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Experimental Investigation on Compressive Strength Of M30 And M40 Grade Of Concrete With Partial Replacement Of Natural Sand by Robo Sand And Cement By Flyash

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ABSTRACT

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in development of infrastructure i.e; buildings, industrial structures, bridges and highways etc. sand is basic material in concrete making that is required in large quantities But in the present scenario it is necessary to find the suitable substitute for sand, easy to produce and has all the required qualities for use in concrete. Manufactured sand is one among such materials to replace river sand, which can be used as an alternative fine aggregate in mortars and concretes.

Cost of concrete is attributed to its cost of ingredients which is scarce and expensive, this leading to the usage of economically alternative materials in its production. This requirement is drawn the attention of investigators to explore new replacements of ingredients of concrete. The present investigation on M 30 and M40 grade of concrete with partial replacement of natural sand with robo sand by 10%,20%,40%,60% and the partial replacement of cement with fly ash by 10%,20%,30%,40%. By weight cubes are tested for compressive strength. In this project work total of 45 cube specimen cubes 150x150x150 were casted for testing the result have been compared with specimens made by natural fine aggregate concrete. The specimens were tested for compressive strength for 3 days, 7 days and 28 days of curing period.

Keywords: Concrete, aggregate, bridges, ingredients, fly ash, specimens

INTRODUCTION

Now a day's the most commonly used structural material for all types of construction is concrete. Concrete owes its unique position as the structural material to the fact, that it is economically highly resistant to fire, wind, water, and earthquakes .In the recent times its use in construction has been increased considerably thus the cities and the towns are virtually becoming concrete jungles. The demand is likely to increase in the future to match the growing population, housing, transportation, and other amenities.

As modern engineering practices become more demanding, there is a corresponding need for special types of materials with novel properties. Scientists, engineers and technologies, are continuously on the lookout for the materials which can act as substitute for conventional materials are which posses such properties as wood enable new design and innovations resulting into economy, so that the structure can be built economically. There have been so far many attempts to develop new materials, which is the combination of the two or more materials. Such materials are called composite materials. Concrete can be regarded as a composite material. For reducing the cost of concrete, use of cheap ingredients was suggested. By use of these materials as substitute materials in concrete would reduce the disposal problem now faced by the thermal power plant and industrial plant and at the same time achieving the required strength of the concrete.

Already investigations have been made by partial replacement of sand by Robo sand. Studies have been revealed that fly ash concrete have less strength when compared to conventional concrete, but with the use of super plasticizers in addition will not only compensate deficiency in its strength but also modifies its properties. Also reveal that with proper proportioning of fly ash the requires strength can be achieved at 28 days. In the present investigation Robo sand has been used as partial replacement of sand. (gap)

Fly ash is finely divided residue resulting from the combustion of the ground or pulverized bituminous coal or sub-bituminous coal. It is available in large quantities in the country as a waste product from a number of thermal power stations and industrial plants using pulverizes coal or lignite as fuel for the boilers. The effective use of flyash for complete replacement of cement as an admixture in cement motor and concrete as established in the country in the recent years. Recent investigation of Indian fly ash has indicated at scope for their utilization as a construction material. Greater utilization of fly ash will lead to not only saving such construction material but also assists in solving the problem of disposal of this waste product. The recent investigation has also indicated the necessity to provide proper collection methods for fly ash so as to yield fly ash of quality and uniformity, which are primary requirements of fly ash for use as construction materials.

CONCRETE

Concrete is the most widely used man made construction in the world. It is obtained by mixing cementations materials, water, aggregate, and sometimes admixtures in required proportions. Fresh concrete or plastic concrete is freshly mixed material which can be moulded into any shape hardens into a rock-like mass known as concrete. The hardening is because of chemical reaction between water and cement, which continues for long period leading to stronger with age.

The utility and elegance as well as the durability of concrete structures, built during the first half of the last century with ordinary Portland cement (OPC) and plain round bars of mild steel, the easy availability of the constituent materials of concrete and the knowledge that virtually any combination of the constituents, leads to a mass of concrete having a bred contempt. Strength was emphasized without a thought on the durability of the structures. As a consequence of the liberties taken, the durability of the concrete and concrete structures is on a southward journey; a journey that seems to have gained momentum on its path to self-destruction. This is particularly true of concrete structures which were constructed since 1970 or there about by which time (a) the use of high strength rebar's with surface deformations started becoming common,(b) significant changes in the constituents and (c) engineers started using supplementary cementations materials and admixtures in concrete, often without adequate consideration.

The setback in the health of newly constructed concrete structures prompted the most direct and unquestionable evidence of the last two/three decades on the resulting challenge that confronts us is the alarming and unacceptable rate at which our infrastructure systems all over world are suffering from deterioration when exposed to real environments. The ordinary Portland cement (OPC) is one of the main ingredients used for the production of concrete and has no alternative in the civil construction industry.

ROBO SAND:

Natural or River sand are weathered and worn out particles of rocks and are of various grades or sizes depending upon the amount of wearing. Now-a-days good sand is not readily available, it is transported from a long distance. Those resources are also exhausting very rapidly. So it is a need of the time to find some substitute to natural river sand. The artificial sand produced by proper machines can be a better substitute to river sand. The sand must be of proper gradation (it should have particles from 150 microns to 4.75 mm in proper proportion). When fine particles are in proper proportion, the sand will have fewer voids. The cement quantity required will be less. Such sand will be more economical. Demand for manufactured fine aggregates for making concrete is increasing day by day as river sand cannot meet the rising demand of construction sector.

The cost of natural sand has been sky rocketed and its consistent supply cannot be guaranteed. Under these circumstances use of manufactured sand becomes inevitable. River sand in many parts of the country is not graded properly and has excessive silt and organic impurities and these can be detrimental to durability of steel in concrete whereas manufactured sand has no silt or organic impurities. Inspired by nature, perfected by Robo Silicon – Robo Sand is an ideal substitute to river sand. It is manufactured just the way nature has done for over a million years. Robo Sand is created by a rock-hit-rock crushing technique using state-of-the-art technology with plant & machinery from a world leader that operates in over 100 countries.

FLY ASH:

Fig. 1.4 Fly ash

Fly ash is an industrial waste produced from thermal power stations on very scale. With increase in number of plants it is estimated that fly ash productions would be about 90 million tons per annum out of which 13% is gainfully utilized. Fly ash is removed by mechanical collectors or electrostatic precipitators. Fly ash contains 20% of the ash particles formed in a pulverized fuel boiler aggregate into larger particles by fusion and get deposited to the bottom ash. The remaining 80% is economizer ash trapped by ESP, bag filters, mechanical cyclone precipitators etc.

In western countries coal is pre-processed before the delivery at the power plants. The resulting waste product will be having around 20% of ash content. Where as in India the coal contains very high percentage of rock and soil and hence ash contents are as high as 50% depending on the nature of the constituents ash is divided into two categories namely lignite ash and bituminous ash. Some of the recent and significant investigations are presented here.

Reduction in heat of hydration and minimization of thermal cracks Absorption of surplus lime released out of OPC to form into secondary hydrated. Pore reinforcement and grain refinement due to the secondary hydrated mineralogy, thus contributing for impermeability. The improved impermeability of the concrete, results in increased resistance against the ingress of moisture and gases. The failure of the moisture and gases to go through the concrete, results in the durability enhancement (N.Bhanumati Das &N.kali das).

THEORITICAL ANALYSIS

CEMENT

Cement is a material that has cohesive and adhesive properties in the presence of water. Such cement is called hydraulic cements. These consist primarily of silicates and aluminates of lime obtained from limestone and clay. There are different types of cement, few of them are,

- Ordinary Portland cement
- Portland slag cement

Ordinary Portland cement (OPC) is the basic Portland cement and is best suited for use in general concrete construction. It is of three types, 33 grades, 43 grades, 53 grades. One of the important benefits is the faster rate of development of strength. Portland slag cement is obtained by mixing Portland cement clinker, gypsum and granulated blast furnace slag in suitable proportion and grinding the mixture to get a thorough and intimate mixture between the constituents. This type of cement can be used for all purposes just like OPC. It has lower heat of evolution and is more durable and can be used in mass concrete production.

AGGREGATES

Aggregate properties greatly influence the behavior of concrete, since they occupy about 80% of the total volume of concrete. The aggregates are classified as

- Fine aggregate

Fig 3.1 Fine aggregate

Coarseaggregate

Fig 3.2 Coarse aggregate

Fine aggregate are material passing through an IS sieve that is less than 4.75mm gauge beyond which they are known as coarse aggregate. Coarse aggregate from the main matrix of the concrete. Whereas fine aggregate from the filler matrix between the coarse aggregate. The most important function of the aggregate is to provide workability and uniformity in the mixture. The fine aggregate also helps the cement paste to hold the coarse aggregate particle in suspension. According to IS 383:1970 the fine aggregate is being classified in to four different zones that is Zone-I, Zone-II, zone-III, Zone-IV. Also in case of coarse aggregate maximum 20 mm coarse aggregate is suitable for concrete work. But where no restriction 40 mm or large size is may be permitted. In case of close reinforcement 10mm size also used.

According to IS 383-1970

Table 3.1 Sizes of Coarse Aggregate for Mass Concrete

Class And Size	Is Sieve Designation	Percentage passing
Very large ,150 to80mm	160mm 80mm	90 to 100 0 to 10
Large,80 to 40mm	80mm 40mm	90 to 100 0 to 10
Medium,40to20mm	40mm 20mm	90 to 100 0 to 10
Small,20to4.75mm	20mm 4.75mm 2.36mm	90 to 100 0 to 10 0 to 2

Table 3.2 Fine aggregates

Is Sieve Designation	Percentage passing For			
	Grading zone-I	Grading Zone-II	rading one-III	Grading Zone-IV
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600micron	15-34	35-39	60-79	80-100
300micron	5-20	8-30	12-40	15-50
150micron	1-10	0-10	0-10	0-15

Table 3.1 Sizes of Coarse Aggregate for Mass Concrete

FACTORS AFFECTING THE CHOICE OF MIX PROPORTIONS

The various factors affecting the mix design are:

1. Compressive Strength

It is one of the most important properties of concrete and influences many others describable properties of the hardened concrete. The mean compressive strength required at a specific age, usually 28 days, determines the nominal water-cement ratio of the mix. The other factor affecting the strength of concrete at a given age and cured at a prescribed temperature is the degree of compaction. According to the Abraham's law the strength of fully compacted concrete is inversely proportional to the water-cement ratio.

2. Workability

The degree of workability depends on three factors. These are the size of the section to be concreted, the amount of reinforcement, and the method of compaction to be used. For the narrow and complicated section with numerous corners and inaccessible parts, the concrete must have a high workability so that full compaction may be achieved with a reasonable amount of effort. This also applied to the embedded steel sections. The desired workability depends on the compacting equipment available at the site.

3. Durability

The durability of a concrete is its resistance to the aggressive environmental conditions. High strength concrete is generally more workable than the low strength concrete. In the situations where high strength concrete is not necessary but the conditions of exposure are not such that high durability is vital, the durability requirement will determine the water-cement ratio to be used.

Maximum nominal size of aggregate

In general, larger the maximum size of aggregate smaller is the cement requirement for a particular water cement-ratio, because the workability of concrete increases with the increase in maximum size of decrease in the size of aggregate.

IS 456:2000 and IS 1343:1980recommend that the nominal size of aggregate should be as large as possible.

5. Grading and type of aggregate

The grading of aggregate influences the mix proportions for a specified workability and water-cement ratio. Coarser the grading linear will be mix which can be used. Very lean mix is not desirable since it does not contain enough finer material to make the concrete cohesive.

The type of aggregate influences strongly the aggregate-cement ratio for the desired workability and stipulated water cement ratio. An important feature of a satisfactory aggregate is the uniformity of the grading which can be achieved by mixing different size fractions.

6. Quality control

The degree of control can be estimated statistically by the variations in the test results. The variation in the strength results from the variations in the properties of the mix ingredients and lack of control of control of accuracy in batching, mixing, placing, curing and testing. The lower the difference between the mean and minimum strengths of the mix lower will be the cement content required. The factor controlling this difference is termed as quality control.

MIX PROPORTION DESIGNATION

The common method of expressing the proportions of ingredients of a concrete mix is in the terms of parts or ratios of cement, fine and coarse aggregates. For e.g., a concrete mix of proportions 1:2:4 means that cement, fine and coarse aggregate are in the ratio 1:2:4 or the mix contains one part of cement, two parts of fine aggregate and four parts of coarse aggregate. The proportions are either by volume or by mass. The water-cement ratio is usually expressed in mass.

Factors to be considered for mix design

- The grade designation giving the characteristic strength requirement of concrete.
- The type of cement influences the rate of development of compressive strength of concrete.
- Maximum nominal size of aggregates to be used in concrete may be as large as possible within the limits prescribed by IS 456:2000.
- The cement content is to be limited from shrinkage, cracking and creep.
- The workability of concrete for satisfactory placing and compaction is related to the size and shape of section, quantity and spacing of reinforcement and technique used for transportation, placing and compaction.

EXPERIMENTAL SET UP

OBJECTIVE OF TESTING

It was proposed to investigate the behavior of robo sand as fine aggregate and fly ash in place of cement in concrete and it is compared with the regular mix.

Experimental Set Up

In the stage collection of materials and the data required for mix design are obtained by sieve analysis and specific gravity test. Sieve analysis is carried out from various FA and CA samples and the sample which suits the requirement is selected specific gravity tests are carried out for fine and coarse aggregate. The various materials used were tested as per Indian standard specifications.

Materials

Raw materials required for the concreting operations of the present work are cement, fly ash, fine aggregate, robo sand, coarse aggregate and water.

CEMENT

Cement :(CHETTINAD cement of 43 Grade ordinary Portland cement was used)

Determination of Specific Gravity of Cement

Empty weight of bottle =31Gms
W_1+Water (W_2) =82Gms
W_{1+}Kerosene (W_3) =71Gms
W_{1+}Cement Sample 25 Gms+ Kerosene (W_4) =90Gms
Weight of cement (W_5) =25Gms
Specific gravity of kerosene =W_3-W1/W2-W_1=0.784
Specific gravity OF CEMENT =W_5 (W_3-W_2)/ (W_5+W_3-W_4) (W_2-W_1)=3.267

PROCEDURE

The bureau of Indian standards, recommended a set of procedure for design of concrete mix mainly based on the work done in national laboratories. The mix design procedures are covered in IS: 10262-82. Their methods can be applied for both medium and high strength concrete. The following mixes are designed based on Indian standard recommended method of concrete mix design IS: 10262-82.

5.7 MIX DESIGN FOR M30 :

(a)Design stipulations:

(1)Characteristic compressive strength : 30 Mpa
Required in the field at 28 days
(2) Maximum size of aggregate : 20mm
(3) Degree of workability : 0.90 compacting Factor ,35 mm slump
(4) Degree of quality control : Good
(5) Type of exposure : Mild

(b) Test data for materials

(1) Specific gravity of cement : 3.267
(2) Specific gravity of coarse aggregate (12 mm) : 2.52
(3) Specific gravity of coarse aggregate (20 mm) : 2.6
(4) Specific gravity of fine aggregate : 2.64
(5) Specific gravity of robo sand : 2.543

(c) Target mean strength of concrete

f_{ck}= f_{ck}+ (t*s) = fck+ (1.65*s)
= 30+ (1.65*4) = 36.6 Mpa
Where f_{ck} = characteristic compressive strength
S = standard deviation =4 (from code book) t =1.65

(d) Water-cement ratio

From figure (11.10) of concrete technology book by Sri M.S.Setty for target mean strength of 36.6 Mpa. The water-cement ratio is 0.425.

(e) Selection of water and sand content

From figure (11.24) of concrete technology book by Sri M.S.Setty for 20mm maximum size aggregates, sand conforming to Zone-3.
Water content per cubic meter of concrete = 186 Kgs
Sand content = 35% of total aggregate

(f) Determination of cement content:

Water cement ratio = 0.425
Water = 186 kg
Cement = 437.64kg/m^3

(g) Determination of fine aggregate and coarse aggregate:

For the specified maximum size of aggregate 20mm, the amount of in trapped air in the wet concrete is 2 percent.

Fine aggregate (f_a)

0.98= [186+ (437.64/3.267) + (1/0.25) x (f_a/2.74)] (1/1000)
f_a= 530.94 kgs/cum

Coarse aggregate (c_a):

0.98= [186+ (470/3.12) + (1/0.25) x (C_a/2.43)]
C_a = 1202.94 kgs/ cum

	Water	Cement	Fine aggregate	Coarse aggregate
Kgs/Cum	86	37.64	530.94	1202.94
Ratio	**0.45 :**	**1 :**	**1.25 :**	**2.75**

MIX DESIGN FOR M40

(a)Design stipulations:

(1) Characteristic compressive strength : 40 Mpa
Required in the field at 28 days
(2) Maximum size of aggregate : 20mm
(3) Degree of workability : 100 mm slump
(4) Degree of quality control : Good
(5) Type of exposure : Mild

(b) Test data for materials

(1) Specific gravity of cement : 3.15
(2) Specific gravity of coarse aggregate (12 mm) : 2.6
(3) Specific gravity of coarse aggregate (20 mm) : 2.75
(4) Specific gravity of fine aggregate : 2.74
(5) Specific gravity of robo sand : 2.643

(c) Target mean strength of concrete

f_{ck}= f_{ck}+ (t*s)= fck+ (1.65*s) = 40+ (1.65*5) = 48.25 mpa
Where f_{ck} = characteristic compressive strength
S = standard deviation =5 (from code book) t =1.65

(d) Water-cement ratio

From figure (11.10) of concrete technology book by Sri M.S.Setty for target mean strength of 48.25 Mpa. The water-cement ratio is 0.525

(e) Selection of water and sand content

From figure (11.24) of concrete technology book by Sri M.S.Setty for 20mm maximum size aggregates, sand conforming to Zone-3.

Water content per cubic meter of concrete = 180 Kgs

Sand content = 35% of total aggregate

(f) Determination of cement content:

Water cement ratio = 0.525

Water = 186 kg

Cement = 450.64 kg/m^3

(g) Determination of fine aggregate and coarse aggregate:

For the specified maximum size of aggregate 20mm, the amount of in trapped air in the wet concrete is 2 percent.

$$V = \left[W + \frac{C}{Sc} + \frac{1}{P}\frac{fa}{Sfa}\right]\frac{1}{1000}$$

$$ca = \frac{1-P}{P} * fa * \frac{Sca}{Sfa}$$

$$0.98 = \left[180 + \frac{450}{3.15} + \frac{1}{0.365} * \frac{fa}{2.6}\right]\frac{1}{1000}$$

$$\frac{fa}{0.365*2.6} = 980 - \left[180 + \frac{450}{3.15}\right]$$

Fine aggregate (f_a)

fa = 623.63 kg/m³

$$ca = \frac{1-0.365}{0.365} * 623.63 * \frac{2.6}{2.6}$$

coarse aggregate (c_a):

ca= 1084.95 kg/m³

Material required for M40 grade concrete per cubic meter quantity of concrete:-

water cement Fine aggregate Coarse aggregate

Kgs/Cum 80 450.64623.631084.95

Ratio 0.4 : 1 : 1.65 : 2.9

RESULTS AND DISCUSSION

COMPRESSIVE STRENGTH VALUES FOR REPLACEMENT OF SAND BY ROBO SAND AND CEMENT BY FLYASH MIX DESIGN M30

Compressive strength Results3-days:

Table 6.1.1: Compressive strength Results3-days:

S.No	Replacement of Natural sand and cement By Robo Sand + Fly ash (%)(M30)	Compressive Strength(MPA)
1	0	21.5
2	10%+10%	22.06
3	20%+20%	26.55
4	40%+30%	29.9
5	60%+40%	24.05

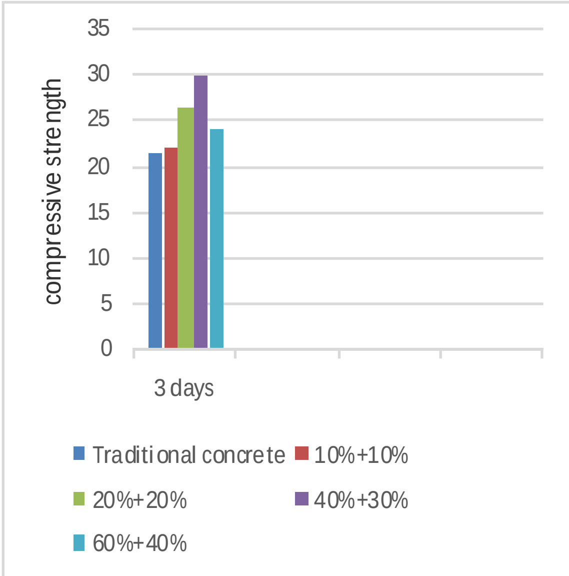

Fig 6.1.1Compressive strength Results3-days

From the above result it can be observed that the compressive strength values for the 3-days are in increasing phase for the first 3 mix proportions i.e., 10% robo sand+10% fly ash, 20% robo sand+20% fly ash, 40% robo sand+ 30% fly ash. But it can be seen that the compressive strength of 60% robo sand+ 40% fly ash has been reduced.

Compressive strength Results 7-days:

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Volume 07 Issue 02
February 2020

Table 6.1.2: Compressive strength Results 7-days

S.no	Replacement of Natural sand and cement By Robo Sand + Fly ash (%)(M30)	Compressive strength(Mpa)
1	0	23.5
2	10%+10%	29.465
3	20%+20%	37.465
4	40%+30%	41.73
5	60%+40%	32.72

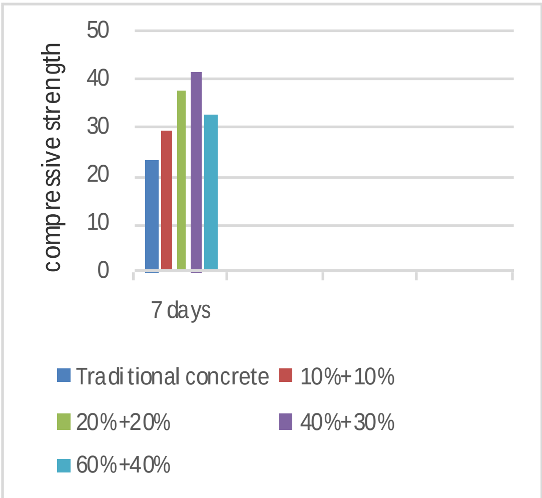

Fig 6.1.2Compressive strength Results 7-days

From the above result it can be observed that the compressive strength values for the 7-days are in increasing phase for the first 3 mix proportions i.e., 10% robo sand+10% fly ash, 20% robo sand+20% fly ash, 40% robo sand+ 30% fly ash. But it can be seen that the compressive strength of 60% robo sand+ 40% fly ash has been reduced.

Compressive strength Results 28-days:

Table 6.1.3: Compressive strength Results 28-days

S.No	Replacement of Natural sand and cement By Robo Sand + Fly ash (%)(M30)	Compressive strength(mpa)
1	0	37.2
2	10%+10%	39.7
3	20%+20%	46.6
4	40%+30%	49.7
5	60%+40%	41.2

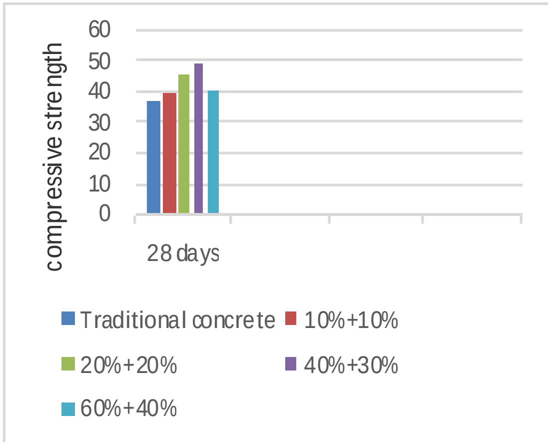

Fig 6.1.3Compressive strength Results 28-days

From the above result it can be observed that the compressive strength values for the 28-days are in increasing phase for the first 3 mix proportions i.e., 10% robo sand+10% fly ash, 20% robo sand+20% fly ash, 40% robo sand+ 30% fly ash. But it can be seen that the compressive strength of 60% robo sand+ 40% fly ash has been reduced.

COMPRESSIVE STRENGTH VALUES FOR REPLACEMENT OF SAND BY ROBOSAND AND CEMENT BY FLYASH FOR M30 GRADE MIX DESIGN:

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Volume 07 Issue 02
February 2020

Table 6.1.4:

S. No	Replacement of Natural sand and cement By Robo Sand + Fly ash (%)(M30)	Compressive Strength 3 days	Compressive Strength 7 days	Compressive Strength 28 days
1	0	21.5	23.5	37.2
2	10%+10%	22.06	29.465	39.7
3	20%+20%	26.55	37.465	46.6
4	40%+30%	29.9	41.73	49.7
5	60%+40%	24.05	32.72	41.2

Fig 6.1.4Comparison of Compressive Strength for replacement of sand by Robo Sand and Cement by Fly ash for 3, 7 and 28 days :

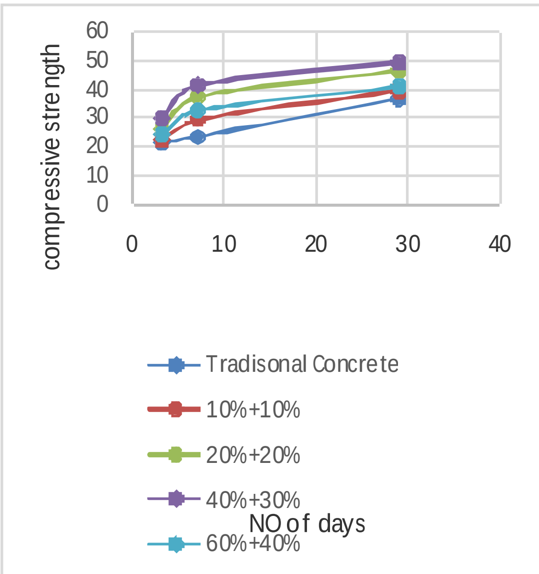
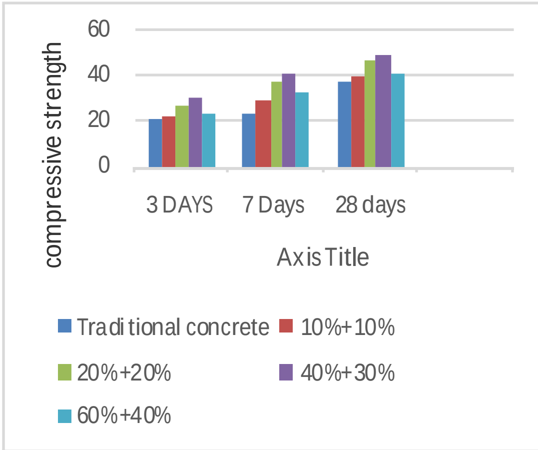


Fig 6.1.5: Comparison of Compressive Strength for replacement of sand by Robo Sand and Cement by Fly ash for 3, 7 and 28 days:



From the above results it can be observed that the compressive strength values for the 3-days, 7-days and 28 days are in increasing phase for the first 3 mix proportions i.e., 10% robo sand+10% fly ash, 20% robo sand+20% fly ash, 40% robo sand+ 30% fly ash. But it can be seen that the compressive strength of 60% robo sand+ 40% fly ash has been reduced.

All the 3- day,7- day and 28-day tests showed retardation for the 60%+40% mix.

COMPRESSIVE STRENGTH VALUES FOR REPLACEMENT OF SAND BY ROBO SAND AND CEMENT BY FLYASHMIX DESIGN M40 :

Compressive strength Results3-days:

Table 6.2.1: Compressive strength Results3-days

S. No	Replacement of Natural sand and cement By Robo Sand + Fly ash (%) (M40)	Compressive Strength(MPA)
1	0	22.53
2	10%+10%	23.06
3	20%+20%	28.55
4	40%+30%	31.92
5	60%+40%	26.05

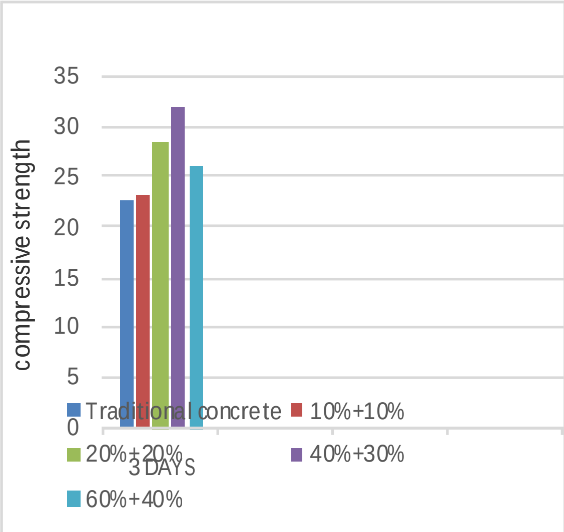


Fig 6.2.1Compressive strength Results3-days

From the above result it can be observed that the compressive strength values for the 3-days are in increasing phase for the first 3 mix proportions i.e., 10% robo sand+10% fly ash, 20% robo sand+20% fly ash, 40% robo sand+ 30% fly ash. But it can be seen that the compressive strength of 60% robo sand+ 40% fly ash has been reduced.

6.2.2 Compressive strength Results 7-days:

Table 6.2.2: Compressive strength Results 7-days

S.no	Replacement of Natural sand and cement By Robo Sand + Fly ash (%) (M40)	Compressive strength(Mpa)
1	0	25.94
2	10%+10%	31.26
3	20%+20%	40.38
4	40%+30%	43.73
5	60%+40%	34.72

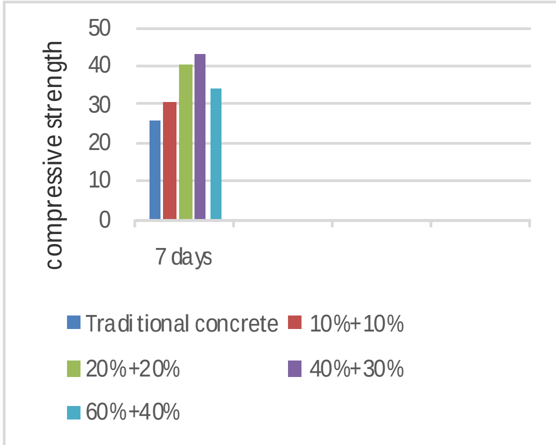


Fig 6.2.2Compressive strength Results 7-days

From the above result it can be observed that the compressive strength values for the 7-days are in increasing phase for the first 3 mix proportions i.e., 10% robo sand+10% fly ash, 20% robo sand+20% fly ash, 40% robo sand+ 30% fly ash. But it can be seen that the compressive strength of 60% robo sand+ 40% fly ash has been reduced.

6.2.3 Compressive strength Results 28-days:

Table 6.2.3: Compressive strength Results 28-days

S. No	Replacement of Natural sand and cement By Robo Sand + Fly ash (%) (M40)	Compressive strength(mpa)
1	0	38.65
2	10%+10%	41.72
3	20%+20%	48.68
4	40%+30%	51.74
5	60%+40%	44.26

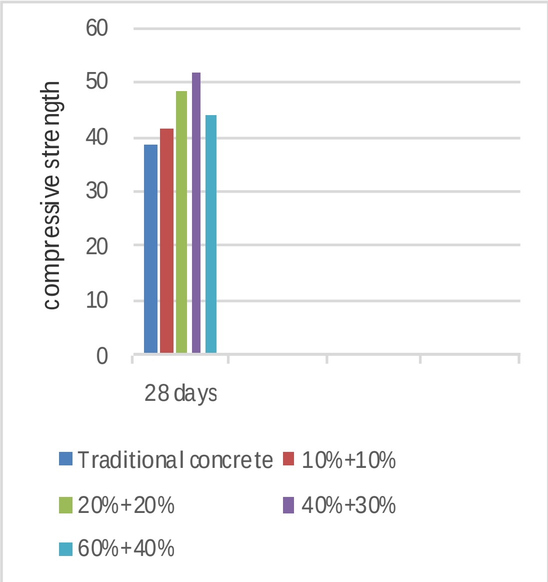


Fig 6.2.3Compressive strength Results 28-days

From the above result it can be observed that the compressive strength values for the 7-days are in increasing phase for the first 3 mix proportions i.e., 10% robo sand+10% fly ash, 20% robo sand+20% fly ash, 40% robo sand+ 30% fly ash. But it can be seen that the compressive strength of 60% robo sand+ 40% fly ash has been reduced.

COMPRESSIVE STRENGTH VALUES FOR REPLACEMENT OF SAND BY ROBO SAND AND CEMENT BY FLYASH for M40 MIX DESIGN :

Table 6.2.4:

S.No	Replacement of Natural sand and cement By Robo Sand + Fly ash (%) (M40)	Compressive Strength 3 days	Compressive Strength 7 days	Compressive Strength 28 days
1	0	22.53	25.94	38.65
2	10%+10%	23.06	31.26	41.72
3	20%+20%	28.55	40.38	48.68
4	40%+30%	31.92	43.73	51.74
5	60%+40%	26.05	34.72	44.26

Fig 6.2.4Comparison of Compressive Strength for replacement of sand by Robo Sand and Cement by Fly ash for 3, 7 and 28 days :

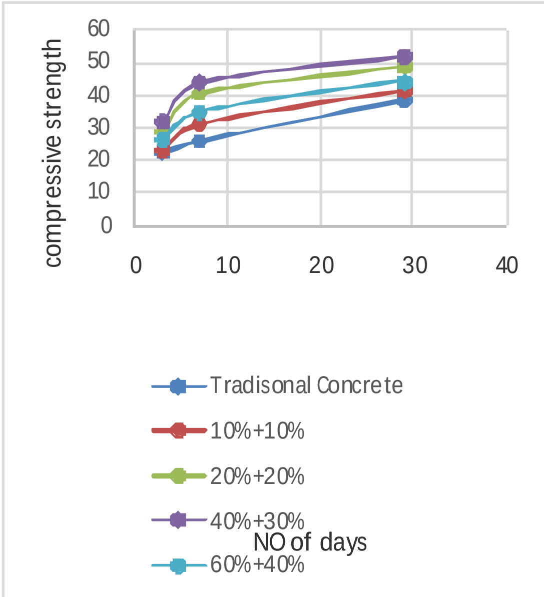
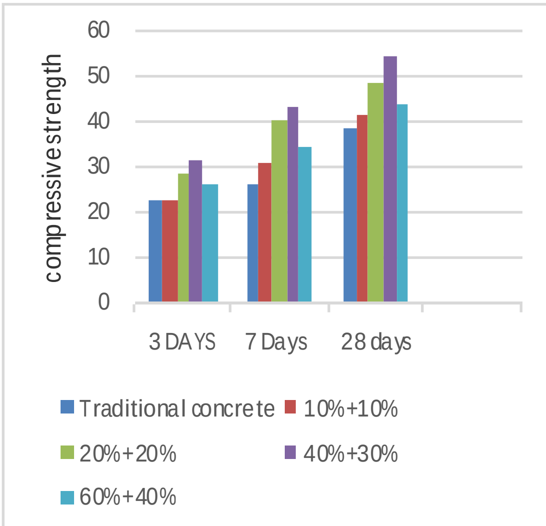


Fig 6.1.5 Comparison of Compressive Strength for replacement of sand by Robo Sand and Cement by Fly ash for 3, 7 and 28 days:



From the above results it can be observed that the compressive strength values for the 3-days, 7-days and 28 days are in increasing phase for the first 3 mix proportions i.e., 10% robo sand+10% fly ash, 20% robo sand+20% fly ash, 40% robo sand+ 30% fly ash. But it can be seen that the compressive strength of 60% robo sand+ 40% fly ash has been reduced.

All the 3- day,7- day and 28-day tests showed retardation for the 60%+40% mix.

CONCLUSION

The compressive strength of the concrete cubes for mix design M30:

- From fig 6.1.1 40%+30% maximum compressive strength of 3 days is 29.9 mph
- From fig 6.1.2 40%+30% maximum compressive strength of 7days is 41.73 mph
- From fig 6.1.3 40%+30% maximum compressive strength of 28 days is 49.7 mph

The compressive strength of the concrete cubes for mix design M40:

- From fig 6.2.1 40%+30% maximum compressive strength of 3 days is 31.92 mph
- From fig 6.2.2 40%+30% maximum compressive strength of 7 days is 43.75 mph
- From fig 6.2.3 40%+30% maximum compressive strength of 28 days is 51.74 mph

The maximum compressive strength optained from the concrete cubes for mix design M30:

- From fig 6.1.4 and fig 6.1.5 Mix design M30 the maximum compressive strength obtained from 3,7,28 days is 40%+30% 49.7 mph for 28 days 43.75 mph

The maximum compressive strength obtained from the concrete cubes for mix design M40:

- From fig 6.2.4 and fig 6.2.5 Mix design M40 maximum compressive strength obtained from 3,7,28 days is 40%+30% 51.74 mph for 28 days

- From the above study I conclude that the compressive strength of the concrete cubes has gradually increased up to addition of 40% robo sand and 30% fly ash.
- Compared to compressive strengths of (10+10) %, (20+20)% and (40+30)% of addition of robo sand-fly ash, the compressive strength of (60+40)% robo sand-fly ash has been decreased.
- Whereas comparing to traditional concrete, compressive strength of (60+40) % has been increased.
- For economical view 60% robo sand + 40% fly ash proportion is preferable.
- In the perspective of compressive strength 40% robo sand + 30% fly ash proportion is suggested.

SCOPE FOR FUTURE STUDY:

(i)There are possibilities to increase the strength by adding admixtures. Tests are to be carried out with different admixtures which give optimum results.

(ii)The acid resistance tests and water absorption tests are to be carried out as the robo sand is weak in reacting with these liquids.

(iii)The fresh concrete properties are to be analyzed and found out experimentally for the practical use of concrete.

(iv)The thermal and fire resistance properties are to be tested for the performance of robo sand under such conditions.

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