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Investigation on Quarry Dust as a Partial Replacement of sand for mix of concrete with a characteristic compressive strength

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ABSTRACT

The purpose of starting this investigation is due to the fact that now the natural sand confirming the Indian standard has become rare due to its non availability in time and due to the unavailability of land law, illegal dredging by river mafia, non-ratification with the IS 383-1970. The lack of natural sand and its cost is the reason behind the discovery of a suitable alternative, which can be used in construction. The availability of sand at low cost is not possible and this is the reason why searching for an alternative material. Quarry dust satisfies the reason behind alternative materials as a substitute for sand at very low cost. During the process of production of coarse aggregates in crushed plants, large amounts of stone dust are produced which are considered less for adequate use. This stone dust, which is a waste material, can be used effectively to make concrete, as a substitute for the fine aggregate.In the current study, an experimental program will be done for the workability and strength of concrete using stone dust as a complete blend in the form of a fine mixture with plasticizers. Quarry dust will be introduced as a partial replacement of fine aggregates in the mix.To increase the strength of the concrete, the stone dust will be presented as a partial replacement of the fine aggregate in M40 concrete mix with water reducer admixture. The strength parameters such as compressive strength, flexural strength and split tensile strength of the casted cubes, beams and cylinders will be tested respectively. Cubes cylinders and beams will be casted by a partial replacement of natural fine aggregate in concrete mix and quarry dust will be used as a fine aggregate. then test data of quarry dust concrete will be compared with test data from a standard concrete without quarry dust

Keywords: Quarry dust concrete, Fine aggregate, Concrete, Compressive Strength, Flexural Strength, Split Tensile Strength, Workability

INTRODUCTION

Concrete is that the most generally used stuff nowadays. The constituents of concrete are coarse combination, fine combination, binding material and water. Among these ingredients, river sand is commonly used as fine aggregate in concrete which is becoming scarce and hence expensive due to excessive cost of transportation from natural sources. In this experimental study, the byproduct of crushing stone plant i.e. quarry dust is used as a sand replacement. Due to the lack of natural construction materials, we have to think about the other alternatives available for replacement. For the past few years, many substitutions have been found to replace the main binding material of concrete i.e. cement. But there is a need to find a better replacement option for sand which is available entirely in the local area, even the option may be a waste material. Rapid industrialization in developing countries is increasing in urbanized areas. To support the urbanization, new building, such as buildings for housing and industries, transit large scale for people to move, and all construction activities are required for facilities to deal with water and sewage. In developing countries, the lack of traditional building materials and abundant industrial waste products has encouraged the recent construction material.

OBJECTIVE

The objectives of this work is to prepare two quarry dust concrete (QDC) mix proportions by replacing sand with quarry dust and in second one concrete mixture incorporating fly ash with a water reducer admixture basically a plasticizer and compare the strength parameters of quarry dust concrete samples with the conventional normal concrete.

1. To check the plastic behavior of the QDC green concrete by workability test.

2. To check the behavior of quarry dust concrete QDC under compression, split tensile test & flexure test.

3. To investigate the effect of quarry dust, super plasticizer & fly ash on the behavior of QDC.

RESULTS AND DISCUSSIONS

This chapter includes the results of the test done for this experimental study work and discussion for the test results. The results of all the tests have been tabulated here and discussed.

Results

Workability Test:

Table 5.1: The slump result for each batch of mix concrete

Batch Mix	Percentage of Quarry Dust	Percentage of sand	Slump (mm)
Mix-01	0%	100%	75
Mix-02	15%	85%	78
Mix-03	30%	70%	84
Mix-04	45%	55%	89
Mix-05	60%	40%	96
Mix-06	75%	25%	98

Compressive Strength

A minimum of three cubes are casted in each batch mix for determining compressive strength. Tests are performed at the age of 28 days of the specimens. Specimens are placed in the test machine as per IS: 516-1959 clause no 5.5.1 page no 11, also loading is applied on the specimen as per the same IS code.

Calculation are made by dividing the maximum applied load by the cross sectional area of the specimen. As there are three specimens for each batch mix, the average of the three values is taken.

Table no. 5.2 Compressive Strength Result for 7 days (Stage 1)

S.NO.	COMBINATION	CUBES	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm2)	AVERAGE COMPRESSIVE STRENGTH (N/mm2)
Mix- 01	C+S+NCA	Cube-1	725.00	32.22	32.07
		Cube-2	720.00	32.00	
		Cube-3	720.00	32.00	
Mix- 02	C+85%S+15% QD+NCA	Cube-1	750.00	33.33	32.96
		Cube-2	745.00	33.11	
		Cube-3	730.00	32.44	
Mix- 03	C+70%S+30% QD+NCA	Cube-1	770.00	34.22	33.62
		Cube-2	760.00	33.77	
		Cube-3	740.00	32.88	
Mix- 04	C+55% S+45% QD+NCA	Cube-1	760.50	33.80	34.16
		Cube-2	770.00	34.22	
		Cube-3	775.50	34.46	
Mix- 05	C+40% S+60% QD+NCA	Cube-1	685.50	30.46	30.21
		Cube-2	670.00	29.97	
		Cube-3	680.00	30.22	
Mix- 06	C+25% S+75% QD+NCA	Cube-1	650.00	28.88	28.81
		Cube-2	640.00	28.44	
		Cube-3	655.50	29.13	

Table no. 5.3 Compressive Strength Result for 28 days (Stage 1)

S.NO.	COMBINATION	CUBES	MAXIMUM LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
Mix- 01	C+S+NCA	Cube-1	1000.00	44.44	44.81
		Cube-2	1020.00	45.33	
		Cube-3	1005.00	44.67	
Mix- 02	C+85%S+15% QD+NCA	Cube-1	1025.00	45.55	45.70
		Cube-2	1020.00	45.33	
		Cube-3	1040.00	46.22	
Mix- 03	C+70%S+30% QD+NCA	Cube-1	1060.00	47.11	47.18
		Cube-2	1070.00	47.55	
		Cube-3	1055.00	46.88	
Mix- 04	C+55% S+45% QD+NCA	Cube-1	1090.00	48.44	48.81
		Cube-2	1100.50	48.88	
		Cube-3	1105.50	49.13	
Mix- 05	C+40% S+60% QD+NCA	Cube-1	990.00	44.00	44.22
		Cube-2	1000.00	44.44	
		Cube-3	995.00	44.22	
Mix- 06	C+25% S+75% QD+NCA	Cube-1	980.00	43.55	43.88
		Cube-2	975.00	43.33	
		Cube-3	985.00	44.77	

Flexural strength

Beams of size 10cm*10cm*50cm are casted for determining flexural strength. Test on beams are performed at the age of 28 days of the specimen. Placement of specimen in machine is done as per IS: 516-1959 in the clause no 8.3.1 page no 17. Load is applied at increasing rate of 108KN/min. Load is applied until specimen fails and load at which specimen fails is recorded. As specified in the IS code flexural strength is calculated and tabulated below:-

Table no. 5.4 Flexural Strength Result for 7 days (Stage 1)

S.NO.	COMBINATION	BEAMS	MAXIMUM LOAD (KN)	FLEXURAL STRENGTH (N/mm^2)	AVERAGE FLEXURALS TRENGTH (N/mm^2)
Mix-01	C+S+NCA	Beam-1	7.7	3.08	3.09
		Beam-2	7.9	3.16	
		Beam -3	7.6	3.04	
Mix-02	C+85%S+15% QD+NCA	Beam-1	8.20	3.28	3.31
		Beam-2	8.30	3.32	
		Beam -3	8.35	3.34	
Mix-03	C+70%S+30% QD+NCA	Beam-1	8.2	3.28	3.33
		Beam-2	8.3	3.32	
		Beam -3	8.5	3.40	
Mix-04	C+55% S+45% QD+NCA	Beam-1	9.00	3.60	3.57
		Beam-2	8.90	3.56	
		Beam -3	8.90	3.56	
Mix-05	C+40% S+60% QD+NCA	Beam-1	7.6	3.04	3.06
		Beam-2	7.9	3.16	
		Beam -3	7.5	3.00	
Mix-06	C+25% S+75% QD+NCA	Beam-1	7.1	2.84	2.82
		Beam-2	7.2	2.88	
		Beam -3	6.9	2.76	

Table no. 5.6 Flexural Strength Result for 28 days (Stage 2)

S.NO.	COMBINATION	BEAMS	MAXIMUM LOAD (KN)	FLEXURAL STRENGTH (N/mm^2)	AVERAGE FLEXURAL STRENGTH (N/mm^2)
Mix- 01	C+S+NCA	Beam-1	11.10	4.44	4.44
		Beam-2	11.15	4.46	
		Beam -3	11.05	4.42	
Mix- 02	C+85%S+15% QD+NCA	Beam-1	11.90	4.76	4.82
		Beam-2	12.10	4.84	
		Beam -3	12.20	4.88	
Mix- 03	C+70%S+30% QD+NCA	Beam-1	12.50	5.00	4.98
		Beam-2	12.40	4.96	
		Beam -3	12.45	4.98	
Mix- 04	C+55% S+45% QD+NCA	Beam-1	13.60	5.44	5.44
		Beam-2	13.50	5.40	
		Beam -3	13.70	5.48	
Mix- 05	C+40% S+60% QD+NCA	Beam-1	11.10	4.44	4.40
		Beam-2	10.95	4.38	
		Beam -3	11.00	4.40	
Mix- 06	C+25% S+75% QD+NCA	Beam-1	10.60	4.24	4.23
		Beam-2	10.60	4.24	
		Beam -3	10.55	4.22	

Split Tensile Strength

Cylinders of size 15 cm diameter and 30 cm height are casted for determining Split Tensile Strength. Test on cylinders are performed at the age of 7 & 28 days of the specimen. Placement of specimen in machine is done as per IS: 516-1959. Load is applied until specimen fails and load at which specimen fails is recorded. As specified in the IS code Split Tensile Strength is calculated and tabulated below:-

. Figure no.5.5. Tested Cylinders Analysis

Table no. 5.7 Split Tensile Strength Result for 7 days (Stage 1)

S.NO.	COMBINATION	CYLINDER S	MAXIMUM LOAD (KN)	SPLIT TENSILE STRENGTH (N/mm^2)	SPLIT TENSILE STRENGTH (N/mm^2)
Mix-01	C+S+NCA	Cylinder-1	190	2.69	2.62
		Cylinder-2	180	2.55	
		Cylinder -3	185	2.62	
Mix-02	C+85%S+15% QD+NCA	Cylinder-1	200	2.83	2.87
		Cylinder-2	200	2.83	
		Cylinder -3	210	2.97	
Mix-03	C+70%S+30% QD+NCA	Cylinder-1	240	3.40	3.28
		Cylinder-2	230	3.26	
		Cylinder -3	225	3.19	
Mix-04	C+55% S+45% QD+NCA	Cylinder-1	230	3.26	3.33
		Cylinder-2	240	3.40	
		Cylinder -3	235	3.33	
Mix-05	C+40% S+60% QD+NCA	Cylinder-1	190	2.69	2.69
		Cylinder-2	195	2.76	
		Cylinder -3	185	2.62	
Mix- 06	C+25% S+75% QD+NCA	Cylinder-1	180	2.55	2.43
		Cylinder-2	175	2.48	
		Cylinder -3	160	2.26	

Table no. 5.8 Split Tensile Strength Result for 28 days (Stage 1)

S.NO.	COMBINATION	CYLINDERS	MAXIMUM LOAD (KN)	SPLIT TENSILE STRENGTH (N/mm^2)	SPLIT TENSILE STRENGTH (N/mm^2)
Mix-01	C+S+NCA	Cylinder-1	340	4.82	4.70
		Cylinder-2	335	4.75	
		Cylinder -3	320	4.53	
Mix-02	C+85%S+15% QD+NCA	Cylinder-1	365	5.17	5.10
		Cylinder-2	355	5.03	
		Cylinder -3	360	5.10	
Mix-03	C+70%S+30% QD+NCA	Cylinder-1	375	5.31	5.26
		Cylinder-2	365	5.17	
		Cylinder -3	375	5.31	
Mix-04	C+55% S+45% QD+NCA	Cylinder-1	390	5.53	5.64
		Cylinder-2	410	5.81	
		Cylinder -3	395	5.60	
Mix-05	C+40% S+60% QD+NCA	Cylinder-1	330	4.68	4.60
		Cylinder-2	320	4.53	
		Cylinder -3	325	4.60	
Mix- 06	C+25% S+75% QD+NCA	Cylinder-1	320	4.53	4.48
		Cylinder-2	310	4.39	
		Cylinder -3	320	4.53	

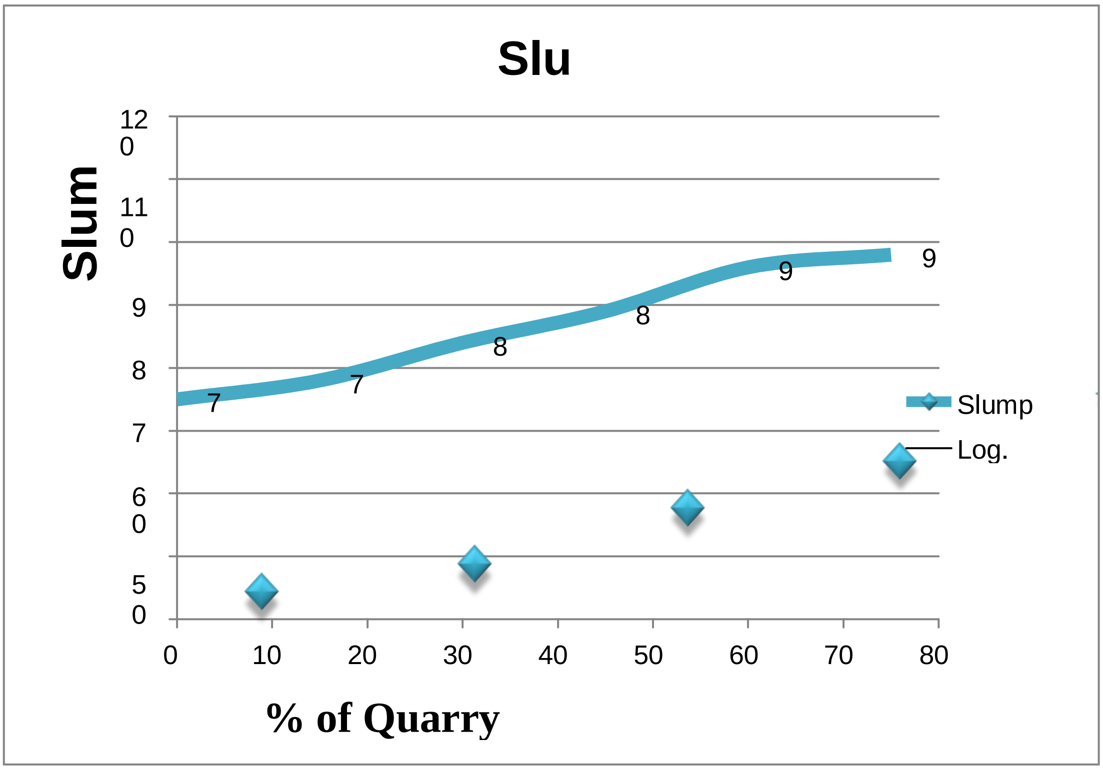
Discussion

SLUMP TEST RESULT AND ANALYSIS

The slump test indicates a decreasing trend of workability when the percentage of recycled aggregate increased. Table 6.2 below shows the average slump recorded during the test. Figure below shows a graphical representation of slump height.

Table 5.8: The slump result for each batch of mix concrete

Batch Mix	**Percentage of Quarry Dust**	**Percentage of sand**	**Slump (mm)**
Mix-01	0%	100%	75
Mix-02	15%	85%	78
Mix-03	30%	70%	84
Mix-04	45%	55%	89
Mix-05	60%	40%	96
Mix-06	75%	25%	98



Graph 1: Variation in Slump value

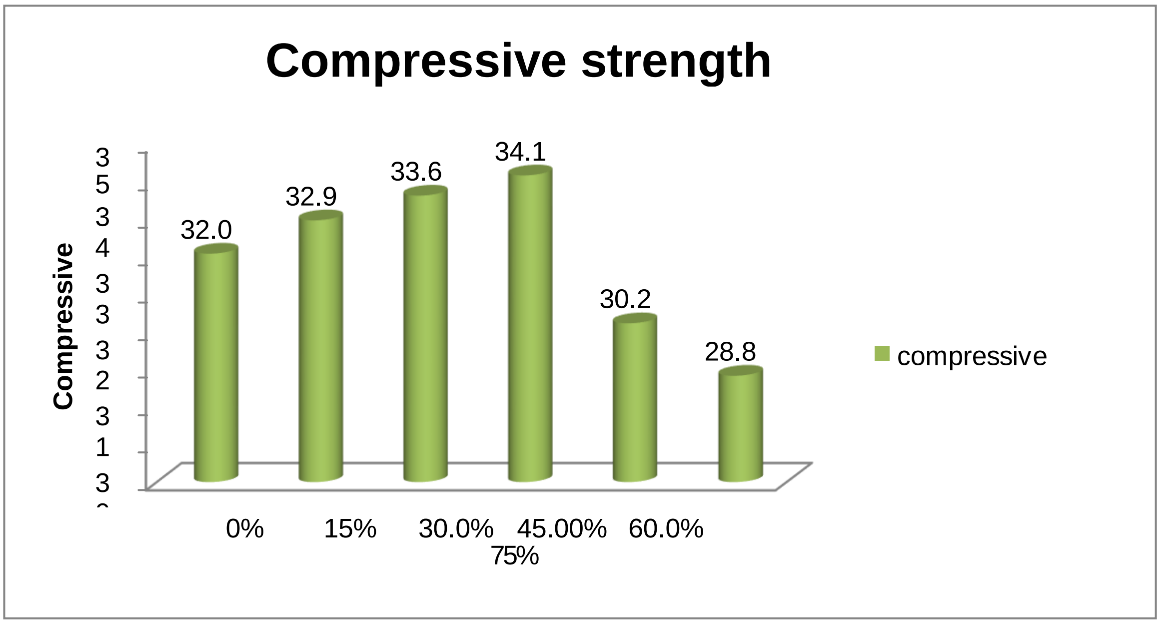
According to these test results, we found that the highest slump obtained was 84 mm and the lowest slump was 58 mm. It has been observed that the workability of the concrete mix was decreases with increase in the replacement level of sand with quarry dust..

COMPRESSIVE STRENGTH TEST RESULT

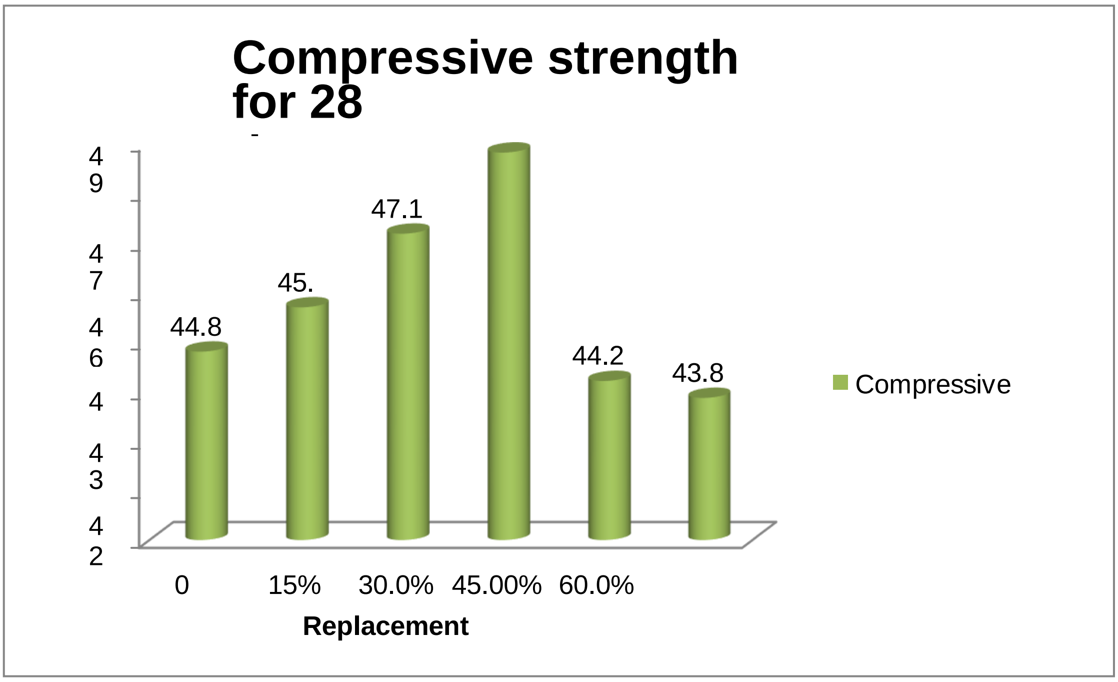
The compressive strength test by Compression Testing machine shows an increasing trend of the compressive strength with age of the concrete specimens Table-5.9 below shows the increase of the compressive strength with age recorded during the test.

Table 5.9: Variation of compressive strength with age

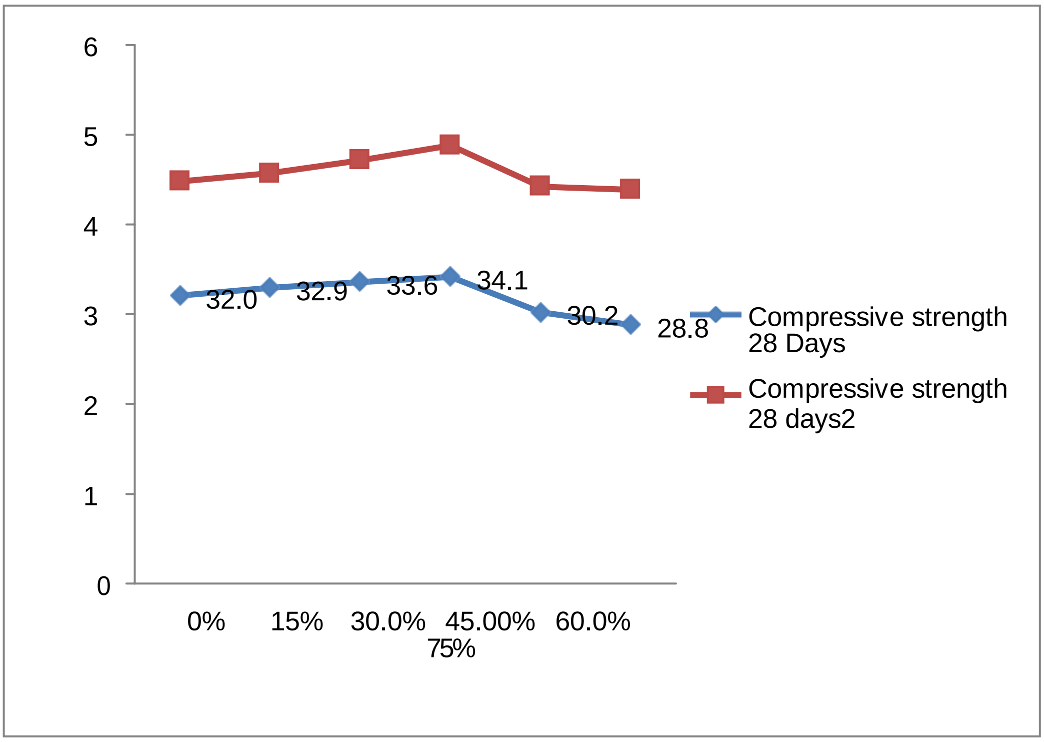
Variation of compressive strength with age						
% of QD	**0%**	**15%**	**30%**	**45%**	**60%**	**75%**
7 Days	32.07 Mpa	32.96 Mpa	33.62 Mpa	34.16 Mpa	30.21 Mpa	28.81 Mpa
28 Days	44.81 Mpa	45.70MPa	47.18.MPa	48.81MPa	44.22MPa	43.88MPa



Graph: 2. Compressive Strength at 7 days (N/mm2)



Graph: 3. Compressive Strength at 28 days (N/mm2)



Graph: 4 Compressive Strength in N/mm^2 at various age (Days)

As shown in the graph: 2 (7 days strength), when sand is partially replaced 45% by quarry dust, compressive strength is increased by 7.67%. Afterwards when addition of % of sand is replaced, strength starts decreasing, a minimum strength is achieved.

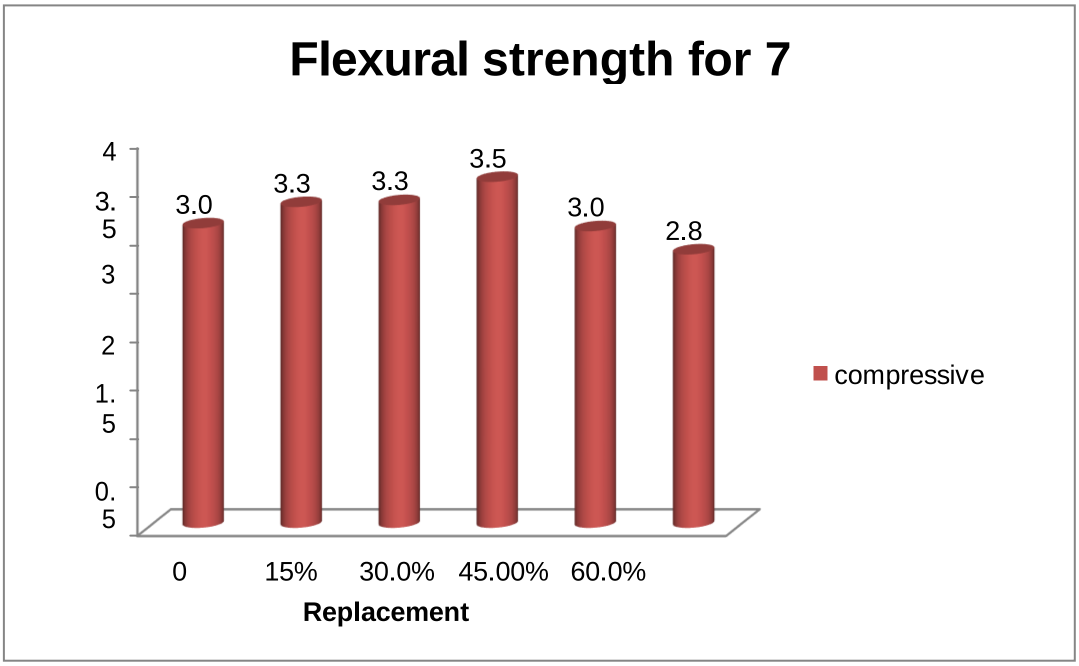
As shown in graph: 3 (28 days strength) show an increment of 10.12% of strength of 45% replacement of quarry dust as compared with conventional concrete. Again strength is decreased when addition of percentage of quarry dust.

Flexural Strength

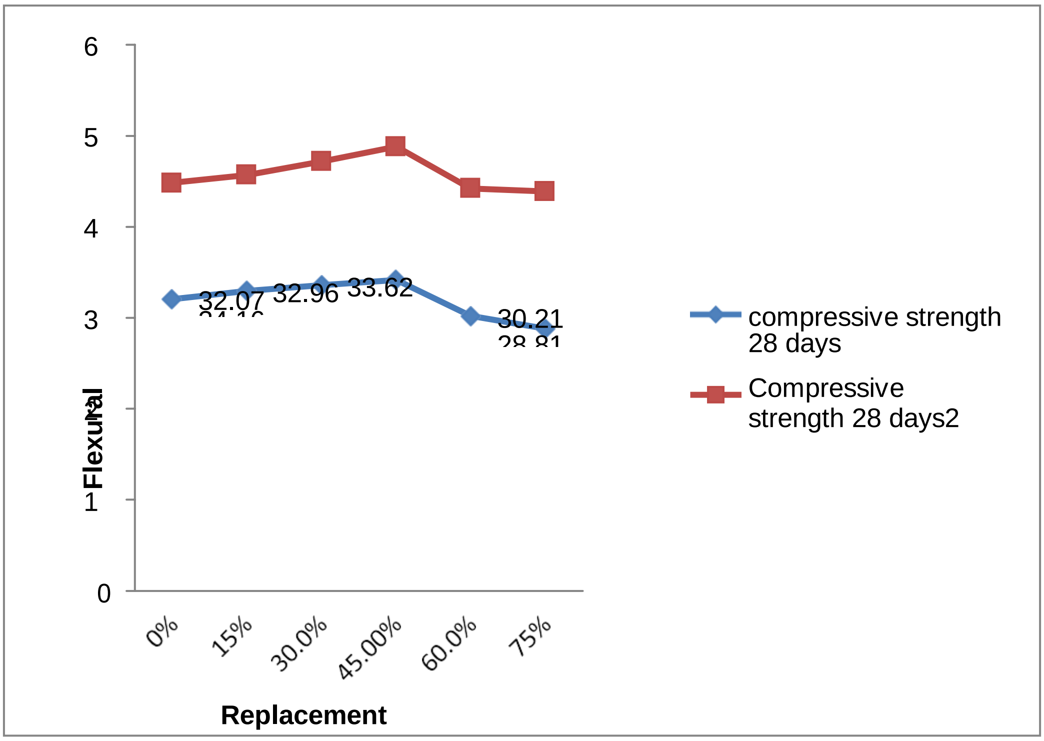
Flexural strength test is performed on 3 beams of each batch mix for 7 days & 28 days. There are 6 batch mixes and each one having 9 beams. Of these 9 beams, 3 beams are tested for 7 days & 28 days each. An average of 3 values as tabulated in table 6.4, are considered for discussions

Table 5.10: Variation of flexural strength with age

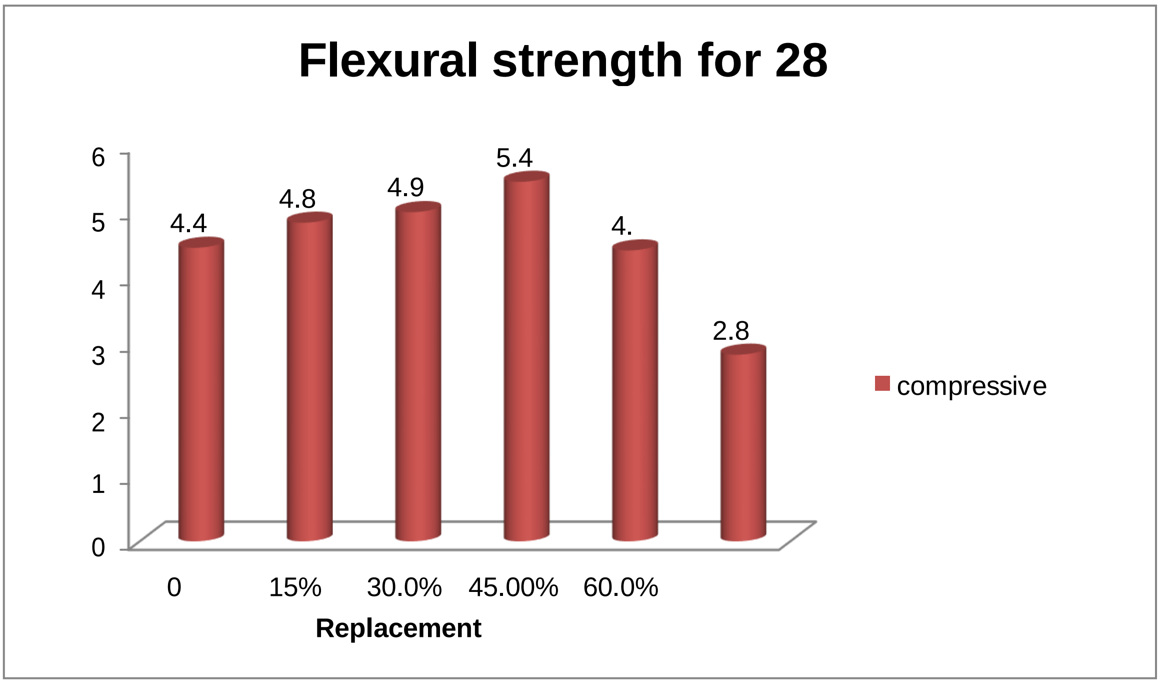
% of QD	**0%**	**15%**	**30%**	**45%**	**60%**	**75%**
7 Days	3.09MPa	3.31 Mpa	3.33MPa	3.57 MPa	3.06MPa	2.82MPa
28 Days	4.44MPa	4.82MPa	4.98MPa	5.44MPa	4.40MPa	4.23MPa



Graph: 5. Flexural Strength at 7 days (N/mm2)



Graph: 6. Flexural Strength at 28 days (N/mm2)



Graph: 7 Flexural Strength in N/mm2 at various age (Days)

As shown in the graph: 5 (7 days strength), when sand is partially replaced 45% by quarry dust, Flexural strength is increased by 15.57%. Afterwards when addition of % of quarry dust is replaced, strength starts decreasing, a minimum strength is achieved.

As shown in graph: 6 (28 days strength) show an increment of 22.22% of strength of 45% replacement of quarry dust as compared with conventional concrete. Again strength is decreased when addition of percentage of quarry dust.

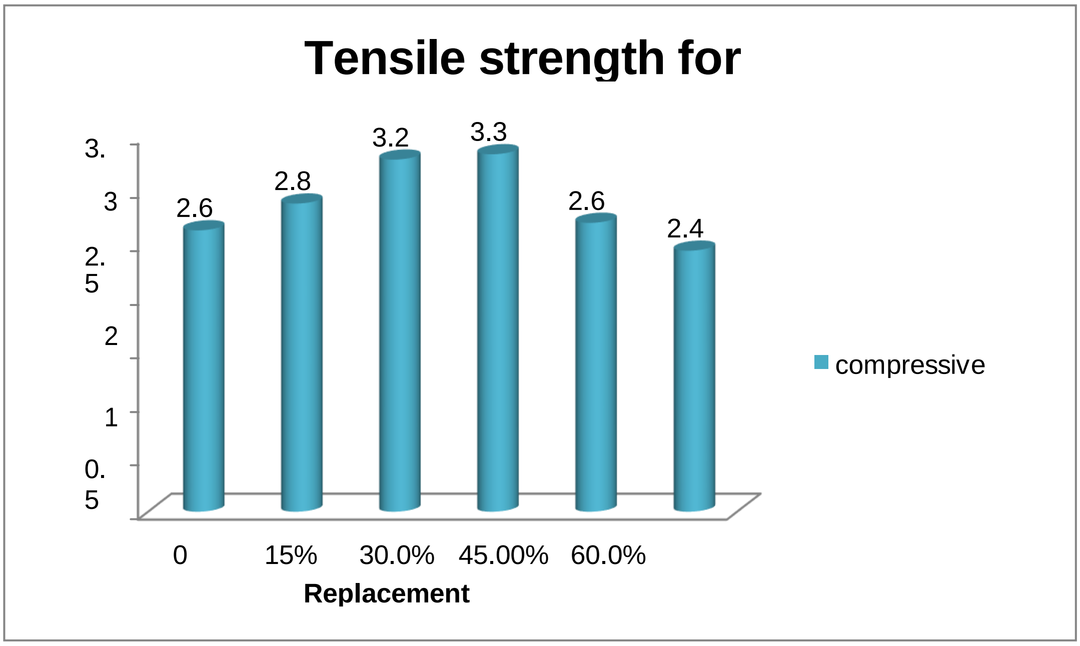
Split Tensile Strength

Tensile strength test is performed on 3 cylinders of each batch mix for 7 days & 28 days. There are 6 batch mixes and each one having 9 cylinders. An average of 3 values as tabulated in table 6.4, are considered for discussions

An experimental study on usage of quarry dust as full replacement for sand in concrete with fly ash and plasticizer

Table 5.11: Variation of flexural strength with age

% of QD	**0%**	**15%**	**30%**	**45%**	**60%**	**75%**
7 Days	2.62 MPa	2.87MPa	3.28MPa	3.33MPa	2.69MPa	2.43MPa
28 Days	4.70MPa	5.10MPa	5.26MPa	5.64MPa	4.60MPa	4.48MPa



Graph:8. Tensile Strength at 7 days (N/mm2)

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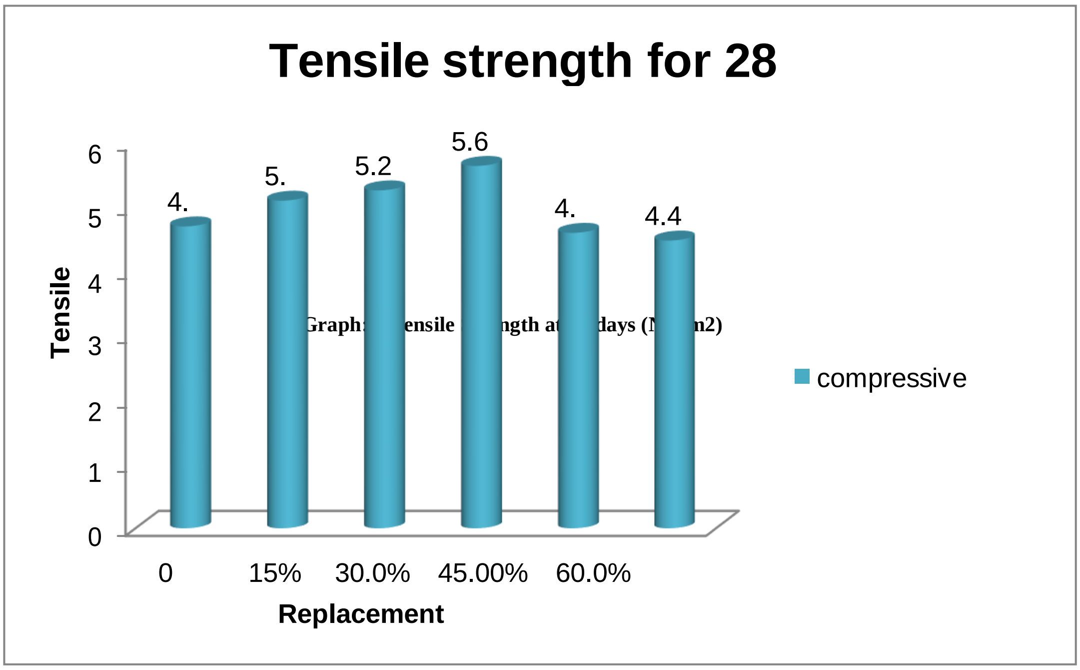
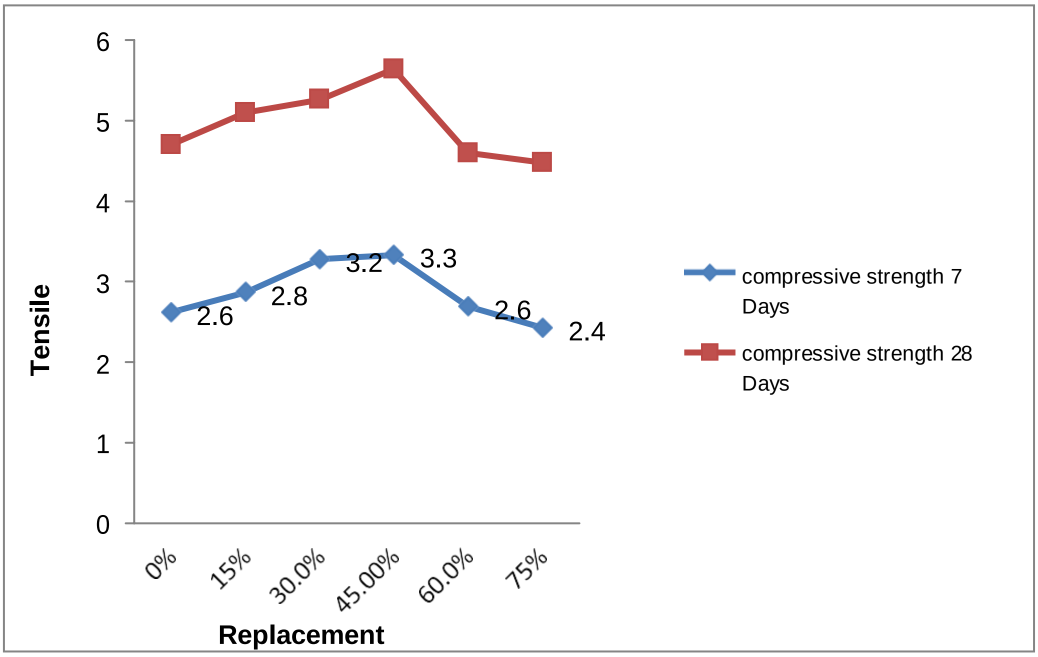


Graph: 10 Tensile Strength in N/mm2 at various age (Days)



An experimental study on usage of quarry dust as full replacement for sand in concrete with fly ash and plasticizer As shown in the graph: 8 (7 days strength), when sand is partially replaced 45% by quarry dust, Tensile strength is increased by 27.07%. Afterwards when addition of % of quarry dust is replaced, strength starts decreasing, a minimum strength is achieved.

As shown in graph: 9 (28 days strength) show an increment of 20% of strength of 45% replacement of quarry dust as compared with conventional concrete. Again strength is decreased when addition of percentage of quarry dust.

CONCLUSION

Quarry dust as a fine aggregate, increased the concrete slump and the flow of the concrete mixture, because the demand for water was reduced due to the surface area of the quarry dust but it did not affect the unit weight and air content of fresh concrete. Due to the deficient grading and excessive flakiness of quarry dust; the compressive strength of the concrete decreased. Thus we use a certain quantity of fly ash as a admixture and add a super plasticizer to the second stage concrete mixture, which is used to fulfill all the requirements arising due to use of quarry dust in the concrete, as a replacement of natural fine aggregate.

Also, the combined use of both quarry dust fine aggregate and fly ash demonstrated excellent performance due to efficient micro-filling capacity and pozzolanic activity of fly ash. Therefore quarry dust can be used as a good alternative to natural sand in concrete mix.

Compressive strength, Flexural strength, Split tensile strength test of concrete Mixes made with and without quarry dust has been determined at 7 & 28 days of curing. The strength gained has been determined of quarry added concrete with addition of 15%, 30%, 45%, 60% & 75% for M40 grade as a partial replacement of sand in conventional concrete. After performing all the tests and analyzing their result, the following conclusions have been derived:

1. Workability of concrete increases as proportion of quarry dust increases.
2. Maximum compressive strength was observed when quarry dust replacement is about 45%.
3. Maximum split tensile strength was observed when quarry dust replacement is about 45%.
4. Maximum flexural strength was observed when quarry dust replacement is about 45%.

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