An Experimental Study on Performance of Concrete M20 with Partial Replacement of Fly Ash and Quarry Dust

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Abstract

Concrete is a manmade composite, the major constituent being natural aggregate such as gravel, or crushed rock, sand and fine particles of cement powder all mixed with water. The concrete as time goes on through a process of hydration of the cement paste, producing required strength to withstand the load. The cost of construction materials is increasing day by day because of high demand, scarcity of raw materials, and high price of energy. From the standpoint of energy saving and conservation of natural resources, the use of alternative constituents in construction materials is now a global concern. For this, the extensive research and development works towards exploring new ingredients are required for producing sustainable and environment friendly construction materials. The recycling of solid wastes in civil engineering applications has undergone considerable development over a very longtime. The utilization of fly ash, blast furnace slag, recycled aggregates, red mud, Kraft pulp production residue, waste tea, Quarry dust etc., in construction materials shows some examples of the success of research in this area. Similarly, the recycling of hazardous wastes for use in construction materials and the environmental impact of such practices has been studied for many years. Rapid increase in construction activities leads to acute shortage of conventional construction materials. It is conventional that sand is being used as fine aggregate in concrete. For the past two years, the escalation in cost of sand due to administrative restrictions in India, demands comparatively greater *cost at around two to three times the cost for crusher waste even in places where river sand is available nearby. When examining the above qualities of fly ash and quarry dust it becomes apparent that if both are used together, the loss in early strength due to one may be alleviated by the gain in strength due to the other, and the loss of workability due to the one may be partially negated by the improvement in workability caused by the inclusion of the other.*

Keywords: *Fly Ash, quarry dust, Compressive strength, Workability, Strength Properties*

INTRODUCTION

Concrete is an artificial material similar in appearance and properties to some natural lime stone rock. The function of the fine aggregate is to assist in producing workability and uniformity in the mixture. The river deposits are the most common source of fine aggregate. Now-a-days the natural river sand has become scarce and very costly. The demand for natural sand is quite high in developing countries owing to rapid infrastructural growth which results supply scarcity.

Therefore, construction industries of developing countries are in stress to identify alternative materials to replace the demand for natural sand. On the other hand, the advantages of utilization of byproducts or aggregates obtained as waste materials are pronounced in the aspects of reduction in environmental load & waste management cost, reduction of production cost as well as augmenting the quality of concrete. In this context, fine aggregate has been replaced by quarry dust a byproduct of stone crushing unit and few admixtures to find a comparative analysis for different parameters which are tested in the laboratories to find the suitability of the replacement adhered to the Indian Standard specifications for its strength.

Quarry dust has been used for different activities in the construction industry such as road construction and manufacture of building materials such as light weight aggregates, bricks, and tiles. Crushed rock aggregates are more suitable for production of high strength.

Coarse aggregate of 20mm maximum size is used in Reinforced cement concrete work of all types of structures. This is obtained by crushing the stone boulders of size 100 to 150mm in the stone crushers. Then it is sieved and the particles passing through 20 mm and retained on 10mm sieve known as course aggregate.

The particles passing through 4.75mm sieve are called as quarry dust. The quarry dust is used to sprinkle over the newly laid bituminous road as filler between the bitumen and coarse aggregate and manufacturing of hollow blocks. As well as the utilization of fly ash in concrete as partial replacement of cement is gaining immense importance today, mainly on account of the improvement in the long-term durability of concrete combined with ecological benefits.

APPLICATIONS

- Road sub-base,
- Public highway,
- Truck lane inlays,
- Overlays,
- Intersection inlays,
- Arterial roads,
- Bridge decks,
- Liner for evaporation/drying beds,
- Sludge drying basins, etc.

ADVANTAGES & DISADVANTAGES OF QUARRY DUST AND FLYASH AS REPLAEMENTS

QUARRY DUST

Advantages

- High percentage of dust in the aggregate increases the fineness and the total surface area of aggregate particles
- The use of quarry dust in concrete is desirable because of its benefits such as useful disposal of by products, reduction of river sand consumption as well as increasing the strength parameters and increasing the workability of concrete
- It is used for different activities in the construction industries such as road construction, manufacture of building materials, bricks, tiles and autoclave blocks.

Disadvantages

- Shrinkage is more in when compared to that of the natural river sand
- Water absorption is present so that increase the water addition to the dry mix.
- Low workability

FLY ASH

Advantages

- Use of fly ash improves the workability of concrete and workability increases with the decreases in the grade of cement.
- Normal consistency increases with increase in the grade of cement and fly ash content.
- Bleeding in fly ash concrete is significantly reduced and other properties like cohesiveness,
- pumping characteristics and surface finish are improved

LITERATURE SURVEY

The purpose for taking up this investigation owing to the fact that now a days natural sand confirming to Indian Standards is becoming scarcer and costlier due to its non availability in time because of Law of Land, illegal dredging by sand mafia, accessibility to the river source during rainy season, non confirming with IS 383-1970.

Hence the present investigation was taken up with a view to verify the suitability, feasibility and potential use of crusher dust, a waste product from aggregate crushing plant in concrete mixes, in context of its compressive strength and workability and in terms of slump, compacting factor, flow table and modified flow respectively.

In view of above discussion, an attempt is made to replace the natural sand in concrete control mixes of M25 and M30 grades designed for 100 to 120mm slump at replacement levels of 30%, 40%, 50% and 60% using Portland Pozzolana Cement. There were in all 5 mixes in each grade of concrete including control mix and four mixes with crusher dust as a partial replacement of natural sand.

It was observed that with use of crusher dust at all replacement levels, the workability of concrete was reduced from 1-6%. From the test results, it was observed that the replacement of natural sand by crusher dust increased the compressive strength of concrete by 5-22%. It was also found that amongst all the mixes, the highest compressive strength was obtained for 40% replacement of sand by crusher dust. Hence it could be concluded and recommended that crusher dust could be effectively used in concrete of above grades for replacement levels of sand by 30-60% economically leading to sustainable development.

NEED FOR STUDY

The present study is taken up with an aim to improve the properties of the concrete by putting new materials, whether it is natural materials or recycle materials or synthetic materials in the concrete mix. The additional material can be replacing the aggregate are just as additive and one form of the additive is natural material published in International Journal of Scientific and Research Publications, Volume 3.

OBJECTIVES

The materials used in the present study are OPC 53 grade (Jaypee) cement, fine aggregate conforming to zone-III, coarse aggregate of maximum 20mm size. Selecting the quarry dust of size which is similar to sand which is passing through 4.75µ and retained on 75 µ sieve. The concrete mix corresponding to M20 is chosen for the study. The mix design yielded a proportion of **1:1$^1/_2$:3.**The target of the experimental program was to determine the contribution of natural material type such as quarry dust and flyash to the development of the strength behavior of the confined concrete. The experimental program comprises the following:

- To investigate the feasibility of the combination of quarry dust as fine aggregate in concrete by determining its compressive strength and split tensile strength,
- To investigate the effect of the quarry dust as fine aggregate in concrete content and length to the workability as lightweight aggregate in concrete and also the mechanical properties mentioned above.
- To determine the optimum content of the quarry dust as fine aggregate in concrete to improve the ductility and does not cause reduction the compressive strength.
- To determine the optimum content of the fly ash as cement in concrete to improve the workability.

MATERIALS AND TESTS ON MATERIALS

Cement

Cement is a material that has cohesive and adhesive properties in the presence of water. It consists primarily of silicates and aluminates of lime obtained from limestone and clay. The cement combines chemically with water to form a hardened mass. The hydraulic cement is usually known as Portland cement because of its resemblance upon hardening to the

Portland stone found near dourest, England. There are different types of cement as classified by bureau of Indian standards (BIS): OPC is the acronym commonly used in reference to Portland cement (or Ordinary Portland Cement, which explains the "O" in the acronym). It is the most common cement type used worldwide. OPC is the basic component used for concrete, mortars, stucco, and other common construction essentials that require cement in the mixture. It is designated as a type of hydraulic cement, which means that it is a type of cement that doesn't only harden as a reaction to being mixed with water, but also becomes water-resistant once it cures. It is produced through pulverizing Portland cement clinkers, which consists of hydraulic calcium silicates, producing a fine powder. The Portland cement clinkers are initially created through heating a mixture of raw materials, the most important being limestone. Secondary materials include a source of aluminosilicate (often clay, but could also be impure limestone). Other common secondary materials are shale, sand, iron ore, bauxite, fly ash, and slag. These are then heated at around 1450 °C, which is the standard temperature used for producing most cements in this day and age. When water is mixed with OPC, it takes some hours to settle and gradually hardens and increases in durability. This process can vary depending on what the mixture is and what the desired result is.

Ordinary Portland cement is the most prevalent because of the readily available raw materials in the area where it is produced. This is also why OPC is an ideal option for cement needs throughout the world today as the costs of producing it is very low without compromising quality. Being a low-cost cement product leads to OPC being widely used in the production of concrete, which is the most popular material used for construction in the world for roads, houses, buildings, dams, and the like. OPC is also used for mortars and in making grouts.

In relation to this, PPC refers to a form of Portland cement which is Portland Pozzolana Cement. PPC is produced when pozzuolans are used in the mixture. A pozzuolans is a cement extender improving the strength and durability of the cement or even reducing the costs of producing concrete. The term came from the root word "pozzuolana" which is a form of volcanic ash. The introduction of pozzuolana into hydraulic cement like OPC, or any similar material, leads to a pozzuolanic reaction. This, in turn, leads to a cementitious material that uses less cement but has the same or even greater material durability than without this addition. A pozzuolanic material by itself has few, if any; cementitious properties by it, but adding it into a cement mixture will result in the above-mentioned results (provided the cement has a greater volume in relation to the pozzuolanic material added).

PPC may take a longer time to settle than OPC, but it will eventually produce similar results given time. Though volcanic ash is the first form of pozzuolana used, this now includes natural and artificial siliceous or siliceous, aluminous materials such as clay, slag, silica fume, fly ash, and shale. Note that some of these are effectively "waste" materials from other processes but are ideal to produce PPC. With the production of PPC, the use of overall OPC is greatly reduced in the mixture (by close to 50 per cent) to produce the same results.

1. 33 grade ordinary Portland cement (IS: 269-1989).
2. 43 grade ordinary Portland cement (IS: 8112-1989).
3. 53 grade ordinary Portland cement (IS: 1229-1987).

In the present context, ordinary Portland cement (opc) confirming to 53 grade, had been utilized.

FLY ASH

A. Origin of the Fly-ash:

The fly ash is the by-product that is formed in the thermal power plants. This is used as a partial replacement of cement now-a-days in general cases.

B. Properties of Fly-ash:

The physical and chemical properties are tested according to the standard specifications.

Table:-1 Showing the Chemical properties [8]

Chemical Compound	Percentage Present
SiO2	55.5
Al2O3	31.3
Fe2O3	6.4
CaO	1.02
MgO	0.21
Alkalis equivalent	Nil
TiO2	2.7
SO3	0.44
Loss on Ignition	0.74

C. Specific gravity of fly ash:

1	Weight of empty bottle	w_1,gm	35.48
2	Weight of empty bottle +fly ash	w_2,gm	53.64
3	Weight of empty bottle + fly ash+ kerosene	w_3,gm	87.45
4	Weight of empty bottle + kerosene	w_4,gm	76.35
5	Weight of empty bottle + water	w_5,gm	87.24
6	Sp. Gr of kerosene s= $\frac{(w4-w1)}{(w5-w1)}$		0.792
7	Sp. Gr of fly ash **S** = $\frac{(w2-w1)}{(w4-w1)-(w3-w2)} * s$		2.0372

AGGREGATES

The aggregate like sand, brick, and stone are inert materials. They occupy about 80% of the total volume of the concrete. It is logical to use maximum of aggregate, since they provide bulk to the concrete, are less expensive than cement and are freely available in nature. The aggregates are classified as:

1. Fine aggregates.
2. Coarse aggregates.
3. Quarry dust

The aggregates comply with the requirements of IS: 380-1970.

FINEAGGREGATES

Fine aggregates are the materials passing through an IS sieve that is less than 4.75mm gauge. Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO_2), usually in the form of quartz.

The second most common form of sand is calcium carbonate, for example aragonite, which has mostly been created, over the past half billion years, by various forms of life, like coral and shellfish. It is, for example, the primary form of sand apparent in areas where reefs have dominated the ecosystem for millions of years like the Caribbean. Heavy minerals (dark) in a quartz beach sand (Chennai, India).

Sand from Coral Pink Sand Dunes State Park, Utah. These are grains of quartz with a hematite coating providing the orange color. Sand from Pismo Beach, California.

Components are primarily quartz, chert, igneous rock and shell fragments.

The most common constituent of sand, in inland continental settings and non-tropical coastal settings, is silica (silicon dioxide, or SiO_2), usually in the form of quartz, which, because of its chemical inertness and considerable hardness, is the most common mineral resistant to weathering.

The composition of sand is highly variable, depending on the local rock sources and conditions. The bright white sands found in tropical and subtropical coastal settings are eroded limestone and may contain coral and shell fragments in addition to other organic or organically derived fragmental material, suggesting sand formation depends on living organisms.

The gypsum sand dunes of the White Sands National Monument in New Mexico are famous for their bright, white color. Arkose is a sand or sandstone with considerable feldspar content, derived from the weathering and erosion of a (usually nearby) granitic rock outcrop. Some sands contain magnetite, chlorite, glauconitic or gypsum. Sands rich in magnetite are dark to black in color, as are sands derived from volcanic basalts and obsidian. Chlorite-glauconitic bearing sands are typically green in color, as are sands derived from basaltic (lava) with a high olivine content. Many sands, especially sand, giving a deep yellow color. Sand deposits in some areas contain garnets and other resistant minerals, including some small gemstones.

COARSE AGGREGATES

Coarse aggregates are the materials that are retained on 4.75mm IS sieve. The coarse aggregate form the main matrix of concrete, whereas fine aggregate form the filter matrix between the coarse aggregate. The most important function of the fine aggregate is to provide workability and uniformity in the mixture. The fine aggregate also helps the cement paste to hold the coarse aggregate particles in suspension. This leads to plasticity in the mixture and presents the possible segregation of paste and coarse aggregate.

Fig 1 Coarse Aggregate

For maximum durability, the aggregate should be packed and cemented as compactly as possible. For this reason the gradation of particle sizes in the aggregate to produce close packing is considerable importance. It is also necessary that the aggregate have good strength, durability and weather resistance, their surface be free from impurities such as loam, silt and organic matter which may weaken the bond with the cement paste, and that no unfavorable chemical reaction takes place between them and the cement.

The aggregate obtained from river beds or creek or pits are most often not clean enough or well graded to meet the quality requirements. It is therefore strongly recommended that they be sieved and washed before use in concrete.

The aggregate should be stored very carefully so that they do not get contaminated with dust, soil mud or vegetation. In the present context, sand confirming to zone-III had been used as fine aggregate which is obtained from river Godavari. The gravel confirming to 20mm average size had been used as a coarse aggregate which is obtained locally.

QUARRY DUST

*A. **Origin of Quarry Dust**:*

The quarry dust is the by-product which is formed in the processing of the granite stones which broken downs into the coarse aggregates of different sizes.

*B. **Physical and chemical Properties**:*

The physical and chemical properties of quarry dust obtained by testing the sample as per the Indian Standards are listed in the below table.

Fig. 2 Quarry dust

Table:-2 Show the physical properties of quarry dust and natural sand [2]

Property	Quarry Dust	Natural Sand	Test method
Specific gravity	2.54 -2.60	2.60	IS2386(Part III)- 1963
Bulk density (kg/m3)	1720- 1810	1460	IS2386(Part III)- 1963
Absorption (%)	1.20- 1.50	Nil	IS2386(Part III)- 1963
Moisture Content (%)	Nil	1.50	IS2386(Part III)- 1963
Fine particles less than 0.075 mm (%)	12-15	6	IS2386(Part III)- 1963
Sieve analysis	Zone-II	Zone-II	IS 383- 1970

Table:-3 Show the Typical chemical properties of quarry dust and natural sand [2]

Constituents	Quarry Dust (%)	Natural Sand (%)	Test method
SiO2	62.48	80.78	IS 4032-1968
Al2O3	18.72	10.52	
Fe2O3	6.54	1.75	
CaO	4.83	3.21	
MgO	2.56	0.77	
Na2O	Nil	1.37	
K2O	3.18	1.23	
TiO2	1.21	Nil	
Loss of ignition	0.48	0.37	

Water

For proper chemical action, the amount of water required is about 25% of the weight of cement used. However, more water is used for proper workability of concrete. The water used for both mixing and curing should be free from injurious amount of oils, acids, alkalis, salts, organic, materials or other substances that may be harmful to concrete. Potable water is considered to be satisfactory for mixing concrete. The water is tested in accordance with IS: 3025-1984 to 1988. The P^H value of water should be more than 6.

TESTS ON CEMENT

The various tests that have been conducted on the above discussed cement are:

1. Specific gravity of cement
2. Fineness of cement
3. Standard consistency of cement
4. Initial and final setting times of cement.

SPECFIC GRAVITY OF CEMENT

Specific gravity is normally defined as the ratio between the mass of a given volume of material and mass of an equal volume of water. One of methods of determining the specific gravity of cement is by the use of a liquid such as water –free kerosene which does not react with cement. A specific gravity bottle may be employed or a standard Le chatelier flask may be used ***(See Figure:-4)***

FINENESS OF CEMENT

It is used to determine the fineness of the given sample by dry sieving. The apparatus used in fineness of cement are IS 9 test sieve confirming to IS: 460-1972 with bottom pan, weighing balance, bristle brush. The degree of fineness of cement is a measure of the mean size of the grains. The finer cement has quicker action with water and grains early strength without change in its ultimate strength finer cement is susceptible to shrinkage and cracking. A correction factor is to be applied for fineness of cement as all sieves are not exactly like.

For the present study,

The fineness of ordinary Portland cement= 2%

Table:- 4

1	Weight of empty bottle w_1,gm	35.77
2	Weight of empty bottle+ cement w_2,gm	68.77
3	Weight of empty bottle +cement+ kerosene w_3,gm	101.19
4	Weight of empty bottle + kerosene w_4,gm	76.63
5	Weight of empty bottle + water w_5,gm	87.24
6	Sp. Gr of kerosene s= $\frac{(w4-w1)}{(w5-w1)}$	0.7938
7	Sp. Gr of cement **S** = $\frac{(w2-w1)}{(w4-w1)-(w3-w2)} * s$	3.14

STANDARD CONSISTENCY TEST

For finding out initial setting time, final setting time and soundness of cement, a parameter known as standard consistency test has to be used. It is pertinent at this stage to describe the procedure of conducting test. The standard consistency of a cement paste is defined as that consistency which will permit a vicat plunger having 10 mm diameter and 50mm length to a depth of 33-35mm from the top of the mould. The apparatus is called vicat apparatus. This apparatus is used to find out the percentage of water required to produce a cement paste of standard consistency. The standard consistency of cement paste is sometimes called normal consistency (CPNC).

The following procedure is adopted to find out standard consistency. Take about 500gms of cement and prepare a paste with a weighed quantity of water (say 24 percent by weight of cement) for the first trail. The paste must be prepared in a standard manner and filled into the vicat mould within 3-5 minutes. After completely filling the mould, shake the mould to expel air.

A standard plunger, 10mm diameter, 50mm long is attached and brought down to touch surface of the paste in the test block and quickly released allowing it to sink into the paste by its own weight. Take the readings by noting the depth of penetration of the plunger. Conduct a 2nd trial (say with 25% of water) and find out the depth of penetration of plunger. Similarly, conduct trails with higher and higher water/cement ratios till such time the plunger penetrates for a depth of 33-35mm from the top. That particular percentage of 33-35mm from the top is known as the percentage of water required to produce a cement paste of standard consistency. This percentage is usually denoted as ‘p’.

INITIAL AND FINAL SETTING TIMES OF CEMENT

Initial setting time

Lower the needle (C) gently and bring it in contact with the surface of the test block and quickly release. Allow it to penetrate into the test block. In the beginning, the needle will completely pierce through the test block. But after some time when the paste starts losing its plasticity, the needle may penetrate only to a depth of 33-35mm from the top. The period elapsing between the time when water is added to the cement and the time at which the needle penetrates the test block to a depth equal to 33-35mm from the taken as initial setting time.

Final setting time

Replace the needle (C) of the vicat apparatus by a circular attachment (F). the cement shall be considered as finally set when, upon, lowering the attachment gently cover the surface of the test block, the center needle makes an impression, while the circular cutting edge of the attachment fails to do so. In other words the paste has attained such hardness that the center needle does not pierce through the paste more than 0.5mm.

For the present project

Standard consistency of ordinary Portland cement=30%

Initial setting time of OPC= 45 min

Final setting time of OPC= 520 min

TESTS ON AGGREGATES

The various tests that have been conducted on the above discussed aggregates are:

1. Bulk density
2. Specific gravity
3. Fineness modulus.

BULK DENSITY

The bulk density or unit weight of aggregate gives valuable information's regarding the shape and grading of the aggregate. For a gives specific gravity the angular aggregate show a lower bulk density. The bulk density of aggregate is measured by filling a container of known volume in a standard manner and weighing. Bulk density shows how densely the aggregate is packed when filled in a standard manner. The bulk density depend s on the particle size distribution and shape of the particles. For determination of bulk density the aggregate are filled in the container and then they are compacted in a standard manner. The weight of the aggregate gives the bulk density calculated in kg/liter.

The bulk density $=\frac{w3-w1}{w2-w1}$, in kg / lit.

Where,

w_1=weight of empty container$A = \pi r^2$

w_2=weight of container with water

w_3=weight of container with compacted aggregates.

For the present study,

The bulk density of fine aggregate= 1556 kg/cubic meter.

The bulk density of coarse aggregate=1695 kg/cubic meter.

FINENESS MODULUS

It is used to determine the fineness modulus of fine aggregate and coarse aggregate. The apparatus used is Indian standard test oven test, weighing balanced sieve shaken, and pen tray. Fineness in the total quantity of aggregate fineness is to grade the given aggregate for most economical mix and workability with less consumption of cement. Lower fineness modulus gives uneconomical mix and higher fineness modulus gives harsh mix. The sieves used fineness modulus are as follows:80mm, 40mm, 20mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 600micron, 300micron, 150micron.

For the present study,

The fineness modulus of fine aggregate=2.78

The fineness modulus of coarse aggregate=7.62

SPECIFIC GRAVITY

In concrete technology, specific gravity of aggregate is made use of in design calculations of concrete mixes. With the specific gravity of each constituent known. Specific gravity of aggregate is also required in calculating the compacting factor in connection with the workability measurements. Similarly, specific gravity of aggregate is required to be considered when we deal with lightweight and heavy weight concrete. Average specific gravity of the rocks varies from 3.6 to 3.8.

Specific gravity Gs = $\frac{w2-w1}{(w4-w1)-(w3-w2)}$

.

Where,

w_1= weight of empty pycnometer

w_2=weight of pycnometer with aggregate

w_3=weight of pycnometer with aggregate and water

w_4=weight of pycnometer full of water.

Table 5 The following table consists of weights of different materials which are used in concrete:

Weight	**Fine aggregates (sand) Kg**	**Coarse aggregates (gravel) Kg**	**Partially replacing aggregates (Quary Dust) Kg**
w_1= weight of empty pycnometer	0.60	0.60	0.60
w_2=weight of pycnometer with aggregate	1.21	0.96	1.10
w_3=weight of pycnometer with aggregate and water	1.83	1.68	1.72
w_4=weight of pycnometer full of water.	1.44	1.46	1.45

Calculation

The specific gravity of coarse aggregate

$$SPG = \frac{w2-w1}{(w4-w1)-(w3-w2)}.$$

$$= \frac{0.96-0.60}{(1.46-0.60)-(1.68-0.96)} = \mathbf{2.57}$$

The specific gravity of fine aggregate =**2.7**

The specific gravity of Quary Dust aggregate = **2.17**

The above values were calculated from the weights of different materials (i.e. coarse aggregates, sand and Quary Dust) shown in table 2.1

DESIGN OF MIX FOR M20 GRADE CONCRETE

The grade of concrete for OPC 53 used in this investigation is M20. The mix design is based on strength criteria and durability criteria used for moderate environment. The ratios by weight of cement, fine aggregate and coarse aggregate are obtained using the equations given in IS: 10262-1982 are given below. These proportions are strictly same throughout the casting process to obtain a uniform standard and workable concrete mix. Cubes were tested for compressive strength after 7days, 14days, 28days curing. The compressive tests on cubes are conducted. Slump cone test also conducted to note the workability of the mix.

Details of trail mix design (durability criteria) for OPC as per IS 456:2000:

Mix proportion by

WEIGHT: 1: 1.24:2.92, w/c=0.5

(See Table 6)

TESTS AND RESULTS OF SAMPLES

Initially we were cast by adding the above materials in the concrete for the normal batching. The specific sizes of mould are 150×150×150mm.Then the tests are conducted after 7days, 14days and 28days.

Table 6 Materials required per 1m3of concrete

Cement (kg)	Sand (kg)	Coarse-Aggregate (kg)	Water
389.16	483.5	1136.5	191.58

For aggregate replacement:

To improve the properties of the concrete by putting new materials, whether it is natural materials or recycle materials or synthetic materials in the concrete mix. The additional material can be replacing the aggregate are just as additive and one form of the additive is natural material i.e. quary dust and fly ash and the proportions are tabulated in the table 7

In this project we were used quary dust and fly ash aggregates, which are more available natural waste in India.

Design of aggregate weights for partially replacement of 0%, 10%, 20%, and 30%.

Required Quantity of Coarse aggregate V = 115.29 kgs.

Quantity of quary dust and fly ash aggregate replaced by of coarse aggregates

$$w = \left[W \times \frac{Sc}{Sg}\right] \times \frac{c}{100}$$

Where w=weight of quary dust and fly ash required for mixing,

W=weight of coarse aggregate as per design,

S_c=specific gravity of quary dust and fly ash aggregate,

S_g=specific gravity of coarse aggregates,

c=percentage of CSA replaced in Coarse aggregates.

Table: - 7 Material compositions at difference percentages of quarry dust

Percentage of partially replacing sand with quarry dust	**Fine aggregate (sand)+ quarry dust**
At 10%	22.65+2.52
At 20%	20.132+5.033
At 30%	17.6155+7.5495
Percentage of partially replacing cement with fly ash	**Fine aggregate(cement)+fly ash**
At 10%	18.2538+2.0282
At 20%	16.2256+4.0564
At 30%	14.1974+6.0846

COMPRESSIVE STRENGTH

Concrete mixture can be designed to provide a wide range of mechanical and durability properties to meet the design requirements of a structure. The compressive strength of concrete is the most common performance measure used by the engineer in designing building and other structure. The compressive strength is measured by breaking concrete cubes specimens in a compressive testing machine .the compressive strength is calculated from failure load divided by the cross sectional area resisting.

The compressive strength of concrete is one of the most important and useful properties of concrete. In most structural applications concrete is employed primarily to resist compressive stresses.

In those cases where strength in tension or in shear is of primary importance, the compressive strength is frequently used as a measure of these properties. Therefore, the concrete making properties of various ingredients of mix are usually measured in terms of the compressive strength. Compressive strength is also used as a qualitative measure for other properties of hardened concrete. No exact quantitative relationship between compressive strength and flexural strength, tensile strength, modulus of elasticity, wear resistance, fire resistance, or permeability have been established nor are they likely to be. However, approximate or statistical relationships, in some cases, have been established and these give much useful information to engineers. It should be emphasized that compressive strength gives only an approximate value of these properties and that other tests specifically designed to determine these properties should be useful if more precise results are required. For instance, the indicated compressive strength increases as the specimen size decreases, whereas the modulus of elasticity decreases. Concrete containing about 6 per cent of entrained air which is relatively weaker in strength is found to be more durable than dense and strong concrete. The compressive strength of concrete is generally determined by testing cubes as shows in fig 5.2 or cylinders made in laboratory or field or cores drilled from hardened concrete at site or from the non-destructive testing of the specimen or actual structures. The testing of hardened concrete is discussed in the subsequent chapter. Strength of concrete is its resistance to rupture.

It may be measured in a number of ways, such as, strength in compression, in tension, in shear or in flexure. All these indicate strength with reference to a method of testing. When concrete fails under a compressive loathe failure is essentially a mixture of crushing and shear failure. The mechanics of failure is a complex phenomenon. It can be assumed that the concrete in resisting failure generates both cohesion and internal friction.

Initially we were cast by adding the above materials in the concrete for the normal batching. The specific sizes of mould are 150×150×150mm.

Then the tests are conducted after 7days, 14days, 28 days and 56 days. The following table consists of ultimate loads or breaking loads of different cubes curing in water at 7days, 14days, 28 days and 56 days. And also the table consist of the strength calculated by using the mathematical formula $f_{ck}=\frac{p}{a}$ and average strength of particular cube.

Compressive strength=$\frac{\text{load}}{\text{surface area}}$.N/mm^2

RESULTS AND TABLES

Results were calculated for normal mixing, quarry dust and fly ash concrete mixing with 0%,10%,20% and 30% of quary dust and fly ash of compressive strength are tabulated and graphs were drawn between strength to curing period and maximum strength of concrete at different percentages are shown in the tables from 8 to 12.

Table:-8 The table shows load and compressive strength of normal mix of M (1:1.24:2.92) for different curing periods

Curing period		**Load (p) KN**	$Strength = \frac{P}{A}$**(N/mm²)**	**Average strength (N/mm²)**
7DaysS	1st sample	462.7	$\frac{462700}{22500}$ =20.56	21.09
	2nd sample	489.2	$\frac{489200}{22500}$ =21.74	
	3rd sample	471.9	$\frac{471900}{22500}$ =20.97	
14Days	1st sample	537.2	$\frac{537200}{22500}$ =23.87	23.97
	2nd sample	543.7	$\frac{543700}{22500}$ =24.16	
	3rd sample	540.5	$\frac{540500}{22500}$ =24.02	

28Days	1st sample	619.1	$\frac{619100}{22500}$ =27.51	27.31
	2nd sample	611.9	$\frac{611900}{22500}$ =27.19	
	3rd sample	613	$\frac{613000}{22500}$ =27.24	
56 Days	1st sample	660.38	$\frac{660380}{22500}$ = 29.35	29.22
	2nd sample	647.55	$\frac{647550}{22500}$ = 28.78	
	3rd sample	664.88	$\frac{664880}{22500}$ = 29.55	

The graph shown compressive strength of 7, 14, 28 and 56 Days for normal mixing

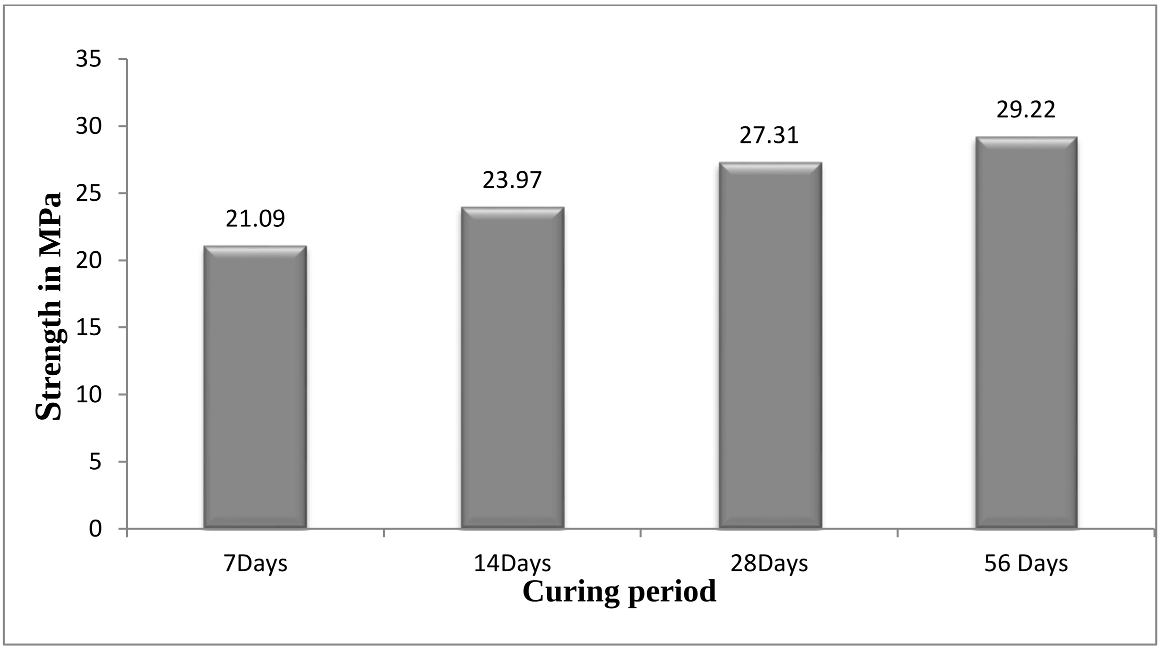

Fig 3 Compressive Strength

- As indicated in the graph (fig 3), after 7 days the compressive strength of sample is 21.09N/mm2.
- As indicated in the graph (fig 3), after 14 days the compressive strength of sample is 23.97N/mm2.
- As indicated in the graph (fig 3), after 28 days the compressive strength of sample is 27.31N/mm2.
- As indicated in the graph (fig 3), after 28 days the compressive strength of sample is 29.22 N/mm2.

Table 9 The table shows loads and compressive strength of 10% replacing with quarry dust in coarse aggregate and of 10% replacing with fly ash in cement of concrete.

Curing period		**Load (p) KN**	$Strength = \frac{P}{A}$ **(N/mm²)**	**Average strength (N/mm²)**
7 Days	1st sample	387.9	$\frac{387900}{22500}$ =17.24	17.43
	2nd sample	393.5	$\frac{393500}{22500}$ =17.49	
	3rd sample	395	$\frac{395000}{22500}$ =17.55	
14 Days	1st sample	421.6	$\frac{421600}{22500}$ =18.74	18.99
	2nd sample	426.9	$\frac{426900}{22500}$ =18.97	
	3rd sample	433.4	$\frac{433400}{22500}$ =19.26	
28 Days	1st sample	524.3	$\frac{524300}{22500}$ =23.3	23.57
	2nd sample	529.4	$\frac{529400}{22500}$ =23.52	
	3rd sample	537.5	$\frac{537500}{22500}$ =23.89	
56 Days	1st sample	574.88	$\frac{574880}{22500}$ = 25.55	25.11
	2nd sample	555.07	$\frac{555070}{22500}$ = 24.67	
	3rd sample	565.20	$\frac{565200}{22500}$ = 25.12	

The graph shows compressive strength of 7, 14, 28 and 56 Days for 30% of QD&FA.

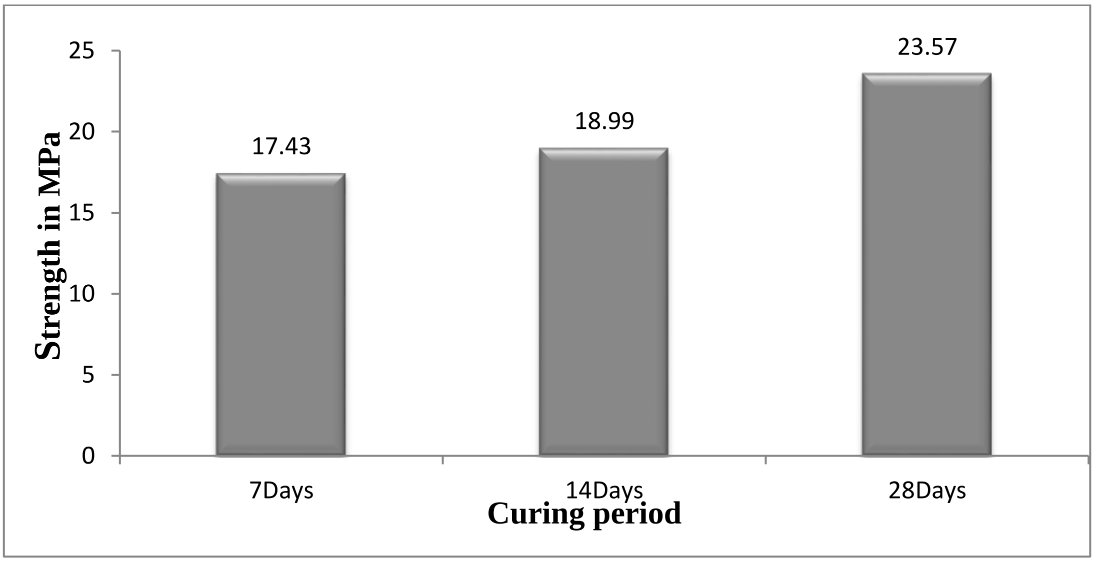

Fig 4 Compressive Strength

- As indicated in the graph (fig 4), after 7 days the compressive strength of sample is 17.43N/mm^2.
- As indicated in the graph (fig 4), after 14 days the compressive strength of sample is 18.99N/mm^2.
- As indicated in the graph (fig 4), after 28 days the compressive strength of sample is 23.57N/mm^2.
- As indicated in the graph (fig 4), after 56 days the compressive strength of sample is 25.11 N/mm^2.

Table 10 The table shows loads and compressive strength of 20% replacing with quarry dust in coarse aggregate and of 20% replacing with fly ash in cement of concrete.

Curing period		Load (p) KN	$Strength = \frac{p}{A}$ (N/mm^2)	Average strength (N/mm^2)
7Days	1st sample	407.5	$\frac{407500}{22500}$ =18.11	17.88
	2nd sample	401.7	$\frac{401700}{22500}$ =17.85	
	3rd sample	398.3	$\frac{398300}{22500}$ =17.7	
14Days	1st sample	451.3	$\frac{451300}{22500}$ =20.06	20.02
	2nd sample	442.7	$\frac{442700}{22500}$ =19.67	
	3rd sample	457.2	$\frac{457200}{22500}$ =20.32	
28Days	1st sample	571.5	$\frac{571500}{22500}$ =25.4	25.45
	2nd sample	577	$\frac{577000}{22500}$ =25.64	
	3rd sample	569.9	$\frac{569900}{22500}$ =25.33	
56 Days	1st sample	610.20	$\frac{610200}{22500}$ = 27.12	27.16
	2nd sample	604.12	$\frac{604120}{22500}$ = 26.85	
	3rd sample	619.42	$\frac{619420}{22500}$ = 27.53	

The graph shows compressive strength of 7, 14, 28 and 56 Days for 20% of QD&FA.

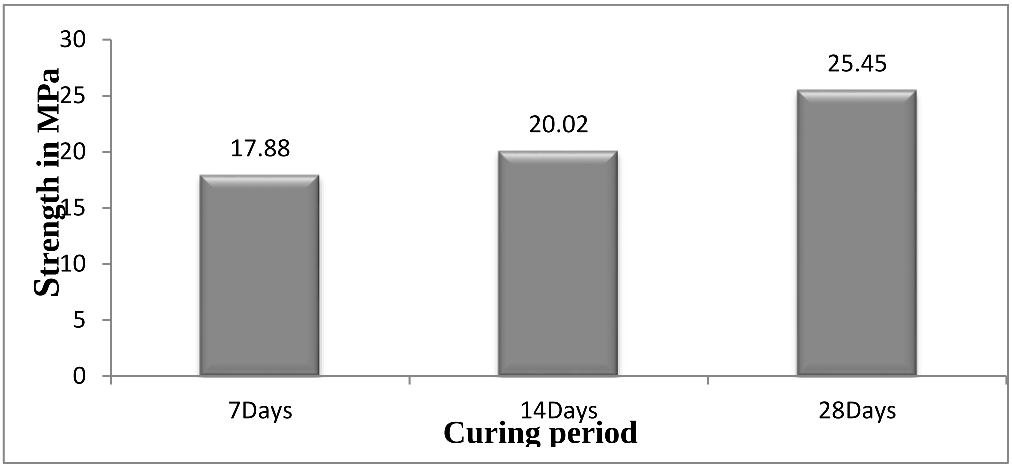

Fig 5 Compressive Strength

- As indicated in the graph (fig 5), after 7 days the compressive strength of sample is 17.88N/mm^2.
- As indicated in the graph (fig 5), after 14 days the compressive strength of sample is 20.02N/mm^2.
- As indicated in the graph (fig 5), after 28 days the compressive strength of sample is 25.45N/mm^2.
- As indicated in the graph (fig 5), after 56 days the compressive strength of sample is 27.16 N/mm^2.

Table 11 The table shows loads and compressive strength of 30% replacing with quarry dust in coarse aggregate and of 30% replacing with fly ash in cement of concrete.

Curing period		Load (p) KN	$Strength = \frac{P}{A}$(N/mm^2)	Average strength (N/mm^2)
7 Days	1st sample	440	$\frac{440000}{22500}$ =19.55	19.42
	2nd sample	431.7	$\frac{431700}{22500}$ =19.18	
	3rd sample	439.5	$\frac{439500}{22500}$ =19.53	
14 Days	1st sample	511.3	$\frac{511300}{22500}$ =22.72	22.8
	2nd sample	521.2	$\frac{521200}{22500}$ =23.16	

	3rd sample	507.2	$\frac{507200}{22500}$ =22.54	
28 Days	1st sample	607.2	$\frac{607200}{22500}$ =26.98	26.75
	2nd sample	601.5	$\frac{601500}{22500}$ =26.73	
	3rd sample	597.3	$\frac{597300}{22500}$ =26.55	
56 Days	1st sample	634.95	$\frac{634950}{22500}$ = 28.22	28.08
	2nd sample	613.12	$\frac{613120}{22500}$ = 27.25	
	3rd sample	647.32	$\frac{647320}{22500}$ = 28.75	

The graph shows compressive strength of 7, 14, 28 and 56 Days for 30% of QD&FA

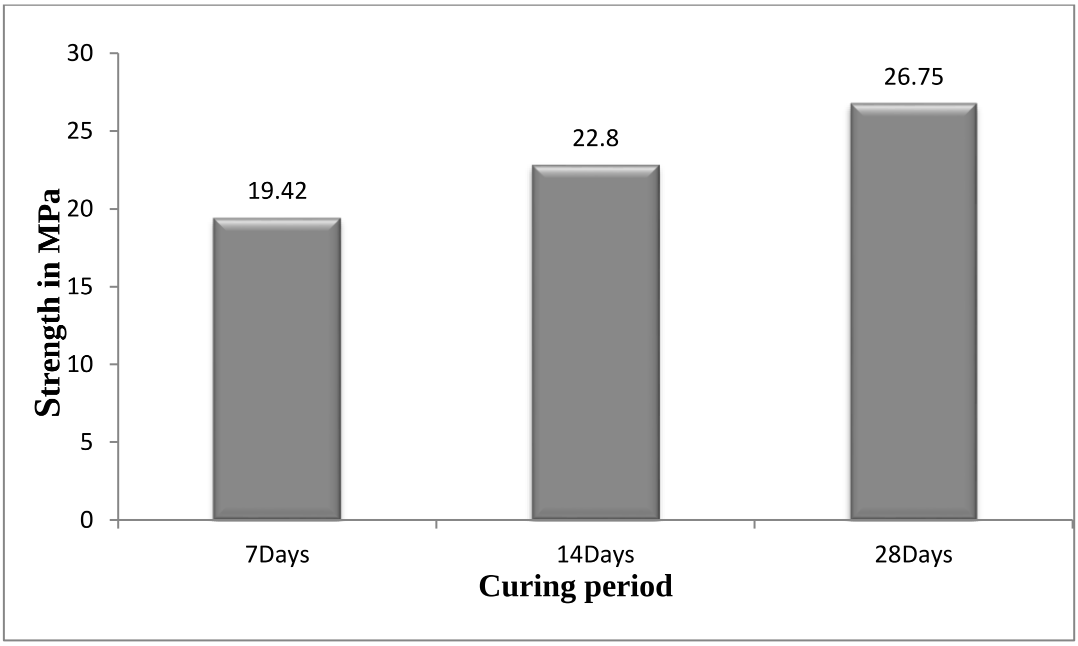

Fig 6 Compressive Strength

- As indicated in the graph (fig 6), after 7 days the compressive strength of sample is 19.42 N/mm^2.
- As indicated in the graph (fig 6), after 14 days the compressive strength of sample is 22.8 N/mm^2.
- As indicated in the graph (fig 6), after 28 days the compressive strength of sample is 26.75N/mm^2.
- As indicated in the graph (fig 6), after 56 days the compressive strength of sample is 28.08 N/mm^2.

The graph shows comparison of normal concrete and quarry dust concrete

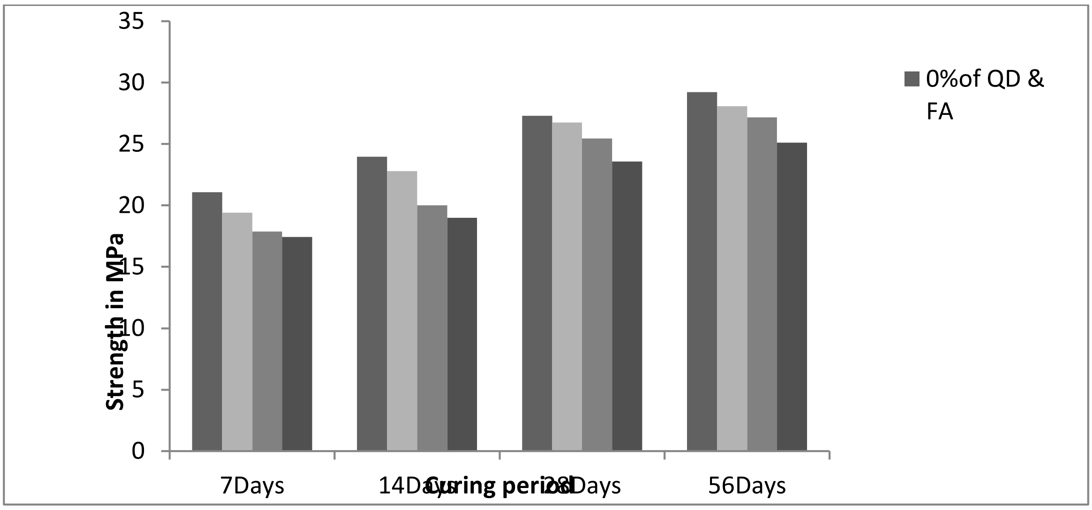

Fig 7 Compressive Strength

The graph shows the maximum compressive strength at different percentage of QD and FA

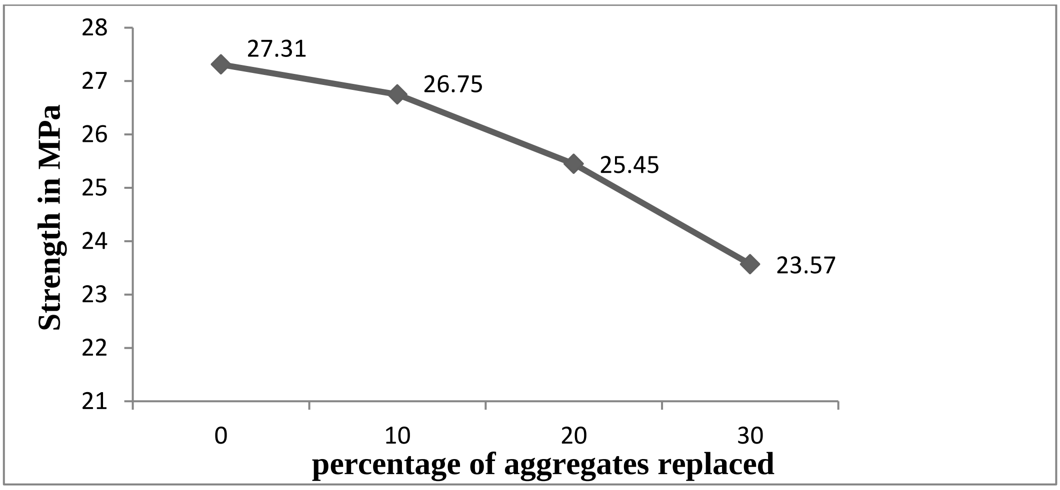

Fig 8 Compressive Strength

As mentioned in above graph (fig 8) shows the maximum strength of concrete after 28days curing of 0%, 10%, 20% and 30% of quarry dust and fly ash Aggregates replaced in mass concrete. According to the graph, strength of quary dust and fly ash concrete with 25% of partially replacing gives max strength than remaining quary dust and fly ash concrete and it is nearly equal to ordinary concrete.

SPLIT TENSILE STRENGTH

This is also sometimes referred as, “Brazilian Test”. This test was developed in Brazil in 1943. At about the same time this was also independently developed in

Japan. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder, along the vertical diameter. Figure 10.6 shows the test specimen and the stress pattern in the cylinder respectively.

When the load is applied along the generatrix, an element on the vertical diameter of the cylinder is subjected to vertical compressive stress or horizontal stress is split tensile strength (sp) $= \frac{2p}{\pi dl}$

Where,

"p" is the compressive load on the cylinder

"l" is the length of cylinder

"d" is its diameter

The loading condition produces a high compressive stress immediately below the two generators to which the load is applied. But the larger portion corresponding to depth is subjected to a uniform tensile stress acting horizontally. It is estimated that the compressive stress is acting for about 1/6 depth and the remaining 5/6 depth is subjected to tension. In order to reduce the magnitude of the high compression stresses near the points of application of the load, narrow packing strips of suitable material such as plywood are placed between the specimen and loading platens of the testing machine. The packing strips should be soft enough to allow distribution of load over a reasonable area, yet narrow and thin enough to prevent large contact area. Normally, a plywood strip of 25 mm wide, 3 mm thick and 30 cm long is used.

5.3.1 RESULTS AND TABLES

Results were calculated for normal mixing, and quary dust and fly ash concrete mixing with 10%, 20% and 30% of quary dust and fly ash split tensile strength are tabulated and graphs were drawn between strength to curing period and maximum strength of concrete at different percentages.

Table 12 The table shows load and split tensile strength for normal mix of M20 (1:1.24:2.92)

Curing period		**Load (p) KN**	**Strength =$\frac{2p}{\pi dl}$ (N/mm^2)**	**Average strength (N/mm^2)**
7Days	1st sample	153.1	2.16	**2.19**
	2nd sample	162.3	2.29	
	3rd sample	149.8	2.12	

14Days	1st sample	168.7	2.38	**2.43**
	2nd sample	172.5	2.44	
	3rd sample	175.1	2.48	
28Days	1st sample	207.1	2.93	**2.99**
	2nd sample	208.2	2.95	
	3rd sample	219.7	3.1	
56Days	1st sample	223.6	3.02	**3.03**
	2nd sample	219.7	3.10	
	3rd sample	218.8	2.99	

The graph shows compressive strength of 7, 14, 28 and 56 Days for normal mixing.

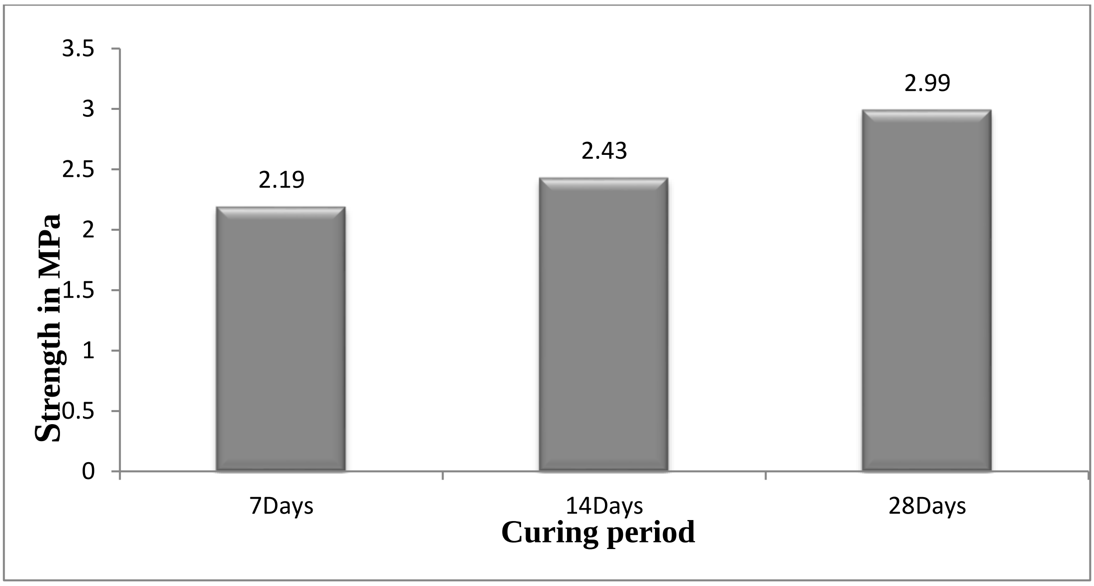

Fig 9 Split Tensile Strength

- As indicated in the graph (fig 9), after 7 days the split tensile strength of cylinder is 2.19N/mm^2.
- As indicated in the graph (fig 9), after 14 days the split tensile strength of cylinder is 2.43N/mm^2.
- As indicated in the graph (fig 9), after 28 days the split tensile strength of cylinder is 2.99N/mm^2.
- As indicated in the graph (fig 9), after 56 days the split tensile strength of cylinder is 3.03 N/mm^2.

Table 13 The table shows loads and split tensile strength of 10% replacing with Quarry Dust and Fly Ash in concrete.

Curing period		Load (p) KN	Strength $=\frac{2p}{\pi dl}$ (N/mm²)	Average strength (N/mm²)
7Days	1st sample	142.6	2.02	2.02
	2nd sample	147.4	2.08	
	3rd sample	139.5	1.97	
14Days	1st sample	156.8	2.22	2.21
	2nd sample	159.2	2.25	
	3rd sample	153.5	2.17	
28Days	1st sample	197.2	2.79	2.75
	2nd sample	191.3	2.71	
	3rd sample	195.7	2.77	
56Days	1st sample	198.2	2.81	2.81
	2nd sample	196.3	2.75	
	3rd sample	199.7	2.88	

The graph shows compressive strength of 7, 14 and 28Days for 10% of QA and FA

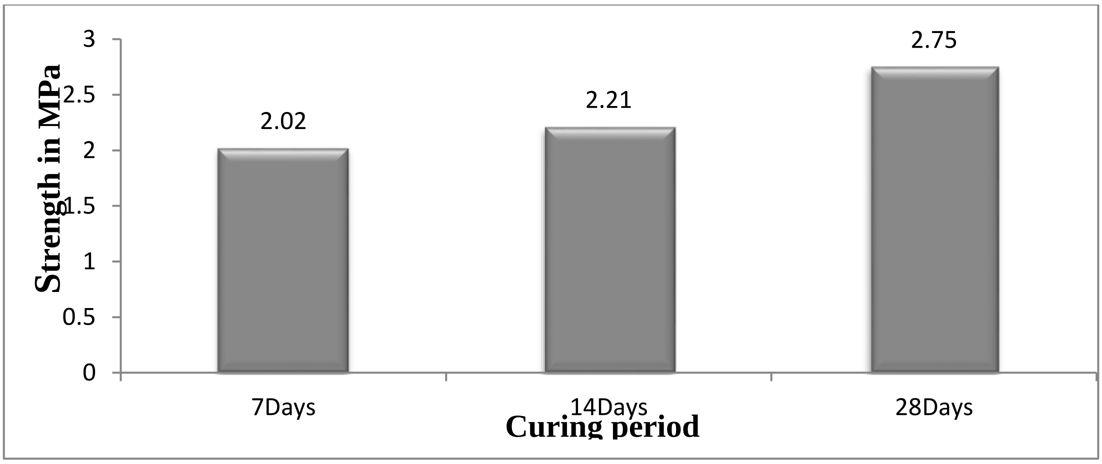

Fig 10 Split Tensile Strength

- As indicated in the graph (fig 10), after 7 days the split tensile strength of cylinder is 2.02N/mm².
- As indicated in the graph (fig 10), after 14 days the split tensile strength of cylinder is 2.21N/mm².
- As indicated in the graph (fig 10), after 28 days the split tensile strength of cylinder is 2.75N/mm².
- As indicated in the graph (fig 10), after 56 days the split tensile strength of cylinder is 2.81 N/mm².

Table 14 The table shows loads and split tensile strength of 10% replacing with 10% replacing with Quarry Dust and Fly Ash in concrete.

Curing period		Load (p) KN	Strength $=\frac{2p}{\pi dl}$ (N/mm^2)	Average strength (N/mm^2)
7Days	1st sample	137.1	1.94	1.92
	2nd sample	138.5	1.96	
	3rd sample	131.6	1.86	
14Days	1st sample	147.2	2.08	2.12
	2nd sample	150.8	2.13	
	3rd sample	151.7	2.15	
28Days	1st sample	190.8	2.69	2.64
	2nd sample	187.5	2.65	
	3rd sample	183.5	2.59	
56 Days	1st sample	197.2	2.79	2.75
	2nd sample	191.3	2.71	
	3rd sample	195.7	2.77	

The graph shows compressive strength of 7, 14 and 28Days for 50% of CSA.

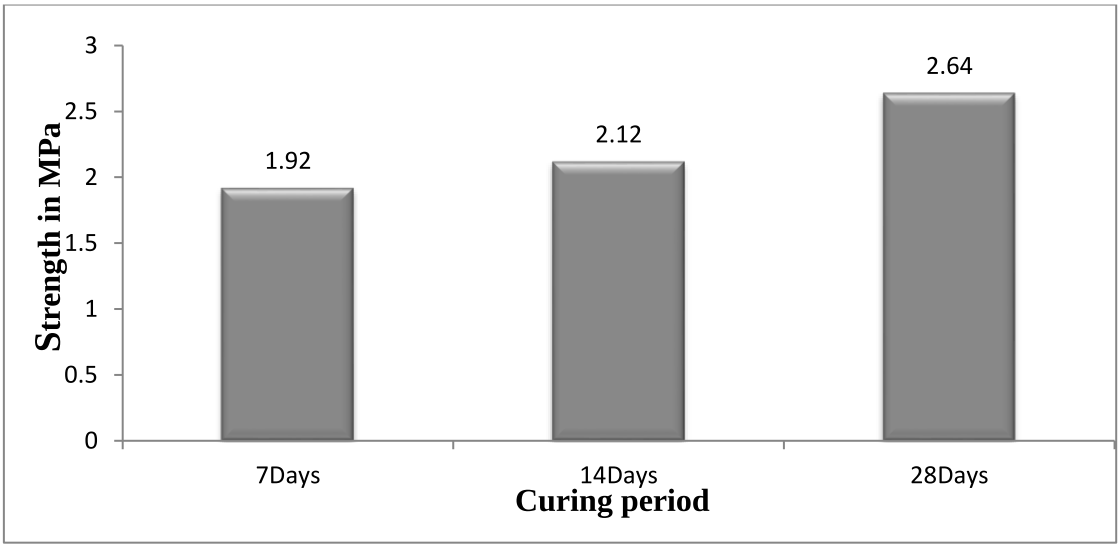

Fig 11 Split Tensile Strength

- As indicated in the graph (fig 11), after 7 days the split tensile strength of cylinder is 1.92N/mm^2.
- As indicated in the graph (fig 11), after 14 days the split tensile strength of cylinder is 2.12N/mm^2.

- As indicated in the graph (fig 11), after 28 days the split tensile strength of cylinder is 2.64N/mm^2.
- As indicated in the graph (fig 11), after 56 days the split tensile strength of cylinder is 2.71N/mm^2

Table 15 The table shows loads and split tensile strength of 10% replacing with Quarry Dust and Fly Ash in concrete.

Curing period		Load (p) KN	Strength $=\frac{2p}{\pi dl}$ (N/mm^2)	Average strength (N/mm^2)
7Days	1st sample	119.9	1.69	1.64
	2nd sample	115	1.63	
	3rd sample	112.8	1.59	
14Days	1st sample	134.2	1.89	1.91
	2nd sample	132.9	1.88	
	3rd sample	139.7	1.97	
28Days	1st sample	173.5	2.45	2.48
	2nd sample	178.9	2.53	
	3rd sample	175.1	2.47	
56Days	1st sample	183.1	2.55	2.58
	2nd sample	188.9	2.62	
	3rd sample	185.1	2.58	

The graph shows compressive strength of 7, 14, 28 and 56 Days for 30% of QD & FA.

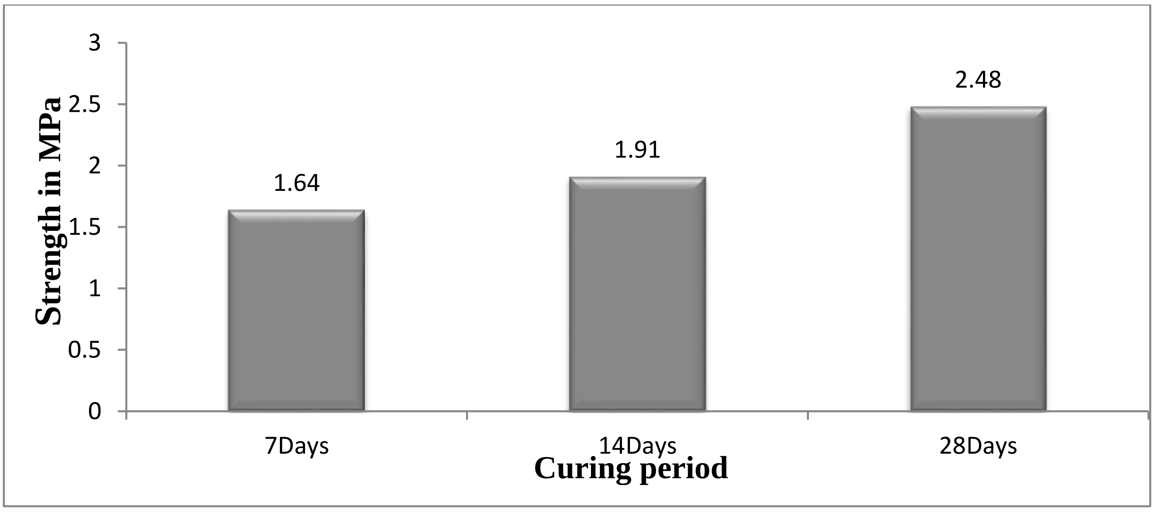

Fig 12 Split Tensile Strength

- As indicated in the graph (fig 12), after 7 days the split tensile strength of cylinder is 1.64N/mm^2.
- As indicated in the graph (fig 12), after 14 days the split tensile strength of cylinder is 1.91N/mm^2.
- As indicated in the graph (fig 12), after 28 days the split tensile strength of cylinder is 2.48N/mm^2.
- As indicated in the graph (fig 12), after 28 days the split tensile strength of cylinder is 2.48N/mm^2.

As mentioned in above graph (fig 13) shows the maximum split tensile strength of concrete after 28days curing of 0%, 10%, 20%, and 30% of quary dust and fly ash aggregates replaced in mass concrete. According to the graph, strength of Quarry Dust and Fly Ash with 30% of partially replacing gives max split tensile strength than ordinary concrete and remaining Quarry Dust concrete.

The graph shows the maximum split tensile strength at different percentage of QD & FA.

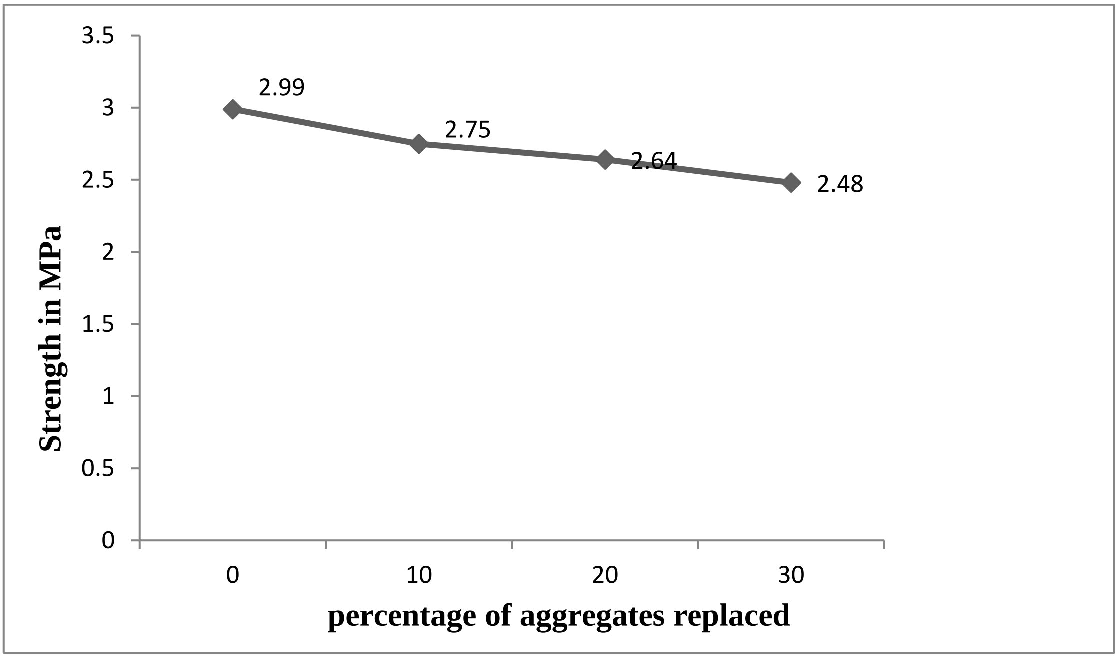

Fig 13 Split Tensile Strength

CONCLUSIONS

1. Non availability of sand at reasonable cost as finer aggregate in cement concrete for various reasons, search for alternative material stone crusher dust qualifies itself as a suitable substitute for sand at very low cost.

2. Aggregates with higher surface area are requiring more water in the mixture to wet the particle surfaces adequately and to maintain a specific workability. Obviously increasing in water content in the mixture will adversely affect the quality of concrete.

3. The Replacement of the sand with quarry dust shows an improved in the compressive strength of the concrete.

4. As the replacement of the sand with quarry dust increases the workability of the concrete.

5. The specific gravity is almost same both for the natural river sand and quarry dust. The variation of the physical properties like particle size distribution and bulking is much varying parameter that which effect the mix design of the concrete

6. Quarry Dust concrete gives 80-90% of strength by adding 30% of Quarry Dust aggregates with fly ash and also it nearly equal to life of an ordinary concrete.

7. Increasing of the replacement of sand with higher percentage of the quarry dust gives the increasing workability as well it is proved.

8. The further increasing the percentage of replacement can be made useful by adding the fly ash along with the quarry dust so that 100% replacement of sand can be achieved.

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