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Workability & Strength Tests on Self-Compacting Concrete for M30 Grade with Silica Fume as Partial Replacement of Cement

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ABSTRACT

Self-compacting concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. Use of SCC can also help minimize hearing-related damages on the worksite that are induced by vibration of concrete. Another advantage of SCC is that the time required to place large sections is considerably reduced. When the construction industry in Japan experienced a decline in the availability of skilled labour in the 1980s, a need was felt for a concrete that could overcome the problems of defective workmanship. This led to the development of self-compacting concrete, primarily through the work by Okamura. A committee was formed to study the properties of self-compacting concrete, including a fundamental investigation on workability of concrete, which was carried out by Ozawa et al. at the University of Tokyo. The first usable version of self-compacting concrete was completed in 1988 and was named "High Performance Concrete", and later proposed as "Self Compacting High Performance Concrete". In Japan, the volume of SCC in construction has risen steadily over the years. Data indicate that the share of application of SCC in precast concrete industry is more than three times higher than that in the ready-mixed concrete industry. This is attributable to the higher cost of SCC. The estimated average price of SCC supplied by the RMC industry in Japan was 1.5 times that of the conventional concrete in the year 2002. Research studies in Japan are also promoting new types of applications with SCC, such as in lattice type structures, casting without pump, and tunnel linings. Since the development of SCC in Japan, many organizations across the world have carried out research on properties of SCC. The Brite-Euram SCC project4 was set up to promote the use of SCC in some of the European countries. A state-of-the-art report on SCC was compiled by Skarendahl and Petersson summarizing the conclusions from the research studies sponsored by the Brite-Euram project on SCC. A recent initiative in Europe is the formation.
Keywords: SCC, CAS, H2O, Pozzolanic, Colloidal Silica

I. INTRODUCTION

For several years beginning in 1983, the problem of the durability of concrete structures was a major topic of interest in Japan. To make durable concrete structures, sufficient compaction by skilled workers is required. However, the gradual reduction in the number of skilled workers in Japan's construction industry has led to a similar reduction in the quality of construction work. One solution for the achievement of durable concrete structures independent of the quality of construction work is the employment of self Compacting concrete, which can be compacted into every corner of a formwork, purely by means of its own weight and without the need for vibrating compaction .The necessity of this type of concrete was proposed by Okamura in 1986. Studies to develop self Compacting concrete, including a fundamental study on the workability of concrete, were carried out by Ozawa and Maekawa at the University of Tokyo.

This SCC concept has been necessary to triumph over these difficulties. This SCC concept could be explained because the concrete that will matches specific effectiveness and also uniformity requirements that will cannot always be received by employing regular components, standard mixing course of action and also curing methods. This SCC is usually an designed product comprising bare cement, aggregates, H2O and also admixtures together with several new constituents similar to colloidal silica, pozzolanic products, compound admixtures to keep up unique requirements, for instance, high-flowability, compressive durability, substantial workability, superior resistances to be able to compound or perhaps kinetic stresses, decrease permeability, sturdiness, level of resistance towards segregation, and also probability within lustrous reinforcement disorders. These houses, for instance, fluidity and also substantial level of resistance to be able to segregation allows the placement of concrete devoid of vibrations with reduced your time, sound and far a lesser amount of wear of tools.

SCC assures homogeneous concrete in predicaments the place that the castings tend to be tough on account of congested reinforcement, tough accessibility and so on.

SCC demonstrates a fantastic answering ability in particular around reinforcement.

SCC is very perfect for specific and also formally stressful set ups for instance canal linings, because the probability to be able to sleek and stylish the concrete is bound within the Most suitable intended for concrete loaded pontoons (CFT) engineering design intended for substantial go up structures. It assures better top quality of in-situ pack ground work.

The environmental & human wellbeing Security:
Lessens sound with sites, the precast manufacturing area, and also town, hence, this can be a hushed concrete.

Gets rid of difficulty with circulation bringing about “white fingers” brought on by compacting tools, hence named proper concrete.

SCC provides sound safety in precast industry, through adding no restrictive steps similar to ear canal safety, designated regions, and also safety guidance are necessary.

Shortens the design moment through quickly moving design process, in particular in pre solid industry.

Reason for the development of SCC:

The main factors for the development of SCC are to achieve high durable, flow able, workable and self compacting of concrete and to solve the weakness properties of concrete as we know the concrete is a brittle material with low tensile strength, volume stability, low ductility and low strength to weight ratio. Normal concrete usually needs vibration. The vibrations cause noise that not only leads to stress on construction site but also effect the surrounding neighborhood. Apart from that, it has harmful physical impact on worker such deafness and “white finger”. Moreover, vibration is time consuming. When the casting is on critical path of the construction process it can produce delay and increase the cost. However, SCC is different because it is more homogenous concrete in the Construction

BACKDROP REGARDING SELF-COMPACTING CONCRETE: Cement-based products are the nearly all plentiful of all man-made products and so are very essential design products, in fact it is more than likely that they'll go on to own similar value in the future. Nevertheless, these design and also anatomist products need to meet new and also larger demands. As soon as struggling with troubles of production, overall economy, top quality and also setting, weather resistant take on some other design products for instance plastic material, material and also timber. Just one direction within this advancement is usually to self-compacting concrete (SCC), some sort of improved product that will, devoid of additional compaction vitality, passes and also consolidates intoxicated by its bodyweight.

Economy & Time cutting down:
Their simple positioning increases the production as well as the price saving as a result of reduced tools and also labour tools

- Reduction in wear of varieties, for that reason, this stretches the program living of varieties. Reduction in the number of member of staff
- It minimizes the consumption of methods and also price, also thinking about a greater value for each cubic meter with the concrete.
- For the substantial fluidity, this specific concrete does not need any kind of vibrations in order that it

will allow to avoid wasting vitality and also ensure appropriate price set up. Reduction of expenses and also manpower essential for patching finished precast aspects.

- It might enable the concrete dealer to deliver better uniformity in delivering concrete, which minimizes the interventions for the plant life or perhaps task sites.
- Building together with SCC isn't troubled by the proficiency on the workers, and also appearance and also agreement of reinforcing cafes on the set ups.
- SCC work with design sites minimizes the possibility of accident through minimizing amount of cables essential for the functioning of compacting tools, hence, minimizes the
- workers settlement prices.
- It provides wide chance of using high-volumes of byproducts products. given that a greater level of powdered product becomes necessary intended for improving the cohesiveness and also minimizing the number of extremely plasticizer and also viscosity adjusting agencies.
- SCC is usually particular simply to regions where by it's nearly all necessary. These include areas where by entry to regular vibration is usually tough, or perhaps.

Engineering properties of Self Compacting Concrete: General:

Self Compacting concrete and traditional vibrated concrete of similar compressive strength have comparable properties and if there are differences, these are usually covered by the safe assumptions on which the design codes are based. However, SCC composition does differ from that of traditional concrete so information on any small differences that may be observed is presented in the following sections. Durability, the capability of a concrete structure to withstand environmental aggressive situations during its design working life without impairing the required performance, is usually taken into account by specifying environmental classes. This leads to limiting values of concrete composition and minimum concrete covers to reinforcement.

In the design of concrete structures, engineers may refer to a number of concrete properties, which are not always part of the concrete specification. The most relevant are:

Compressive strength
Tensile strength
Creep
Shrinkage
Fire resistance
Durability
Following are the properties of hardened self compacting concrete.

Compressive strength of Self Compacting Concrete:

In all SCC mixes compressive strengths of standard cube specimens were comparable to those of traditional vibrated concrete made with similar water -cement ratios if anything strengths were higher.

In-situ strengths of SCC are similar to those of traditional vibrated concrete, indeed somewhat higher when limestone powder is used as filler, probably because of a densifying mechanism and the observed lower susceptibility to imperfect curing, both attribute to this type of filler.

Tensile strength: Tensile strength was assessed indirectly by the splitting test on cylinders. For SCC, both the tensile strengths themselves, and the relationships between tensile and compressive strengths were of a similar order to those of traditional vibrated concrete.

Bond strength: The strength of the bond between concrete and reinforcement was assessed by pullout tests, using deformed reinforcing steel of two different diameters, embedded in concrete prisms. For both civil engineering and housing categories, the SCC bond strengths, related to the standard compressive strengths, were higher than those of the reference concrete were

Shrinkage and creep: Creep is defined as the gradual increase in deformation (strain)with time for a constant applied stress, also taking into account other time dependent deformations not associated with the applied stress, i.e. shrinkage, swelling and thermal deformation. Creep in compression reduces the pre-stressing forces in pre-stressed concrete elements and causes a slow transfer of load from the concrete onto the reinforcement. Creep in tension can be beneficial in that it in part relieves the stresses induced by other restrained movements, e.g. drying shrinkage and thermal effects. Creep takes place in the cement paste and it is influenced by its porosity which is directly related to its water/cement ratio. During hydration, the porosity of the cement paste reduces and so for a given concrete, creep reduces as the strength increases. The type of cement is important if the age of loading is fixed. Cements that hydrate more rapidly will have higher strength at the age of loading, a lower stress/strength ratio and a lower creep.

Shrinkage is the sum of the Autogenously and the drying shrinkage Autogenously shrinkage occurs during setting and is caused by the internal consumption of water during hydration

Drying shrinkage is caused by the loss of water from the concrete to the atmosphere. Generally this loss of water is from the cement paste, but with a few types of aggregate the main loss of water is from the aggregate. Drying shrinkage is relatively slow and the stresses it induces are partially balanced by tension creep relief.

Tests performed on creep and shrinkage of different types of SCC and a reference concrete show that the deformation caused by shrinkage may be higher the deformation caused by creep may be lower.

The value for the sum of the deformations due to shrinkage and creep are almost similar. Due to the restrain of the presence of reinforcement in a cross section the shrinkage strain will cause tension in concrete and compression in the reinforcement.

Some aspects of durability

The durability of a concrete structure is closely associated to the permeability of the surface layer, the one that should limit the ingress of substances that can initiate or propagate possible deleterious actions (CO_2, chloride, sulphate, water, oxygen, alkalis, acids, etc.). In practice, durability depends on the material selection, concrete composition, as well as on the degree of supervision during placing, compaction, finishing and curing.

Lack of compaction of the surface layer, due to vibration difficulties in narrow spaces between the formwork and the re-bars or other inserts (e.g. post-tensioning ducts) has been recognized as a key factor of poor durability performance of reinforced concrete structures exposed to aggressive environments. Overcoming this was one of the main reasons for the original development of SCC in Japan. Traditional vibrated concrete is subjected to compaction via vibration(or tamping), which is a discontinuous process. In the case of internal vibration, even when correctly executed, the volume of concrete with it the area of influence of the vibrator does not receive the same compaction energy.

II. LITERATURE REVIEW

Present-day self Compacting concrete can be classified as an advanced construction material. As the name suggests, it does not require to be vibrated to achieve full compaction. This offers many benefits and advantages over conventional concrete.

These include an improved quality of concrete and reduction of on-site repairs, faster construction times, lower overall costs, facilitation of introduction of automation into concrete construction. An important improvement of health and safety is also achieved through elimination of handling of vibrators and a substantial reduction of environmental noise loading on and around a site. The composition of SCC mixes includes substantial proportions of fine-grained inorganic materials and this gives possibilities for utilization of mineral admixtures, which are currently waste products with no practical applications and are costly to dispose of (St John, 1998).

Previous Research Work on Self Compacting Concrete

Self Compacting concrete extends the possibility of use of various mineral by-products in its manufacturing and with the densification of the matrix, mechanical behavior, as measured by compressive, tensile and shear strength, is increased. On the other hand, the use super plasticizers or high range water reducers, improves the stiffening, unwanted air entrainment, and flowing ability of the concrete. Practically, all types of structural constructions are possible with this concrete. The use of SCC not only shortens the construction period but also ensures quality and durability of concrete. This non-vibrated concrete allows faster placement and less finishing time, leading to improved productivity.

Hajime Okamura: A new type of concrete, which can be compacted into every corner of a formwork purely by means of its own weight, was proposed by Okamura (1997). In 1986, he started a research project on the flowing ability and workability of this special type of concrete, later called self-compacting concrete. The self-compact ability of this concrete can be largely affected by the characteristics of materials and the mix proportions. In his study, Okamura (1997) has fixed the coarse aggregate content to 50% of the solid volume and the fine aggregate content to 40% of the mortar volume, so that self compact ability could be achieved easily by adjusting the water to cement ratio and super plasticizers dosage only .A model formwork, comprised of two vertical sections (towers) at each end of a horizontal trough, was used by professor Okamura to observe how well self compacting concrete could flow through obstacles.

Kuroiwa: Kuroiwa (1993) developed a type of concrete, which contained materials normally found in conventional concrete such as Portland cement, aggregate, water, mineral and chemical admixtures. The chemical admixtures were added in order to improve the deformability and the viscosity of the concrete. The newly developed type of concrete was called super-workable concrete and showed excellent deformability and resistance to segregation. It could also fill completely heavily reinforced formworks without any use of vibrators.

Khayat et al.: The use of self-consolidating concrete can facilitate the placement of concrete in congested members and in restricted areas. Given the highly flow able nature of such concrete, care is required to ensure adequate stability. This is especially important in deep structural members and wall elements where concrete can segregate and exhibit bleeding and settlement, which can result in local structural defects that can reduce mechanical properties

The objective of Khayat's (1997) et al. research was to evaluate the uniformity of in situ mechanical properties of self-consolidating concrete used to cast experimental wall elements. Eight optimized SCC mixtures with slump flow values greater than 630 mm and a conventional concrete with a slump of 165 mm were investigated. The self-compacting concrete mixtures incorporated various combinations of cementitious materials and chemical

Dehn et al.: Dehn (2000) et al. have focused their research work on the time development of SCC compressive and splitting tensile strength and the bond behaviour between the reinforcing bars and the self-compacting concrete compared to normal concrete. In order to ensure a good production of SCC, a mix design should be performed, so that the predefined properties of the fresh and hardened concrete would be reached for sure. All the components should be coordinated so that bleeding and segregation would be prevented. Because of these aspects, their mix design was based on experience from Japan, Netherlands, France, and Sweden. Due to the fact that the load bearing capacity of a reinforced concrete structure is considerably influenced by the bond behavior between the reinforcing bars and the concrete, the following items were taken into account:

- Anchorage of the reinforcing bars
- Crack width control
- Lapped reinforcing bars

Subramanian and Chattopadhyay: Subramanian and Chattopadhyay (2002) are research and development engineers at the ECC Division of Larsen & Toubro Ltd (L&T), Chennai, India. They have over 10 years of experience on development of self-compacting concrete, underwater concrete with anti washout admixtures and proportioning of special concrete mixtures. Their research was concentrated on several trials carried out to arrive at an approximate mix proportion of self-compacting concrete, which would give the procedure for the selection of a viscosity modifying agent, a compatible super plasticizer and the determination of their dosages. The Portland cement was partially replaced with Silica fume and blast furnace slag, in the same percentages as Ozawa (1989) has done before and the maximum coarse aggregate size did not exceed 1".

ADVANTAGES AND DRAWBACKS

SCC offers numerous points of interest for the precast, pre-stressed solid industry and for cast-in situ development:

Advantages of Compacting toward oneself Cement :-

- Low clamor level in the plants and development locales.
- Eliminated issues connected with vibration.
- Less work included.
- Faster development.
- Improved quality and strength.
- Higher quality.

SCC can be set at a quicker rate with no mechanical vibration and less screening, bringing about funds in situation costs.

- Improved and more uniform design surface completion with next to zero therapeutic surface work.
- Ease of filling confined areas and difficult to-achieve territories. Chances to make basic and building shapes and surface completes not achievable with customary cement.
- Improved union around fortification and bond with support.
- Improved pumpability.
- Improved consistency of set up cement by dispensing with variable administrator related exertion of union.
- Labour investment funds.
- Shorter development periods and coming about expense investment funds.
- Quicker solid truck pivot times, empowering the maker to administration the venture eall the more productively.
- Reduction or disposal of vibrator commotion, conceivably expanding development hours in urban regions.
- Minimizes development of prepared blended trucks and pumps amid situation.
- Increased jobsite wellbeing by SCC

Construction Issues: Since the development of the prototype of self-compacting concrete in 1988, the use of self-compacting concrete in actual structures has gradually increased. The main reasons for the employment of self-compacting concrete can be summarized as follows:

- To shorten construction period.
- To assure compaction in the structure - especially in confined zones where vibrating compaction is difficult
- To eliminate noise due to vibration - effective especially at concrete products plants.

Self-compacting concrete is often employed in concrete products to eliminate the noise of vibration. This improves the working environment at plants and makes it possible for concrete product plants to be located in the urban area. By employing self-compacting concrete, the cost of chemical and mineral admixtures is compensated by the elimination of vibrating compaction and work done to level the surface of the normal concrete (Khayat et al., 1997). However, the total cost for a certain construction cannot always be reduced, because conventional concrete is used in a greater percentage than self-compacting concrete.

SILICA FUME

Silica fume, also known as micro silica, is an amorphous (non-crystalline) polymorph of silicon dioxide. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as pozzolanic material for high performance concrete. Silica fume is an ultrafine airborne material with spherical particles. Micro-silica in concrete contributes to strength and durability two ways: As a pozzolanic material, micro-silica provides a more uniform distribution and a greater volume of hydration products. As a filler, micro-silica decreases the average size of pores in the cement paste. Micro- silica effectiveness as a pozzolanic material and as a filler depends largely on its composition and particle size which in turn depend on the design of the furnace and the composition of the raw materials with which the furnace is charged.

What is SILICA FUME: Silica fume, also known as Micro silica, is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as pozzolanic, material for high performance concrete.

It is sometimes confused with fumed silica (also known as pyrogenic silica, CAS number 112945-52-5). However, the production process, particle characteristics and fields of application of fumed silica are all different from those of silica fume

HOW SILICAFUME WORKS IN CONCRETE?

Silica fume in concrete contributes to strength and durability two ways:

As a pozzolan, silica fume provides a more uniform distribution and a greater volume of hydration products.

As a filler, silica fume decreases the average size of pores in the cement paste.

Silica fume's effectiveness as a pozzolan and a filler depends largely on its composition and particle size—which in turn depend on the design of the furnace and the composition of the raw materials with which the furnace is charged.

Protection of reinforcement

Concrete's ability to protect embedded steel against corrosion depends mainly on the alkalinity of the pore water. As long as the water is highly alkaline, a passive oxide film on the steel protects it. If the passivity is destroyed by aggressive ions, either carbonates or chloride ions, the steel will corrode rate depending on the concrete's electrical resistivity and rate of oxygen transport through water- saturated concrete.

Micro-filler effect: Micro-silica is an extremely fine material, with an average diameter 100 times finer than cement. At a typical dosage of 8% by weight of cement, approximately 100,000 particles for each grain of cement will fill the water spaces in fresh concrete. This eliminates bleed and the weak transition zone between aggregate and paste found in normal concrete. This micro-filler effect will greatly reduce permeability and improve the paste-to-aggregate bond of silica fume concrete compared to conventional concrete.

Silica Fume Applications in Concrete

Because of the pozzolanic and micro-filler effect of micro-silica, its use in concrete can improve many of its properties opening up a wide range of applications including:-

Corrosion Resistance :The reduced permeability of micro-silica provides protection against intrusion of chloride ions thereby increasing the time taken for the chloride ions to reach the steel bar and initiate corrosion. In addition, micro-silica concrete has much higher electrical resistivity

Sulphate Resistance: Micro-silica concrete has a low penetrability and high chemical resistance that provides a higher degree of protection against sulphates than low C3A sulphate resisting cements or other cementitious binder systems.

Heat Reduction: By replacing cement with Micro-silica and observing the efficiency factor of Micro silica, a lower maximum temperature rise and temperature differential will take place for concrete with the same strength. It performs better than slag and fly-ash blends in thick sections. It is also the most effective way of achieving low heat without sacrificing early age strength.

Silica Fume Waterproof Concrete

Because of its low permeability, micro-silica can be use as an integral water-proofer for below ground structures where some dampness is acceptable, eg Car parks`

High Strength Concrete

Silica fume in conjunction with super-plasticizers is used to produce very high strength concrete (70 – 120 MPa). It is also much easier to pump micro-silica concrete up the high rise buildings during construction.

Abrasion Resistance: Silica fume concrete has very high abrasion resistance. In floor and pavement construction it's use saves money and time and improves operational efficiencies for the facility operator. It also improves the hydraulic abrasion-erosion resistance of concrete thus making it suitable for use in dam spillways.

Chemical Resistance: Micro-silica concrete is widely used in industrial structures exposed to an array of chemicals aggressive. In the alimentary industry the exposure comes from fat acids and other acids, detergents, etc. In the chemical industry there is exposure from mineral acids, phosphates, nitrates, petrochemicals, etc. Micro-silica concrete is therefore invaluable in the industrial and agricultural sector.

MATERIALS OF SCC

SCC is something different than the conventional concrete or modification of conventional concrete. It has similar ingredients such as Aggregate binder, however, there blending is changed so as to get the advantages of self-compactness:

MATERIALS USED

Cement: Ordinary Portland Cement of Ultratech brand of 53 grade confirming to IS: 12269-1987 was used in the present study. It is blended with water and materials. The bond and water frame a glue that ties alternate materials together as the cement solidifies. The standard concrete contains two fundamental fixings in particular argillaceous and calcareous. In argillaceous materials mud prevails and in calcareous materials calcium carbonate prevail

PROPERTIES OF CEMENT

SI. NO	PROPERTY	RESULT
1.	Standard Consistency	32%
2.	Initial Setting time of	40 min
	Cement	
3.	Final setting time of cement	11 hrs
4.	Specific gravity of cement	3.1
5	Fineness of cement	3gms < 10%

Aggregates: Generally, aggregates occupy 50% to 60% of the volume of concrete and have an important influence on its properties. They are granular materials, derived for the most part from natural rock (crushed stone, or natural gravels) and sands, although synthetic materials such as slag and expanded clay or shale are used to some extent, mostly in lightweight concretes. In addition to their use as economical filler, aggregates generally provide concrete with better dimensional stability and wear resistance .Although aggregate strength can play sometimes an important role, for example in high-strength concretes, for most applications the strength of concrete and mix design are essentially independent of the composition of aggregates. However, in other instances, a certain kind of rock may be required to attain certain concrete properties,

Mixing water: Ordinary potable water of normally PH 7 is used for mixing and curing the
concrete specimen.

Admixture for SCC: An admixture is a material other than water, aggregates and cement and is added to the batch immediately before of during the mix.

Admixtures are used to improve or give special properties to concrete. The use of admixture should offer an improvement not economically

Properties of Fine Aggregate

SI.NO	PROPERTY	RESULT
1.	Specific gravity of fine	2.5
	aggregate	
2.	Fineness modulus	2.28
3.	Grading zone	Zone-2
4.	Sieve Analysis	3gms – pan

attainable by adjusting the proportions of cement and aggregates and should not adversely affect any properties of concrete.

The admixture consist chiefly of those which accelerate and those which retard hydration or setting of the cement, finely divided materials which improves workability, water proof, pigments, wetting, dispersing, and air-entraining agents and pozzolan.

PROPERTIES OF COARSE AGGREGATE

SI.NO	PROPERTY	RESULT
	Specific gravity of	2.65
1	coarse aggregate	
2	Fineness modules	7.2

Sieve analysis of fine aggregate

Sieve Size (mm)	Weight Retained (gms)	% Weight retained	Cumulative (%) weight retained	Cumulative (%) weight passing	Specification as per IS 383-1970for zone-2
4.75	27	2.7	2.7	97.3	90-100
2.36	38	3.8	6.5	93.5	75-100
1.18	132	1.32	19.7	80.3	55-90
600	260	2.6	45.7	54.3	35-90
300	420	4.2	87.7	12.3	30-Aug
150	105	1	98.2	1.8	0-10
75	10	0.1	99.2	0.8	--

The admixture consist chiefly of those which accelerate and those which retard hydration or setting of the cement, finely divided materials which improves workability, water proof, pigments, wetting, dispersing, and air-entraining agents and pozzolan

III. METHODS AND MATERIAL

Chemical Admixture

Super plasticizer:

GLENIUM B233 is used because it is essential component of SCC to provide necessary workability. Chemical admixture, which was a little bit different from the conventional ones, the ability of water reduction was increased along with the retention of high workability for a longer time. In situ test results obtained by Ozkul and Dogan (1999) demonstrated that the Super plasticized concrete could be pumped easily from a height of about 13 m and the filling capacity was greater than 85%.%. The pumping pressure was the same as for normal pumpable concrete and no segregation was observed. For mixtures with water-cement ratios between 0.3 and 0.45, the slump diameters were between 500 mm and 740 mm and the compressive strength varied between 53 MPa and 68 MPa at 28 days of age. In their work, Roncero(1999) et al. evaluated the influence of two super plasticizers (a conventional melamine based product and a new-generation combo type polymer) on the shrinkage of concrete exposed to wet and dry conditions.

Mineral Admixture

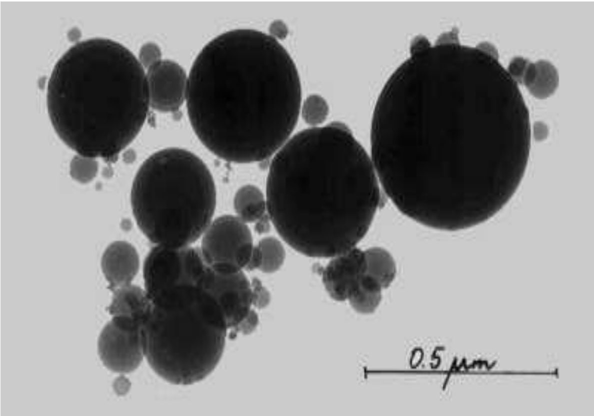
SILICA FUME:Silica fume in appropriate quantity may be added to improve the quality and durability of SCC. Silica fume in concrete has a 60 year history,

- Development of the use in concrete has been a long story. Silica Fume, aka. Silica fume, condensed silica fume etc, was first mentioned in a US patent from 1944.
- This patent mainly touched upon the use in mortar, and little is known of commercial use of the process. Silica fume is an inherent co-product of silicon and ferrosilicon.
- Silicon is not found in nature, and is normally produced from silica (SiO_2) and carbon (C).
- Ideally, the following reaction is intended

$SiO_2 + 2C = Si + 2CO$

Where

- SiO_2 is normally quartz
- C is a mix of coal, coke and wood chips
- For ferrosilicon: an iron source is added, iron oxide Production take place in large electric smelting furnaces at temperatures >2000 –degree-centigrade.
- However, the chemistry is much more complex, and a number of side-reactions are involved.
- Silicon carbide (Sic) and the (unstable) gas Sio are important intermediate products.
- In practice, some of the Sio-gas escapes from the furnace and reacts with air $SiO + ½O_2 = SiO_2$
- This is silica fume. Of the quartz added to the furnace, some 10- 25% ends up as silica fume



James William Sharp (1944)

- Patent on "Silica modified cement", assigned to Permanente Cement Company.
- Focused on plastic cements, 3-5% silica fume.
- Noted that bleeding was substantially reduced.
- Also observed a 40% increase in 90-days strength for concrete
- Carl Johan Bernhardt (1952).
- Worked with cement replacement – up to 30%.
- Reported a significant increase in compressive strength" in reasonable mixes.
- Documented improvements in sulphate- and freeze-thaw resistance in mixes with 10-15% cement replacement
- First known published technical paper on silica fume-concrete (April 1952).\

Mix Design of Self-Compacting Concrete Till now there is no specified method for the proportioning of Self-Compacting Concrete. Different people followed different methods. Some of the methods are discussed here.

Method of mix design by Okamura and Ozawa: For SCC, it is generally necessary to use super plasticizers in order to obtain high mobility. Adding a large volume of powdered material or viscosity modifying admixture can eliminate segregation. The powdered materials that can be added are fly ash, silica fume, lime stone powder, glass filler and quartzite filler. In this system, the coarse aggregate and fine aggregate contents are fixed and self-compact ability is to be achieved by adjusting the water /powder ratio and super plasticizer dosage.

The European Guidelines for Mix design of Self-Compacting Concrete

General: The mix composition is chosen to satisfy all performance criteria for the concrete in both the fresh and hardened states. In the case of ready-mixed concrete, these criteria will be supplied as a specification by the purchaser and should meet the requirements set out in of this document.

Mix design principles: To achieve the required combination of properties in fresh SCC mixes:

- The fluidity and viscosity of the paste is adjusted and balanced by careful selection and proportioning of the cement and additions, by limiting the water/powder ratio and then by adding a super plasticizer and (optionally) a viscosity modifying admixture. Correctly
- The coarse to fine aggregate ratio in the mix is reduced so that individual coarse aggregate particles are fully surrounded by a layer of mortar. This reduces aggregate interlock and bridging when the concrete passes through narrow openings or gaps between reinforcement and increases the passing ability of the SCC. These mix design principles result in concrete that, compared to traditional vibrated concrete, normally contains:
- Lower coarse aggregate content
- Increased paste content
- low water/powder ratio
- Increased super plasticizer
- Sometimes a viscosity modifying admixture.

of powder, SCC may show more plastic shrinkage or creep than ordinary concrete mixes. These aspects should therefore be considered during designing and specifying SCC.

Characteristics and Test Methods of SCC

The coarse to fine aggregate ratio in the mix is reduced so that individual coarse aggregate particles are fully surrounded by a layer of mortar. This reduces aggregate interlock and bridging when the concrete passes through narrow openings or gaps between reinforcement and increases the passing ability of the SCC. These mix design principles result in concrete that, compared to traditional vibrated concrete, normally contains: lower coarse aggregate content increased paste content low water/powder ratio increased super plasticizer Sometimes a viscosity modifying admixture

Requirements of S.C.C:SCC can be designed to fulfill the requirements of ENFNARC 206 regarding density, strength development, final strength and durability. Due to the high content Current knowledge of these aspects is limited and this is an area requiring further research. Special care should also be taken to begin curing the concrete as early as possible.

Filling ability
Passing ability
Segregation resistance

Test methods : Many different test methods have been developed in attempts to characterize the properties of SCC. So far no single method or combination of methods has achieved universal approval and most of them have their adherents. Similarly no single method has been found which characterizes all the relevant workability aspects so each mix design should be tested by more than one test method for the different workability parameters.

Initial mix composition: In designing the mix it is most useful to consider the relative proportions of the key components by volume rather than by mass. Indicative typical ranges of proportions and quantities in order to obtain self-compactability are given below.

Water/powder ratio by volume of 0.48 to 1.10 Total powder content - 160 to 240 litres (400-600 kg) per cubic meter. Coarse aggregate content normally 28 to 35 per cent by volume of the mix.

Water: cement ratio is selected based on requirements in EN206. Typically water content does not exceed 200 litre /m^3. The sand content balances the volume of the other constituents. **Procedure for mix design** An example of a procedure for efficiently designing SCC mixes is shown below. It is based on a method developed by Okamura

It is important to appreciate that this method may result in parameters which differ from those, the sequence is determined as:

- Definition of desired air content (mostly 2 %.)
- Determination of coarse aggregate volume.
- Determination of sand content.
- Design of paste composition.
- Determination of optimum water: powder ratio and super plasticizer dosage in Mortar.
- Finally the concrete properties are assessed by standard tests.

Properties of SCC

FRESH SCC PROPERTIES

The main three properties of SCC in plastic state are:

- Filling ability (excellent deformability)
- Passing ability (ability to pass reinforcement without blocking)
- High resistance to segregation.

FILLING ABILITY

Self-compacting concrete must be able to flow into all the spaces within the formwork under its own weight. This is related to workability, as measured by slump flow or Orimet test.

The filling ability or flow ability is the property that characterizes the ability of the SCC of flowing into formwork and filling all space under its own weight, guaranteeing total covering of the reinforcement. The mechanisms that govern this property are high fluidity and cohesion of mixture.

Passing Ability

Self-compacting concrete must flow through tight openings such as space between steel reinforcing bars under its own weight. The mix must not 'block' during placement.

The passing ability is the property that characterizes the ability of the SCC to pass between obstacles- gaps between reinforcement, holes, and narrow sections, without blocking. The mechanisms that govern this property are moderate viscosity of the paste and mortar, and the properties of aggregates, principally, maximum size aggregates.

High Resistance to Segreegation

Self compacting concrete must meet the requirements of 1&2 while its original composition remains uniform. The key properties must be maintained at adequate levels for the required period of time after completion of mixing. It is property to the passing ability and property and resistance to segregation that constitute the major advance, form a merely super plasticizer fresh mix which may be more fluid than self compacting concrete mix.

SCC and Measurement Of Its Flow

PROPERTIES

It is important to appreciate that none of the test methods for SCC has yet been standardized and the tests described are not yet perfected or standardized. The methods presented here are descriptions rather than fully detailed procedures. They are mainly ad-hoc methods, which have devised specifically for SCC. Hence for the validation of concrete these tests are have not been considered.

In considering these test, there are number of points which should be taken into account.

- One principal difficulty in devising such tests is that they have to assess three distinct, though related, properties of fresh SCC –its filling ability, its passing ability and its resistance to segregation. No single is so far derived which can be measured all the three properties.
- There is no clear relation between test results and performance on site.
- There is a little precise data, therefore no clear guidance on compliance limits. Repetition of the tests is advised.
- The test methods and values are tests for maximum aggregate size upto 20mm, different test values and/or different equipment dimensions will be appropriate for other

aggregate sizes.

- Different test values may be appropriate for concrete being placed in vertical and horizontal elements.
- Similarly, test values may be appropriate for different reinforcement densities.

Test Methods:

Existing Tests for Fresh SCC Mixes:

Slump Flow test:

The essential gear utilized is the same with respect to the customary Droop test.

The test system varies from the traditional one by the way that the solid specimen put into the mold is not rodded and when the droop cone is evacuated the example collapses. The measurement of the spread of the example is measured, i.e. a level separation is dead set rather than the vertical separation in the traditional Droop test. The Droop Stream test can give an Evidence as to the consistency, filling capacity and workability of SCC. The SCC is expected of having a decent filling capacity and consistency if the width of the spread achieves values between 650mm to 800mm.

V-funnel test: Thickness of the compacting toward oneself solid is gotten by utilizing a V-pipe greatest total distance across is 20 mm. The time for the measure of cement to move through the opening is being measured. In the event that the solid begins traveling through the hole, it implies that 30 the anxiety is higher than the yield stress; along these lines, this test measures an esteem that is identified with the thickness. In the event that the solid does not move, it demonstrates that the yield anxiety is more noteworthy than the heaviness of the volume utilized. A proportionate test utilizing littler pipes (side of just 5 mm) is utilized for concrete glue as an observational test to focus the impact of concoction admixtures on the stream of bond glues. Figure has specific measurements, in place for a given measure of cement to go through an opening (Dietz, Mama, 2000). The measure of cement required is 12litters.

L-Box test The passing ability is determined using L-Box test. The vertical section of L.box is filled with concrete, the gate lifted to let the concrete flow into the horizontal section. The height of the concrete at the end of horizontal section is expressed as a proportion that remained in the vertical section (H2/Hl). This is an indication of passing ability. The T20 and T40 are the times taken for concrete to reach the 20cm and 40cm marks of horizontal section of L-Box. These are indications of the ease of flow of concrete. The specified requisites are the time needed to flow up to 20cm (T20) = 1±0.5 see, the time needed to flow up to 40cm(T40) = 2 ± 0.5sec and a ratio between the height of the concrete at each end (or) blocking ratio less than 0.80.

AIM OF EXPERMENTATION
GENERAL

Self-compacting concrete is a high performance concrete that can flow under its own weight to completely fill the form work without segregation and self consolidate without any mechanical vibrations, even in the presence of congested reinforcements. Such concrete can accelerate placement and reduce labour required for consolidation and finishing.

In other words, “Self compacting concrete is a highly flow able, yet stable concrete that can spread readily into place and fill the form work without any consolidation and undergoing any significance separation.”

Self- compacting concrete offers a rapid rate of concrete placement, with faster construction times and ease of flow around congested reinforcement. The fluidity and segregation resistance of self compacting concrete ensures a high level of homogeneity, minimum concrete voids and uniform concrete strength, providing the potential for a superior level of finish and durability to the structure.

In addition there are some more following points, which makes self compacting concrete more reliable in concreting works

- Improved compaction around congested reinforcement.
- Potential to enhance durability through improved compaction of cover concrete.
- Improved build ability. (e.g., concreting elements in single lifts).

- Elimination of vibration leading to environmental, health and safety benefits.
- Quicker and easier concrete placement.

The field of concrete technology has been miraculous changes due to the invention of various admixtures. The admixtures modify the properties the properties f fresh concrete and offer many advantages to the user.

The main aim of this experimentation is to find out the effect of addition of silica fume, which is a waste product from the ferro-silica manufacturing industries, on the properties of self compacting concrete containing one admixture.

The flow characteristics and strength characteristics of self compacting concrete produced from different waste material and different percentages of that material are found. The different percentages of silica fume are 5%, 10%, 15%, 20%.

IV. RESULTS AND DISCUSSION

Experimental Procedure and Test Results

GENERAL:The proposed study is being carried out to develop Self-Compacting concrete of different grades with Silica fume as admixture for use in the Indian conditions satisfying European Standards for rheological properties of concrete in fresh state.

Materials Used:

The different materials used in this investigation are

- 53 grade Ordinary Portland Cement
- Coarse Aggregate
- Fine Aggregate
- Silica fume
- Super plasticizer
- Water

In this experimentation OPC was used. Locally available sand and coarse aggregate were used. The specific gravity of fine aggregate was found to be 2.5. The specific gravity of coarse aggregate is 2.6 and was zone-2. The coarse aggregate used were 20mm and 10mm size. The mix proportion adopted was 1: 2.14 : 2.70 and with a water binder ratio 0.48.

Properties of Silica Fume and OPC

Properties	OPC	SILICA FUME
(Physical)		
Specific gravity	3.1	2.2
Mean grain size	22.5	0.1
Specific area ^{2}/gm	3250	200000
Colour	Dark grey	Light to dark grey

Super-Plasticizer (Glenium B233):

The super plasticizer used in this experiment is Glenium B233. It is manufactured by BASF construction chemical India pvt.ltd, Mumbai. It complies to IS: 9103-1999 standards.

On adding to concrete, it enhances the workability without much affecting the set of concrete.
In the present investigation super plasticizer is used only to improve quality of concrete

Description:

GLENIUM B233 is an admixture of a new generation based on modified poly carboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required.

Composition of silica fume and cement

Chemical composition	OPC	SF
Silicon dioxide (SiO_2)	22.03	96.0
Aluminum oxide (Al_2O_3)	4.03	0.1

Iron oxide (Fe_2O_3)	3.67	0.6
Calcium oxide (CaO)	65.19	0.1
Magnesium oxide (MgO)	0.88	0.2
Sulphite (So_3)	2.86	--
Sodium oxide (Na20)	0.12	01
Potassium oxide (K_2O)	0.20	0.4
Loss on ignition	0.98	1.7

GLENIUM B233 is free of chloride & low alkali. It is compatible with all types of cements.

Uses:

Description:GLENIUM B233 is an admixture of a new generation based on modified poly carboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. GLENIUM B233 is free of chloride & low alkali. It is compatible with all types of cements.

- Production of Rheodynamic concrete
- High performance concrete for durability
- High early and ultimate strength concrete
- High workability without segregation or bleeding
- Precast & Pre-stressed concrete
- Concrete containing pozzolans such as micro silica, GGBFS,PFA including high volume fly ash concrete.

Advantages:

- Elimination of vibration and reduced labour cost in placing
- Marked increase in early & ultimate strengths
- Higher Young's modulus
- Improved adhesion to reinforcing and stressing steel
- Better resistance to carbonation and other aggressive atmospheric conditions
- lower permeability - increased durability
- Reduced shrinkage and creep

Typical Properties

Aspect: Light brown liquid
Relative density: 1.09±0.01 at 25°C
Ph :> 6
Chloride ion content :< 0.2%

Standards:

ASTM C494 Types F
EN 934-2 T3.1/3.2
IS 9103: 1999

Direction for use:

GLENIUM B233 is a ready-to-use liquid which is dispensed into the concrete together with the mixing water. The plasticizing effect and water reduction are higher if the admixture is added to the damp concrete after 50 to 70% of the mixing water has been added. The addition of GLENIUM B233 to dry aggregate or cement is not recommended. Automatic dispensers are available.

Thorough mixing is essential and a minimum mixing cycle, after the addition of the GLENIUM B233, of 60 seconds for forced action mixers is recommended

Dosage:

Optimum dosage of GLENIUM B233 should be determined with trial mixes. As a guide, a dosage range of 500 ml to 1500ml per 100kg of cementitious material is normally recommended. Because of variations in concrete materials, job site conditions, and/or applications, dosages outside of the recommended range may be required. In such cases, contact your local BASF representative.

Effects of over dosage: A severe over-dosage of GLENIUM B233 can result in the following:

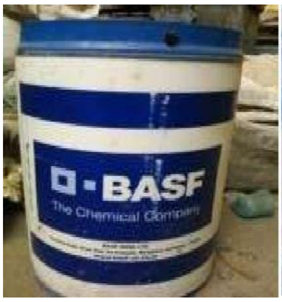
- Extension of initial and final set
- Bleed/segregation of mix, quick loss of workability
- Increased plastic shrinkage

Workability:GLENIUM B233 ensures that

Rheo-plastic concrete remains workable in excess of 45 minutes at +25°C. Workability loss is dependent on temperature, and on the type of cement, the nature of aggregates, the method of transport and initial workability. To achieve longer workability period please use POZZOLITH 55R as retarder or use GLENIUM SKY instead. It is strongly recommended that concrete should be properly cured particularly in hot, windy and dry climates. The use of MASTERKURE 111CF, evaporation reducer to prevent quick moisture loss from the surface of the flat works such as pavements in the dry, windy and hot climates is highly recommended.

Storage:GLENIUM B233 must be stored where temperatures do not drop below +5°C. If product has frozen, thaw at +5°C or above and completely reconstitute using mild mechanical agitation. Do not use pressurized air for agitation. Store under cover, out of direct sunlight and protect from extremes of temperature.

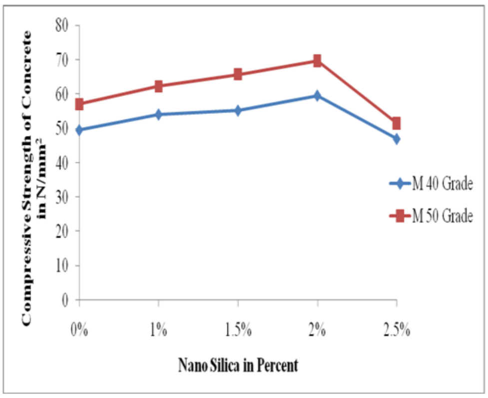
Safety precautions: As with all chemical products, care should be taken during use and storage to avoid contact with eyes, mouth, skin and foodstuffs (which can also be tainted with vapour until product fully cured or dried). Treat splashes to eyes and skin immediately. If accidentally ingested, seek immediate medical attention. Keep away from children and animals. Reseal containers after use. Do not reuse containers for storage of consumable item.



Experimental Procedure

Based on the Mix design procedures explained and considering the EFNARC guide lines and The European Guidelines for typical ranges of proportions and quantities the following conclusions were made and used in the Mix designing process for preliminary mix design trials in this investigation.

GRAPH OF AVERAGE COMPRESSIVE STRENGTH

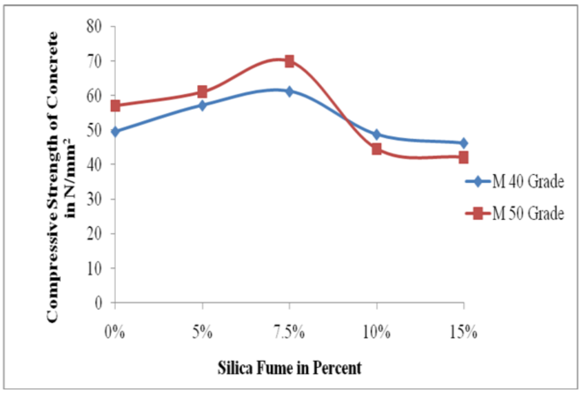


Discussions of Test Results

The effect of replacement of the cement with different percentages of Silica fume on the compressive strength of concrete is shown on the Split tensile Strength of concrete. It can be observed that the increase in Percentage replacement of cement with Silica fume from 0% to 10% causes increase in the compressive strength of concrete from 19.30 MPa to 28.8MPa and from 25.18 MPa to 35.8Mpa and from 28.8MPa to 38.2MPa for 3 days, and 28 days curing respectively. Further increase in percentage replacement of cement with silica fume from10% to 20% causes decrease in the compressive strength of concrete from 20.4 MPa to 28.4 MPa and from 18.79 MPa to 27.4 Mpa and from 28.39MPa to 24.38MPa for 3days,14 days and 28days curing respectively. It can be observed that the increase in percentage replacement of cement with Silica fume from 0% to 10% causes increase in the Split Tensile strength of concrete from 3.372 Mpa to 6.2 MPa and from 6.8 MPa to 8.5MPa for 3 days and 2 days curing respectively. Further increase in percentage replacement of cement with Silica fume from 10% to 20% causes decrease in the Split tensile strength of concrete from 4.2 MPa to 3.3 MPa and from 5.6 MPa to 5.3 MPa for 28days curing respectively. The Target Mean Strengths of M15, M20, M25, M30, M35, M40 grade concretes are 20.77N/ mm², 26.6 N/ mm², 31.6 /mm², 38.25 N/mm², 43.25 N/mm², 48.25 N/mm² respectively. These Target Mean Strengths and the 28 days Compressive Strengths of SCC1,SCC2, SCC3, SCC4,SCC5 Mixes are shown.

SI.NO	MIX	% OF SILICA FUME	SPLIT TENSILE STRENGTH IN N/at 28 days
`1	SSC1	0%	6.2
2	SCC2	5%	6.5
3	SCC3	10%	8.5
4	SCC4	15%	5.6
5	SCC5	20%	5.3

GRAPH OF SPLIT TENSILE STRENGTH



V. CONCLUSION

In present scenario there is a greater need for self-compacting concrete due to sickness of the member and architectural requirement, also to improve durability of structure.

Now the world is going to facing greater need of high performance concrete, durability point of view and SCC where the conventional way of compacting may not always be useful under different site condition. So instead of going for the conventional concrete let us mix the concrete compacting on its own which is called self-compacting concreting.

Now due to industrialization there is a greater scope for the formation of silica fume at ferrosilicon manufacturing industries. So, instead of dumping it or throwing it as a waste product we made it to do experimentation on partial replacement of cement, which in reduces the cost of construction and also it makes the high performance concrete from the durability point of view.

Based on the experiments conducted, the following observations were made and hence some conclusions:

It has been observed that the compressive strength of self-compacting concrete produced with the combination of admixtures such as silica fume and super

- plasticizer, goes on increasing from 0% to 10%. The compressive strength increases from 19.30 N/ ^{2} to 28.8 N/ ^{2}for 3-days. And it varies from 20.76 N/ ^{2} to 37.15 N/ ^{2} after 14-days. And gains strength of 38.2 N/ ^{2} after 28 days of 10% of adding silica fume and starts decreasing after adding 15% and 20% of silica fume. The strength falls from 28.8 N/ ^{2}to 28.4 N/ ^{2} for 15% and to 27.4 N/ ^{2} for 20% after 3- days.
- It has also been observed that the tensile strength of self compacting concrete produced with the combination of admixture such as silica fume and super plasticizer, goes on likes this. The tensile increases from from3.372 N/ ^{2}
- 6.2 N/ ^{2}for 3-days from 0% to 10%. And continues to increase in tensile strength to 85 N/ ^{2} from 6.8. It starts decreasing after adding 15% of silica fume. The tensile strength decreases from 4.2 N/ ^{2}to 3.3 N/ ^{2}.
- SCC mix requires high powder content, lesser quantity of coarse aggregate, high range Super plasticizer to give stability and fluidity to the concrete mix.
- Thus, it can be concluded that the maximum compressive strength of self compacting concrete with the combination of admixtures be obtained by adding
- 15 % of silica fume.

- The workability of SCC is equilibrium of fluidity, deformability filling ability and resistance to segregation. This equilibrium has to be maintained for a
- Sufficient time period to allow for transportation, placing and finishing.
- An industrial waste like silica fume helps in the strength development of calcined products and hence it can be used in construction industry for preparation of concrete replacing some quantity of cement, which is a valuable ingredient of concrete to achieve economy.
- With 10% replacement of cement with silica fume not only the compressive strength increased significantly with age but also the split tensile strength at 28th days increased. However, further replacement of cement with fly ash lead to drastic reduction in compressive strength.

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