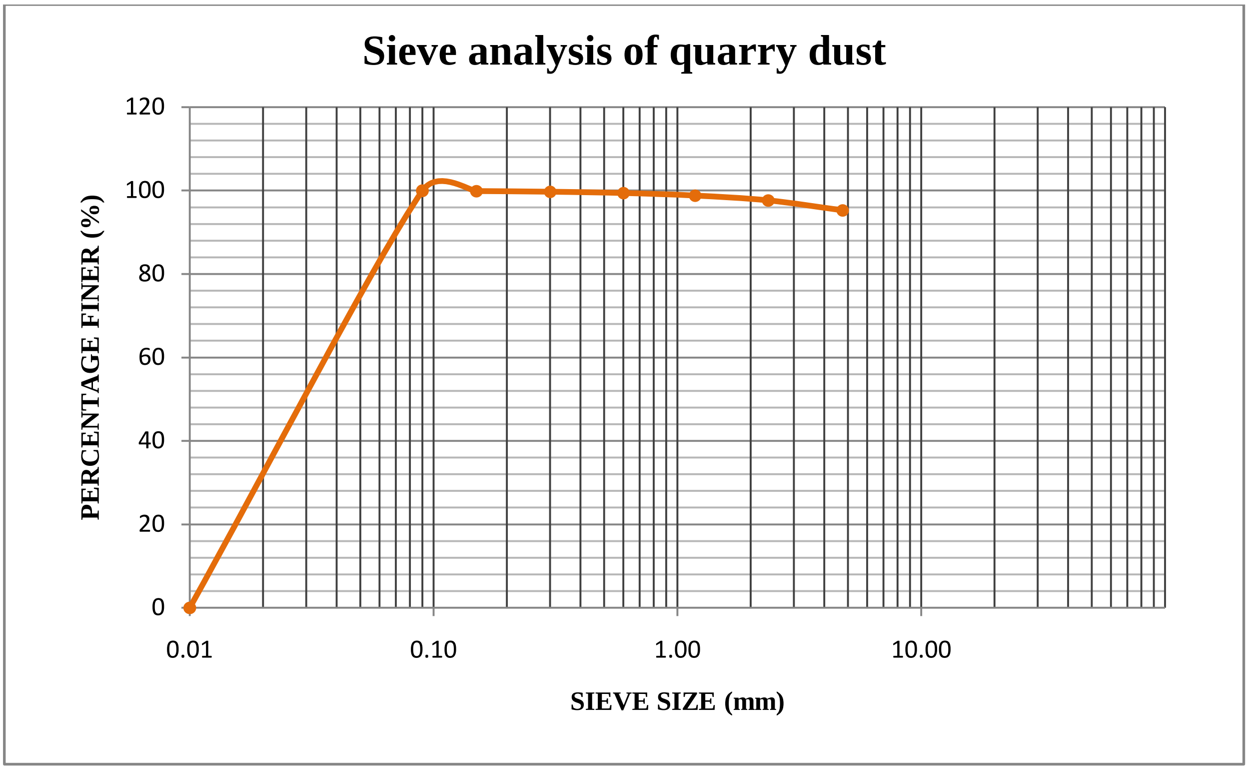

Fig. 2: Chart showing particle size distribution of quarry dust

The value of fineness modulus of quarry dust sample is 2.64 and as per the given ranging values (fineness modulus) for different types of fine aggregates, the given sample is of fine nature. Also, it can be concluded from Table 4 IS 383-1970, the sample is conforming to zone I.

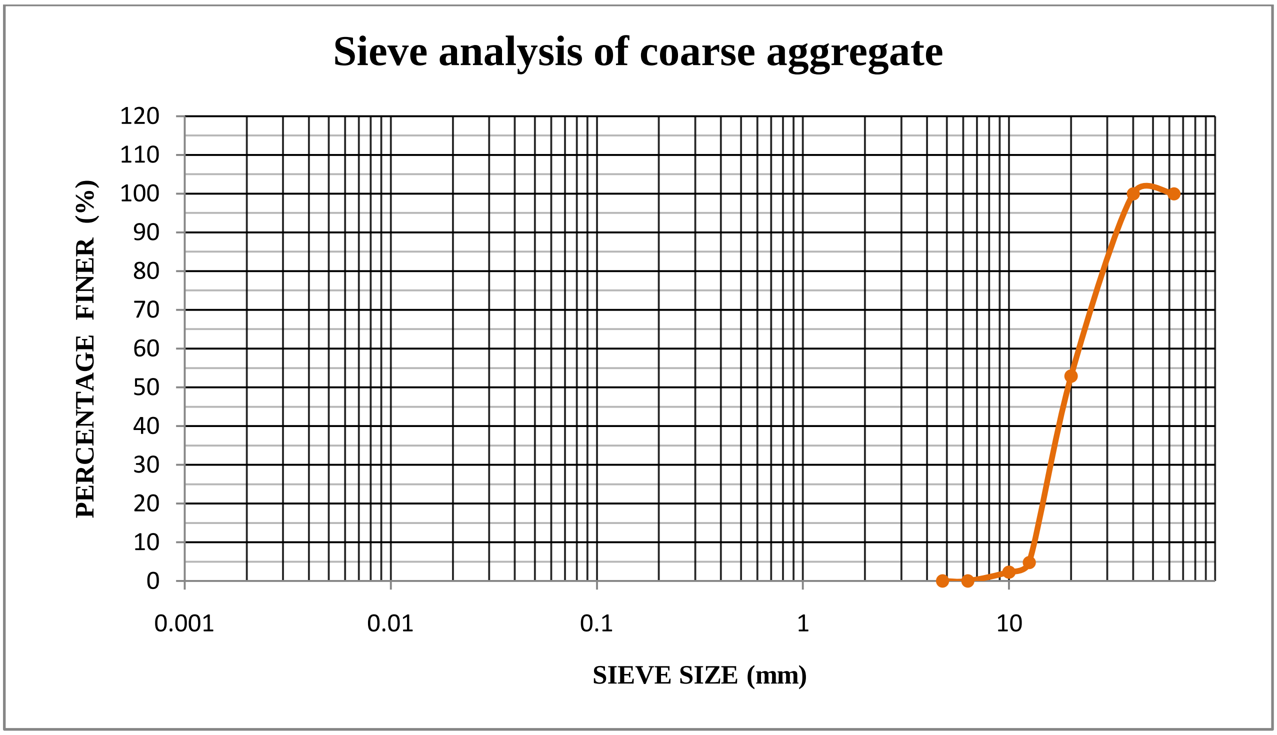

Fig. 3: Chart showing particle size distribution of coarse aggregates

The value of fineness modulus of coarse aggregate is 4.39 and the given sample of aggregates conforms to Table 2 of IS 383:1970. The graph (Fig. 3) shows uniform gradation of sample.

C. Workability test:

The workability test or the determination of consistency of concrete was done for ordinary mix and for the different mixes, which were partially replaced with quarry dust. The water-cement ratios for different mixes were taken constant as 0.40. The height of cone after removing the mould is measured using standard tamping rod and the values of the cone height is recorded in tabular format.

TABLE II
WORKABILITY TEST RESULTS

Percentage replacement of sand	**Water-cement ratio**	**Height of slump (in mm)**
0%	0.40	300
10%	0.40	300
20%	0.40	300
30%	0.40	300
40%	0.40	300
50%	0.40	300

Fig. 4: Slump

The slump values for every mix i.e. ordinary mix as well as partially replaced mixes were found to be constant under same w/c ratio. The following chart shows the tests result of workability.

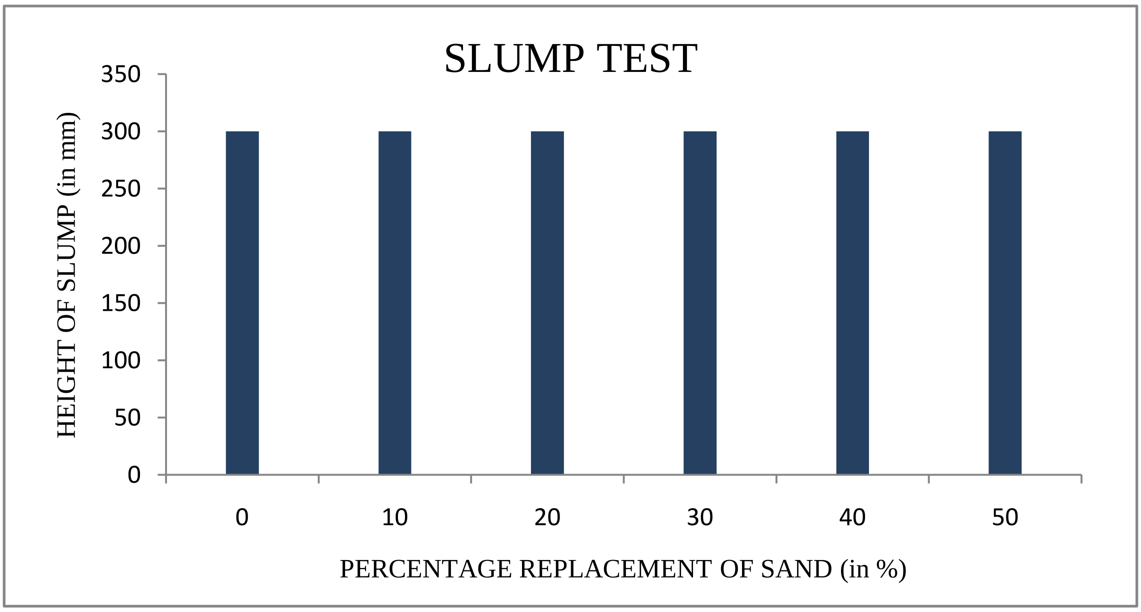

Fig. 5: Chart showing the pattern of slump cone for different percentage replacements of sand in concrete

D. Compressive strength:

The mean compressive strength test results as tabulated

TABLE III

MEAN COMPRESSIVE TEST RESULTS

Percentage replacement of sand	**Compressive strength in MPa**	
	7 days	**28 days**
0%	18.93	32.13
10%	16.35	29.55
20%	19.55	32.75
30%	14.88	32.23
40%	19.35	32.55
50%	17.70	33.05

The above table (Table III) shows the mean compressive strength values of the tested samples with respect to 7 days and 28 days. The strength variation can be depicted in figure 6. The result shows the increase in strength with the increase in percentage replacement of sand as fine aggregate.

The considerable increase in 28 days compressive strength is attained for 50% replacement of sand by quarry dust and also for 20% replacement. The workability of the concrete tends to decrease with the rise in percentage replacement and remains constant at the level of 300mm keeping water-cement ratio as 0.40 for all mixes. It is important to note that with increase in percentage replacement is that the absorption rate of water by quarry dust increases.

This depicts that the use of Portland Pozzolana cement (Fly ash based) in combination with quarry dust as a partial replacement of sand as fine aggregate yields a noticeable and good amount of strength of concrete. And also this also notifies that usage of quarry dust as replacement for sand can be done for the constructional purpose.

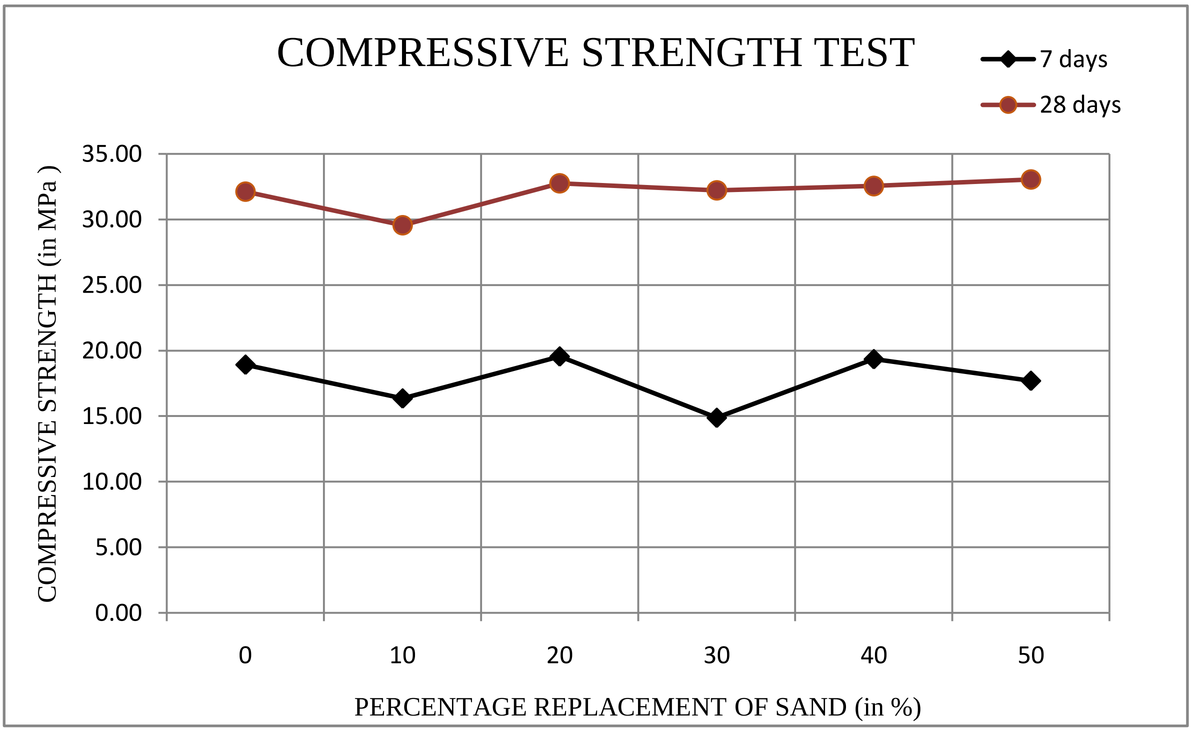

Fig. 6: Chart showing variation of compressive strength of concrete (for 7 and 28 days)

VI. CONCLUSIONS

1. It can be estimated that the replacement of sand by quarry dust tends to increase the compressive strength of concrete.
2. With the increase in percentage replacement of sand by quarry dust, the workability of mix tends to decrease, as at the same time water requirement increases owing to rise in water absorption rate of quarry dust. So, the care should be taken while mixing so that water-cement ratio may not be affected.
3. The additional water content may be added by adjusting water-cement ratio for dry ingredients with respect to mix design results. The height of slump cone after subsidence for all mixes was constant at 300mm i.e. the slump value is 0mm.
4. The physical and chemical characteristics of quarry dust can be determined using the same procedures and IS standards used for sand.
5. The strength variation can be determined that from 0% to 10% replacement of sand, there is a decrease in strength of 8.029%. From 10% to 20% replacement, the increase in strength is about 10.829%, from 20% to 30%, there is a decrease in strength of 1.587%. There is an increase in strength of 0.993% and 1.536% from 30% to 40% replacement and 40% to 50% replacement respectively.
6. The concrete attains maximum rise in compressive strength (28 days), when 50% replacement of sand is made and also for 20% replacement, considerable increase can be noticed.
7. The percentage replacement of sand with quarry dust can be increased more than 50%. This can be done and advantageous if used along with the addition of materials such as fly ash to cement (OPC) or use of PPC (Fly ash based cement), so that the reduction in early strength and decrease in workability can be mitigated by functioning of both materials in combination as a symbiosis.

It can be concluded that the use of Portland Pozzolana Cement (Fly ash based) in combination with quarry dust as a partial replacement of sand as a fine aggregate can be done.

REFERENCES

[1] **Chandhan Sukesh, Katakam Bala Krishna, P. Sri. Lakshmi Sai Teja, S.Kanakambara Rao.** Partial replacement of sand with quarry dust in concrete. International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-2, Issue-6, May, 2013.

[2] **G.Balamurugan, Dr. P. Perumal.** Use of quarry dust to replace sand in concrete- An experimental study. International Journal of Scientific and Research Publications, Volume 3, Issue 12, December 2013.

[3] **K. Subramanian, A. Kannan.** An experimental study on usage of quarry dust as partial replacement for sand in concrete and mortar. Australian Journal of Basic and Applied Sciences, 7(8): 955-967, 2013 ISSN 1991-8178.

[4] **Dr.A.Vijayakumar, K.Revathi.** C.Bharathi. Strength and durability on concrete using quarry dust as fine aggregate. International Research Journal of Engineering and Technology (IRJET) Volume: 02 Issue: 07, Oct-2015.

[5] **M.S. Shetty**. Concrete Technology Theory and Practice, 5^{th} edition, S.Chand & Co. Ltd., New Delhi.

[6] IS 456-2000 Indian standard code of practice for plain and reinforced concrete, Bureau of Indian standards, New Delhi.

[7] IS 10262-2009, Indian Standard Concrete Mix Proportioning- guidelines (First Revision and Second Revision).

[8] IS 383-1970, 'Specification for coarse and fine aggregates from natural sources for concrete,' Bureau of Indian standards, New Delhi.

[9] IS 2386-1963 (Part I to VIII) 'Indian standard Methods of test for Aggregate for Concrete,' Bureau of Indian standards, New Delhi.