Scientific Journal of Impact Factor (SJIF): 4.72
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406
International Journal of Advance Engineering and Research Development
Volume 4, Issue 9, September -2017

Experimental Investigation on Mechanical Properties of Self Compacting Concrete by Partial Replacement of Fly Ash and GGBS

G. Pavan Kumar*N.R. Gowthami ** T. Naresh Kumar***

**. Post Graduate Student, Department of Civil Engineering, AITS, Rajampet*
***. Assistant Professor, Department of Civil Engineering, AITS, Rajampet.*
**** Assistant Professor, Department of Civil Engineering, AITS, Rajampet.*

Abstract:-*Self-compacting concrete (SCC) are often characterized as concrete that has superior flow ability under maintained stability (i.e.no segregation) therefore permitting self-compaction i.e., material consolidation with no loss of energy. Self-compacting concrete is a liquid mix acceptable for setting in structures with full reinforcement without vibration and it helps in achieving higher quality. In this investigation the cement is replaced by Fly ash 10% as constant and Ground Granulated blast furnace Slag (GGBS) of various proportions 0%, 5%, and 10%. This paper reviews on the fresh and hardened properties of fly ash and GGBS based on self-compacting concrete (SCC), to show the accessible advantages of GGBS in self-compacting concrete research and to conclude the sustainability and economy of cement. In this investigation to study the mechanical properties such as compressive strength, split tensile strength, flexural strength, young's modulus and Non- destructive test 7, 14, 28, 60, 90 days strength of self-compacting concrete.*

Keywords: *Self–Compacting Concrete, fly ash, GGBS, Super Plasticizer, workability tests.*

I. INTRODUCTION

Concrete technology has huge developments and innovations in the past decade. Now a day's concrete isn't a fabric that consist only cement, fine aggregate, coarse aggregate associated water however it's a building material that consists of the many new materials that performs satisfactorily under surrounding environment. Newly fresh concrete consists of various materials like fly ash, GGBS etc.

Self-Compacting Concrete (SCC) as well as referred to as "self consolidating concrete" a developed in Japan in the late 1980s, to improve the reliability of concrete and concrete structures. highly flow able or self levelling cohesive concrete that can spread willingly into place (low thickness) through and around thick reinforcement in its individual weight. It sufficiently fills form work with no segregation or bleeding SCC mix has a low yield stress as well as an increased flexibility thickness. The mix require bare minimum force to initial flow yet have sufficient cohesion to oppose aggregate segregation and extreme bleeding.., The yield stress is condensed by means of a highly developed synthetic high range water-reducing admixture (HRWR), while the viscosity of paste is improved by using a viscosity modify admixture (VMA) or by rising the percentage of fines integrated into the Self Compacting Concrete mix design.

In order to achieve this property, SCC must have good deformability, high segregation resistance, and no blocking around reinforcements without applying any vibration. New era of admixtures added to crisp SCC to build union with isolation resistance. Good segregation resistance implies that the dispersions of total molecule inside the solid are generally comparable at all areas and at all levels. The solidified SCC is thick, homogeneous, and has preferred building and mechanical properties over customary vibrated concrete. Though, to design a proper Self Compacting Concrete mixture is not an easy task. A key part, when manufacturing Self Compacting Concrete, deformation on the selection of ingredient materials with the design of mix proportions so as to get sufficient properties of freshly concrete. Applications of self-compacting concrete (SCC) is determined on high performance; improved and new consistent excellence, thick and consistent surface texture, improved durability, high-strength, and earlier construction.

II. MATERIALS USED

Cement

Cement is a binding material. Ordinary Portland cement 53 grade manufactured by ultra tech company confirming to IS 12269-1987 is used. The main benefit is the faster rate of development of strength. The specific gravity of cement is 3.15 and fineness modulus of cement is 225m^2/kg, initial setting time is 30 minutes and final setting time is 10hrs.

Aggregate

The aggregate is the basic material used in any concrete to comprise the body of concrete for increasing the strength of the material quantity, and to minimize the consequential volume change of concrete. The fine and coarse aggregates generally occupy 60% to 75% of concrete volume and strongly influence the concrete fresh and hardened properties, mix proportions and economy. The natural sand with specific gravity is 2.65 and fineness modulus is 2.89 and the coarse aggregates of 12mm size with specific gravity is 2.75 were used plane form quarry local

Fly Ash

Fly ash confirming to the requirements of IS 1727 (1967) obtained from RTPP conforming to class F with specific gravity of 2.2 and Fineness of fly ash is 320m^2/kg was used as supplementary cementitious material in concrete mixtures.

Fig.1: Fly Ash

GGBS

In this research, commercially obtainable GGBS particle size less than 20 Nano meters was supplied by ASTRRA chemicals pvt, Chennai with specific gravity 2.9 was used for all concrete mixtures Fineness modulus of Ground Granulated Blast furnace Slag is 400m^2/kg

Fig.2: GGBS

Table No.1 Chemical Composition of Fly Ash and GGBS

Chemical Composition					
Material	SiO_2	Al_2O_3	Fe_2O_3	MgO	Cao
Fly Ash	58	22.5	5.75	1.6	2.12
GGBS	38.1	12.4	3.12	10.9	36.5

Super plasticizer

Super plasticizer is also called as High range water reducing admixture (HRWA) based on polycarboxylates ethers are typically used to plasticize the mix. In this experimental investigation have used CONPLAST 430 as super plasticizer.

X-Ray Diffraction:

Particle size of GGBS

It contains calcite, Silica and alumina.

By using Williamson-Hall method crystallite size and lattice strain is obtained for GGBS crystallite size is 268 A^o and 0.1% of strain.

Quantitative analysis results for GGBS, it contains calcite 34.35, Silica 38.56% and alumina 9.75%.

Particle size should satisfy by Bragg's Law equation ($n\lambda=2d \sin\theta$).2θ obtained by rotating sample, d is spacing of unit cell dimensions, λ is wave length, n is an integer.

By using Debye – Scherer equation Nano particle size can be obtained $D=\frac{K\lambda}{\beta \cos\Theta}$ where λ=1.54 A^o, β = full width at maximum intensity (FWHM) of the peak in radians. Θ= angle, K is constant 0.9.

Sample calculation for particle size of GGBS is given below by using Debye – Scherer equation for calculating particle $K=0.9$, $\lambda= 0.154$ nm, $\beta = \frac{\pi}{180} \times$ FWHM, $2\Theta= 30.45^{o}$ $\frac{\pi}{180} \times 8.14$ $\Theta= 15.225$ =.142 $D=\frac{K\,\lambda}{\beta \cos \Theta} = \frac{0.9\times0.154}{0.142\times\cos 15.225}$ = 1.011 nm.

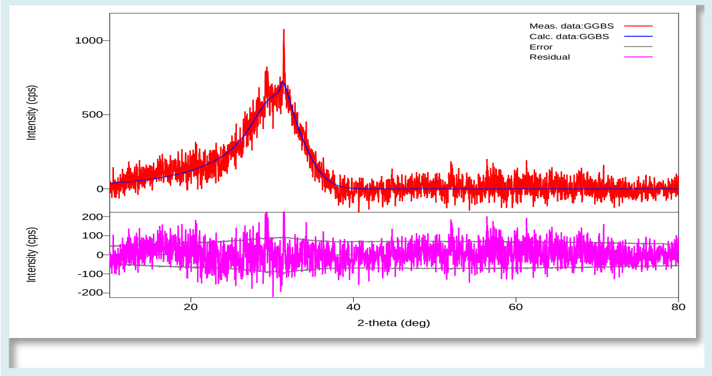

Fig.3: XRD Test for GGBS

III METHODOLOGY

Fresh Properties of Self- Compacting Concrete

The mix design is focused on the ability to flow under its own weight without vibration, the ability to flow through heavily congested reinforcement under its own weight, and the ability to retain homogeneity without segregation. The workability of Self- Compacting Concrete is higher than conventional concrete "very high" degree of workability mentioned in IS 456:2000.

A concrete mix can only be classified as Self-Compacting Concrete if it has the following characteristics.

- Filling ability
- Passing ability
- Segregation resistance

Several test methods have been developed in attempts to characterize the properties of Self-Compacting Concrete. In this study three methods are used to evaluate the fresh properties of Self-Compacting Concrete. Each method has its different property and listed in table below.

In all, these proportions of specimens were investigated in this experimental work.

Table no.2 Workability Tests

% Of Fly Ash And GGBS	Slump Flow In mm	Slump Flow In Sec (T_{50cm})	V-Funnel In Sec	L-Box (H_2/H_1)
10% & 0%	670	5	10	0.9
10% & 5%	650	7	9	0.83
10% & 10%	630	7	12	0.8
10% &15%	620	6	10	0.7

Mix Design and proportions

Based on 2002 EFNARC published their "Specification & Guidelines for Self-Compacting concrete" which, at that time, provided state of the art information for producers and users. Since then, much additional technical information on SCC has been published but European design, product and construction standards do not yet specifically refer to SCC and for site applications this has limited its wider acceptance, especially by specifies and purchasers, concrete mix of M30 grade was designed. Mix proportion given in given in below was arrived based on trials.

Table No.3 Mix Proportions

Concrete	Cement	F.A	C.A	W/C
NC	**1**	**1.8**	**2.4**	**0.4**
SCC	**1**	**1.87**	**1.7**	**0.5**

For the design mix material quantities are given in the below table 4.

Table No.4

Materials	SCC	NC
Cement (kg/m^3)	453.2	380
Sand (kg/m^3)	850.805	711
Gravel (kg/m^3)	771.84	924
Fly Ash (kg/m^3)	199.677	-
GGBS (kg/m^3)	53.3	-
Water (lit/m^3)	26.65	160
Super plasticizer (lit/m^3)	4.8	-

Mixing and Casting

Dry aggregates like gravel and sand were mixed in dry state. Then fly ash and GGBS added to the dry mix with cement against the coarse aggregates and mixing is continued for 2minutes. Subsequently, cement, fly ash and GGBS with water and the water reducing admixture is added and mixed for a further 2 minutes. Concrete moulds are test specimens for 7, 14, 28, 60,90days strength testing.

Specimens

- 150mm cubes are cast for testing compressive strength, rebound hammer, and modulus of rigidity
- 150mm diameter 300mm long cylindrical specimens for studying split tensile strength as well as the energy absorption characteristics.
- 700mm length 150mm breadth and 150mm height beams specimens for testing flexure strength.

All the test specimens were carefully covered with durable plastic sheets to prevent the loss of moisture immediately after casting. They were demoulded after 24 hours and kept curing for 7, 14, 28, 60 and 90 days time period.

Mix Designation	Proportions of Binding Materials
A1	100% cement
A2	90% cement + 10% fly ash
A3	85% cement + 10% fly ash + 5% GGBS
A4	80% cement + 10% fly ash + 10% GGBS
A5	75% cement + 10% Fly ash + 15% GGBS

IV. EXPERIMENTAL RESULTS AND DISCUSSION

A. Compressive Strength

Concrete cubes of size150mm×150mm×150mm were tested for crushing strength. The specimens were placed centrally on the base plate of the machine and the load was applied gradually at the constant rate of 140 kg/cm2/min till the specimen failed. The maximum load applied was noted for each test. The crushing strength is the ratio of failure load to the area of cross section of specimen. The compressive strength of concrete mixes by replacing OPC with fly ash and GGBS, fly ash is constant and GGBS by 10% and 0%, 5%, 10%, 15% as GGBS. The test result has been carried out on specimens at 7, 14, 28, and 90 days strength. As comparing the compressive strength and Rebound hammer NDT results and graphs are given below in table.5 & 6.

The Compressive Strength result of Normal Concrete is increased when compared to all proportions. The Compressive Strength of Concrete is decreased by 4% with admixture of 10% fly ash and while added the 5% GGBS increased 2% of strength. At last added 10% GGBS increased 0.5% and added 15% GGBS decreases 3% as compared to plain concrete.

Compressive strength test results for SCC using Fly Ash and GGBS

Table.5: Compressive Strength results

Mix	Compressive strength(N/mm^2)				
	7-Days	14-Days	28-Days	60- Days	90-Days
A1	31.85	32.08	38.56	42.12	43.54
A2	28.86	29.75	33.74	38.21	41.53
A3	28.92	29.77	33.86	38.60	42.67
A4	32.17	32.31	34.66	41.60	43.76
A5	30.2	31.8	32.6	37.1	42.2

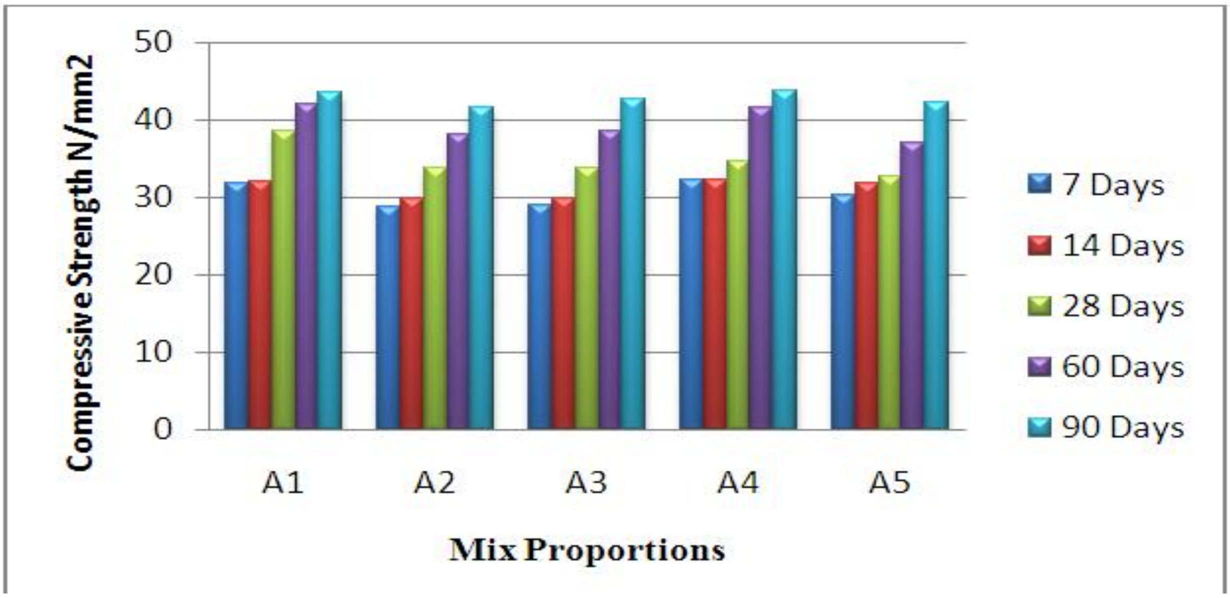

Fig.4: Compressive Strength Results

Rebound Hammer results for N.C and SCC using Fly ash and GGBS

Table.6: Rebound Hammer Results

Mix designation	**Rebound Hammer (N/mm^2)**	
	28 Days	**60 Days**
A1	34	37.6
A2	31.6	33
A3	32	34
A4	32	38.1
A5	31	36

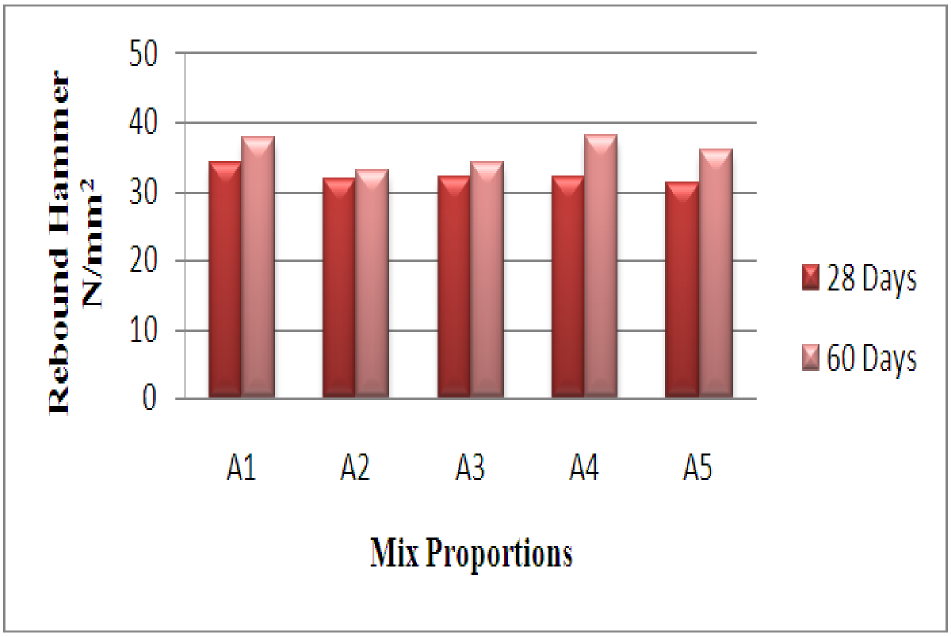

Fig.5: Rebound Hammer Results

The Rebound Hammer test result of Normal Concrete is increased when compared to all proportions. The Rebound Hammer test of Concrete is decreased by 12% with admixture of 10% fly ash and while added the 5% GGBS decreased 9% of strength. Adding 10% GGBS decreased 2%, added 15% by GGBS decreases 4.25% of plain concrete.

B. Split Tensile Strength

The test consists of applying a compressive line load along the opposite generators of a concrete cylinder placed with its horizontal axis between the compressive plates. Due to the compression loading a fairly uniform tensile stress is developed over nearly 2/3 of the loaded diameter as obtained from an elastic analysis. The strength of concrete mixes by replacing OPC with fly ash 10% as well as GGBS at 0%, 5%, 10% & 15% as replaced. The test result has been carried out on specimens at 7 days, 14 days, 28 days and 60 days strength. The results and graph are given below in table 7.

Split Tensile strength test results for SCC using Fly Ash and GGBS

Table.7: Split Tensile Strength Results

Mix	Split Tensile strength(N/mm^2)			
	7 Days	14 Days	28 Days	60 Days
A1	2.85	3.44	4.18	4.22
A2	2.57	2.78	2.81	2.90
A3	2.78	2.82	2.96	3.10
A4	3.05	4.07	4.10	4.21
A5	2.82	3.08	3.15	3.82

The Split Tensile Strength result of Normal Concrete is decreased when compared to all proportions. The Split Tensile Strength of Concrete is decreased by 31% with admixture of 10% fly ash and while added the 5% GGBS decreased 26.5% of strength, adding of 10% GGBS decreased 0.24% & 15% of GGBS strength decreases 9.47% as compared to plain concrete.

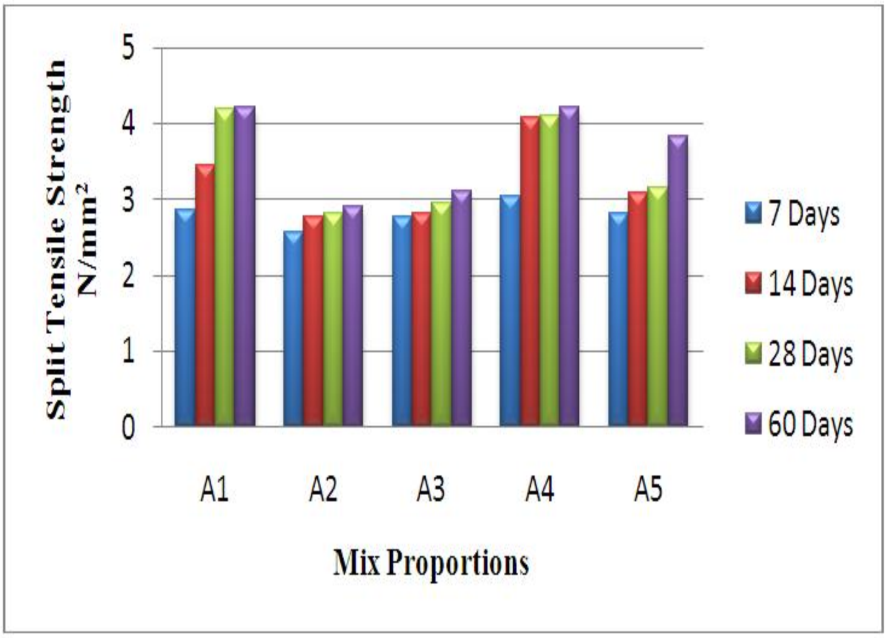

Fig.6: Spilt Tensile Results

C. Flexure Test Results

Flexural strength test on concrete beam is to determine the strength of concrete. Flexural strength test was conducted by using the method prescribed by IS 516 - 1959.Beams of 700mm × 150mm × 150mm were used for this test, the test specimen is placed in the machine at the bearing surfaces of the supporting and loading rollers. So that the load shall be applied without shock and increasing continuously at a stress increases at approximately 7 kg/sq mm that is at a rate of loading 400 kg/min for the 150mm specimens. The load shall be increased until the specimen fails, and the maximum load applied to the specimen during the test shall be recorded. The strength of concrete mixes by replacing OPC with fly ash 10% as well as GGBS at 0%, 5%, 10% & 15% was investigated. The test result has been carried out on specimens at 28 days and 60 days strength. The results and graph are given below in table 8.

Flexural strength results for NC and SCC using Fly ash and GGBS

Table.8: Flexural Strength Results

Mix designation	Flexural strength (N/mm^2)	
	28 Days	60 Days
A1	6.10	6.23
A2	4.24	4.31
A3	5.87	6.14
A4	6.08	6.42
A5	4.18	5.12

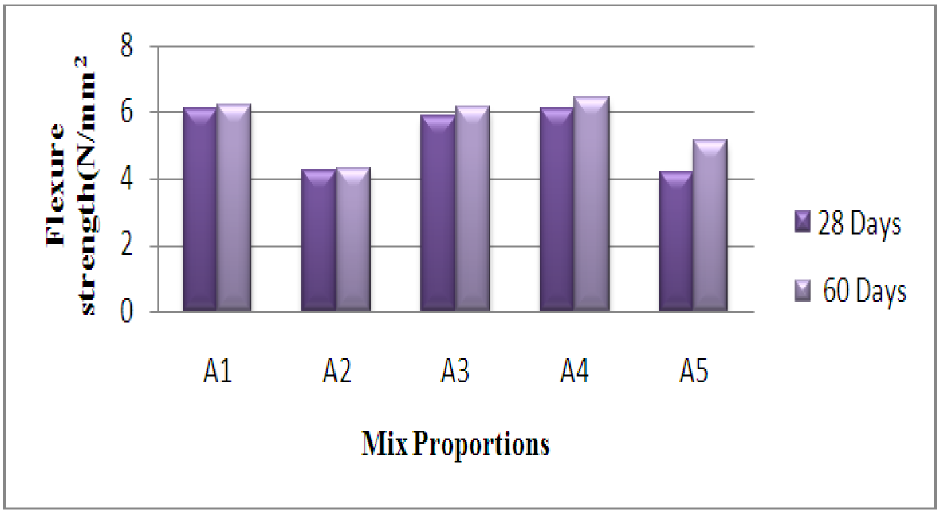

Fig.7: Flexure Strength Results

The Flexure Strength result of Normal Concrete is decreased when compared to all proportions. The Flexure Strength of Concrete is decreased by 30% with admixture of 10% fly ash and while added the 5% GGBS decreased 2% of strength. added 10% GGBS increased 3% of plain concrete, added 15% GGBS decreases 17.81% strength as compared to plain concrete.

D. Young's Modulus Test Results

The young's Modulus test strength results for various replacement levels of fly ash and GGBS by Cement such as normal concrete and 0%, 5%, 10% & 15% percentages of SCC consider at 28-days and 60- days strength results and graph are given below. According to stress- strain graph up to elastic limit the E value is evaluated. The results are given below in table 9.

Young's Modulus test results for NC and SCC using Fly ash and GGBS

Table No.9 Young's Modulus Test

Mix designation	Young's Modulus Test (N/mm^2)	
	28 Days	60 Days
A1	3.3×10^4	4.2×10^4
A2	2.4×10^4	3.3×10^4
A3	2.8×10^4	3.6×10^4
A4	3.6×10^4	4.4×10^4
A5	$3.4x10^4$	$4.2x10^4$

The Young's Modulus test result of Normal Concrete is decreased when compared to all proportions. The Young's Modulus of Concrete is increased by 27% with admixture of 10% fly ash and while added the 5% GGBS increased 21% of strength, adding 10% GGBS increased 19%, added 15% GGBS strength increases 22.22% as compared to normal concrete.

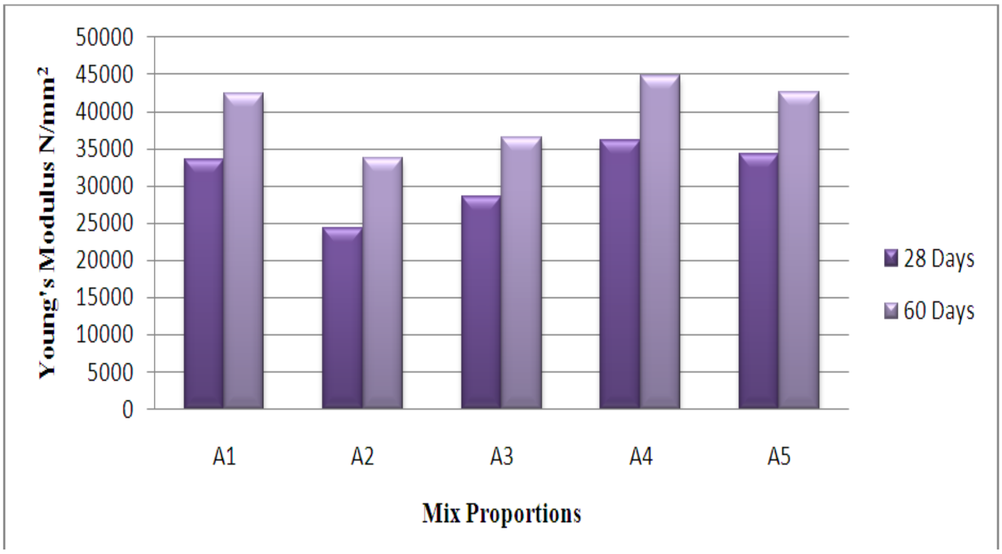

Fig.8: Young's Modulus Results

V. CONCLUSION

Based on the investigation conducted for the study of behaviour of self-compacting concrete the following conclusions are arrived.

- As no specific mix design procedure for SCC is available mix design as per Euro code EFNARC 2002.
- To check the workability test as filling ability, flowing ability and segregation resistance.
- In this investigation 0.5% of super plasticizer it is possible to get a mix with low water to cement ratio to get the desired workability.
- The compressive strength and Rebound hammer (NDT) comparing with normal concrete and SCC of A4 proportion as increased strength of 0.5% & A5 proportion of 3% of decreased strength as plain concrete. NDT of A5 proportion decreased strength 1.6% of NC.
- Tensile strength of A1 proportion of NC & A4 as 10% FA & GGBS increased strength 0.24% and A5 strength decreased as 9.47% NC
- Flexural strength of NC A1 proportion of NC & A4 proportion increase strength as 3% & A5 proportion decrease the strength 17.81% comparing plain concrete.
- Young's Modulus according to stress-strain graph, find the E value comparing the A1 proportion increases the strength 19% & A5 proportion increases the 22.22% compared the plain concrete.
- Comparing SCC A4 proportion of 10% Fly Ash and 10% GGBS as optimum and similar to Normal concrete.

REFERENCES

- Albert K.H. Kwan (2010) "Improving performance and robustness of SCC by adding supplementary cementitious materials" published in Elsevier journal of Construction and Building Materials 24(2010) 2260-2266
- S. Girish (2010) "Influence of powder and paste on flow properties of SCC" published in Elsevier journal of Construction and Building Materials 24(2010) 2481-2488
- Her-Yung Wang (2010) "A study on the properties of fresh self-consolidating glass concrete (SCGC)" published in Elsevier journal of Construction and Building Materials 24(2010) 619-624
- Miao Liu (2010) "Self-compacting concrete with different levels of pulverized fuel ash" published in Elsevier journal of Construction and Building Materials 24(2010) 1245-1252
- N. Diamantonis (2010) "Investigations about the influence of fine additives on the viscosity of cement paste for self-compacting concrete" published in Elsevier journal of Construction and Building Materials 24(2010) 1518-1522
- F.M. Almeida Filho (2010) "Hardened properties of self-compacting concrete a statically approach" published in Elsevier journal of Construction and Building Materials 24(2010) 1608-1615

