AN EXPERIMENTAL STUDY ON SLICA FUME CONCRETE WITH ADDITION OF FIBRES

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Abstract

The experiment work was done using silica fume as an additive to cement and evaluates cement for concrete of the M40 grade. In addition to adding glass fibre and coconut fibre, we are adding cement in concrete at weights of 0%, 5%, 10%, and 15%. The purpose of the investigation is to examine the viability of using glass and coconut fibre in addition to other concrete constituents and strength properties. To assess the impact of glass fibres improving the properties of concrete, the influence of each 1%, fibres content by mass of cement, aspect ratio 857, and fibre cut length 12mm is investigated. The compressive strength test and split tensile strength are best at 2% addition of glass fibre, 10% silica fume, and water cement ratio 0.45. The best results in concrete come from the compressive strength test and split tensile strength.1% coconut fibre and 1% glass fibre are added to all concrete mixtures. Cubes and cylinders were cast for each mix. Workability is decreased because coconut fibre is present. Compared to the control mix, the mixture with 10% silica fume and 2% fibre added produced better results.

Fibers are added to concrete to prevent and delay the tensile cracking of composite materials. In this case, an effort is made to reuse coconut fibre materials as fibre composites in concrete, which partially resolves the waste disposal issue as well as the ductility issue. Thermally, coconut fibre causes the room temperature to drop more than the temperature of the air. It is well known that silicafume enhances the durability and mechanical properties of concrete

Keywords: Coconut fiber, Glass fiber, Slica fume, Cement 43 grade, M_{40}, durability, Mechanical Properties

Literature Review

"An experimental investigation on glass fibre reinforced concrete with silica fume as admixture". By Vaishali Ghorpade

High performance concrete (HPC) has been used in various structures all over the world since last two decades. Recently a few infrastructure projects have also seen specific application of high-performance concrete. The development of high performance concrete (HPC) has brought about the essential need for additives both chemical and mineral to improve the performance of concrete. Most of the developments across the work have been supported by continuous improvement of these admixtures. Hence variety of admixtures such as fly ash, rice husk ash, stone dust have been used so for. Also different varieties of fibres have below tried as additions. Hence, an attempt has been made in the present investigation to study the behaviour of Glass fibres in High Performance Concrete. To attain the set out objectives of the present investigation, an aggregate binder ratio of 2.0 has been chosen and cement has been replaced partially with Silica fume in four different Hardened Glass fibre Reinforced High Performance Concrete (GFRHPC) is tested for Compression, split tension and flexural strengths. This investigation concluded that 10% of silica fume and 1.0% of glass fibre volume which can be used for giving maximum possible compressive strength and split tensile strength at any age for glass fibre reinforced high performance concrete percentages viz. 0, 10, 20 and 30% Glass fibres by 0, 0.5, 1.0, and 1.5 % to produce High Performance Concrete.

Study of compressive strength of concrete with glass fibre and silica fume. By Akash Kumar Patel and Dr. Rajiv Chadsk

In the world, concrete is most widely used construction material they are made in any form and shape. The strength and durability of concrete can be changed by making appropriate changes in its ingredient like cementation material, aggregate and water and by adding some special ingredient likesilica fume and Glass fibre. They are produced better strength in concrete. The presence of micro cracks in the mortar aggregate produce weakness in concrete 8 The aim of this paper is to study the behaviour of M-35 grade of concrete to determine the compressive strength by partially replacement of cement by mineral admixture such as silica fume and also added Glass fibre. Cement was partiallyreplaced by silica fume in 10% by weight of cement and glass fibres in 1%, 2%, and 3%. The tests were performed according to Bureau of Indian standards. The results thus obtained were compared and examined with respect to the control specimen. It was found that addition of glass fibre in concrete they give variation in strength.

From the study they concluded that compressive strength reduces when cement replaced by silica fume. As silica fume percentage increases compressive strength and split tensile strength decreases. It has been observed that the increase in compressive strength for M-35 grade of concrete at 7 and 28 days are observed to be more at 1%. We can likewise utilize the waste product of glass as fibre.

The Mechanical Properties of Concrete Incorporating Silica Fume as Partial Replacement of Cement.By Hnumesh B M, B K Varun Harish B A.

In this paper their study an attempt has been made to use silica fume as a supplementary material for cement and to evaluate the limit of replacement of cement for M20 grade concrete. The main aim of this work is to study the mechanical properties of M20 grade control concrete and silica fume concrete with different percentage 5, 10, 15 and 20% of silica fume as a partial replacement of cement.

From the study concluded that compressive strength and split tensile strength of concrete is increased by the use of silica fume up to 10% replacement of cement. From 10% there is a decrease in compressive strength and split tensile strength. The compressive strength mainly depends on the percentage of silica fume because of its high pozzolanic nature to form more densely packed C-S-H gel. The split tensile strength increases mainly due to improvement in packing, i.e., action of it as a filler material.

Glass Fibre Reinforced Concrete Use in Construction.By Pshtiwon N. Shakor , and s. s. Pimplikar.

In this study trial tests for concrete with glass fibre and without glass fibre are conducted to indicate the differences in compressive strength and flexural strength by using cubes of varying sizes.Various applications of GFRC shown in the study, the experimental test results, techno-economic comparison with other types, as well as the financial calculations presented, indicate the tremendous potential of GFRC as an alternative construction material.Glass fibre Reinforced Concrete offers many advantages, such as being lightweight, fire resistance, good appearance and strength. The glassfibres are used in this experiment 0, 0.11, 1.5 and 2.0% by weight of cement. From this study concluded that average compressive strength of concrete is maximum, when 1.5% of glass fibre is used. And 2% of glass fibre gave a maximum flexural strength of concrete, which is 10% more than that obtained at 1.5%

Material and Methodology

Materials

- Cement
- Fine aggregate
- Coarse aggregate
- Silica fume
- Glass fibre & Cocount fibre

Cement

In this present work Ultratech cement of 43 grade ordinary Portland cement was used for casting cubes and cylinder for all concrete mixes. The cement is uniform colour and free from any hard

lumps. The various testes conducted on cement are standard consistency, initial and final setting time, specific gravity, fineness and compressive strength.A Cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Cements used in construction are usually inorganic, often lime or calcium silicate based, which can be characterized as nonhydraulic or hydraulic respectively, depending on the ability of the cement to set in the presence of water (see hydraulic and non-hydraulic lime plaster). Non-hydraulic cement does not set in wet conditions or under water. Rather, it sets as it dries and reacts with carbondioxide in the air. Hydraulic cements set and
become adhesive due to a chemical reaction between the dry ingredients and water. Cement starts to set when mixed with water, which causes a series of hydration chemical reactions. Generally, the specific gravity of cement ranges from 3.1 to 3.16 g/cc. From this we can say that the specific gravity of cement is more than the specific gravity of water that is 1. It means cement will sink in water if we put on thewater.

Figure1: Cement43 Grade

Table1 Physical Properties of Cement

S.N0	Physical Property	Test Result
1	Standard Consistency	30.00%
2	Fineness	5.00%
3	Special Gravity	3.15
4	Initial Setting time	28 min

Physical Properties	Value
Fineness Modulus	2.5
Water Absorption	0.8%
Specific Gravity	2.65
Bulk Density	1610k

Table.2 Physical Properties Of Fine Aggregate

Property	Value	Specification(ASTMC33Limit)
Specific Gravity	2.68	2.4-2.9
Unit Weight(Bulk density)	1513.2	1200-1750Kg/m3
Water Absorption	2.81%	<4%
Voids in Aggregate	36.25%	30-45%
Sit Content	4.87%	<5%
Moisture Content	3.62%	0-4%
Fineness Modulus	2.40	5%

Coarse Aggregate (CA):

Locally available coarse aggregate having the maximum size of 20mm is used in the present work. The specific gravity of coarse aggregate is found to be 2.69 and water absorption is found to be

4%.Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and Portland cement, are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete. Aggregates, which account for 60 to 75 percent of the total volume of concrete, are divided into two distinct categories--fine and coarse. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve. Coarse aggregates are any particles greater than 0.19inch, but generally range between 3/8 and 1.5 inches in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.
Natural gravel and sand are usually dug or dredged from a pit, river, lake, or seabed. Crushed aggregate is produced by crushing quarry rock, boulders, cobbles, or large-size gravel. Recycled concrete is a viable source of aggregate and has been satisfactorily used in granular subbases, soil- cement, and in new concrete.
After harvesting, aggregate is processed: crushed, screened, and washed to obtain proper cleanliness and gradation. If necessary, a benefaction process such as jigging or heavy media separation can be used to upgrade the quality. Once processed, the aggregates are handledand stored to minimize segregation and degradation and prevent contamination.

Aggregates strongly influence concrete's freshly mixed and hardened properties, mixture proportions, and economy. Consequently, selection of aggregates is an important process. Although some variation in aggregate properties is expected, characteristics that areconsidered include:

- durability
- particle shape and surface texture
- abrasion and skid resistance
- unit weights and voids
- absorption and surface moisture

Grading refers to the determination of the particle-size distribution for aggregate. Gradinglimits and maximum aggregate size are specified because these properties affect the amountof aggregate used as well as cement and water requirements, workability, pumpability, and durability of concrete. In general, if the water-cement ratio is chosen correctly, a wide range in grading can be used without a major effect on strength. When gap-graded aggregate are specified, certain particle sizes ofaggregate are omitted from the size continuum. Gap-graded aggregate are used to obtain uniform textures in exposed aggregate concrete. Close control of mix proportions is necessary to avoid segregation.

Coarse aggregate Shape and Size Matter

More so than the properties of hardened concrete, the properties of freshly mixed concrete are influenced by particle shape and surface texture. To produce workable concrete, rough-textured, angular, and elongated particles need more water than smooth, rounded compact aggregate. To keep the water-cement ratio constant, the cement content must also be raised. In general, flat and elongated particles should be avoided or kept to no more than 15% of the aggregate weight.Measured by unit-weight is the volume of the graded aggregate. The amount of cement paste needed for the mix depends on how much space there is between the particles. Aggregates with angles raise the void content. Improved grading and larger sizes of well-graded aggregate reduce the voidcontent. When choosing aggregate mixed concrete are influenced by particle shape and surface texture. Aggregate is composed of solid material and voids that may or may not contain water. Particles with rough textures, angles, and lengths require more water to bind them together. The water content of the concrete mixture must be adjusted to account for the aggregate's moisture levels.

Figure-2 Coarse Aggregate

Table-3 Physical Properties of Coarse Aggregate

S.N0	Coarse Aggregate	Result Achieved
1	Specific Gravity	2.7
2	Unit Weight(kg/m3)	1580
3	Fineness	6.63
4	Water Absorption	1.09

Table-4 Test type of coarse aggregates

Tests Types	Conventional aggregate
Maximum Size	12.5
Specific gravity	2.7
Bulk density(Kg/M3)	1656
Fineness modulus	6.77
Crushing value	20.03%

Silica fume

Silica fume is a byproduct of making ferrosilicon alloys or silicon metal. Concrete made with silica fume can be extremely strong and long-lasting. A highly pozzolanic material called silica fume, a by-product of the ferrosilicon industry, is used to improve the mechanical and durability propertiesof concrete. It can be mixed with silica fume and Portland cement, or it can be added directly as an ingredient to concrete. In the US, silica fume is primarily used to create concrete that is more resistant to chloride penetration for uses such as parking garages, bridge decks, and bridges.

Physical characteristics

The primary micro silica particle is spherical and has a mean diameter of about 0.15 µm. shows a collection of particles in a transmission electron micrograph. shows typical grain size distributions of micro silica.

Figure-3 Silica Fume

Incorporation of NS also improves the strength properties. Shaikh et al. (2014) observed thataddition of NS (up to 2%) as partial replacement of cement enhanced the compressivestrength by 16% and 14% at 7 and 28 days, respectively. The addition of higher NS content (6%) decreased the strength due to the agglomeration of NS particles in the wet mix resulting in a significant reduction of effective specific surface area.

Table-5 Physical Properties Of Silica Fume

Properties	Cement	Silica Fume
Physical properties		
Specific Gravity	3.15	2.25
Surface area,m2/kg	320	20,000
Size,micron	_	0.1
Bulk density,kg/m	_	576
Initial setting time(min)	45	_
Final setting time(min)	375	_
Chemical Properties Percentage		
Sio2	90-96	20-25
Al2o3	0.5-0.8	4-8

Glass fibre

Dimensionality and su Glass fibre is a substance made up of numerous, incredibly fine glass fibres. By varying the amount of raw materials, such as sand for silica, clay for alumina, calcite for calcium oxide, and colemanite for boron oxide, glass fibres can be produced in a variety of compositions. Therefore, using varying amounts of silica or other sources, various glass fibre types exhibit varying performances, such as alkali resistance or high mechanical properties. Products made of glass fibre are categorised based on the type of composite at which they are used. In addition, the key components used in the injection moulding, filament winding, pultrusion, sheet moulding, and hand layup processes to create glass fiber-reinforced materials are chopped strands, direct draw rovings, assembled rovings, and mats. Whether making glass fibre or creating composites, protecting the glass fibre filaments from breakage or disintegration is a crucial issue. From an energy standpoint, reducing vehicle weight is the primary way to save energy in the transportation sector, and in this context, the importance of glass fiber-reinforced composites is demonstrated by the growth in the production of lightweight cars to about 50%. As a result, there has been and will continue to be growth in the production of glass fibre. Surface texture affects the characteristics of newly

Figure-4 Glass Fibre

Table-6 Physical Properties of Glass Fibre

Property	**Units**	**E-glass fibre**
Density	Gr/cm3	2.56
Tensile Strength	Mpa	3,445
Modulus of elasticity	Gpa	76
Tensile elongation	%	2.75
Fibre diameter	um	13
Chopped length	mm	3
Moisture content	%	Maks.0.1
Chemical Composition	%(weight)	52.4 Sio2
		14.4 Al2o3

Coconut Fibre

Using a cutting machine, uniform fibre length was achieved. Vernier scales were used to measure the fibre length and micrometres to measure the diameter. Using a pycnometer, the specific gravity and density of coir fibres were calculated. The specific gravity and density of the coir fibre were determined after 24 hours of immersion in water because of its propensity to absorb water, particularly in the first few hours.

Figure-5 Coconut fibre-I

Table-7 Physical properties of coconut fibre

Specific Fibre	1.12
Water absorption	98%
Thickness of fibre	0.05mm

Properties of coconut fibre

Physical properties and Chemical properties

- Compared to other typical natural fibres, coconut fibre has higher lignin and lower cellulose and hemicellulose, together with its high microfibrillar angle, offers various valuable properties, such as,resilience, strength, damping, wear, resistance to weathering, high elongation at break.

Figure-6 Coconut fibre-II

Coir Fibre

Specific Fibre	1.12
Water absorption	98%
Thickness of fibre	0.05mm

Testing Of Specimens (Test On Fresh Concrete)

Slump Cone Test

The concrete slump test gauges how fluid new concrete is before it hardens. It is done to examine whether freshly made concrete is workable and, consequently, whether concrete flows easily. It can also be used as a sign of a batch that was not properly mixed.

The basic component of a slump cone test is a steel mould in the shape of a cone, with interior dimensions of a top diameter of 10 cm, a base diameter of 20 cm, and a height of 30 cm.

The purpose of the concrete slump test, also known as the slump cone test, is to assess the workability or consistency of the concrete mix produced in the laboratory or on the construction site as the project is being carried out. To ensure that concrete is of a consistent quality throughout the construction process, concrete slump tests are performed from batch to batch. The slump test is the simplest, least expensive, and fastest way to determine whether concrete is workable. It has been widely used for workability tests since 1922 as a result of this. According to the steps outlined in ASTM C143 in the United States, IS: 1199 - 1959 in India, and EN 12350-2 in Europe, the slump is carried out. There are a number of factors, but typically the concrete slump value is used to determine workability, which represents the water-cement ratio including properties of materials, mixing methods, dosage, admixtures etc. also affect the concrete slump value.

Figure-7: Concrete Slump Test

- edge to top of slumped concrete at a point over original centre of Fill cone tooverflowing, rod layer 25times with penetrating both layers
- Remove excess concrete from, top of cone, using tamping rod as a screed. Cleanoverflow from base of cone
- Invert the cone, place next to but not touching slumped cone
- Measure amount of slump in inches from bottom of straight base

Result

The resulting slump is 66mm which is medium workable and it is a true slump

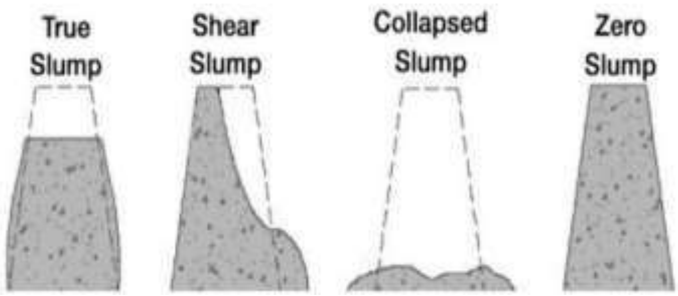

Figure-8: slump cone test-II

Compaction Factor Test

The workability of fresh concrete can also be evaluated using the compaction factor test. Compared to the Slump cone test, the compacting factor experiment provides a more accurate assessment of the workability of fresh concrete. The "drop test" is another name for the compaction factor test. The ratio of the weight of partially compacted concrete to that of fully compacted concrete is known as the compaction factor test.

Compaction Factor Test for Concrete Workability

The workability test for concrete that is carried out in a lab is called the compaction factor test. The ratio of the weights of partially compacted to fully compacted concrete is known as the compaction factor. It was created by the Road Research Laboratory in the UK and is used to assess the concrete's workability. For concrete that is difficult to work with and for which the slump test is ineffective, the compaction factor test is used.

Apparatus

Compaction factor apparatus consists of trowels, hand scoop (15.2 cm long), a rod of steel orother suitable material (1.6 cm diameter, 61 cm long rounded at one end) and a balance.

Sampling

Concrete mix is prepared as per mix design in the laboratory

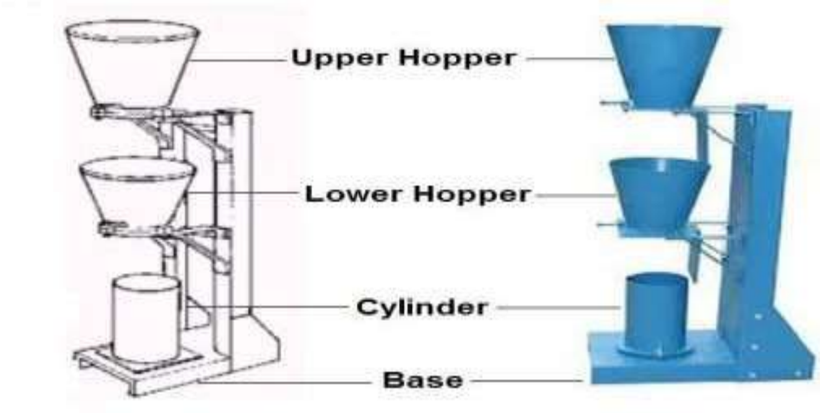

Figure-9: Compaction Factor Test

Apparatus for Concrete Cube Test Compression testing Machine Preparation of Concrete Cube Specimen. The proportion and material for making these test specimens are from the same concrete used in the field.

Specimen

6 cubes of 15 cm size Mix. M15 or aboveMixing of Concrete for Cube Test

Mix the concrete either by hand or in a laboratory batch mixer

Split Tensile Strength Experiment

The capacity of a material or constitution to withstand tension is known as tensile force. Utilizing a compression testing machine, it is measured on a concrete cylinder with standard dimensions.Various percentages of fibre and silica fume were tested in conventional and fiber-included concrete specimens. The split tensile strength was calculated using a cylinder specimen with a 150mm diameter and 300mm height.

One of the fundamental and crucial characteristics of concrete that significantly influences the size and extent of cracking in structures is its tensile strength. Additionally, because concrete is brittle, it is very weak in tension. It is therefore not anticipated to resist the direct tension. As a result, cracks form in concrete when tensile forces are greater than its tensile strength. In order to determine the load at which the concrete members may crack, it is necessary to determine the tensile strength of concrete. In addition, one method for figuring out concrete's tensile strength is to split a concrete cylinder. Based on ASTM C496 (Standard Test Method of Cylindrical Concrete Specimen), which issimilar to other codes, the procedure.

Figure-10 Split Cylinder Testing Machine

Concrete pouring and compaction

- After the mixture is prepared, it is poured into the oiled mould in layers approximately 5 cm deep.
- Then, each layer is compacted either by hand or by vibration.
- For manual compaction, use tamping bar.
- Distributed bar stroke uniformly in order to compact it properly.
- Minimum tamping bar stroke for each layer is 30.
- Penetrate strikes in to the underlying layer
- Apply the rode for the entire depth of bottom layer
- complete top layer compaction

Lastly, the surface of the concrete should be finished level with the top of the mould,using atrowel and covered with a glass or metal plate to prevent evaporation

Figure-10: Concrete specimen

Curing of Specimen

- Casted specimen should be stored in a place at a temperature of 27° +/- 2°C for 24 +/- 0.5 hrs from the time addition of water to the dry ingredients.
- After that, the specimen should be marked and removed from the mould and immediately submerged in clean fresh water or saturated lime solution and kept there until taken out just prior to the test.
- The water or solution in which the specimens are kept should be renewed every seven days and should be maintained at a temperature of 27° +/- 2°c.
- For design purpose, the specimen cured for 28 days

Figure-11 Curing concrete cylinders

Procedure of Splitting Tensile Test

- Initially, take the wet specimen from water after 7, 28 of curing; or any desired age atwhich tensile strength to be estimated.
- Then, wipe out water from the surface of specimen
- After that, draw diametrical lines on the two ends of the specimen to ensure that theyare on the same axial place.
- Next, record the weight and dimension of the specimen.
- Set the compression testing machine for the required range.
- Place plywood strip on the lower plate and place the specimen.
- Align the specimen so that the lines marked on the ends are vertical and centred overthe bottom plate.
- Place the other plywood strip above the specimen.
- Bring down the upper plate so that it just touch the plywood strip.
- Apply the load continuously without shock at a rate within the range 0.7 to 1.4MPa/min (1.2 to 2.4 MPa/min based on IS 5816 1999)
- Finally, note down the breaking load(P)

Figure-12 Testing cylindrical concrete specimen-I

Results and Discussion

Split tensile strength

Split tensile strength of cylindrical concrete specimen results in a 10% strength increase (5.12,5.09,5.16 N/mm2) when compared to conventional and slica fume 5% and 15% cylindrical concrete specimens for a mix proportion of 2% fibre and 10% slica fume. reduce concrete cracking and relatively good bonding technique with concrete with slica fume addition of fibre and high tensile strength of concrete Furthermore, the mix portion for concrete is more than 15% and the addition of 2% produces less strength compared to the conventional concrete.

7 days	**14 days**	**28 days**
2.96	3.84	4.73
2.86	3.79	4.79
2.93	3.72	4.81

5% of silica fume concrete

7 days	**14 days**	**28 days**
3.72	3.98	5.12
3.69	4.02	5.09
3.65	4.06	5.16

10 % of silica fume concrete

7 days	**14 days**	**28 days**
3.92	4.48	5.34
3.98	4.44	5.31
3.89	4.06	5.29

15% of silica fume concrete

7 days	14 days	28 days
3.86	3.98	5.06
3.89	4.04	5.11
3.88	4.09	5.08

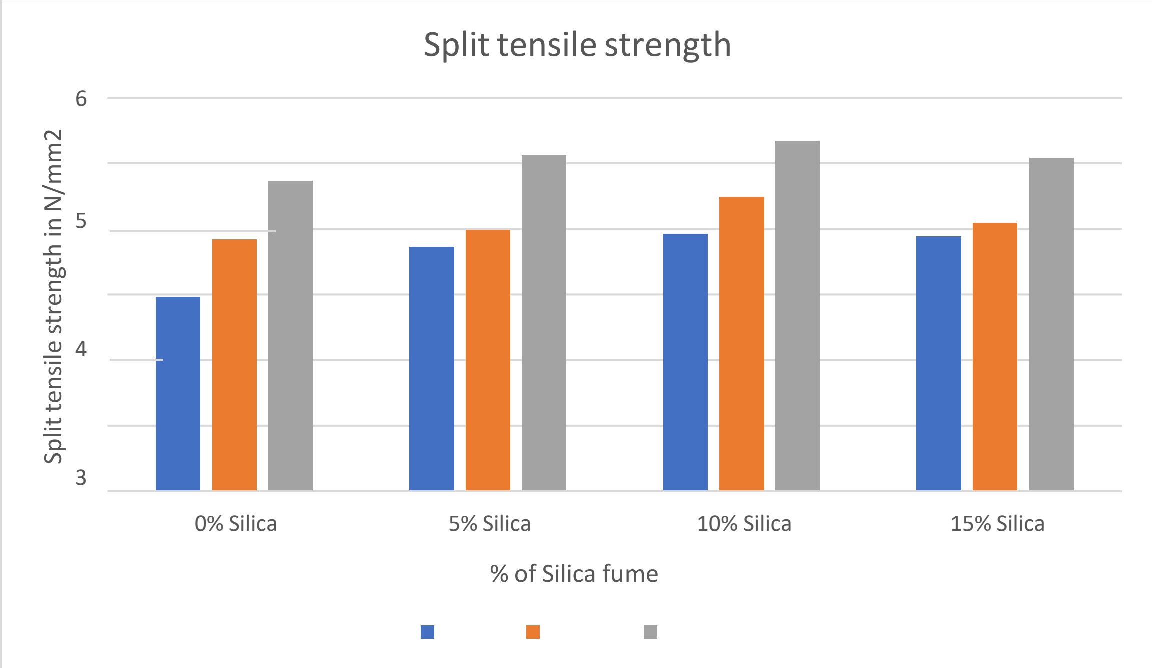

Figure12: Split tensile strength

Compressive strength

Compressive strength of concrete specimen (cube) produce 10 % strength increment (5.12,5.09,5.16 N/mm^2) compared to conventional and replacement of cement in slica fume for the 5% and 15% cube concrete specimen for the mix proportion concrete with 2% fibre with 10% of slica fume. more over reduce the crack in concrete and relatively good bond technique with concrete with slica fume addition of fibre and high compressive strength of concrete. Further the mix portion for concrete more then 15% and addition of 2% is produced less strength compared to the conventional concrete

0% of silica fume concrete

7 days	14 days	28 days
25.97	35.68	39.61
26.11	35.72	39.49
26.17	35.85	39.63

5% of silica fume concrete

7 days	14 days	28 days
29.92	41.23	46.23
30.19	41.41	46.18
30.24	41.23	46.14

10% of silica fume concrete

7 days	14 days	28 days
32.34	42.39	48.21
32.41	42.42	48.92
32.36	42.48	47.96

15% of silica fume concrete

7 days	14 days	28 days
27.16	36.72	42.10
27.19	36.43	41.98

27.24	36.48	41.86

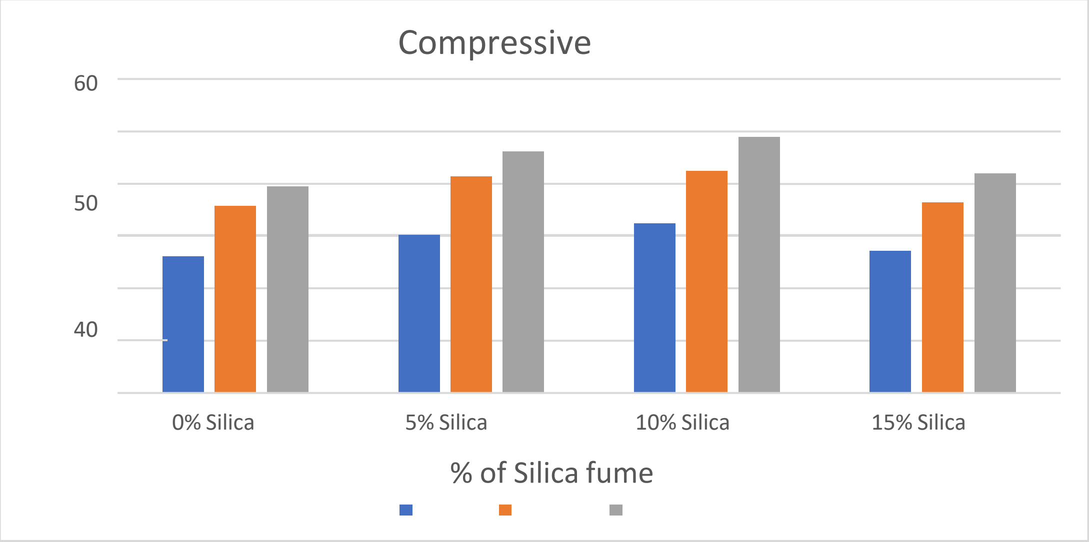

Figure12: Compressive strength of concrete

Conclusion

- Strength of concrete is increased at addition of 10 percent silica fume and with addition of 2percent fibre. For 15 percent addition of silica fume along with fibres strength decreased.
- Silica fume, glass fibre, coconut fibre increases the strength of the mix like Compressive strength, tensile strength. These strengths are very useful in any construction hence the addition gives the additional strength to the concrete it opens the many doors for the new construction which involves many challenges in real life situations. These new mix design promotes an engineer to allocate this mix to complicated structures which carry heavy load.

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