# SELF-COMPACTING CONCRETE WITH USE OF WASTE MATERIAL

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***Abstract: Concrete is a family of binding material, fine aggregate, coarse aggregate and water. Concrete is normally used in the frame structure. But there is some limitation like self-compaction, surface finishes, maintains strength at congested area. Due to this limitation we are trying to make self- compacting concrete with the use of mineral admixture. SCC is concrete that can be placed and compacted under its own weight without any vibration effort, assuring complete filling of formwork even when access is hindered by narrow gaps between reinforcement bars. The primary objective of this study is to make use of Ground granulated blast furnace slag (GGBS) as a replacement of cement and understand its effects on the fresh properties, compressive strength weathering. The study also intended to quantify the amount of Ground granulated blast furnace slag (GGBS) to be added to the concrete according to the value of concrete properties Measured. The workability of self-compacted concrete is increased as content of GGBS increased. Compressive strength of SCC with GGBS is increased up to 10% replacement of cement with GGBS.***

***Index Terms: Ground granulated blast furnace slag (GGBS), SCC (self-compacted concrete), super plasticizer, viscosity modify agent.***

## I. INTRODUCTION

Cement-based materials are the most abundant of all man-made materials and are among the most important construction materials, and it is most likely that they will continue to have the same importance in the future. However, these construction and engineering materials must meet new and higher demands. When facing issues of productivity, economy, quality and environment, they have to compete with other construction materials such as plastic, steel and wood. One direction in this evolution is towards self-compacting concrete (SCC), a modified product that, without additional compaction energy, flows and consolidates under the influence of its own weight. The use of SCC offers a more industrialized production. It reduces the unhealthy tasks for workers as well as it can also reduce the technical costs of in situ cast concrete constructions. However, SCC is a sensitive mix, strongly dependent on the composition and the characteristics of its constituents. [1]

It has to possess the incompatible properties of high flow ability together with high segregation resistance. This balance is made possible by the dispersing effect of high-range water-reducing admixture (super plasticizer) combined with cohesiveness produced by a high concentration of fine particles in additional filler material. The main mechanisms controlling this fine balance are related to surface physics and chemistry hence, SCC is strongly dependent on the activity of the admixtures, as well as on the large surface area generated by the high content of fines. Fresh SCC, like all cement materials, is a concentrated particle suspension with a wide range of particle sizes (from 10-7 to 30 mm for concrete). The particles are affected by a complex balance of inter-particle forces (i.e. interlocking, frictional, colloidal, and electrostatic forces), generating a time dependence and viscous-plastic non-Newtonian behaviour. [1]Self-compacting concrete (SCC) represents one of the most significant advances in concrete technology for decades. Inadequate homogeneity of the cast concrete due to poor compaction or segregation may drastically lower the performance of mature concrete in-situ. SCC has been developed to ensure adequate compaction and facilitate placement of concrete in structures with congested reinforcement and in restricted areas. SCC was developed first in Japan in the late 1980s to be mainly used for highly congested reinforced structures in seismic regions. As the durability of concrete structures became an important issue in Japan, an adequate compaction by skilled labours ware required to obtain durable concrete structures. This requirement led to the development of SCC and its development was first reported in 1989. SCC can be described as a high performance material which flows under its own weight without requiring vibrators to achieve consolidation by complete filling of formworks even when access is hindered by narrow gaps between reinforcement bars. SCC can also be used in situations where it is difficult or impossible to use mechanical compaction for fresh concrete, such as underwater concreting, cast in-situ pile foundations, machine bases and columns or walls with congested reinforcement. The high flow ability of SCC makes it possible to fill the formwork without vibration. Since its inception, it has been widely used in large construction in Japan. Recently, this concrete has gained wide use in many countries for different applications and structural configurations. It can also be regarded as "the most revolutionary development in concrete construction for several decades". Originally developed to offset a growing shortage of skilled labour, it is now taken up with enthusiasm across European countries for both site and precast concrete work. [1]

Fig. 1.Congested Reinforcement

It has proved beneficial because of a number of factors as mentioned below [4]

Faster construction
Thinner concrete section
Reduced noise level (due to absence of vibration)
Safer working environment
Reduction in site manpower
Easier placing
Uniform and complete consolidation
Better surface finishes
Improved durability
Increased bond strength
Greater freedom in design

The method for achieving self-compatibility 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. High flow ability and high segregation resistance of SCC are obtained by:

a).A larger quantity of fine particles, i.e., a limited coarse aggregate content.

b).A low water/powder ratio, (powder is defined as cement plus the filler such as fly ash, silica fume etc.

SCC may have a lower modulus of elasticity, which may affect deformation characteristics of pre-stressed concrete members. Creep and shrinkage will be higher, affecting pre-stress loss and long-term deflection. Self-compacting concrete can be produced using standard cements and additives. It consists mainly of cement, coarse and fine aggregates, and filler, such as fly ash or other mineral admixture, water, super plasticizer and stabilizer. [4] Three basic characteristics that are required to obtain SCC are high deformability, restrained flow ability and a high resistance to segregation. High deformability is related to the capacity of the concrete to deform and spread freely in order to fill all the space in the formwork. [2]Segregation is usually related to the cohesiveness of the fresh concrete, which can be enhanced by adding a viscosity-modifying admixture (VMA) along with a HRWR, by reducing the free-water content, by increasing the volume of paste, or by some combination of these constituents. Two general types of SCC can be obtained: (1) one with a small reduction in the coarse aggregates, containing a VMA, and (2) one with a significant reduction in the coarse aggregates without any VMA. [1]

## II. OBJECTIVE, SCOPE AND METHODOLOGY

The primary objective of this study is to make use of the GGBS (Ground granulated blast-furnace slag) as a replacement of cement by varying proportion and understand its effects on the fresh properties & compressive strength

The study also intends to quantify the amount of GGBS (Ground granulated blast-furnace slag)

Methodology

Effect of GGBS on following properties of SCC. The varying proportion of GGBS is 9%, 14%, and 18% of total cement content.

Fresh Properties

1). Filling ability
2). Passing ability
3). High resistance to segregation

Compressive Test

1). Cube Compressive Strength,

## III. MATERIAL

Cement: - Ordinary Portland cement (53 Grades)
Fine Aggregates: - Particles smaller than 0.125 mm
Course Aggregates: -Aggregate passing 12mm sieve and Retained on 10 mm sieve.
Water: - Ordinary potable water of normally pH 7 is used for mixing and curing the Concrete specimen

Chemical Admixtures:-

*1. Super plasticizer:* - Super plasticizer (high-range water-reducers) are low molecular-weight, water-soluble polymers designed to achieve high amounts of water reduction (12-30%) in concrete mixtures in order to attain a desired slump (Gagne et al., 2000). These admixtures are used frequently to produce high-strength concrete (> 50 MPa). They also can be used without water reduction to produce concretes with very high slumps, in the range of 150 to 250 mm (6 to 10 inches). At these high slumps, concrete flows like a liquid and can fill forms efficiently, requiring very little vibration. [2]

*2. Viscosity Modifying Agent:* - Viscosity modifiers are high molecular-weight, water-soluble polymers used to raise the viscosity of water. Such compounds increase the cohesiveness of fresh concrete, reducing its tendency to segregate and bleed (Ferraris, 1999). They work by attaching their long molecules to the water molecules, process which inhibits the free displacement of water. These admixtures are helpful in improving the properties of lean concretes with low cement contents, concrete placed under water, and concretes or grouts that are placed by pumping. In the latter case, they reduce pumping pressures through improved lubricating properties, as well as reducing segregation tendencies. When compounds in this category are used to improve the cohesiveness of concrete being placed underwater, they are classified as ant washout admixtures. Viscosity-modifying admix configurations or unusual geometry forms, where fluid but cohesive concrete is required in order to resist bleeding and segregation (Dodson, 1990). [2] The materials commonly used are polyethylene oxides, cellulose ethers, natural gums, and polyacrylamides or polyvinyl alcohol. Other materials used are finely divided solids such as clays and lime, but they tend to reduce the strength of the concrete and for this reason is primarily used in grouts when strength is not of major importance. [2] We have used glenium 6150 as a super plasticizer and master glenium stream 2 as a viscosity modify agent.

*3. Mineral Admixtures:* - GGBS (Ground granulated blast-furnace slag) Ground granulated blast furnace slag (GGBS) is a by-product from the blast-furnaces used to make iron. These operate at a temperature of about 1,500 degrees centigrade and are fed with a carefully controlled mixture of iron-ore, coke and limestone. The iron ore is reduced to iron and the remaining materials form a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching optimises the cementations properties and produces granules similar to coarse sand. This 'granulated' slag is then dried and ground to a fine powder. [3] Chemical and physical proportion of GGBS is as shown in Table-I and II.

TABLE I Chemical Composition of GGBS [5]

| Chemical Constituent | Portland | GGBS |
|---|---|---|
| CaO | 65% | 40% |
| SiO2 | 20% | 35% |
| AI2O3 | 5% | 10% |
| MgO | 2% | 8% |

TABLE II Physical Properties of GGBS [5]

| Colour | Off-white powder |
|---|---|
| Bulk density (loose) | 1.0–1.1 tonnes/m3 |
| Bulk density (vibrated) | 1.2–1.3 tonnes/m3 |
| Relative density | 2.85–2.95 |
| Surface area | 400–600 m2/kg Blaine |

The mix design of Self compacted concrete is as shown in table III.We have designed our concrete for M50 grade.

TABLE III concrete mix design for SCC

| | **Cement kg** | **GGBS Kg** | **Water kg** | **F.A kg** | **C.A kg** | **SP kg** | **VMA kg** |
|---|---|---|---|---|---|---|---|
| **SCC 1** | 550 | 00(0%) | 175 | 887 | 800 | 5.5 | 0.82 |
| **SCC 2** | 500 | 50(9%) | 175 | 887 | 800 | 5.5 | 0.82 |
| **SCC 3** | 475 | 75(14%) | 175 | 887 | 800 | 5.5 | 0.82 |
| **SCC 4** | 450 | 100(18%) | 175 | 887 | 800 | 5.5 | 0.82 |

## IV. RESULT AND DISCUSSION

### *A. Effect on Fresh property of self-compacted concrete*

TABLE IV Slump flow test Result

| **Design** | **Slump flow (mm)** | **T50 cm slump flow (sec)** |
|---|---|---|
| **SCC 1** | 640 | 6.35 |
| **SCC 2** | 710 | 3.13 |
| **SCC 3** | 660 | 5 |
| **SCC 4** | 655 | 6 |

The results of slump flow & T50 cm slump flow (sec) of all Self-compacting concretes are included in Table IV In slump flow test SCC2, SCC3, SCC4 exhibited satisfactory slump flows in the range of 650–800 mm, & In T50 cm slump flow (sec) test SCC2 and SCC3exhibited satisfactory slump flows in the range of 2-5 sec which is an indication of a good workability.

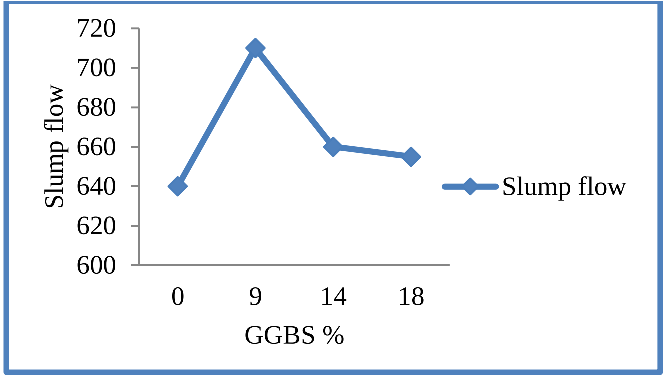

Fig. 2. Slump flow test Result

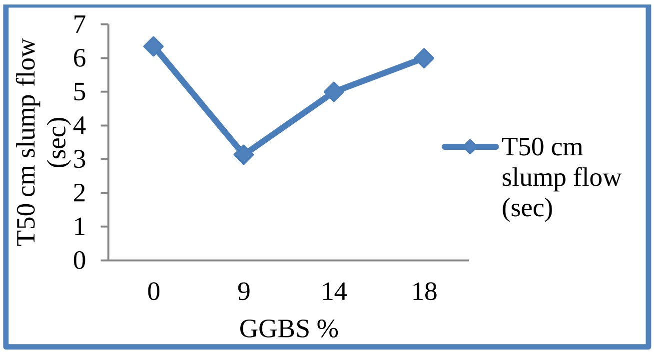

Fig. 3. Slump flow test T5 Result

TABLE V J-ring test Result

| **Design** | **J-ring (mm)** |
|---|---|
| **SCC 1** | 3.5 |
| **SCC 2** | 2.3 |
| **SCC 3** | 2.9 |
| **SCC 4** | 2.8 |

The results of J-ring test of all Self-compacting concretes are included in Table V In J-ring test all SCC exhibited satisfactory J-ring in the range of 0-10 mm.

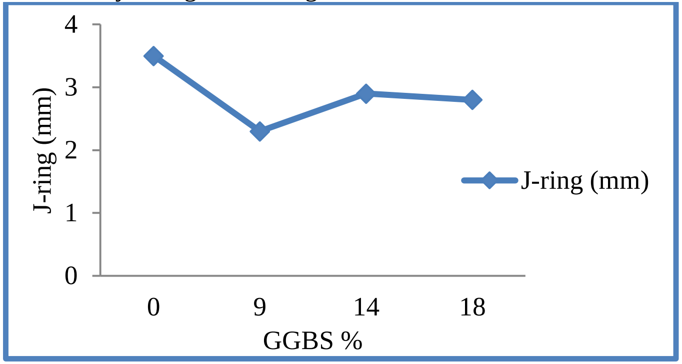

Fig. 4. J-ring test Result

TABLE VI V-funnel

| Design | V-funnel (sec) | V-funnel at T5 minutes(sec) |
|---|---|---|
| **SCC 1** | 17 | 21 |
| **SCC 2** | 8.84 | 9.96 |
| **SCC 3** | 9.81 | 13 |
| **SCC 4** | 10 | 13.15 |

As per EFNARC, time ranging from 8 to 12 seconds is considered adequate for a SCC. In table VI V-funnel flow times were in the range of 8-17 seconds. Test results of this investigation indicated that SCC2, SCC3, SCC4, mixes meet the requirements of allowable flow time.

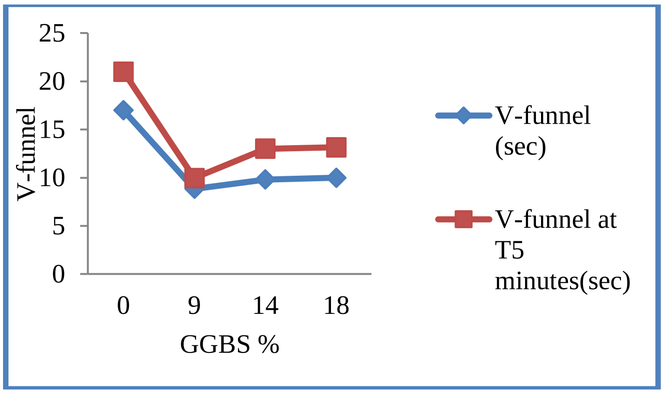

Fig. 5. V-funnel

TABLE VII U-box

| Design | Height of conc. In 1st compartment H1 (mm) | Height of conc. In 2nd compartment H2 (mm) | Filling height H1-H2 (mm) |
|---|---|---|---|
| **SCC 1** | 25.8 | 44.8 | 18.5 |
| **SCC 2** | 33.5 | 46.5 | 13 |
| **SCC 3** | 40 | 37 | 3 |
| **SCC 4** | 45.6 | 45.6 | 0 |

The results of fresh properties of U-box (passing ability) Self-compacting GGBS concretes are included in Table VII U-box difference in height of concrete in two compartments was in the range of 0-30 mm as per EFNARC. Test results of this investigation indicated that all SCC mixes meet the requirements of allowable height.

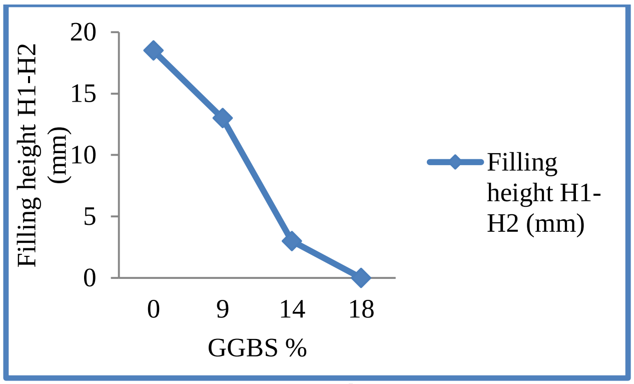

Fig. 6. U-box

TABLE VIII L-box

| Design | H1 | H2 | Blocking ratio H2 /H1 | Time require to reach 200mm | Time require to reach 400mm |
|---|---|---|---|---|---|
| **SCC1** | 15 | 9.5 | 0.63 | 4.12 | 6.20 |
| **SCC2** | 12.9 | 10.4 | 0.81 | 1.86 | 3.86 |
| **SCC3** | 15 | 10.5 | 0.7 | 2 | 4.19 |
| **SCC4** | 12.8 | 10.4 | 0.82 | 3.19 | 5.70 |

The results of fresh properties of L-box (passing ability) Self-compacting GGBS concretes are included in Table VIII Maximum size of coarse aggregate was kept as 12 mm in order to avoid blocking effect in the L-box. The gap between re-bars in L-box test was 35 mm. The L-box ratio H2/H1 for the mixes was above 0.8-1.0 which is as per EFNARC standards. Test results of this investigation indicated that SCC2 and SCC4 mixes meet the requirements of allowable Blocking ratio H2/H1

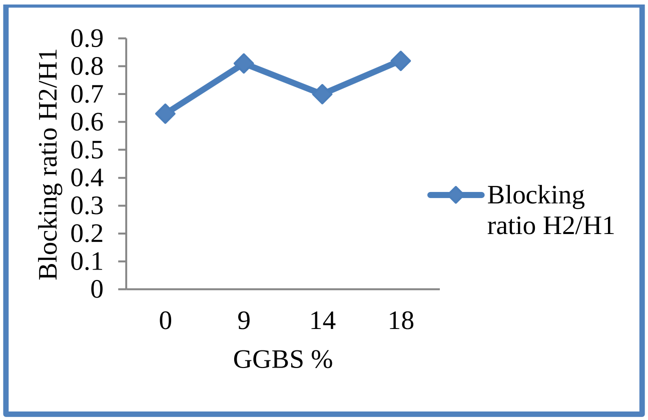

Fig. 7. L-box Blocking ratio H2/H1

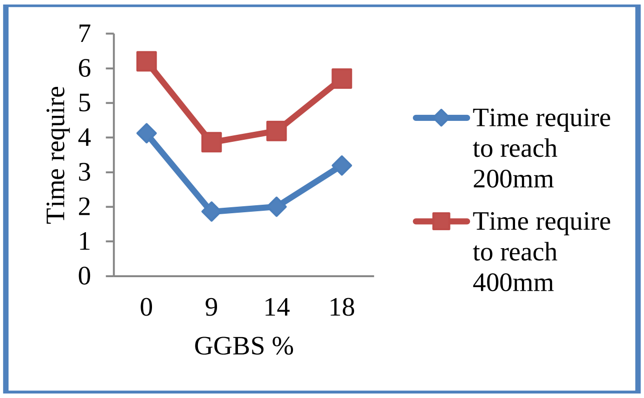

Fig. 8. L-box Time require to reach 200mm & 400mm

### *B. Compressive strength test*

TABLE IX SCC 1 Compressive strength test

| | **Compressive strength (MPa)** | | | **Average Compressive strength (MPa)** |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| **Day7** | 31.26 | 33.26 | 34.96 | 33.16 |
| **Day28** | 46.20 | 48.34 | 54.70 | 49.74 |

TABLE X SCC 2 Compressive strength test

| | **Compressive strength (MPa)** | | | **Average Compressive strength (MPa)** |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| **Day7** | 40.59 | 29.07 | 29.16 | 32.94 |
| **Day28** | 51.45 | 57.25 | 51.07 | 53.25 |

TABLE XI SCC 3 Compressive strength test

| | **Compressive strength (MPa)** | | | **Average Compressive strength(MPa)** |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| **Day7** | 39.94 | 27.21 | 30.58 | 32.71 |
| **Day28** | 42.36 | 44.39 | 43.91 | 43.55 |

TABLE XII SCC 4 Compressive strength test

| | **Compressive strength (MPa)** | | | **Average Compressive strength(MPa)** |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| **Day7** | 22.01 | 26.24 | 20.14 | 22.80 |
| **Day28** | 38.27 | 40.92 | 41.53 | 40.25 |

TABLE XIII Overall Test Results

| **Design** | **Compressive strength (MPa)** |
|---|---|
| **SCC 1** | 49.74 |
| **SCC 2** | 53.25 |
| **SCC 3** | 43.55 |
| **SCC 4** | 40.25 |

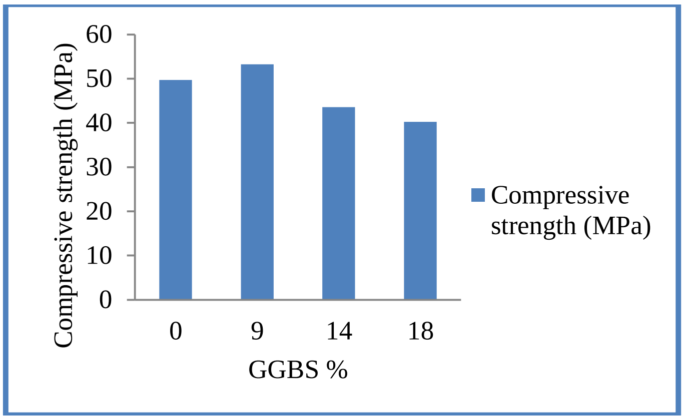

Fig. 9. Overall Test Results

## V. CONCLUSION

For GGBS replacement, the fresh properties observed were good as compare to SCC without mineral admixture. Hence if we add the GGBS replacement for we can have a better workable concrete. It has been verified, by using the slump flow, T50 cm slump flow J-ring test, L-box test and U-tube tests, that self-compacting concrete (SCC) achieved consistency and self-compatibility under its own weight, without any external vibration or compaction. In present study Fresh property concrete test are slump flow test SCC 2 ,SCC 3, SCC 4 exhibited satisfactory slump flows in the range of 650–800 mm, In T50 cm slump flow (sec) test SCC 2 ,SCC 3, SCC 4 exhibited satisfactory slump flows in the range of 2-5 sec, In J-ring test all SCC 2 ,SCC 3, SCC 4 exhibited satisfactory J-ring in the range of 0-10 mm, IN V-funnel test results of this investigation indicated that SCC 2 ,SCC 3, SCC 4 mixes meet the requirements of allowable flow time 8-12sec, U box test results of this investigation indicated that all SCC 2 ,SCC 3, SCC 4 mixes meet the requirements of allowable height 0-30mm and L-box test results of this investigation indicated that SCC 2 ,SCC 3, SCC 4 mixes meet the requirements of allowable Blocking ratio H2/H1 0.8-1.0 which is an indication of a good workability. SCC with GGBS exhibited satisfactory results in workability, because of small particle size and more surface area. The influence of GGBS on compressive strength of self-compacting concrete is given in Table XIII and Fig.9 The percentage of GGBS was 9%, 14% and 18% and the water- cement ratios ranged from 0.32.The test results indicated that, 9% percent by mass replacement of GGBS for cement gives the highest strength for short and long terms and when GGBS is replaced by 14% and 18% the strength decreases.

## VI. ACKNOWLEDGMENT

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