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STUDY ON STRENGTH CHARACTERISTICS OF CONCRETE BY USING FLY ASH AND SILICA FUME

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Abstract: Concrete, is one of the key construction materials having good compressive &, flexural strengths and durable properties among others. With comparative low cost made from some of the most widely available elements, it has found wide usage. It is mouldable, adaptable and relatively fire resistant. The fact that it is an engineered material which satisfy almost any reasonable set of performance specifications, more than any other material currently available has made it immensely popular construction material. In fact, every year more than 1 m3 of concrete is produced per person worldwide.As our project title suggests, the objective of our project is to find out the strength parameters, in specific, the compressive and flexural strengths**.**

Index Terms **- Compressive.Flexural,mouldable.**

I. INTRODUCTION

Concrete, is one of the key construction materials having good compressive &, flexural strengths and durable properties among others. With comparative low cost made from some of the most widely available elements, it has found wide usage. It is mouldable, adaptable and relatively fire resistant. The fact that it is an engineered material which satisfy almost any reasonable set of performance specifications, more than any other material currently available has made it immensely popular construction material. In fact, every year more than 1 m^3 of concrete is produced per person (more than 10 billion tonnes) worldwide.

Strength (load bearing capacity) and durability (its resistance to deteriorating agencies) of concrete structures are the most important parameters to be considered while discussing concrete. The deteriorating agencies may be chemical – sulphates, chlorides, CO_2, acids etc. or mechanical causes like abrasion, impact, temperature etc. The steps to ensure durable and strong concrete encompass structural design and detailing, mix proportion and workmanship, adequate quality control at the site and choice of appropriate ingredients of concrete. Type of cement is one such factor. In this paper, the significance and effect of the type of cement on strength and durability of its corresponding concrete is focussed on.

1.1 WHAT IS TRIPLE BLENDED CONCRETE.

Triple blended concretes belong to that strata of concretes where the strength and durability characteristics are maximized to the highest extent possible, in comparison to various other types of concretes, by subtle tailoring of its chemical composition, fineness and particle size distribution. Greater varieties are introduced by the incorporation of additives like pozzolana, granulated slag or inert fillers. These lead to different „specification" of cements in national and international standards.

In simple words, triple blended cement is characterised by part replacement of cement with mineral admixtures/additives such as pozzolanic admixtures (fly ash, silica fume, granulated slag etc.) or inert fillers. The corresponding concrete is termed as triple blended concrete. These admixtures are found to enhance the physical, chemical and mechanical properties of the concrete i.e. in terms of its strength parameters (compressive and flexural) as well as durability parameters.

1.2 TRIPLE BLENDED HIGH STRENGTH CONCRETE

At the commencement of a concrete construction, the anticipated exposure conditions generally decide the type of cement. Requirements of load-carrying capacity are met by the structural design of the members, which decide the required strength grade of concrete and strength class of cement. From logistic and management considerations, it helps if one cement can meet the diverse performance demands. Thus, in order to meet all these requirements, incorporation of high strength concrete into a new yet effective concept of triple blended concretes is considered a needful solution. The objective of doing so is to optimize the thrust in strength and durability parameters achieved by both triple blended cements as well as high strength concrete to obtain what is known as triple blended high strength concrete. But beforeproceeding further, let us understand thoroughly, what is high strength concrete?

1.3 FIBRE REINFORCED CONCRETE

The concerns with the inferior fracture toughness of concrete are mitiagated to a large extent by reinforcing it with fibres of various materials. The resulting material with a random distribution of short, discontinuous fibres is termed fibre reinforced concrete (FRC). When the loads imposed on concrete approach that for failure, cracks will propagate, sometimes rapidly, fibres in concrete provide a means of arresting the crack growth. Reinforcing steel bars in concrete have the same beneficial effect because they act as long continuous fibres. Short discontinuous fibres have the advantage, however, of being uniform.If the modulus of elasticity of the fibre is high with respect to the modulus of elasticity of concrete or the mortar binder, then the fibres help to carry the load, thereby increasing the strength of the material.

LITERATURE REVIEW

In order to fulfilthe aims and objectives of the present study following literatures have been reviewed.

2.1 NOTABLE PREVIOUS RESEARCH

A number of reports have demonstrated that concretes containing combinations of fly ash and silica fume with Portland cement are superior in certain respects to concretes containing Portland cement only. Studies at the Virginia Transportation Research Council have also demonstrated that silica fume added in relatively small amounts to fly ash concrete significantly improves early resistance of the concrete to penetration by chloride ions when tested in accordance with ASTM C1202.4, 5 The type and source of the cement, characteristics and amounts of fly ash, and silica fume affected the results.

2.1.1 Triple Blended Concrete

R.V Balendran, T.M Rana, T. Masqood and W.C Tsong (2002) studied on "strength and durability performance of High Performance incorporating pozzolanas at elevated temperatures". The inclusion of pozzolanas like fly ash and silica fume enhances the properties of concrete both in fresh and hardened states. In the case of high performance concrete (HPC), their role in enhancing the workability, strength and durability is extremely significant.

Tahir Kemal Erdem and OnderKırca(2009), used the ternary blend of silica fume and fly ash to obtain high strength concrete mix. They have shown that triple blends almost always made it possible to obtain higher strengths than PC (plain concrete) + SF(silica fume) mixtures at all ages provided that the replacement level by Fly Ash (class F) or Fly Ash (class C or S) was chosen properly. They also showed that the improvements in strengths by ternary blends were more significant at 7 and 28 days than at 3 days.

Isaia GC, Gastaldini ALG et al. (2003), observed the physical and pozzolanic action of mineral additions on the mechanical strength of high-performance concrete. Particlepacking is one reason. In the case of fly ash, the particle is often finer thanthe cement, this means that the small silica fume particles can perform better in particle packing since the intermediate particlespace, slightly smaller than cement, is filled by the fly ash.The chemical binding of chlorides by fly ash due to its content of aluminium works together with the pore refinement due to silica fume to give excellent performance in a chloride environment. Due to low reaction rate, fly ash has often been used in HPC to reduce the heat of hydration and will also give good flow in fresh concrete. However, this gives a problem in fly ash concrete.

2.1.2 Fibrous-reinforced Concrete

Jon M. Rouse and Sarah L. Billington (2007) "creep and shrinkage of high performance fibre reinforced cementitious composites" describes a class of high performance fibre reinforced cementitious composites, referred to as engineered cementitious composites that were studied for its time dependant properties. The material exhibits a pseudo strain-hardening response with multiple fine cracking in uniaxial tension. A series of experiments on Fibre reinforced concrete specimens were conducted to provide information about the shrinkage, basic creep, dying creep and shrinkage of concrete were made.
The study of mechanical behaviour of fibre reinforced concrete was conducted by **Swamy and Hannat.** As a consequence of the above investigation it has been observed that compared flexural strength and ultimate flexural strength of fibre reinforced concrete.

EXPERIMENTAL INVESTIGATIONS

3.1 GENERAL

An experimental study is conducted to find out the compressive strength and flexural strength of concrete at 28days.In concrete the partial replacement of cement by Fly ash and Silica fume are varied from (0+5)%,(25+5)%,(45+5)%,(0+15)%,(25+10)%,(45+10)%,(0+10)%,(20+10)%,(40+10)%, by weight.
M80 grade of concrete is designed according to DOE method.
The effect of partial replacement of cement by Fly ash and Silica fume (% by weight) on strength and workability of concrete are investigated.

3.2 MATERIALS

3.2.1CEMENT:

Ordinary Portland cement 53 grade brand conforming to I.S.I standard is used in the present investigation.

Test on Cement:

Following are the tests to be conducted to judge the quality of cement.

1. FINENESS
2. SOUNDNESS
3. CONSISTENCY
4. INITIAL AND FINAL SETTING TIME

3.2.2 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 IS 2386-1963(28). Grain size distribution of sand shows that it is close to the zone 1 of IS 383-1970(29). The properties of sand are shown in table 3.4. Details of sieve analysis are shown in table 3.5. Grading curve

3.2.3COARSE AGGREGATE:

Machine crushed angular granite metal from the local source is used as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter etc. The coarse aggregate is also tested for its various properties.

The specific gravity and fineness modulus of coarse aggregate are 2.64,7.14 respectively. The bulk density of coarse aggregate is 1700 kg/m³. The details are tabulated in table 3.6. Sieve analysis is carried out ant grading.

3.2.4 FLY ASH

Fly ash, an artificial pozzolanna is the unburned residue resulting, from combustion of pulverized coal or lignite. It is collected by mechanical or electrostatic separators called hoppers from flue gasses of power plants where powdered coal is used as fuel. This material, once considered as a by-product finding difficulty to dispose off, has now become a material of considerable value when used in conjunction with concrete as an admixture.

3.2.4.1 Classification of Fly Ash

ASTM-C 618-93categories natural pozzolannas into the following categories.

Class N fly ash: Raw or calcined natural pozzolannas such as some diatomaceous earths, opalinechert and shale, stuffs volcanic ashes and pumice comes in this category. Calcinedkaoline clay and laterite shale also fall in this category of pozzollanas.

Class F fly ash: Fly ash normally produced from burning anthrdoete or bituminous coal falls in this category. This class of fly ash exhibits pozzolanic property but rarely if any, self-hardening property.

3.2.5 SILICA FUME

Condensed Silica fume, also known as microsilica,is a dry amorphous powder which, when added with standard cements will increase the durability and strength of the concrete as well as reducing permeability and improving abrasion-erosion resistance. It may also be used in many applications where high strength is required.

The addition of silica fume produces concrete with reduced permeability resulting in increased water tightness enhanced chemical resistance and reduced corrosion of reinforcing steel. Silica fume has a bulk density of approximately 610kg/m³.

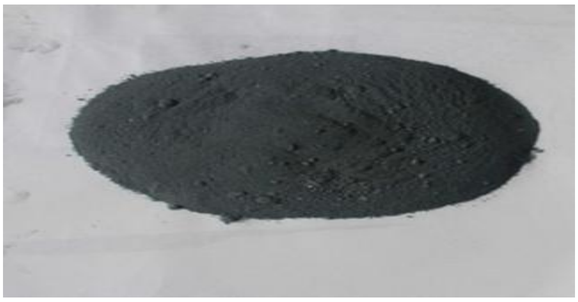


Fig 2: Condensed Silica Fume (CSF)

3.2.6 FIBRES:

The use of fibres in brittle matrix materials has a long history going back at least 3500 years when sun-baked bricks reinforced with straw were used to build the 57 m high hill of AqarQuf near Baghdad (Newman et al, 2003). In addition, horsehair was used to reinforce masonry mortar and plaster (ACI Committee 544.1R, 1996). After that, asbestos fibres have been used to reinforce cement products, such as roofing sheets, for about 100 years. However, primarily due to health hazards associated with asbestos fibres, alternate fibre types were introduced throughout the 1960s and 1970s.

The low tensile strength and brittle character of concrete have been bypassed by the use of reinforcing rods in the tensile zone of the concrete since the middle of the nineteenth century (ACI Committee 544, 1986). Moreover, patents have been granted since the turn of the century for various methods of incorporating discontinuous steel reinforcing elements such as, nails, wire segments or metal chips into concrete.

3.2.8 SUPER PLASTICIZER:

The super plasticizer used in this experiment is SP430. It is manufactured by FOSROC.
Super plasticizers are new class of generic materials which when added to the concrete causes increase in the workability.
They consists mainly of naphthalene or melamine sulphonates, usually condensed in the presence of formaldehyde.
Super plastised concrete is a conventional concrete containing a chemical admixture of super plasticizing agent. It enhances workability state to make reduction in water cement ratio of super plasticized concrete, while maintaining workability of concrete. The use of super plasticizers in ready mixed concrete and construction reduces the possibility of deterioration of concrete for its appearance and density. On the other hand, it makes the placing of concrete more economical by increasing productivity at the construction site.

3MIX DESIGN

The selection of mix materials and their required proportion is done through a process called mix design. There are number of methods for determining concrete mix design. The method that we have adopted is called the D.O.E Method which is in compliance to the British Standards. The objective of concrete mix is to find the proportion in which concrete ingredients-cement water fine aggregate and coarse aggregate should be combined in order to provide the specified strength workability and durability and possibly meet other requirements as listed in standards such as IS: 456-2000.

The DOE method was first published in 1975 and then was revised in 1988, as per the BS code 1988 year. The DOE method is applicable to concrete for most purposes. The method can be used for concrete using fly ash.

3.4 CASTING OF TEST SPECIMENS

The present experimental programme includes casting and testing of specimens for compression. Specimens are prepared M80 grade of concrete with and without Fly ash. Total of 18 cube specimens with various percentages of Fly ash are casted. The details of casting and testing of specimens are described below. (Note: all of the following specifications are in adherence to IS: 516-1959)

Workability

Each batch of concrete was tested for consistency immediately after mixing by the compaction factor method as described in IS : 1199 – 1959. No water or any other material was lost. The concrete used for the consistency tests was remixed with the remainder of batch before making the test specimens. The period of re-mixing was kept as short as possible and yet at the same time, was sufficient to produce a homogenous mass. The fresh concrete is tested for workability using compaction factor apparatus.

Compaction Factor:

Weightof partially compacted concrete/Weight of fully compacted concrete:
The compaction factor is calculated for various percentages of Fly ash concretes and various ordinary concretes keeping the water cement ratio constant.

For compression test

As the largest size of aggregate exceeded 2 cm, the size of test specimen used was 100 x 100 x 100 mm cubes, as proposed by the IS Code.

For flexure test

As the largest nominal size of aggregate does not exceed 19 mm, the size of test specimen made is 100 x 100 x 500 mm.

Casting of specimen

For casting the specimens, standard C.I metal moulds 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 in to mould.

Compaction by vibration

Each layer of concrete in the mould was vibrated using a vibrating table till the specified condition was achieved and till each corner and void within the mould was not completely and properly filled.

Compressive strength test

Testing Machine

The compressive testing machine, which has been used in our project, is of a reliable type and of sufficient capacity for the tests. Its permissible error is not greater than ± 2 percent of the maximum load. The testing machine is equipped with two steel bearing platens with hardened faces. One of the platens (the one that will bear on the upper surface of the specimen) is fitted with a ball seating in the form of a portion of a sphere, the centre of which coincides with the central point of the face of the platen. The other compression platen is a plain rigid bearing block. The bearing faces of both the platens larger than the nominal size of the specimen to which the load is applied. The bearing surfaces of the platens do not depart from a plane by more than 0.01mm at any point and they are maintained with a permissible variation limit of 0.02mm. The movable portion of the spherically seated compression platen is held on the spherical seat but the design is such that the bearing face is rotated freely and can be tilted through small angles in any direction.

Test Procedure

Specimens stored in water were tested immediately upon removal from water and while they were still in wet condition. Surface water and grit were wiped off the specimens and any projecting fins were removed. Specimens when received dry were kept in water for 24 hours before being taken for testing.

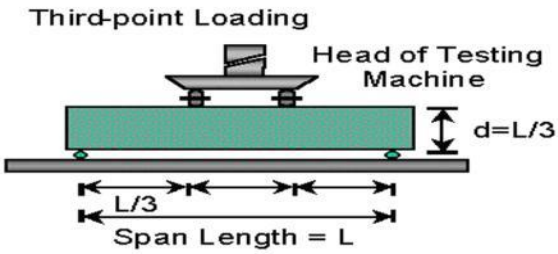
Calculation

The measured compressive strength of the specimen was calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area, calculated from the mean dimensions of the section and are expressed to the nearest kg per sq.cm. Average of the obtained values have been taken as the representative of the batch that is when the individual variation was not more than ± 15 percent of the average.

3.5.2 Flexure test

Apparatus

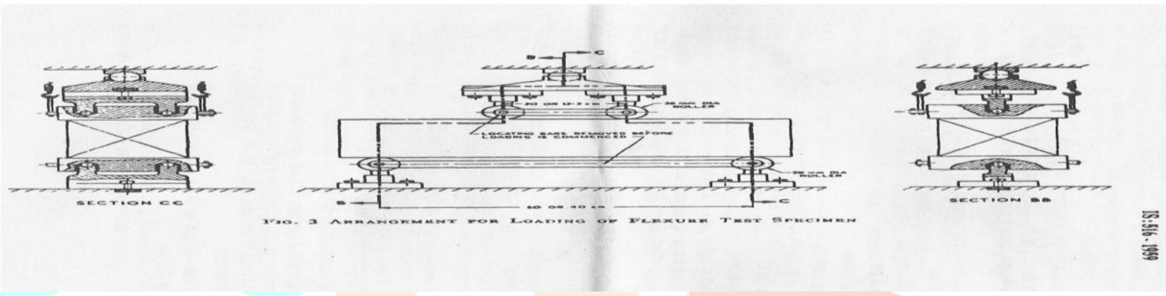
The testing machine is of a reliable type of sufficient capacity for the tests and capable of applying the load at the rate specified. The permissible errors are not greater than + 0.5 percent of the appointed load where a high degree of accuracy is required and not greater than + 1.5 percent of the applied load for commercial type of use. The bed of the testing machine is provided with two steelrollers, 38 mm in diameter, on which the specimen is supported and these rollers are so mounted that the distance from centre to centre is 60 cm for 15 cm specimens or 40 cm for 10 cm specimens. The load is applied through two similar rollers mounted at the third points of the supporting span that is, spaced at 20 or 13.3 cm centre to centre. The load is divided equally between the two loading rollers and all rollers are mounted in such a manner that the load is applied axially and without subjecting the specimen to any torsional stresses or restraints.



third point loading arrangement

Test procedure

Test specimens stored in water at a temperature of 24o C to 30o C for 48 hours before testing will be tested immediately on removal of water whilst they are still in a wet condition. The dimensions will be noted before testing. No preparation of the surfaces will be required.



Calculations

The flexural strength of the specimen shall be expressed as the modulus of rupture fb, which if „a „equals the distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen, in cm, shall be calculated to the nearest 0.5 kg/sq. cm as follows:

Case 1: *when 'a' is greater than 20 cm for 15 cm specimen or greater than 13.3 cm for a 10 cm specimen:*

$$f_b = \frac{p \times l}{b \times d^2}$$

Case 2: *When 'a' is less than 20 cm but greater than 17 cm for 15 cm specimen or less than 13.3 cm but greater than 11 cm for a 10 cm specimen:*

IV. RESULTS AND DISCUSSION

2 Variation of compressive strength at 28 days with addition of 0.5% fibre by volume of concrete and with various % of Silica Fume and Fly ash

S.NO	% SILICA FUME	% FLY ASH	28 DAYS COMPREESIVE STRENGTH IN MPA		
			STRENGTH	% INCREASE OVER 0%	% INCREASE OVER PRECEDING
1	0	0	77.21		
2	5	0	78.94	2.24	2.24
3	10	0	79.47	2.92	0.67
4	15	0	79.15	2.51	-0.40
5	0	20	78.14	1.20	-1.27
6	5	20	79.59	3.08	1.85
7	10	20	79.96	3.56	0.46
8	15	20	79.56	3.04	-0.50
9	0	40	77.83	0.80	-2.17
10	5	40	79.18	2.55	1.73
11	10	40	79.62	3.12	0.55
12	15	40	79.38	2.81	-0.30

4.4 Graphs depicting results for flexural strength

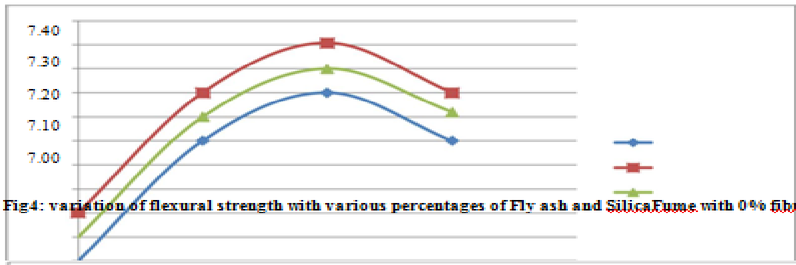


Fig4: variation of flexural strength with various percentages of Fly ash and SilicaFume with 0% fibre

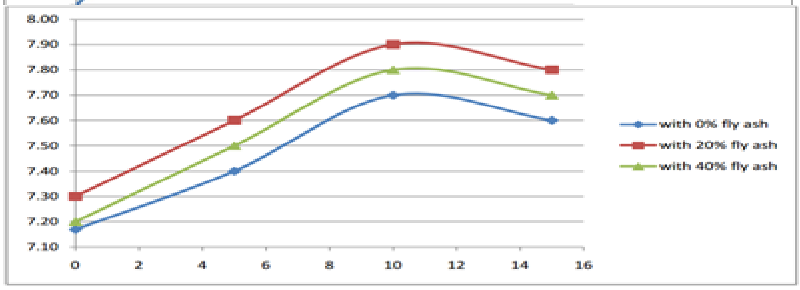


Fig5: variation of flexural strength with various percentages of Fly ash and SilicaFume with 0.5% fibre

CONCLUSIONS

Based on the present experimental investigations the following conclusions are drawn:

1. Higher dosages of superplasticizer are required for high strength concrete mixes particularly when mineral admixtures and fibres were employed to maintain workability.

2. For this combination of 10% silica fume with 20% fly ash the compressive strength has shown an increase from 2 to 7 % with various percentages of fibre

3. 20% fly ash generates marginal increase in strength. To compensate for the loss of strength when higher percentages of fly ash is used silica fume is added

4. Fly ash is pozzolanic in nature and slowly reacting and it requires longer curing periods even beyond 28 days to generate high strength particularly when percentage is more

5. As the percentage of steel fibre is increased there is marginal increase in the compressive strength for all the combinations

6. For this combination of 10% silica fume with 20% fly ash the compressive strength has shown an increase from 15 to 31.5 % with various percentages of fibre

7. As the percentage of steel fibre is increased there is higher increase in the flexural strength for all the combinations

8. An optimum high strength concrete mix possessing optimum strength properties can be obtained resorting to triple blending.

9. In the case of triple blended cement concrete mixes, adding certain percentages of steel fibres would help in generating optimum structural concrete mixes possessing all the strength and durability properties

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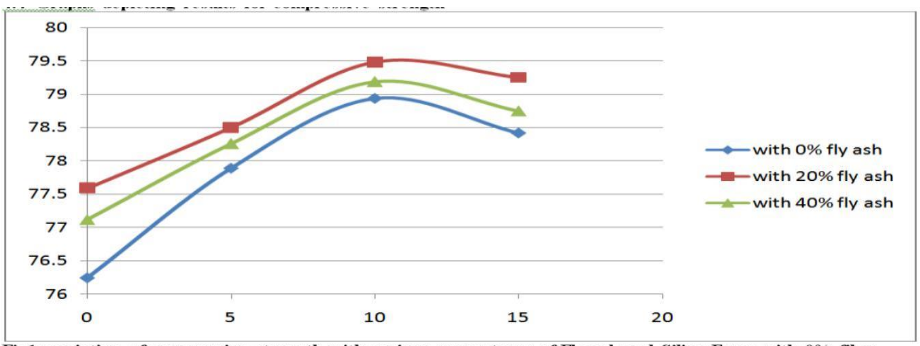


Fig1: variation of compressive strength with various percentages of Fly ash and Silica Fume with 0% fibre

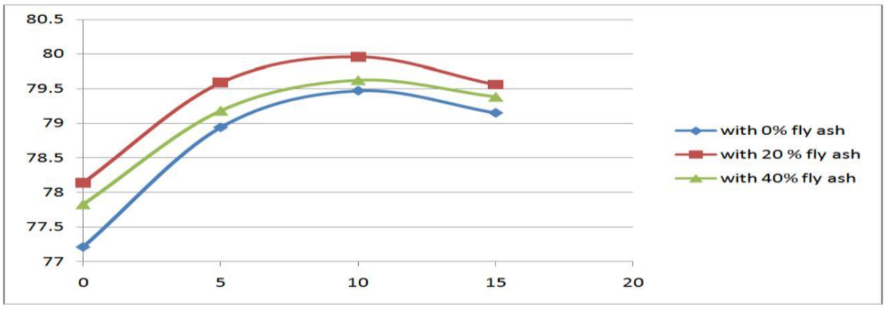
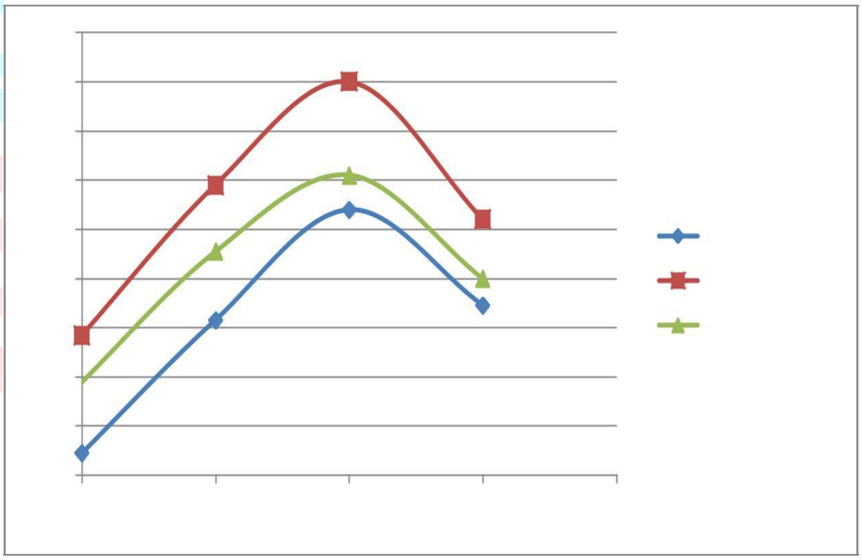
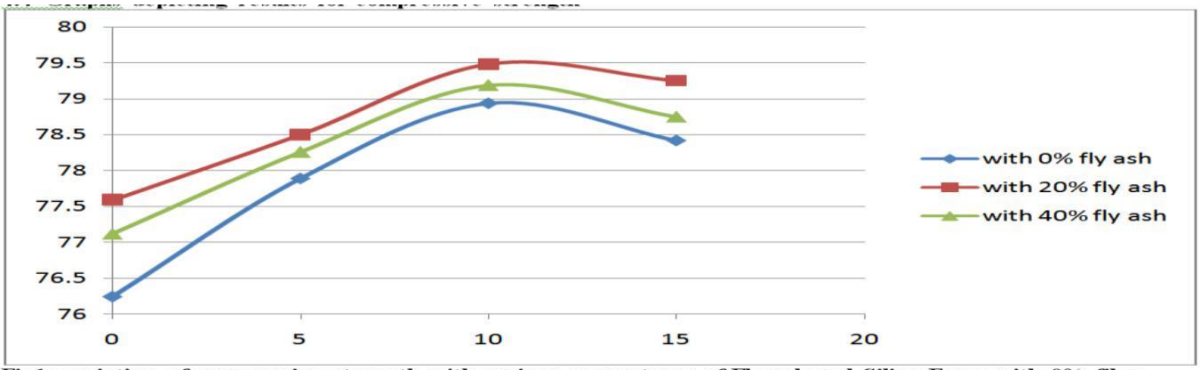


Fig2: variation of compressive strength with various percentages of Fly ash and Silica Fume with 0.5% fibre





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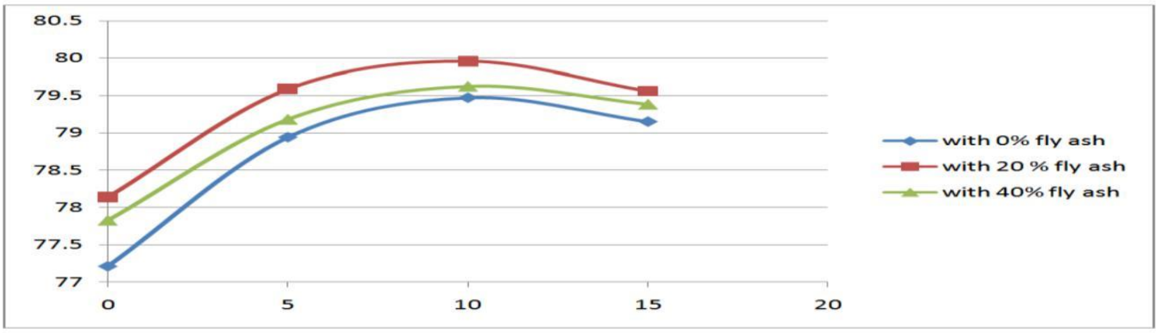

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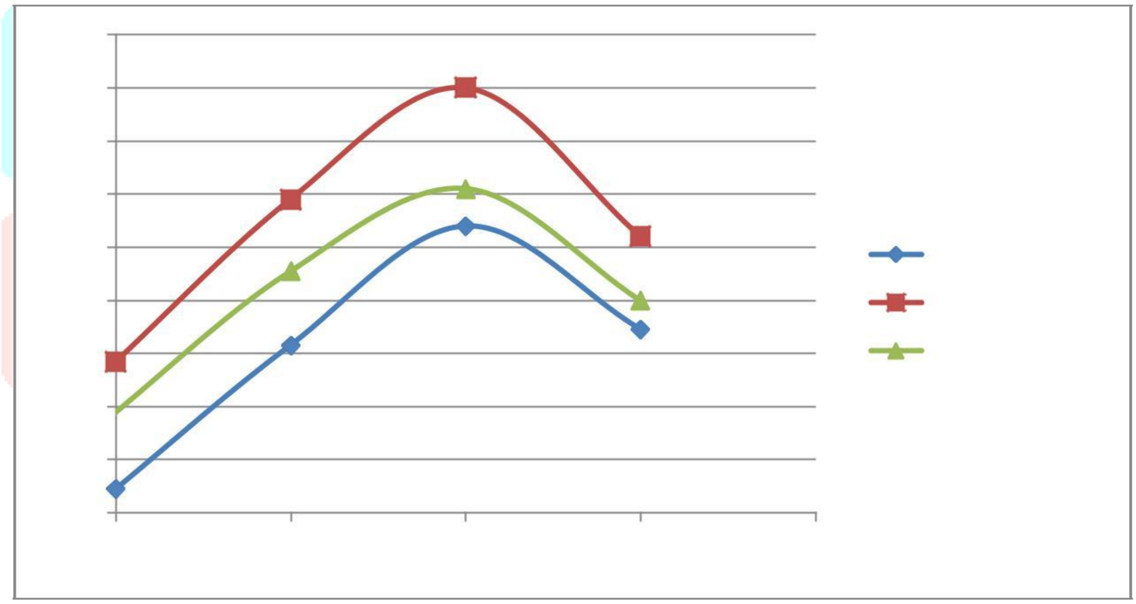

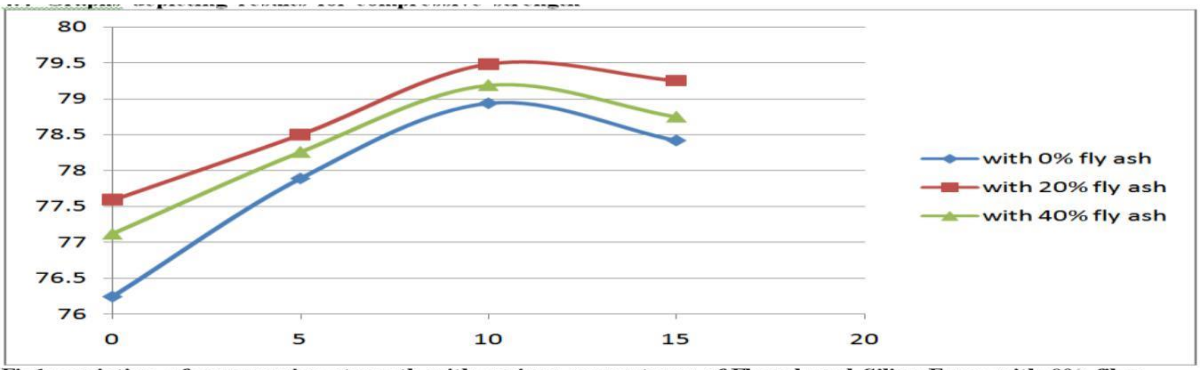

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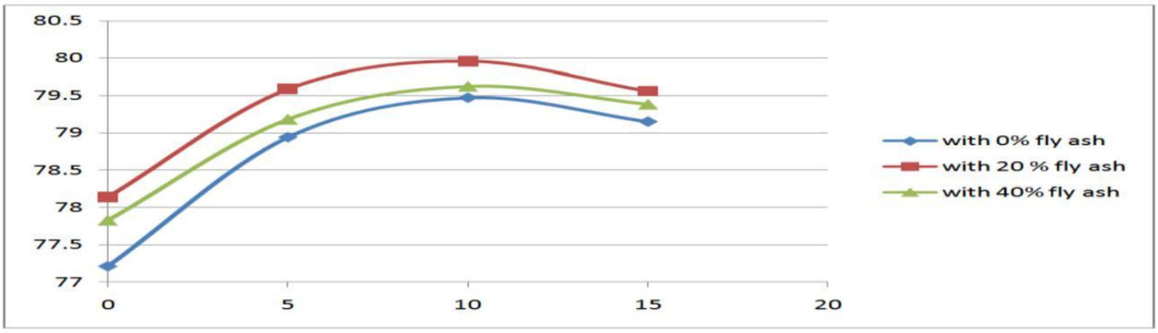

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