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Partial Replacement of Fine Aggregates with Quarry Dust and Marble Powder in Concrete

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ABSTRACT

Quarry dust and Marble powder are the most used among such materials to replace river sand, which can be used as alternative to fine aggregate in concrete. In the present investigation workability and strength of concrete was evaluated by replacement of natural sand by Quarry dust and marble powder in equal proportions of 0%, 10%, 20%, 30%,40%,50% and 60% is studied for M25grade concrete cubes. Slump cone method is taken for finding workability. For strength parameters for each grade of concrete Cubes were casted and tested at the age of 7 and 28 days. In this present experimental study on concrete having grades of M25 are prepared by replacing natural sand by Quarry dust and Marble powder.

The main cause of concern is the non-renewable nature of natural sand and the corresponding increasing demand of construction industry. River sand which is one of the basic ingredients in the manufacture of concrete has become highly scarce and expensive. Therefore looking for an alternative to river sand has become a necessity. Hence, the crusher dust which is also known as Quarry dust and Marble powder can be used as an alternative material for the river sand. Quarry dust and Marble powder contains similar properties as that of river sand and hence accepted as a building material. The present paper focuses on investigating maximum percentage replacement of river sand by Quarry dust and Marble powder in varying equal percentages 0%, 10%, 20%, 30%, 40%, 50%, and 60% for M25 mix designations. The cubes and cylinders are casted for each proportion and tests conducted for obtaining the compressive strength, split tensile strength of concrete.

Keywords:- Marbel, Dust, Quary

I. INTRODUCTION

1.1 GENERAL:

Concrete is a widely used construction material consisting of cementing material, fine aggregate, coarse aggregate and required quantity of water, where in the fine aggregate is usually natural sand. The use of sand in construction results in excessive sand mining which is objectionable. Due to rapid growth in construction activity, the available sources of natural sand are getting exhausted. Also, good quality sand may have to be transported from long distance, which adds to the cost of construction. In some cases, natural sand may not be of good quality. Therefore, it is necessary to replace natural sand in concrete by an alternate material either partially or completely without compromising the quality of concrete. CRP is one such material which can be used to replace sand as fine aggregate. CRP is also commonly known as QUARRY DUST. The present project is aimed at utilizing Crushed Rock Powder (CPR)/Quarry dust (QD) as fine aggregate in cement concrete, replacing natural sand. The study on concrete includes determination of compressive strength and split tensile strength of different grades of concrete.

Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river or pit sand. Fine and coarse aggregate constitute about 75% of total volume. It is therefore, important to obtain right type and good quality aggregate at site, because the aggregate form the main matrix of concrete or mortar. The global consumption of natural sand is very high, due to the extensive use of concrete. In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructural growth, in this situation developing country like India facing shortage in good quality natural sand. Particularly in India, natural sand deposits are being depleted and causing serious threat to environment as well as the society. Increasing extraction of natural sand from river beds causing many problems, loosing water retaining sand strata, deepening of the river courses and causing bank slides, loss of vegetation on the bank of rivers, exposing the intake well of water supply schemes, disturbs the aquatic life as well as affecting agriculture due to lowering the underground water table etc are few examples. In past decade variable cost of natural sand used as fine aggregate in concrete increased the cost of construction. In this situation research began for inexpensive and easily available alternative material to natural sand.

Some alternatives materials have already been used as a part of natural sand e.g. slag limestone and siliceous stone powder were used in concrete mixtures as a partial replacement of natural sand. However, scarcity in required quality is the major limitation in some of the above materials. Now a day's sustainable infrastructural growth demands the alternative material that should satisfy technical requisites of fine aggregate as well as it should be available abundantly.

1.2 Properties of Quarry dust:

Table 1.2 Properties of Quarry dust

Organic material content	Nil
Compatibility with cement	Use any type of Portland cement and blended cements for various mix designs
Setting time	Normal as preformed by river sand
Workability	Good
Yield	Rich mix
Standard mix design for M20 grade concrete per Cum.	Cement:300kg+quary dust:693kg+20mm: 749kg+20mm:543kg

1.3 Properties of Marble powder:

Table 1.3 Properties of Marble powder

Organic material content	Nil
Compatibility with cement	Use any type of Portland cement and blended cements for various mix designs
Setting time	Normal as preformed by river sand
Workability	Good
Yield	Rich mix
Standard mix design for M20 grade concrete per Cum.	Cement:300kg+marble powder:693kg+20mm: 749kg+20mm:543kg

II. METHODOLOGY OF EXPERIMENTAL WORK

2.1 General:

In this study it deals with the materials that are used in the study, namely: Cement, Coarse aggregate, Fine aggregate and crushed rock powder. The test methods adopted to measure the properties of Concrete such as Compression Test, Split tensile Test are to be explained. Compression and split tensile tests are conducted on cubes of standard dimensions respectively. Based on the result of the tests conducted in the laboratory, conclusions are drawn

III. MATERIALS AND PROPERTIES

3.1 CEMENT:

Cement is a binder material which sets and hardens independently, and can bind other materials together. Cement is made up of four main compounds tricalcium silicate (3CaO SiO_2), dicalcium Silicate (2CaO SiO_2), tricalcium acuminate (3CaO Al_2O_3), and tetra-calcium aluminoferrite (4caco Al_2O_3 Fe_2O_3).tetra-calcium aluminoferrite (4CaO Al_2O_3 Fe_2O_3). In an abbreviated notation differing from the normal atomic symbols, these compounds are designated as C_3S, C_2S, C_3A, and C_4AF, where C stands for calcium oxide (lime), S for silica and A for alumina, and F for iron oxide. Small amounts of uncombined lime and magnesia also are present, along with alkalis and minor amounts of other elements.

Cement is material, generally in powder form, that can be made into a paste usually by the addition of water and, when molded or poured, will set into a solid mass. Numerous organic compounds used for adhering, or fastening materials, are called cements, but these are classified as adhesives, and term cement alone means a construction material. The most widely used of the construction cements is Portland cement. It is a bluish gray colour obtained by finely grinding the clinker made by strongly heating an intimate mixture of calcareous and argillaceous minerals. The chief raw material is a mixture of high calcium lime stone, known as cement rock, and clay or shale. Blast furnace slag may also be used in some cements is called Portland slag cement. The colour of the cement is due chiefly to iron oxide. In absence of impurities, the colour would be white, but neither the colour nor the specific gravity is a test of quality.

Ordinary Portland cement is by far the most important type of cement. Prior to 1987, there were only one grade of OPC which is governed by IS 269-1976.After 1987 higher grade cements were introduced in India. The OPC was classified into three grades, namely 33 grade, 43 grade, 53 grade depending upon the strength of the cement at 28 days when tested as per IS 4031-1988. If the 28 days strength is not less than 33 N/mm2, it is called 33 grade cement. If the strength is not less than 43 N/mm2, it is called 43 grade cement. If the strength is not less 53 N/mm2, it is called 53 grade cement. But the values of actual strength obtained by this cements at the factory are much higher than BIS specifications.

Ordinary Portland cement 43 grade was used conforming to IS 456-2000 and physical property was given below:

3.2.1 AGGREGATES:

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. Earlier, aggregates were considered as chemically inert materials but now it has been recognized that some of the aggregates are chemically active and also that certain aggregates exhibit chemical bond at the interface of aggregate and paste. The mere fact that the aggregates occupy 70-80 per cent of the volume of concrete, their impact on various characteristics and properties of concrete is undoubtedly considerable. To know more about the aggregates which constitute major volume in concrete.

Aggregates are divided into two categories from the consideration of size.

- Coarse aggregates
- Fine aggregates

The size of the aggregate bigger than 4.75 mm is considered as coarse aggregates and aggregate whose size is 4.75 mm and less is considered as fine aggregates.

All aggregates are to be sampled properly before taking them for testing. The purpose of sampling is to get representative material for testing the wrong sampling of aggregate may lead to any of the following:

- Consuming of bad quality of aggregates in concrete by accepting the bad quality of materials at site
- Disputing with the suppliers.

3.2.1(a) FINE AGGREGATES:

Fine aggregates or sand is an accumulation of grains of mineral matter derived from the disintegration of rocks. It is distinguished from gravel only by size of the grains or particles, but is distinct from clays which contain organic materials.

Sands that have been stored out and separated from the organic material by the action of currents of water or by winds across arid lands are generally quite uniform in size of grains. Usually commercial sand dunes originally formed by the action of winds.

Much of the earth's surface is sandy, and these sands are usually quartz and other siliceous materials. The most useful commercially are silica sands, often above 9% pure. Beach sands usually have smooth, spherical to overload particles from the abrasive action of waves and tides and are free of organic matter. The white beach sands are largely silica but may also be of zircon, monazite, garnet, and other minerals, and are used for extracting various elements. Sand is used for making mortar and concrete and for polishing and sand blasting.

Sands containing a little clay are used for making molds in foundries. Clear sands are employed for filtering water. Sand is sold by the cubic yard (0.76 m3) or ton (0.91 metric ton) but is always shipped by weight. The weight varies from 1538 to 1842 kg/m3, depending on the composition and size of grain. Construction sand is not shipped great distances, and the quality of sands used for this purpose varies according to local supply. Standard sand is silica sand used in making concrete and cement tests. The fine aggregates obtained from river bed of koel clear from all sorts of organic impurities was used in this experimental program.

River sand was used throughout the investigation. The sand was air dried and sieved to remove any foreign particles prior to mixing.

Sand conforming to Zone-III was used as the fine aggregate, as per I.S 456-2000. The sand was air dried and free from any foreign material, earlier than mixing.

3.2.1(b) COARSE AGGREGATES:

Coarse aggregates are the crushed stone is used for making concrete. The commercial stone is quarried, crushed, and graded. Much of the crushed stone is granite, limestone, and trap rock.

The last is a term used to designate basalt, gabbros, diorite, and other dark coloured, fine grained igneous rocks. Graded crushed stone usually consists of only one kind of rock and is broken with sharp edges. The sizes are from 0.25 to 2.5 in (0.64 to 6.35 cm) although larger sizes may be used as coarse aggregates. The maximum size of coarse aggregates was 20 mm and specific gravity of 2.70.

Granite is a coarse grained, igneous rock having an even texture and consisting largely of quartz and feldspar with often small amounts of mica and other minerals. There are many varieties. Granite is very hard and compact and it takes a fine polish showing the beauty of the crystals. Granite is the most important building stone. Granite is extremely durable and since is does not absorb moisture as limestone do, it does not weather or crack as these stones do. The colours are usually reddish, greenish, or gray. Rainbow granite may have a black or dark green background with pink, yellowish, and reddish mottling or it may have a pink or lavender background with dark mottling.
Crushed granite stone aggregates 10 to 20 mm size was used for cement concrete for comparison. Granite concrete was produced as normal weight concrete to compare with coconut shell aggregate concrete. The bulk density, specific density, water absorption, aggregate impact value, aggregate crushing value, aggregate abrasion value, and particle size distribution were determine

3.2.1(c) Water:

The quality of water is important because contaminants can adversely affect the strength of concrete and cause corrosion of the steel reinforcement. Water used for producing and curing concrete should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete or steel. If the water is drinkable, it is considered to be suitable for concrete making. Hence, potable tap water was used in this study for mixing and curing.

The PH value of water should be in between 6.0 and 8.0 according to IS 456 – 2000.

4. MIX DESIGN:-

M25 GRADE CONCRETE: (IS 10262:2009, IS 10262:1989, IS 456:2000)

MIX PROPORTIONS

Cement = 413.33 kg/m³
Water = 186 kg/m³
Fine aggregate = 632.44 kg/m³
Coarse aggregate = 1115.47 kg/m³
Water-cement ratio= 0.45

CASE-1: (0% sand replace by quarry dust and marble powder)

Proportions of materials

Table 4.18 proportions of ingredients in 0% replacement

Materials	Quantity	
	per 1m³ cube	per 150x150x150 mm³ cube
Cement	413.33 kg	1.39 kg
Fine aggregate	632.44 kg	2.13 kg
Coarse aggregate	1115.47 kg	3.76 kg
Water	186kg	0.62 kg

Usual way of expression:

Cement	Fine aggregate	coarse aggregate	water
1	1.53	2.70	0.45

V. TEST RESULTS

After conducting the necessary tests on materials for mix design and the concrete with various proportions are prepared and tested for its workability as slump cone and compaction factor test with the strength of concrete assessed by compressive strength test and spilt tensile test .

5.1 WORKABILITY TESTS:

The property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product. 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. Unworkable concrete needs more work or effort to be compacted in place, also honeycombs &/or pockets may also be visible in finished concrete. Two tests basically have done for workability namely slump test and compaction factor test with fresh mix.

5.2 STRENGTH TESTS:

Strength test results are used to find out the resistive strength of the material when we used that material. In this experiment we conduct two strength tests namely COMPRESSIVE STRENGTH and SPILT TENSILE STRENGTH

5.3 WORKABILITY TEST RESULTS:

5.3.1 SLUMP CONE TEST VALUES:

Table 5.1 slump cone values

Replacement percentage **Sand : Quarry dust : Marble powder**	**Slump values in mm**
100 : 0: 0	**70**
90 : 5 : 5	**67**
80 : 10 : 10	**64**
70 : 15 : 15	**60**
60 : 20 : 20	**55**
50 : 25 : 25	**53**
40 : 30 : 30	**50**

GRAPH OF SLUMP CONE VALUES:

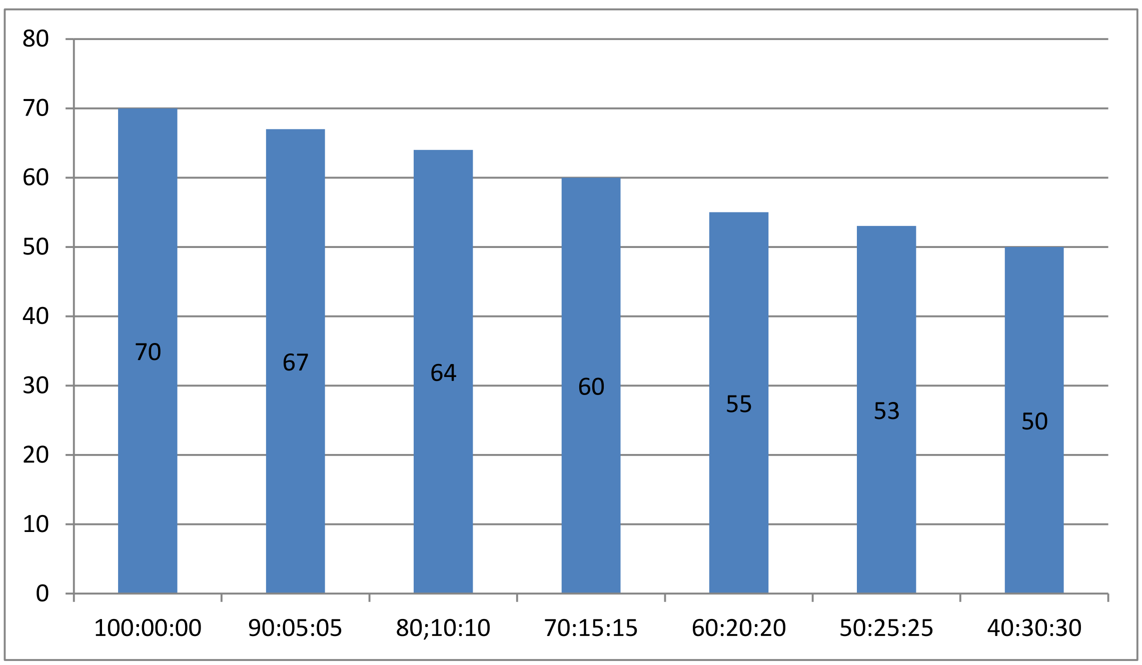

Fig 5.1 Graph of slump cone values

5.3.2 COMPACTION FACTOR RESULTS:

Table 5.2 compaction factor values

Replacement percentages Sand : Quarry dust : Marble powder	Compaction factor values
100 : 0 : 0	**0.922**
90 : 5 : 5	**0.914**
80 : 10 : 10	**0.905**
70 : 15 : 15	**0.891**
60 : 20 : 20	**0.870**
50 : 25 : 25	**0.869**
40 : 30 : 30	**0.855**

GRAPH OF COMPACTION FACTOR VALUES:

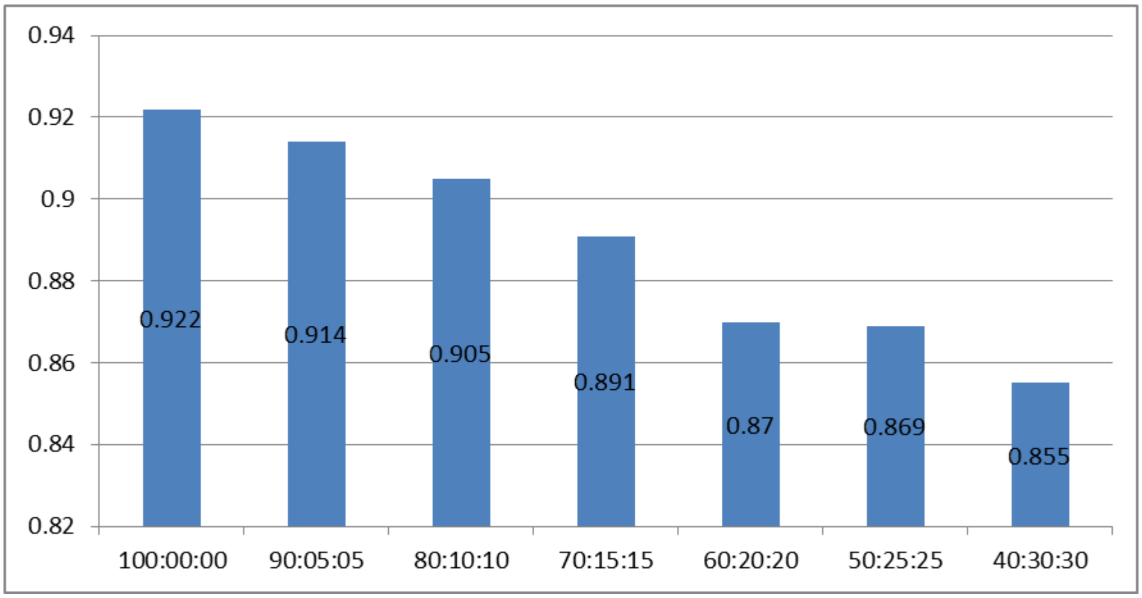

Figure 5.2 Graph of compaction factor values

5.4 STRENGTH TEST RESULTS:

5.4.1 COMPRESSIVE STRENGTH VALUES:

For 7 days

Table 5.3 Compressive strength values at 7 days

S no	Replacement percentage Sand Quarry dust(QD) Marble powder(MP) Sand:QD:MP	Compressive strength values At 7 days N/mm^2			Final compressive Strength value N/mm^2
		Cube1	Cube2	Cube3	
1	100:0:0	21.78	21.52	21.73	22.21
2	90 : 5 : 5	21.76	22.15	21.86	22.54
3	80 :10:10	21.96	22.53	22.58	23.97
4	70:15:15	21.83	23.65	21.83	24.12
5	60 : 20 : 20	23.67	23.82	24.77	24.89
6	50 : 25 : 25	23.92	25.83	26.93	25.59
7	40 : 30 : 30	20.17	2.18	21.23	21.12

GRAPH OF COMPRESSIVE STRENGTH AT 7 DAYS VALUES:

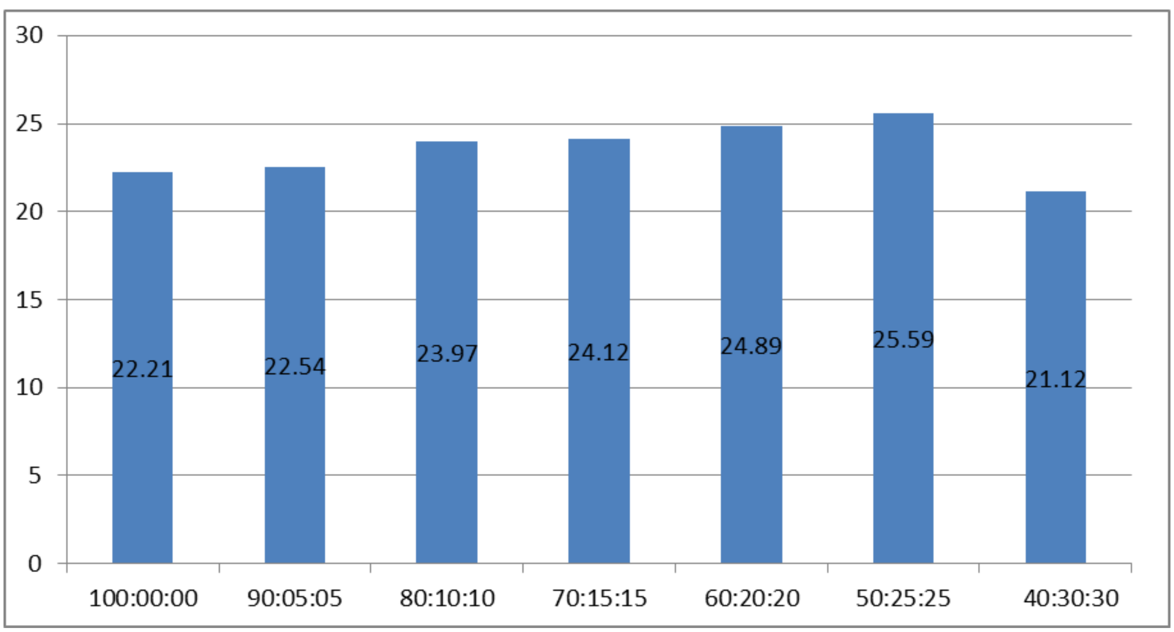

Fig 5.3 Graph of compressive strength values at 7 days

For 28 days

Table 5.4 Compressive strength values at 28 days

S no	Replacement percentage Sand Quarry dust(QD) Marble powder(MP) Sand : QD : MP	Compressive strength values at 28 days N/mm^2			Final compressive Strength value N/mm^2
		Cube1	Cube2	Cube3	
1	100 : 0 : 0	29.97	31.77	32.22	31.67
2	90 : 5 : 5	31.93	31.57	31.71	32.09
3	80 : 10 : 10	31.97	32.82	34.68	33.12
4	70 : 15 : 15	33.17	34.83	33.87	33.97
5	60 : 20 : 20	33.67	34.31	35.67	34.52
6	50 : 25 : 25	34.67	34.81	34.78	35.37
7	40 : 30 : 30	32.04	33.12	33.60	33.12

GRAPH OF COMPRESSIVE STRENGTH AT 28 DAYS VALUES:

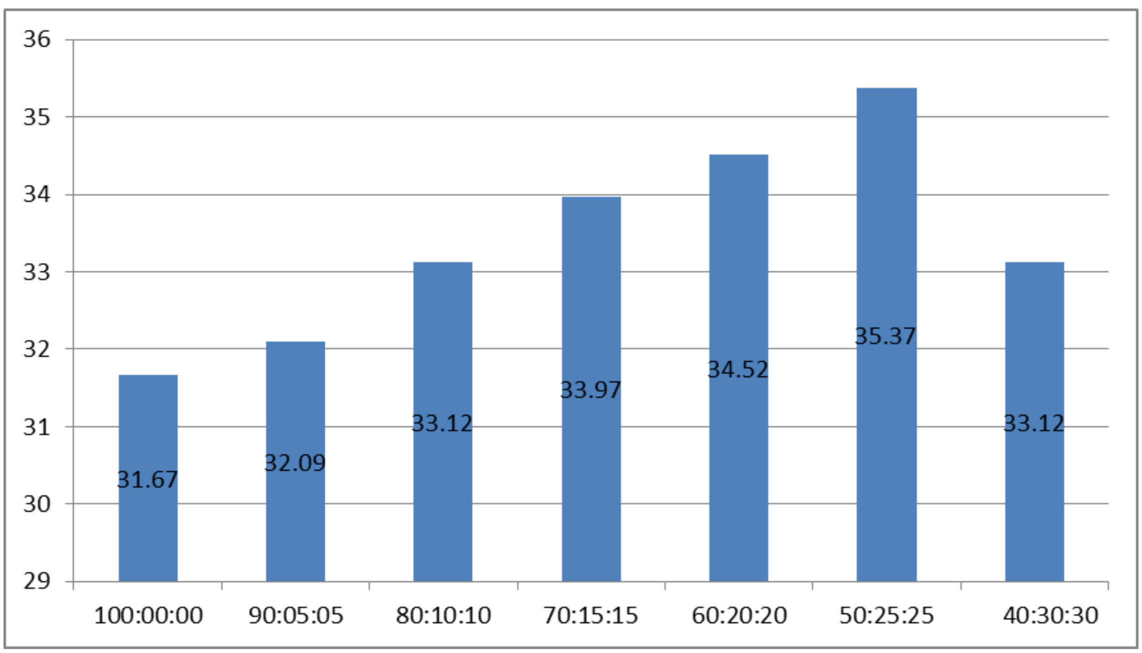

Fig 5.4 Graph of compression strength values at 28 days

5.4.2 SPLIT TENSILE VALUES:

For 7 days

Table 5.5 Split tensile strength values at 7 days

S no	Replacement percentage Sand Quarry dust(QD) Marble powder(MP) Sand : QD : MP	Split tensile strength values at 7 days N/mm²			Final split tensile Strength value N/mm²
		Cylinder 1	Cylinder2	Cylinder3	
1	100 : 0 : 0	1.85	2.0	2.12	1.90
2	90 : 5 : 5	1.94	2.15	2.28	2.11
3	80 : 10 : 10	2.17	2.25	2.31	2.23
4	70 : 15 : 15	2.28	2.41	2.35	2.30
5	60 : 20 : 20	2.31	2.38	2.41	2.37
6	50 : 25 : 25	2.28	2.37	2.49	2.41
7	40 : 30 : 30	2.05	2.01	2.12	2.06

GRAPH OF SPILT TENSILE STRENGTH VALUE AT 7 DAYS:

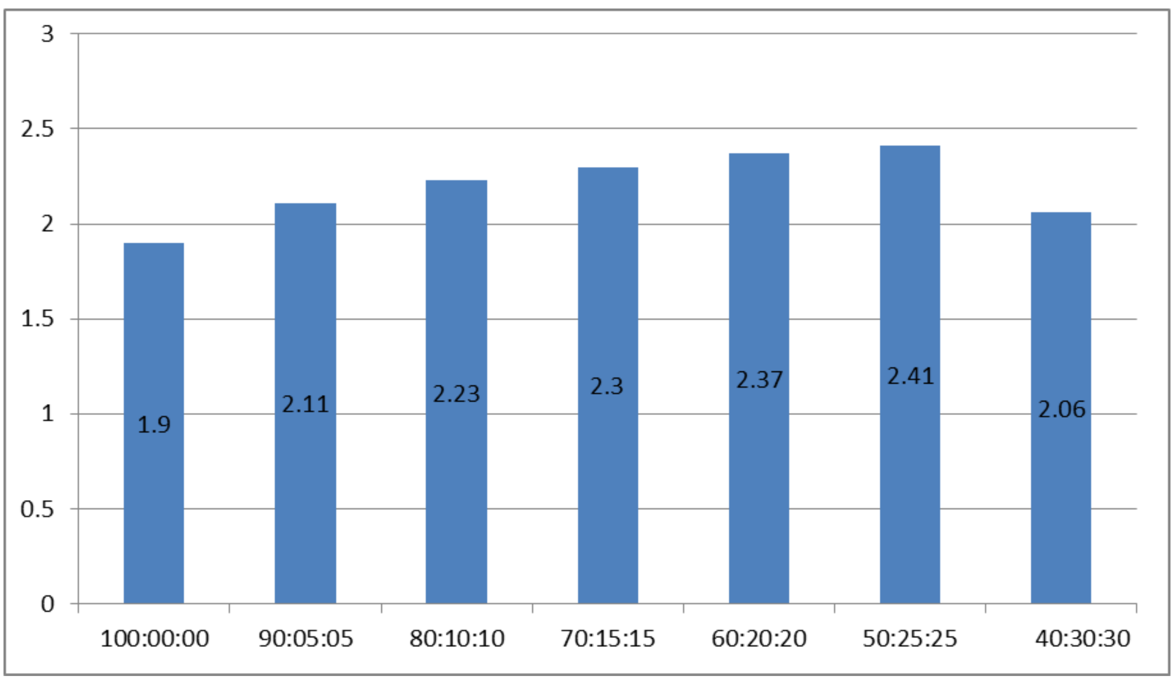

Fig 5.5 Graph of spilt pensile strength values at 7 days

For 28 days

Table 5.6 Split tensile strength values at 28 days

S no	Replacement percentage Sand Quarry dust(QD) Marble powder(MP) Sand : QD : MP	Split tensile strength values at 28 days N/mm^2			Final split tensile Strength value N/mm^2
		Cylinder1	Cylinder2	Cylinder3	
1	100 : 0 : 0	2.94	3.15	3.29	3.17
2	90 : 5 : 5	3.36	3.25	3.48	3.35
3	80 : 10 : 10	3.38	3.48	3.52	3.42
4	70 : 15 : 15	3.31	3.58	3.79	3.52
5	60 : 20 : 20	3.47	3.61	3.52	3.60
6	50 : 25 : 25	3.58	3.70	3.75	3.72
7	40 : 30 : 30	3.31	3.38	3.42	3.37

GRAPH OF SPILT TENSILE STRENGTH VALUE AT 28 DAYS:

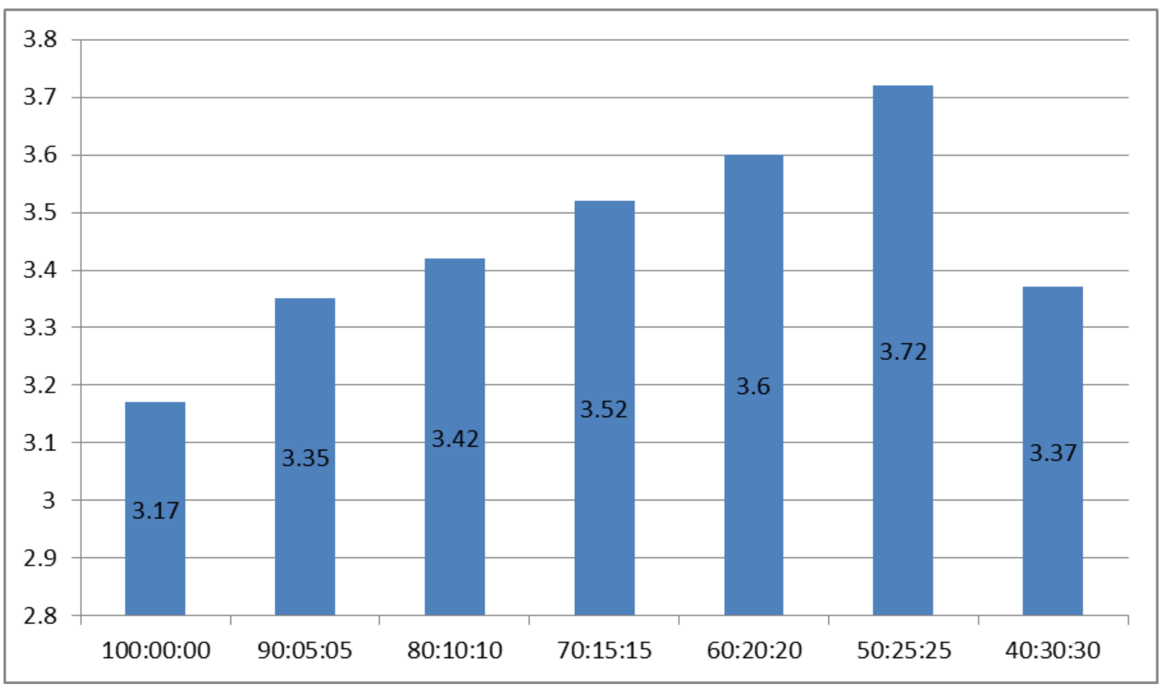

Fig.5.6 Graph of split tensile values at 28 days

VI. DISCUSSIONS

6.1WORKABILITY TESTS:

6.1.1 SLUMP CONE TEST:

From the results it is observed that the workability is decreased by an amount of 4.2%, 8.5%, 14.2%, 21.4%, 24.28% and 28.57% for 10%, 20%, 30%, 40%, 50% and 60% replacement mixes respectively over conventional M25 concrete grade (0% replacement).

6.1.2 COMPACTION FACTOT TEST:

From the results it is observed that the workability is decreased by an amount of 0.86%, 1.84%, 3.36%, 5063%, 5.7% and 7.2% for 10%,20%,30%,40%,50% and 60% replacement mixes respectively over conventional M25 concrete grade (0% replacement).

The workability from both slump cone and compaction factor tests is similar in decreasing manner. The work ability decrease with increase in quarry dust and marble powder content.

6.2STRENGTH TESTS:

6.2.1COMPRESSIVE STRENGTH TEST:

The concrete mix is prepared for M25 grade and fine aggregates is replaced by quarry dust and marble powder as certain equal percentage. These are the values which shows the 7 days and 28days strength of the concrete mix, graph also says, there is increase in strength as compared to conventional concrete. However there is a decrease in compressive strength value concrete mix more than 50% replacement of fine aggregates with quarry dust and marble powder

6.2.2 SPILT TENSILE STRENGTH TEST:

The concrete mix is prepared for M25 grade and fine aggregates is replaced by quarry dust and marble powder as certain equal percentage. These are the values which shows the 7 days and 28days strength of the concrete mix, graph also says, there is increase in strength as compared to conventional concrete. However there is a decrease in spilt tensile strength value concrete mix more than 50% replacement of fine aggregates with quarry dust and marble powder

VII. CONCLUSION

After conducting all testes like workability, compression strength and split tensile strength tests on the prepared cubes and cylinders with the replacement of sand with quarry dust and marble powder concrete. The above all results were obtained, with those the following conclusions are drawn:

- The replacement of fine aggregates is done in the combination of quarry dust and marble powder in equal proportions
- Workability of concrete mix decreases with increase in quarry dust and marble powder content.
- The concrete (After replacement) is acceptable with the values obtained
- The compressive strength of concrete increases up to 50% of replacement(25% quarry dust+25% marble powder)
- The spilt tensile strength of concrete increases up to 50% of replacement(25% quarry dust+25% marble powder)
- The strength of concrete increases because of the rough texture of quarry dust and marble powder which providing higher bonding while reducing the workability compared to conventional concrete
- We also concluded that environmental pollution is reduced by using quarry dust and marble powder as replacement

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