COMPARITIVE STUDY OF FRESH & HARDENED CONCRETE PROPERTIES OF SELF COMPACTING CONCRETE USING DIFFERENT POZZOLANS.

[1]Vaibhav.T, [2] Monika.B,
[1]PG Student, Structural Engineering, Department of Civil Engineering, RYMEC, Ballari, India
[2]Assistant professor, Department of Civil Engineering, RYMEC, Ballari, Inida.

Abstract: **The primary intension of this study aims at producing and evaluating SCC for ternary and quaternary blends incorporating fly ash, GGBS, sugarcane bagasse ash and alccofine as partial replacement of cement. Twelve number of SCC mixtures were investigated in this study. The self-compacting mixes have cement replacement with different percentages of mineral admixtures while keeping cement quantity fixed for 350kg/m^3.The tests such as slump flow test, V funnel test, T_{500} slump flow test, J ring test and V_{5min} test were carried on fresh properties of SCC mixes to check the prerequisites mentioned in EFNARC, the mechanical properties of hardened concretes such as compressive strength, split tensile strength and durability tests such as alkali attack test and sulphate attack test were also carried on all the mixes. Incorporating these mineral admixtures resulted in producing economical concrete and the workability requirements of SCC were satisfied, the strength obtained was maximum when alccofine and GBBS were added in the concrete.**

IndexTerms **– Fly ash, GGBS, Sugarcane bagasse ash, Alccofine, Ternary blends, Quaternary blends, Self-compacting concrete.**

I. INTRODUCTION

Concrete is the most widely used material in any type of construction work. Concrete is a composite material which includes cement and cementitious materials, fine aggregates, coarse aggregates, water and sometimes chemical admixtures. Concrete is usually designed for certain strength. Compaction is one of the important criteria for a concrete to reach its potential design strength. Compaction is a process in which the entrapped air in the fresh concrete is expelled out thus increasing the density of concrete by packing the aggregate particles together. Compaction enhances the bond with the reinforcement and increases the strength of concrete. Conventional compaction process is usually done through external force usually using machines and vibrators. It is difficult to achieve and maintain proper compaction in the structures having congested reinforcements, lack of labours is also one of the problems for compaction in construction sites. In the underwater construction, concrete is required to be in its fresh state, which can be placed without compaction because in such circumstances compaction or vibration is clearly impossible. To overcome these problems a special concrete known as Self compacting concrete (SCC) was introduced. Self-compacting concrete is a type of concrete which does not need any type of external compaction as it is designed in a way that it gets compacted by its own weight. The property of the self-compacting concrete is such that it enables the flow of concrete through congested reinforcement and also fills every corner of the formwork undergoing compaction on its own.Self-compacting concrete is also known as super workable concrete because of its high flow ability and self-leveling property.To accomplish SCC, the concrete must be profoundly fluid and stable i.e., the self-compacting concrete blend must stay homogenous amid the whole procedure from plant to workplace without segregation and bleeding.

II. NEED FOR STUDY

As self compacting concrete is not widely used even with its wide range of advantages which includes reduction of labour, reduction of noise and also fast construction. SCC is not widely used in India due to insufficient data and information.As per EFNARC guidelines for mix design of SCC, the main difference in the design of conventional concrete and SCC is the addition of mineral admixture.

As SCC contains large amount of cement content and thus to reduce heat of hydration and to have economical concrete it is necessary to replace cement with mineral admixtures such as industrial wastes. SCC can replace cement with mineral admixtures for more than 200kg/m^3 Hence the study includes replacement of cement with various industrial wastes like Ground granulated blast furnace slag i.e.,GGBS, Fly ash, Alccofine and Sugarcane baggasse ash.

III. OBJECTIVES

- To design self-compacting concrete using guidelines provided in EFNARC.
- To study the fresh concrete properties such as workability of self compacting concrete as per the guidelines of EFNARC.

- To study harden properties such as the variation of compression strength, split tensile strength and flexural strength.
- To study durability properties of Self compacting concrete by carrying out tests such as alkaline attack test and sulphate attack test by partially replacing cement with Fly Ash , Alccofine, Sugarcane Bagasse Ash and GGBS in SCC.

IV. MATERIALS USED IN STUDY

In this study ordinary Portland cement of 43 grade is used, Fine aggregate conforming to zone II grade was used and coarse aggregate of 12mm were used, fly ash of class-f is used, GGBS obtained from Shub minerals hospet, sugarcane bagasse ash obtained from hospet sugar factory and alccofine-1203 are used in this present study. Super plasticizer Poly Carboxylated Ether(PCE) is used, its commercial name is glenium sky 8233, its properties are tabulated in table1.

Table1: properties of glenium sky 8233

SI.No	Properties	Range
1	Specific gravity	1.08 at 25°C
2	Aspect	Light brown liquid
3	pH	>6
4	Relative density	1.08+0.01
5	Chloride ion content	<0.2%

V. METHODOLOGY

In this study SCC mix is obtained by using volume,of paste Vp i.e. sum of volume fraction of cement along with filler and water with range of 0.38±0.03. The water to cement ratio of 0.45 was adopted. It is necessary to take more fine aggregates and lesser coarse aggregates. So the ratio of 55:45 FA:CA was taken. Fine aggregates and coarse aggregates were taken with ratio of 55:45. The coarse aggregates had size passing through 12.5mm retained on 4.75mm. Super plasticizer used was Glenium sky 8233. The dosage of super plasticizer was taken as 0.5% of total weight of cementatious material.

Mix design method adopted was absolute volume method. Where volume of paste was fixed to 0.4 and water cement ratio to 0.45. Further SCC mix were prepared for cement replacement by fixing the cement content to 350kg/m3. The remaining cement content was replaced with fly ash, bagasse ash , alccofine and GGBS.

A total of 12 mix were designed as listed in table2. 5 mixes were designed for ternary blends and 7 mixes were designed for quaternary blends. The last 3 mixes of quaternary blends had one of its admixture replaced with 50% of the total replacement of cement. Cylinders of size 150mm diameter and length 300mm and cubes 150mmX150mm were casted and tested after 28 days of curing.

Table 2: list of mixes designed

Mix no.	Type of mix	Admixture used
Mix 1	Ternary blend	Cement + GGBS +fly ash
Mix 2	Ternary blend	Cement + fly ash+ alccofine
Mix 3	Ternary blend	Cement +fly ash+ sugarcane bagasse ash
Mix 4	Ternary blend	Cement + GGBS + alccofine
Mix 5	Ternary blend	Cement + GGBS + sugarcane bagasse ash
Mix 6	Quaternary blend	Cement + GGBS + fly ash + alccofine
Mix 7	Quaternary blend	Cement + GGBS + fly ash + sugarcane bagasse ash
Mix 8	Quaternary blend	Cement + GGBS + alccofine + sugarcane bagasse ash
Mix 9	Quaternary blend	Cement + fly ash + alccofine+ sugarcane bagasse ash
Mix 10	Quaternary blend	Cement + 50% flyash+ GGBS+ alccofine
Mix 11	Quaternary blend	Cement + 50% GGBS+ alccofine +flyash
Mix 12	Quaternary blend	Cement +50% alccofine+ flyash+ GGBS

VI. MIX DEISGN

In this study V_p (i.e., sum of volume fractions of cement, filler and water) is taken as 0.4, Assumptions made are for water cement ratio 0.45.

$V_{paste} = V_{cement} + V_{filler} + V_{water}$

$V_{Filler} = V_{paste} - (V_{cement} + V_{water})$

$V_{agg} = 1 - V_{paste}$

The ratio of FA: CA (55:45)

Vsp = 0.5% of mass of cementitious material

$V_{concrete} = 1$

Choosing V_{paste}= 0.4 for SCC and W/C ratio = 0.45

Vol. cement =300/(3.1×1000) = 0.097

W/C by volume= $\frac{\text{wt of water X density}}{\text{wt of cement X density}}$ = 0.45

$\frac{\text{wt of water X 1}}{\text{wt of cement X 3.12}}$ =0.45

W/C by volume =1.404

Mass of water= $\frac{Vp\ X\frac{w}{c}by\ volume\ X\ 1000}{2.404}$ = $\frac{0.4\ X\ 1.404\ X\ 1000}{2.404}$ = 233.610 L/m^3

Volume of water = 233.61/(1 × 1000) = 0.233

Mass of cement = 233.6/0.4 = 519.13 kg/m^3

Volume of cement =350/ (3.12 ×1000) = 0.112

Volume of filler to be found out by

$V_{paste}= V_{cement}+ V_{filler} + V_{water}$

$V_{Filler} = V_{paste}- (V_{cement} +V_{water})$

V_{Filler} = 0.4 – (0.112+ 0.233)= 0.055 m^3

For 2 mineral admixtures each with volume 0.0275 m^3

For 3 mineral admixtures added volume of each will be 0.01833m^3

V_{FA}=0.55 × Vagg

V_{FA}=0.55 × 0.6 =0.33

V_{CA} = 0.45 × Vagg

V_{CA} = 0.45 × 0.6 = 0.27

Mass of Fine Aggregate = 0.33× 2.62×1000 = 864.6 kg/m^3

Mass of Coarse Aggregate = 0.27 × 2.8 × 1000 = 764.1 kg/m^3

SP = 0.5% of cementatious content

= 0.5/100 × 519.13 =2.149 L/m^3 = 2.59 kg/m^3

∴ Total mass of concrete = 2402.1 kg/m^3

Further SCC mixes were prepared for cement replacement by fixing the cement content to 350kg/m^3. The remaining cement content was replaced with fly ash, bagasse ash, alccofine and GGBS.

A total of 12 mixes were casted with varying mineral admixture including both ternary and quaternary blends. Then the mixes were all tested for both fresh and hard properties and the results obtained are listed in the table 3

Table3 Mix design

Mix No.	Vp	V_{CEMENT}	V_{flyash}	V_{GGBS}	$V_{ALCOFINE}$	V_{SBA}	V_{agg}	V_{FA}	V_{CA}
MIX 1	0.4	0.113	0.0275	0.0275	-	-	0.6	0.33	0.27
MIX 2	0.4	0.113	0.0275	-	0.0275	-	0.6	0.33	0.27
MIX 3	0.4	0.113	0.0275	-	-	0.0275	0.6	0.33	0.27
MIX 4	0.4	0.113	-	0.0275	0.0275	-	0.6	0.33	0.27
MIX 5	0.4	0.113	-	0.0275	-	0.0275	0.6	0.33	0.27
MIX 6	0.4	0.113	0.0183	0.0183	0.0183	-	0.6	0.33	0.27
MIX 7	0.4	0.113	0.0183	0.0183	-	0.0183	0.6	0.33	0.27
MIX 8	0.4	0.113	-	0.0183	0.0183	0.0183	0.6	0.33	0.27
MIX 9	0.4	0.113	0.0183	-	0.0183	0.0183	0.6	0.33	0.27
MIX 10	0.4	0.113	0.0275	0.0183	0.0183	-	0.6	0.33	0.27
MIX 11	0.4	0.113	0.0183	0.0275	0.0183	-	0.6	0.33	0.27
MIX 12	0.4	0.113	0.0183	0.0183	0.0275	-	0.6	0.33	0.27

VII. RESULTS AND DISCUSSION

In this section, results of various tests conducted on both ternary and quaternary blends, both in fresh and hardened states are discussed. In fresh state, the slump tests are conducted and in hardened state the mechanical properties (compressive strength, split tensile strength & flexural strength) at 7 and 28 days of curing are evaluated and discussed, the durability test conducted are also discussed.

Results from tests on fresh properties of self-compacting concrete.

The fresh properties for workability are checked here. The tests include V- funnel, slump flow, T-5min slump flow, J-ring. The following graphs below shows the results obtained.

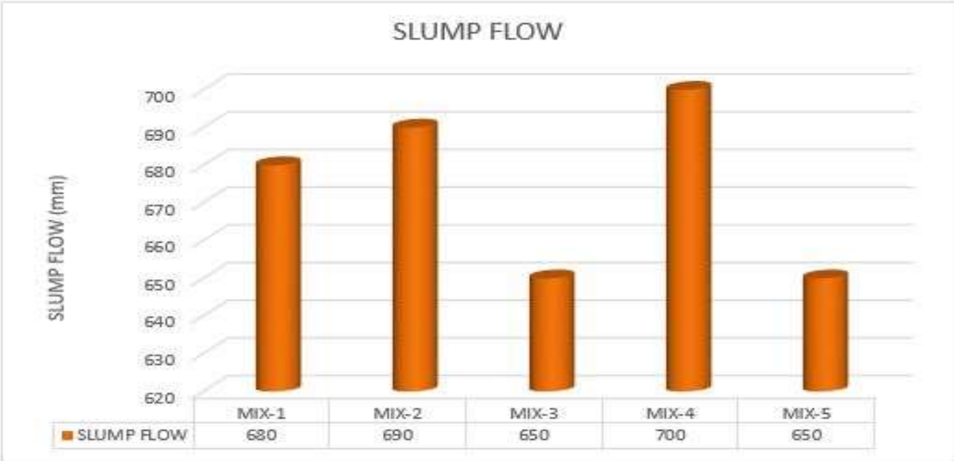

Figure: 1 Slump flow for ternary blends.

Figure: 2 V-funnel for ternary blends

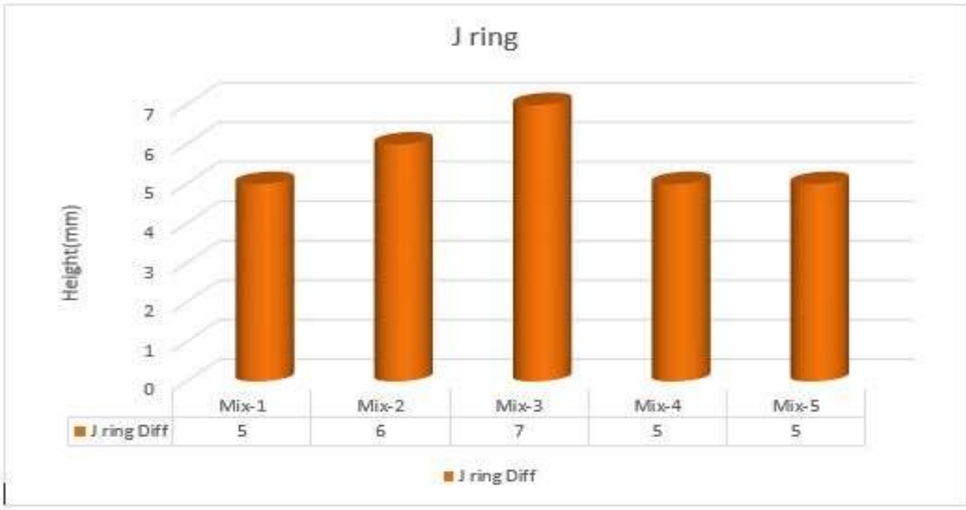

Figure: 3 J-ring for ternary blends.

Figure: 4 Slump flow for quaternary blends.

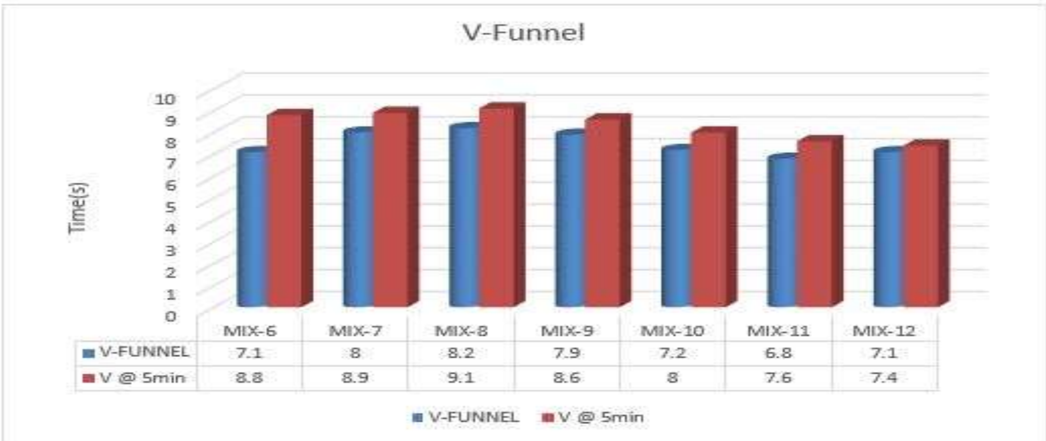

Figure: 5 V-Funnel for quaternary blends.

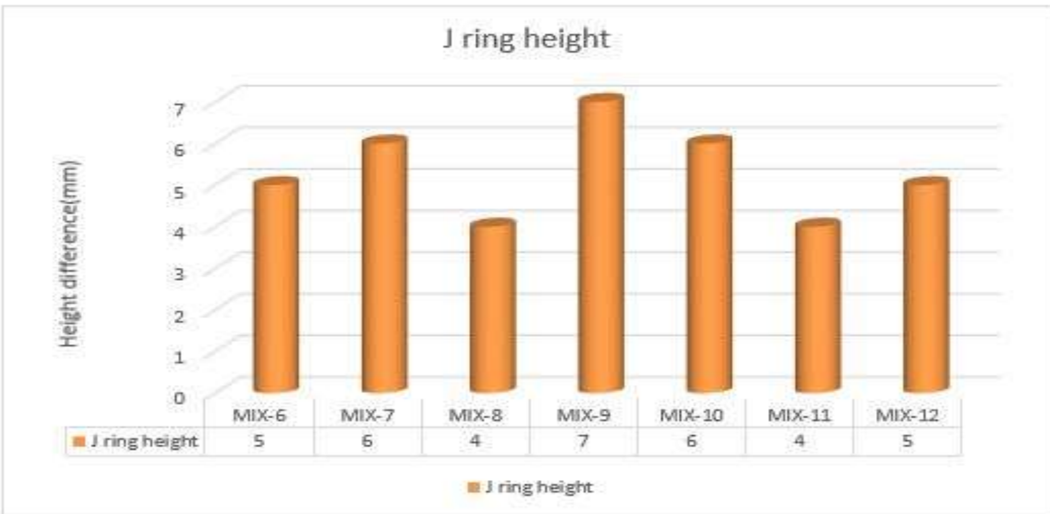

Figure: 6 J-ring for quaternary blends.

Results from tests conducted on hardened properties of self-compacting concrete.

The tests conducted on hardened concrete are discussed in this section, which includes compressive strength, tensile strength and flexural strength for both ternary and quaternary blends.

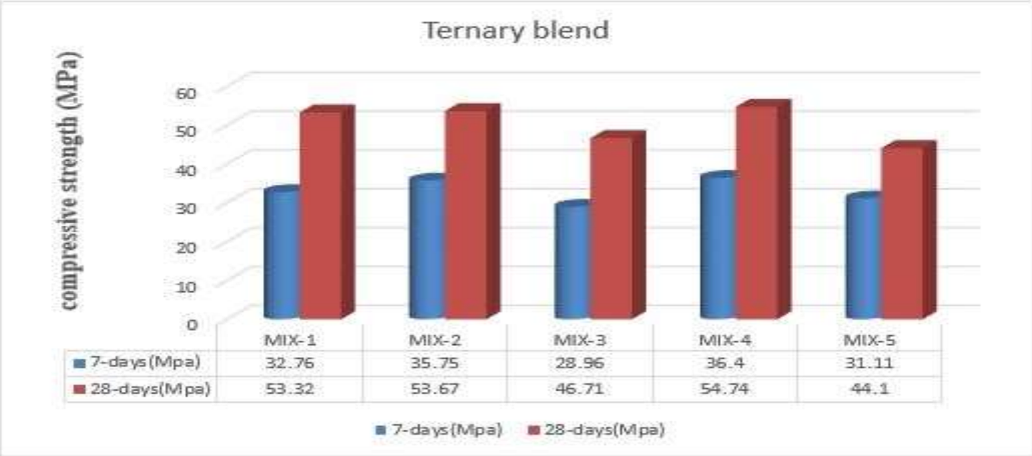

Figure: 7 Compressive strength for ternary blends.

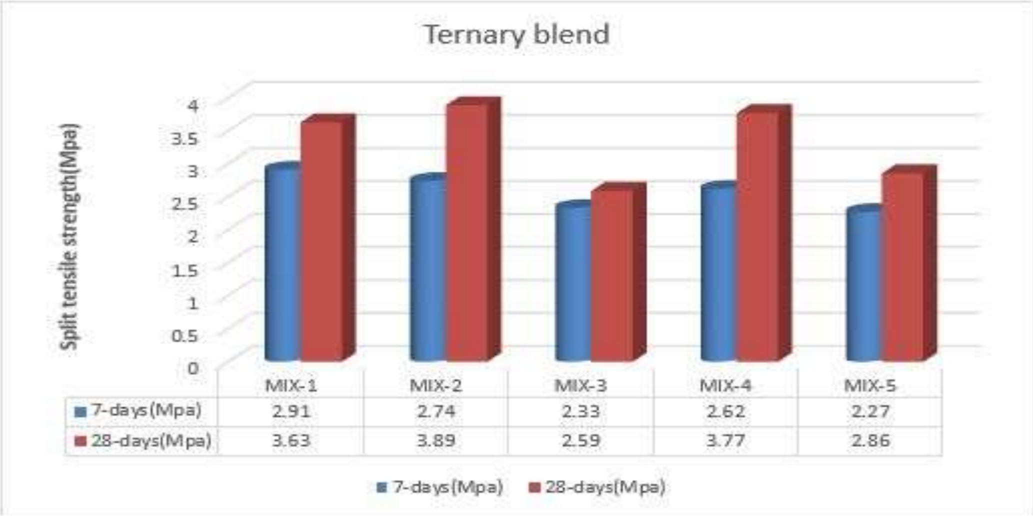

Figure: 8 Split tensile strength for ternary blends.

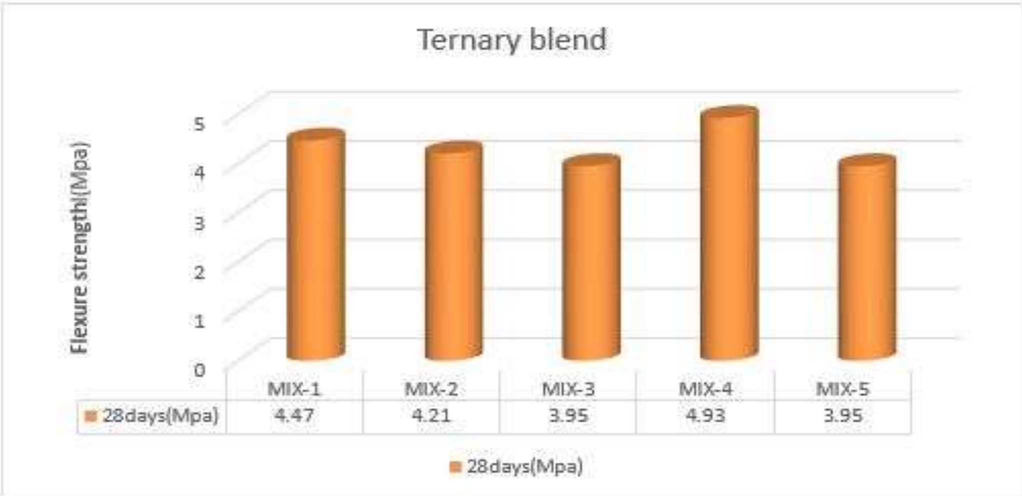

Figure: 9 Flexural strength for ternary blends.

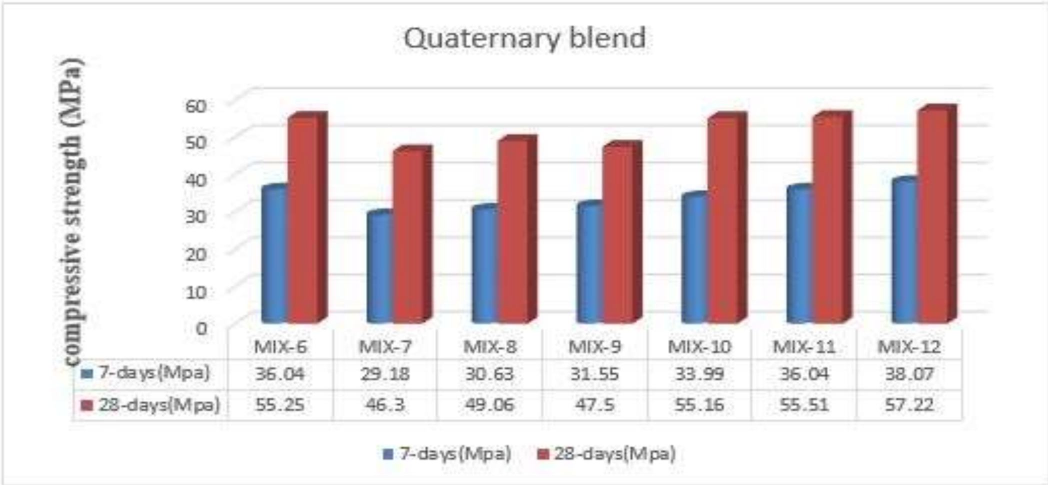

Figure: 10 Compressive strength for quaternary blends.

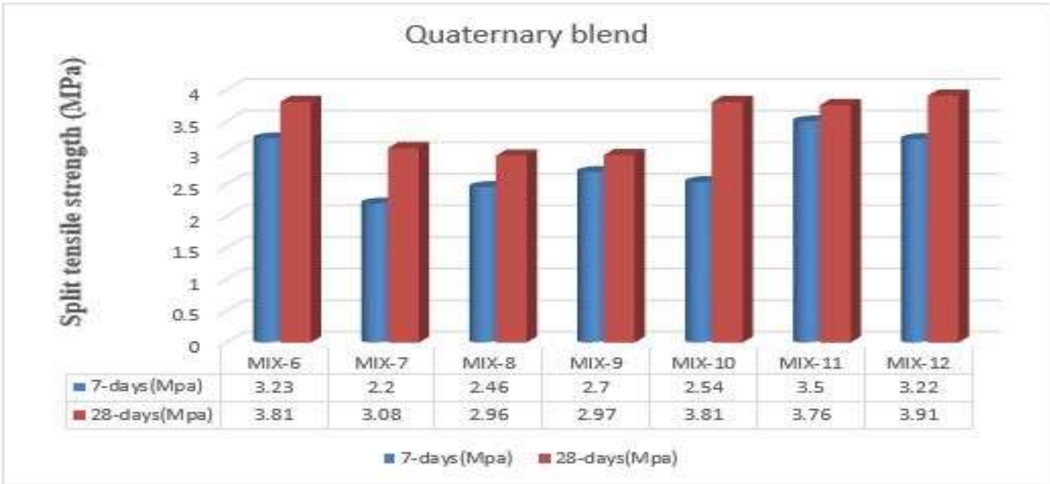

Figure: 11 Split tensile strength for quaternary blends.

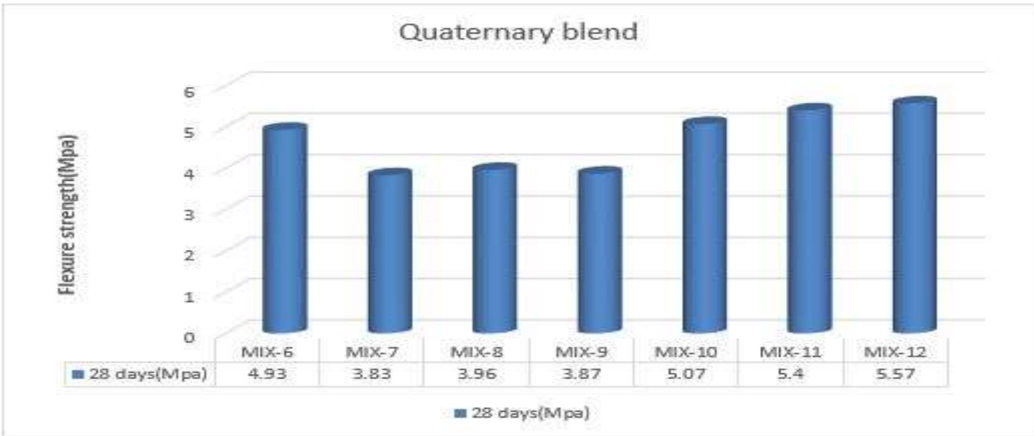

Figure: 12 Flexural strength for quaternary blends.

Results from tests on fresh properties of self-compacting concrete.

Here the durability test results are studied graphically, sulphate and alkali tests are conducted for both ternary and quaternary blends.

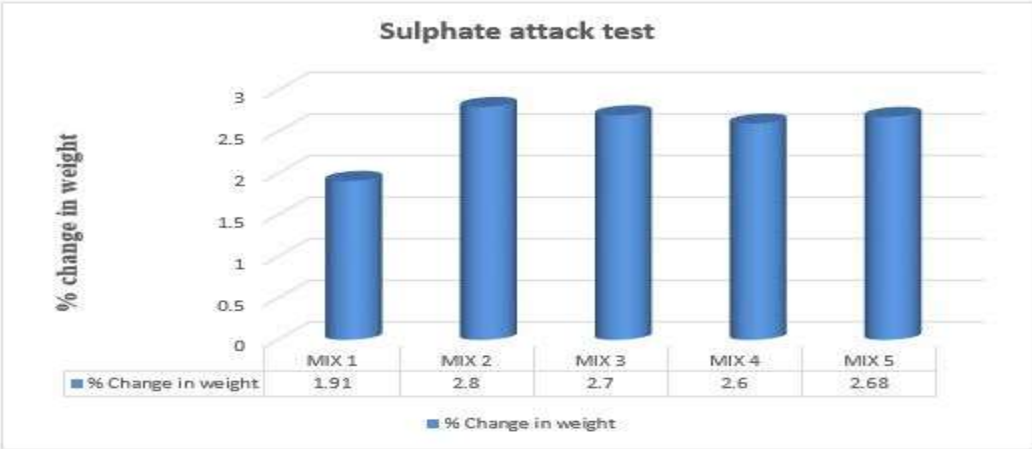

Figure: 13 Sulphate attack for ternary blends.

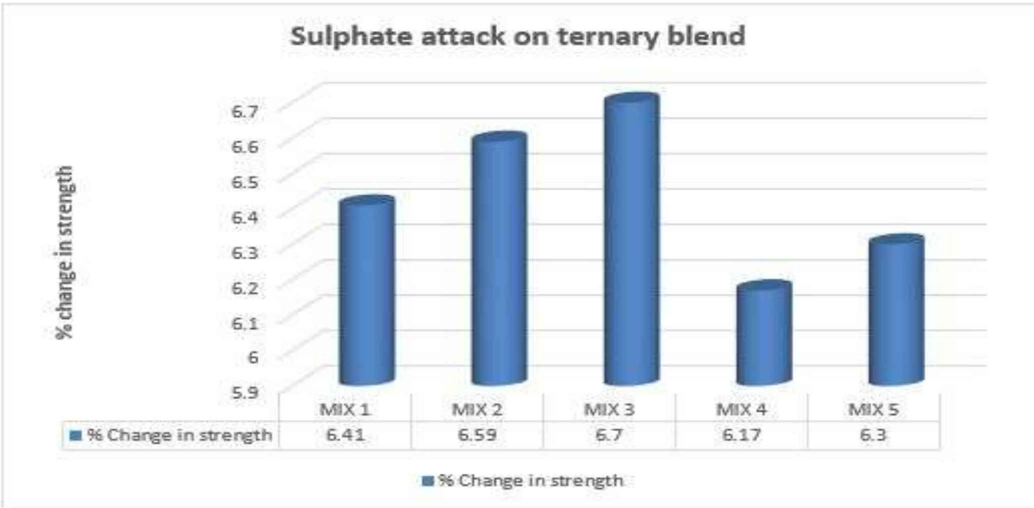

Figure: 14 Sulphate attack for ternary blends.

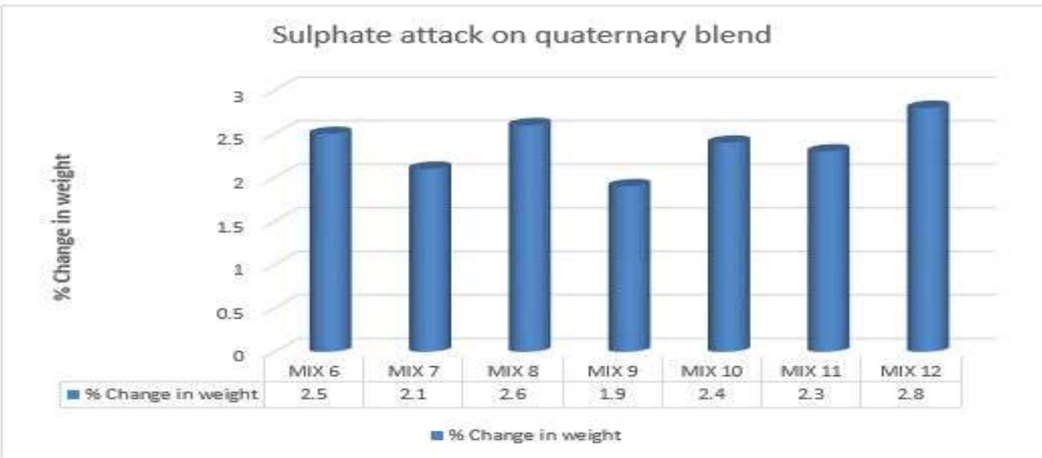

Figure: 15 Sulphate attack on quaternary blends.

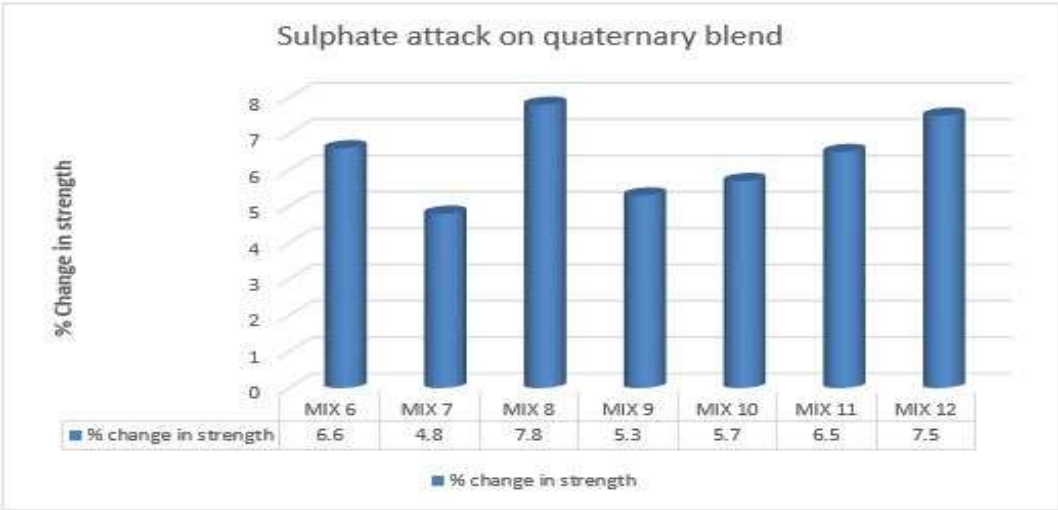

Figure: 16 Sulphate attack on quaternary blends.

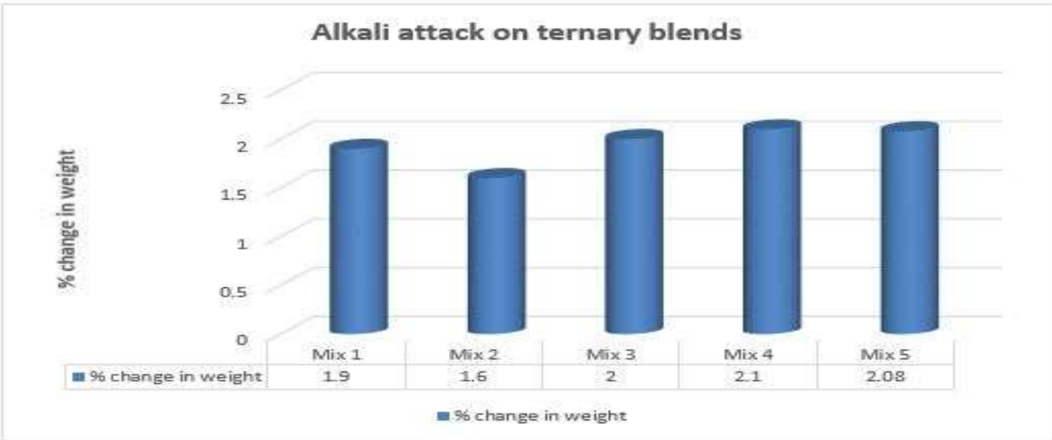

Figure: 17 alkali attack on ternary blends.

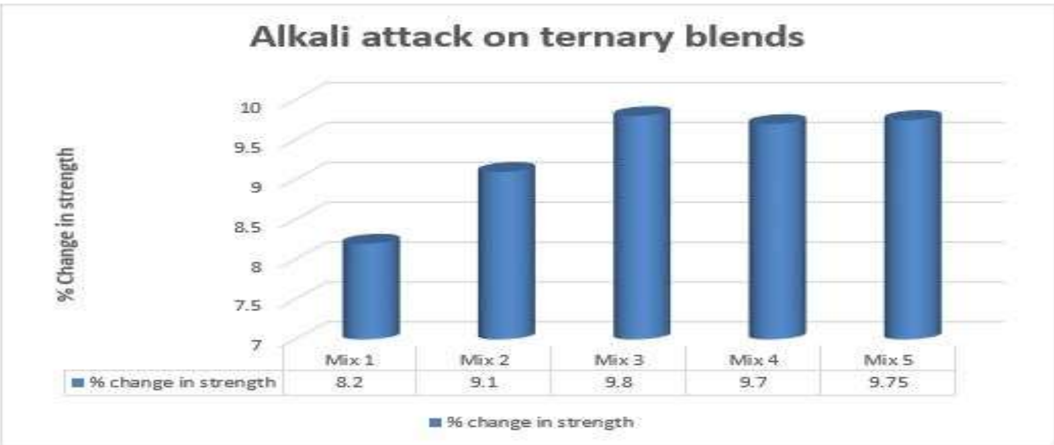

Figure: 18 alkali attack on ternary blends.

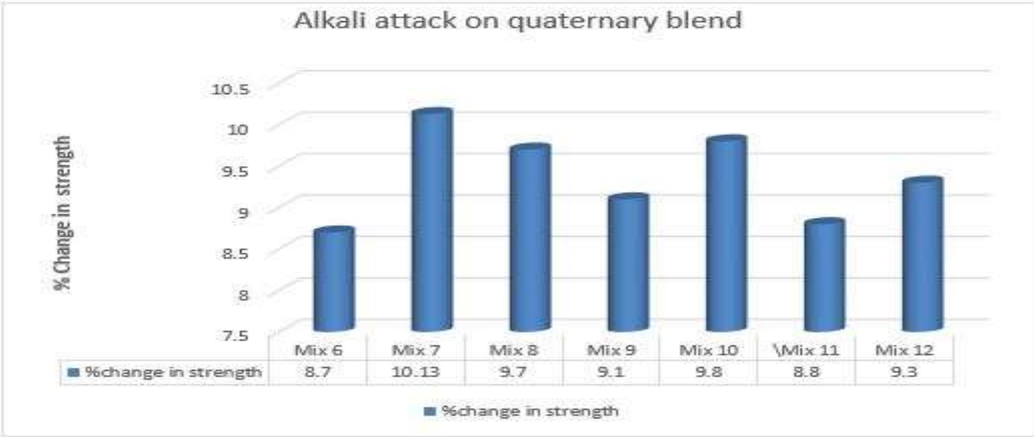

Figure: 19 alkali attack on quaternary blends

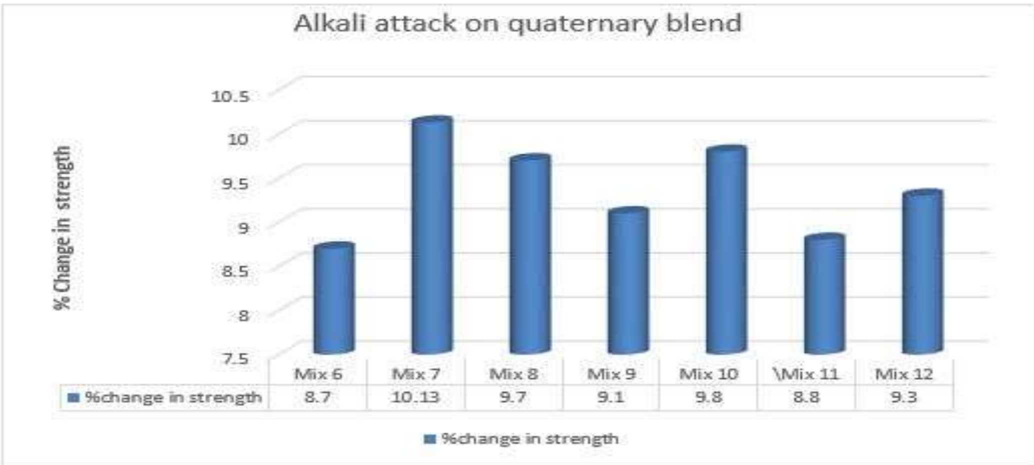

Figure: 20 alkali attack on quaternary blends

VIII. CONCLUSION

Based on the experimental investigation on ternary blended SCC and quaternary blended SCC mixes few conclusions can be drawn which are as follows:

1. The design method based on absolute volume concept can be successfully employed for achieving SCC. The method is simple and reduces the number of trials for achieving SCC.
2. The workability of SCC is high and all the mixes satisfied the SCC characteristics such as segregation resistance, flowability and passing ability as per European standards. Thus mineral admixtures can be used in production of ternary and quaternary mix blends for SCC.
3. Slump flow of all the mixes was above 600mm and within 800mm as per the requirements of EFNARC.
4. The T500 of slump low of all the mixes had flow time less than 2 sec hence fulfilling the prerequisite for filling capacity.
5. The v funnel test and t5min test carried out on the mixes gave the results in which both ternary and quaternary blends satisfied the prerequisite of scc for its filling ability and segregation resistance.
6. The J ring test results showed that all the mixes satisfied the passing ability test requirement for scc with height difference of less than 10mm.
7. Incorporating alccofine in scc gave better strength when compared to other mineral admixtures. When sugarcane bag gaseash was used the strength obtained was less thus it can be concluded that alccofine should be incorporated for high strength concrete when compared to bagasse ash.
8. Resistance to alkali attack was better for fly ash and ggbs when compared to alccofine.
9. Resistance to sulphate attack was very less for blends which were incorporated with bagasse ash.
10. The replacement of cement with mineral admixtures results in economical concrete and its utilization can minimize environmental impact by reducing the huge consumption of natural resources used for concrete applications

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