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# AN EXPERIMENTAL STUDY ON SELF-COMPACTING CONCRETE USING GGBS

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## ABSTRACT

Concrete is one of the most widely used construction material due to its good compressive strength and durability. Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in the development of infrastructure Viz., buildings, industrial structures, bridges and highways etc., leading to utilization of large quantity of concrete. On the other side, cost of concrete is attributed to the cost of its ingredients which is scarce and expensive, this leading to usage of economically alternative materials in its production. This requirement is drawn the attention of investigators to explore new replacements of ingredients of concrete. The present technical report focuses on investigating characteristics of concrete with partial replacement of cement with Ground Granulated Blast furnace Slag (GGBS). The topic deals with the usage of GGBS and advantages as well as disadvantages in using it in concrete. This usage of GGBS serves as replacement to already depleting conventional building materials and the recent years and also as being a by-product, it serves as an Eco-Friendly way of utilizing the product without dumping it on ground.

The Ground granulated Blast furnace slag (GGBFS) is a waste of industrial materials, it is relatively more recent pozzolanic material that has received considerable attention in both research and application. Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steelmaking) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. Ground-granulated blast furnace slag is highly cementitious and high in calcium silicate hydrates (CSH) which is a strength enhancing compound which improves the strength, durability and appearance of the concrete. The Ground granulated blast slag (GGBS)as a partial pozzolanic replacement of cement in concrete. The replacement of cement by GGBS helps to reduce the cement content of concrete, thereby reducing the cost of construction because the price of GGBFS is about 25 - 50% less than that of OPC. Reuse of the slag helps to protect the environment from pollution (reduced CO2 emission)

**Key words:** Self-compacting concrete, Compressive strength, split tensile strength, flexural strength, GGBS, Green

## I.INTRODUCTION

For several years, the problem of the durability of concrete structures was a major topic of interest in Japan. The creation of durable concrete structures requires adequate compaction by skilled workers. 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 was formed to study the properties of SCC, inducing the fundamental investigation on the workability of concrete, which was carries out by Ozawa at the

University of Tokyo. Studies to develop self-compacting concrete, including a fundamental study on the workability of concrete, have been carried out.

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 section 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.

Self-compacting concrete (SCC) is a concrete which flows under its own weight and doesn't require any external vibration for compaction, it has revolutionized concrete placement. Such concrete should have relatively low yield value to ensure high flow ability, a moderate viscosity resists segregation and bleeding and must maintain its homogeneity during transportation, placing and curing to ensure adequate structural performance and long-term durability.

Self-compacting concrete (SCC) is a modern high-performance concrete, which is characterised by excellent performance in flowing and filling ability which required a high amount of cement. Nowadays there are many alternative materials, which possible to be used as a replacement of cement to overcome the negative effect due to the usage of cement such as ground granulated blast furnace slag (GGBS) and metakaolin (MK). This study aimed at investigating the fresh and hardened properties of SCC produced by GGBS and MK as partial cement replacement. Cement was replaced with MK at a constant level of 10% while GGBS is substituted cement at various levels of 15%, 20%, 25% and 30% as a ternary blending powder. Results obtained indicates that the inclusion of MK reduced the workability, oppose finding for GGBS exhibited improvement in the workability. For the hardened properties at an early age, mix which contained MK showed improvement in the strength characteristics, whilst at later age the mix with a combination of MK and GGBS exhibited better performance. From this study, it can be concluded that the optimum replacement level of cement to produce good quality of SCC is 10% and 25% for MK and GGBS, respectively.208

Self- compacting concrete (SCC) can be defined as a fresh concrete which possesses superior flow ability under maintained stability (i.e., no segregation) thus allowing self-compaction that is, material consolidation without addition of energy.

It is a fluid mixture suitable for placing in structures with congested reinforcement without vibration and it helps in achieving higher quality of surface finishes.

The three properties that characterise a concrete as self-compacting concrete are:

- Flowing ability: the ability to completely fill all areas and corners of the formwork into which its placed.
- Passing ability: the ability to pass through congested reinforcement without separation of the constituents or blocking.
- Resistance to segregation: the ability to retain the coarse components of the mixing suspension in order to maintain a homogenous.

1.1 Characteristics of SCC in the fresh state

The design of SCC must meet three criteria as shown in Figure 2.1: high filling ability, high

passing ability, and good stability (Khayat et al., 1999b). Stability comprises two aspects:

static segregation, which is defined as the separation of coarse aggregate and paste when the concrete is at rest, and dynamic segregation which occurs during the transport and

casting of the concrete, i.e., during flow.

These three key requirements are related. A change in one property will lead to a change in one or both of the others. Both insufficient filling ability and segregation result in unsatisfactory passing ability. Segregation resistance increases as filling ability increases. When designing an SCC mix for a particular application there is a trade-off between these parameters.

**1.4 Procedure for achieving viable SCC mixes**

The method used to select the correct proportion of constituent materials is fundamental to achieving the required plastic and hardened properties of SCC. Five rules need to be followed in the selection of ingredients:

• Limit coarse aggregate content

• Use super-plasticiser

• Reduce water–powder ratio

• Increase paste content

• Sometimes use of a viscosity modifying agent

**1.5 SCC development**

The first prototype of SCC was developed in 1986 by Prof. Okamura and his students at the University of Tokyo (e.g. Ozawa and Maekawa (Ouchi et al., 1998) in Japan when skilled labour was in limited supply. This initial version of SCC has since been developed for specialized applications. Since these developments, Japan has undertaken intensive research, particularly within the research institutes of large construction companies, and consequently, SCC has been used in many applications (Billberg, 1999; Okamura and Ouchi, 1999). The successful use of SCC in Japan has drawn the attention of many European countries. Sweden was the first country in Europe to develop SCC, from where the technology spread to other Scandinavian countries at the end of the 1990s (Goodier, 2003).

Since its introduction in Japan in the late 1980s, the use of SCC in the building industry has become ubiquitous. The main benefits from using SCC in building structures include shortening the construction period and thus increasing productivity, and assuring compaction in the structure (particularly in confined zones) thus enhancing the construction quality and eliminating noise due to vibration. In addition, these factors have led to substantial improvements in the on-site working environment (Bartos and Cechura, 2001; Rwamamara and Simonsson, 2012).

**Aim and Objective of the project:**

The aim and objective are to study the effect of GGBS on strength characteristics of concrete.

• To determine the most optimized mix of GGBS-based concrete.

• To optimize strength characteristics of concrete by partially replacement of cement by GGBS.

• To determine the variation of workability of concrete by partially replacing the cement by GGBS.

• To investigate the structural behavior of concrete by adding replacing materials.

• To increase the strength of concrete by using GGBS.

• To obtain compressive strength results of various mix design of concrete with normal concrete and 30% replacement of GGBS with cement.

• To conduct laboratory test on designed SCC, On Fresh concrete and Hardened concrete of designed SCC.

• To reduce the cost of concrete.

• To reduce the amount of cement in concrete.

• To use GGBS, an industrial waste for the manufacture of concrete which otherwise would have been available as a waste material.

**Scope of the work:**

Based on the aim and objective mentioned in the preceding sections, the scope of the present investigation is outlined as under:

• GGBS can be ideal choice in civil engineering infrastructural applications.

• Future scopes of GGBS are positive due to benefits in durability, sustainability, appearance and strength obtained by partial replacement of GGBS with cement in concrete.

• Hence, the scope of the work or research is to study the mechanical characteristics of concrete such as compressive strength, by varying the percentage of GGBS by weight of cement for M20 and M50 grade of concrete.

**1.6 Defination of self-compacting concrete: -**

Self-compacting concrete also referred to as "Self-consolidating concrete" has recently been one of the most important developments in building industry. Self-compacting concrete (SCC) is a special concrete that can settle into the heavily reinforced, deep, and narrow sections by its own weight, and can consolidate itself without necessitating internal or external vibration, and at the same time maintaining its stability without leading to segregation and bleeding .SCC demands a large amount of powder content compared to conventional vibrated concrete to produce a homogeneous cohesive mix.

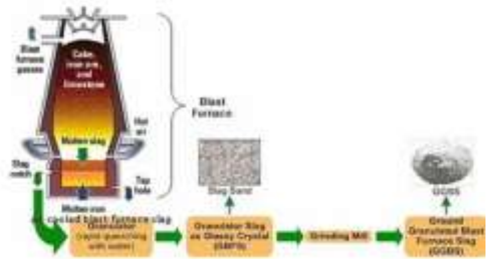
• Self-compacting concrete (SCC) is a pioneering concrete that does not involve shuddering and compaction.

• Self-compacting concrete is a concrete mix which has low yield stress, high deformation, good resistance and segregation resistance and moderate viscosity.

• The hardened concrete is dense, uniform and has the same property and durability as standard vibrated concrete.

**1.8 GROUND GRANULATED BLAST FURNACE SLAG (GGBS)**

Ground Granulated Blast Furnace is a by-product from the blast furnace slag is a solid waste discharged in large quantities by the iron and steel industry in India. These operate at a temperature of about 1500 degree centigrade and are fed with a carefully controlled mixture of iron – ore, coke and limestone. The iron ore is reduced to iron and remaining materials from slag that floats on top of the iron. It is a granular material formed when molten iron blast furnace slag is rapidly chilled by immersion of water. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has been rapidly quenched in large volumes of water. The quenching optimizes the cementations properties and produces granules similar to coarse sand. This granulated slag is then dried and ground to a fine powder. The recycling of these slags will become an important measure for the environmental protection. Iron and steel are basic materials that underpin modern civilization, and due to many years of research the slag that is generated as a by-product in iron and steel production.



The primary constituents of slag are lime (Cao) and silica (SiO2). Portland cement also contains these constituents.

### 1.9 EFFECTS OF GGBS ON CONCRETE

**Effect on Setting Time:**

Setting times of concrete containing slag increases as the slag content increases. An increase of slag content from 35 to 65% by mass can extend setting time by as much as 60 minutes. This delay can be beneficial, particularly in large pours and in hot weather conditions in which this property prevents the formation of "cold joints" in successive pours. Concrete requires longer setting times than Portland cement concrete, probably due to smooth and glassy particle forms of GGBS. The setting time also increases with the increase in the percentage of GGBS replacements. Duos and Eggers (1999) reported that if the temperature was at 230c, the setting times were not significantly affected by the GGBS replacement levels. Other research reported that if the GGBS replacement level was less than 30%, the setting times would not be significantly affected (Slag Cement Association, 2005). The setting times of GGBS concrete are sensitive to low ambient temperatures. For example, in a development project in Beijing, the demoulding time was delayed by six to eight hours when the ambient temperature was lowered from 15oc to below 5oc.

**Effect on Bleeding:**

The rate and quantity of bleeding in concrete slag or slag cement is usually less than that of in concrete containing no slag because of the relatively higher fineness of slag. The higher fineness of slag also increases the air-entraining agent required, compared to conventional concrete. However, slag unlike fly ash does not contain carbon, which may cause instability and air loss in concrete. A reviewing of literature reveals that there have been contradictory views on the bleeding of GGBS concrete. It has been reported by the concrete society (1991) that when GGBS replacement level is less than 40%, bleeding is generally unaffected. At higher replacement levels bleeding rates may be higher (concrete society, 1991). Slag cement Association (2005).

reported that most of the concrete made with GGBS in the USA had less bleeding than concrete made with cement alone, because the slag was grounded to a finer state than normal cement. On the other hand, coarser slag had equal or greater bleeding (Slag Cement Association, 2005). In general, bleeding reduces with the increase in the fineness of cementitious material used. GB/T 8046 requires the minimum fineness of GGBS to be 3000 cm2/g for grade S75 GGBS, 4000 cm2/g for grade S95, and 5000 cm2/g for grade S105 respectively. Concrete with GGBS of grade S95 or grade S105 may have less bleeding effect than that of Portland cement (with fineness at around 3500 cm2/g), whereas the bleeding in concrete with GGBS of grade S75 may be greater.

## II.LITERATURE REVIEW

2.2.2 L. Sai Indrasena Reddy, M. M. Vijayalakshmi & T. R. Praveen Kumar (2020) The objective of this research is to know" Thermal Conductivity and Strength Properties of Nano silica and GGBS Incorporated Concrete Specimens". An important property which affects the heat transfer process in buildings and to minimize the usage of artificial energy in buildings is thermal conductivity. The transfer of heat through walls and roofs determines the amount of artificial energy required in the buildings. The conventional methods used to determine the thermal conductivity of buildings are transient and steady state methods. The objective of this paper is to measure the thermal conductivity of concrete specimens replacing nano silica and GGBS by weight of ordinary Portland cement. Nano silica was replaced by weight of cement in different proportions ranging from 1% to 5%. Addition of nano silica and GGBS in concrete improves the compressive strength and split tensile strength of concrete by around 10%. Improvement in strength properties is mainly due to densification of concrete microstructure by filling pores in concrete specimens. In addition to the strength characteristics, nanosilica incorporated concrete specimens showed better thermal resistance as compared with conventional concrete mix. Lower heat transfer rate is due to the better particle packing nature of nanoparticles in concrete. Nanosilica acts as better heat retarding agent in concrete and thus it minimizes the use of artificial energy in the buildings. It is concluded that utilization of nanosilica reduces the heat transfer rate in to the buildings and the optimum amount of nanosilica was found to be 3% by weight of cement.

2.2.3 Samina E. Alharthy (2021) The objective of this research project is to investigate “Destructive and Non-Destructive Test Characteristics of Concrete Produced with Iron Slag Aggregate”, Blast Furnace Slag from local industries has been utilized to find its suitability as a coarse aggregate in self-compacting concrete (SCC) making. Replacing all or some portion of natural aggregates with slag would lead to considerable environmental benefits. SCC mixes were designed and coarse aggregates were replaced by 0, 20, 40, 60, 80, and 100% steel slag by weight. Tests were conducted to assess the fresh properties, strength properties and durability behavior (permeability) of SCC. Properties such as slump flow, flow diameter, passing ability, segregation resistance, compressive strength, and both rebound number and ultrasonic pulse velocity were measured.

2.2.4 Pathan V.G, Ghutke V.S and Pathan G have concluded in their project that ground granulated blast furnace slag is better replacement of cement than various other alternatives. The rate of strength gain in slag replaced concrete is slow in early stages but with proper curing the strength goes on increasing tremendously. The compressive strength decreases when the cement replacement is more than 50%. Use of slag or slag cements usually improves workability and decreases the water demand due to the increase in paste volume caused by the lower relative density of slag. From their results they concluded that 45% replacement of cement by GGBS gives the highest amount of compressive strength. They suggested that the replacement of cement with slag should be limited to 40% in India.

2.2.5 Latha K.S, Rao M.V.S and Reddy V.S have concluded from their research that Strength efficiency of GGBS increases by 89% in M20, 41% in M40 and 20% in M60 grade concrete mixes when compared to M20, M40 and M60 grade concrete mixes without any mineral admixture at 28 days respectively. The optimum dosage of percentage of replacement of cement with GGBS was found to be 40%, 40%and 50% in Ordinary (M20), Standard (M40) and High strength grade (M60) grades of concrete respectively. They also concluded that the partial replacement of cement with GGBS in concrete mixes has shown enhanced performance in terms of strength and durability in all grades. This is due to the presence of reactive silica in GGBS which offers good compatibility. It is observed that there is an increase in the compressive strength for different concrete mixes made with GGBS replacement mixes.

## III.RESEARCH METHODOLOGY

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The above objectives were realised using the following methodology:

➢ First: collecting data available for concrete, mortar and cement paste containing ggbs as a partial replacement up to 80% of total cement weight, and processing these data to find a correlation between plastic viscosity of cement paste and ggbs percentage on one hand and with the water to binder ratio on the other hand, then relating the impact of increasing ggbs in mixes to the yield stress with the change in spreading time stop.

➢ Second: extending an existing rational hydration model to SCCs with up to 80% ggbs CRM, including developing new formulae for 28 day and full hydration strengths, and validating the model using new experimental data gathered in this programme of research.

➢ Third: adapting the formulae for estimating the plastic viscosity of an SCC mix based on micromechanical principles (Ghanbari and Karihaloo, 2009) and extending the method to mixes with ggbs levels of up to 80%.

➢ Fourth: proving the validity of the proposed mix design method by preparing a series of SCC mixes for a range of target plastic viscosities and compressive Chapter 1 Introduction 20 strengths. Demonstrating that all of the designed mixes satisfy the relevant flow, compaction and hardened state criteria using the slump cone apparatus, J-ring assembly and compressive strength tests respectively.

➢ Fifth: Predicting and then validating a time-dependent compressive strength model for SCC with ggbs cement replacement levels from 0 to 80%, along with an associated strength gain potential factor (R) that quantifies the post 28-day strength gain potential of the mix.

**MECHANISM OF ACHIEVING SELF COMPACTION**

Self -compacting high-performance concrete is a high-performance concrete that can be compacted into every corner of a formwork, purely by means of its own weight and without the need for vibrating compaction. This concrete is defined as follows at the three stages of concrete:

(1) Fresh: self-compactable

(2) Early age: avoidance of initial defects

(3) After hardening: protection against external factors.

The self-compactability of fresh concrete depends mainly on its ability to flow through obstacles. The method for achieving self-compactability involves not only high deformability of paste or mortar, but also resistance to segregation between coarse aggregate and mortar when the concrete flows through the confined zone of reinforcing bars. Okamura and Ozawa have employed the following methods to achieve self-compactability:

(1) Limited aggregate content

(2) Low water-powder ratio

(3) Use of super plasticizer.

Figure 1: Mechanism of achieving self-compaction

**Plastic properties**

The ability to control the workability and self-compatibility of SCC is key to its effective production and use. Without this knowledge the design of an SCC mix for a particular application is an inefficient trial and error process. Tools to assess the plastic characteristics of SCC have been divided into three categories (Tattersall, 1991): qualitative assessment, quantitative empirical assessment and quantitative fundamental assessment. In the previous chapter, methods for the qualitative and quantitative assessment of SCC were presented; flow-ability, passing-ability and stability for the former; and slump flow latter. In this chapter, methods for describing and predicting the workability of SCC will be reviewed in terms of its fundamental rheological properties.

### 4.2 Rheological properties

Rheology is a science of deformation and flow. It has been recognised as an crucial field of scientific study and by common consent is a difficult subject (Barnes et al., 1993). Innovative concretes have explicit properties, often gained by using additives, and these properties are substantially affected by rheological characteristics of the fresh cement paste. The first ideas of choosing materials having complementary resistance and rigidity was necessary at a time when the only available materials were obtained directly from soils. Workability is a way of describing the performance of concrete in the plastic state and for SCC it is often characterised using the following properties: flowing-ability, filling-ability, passing-ability, and stability (segregation resistance).

Cement paste, mortar and concrete should be studied as systems; looking at these materials as systems represents a step forward, and the term "system properties (Rheology)" may be used as an alternative to "materials properties" when discussing mechanisms of plastic behaviour. Looking at cement paste, mortar and concrete as systems puts our mind set in the right direction for investigating cement-based materials at different scales and in all subsequent stages of their lifetime. Rheology in the broad sense is the science of flow and deformation of matter under stress (Tattersall and Banfill, 1983). Fundamental rheological approaches make it possible to predict fresh properties, select materials and model processes to achieve the required performance. Knowing the rheological parameters (yield stress and plastic viscosity) of a fluid provides a quantitative and fundamental way of characterizing the flowing-ability, filling-ability, passing-ability and stability of SCC.

### 4.3 The rheological parameters of SCC

SCC in the plastic state behaves as a viscous non-Newtonian fluid, which can be described by a bi-linear Bingham-type rheological model (Heirman et al., 2009). This model uses two parameters, namely the plastic viscosity (η) and the yield stress ($\tau y$). Plastic viscosity is the measure of the resistance to flow due to internal friction. It can also be regarded as the ability of this fluid to resist shear or angular deformation, which is mainly due to the interaction between fluid particles. SCC should have a sufficiently high viscosity to ensure that aggregate particles are suspended in a homogenous manner within the concrete matrix without segregation, and to prevent excessive bleeding or paste separation. The yield stress is the measure of the minimum amount of energy required to initiate SCC flow. Flow starts once the shear stress becomes higher than the yield stress. However, when its value becomes equal to or lower than the yield stress, the flow stops. To be considered SCC, concrete must flow easily under its own weight, so its yield stress should be low as possible.

It is generally known that the slump property of a normal fresh cementitious mix is mainly governed by its yield stress (Kong et al., 2003). When the yield stress of a fresh concrete mix is greater than the stress caused by gravitational forces (termed the 'gravitational stress'), the fresh mix is prevented from completely collapsing to the plate surface. As the yield stress becomes less than the gravitation stress, the final slump height decreases meaning that the slump displacement increases. In this process, the contribution of the viscosity to the fresh properties is considered to be relatively small. Once the gravitational stress acting on the fresh mix is much greater than the yield stress, the fresh mix completely collapses onto the plate, followed by the spreading of the mix over the plate surface. A number of investigations have shown that the role of viscosity is more important during spreading and that the yield stress of SCC mixes is very low (circa 200 Pa) (Dransfield, 2003; Badry et al., 2016) in comparison with normal concretes (thousands of Pa), and remains nearly constant over a large range of plastic viscosities

**TEST PERFORMED ON HARDENED CONCRETE**

Destructive tests

**Compression test:**

The ability of hardened concrete cube to resist the compression loads applied on the surface is known as compressive strength.

Apparatus Required

1. Steel Mould (150mm x 150mm x 150mm)

2. Tamping rod

3. CTM Machine

4. Trowel

5. Weighing machine Cube casting:

**Compression Testing Machine**

**Cube casting:**

1. Estimate the adequate ingredients to prepare the concrete with a proper water cement ratio.

2. Ensure that the cube mould should be free from dust and rust.

3. Now, pour the concrete into the mould by proper compaction with the help of a tamping rod.

4. Finish the top surface as smooth by the trowel.

5. The mould should be covered with a gunny bag and placed undisturbed for 24 hours at a temperature of 27 ° Celsius + 2.

6. After 24 hours, the cube specimen shall be removed from the mould, and it should be immersed into the water for 7 or 28 days based on the test.

**procedure:**

1. The cube should be removed from the water 30 minutes before the test, and it should be in dry condition.

2. The specimen should be weighed before the test.

3. The specimen should be placed between the plate with proper alignment.

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4. Now, apply the load (kilonewton) gradually to the specimen.

5. The specimen will break at maximum load which is noted down as the crushing value of the cube.

6. The average (Minimum Three Sample) crushing value should be note down as the compression value of the selected concrete batch.

**TABLE: Compressive Strength on 7, 14 and 28 Days**

| Mix Designation | Compressive strength in N/mm2 | | |
|---|---|---|---|
| | 7 Days | 14 Days | 28 Days |
| Mix-1 Control mix | 26.95 | 30.22 | 40.37 |
| Mix-2 25% of GGBS | 32.1 | 39.94 | 47.56 |
| | | | |
| Mix-3 30% of GGBS | 31.53 | 36.96 | 45.22 |
| Mix-4 35% of GGBS | 29.2 | 34.12 | 44.29 |
| Mix-5 40% of GGBS | 29.6 | 32.14 | 43.26 |

**Split Tensile Test:**

The tensile strength of concrete is an important property when it is to be used in making prestressed concrete structure, roads, and runways, this test shall follow as per the IS Code: 5816. The tensile strength of concrete is generally in the range of 10 % to 12% of its compressive strength.

The concrete cube was used to find the compressive strength of concrete, but to find the tensile strength of concrete a cylindrical specimen has to be used.

• Specimen - The concrete sample should have a cylindrical shape with a diameter of 150 mm and length 300mm.

• Range of Load - The testing machine can consistently apply the loads in the range of 1.2 MPa/min to 2.4 Mpa/min.

• Age of Test - The test shall be made at the period of 7 days and 28 days. Tests at any other age at which the tensile strength is desired may be made if so required.

• Number of Specimens - At least three specimens should be tested for each period of the test.

**RESULTS**

When the percentage of GGBS added to cement with varying percentage from 25% to 40% the following results were drawn.

1. With 25% of GGBS the compressive strength at the end of 7,14 and 28 days 32.1, 39.94 and 47.56N/mm2 respectively.

2. The compressive strength at the end of 28 days decreases when the GGBS percentage is increased beyond 40%. However, the compressive strength of M30 concrete at the end of 28 days for 40% replacement of GGBS is 43.26 N/mm2.

3. The compressive strength showed a steep decrease when the GGBS percentage is increased

4. A similar increase in the split tensile strength was observed when the GGBS is increase 25% (5.55 N/mm2 at the end of 28 days).

5. The split tensile strength at the end of 28 days decreases when the GGBS percentage is increased beyond 40%. However, the split tensile strength of M30 concrete at the end of 28 days for 40% replacement of GGBS is 5.01 N/mm2.

6. The split tensile strength showed a steep decrease when the GGBS percentage is increased beyond 40%.

7. A similar increase in the Flexural strength was observed when the GGBS is increase 25% (10.1N/mm2 at the end of 28 days).

## VI.CONCLUSION

- It has been verified, by using the slump flow test and other tests on fresh SCC that self-compacting concrete (SCC) achieved consistency and self-compatibility under its own weight, without any external vibration or compaction.
- The addition of GGBS mixes has shown improved performance in terms of strength and durability in all grades of SCC. This is due to the presence of highly reactive silica in GGBS.
- Studies indicated that there is a good compatibility between mineral combinations GGBS along with the chemical admixtures. And acts as a good binder and improves the finishing of the concrete surface.
- Experimental studies on efficiency of GGBS Combination in SCC confirmed the enhanced performance in terms of both strength and durability aspects with respect to performance of GGBS alone in SCC.
- It is observed that there is an increase in the peak compressive strength for different SCC mixes made with GGBS. The increase is due to high reactivity with GGBS.
- Addition of GGBS control the initiation of micro cracks, Improve the first crack load, the ultimate load and ductility of SCC. They are also effective in resisting deformation.
- The strength loss and weight loss observed to be less in mixes with GGBS.
- The ggbs level limits the range of plastic properties and compressive strengths achievable for SCC mixes with ggbs levels greater than 25% when compared to those for mixes with ggbs levels ≤25%.

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