Study on Compressive Strength of Fibrous Triple Blended Concrete with Flyash and Silica Fume

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Abstract— **Concrete is the key material used in various types of constructions, from the flooring of a hut to a multi-storied high rise structures. Concrete is one of the versatile heterogeneous materials. With the advent of concrete civil engineering has touched highest peak of technology. It is the material of choice where strength, durability, impermeability, fire resistance and abrasion resistance are required. The properties of concrete mainly depend on the constituents used in concrete making. The main aim of the present study is to determine the compressive strength, split tensile strength and flexural strength of concrete mix of M60 grade, with partial replacement of cement with Ground Granulated Blast furnace Slag and fly ash. Our study includes the concept of triple blending of cement with GGBS and FLY-ASH, this triple blend cement exploits the beneficial characteristics of both pozzolanic materials in producing a better concrete.**

Index Terms— **Concrete, Fly Ash, condensed silica fume, steel fibers, and Compressive Strength.**

I. INTRODUCTION

Concrete is one of the versatile heterogeneous materials, civil engineering has ever known. With the advent of concrete civil engineering has touched highest peak of technology. Concrete is a material with which any shape can be cast and with equal strength or rather more strength than the conventional building stones. It is the material of choice where strength, performance, durability, impermeability, fire resistance and abrasion resistance are required.

Cement concrete is one of the seemingly simple but actually complex materials. The properties of concrete mainly depend on the constituents used in concrete making. The main important material used in making concrete are cement ,sand, crushed stone and water .Even though the manufacturer guarantees the quality of cement it is difficult to produce a fault proof concrete. It is because of the fact that the building material is concrete and not only cement. The properties of sand, crushed stone and water, if not used as specified, cause considerable trouble in concrete. In addition to these, workmanship, quality control and methods of placing also plays the leading role on the properties of concrete.

II. MATERIALS

A. High Strength Concrete:

High-strength concrete offers significantly better structural engineering properties, such as higher compressive and tensile strengths, higher stiffness, better durability, when compared to the conventional normal strength concrete (NSC).

Concrete of very high strength entered the field of construction of high raised buildings and long span bridges. In India, there are cases of using high strength concrete for pre-stressed concrete bridges.

The requirement of high strength concrete requires a higher cementitious material in the concrete mixture, which could be in the range of 400kg plus per m3. The hunger for the higher strength leads to other materials to achieve the desired results thus emerged the contribution of cementitious material for the strength of concrete.

B. Fly Ash

The term Fly ash was first used in the electrical power industry in 1930. The first comprehensive data of its use in concrete, in North America, was reported in 1937 by Devis et al. The United States Bureau of reclamation of data reported the major practical application in 1948, with the publication on the use of Fly ash in the construction of Hungry Horse Dam. Worldwide acceptance of Fly ash slowly followed these early costs (and hence cement cost) that occurred during the 1970's and then a number of investigations were carried out both within and outside of this country on Fly ash concrete. Conservation of natural resource is the need of the hour throughout the world. Steps are to be adopted in this direction which, include minimization of production of energy consuming materials & bulk utilization of industrial by-products, thereby making a major contribution towards solving the global warming problem and also by bringing down the levels of environmental pollution. It is found that use of high volumes of Fly ash, is the most effective and economical way to improve the durability of concrete.

B.1.1 Physical Properties of Fl y Ash

i) Particle Morphology

As per morphological studies, Fly ash particles usually consist of clear glassy spheres and spongy aggregate ranging in diameter from 1 to 150µm, the majority being less than 45µm as seen under-energy dispersive X-ray analysis (EDXA).

ii) Fineness

Fineness is one of the primary characteristics of Fly ash that relates to its pozzoloanic activity. A large fraction of ash particles is smaller that 3µmin size. In bituminous ashes, the particle sizes range from less than 1 to over 100µm. The average size lies in the range of 7 to 12µm.

iii) Specific Gravity

The specific gravity of Fly ash is related to shape as well as chemical composition of particles. Specific gravity of Fly ash

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usually varies from 1.3 to 4.8. Coal particles with some mineral impurities have specific gravity between 1.3 to 1.6. Opaque spherical magnetite (ferrite spinal) and hematite particles, light brown to black in colour, when present in sufficient quantity in Fly ash increases the specific gravity to about 3.6 to 4.8

B.1.2 Proportioning of Fly Ash Concretes

Using of Fly ash in concrete has to meet one or more of the following objectives.

i. Reduction in cement content,
ii. Reduced heat of hydration,
iii. Improved workability and
iv. Gaining levels of strength in concrete beyond 90 days of testing

Fly ash is introduced into concrete by one of the following methods.

1) Cement containing Fly ash may be used in place of OPC.
2) Fly ash is introduced as an additional component at the time of mixing.

The first method is simple and problems of mixing additional materials are not there,
there by uniform control is assured. The proportions of Fly ash and cement are predetermined, and mix proportion is limited.

The second method allows for more use of Fly ash as component of concrete. Fly ash
plays many roles such as, in freshly mixed concrete, it acts as a fine aggregate and also reduces water cement ratio in hardened state, because of its pozzolanic nature, it becomes a part of the cementitious matrix and influences the strength and durability.

The assumptions made in selecting an approach to mix proportioning Fly ash concrete are

1. It reduces the strength of concrete at early ages.
2. For same workability, concrete containing Fly ash requires less water than concrete containing ordinary Portland cement
The basic approaches that are generally used for mix proportioning are
1. Partial Replacement of cement,
2. Addition of Fly ash as fine aggregates and
3. Partial replacement of cement, fine aggregate and water

C. SILICA FUME

C.1.1 Silica Fume and its sources

Silica fume is very fine pozzolanic material composed of amorphous silica produced by electric arc furnaces as a byproduct of the production of elemental silica or ferro-silicon alloys. High-purity Quartz is heated to 2000oc with coal, coke or wood chips as fuel and an electric arc introduced to separate out the material. As the quartz is reduced it releases silicon oxide vapour. This mixes with oxygen in the upper parts of the furnace where it oxidizes and condenses into micro spheres of amorphous silicon dioxide. The fumes are drawn out of the furnace through a pre-collector and a cyclone, which remove the larger coarse particles of unburnt wood or carbon, and then blown into a series of special filter bags.

C.1.2 Characteristics

Silica fume is, when collected, an ultra fine powder having the following basic properties:
1. At least 85% SiO2 content.
2. Mean particle size between 0.1 and 0.2 micron
3. Minimum specific surface of 15,000 m2/kg.
4. Spherical particle shape
The powder is normally grey in colour but this can vary according to the source

Silica Fume in Concrete

Because of its extreme fineness and high silica content, silica fume is a very effective
pozzolonic material. Silica fume is added to Portland cement concrete to improve its properties, in particular its compressive strength, bond strength and abrasion resistance. These improvements stem from both mechanical improvements resulting from addition of a very fine powder to the cement paste mix as well as from the pozzolonic reactions between the silica fume and free calcium hydroxide in the paste. Addition of silica fume also reduces the permeability of concrete to chloride ions, which protects the reinforcing steel of concrete from corrosion, especially in chloride-rich environments such as coastal regions. When it is used in concrete, it acts as filler and as a cementitious material. The small silica fume particles fill spaces between cement particles and between the cement paste matrix and aggregate particles. The silica fume also combines with calcium hydroxide to form additional calcium hydrate through the pozzolonic reaction. Both of these actions result in a denser, stronger and less permeable material.

Effects on Fresh Concrete

Due to the nature and size of the silica fume, a small addition to a concrete mix will produce marked changes in both physical and chemical properties. The primary physical effect is that of adding, at the typical dosage of 8-10% by cement weight between 50,000 and 1,00,000 micro spheres per cement particle. This means that mix will be suffused with fine material causing an increase in the cohesiveness of the concrete. When using a powder form of silica fume this will mean an increased water demand to maintain mixing and workability, and therefore powders are most often used with plasticizers or super plasticizers.

The ultra fine nature of the particles will provide a much greater contact surface area between the fresh concrete and the substrate or reinforcement and thus will improve the bond between these and the hardened concrete.

Triple Blended Cement Mixes:

While silica fume is compatible with pulverized Fly ash, it is a pozzolanic material and hence will give differing results depending on the mix design used. If present in high proportions the reactivity of Fly ash will be affected by the ability of the micro silica to rapidly consume the calcium hydroxide. This may provide high early strengths but a reduced rate of long-term gain. High levels of Fly ash can cause problems with high water contents leading to segregation and bleeding, not only on the surface of the concrete but also within the matrix itself. The silica fume will virtually eliminate this bleeding and hence maintain the integrity of the concrete. With more normal levels of Fly ash (say 10-30%) silica fume can be added to give enhanced performance. In such cases, where there would be a minor reduction in strength due to using these additions, this is offset by the silica fume and high early, and ultimate , strength can be achieved without an excessive increase in the cost of the concrete. These triple blend cements exploit the beneficial characteristics of both pozzolanic materials in producing a durable concrete. This type of concrete is being specified where concrete structures are expected to last for upwards of 100 years such as the Storebaelt in Denmark and the Tsing Ma bridge in Hong Kong. Here again, caution must be exercised and full trials conducted. While silica fume can enhance concretes with high replacement levels of Fly ash, none of them can react properly without sufficient cement in the mix to produce calcium hydroxide. There will always be a point of no return in replacing cement with pozzolonas and the target should always be the ultimate quality of the concrete not just the required compressive strength.

Fibers:

Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle fracture of the concrete.

In the past, attempts have been made to impart improvements in tensile properties of concrete members by way of using conventional reinforced steel bars and also by applying restraining techniques. Although both these methods provide tensile strength to the concrete members, they however, do not increase the inherent tensile strength of concrete itself.

In plain concrete and similar brittle materials, structural cracks (micro cracks) develops even before loading, particularly due to drying shrinkage or other causes of volume change. The width of these initial cracks seldom exceeds a few microns, but there two dimensions maybe of higher magnitude.

When loaded, the micro cracks propagate and open up and owing to the effect of strength concentration, addition cracks from the places of minor defects would usually happen. The structural cracks proceed or by tiny jumps because they are retarded by various obstacles, changes of direction in by passing the more resistant grains in matrix. The development of such micro cracks is the main cause of elastic determination of concrete.

It has been recognized that the addition of small, closely spaced and uniformly dispersed fibres to concrete would act as crack arrester and would substantially improve its static and dynamic properties and does not notably increase the mechanical properties before failure but governs the post failure behavior. Thus, plain concrete which is quasi-brittle material is turned on the pseudo ductile material by using fibre reinforced. This type of concrete is known as" Fibre Reinforced Concrete."

FIBRE REINFORCED CONCRETE

Fibre Reinforced Concrete is a concrete composed of normal setting hydraulic cements,
fine or fine and coarse aggregates and discontinuous discrete fibre with different proportions, different length and different gauges as parameters.
Concrete is an artificial material in which the arrangements both fine and coarse aggregate are bonded together by the cement when mixed with water. The concrete has become so popular and indispensable because of its inherent characteristics and advantages either when green or hardened. The use of reinforcement in concrete brought a revolution in application of concrete. Concrete has unlimited opportunities for innovative application, design and construction techniques. Its great versatility and relative economy in filling wide range of needs has made it a very competitive building material.

NECESSITY OF FIBRE REINFORCED CONCRETE

The use of concrete as a structural material is limited to certain extent by deficiencies like brittleness, poor tensile strength, poor resistance to impact and fatigue and low level durability and ductility. It is also very much limited to receive dynamic stresses caused due to explosions.

The brittleness is compensated in structural member by the introduction of reinforcement (or) pre-stressing steel in the tensile zone. However it does not improve the basic character of concrete. It is merely a method of using two materials for the required performance. The main problem of low tensile strength still remains and it is to be improved by different types (or) of different materials.

Mixing

Mixing of fiber reinforced concrete needs careful conditions to avoid balling of fibers, segregation, and in general the difficulty of mixing the materials uniformly. Increase in the aspect ratio, volume percentage and size and quantity of coarse aggregate intensify the difficulties and balling tendencies. Steel fiber content in excess of 2 percent by volume and an aspect ratio of more than 100 are difficult to mix. It is important that the fibers are dispersed uniformly throughout the mix; this can be done by the addition of fibers before the water is added. When mixing in a laboratory mixer, introducing the fiber through a wire mesh basket will help even distribution of fibers. For field use, other suitable method must be adopted.

III. EXPERIMENTAL INVESTIGATION GENERAL

An experimental study is conducted to find out compressive strength for 7 and 28 days concrete. In concrete the partial replacement of cement fly ash are varied as (10%) ,(15%), (20%), (25%), (30%) and (35%) and silica fume varied as (0%) and (15%).

- M60 grade of concrete is designed according to DOE method.

- The effect of partial replacement of cement by silica fume (% by weight) on strength and workability of concrete are investigated.

Cement:
Ordinary Portland cement 53 grade conforming to I.S specifications is used in the
present investigation. The cement is tested for its various properties as per IS code. The results on cement are shown in table 3.1.

PHYSICAL PROPERTIES OF PORTLAND CEMENT

S.NO	PROPERTY	TEST RESULTS
1	Normal consistency	30%
2	Specific gravity	3.04
3	Initial setting time Final setting time	42 min 450 min
4	Soundness(expansion) Lechatlier Method	2 mm
5	Fineness of cement	5%

Fine Aggregate:

The locally available sand is used as fine aggregate in the present investigation. The sand is free from clayey matter, salt and organic impurities. The sand is tested for various properties like specific gravity, bulk density etc., in accordance with Indian Standard 2386-1963(28).

Coarse Aggregate:
Machine crushed angular granite metal from the local source issued as coarse aggregate (confined to Indian Standard: 383-1970). It is free from impurities such as dust, clay particles and organic matter etc. The coarse aggregate is also tested for
its various Properties.

CASTING OF TEST SPECIMENS
The present experimental programme includes casting and testing of specimens for compressive strength. Specimens are prepared for M60 grade of concrete with and without SILICA FUME and FLY ASH. Total of 18 cube specimens, are cast. The details of casting and testing of specimens are described below

TABLE 3.2 Mixing Proportions

S. NO	NOTATION	CEMENT %	FLYASH %	CSF %	FIBERS %
1	C01	100	0	0	0
2	C02	100	0	0	0.5
3	C03	90	10	0	0
4	C04	90	10	0	0.5
5	C05	90	10	0	1.5
6	C06	85	0	15	0
7	C07	85	0	15	0.5
8	C08	85	0	15	1.5
9	C09	80	20	0	0
10	C10	80	20	0	0.5
11	C11	80	20	0	1.5
12	C12	75	10	15	0
13	C13	75	10	15	0.5
14	C14	75	10	15	1.5
15	C15	70	30	0	0
16	C16	70	30	0	0.5
17	C17	65	20	15	0
18	C18	65	20	15	0.5

MIXING:

Manual mixing is adopted throughout the experiment work. First the materials cement, silica fume, fine aggregate, coarse aggregate are weighed exactly. First the cement and silica fumes are blended with hand and then fine, coarse aggregate is added to this and thoroughly mixed. Water is weighed exactly and added to the dry mix and entire mix is thoroughly mixed till uniformity is arrived at. Immediately after thoroughly mixing, the fresh concrete is tested for workability using compaction factor apparatus

CASTING OF SPECIMENS:
For casting the cubes, standard C.I Metal cubes of size 150 mm x 150 mm have been used. The moulds have been cleaned of dust particles and applied with mineral oil on all sides, before concrete is poured into the mould. Thoroughly mixed concrete is filled into the mould.
CURING OF SPECIMENS:
After casting the molded specimens are stored in the laboratory free from vibrations, in moist air and at room temperature for 24 hrs. After this period, the specimen are removed from the moulds and immediately submerged in the clean fresh water of curing tank. The curing water is renewed after every 5 days. The specimens are cured for 7 and 28 days in the present work.

TESTING OF CUBE SPECIMENS:
The cube specimens cured as explained above are tested as per standard procedure after removal from curing tank and allowed to dry under shade. The cube specimens are tested for

- Compressive strength for 7days
- Compressive strength for 28days

IV. RESULTS

GENERAL:
Cubes are casted with M60 grade concrete. Up to thirty five percent of cement is replaced by a combination of Fly Ash and Silica Fume in different proportions and fibres are added to the combinations in different percentages. as shown in table 3.6. The cubes are tested after 28 days.
An experimental study is to be conducted to find out the compressive strength and at 7days and 28 days. In concrete the partial replacement of cement by Fly ash as varied from35%, 30%, 25%, 20% and 15%, 10% by weight and silica fume as varied from 0% and 15% by weight. M60 grade

of concrete is designed according to DOE (Direct Elimination) method. Steel Fibers are mixed in concrete like 0%, 0.5% and 1.5%.

Triple Blended Concrete mixes:

Triple blending of cement by partially replacing cement with pozzolonas like Fly ash and condensed silica fume contribute to the enhanced properties of the concrete mix. By replacing the cement with readily and cheaply available pozzolonas contribute to economy.

Use of Fibers in Concrete:

Plain concrete possesses a very low tensile strength, limited **ductility and little resistance to cracking. Internal micro cracks are** inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle fracture of the concrete.

It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic governs the post failure properties and does not notably increase the mechanical properties before failure but behavior. The addition of fibres contribute to the enhanced properties in tensile strength and flexural strength of the concrete.

COMPRESSIVE STRENGTH VALUES FOR 7 DAYS

S. NO	NOTATION	CEMENT %	FLY ASH %	CSF %	FIBERS	COMPRESSIVE STRENGTH 7 DAYS
1	C01	100	0	0	0	43.6
2	C02	100	0	0	0.5	43.73
3	C03	90	10	0	0	45.09
4	C04	90	10	0	0.5	46.09
5	C05	90	10	0	1.5	46.47
6	C06	85	0	15	0	46.22
7	C07	85	0	15	0.5	46.26
8	C08	85	0	15	1.5	47.22
9	C09	80	20	0	0	45.26
10	C10	80	20	0	0.5	45.86
11	C11	80	20	0	1.5	46.73
12	C12	75	10	15	0	46.47
13	C13	75	10	15	0.5	47.09
14	C14	75	10	15	1.5	48.24
15	C15	70	30	0	0	42.73
16	C16	70	30	0	0.5	46.09
17	C17	65	20	15	0	40.09
18	C18	65	20	15	0.5	41.09

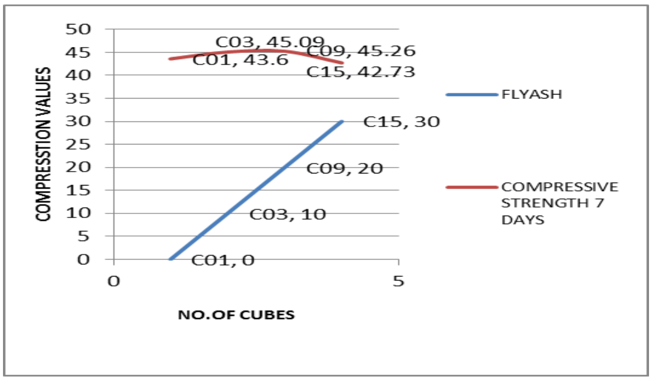
COMPRESSIVE STRENGTH VALUES FOR 28 DAYS

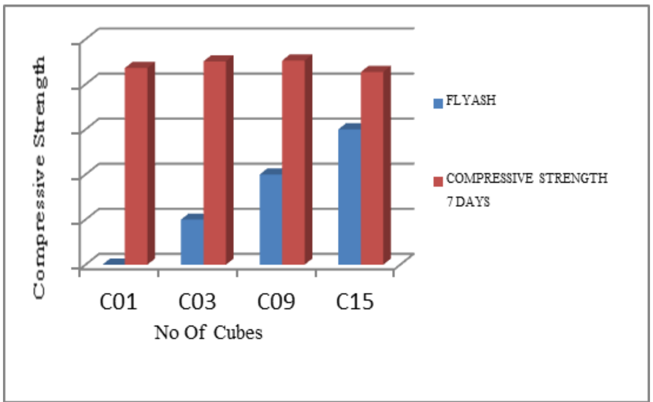
S.No	Notation	Cement %	Flyash %	Csf %	Fibers	Compressive Strength 7 Days	Compressive Strength 28 Days
1	C01	100	0	0	0	43.60	66.09
2	C02	100	0	0	0.5	43.73	66.03
3	C03	90	10	0	0	45.09	68.08
4	C04	90	10	0	0.5	46.09	69.59
5	C05	90	10	0	1.5	46.47	70.16
6	C06	85	0	15	0	46.22	69.79
7	C07	85	0	15	0.5	46.26	69.85
8	C08	85	0	15	1.5	47.22	71.30
9	C09	80	20	0	0	45.26	68.34
10	C10	80	20	0	0.5	45.86	69.24
11	C11	80	20	0	1.5	46.73	70.56
12	C12	75	10	15	0	46.47	70.16
13	C13	75	10	15	0.5	47.09	71.10
14	C14	75	10	15	1.5	48.24	72.84
15	C15	70	30	0	0	42.73	64.52
16	C16	70	30	0	0.5	46.09	69.59
17	C17	65	20	15	0	40.09	60.53
18	C18	65	20	15	0.5	41.09	62.04

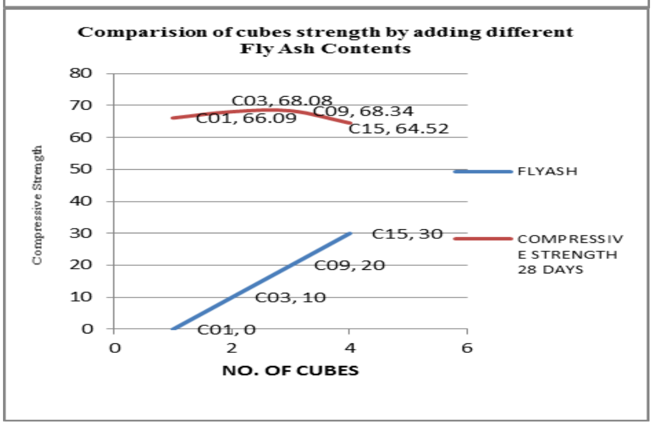
Table 1

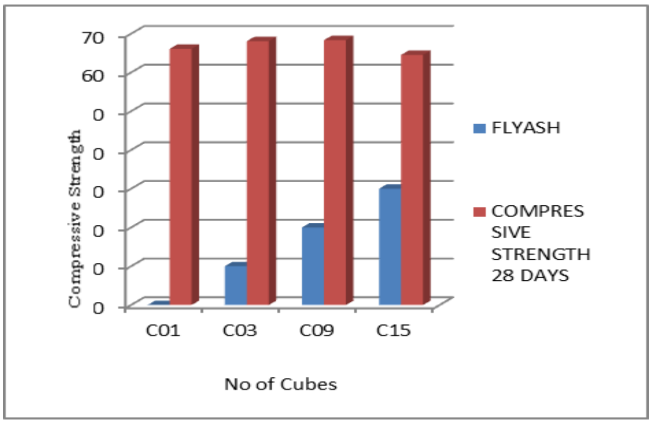
In the four cubes C01, C03, C09,C15 the compressive strength for 7 days & 28 days is obtained by the replacement of cement with flyash in 10%, 20%, 30% .

NOTATION	FLYASH	COMPRESSIVE STRENGTH 7 DAYS	COMPRESSIVE STRENGTH 28 DAYS
C01	0	43.60	66.09
C03	10	45.09	68.08
C09	20	45.26	68.34
C15	30	42.73	64.52









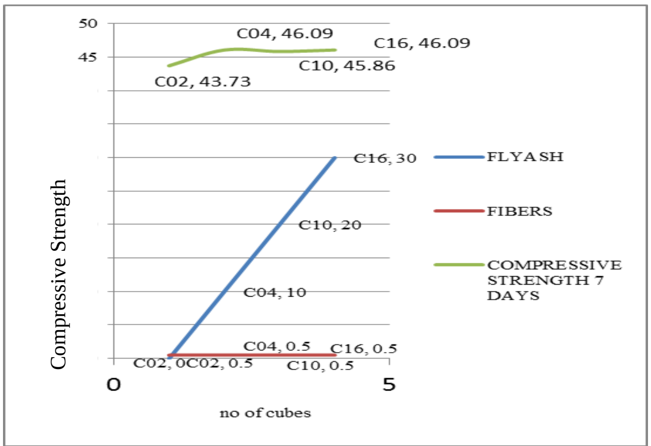
V. DISCUSSION:

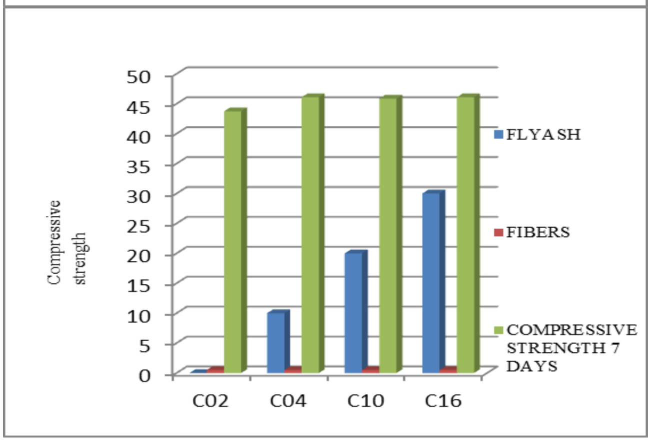
When flyash is replaced to cement with 10%, 20%, 30% the compressive strength obtained is higher at 10%, 20% & strength decreases at 30% . Since , the change in properties of both cement & flyash once the optimum level is reached.

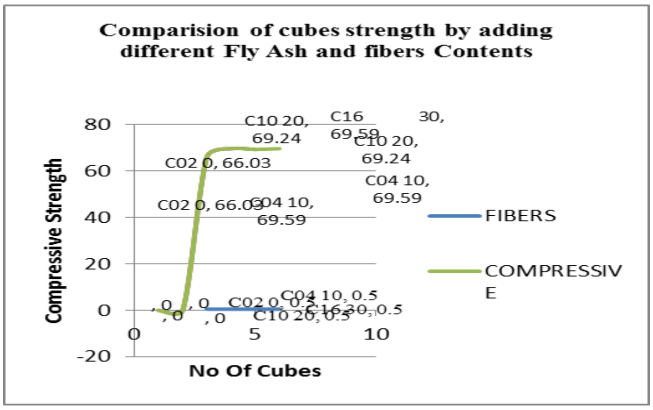
Table 2

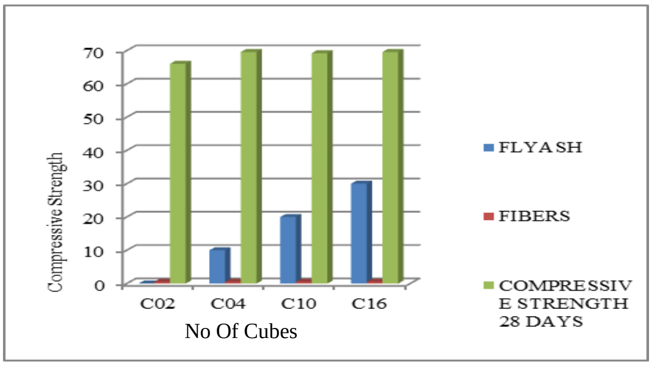
In the four cubes C02, C04, C10,C16 the compressive strength for 7 days & 28 days is obtained by the replacement of cement with flyash in 10%, 20%, 30% & fibers with 0.5%.

Notation	Fly Ash	Fibers	Compressive Strength 7 Days	Compressive Strength 28 Days
C02	0	0.5	43.73	66.03
C04	10	0.5	46.00	69.00
C10	20	0.5	46.09	69.59
C16	30	0.5	45.86	69.24









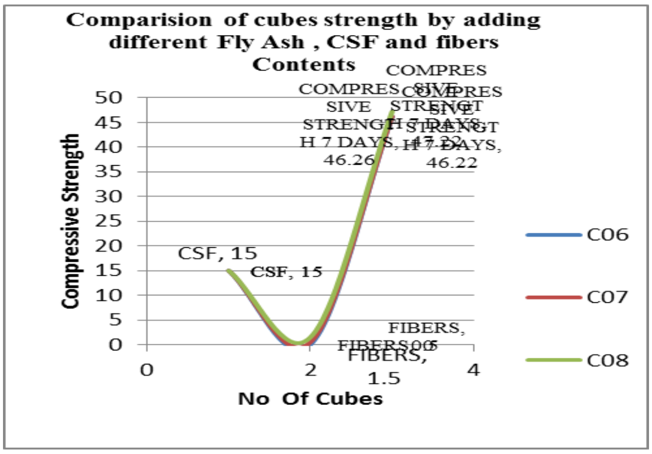
VI. DISCUSSION:

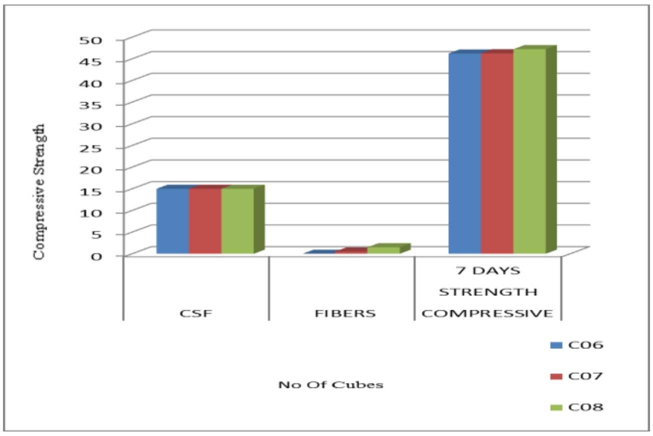
When flyash is replaced to cement with 10%, 20%, 30% & 0.5% fibers the compressive strength obtained is higher at 10%, 20% & strength decreases at 30% . Since , the change in properties of both cement & flyash once the optimum level is reached.

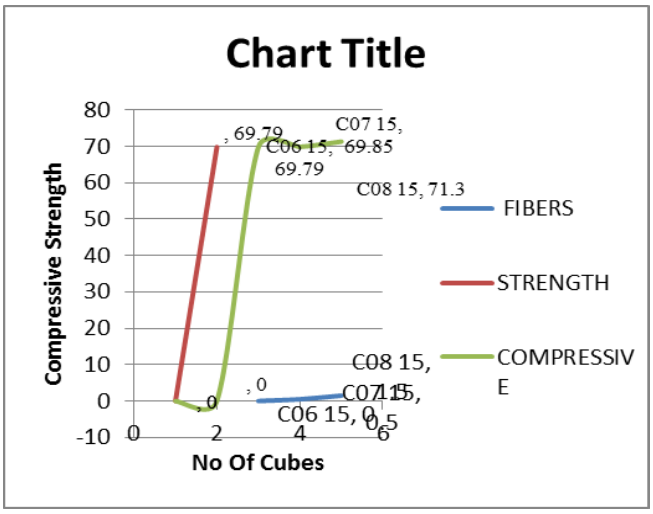
Table 3

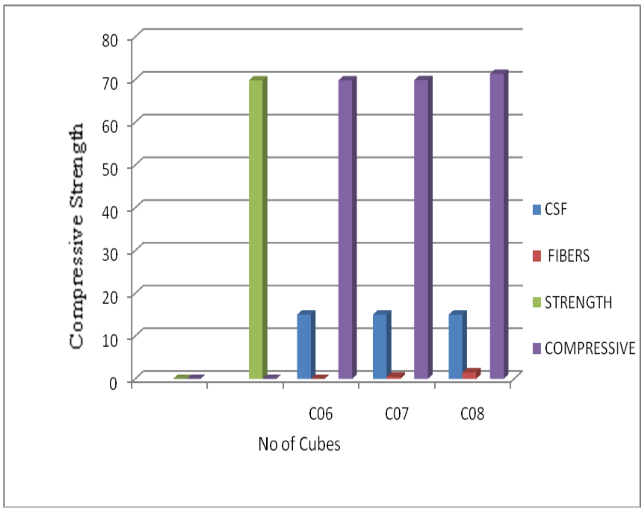
In the three cubes C06, C07, C08 the compressive strength for 7 days & 28 days is obtained by adding 15% of Condensed Silica Fume(CSF) along with 0.5%, 1.5% of fibers. when the fibers are added to CSF the compressive strength increases when compared to fibers not added to CSF.

Notation	Csf	Fibers	Compressive Strength 7 Days	Compressive Strength 28 Days
C06	15	0	46.22	69.79
C07	15	0.5	46.26	69.85
C08	15	1.5	47.22	71.30





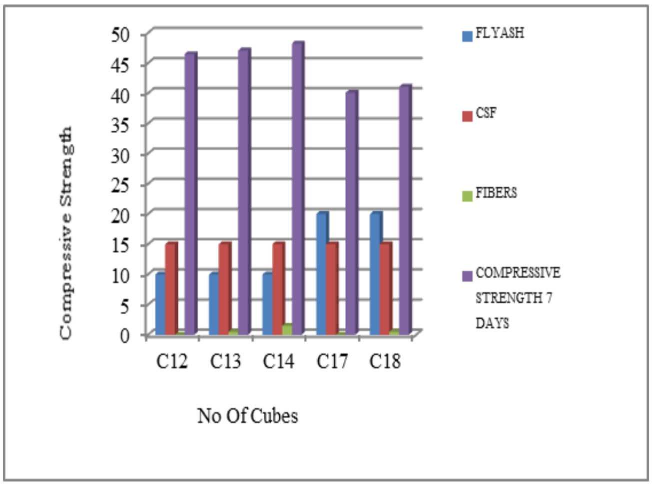


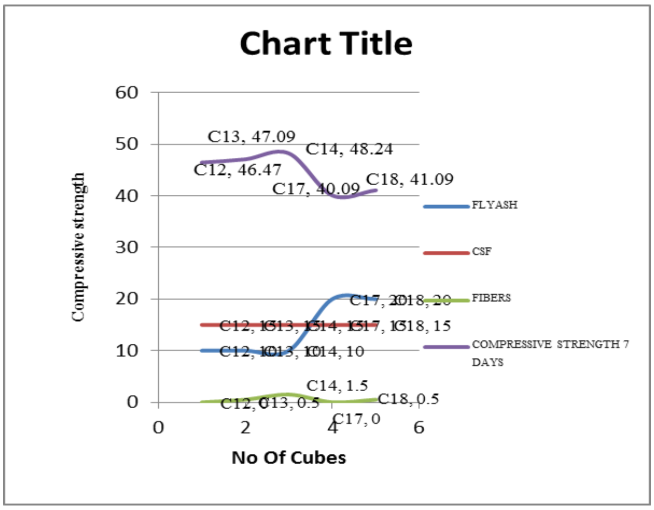


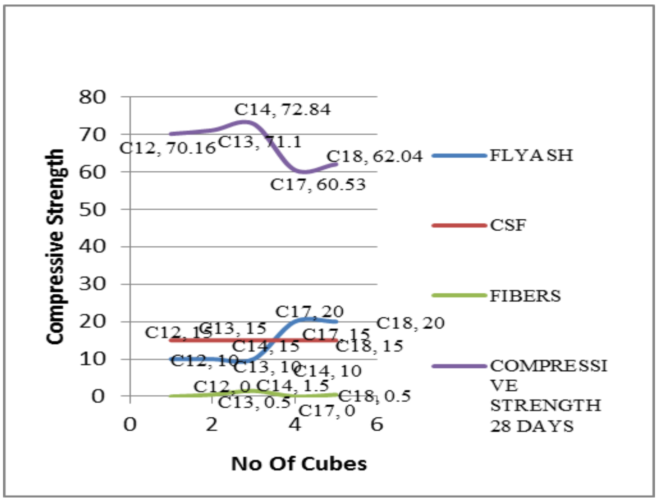
When 15% of Condensed Silica Fume(CSF) along with 0.5% & 1.5% of fibers are added to concrete cube the compressive strength increases when compared to fibers not added to CSF. But, if the fibre content increases more than 1.5% the self weigth of concrete increases.

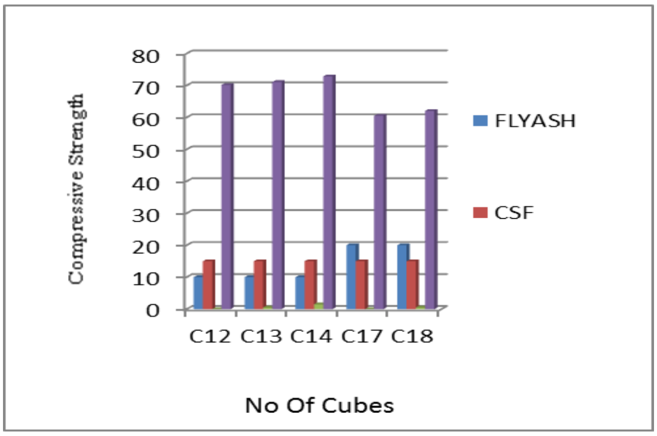
Table 4:
In the four cubes C12, C13, C14,C17, C18 the compressive strength for 7 days & 28 days is obtained by the replacement of cement with flyash in 10% & 20% along with 15% of silica fume & 0.5%, 1.0%, 1.5% 0f fibers

Notation	Flyash	Csf	Fibers	Compressive Strength 7 Days	Compressive Strength 28 Days
C12	10	15	0	46.47	70.16
C13	10	15	0.5	47.09	71.1
C14	10	15	1.5	48.24	72.84
C17	20	15	0	40.09	60.53
C18	20	15	0.5	41.09	62.04







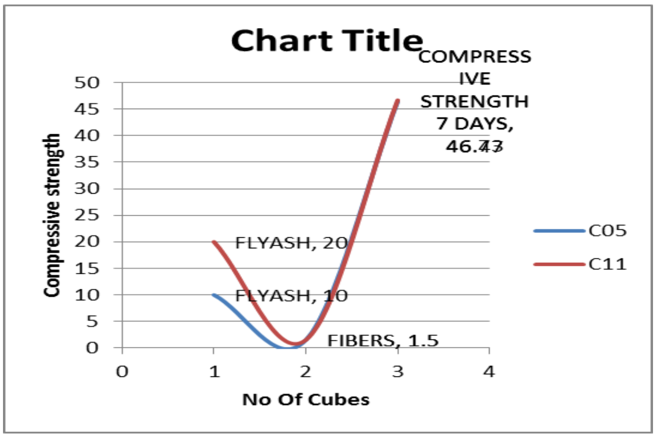


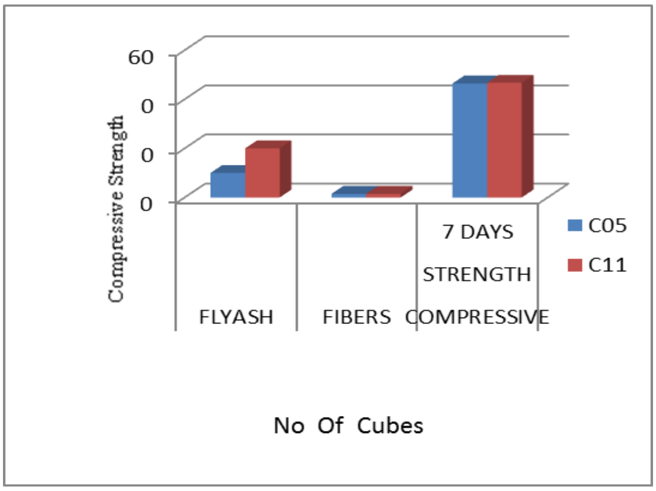
When 15% of Condensed Silica Fume(CSF) along with 10%, 20% fly ash and 0.5% ,1.5% of fibers are added to concrete cube the compressive strength increases when compared to fibers not added to CSF. But, if the fibre content increases more than 1.5% the self weigth of concrete increases.

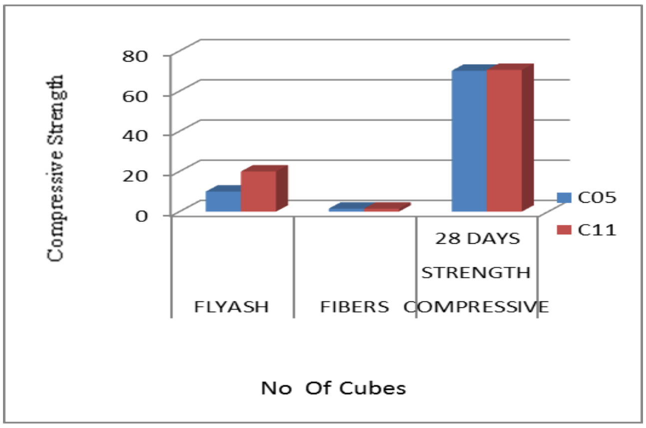
Table 5:

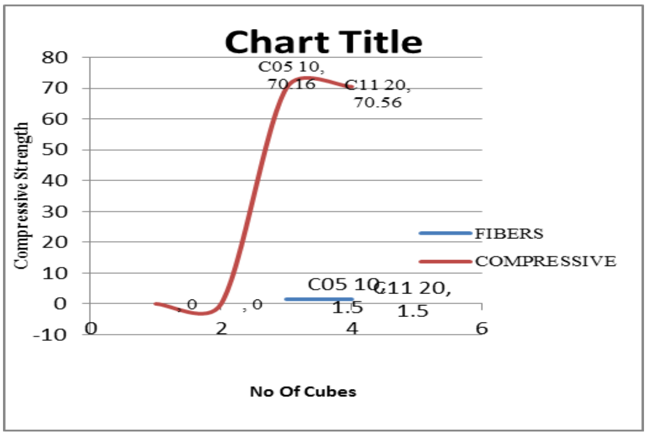
In the two cubes C05, C11 the compressive strength for 7 days & 28 days is obtained by the replacement of cement with flyash in 10%, 20%.

Notation	Flyash	Fibers	Compressive Strength 7 Days	Compressive Strength 28 Days
C05	10	1.5	46.47	70.16
C11	20	1.5	46.73	70.56









when, 10% & 20% of fly ash is added with 1.5% of fibers the compressive strength will be higher for the cube where 20% of flyash along with 1.5% of fibers. Since, fly ash content is more.

VII. CONCLUSION

Based on the experimental investigation conducted in the present project, the following

Conclusions are drawn.

1.By using triple blended cements a better concrete mix possessing higher strength can be produced as found out in this study.

2.In the case of high strength concrete mixes as the water cement ratio is low. When fibers are used in the mix with mineral admixtures, the workability is adversely affected.

3.Hence role of super plasticizer becomes necessary to maintain the workability level.

4.On increasing the Fly ash content from 0-30 percentage and with no silica fume, compressive strength is reduced.When Fly ash is used along with silica fume in triple blended concrete mixes, the strength can be maintained.

5.The presence of silica fume in the concrete mix helps in the strength gain. As the silica fume percentage added is increased up to 15 percent, there is maximum strength gain.

6.The presence of silica fume compensates for the loss of strength which occurs when higher percentages of Fly ash are used.

7.Steel fibers in the concrete mix contribute towards higher compressive strength.

8.Triple blended concrete mix with 15 percent silica fume and Ten percent Fly ash and 1.5 percent fibers is giving the highest Compressive strength.

9.On the whole, in almost all the mixes tried in the investigation, the enhanced properties of the concrete mix are fairly good when compared to the reference mix.

10. Triple blended concrete mixes with suitable percentages of steel fibres serve all the requirements and hence provide the best answer to the production of high performance concrete.

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