ISSN(ONLINE):2278 - 3814

Volume-11, Issue 05, May 2022

JOURNAL OF COMPUTING TECHNOLOGIES (JCT)

International Journal

Page Number: 01-07

A COMPARATIVE ANALYSIS OF CRUSHED QUARTZITE AND BLACK METAL FOR M30 GRADE CONCRETE MIX

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***Abstract*— In this world, concrete is the most widely utilized material after water. It comprises of cement, sand, coarse aggregates and water. Along with these materials various admixtures can also be used which can enhance the properties of concrete. There are various alternative materials which are being tested in order to replace the ingredients of concrete. Some of the industrial and agricultural waste is being used as a partial replacement. Concrete has strength, and ability to attend desire shape properties but with all these advantages it's also cognition that concrete has very low tensile strength due to which it cannot use in tension zone. The concrete is thus reinforced to make it helpful in bearing the tensile load. Also the ingredients of concrete can be replaced by alternate materials, which can improve some or the other properties of our concrete mix. In this study I have tried to compare the concrete mixes containing crushed quartzite (100%) as coarse aggregates, Black gravels (100%) as coarse aggregates and thirdly 50% quartzite and 50% gravels as coarse aggregates in M30 grade concrete mix. Also the effect of using admixture Conplast SPG8 in these concrete mixes has been taken into consideration. The ultimate aim is to find out the best type mix amongst these in terms of the compressive strength. The detailed study on determining the compressive strength for 7days, 14days and 28days has been carried out with and without adding the admixture. Finally the analysis has been done to find out the best type of aggregates with or without the admixture in the concrete.**

Keywords: Crushed quartzite, super plasticizer, compressive strength, black metal, Ordinary Portland cement, specific gravity

I. INTRODUCTION

Concrete is the most important and valuable discovery in construction which has been utilized from last several years, although experiments have been done continuously in mounting the important properties and applications of concrete. Now a days concrete has bypassed the stage of only being the combination of cement, water, coarse and fine aggregates. It could be the blending of extreme supplementary number of ingredients such as even the sensible grouping of as many as 8 to 10 materials.

The most important materials are:

Cement-When it comes to the cementing substance in concrete, Portland cement is extensively employed. Basic compounds of cement are calcium, silicon, aluminum, iron, and another metallic oxide. Aggregate- These are primarily naturally available granular material like sand, gravel, or crushed stone comes in this category but with new technology recycled material and synthetic product also be used as an aggregate.

Classification of aggregate

Natural Aggregate- For the most part, these materials may be found in sand and gravel pits or quarries where rocks have been chopped into smaller pieces.

Natural sand and gravel are the most affordable options.

Artificial aggregate – The most widely used artificial aggregate are clean broken bricks and air-cooled fresh blast furnace slag.

The broken bricks of good quality provide a satisfactory aggregate for the mass concrete and are not suitable for reinforced concrete work if the crushing strength of bricks is less than 30-35 MPa.

Classification According to Size

- **Fine Aggregate** – This type of aggregate mostly which passes through a 4.75 mm IS sieve and contains only that much coarser material as is permitted by the specification. Sand is generally considered to have a lower size limited of about 0.07mm.
- **Natural sand** i.e. is fine aggregate resulting from natural disintegration of rock or that which has been deposited by the stream and glacial agencies
- **Crushed stone sand,** i.e. the fine aggregate produce by crushing hard stone.
- **Crushed gravel sand,** i.e. the fine aggregate produced by crushing natural gravel.
- **Coarse Aggregate** – The aggregates most of which are

retained on the 4.75mm IS sieve and contain only that much of fine material as permitted by the specification and termed coarse aggregate.

Types of Admixtures of Concrete

- **Chemical admixtures** - Accelerators, Retarders , Super plasticizers
- **Mineral admixtures** - Fly-ash Blast-furnace slag, Silica fume, and Rice husk Ash etc.
- **Water-reducing admixture / Plasticizers**:

These admixtures used to achieve a higher strength by decreasing the water-cement ratio at the same workability as an admixture free mix. These also help to achieve the same workability by decreasing the cement content so as to reduce the heat of hydration in mass concrete and water reduction more than 5% but less than 12% is possible by them.

- **Super Plasticizers:**

These are more reagent and more effective type of water reducing admixtures also known as a high range water reducer.

✓ The main benefits of superplasticizers can be summarized as follows:

✓ They are able to increased fluidity of concrete, Flowing behavior, Self-leveling and Self-compacting concrete.

✓ The commonly used Super Plasticizers are as follows:

i) Sulfonated melamine formaldehyde condensates (SMF)
ii) Sulfonated naphthalene formaldehyde condensates (SNF)
iii) Polycarboxylate ether superplasticizers (PCE)

Objective of Study

- To compare the effect of using Crushed quartzite as a coarse aggregate in concrete by its partial and full replacements of gravels that is black metal.
- To make comparative study based on the replacement of gravel with crushed quartzite partially and fully with and without adding admixture.
- To identify the effect of using admixture in M30 grade concrete with black metal, crushed quartzite and a mixture of both these as coarse aggregates.
- Design of M30 concrete with partial replacement of fine aggregates and partial replacement of cement.
- Determination of properties of above modified concrete mixes with different % of replacement.
- Cost economics of modified concrete with conventional M30 concrete mixes.

II. LITERATURE SURVEY

Abdullahi. M Civil Engineering Department, Federal University of Technology , 2012 published a journal on "Effect of aggregate type on Compressive strength of concrete" Concluded that the aggregate type has effect on the compressive strength of normal concrete. The highest compressive strength was achieved from theconcrete containing crushed quartzite, followed by concrete made from river gravel. Concrete containing crushed granite shows the least strength development in all phases of life.They adopted a nominal mix of concrete (1:2:4) and prepared concrete of three different types that is by replacing coarse aggregates with crushed quartzite, crushed granite and river gravels. They tested the compressive strengths at 3, 7, 14, 21 and 28 days respectively.The highest compressive strengths were obtained when crushed quartzite was replaced with the coarse aggregates as compared to granite and river gravels replacement. The water cement ratio chosen was 0.6 for entire work.The coarse aggregates were utilized as 100% replacement in all the three cases [1].**K. Surendra and G. Nagesh** Crushed quartzite as fine aggregates replacement along with super plasticizer and performed compressive strength, Tensile strength test, slump flow test to check the properties of Self compacting concrete (SCC).They replaced cement with fly ash in proportions of 10%, 20%, 30% and 40% and simultaneously crushed quartzite was replaced with fine aggregates in 10%, 20%, 30%, 40% and 50% proportions. The research showed that on 10%, 20%, 30% and 40% replacement of fine aggregate with quartzite showed positive effect on fresh properties of concrete whereas negative effects were seen on 50% replacement only. Also the hardened properties of concrete were not influenced due to replacement of fine aggregates with quartzite up to 50%.The super plasticizer used in mix design was Master Glenium Sky. The water cement ratio of 0.4 was maintained. [2] **S. Sneka, Dr. G. Dhanalakshmi, (Size effect of aggregate in the mechanical properties of concrete)** They utilized aggregates of different sizes like 19, 25 and 37.5mm size in a nominal mix of concrete (1:1.5:3) and they used a water cement ratio of 0.5 in the entire project.The conclusions were that the compressive and split tensile strength got increased as soon as they increased the bigger size of aggregates in preparing the concrete.Although the flexural strength started declining as they used bigger size of coarse aggregates in the concrete. The coarse aggregate size shows a direct proportion with the workability of the concrete mix.The value of workability increased from 135mm to 168mm as the coarse aggregate size increased from 19mm to 37.5mm.[3].**"Ryza Polat, Mehrzad Modabbi** " According to the study, "The association between aggregate shape and compressive strength of concrete: A digital image processing method," the mechanical behaviour of concrete was investigated based on the usage of various kinds of aggregates such as flat and rounded aggregates. elongated, spherical and mixed shape (control). They determined that spherical size of aggregates are better for compressive strength factor and workability of the concrete mix. Flat shape of particles in coarse aggregate content produces concrete mix of comparatively lesser compressive strength. The spherical shape of aggregates gave the highest compressive strength followed by aggregates of mixed shape. The admixture used in this study was Glenium 303 and water cement ratio of 0.3 was maintained for preparing the concrete mix with all the 4 types of coarse aggregates [4].

Table I. Mix Proportions for SCC

S, No.	Mix Designation	Mix Proportions
1	M0	100% Cement
2	M1	90% Cement+ 10% Fly ash
3	M2	80% cement + 20% fly ash
4	M3	70% cement + 30% fly ash
5	M4	60% cement + 40% fly ash
6	M5	70% cement + 30% fly ash + 10% Crushed quartzite
7	M6	70% cement + 30% fly ash + 20% Crushed quartzite
8	M7	70% cement + 30% fly ash + 30% Crushed quartzite
9	M8	70% cement + 30% fly ash + 40% Crushed quartzite
10	M9	70% cement + 30% fly ash + 50% Crushed quartzite

III METHODOLOGY

For the research work regarding the objectives, some of the test in the lab is required to be done so that we can get the desired results. Some of the steps which needs to be followed includes

a) Performing the required test.
b) Preparing the charts and tables of obtained values.
c) Comparative analysis of the obtained values.
d) Maintaining proper record of the used materials and the experiments performed.

3.1 Concrete Specimen

In order to prepare the standard cubical specimens of the concrete we need the mould of specified sizes that is 15cmx15cmx15cm. The coarse aggregates are chosen in such a way that the maximum size of the material does not exceed 20mm.

3.2 Vicat Apparatus

In order to determine the consistency, initial and final setting time of the cement paste, It consist of a frame with a movable rod along with a platform. For determining the initial and final setting time, needle is required and for obtaining the consistency, plunger is utilized. All these attachments are as per IS 5513- 1996

Initial and final setting ttime are found out by help of IS 4031 (Part-5) 1988

3.3 Slump Cone Test

A slump cone test is carried out in order to determine the concrete mix's workability. Alternatively, in order to assess the simplicity with which a concrete mix may be applied, the range of the slump height shall be as per the IS 456:2000 by selecting the type of concrete mix as per the utilization,Slump height is a term used to describe the decrease in the height of concrete slump. 30cms (300mms) is the overall vertical height of the slump cone device.

3.4 Compression Testing Machine

Properly calibrated machine was used for determining the compressive strength of the concrete mix specimen. This test is performed as per the IS 516-1959

The load is applied at the centre of the concrete cubes after dusting the surface and taking precautions for getting the surface even and hence the results will be correct and valid.

3.5 Raw Materials

3.5.1Ordinary portland Cement (OPC)

The cement utilised in this investigation is an ACC ordinary portland cement of Grade 53 that complies with IS 12269-87. As per Indian guidelines, a number of tests were carried out on cement, including

a)Compressive strength test as per IS 4031 (part 7) 1988
b)Specific gravity
c)As specified in IS 4031 (part 4) 1988, the consistency test is performed.
d) IS 4031 (part 5) 1988 specifies the initial and final setting times. rotor.

3.5.2 Coarse Aggregates

Ordinarily used gravel that is black metal and crushed quartzite was used for this research work.The railway ballast process also uses crushed quartzite. Quartzite, formerly quartz sandstone, is a metamorphic rock that was formed as a result of extreme heat and pressure. Using coarse material, crushed granite of 20 mm in size was employed. The test performed over the coarse aggregates is

a) Water absorption test
b) Impact value test
c) Sieve analysis test.

3.5.3 Fine aggregates

Sand conforming to zone 2 was used in this research work after having performed the desired test same as for coarse aggregates.

Natural sand from the local market was utilised in the inquiry to validate the grading zone II according to IS: 383-

1997. Specific gravity, gradation, and fineness modulus are all measured in line with IS: 2386 for fine aggregate. The 2.72 specific gravity of the tiny aggregates employed in this investigation is noteworthy. Prior to employing fine aggregate sieve analysis and bulking of sand, this was done .

3.5.4 Admixtures

The materials which are added in order to enhance the qualities of prepared mix are known as admixtures. They are either added just before preparing the mix or while mixing the ingredients of the concrete mix. They helps in improving the properties of the concrete mix as per the requirements.

According to the IS 9103: 1999 admixtures falls under the following categories.

a) Admixtures that have been accelerated
b) Reducers of water content
c) Admixtures with very plasticizing properties
d)Improving the speed of admixture

3.5.5 Water

Along with all of the used materials described above, water is the most important material among all as it helps in initializing the hydration of the cement. The water shall be fresh and should have a pH around 7.0

The pH value shall not be less than 6.0 and the hardness of used water shall be about 200 ppm.

The quality of water used affects
a) Consistency of the used cement
b) Initial and final setting time of the used cement
c) The compressive strength of the used cement.

IV. MIX DESIGN OF DESIRED CONCRETE

4.1 Testing of materials

Before starting the design mix procedure, the initial test to be performed on materials are discussed as below

A-2 TEST DATA FOR MATERIALS

- Cement used : OPC 53 Grade conforming IS 12269
- Specific gravity of cement : 3.15
- Chemical admixture : Super Plasticizer conforming to IS 9103 (ECMAS HP 890)
- Specific gravity of
- Coarse aggregate 20mm : 2.67
- Fine aggregate : 2.65
- GGBS : 2.84 (JSW)
- Water absorption:
- Coarse aggregate : 0.5 %
- Fine aggregate (M.sand) : 2.5 %
- Free (surface) moisture:
- Coarse aggregate : Nil (Absorbed Moisture also Nil)
- Fine aggregate : Nil

Test of cement

- The test conducted on Ordinary Portland cement of grade 53 of the brand name ACC is Consistency test-

The consistency of the cement paste will be the water content during which the plunger will penetrate in the paste of cement about 5 to7mm from the top of its reading scale.

- Weight of the cement= 400gms
- Initial quantity of water= 80gms
- First reading by plunger= 2mm
- Then water used= 100gms
- Reading by plunger= 5mm
- Then water used= 105gms
- Reading by plunger= 6mm
- Hence the standard consistency= (Weight of water/ Weight of cement) x 100 = (105/400)x 100 = 26.26%
- Hence the standard consistency for the tap water = 26.26%

Initial and final setting time of cement

- This test conforms to IS 4031: 1988 (part 5)
- Initial weight of cement= 400gms
- Weight of water = 0.85 times of water required for standard consistency
- Weight of water will be = 0.85x 105 = 90gms (almost) Prepared paste was filled in the mould and time of mixing water in cement was noted with the aid of stop watch (T1)
- The plunger is allowed to fall after every 2 minutes interval and the time at which plunger will penetrate 5mm from the bottom of the mould was noted down (T2) Initial setting time = (T2-T1) = 38 minutes (for used water) Similarly final setting time was 9 hr 33 minutes

Specific Gravity test

- Specific gravity of both the type of metals were found out by the aid of Pycnometer jar
- W1 = Weight of pycnometer
- W2 = Weight of jar + weight of aggregates
- W3 = Weight of aggregate + weight of jar + weight of water
- W4 = weight of jar + weight of water
- Specific gravity = (W2 - W1) / [(W2 - W1) - (W3 - W4)]

a) For gravels (Black Metal)
b) For Crushed Quartzite (Red metal)
c) Gravels + Crushed Quartzite

Table 4.1 Specific gravity for different samples

S. No.	Weight	Sample 1 Gravel (kg)	Sample 2 Crushed quartzite (kg)	Sample 3 Gravel + Crushed Quartzite (kg)
1	W 1	0.235	0.235	0.235
2	W 2	0.735	0.735	0.735
3	W 3	1.542	1.527	1.534
4	W 4	1.216	1.216	1.216
	Sp. Gravity	2.87	2.64	2.74

Mix Proportions:
The design mix was done as per the IS 456:2000.
The grade chosen is M30 for reinforced pump able concrete and for mix proportioning IS 10262-2009 was used. The mix proportion is calculated by using volume method.

- Cement = 288 kg/m3
- GGBS = 72 kg/m3 (20% By Total weight of Cement)
- Water = 158 l/m3
- Fine aggregate = 798 kg/m3 Coarse aggregate 20mm = 882 kg/m3
- 12mm = 223 kg/m3 (20% By Total weight of Coarse Aggregate)
- Chemical admixture = 1.34 kg/m3 (0.4% by the weight of cement)
- Density of concrete = 2430 kg/m3
- Water-cement ratio = 0.47
- Mix Proportion By weight = 1:2.21:3.09

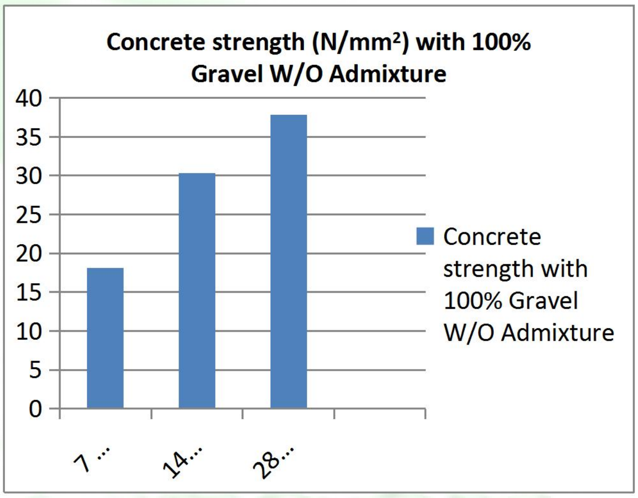
4.3 Method of testing the specimen
Two types of coarse aggregates were used namely
1. Gravel used as 100% as coarse aggregates.
2. Crushed Quartzite used as 100% as coarse aggregates.
3. Gravel and Crushed Quartzite (Both 50% as coarse aggregates)

Image 1: Filling up the Concrete moulds

Image 2: Curing of prepared concrete blocks

Image 3: Failure crack pattern of concrete cubes

V. TEST RESULTS



5.1 Results of compressive strength for gravels

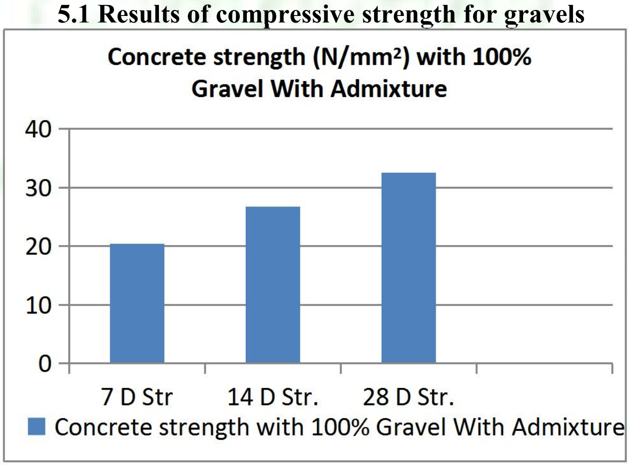


Fig 5.2: Compressive strength for gravels With admixture

ISSN(ONLINE):2278 - 3814

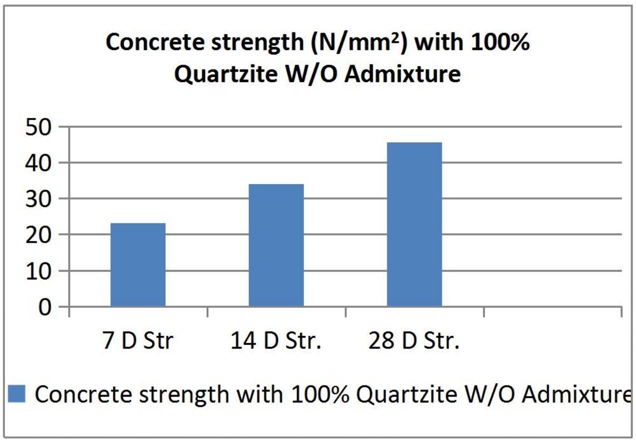


Fig 5.3: Compressive strength for crushed quartzite W/O admixture

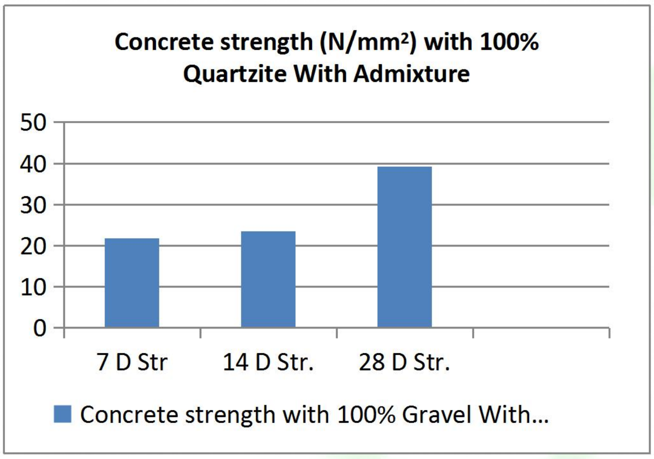


Fig 5.4: Compressive strength for crushed quartzite with admixture

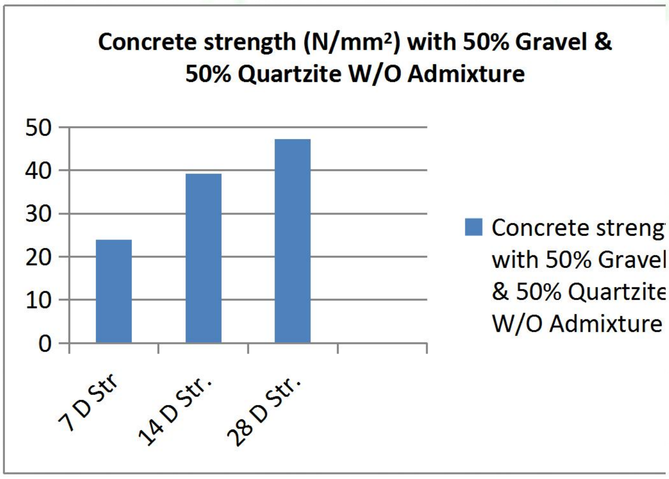


Fig 5.5: Compressive strength for crushed quartzite & gravels W/O admixture

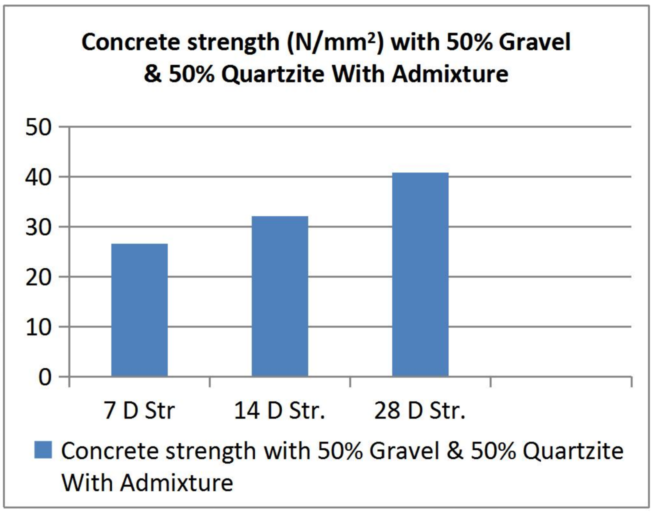


Fig 5.6: Compressive strength for crushed quartzite & gravel with admixture

Comparison of results

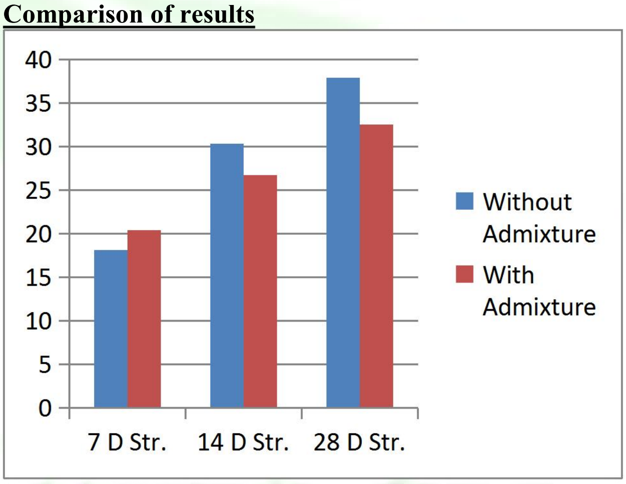


Fig. 5.7 Comparative analysis of strength for concrete made of 100% gravel as coarse aggregate

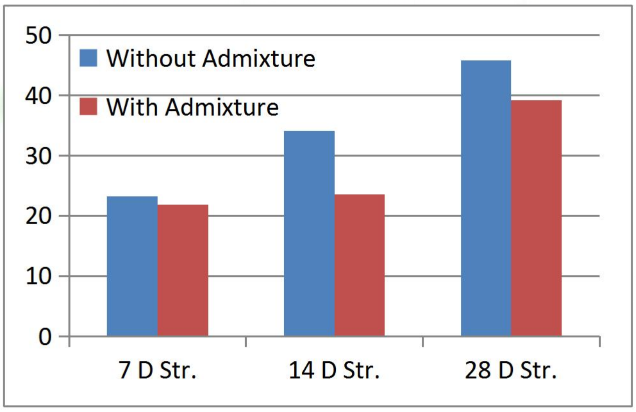


Fig 5.8 Comparative analysis of strength for concrete made of 100% Quartzite as coarse aggregate

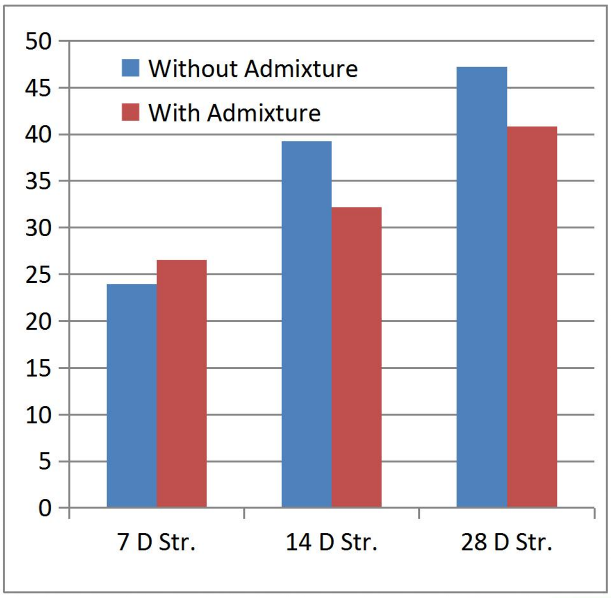


Fig 5.9 Comparative analysis of strength for concrete made of 50% Quartzite and 50% gravel as coarse aggregate

VI CONCLUSIONS & FUTURE SCOPE

It took 28 days for the maximal compressive strength to be attained, which was 47.19 N/mm2. when both gravels and crushed quartzite were used as coarse aggregates without any admixture while the least compressive strength was 37.85N/mm2 when only gravel was used. Thus the highest compressive strength is 24.67% more than the least strength. After 14 days, the strongest specimen exhibited a compressive strength of 39.26 MPa, which was significantly higher than the averagewhen both gravels and crushed quartzite were used as coarse aggregates without any admixture while the least compressive strength was 30.30 N/mm2 when only gravels were used. So the highest compressive strength is 22.82% more than the least compressive strength. The highest compressive strength obtained after 7 days was 26.59 N/mm2 when both gravels and crushed quartzite were used as coarse aggregates with 0.5% admixture while the least compressive strength is 20.37 N/mm2 when only gravels were used with admixture. Thus the highest compressive strength is 23.39% more than the least compressive strength after 7 days.

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