International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 07 | July -2017 www.irjet.net p-ISSN: 2395-0072

Experimental Investigation on Self Compacting Concrete by Introducing Fly Ash with Varied Size of Aggregate

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Abstract - *Self-compacting concrete is a most preferred type of concrete, due to its complete flow ability without using vibrating tools. It is easily feasible for any shape and size of the formwork. Self-compacting concrete is one of the green technics for avoiding sound effect on construction site. The fly ash will be very helpful to reduction of natural resources for manufacturing cement and also very little effect in production of carbon emission gases.*

The mix design is made according to IS 10262:2009. In this study, 10mm coarse aggregate is replaced by 20mm at a percentages of 10%, 20%, 30%, 40%, 50% and cement by 30% of Fly ash. The rodded density and voids ratio of 20mm with 10mm coarse aggregate are obtained. The aggregate mix ratio has been kept with 60% of coarse aggregate and 40% of fine aggregate. The fresh state properties are conducted for Inverted slump flow test, Inverted T50cm slump flow test, V-funnel test, V-funnel at T5 minutes, L-box test and Orimet test, all the tests results are acceptable up to 50% of 10mm coarse aggregate replacement by 20mm Coarse aggregate, except for the V-funnel at T5 minutes test at 0% CASCC and Orimet test at 50%CASCC. The hardened state properties tests are conducted after curing of 7days, 14days, and 28days. The results obtained in the hardened state for Compressive strength and Split tensile strength at 30% replacement of 10mm coarse aggregates by 20mm are giving optimum results.

Key Words: SCC (Self Compacting Concrete), Compressive Strength, Split Tensile Strength, Cement, Fly Ash, CA (Coarse Aggregate).

1. INTRODUCTION

1.1 General:

There is a rapid development in concrete technology in the past three to four decades due to enhancement in its strength and durability as well as various other properties which were developed earlier as use of steel reinforcement, reinforced cement concrete, and pre-stressed concrete.

A concrete which totally gets compacted by itself covering the required size and shape of elements is defined as Self Compacting concrete. Self-Compacting concrete was first discovered in early 1980's in Japan and since, then it was adopted all over the world as it is having high time efficient process, requires less labours, consumes less energy and gives a smooth finishing surface. In India Self-compacting concrete is not utilized much, as people are not aware about it and also its reimbursements. Once people get attentive about its replacement for a conventional concrete, it may be used at high pace in coming years for projects under taken by National and International construction companies.

The construction industries are slowing down with the use of conventional concrete in recent years and have switched for construction of green buildings, so as to make efficient usefulness of naturally available materials and other resources which are energy efficient, sustainable, improve performance of the building reducing impact on the environment. Fly ash is the byproduct of coal combustion which is used as replacement of cement as sustainable or green product. India is more relied on non-renewable energy like thermal energy, which largely uses coal for producing electricity. The fly ash obtained as byproduct is taken to larger area for disposal purpose which pollutes air, water can be utilized as green material which gives an added strength and properties to the concrete structures.

1.2 Self Compacting Concrete:

This concrete is a most preferred type of a concrete, due to its complete flow ability without using vibrating tools. It is easily feasible for any shape and size of the formwork, thus concrete is infilled with a very congested narrow space reinforcement with penetrated due to its self-compacting nature. Hence, homogeneity is achieved without segregation and bleeding which prevents honeycombing in the future.It reduces noise level as we deny the use of vibrating tools during the construction work, the better working environment. SCC has a greater advantage over the other type of concrete because it provides minimum percentage of voids and also provides smooth surfaces, greater workability and reduces the labors. SCC provides ease in providing and dismantling of the formworks. It easily feasible with different size of coarse aggregates and without effecting the flowing ability, provides the design flexibility to the designer with the help of guidelines. Superior quality control, durability is achieved and also construction speed.

2. MATERIAL USED

2.1 Cement:

The cement is used in this study, was an Ordinary Portland Cement with 43 grade, and confirmed according to IS: 8112-1989. Various tests were conducted in the laboratory, the following results are mentioned below.

Table -1: Results of Cement Characteristics

Name of Tests	Results	Units
Normal consistency	32	Percentage
Initial setting	70	Minutes
Final setting	390	Minutes
Specific gravity	3.1	Unit less
Fineness	7	Percentage

2.2 Fly ash:

It is obtained from combustion of powdered coal collected by the electrostatic precipitator transported by the fuel gases. It is available in finely divided residue form. For the study fly ash is brought form WCPM limited at Dandeli and confirmed according to IS 3812, Part-1. Different types of tests were carried out, it has been used as a replacement material of cement powder, the results obtained for the tests shown below.

Table -2: Results of Fly Ash Characteristics

Name of Test	Results	Units
Specific gravity	2.24	Unit less
Color	Medium dark gray	Unit less
Fineness	14.2	Percentage
Water content	0.2	Percentage

2.3 Natural sand:

It is a fine granular material naturally available which is composed of finely divided rock particles. The size of the fine aggregate varies between IS sieve no. 4.75mm to 150 microns is defined fine aggregate. For present study and specifications of sand were satisfied of IS: 383-1970. In the laboratory tests have been conducted and results are mentioned below.

Table -3: Results of Natural Sand Characteristics

Name of Tests	Results	Units
Water absorption	4	Percentage
Specific gravity	2.44	Unit less
Bulk density	1612	kg/m3
Silt content	3.01	Percentage
Fineness modulus of sieve analysis	2.27	Unit less

2.4 Coarse aggregate (10mm and 20mm):

The naturally available aggregate with the size varying from 40mm down size to 4.75mm sieve as IS Sieves is called as coarse aggregate. In this present study, which is mainly focused on substitution for 10mm by 20mm coarse aggregate. Both coarse aggregate were bought form Tahsildar crusher plant at Rana-Kunde, shape of aggregates were acceptable. Characteristics of aggregates are rounded, cubical along with quality and uniform grading, the tests had conducted in the college laboratory with results are mentioned below.

Table -4: Results of Both 20mm and 10mm Coarse Aggregate Characteristics

Name of Tests	Results		Units
	20mm	10mm	
Specific gravity	3	2.95	Unit less
Water absorption	0.4	0.5	Percentage
Bulk density	1528	1669	kg/m3

2.5 Super plasticizer:

It's a liquid based admixture, it shows effective results to water content and provides the greater workability in the blending of concrete. The super plasticizer was adopted based as a conflow poly carboxylic of boxer construction chemicals and the dosage were not changed at variety of alterations. The specific gravity is 1.24.

2.6 Water:

Water which is used for the study is potable and reasonably free from suspended solids, dissolved salts and organic matter. Clean water shall be used and it shall not contain any impurities. The quality of water should be satisfied with IS 456:2000.

3. METHODOLOGY

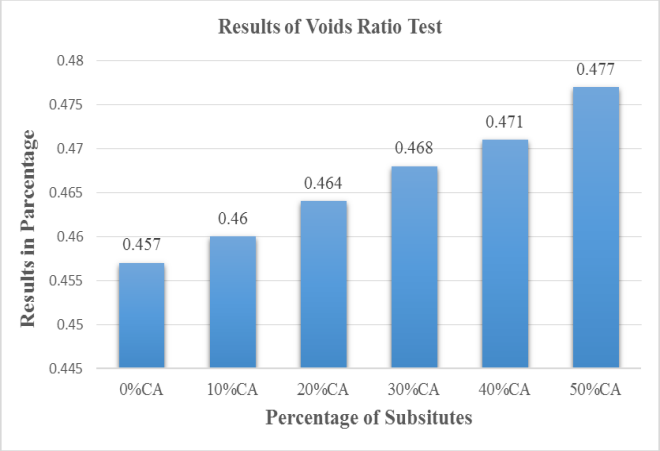
The practical test assessments were conducted on fresh properties and hardened properties of concrete as well as coarse aggregate.

1 Voids Ratio Test
2 Rodded Density Test
3 Inverted Slump Flow Test
4 T50cm Flow Test
5 V-Funnel Test
6 Orimet Test
7 L-Box test
8 V-Funnel at T5minutes Test
9 Compression Test
10 Split Tensile Test

4. Results and Discussions

Table -5: Results of Voids Ratio Test

Percentage of Substitutes of 20mm Coarse Aggregate	Details	Results in Percentage
0%CA	CA with 0%substitute to 10mm by 20mm	0.457
10%CA	CA with 10%substitute to 10mm by 20mm	0.460
20%CA	CA with 20%substitute to 10mm by 20mm	0.464
30%CA	CA with 30%substitute to 10mm by 20mm	0.468
40%CA	CA with 40%substitute to 10mm by 20mm	0.471
50%CA	CA with 50%substitute to 10mm by 20mm	0.477

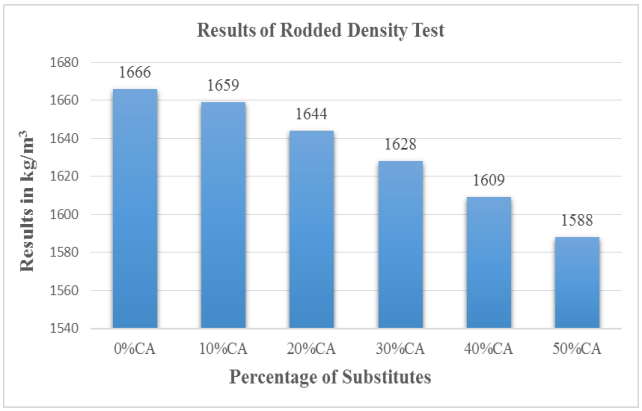


Graph -1: Results of Voids Ratio Test

Graph represents the voids ratio for the coarse aggregate is gradually increasing with increase in the percentage of coarse aggregate from 0%CA to 50%CA.

Table -6: Results of Rodded Density Test

Percentage of Substitutes of 20mm Coarse Aggregate	Details	Results in kg/m3
0%CA	CA with 0%substitute to 10mm by 20mm	1666
10%CA	CA with 10%substitute to 10mm by 20mm	1659
20%CA	CA with 20%substitute to 10mm by 20mm	1644
30%CA	CA with 30%substitute to 10mm by 20mm	1628
40%CA	CA with 40%substitute to 10mm by 20mm	1609
50%CA	CA with 50%substitute to 10mm by 20mm	1588

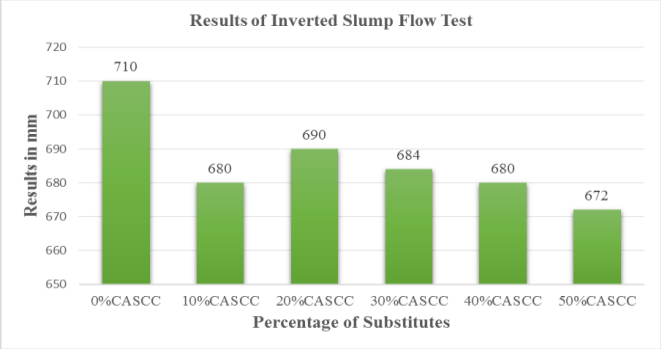


Graph -2: Results of Rodded Density Test

Graph represents the rodded density of coarse aggregate is gradually decreasing with increasing in the percentage of coarse aggregate from 0%CA to 50%CA.

Table -7: Results of Inverted Slump Flow Test

Percentage of Substitutes of 20mm Coarse Aggregate	Results	Limits for Value	
0%CASCC	710	Lowest	Highest
10%CASCC	680	650mm	800mm
20%CASCC	690		
30%CASCC	684		
40%CASCC	680		
50%CASCC	672		

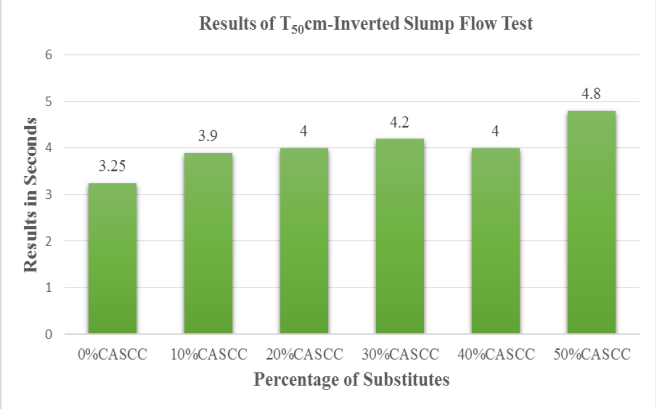


Graph -3: Results of Inverted Slump Flow Test

Graph represents the inverted slump flow test results showing the ability of filling, with a very high ability of filling at 0%CASCC and very low ability of filling at 50%CASCC. Also it is found that all percentage of coarse aggregates is within the standard limit.

Table -8: Results of T50cm-Inverted Slump Flow Test

Percentage of Substitutes of 20mm Coarse Aggregate	Results	Limits for Value	
0%CASCC	3.25	Lowest	Highest
10%CASCC	3.9	2seconds	5seconds
20%CASCC	4		
30%CASCC	4.2		
40%CASCC	4		
50%CASCC	4.8		

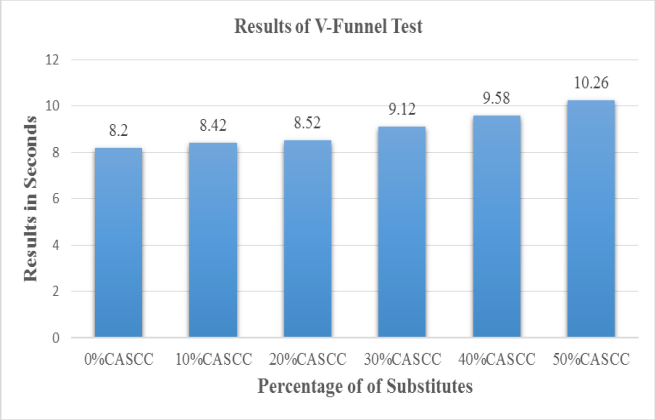


Graph -4: Results of T50cm-Inverted Slump Flow Test

Graph represents the T50cm inverted slump flow test ability of filling in seconds, which are well within the standard range. It is also representing that less duration is required at 0%CASCC and more duration is required at 50%CASCC.

Table -9: Results of V-Funnel Tests

Percentage of Substitutes of 20mm Coarse Aggregate	Results	Limits for Value	
0%CASCC	8.2	8seconds	12seconds
10%CASCC	8.42		
20%CASCC	8.52		
30%CASCC	9.12		
40%CASCC	9.58		
50%CASCC	10.92		

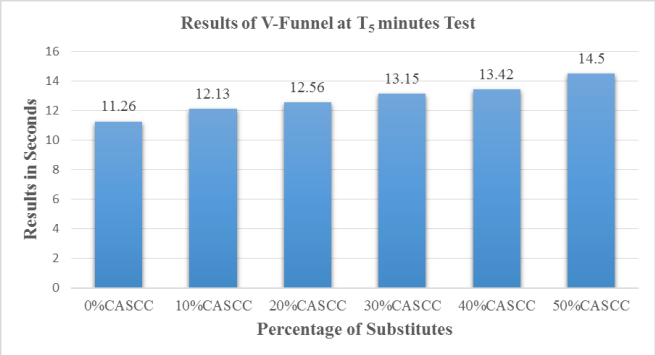


Graph -5: Results of V-Funnel Test

Graph represents the V-funnel test ability of filling in seconds, which are well within the standard range. Also it is representing very high ability of filling at 0%CASCC and very low ability of filling at 50%CASCC.

Table -10: Results of V-Funnel at T5 minutes Test

Percentage of Substitutes of 20mm Coarse Aggregate	Results	Limits for Value	
0%CASCC	11.26	Lowest	Highest
10%CASCC	12.13	12seconds	12+3seconds
20%CASCC	12.56		
30%CASCC	13.15		
40%CASCC	13.42		
50%CASCC	14.5		

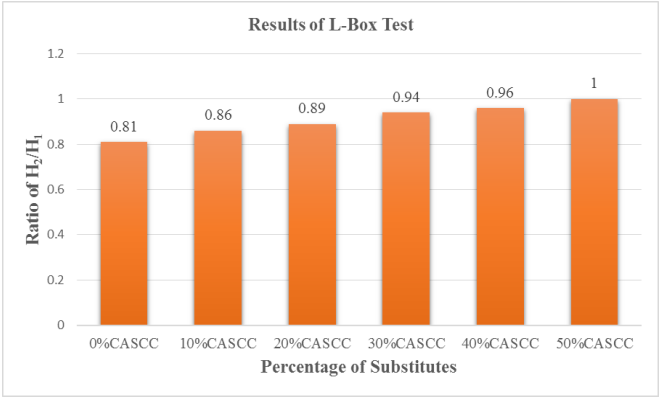


Graph- 6: Results of V-Funnel at T5 minutes Test

Graph represents the V-funnels at T5 minutes test resistance to segregation of coarse aggregates. It also seen that for 10%CASCC to 50%CASCC is well within the standard range. At 0%CASCC the result was below the standard range, which is not much acceptable.

Table -11: Results of L-Box Test

Percentage of Substitutes of 20mm Coarse Aggregate	Ratio of H2/H1	Limits for Value	
0%CASCC	0.81	Lowest	Highest
10%CASCC	0.86	0.8	1
20%CASCC	0.89		
30%CASCC	0.94		
40%CASCC	0.96		
50%CASCC	1		



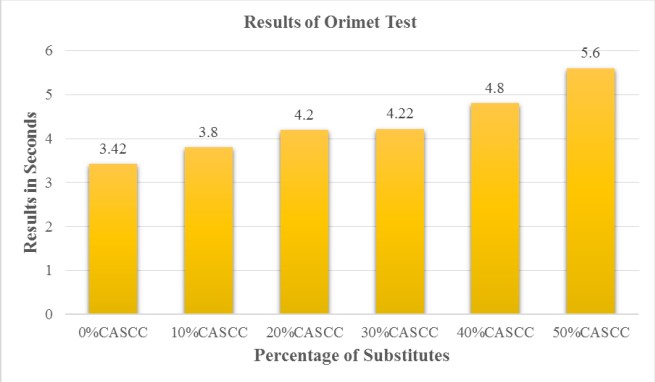
Graph -7: Results of L-Box Test

Graph represents the L-box test results showing the ratios of ability of passing, which are well within the standard range. It is seen that ratio of H2/H1as 0.81 at 0%CASCC as the minimum required range and 1.00 at 50%CASCC as maximum required range.

Table -12: Results of Orimet Test

Percentage of Substitutes of 20mm Coarse Aggregate	Results	Limits for Value	
0%CASCC	3.42	Lowest	Highest
10%CASCC	3.8	0seconds	5seconds
20%CASCC	4.2		

30%CASCC	4.22		
40%CASCC	4.8		
50%CASCC	5.6		

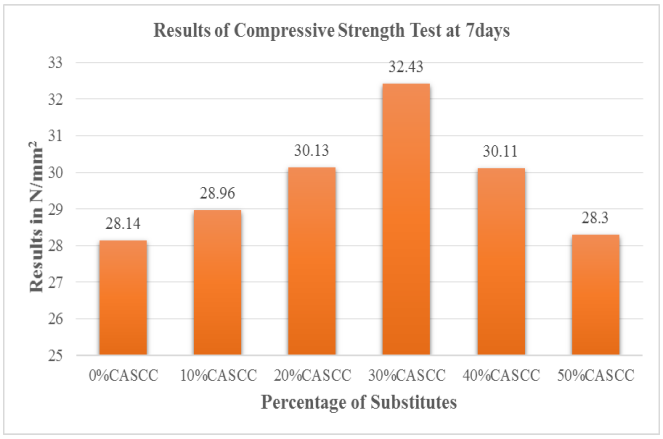


Graph -8: Results of Orimet Test

Graph represents the Orimet test ability of filling in seconds. It is marked that the ability of filling is less duration at 0%CASCC and more duration at 40%CASCC. The ability of filling is failed at 50%CASCC.

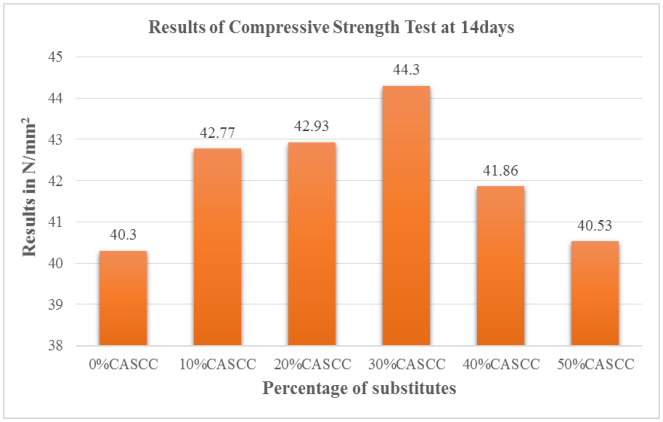
Table -13: Results of Compressive Strength Test

Percentage of Substitutes of 20mm Coarse Aggregate	Results in N/mm2		
	7days	14days	28days
0%CASCC	28.14	40.30	45.53
10%CASCC	28.96	42.77	46.73
20%CASCC	30.13	42.93	47.30
30%CASCC	32.43	44.30	49.47
40%CASCC	30.11	41.86	47.97
50%CASCC	28.30	40.53	45.73



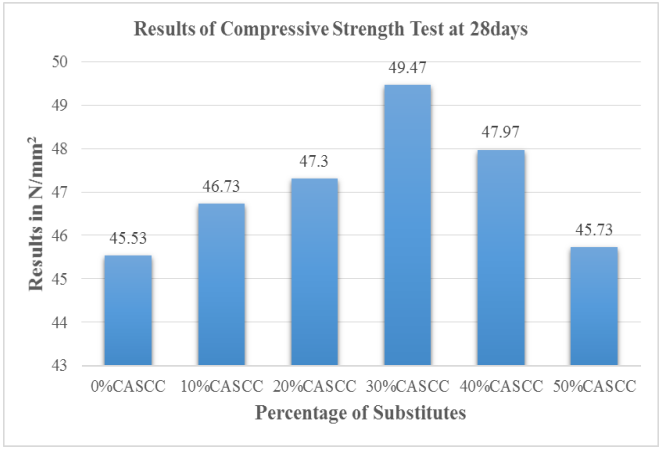
Graph -9: Results of Compressive Strength Test at 7days

Graph represents the compressive strength test results at 7days, it is seen that higher value of compressive strength at 30%CASCC.



Graph -10: Results of Compressive Strength Test at 14days

Graph represents the compressive test results at 14days, it is seen that higher value of compressive strength at 30%CASCC.

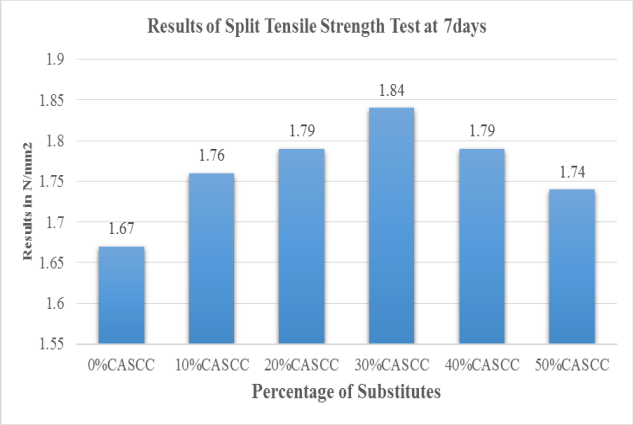


Graph -11: Results of Compressive Strength Test at 28days

Graph represents the compressive test results at 28days, it is seen that higher value of compressive strength at 30%CASCC.

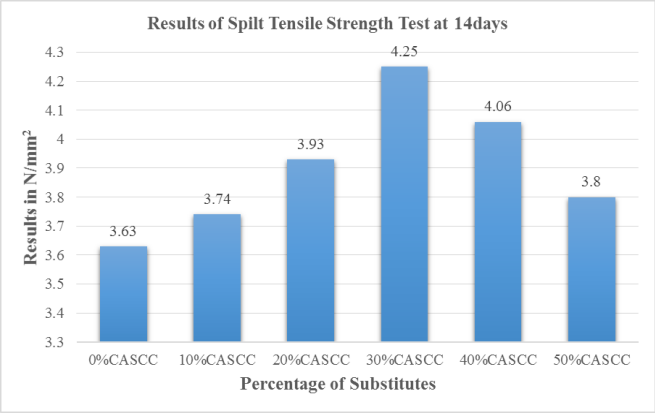
Table -14: Results of Split Tensile Strength test

Percentage of Substitutes of 20mm Coarse Aggregate	Results in N/mm2		
	7days	14days	28days
0%CASCC	1.67	3.63	4.28
10%CASCC	1.76	3.74	4.43
20%CASCC	1.79	3.93	4.63
30%CASCC	1.84	4.25	4.65
40%CASCC	1.79	4.06	4.43
50%CASCC	1.74	3.8	4.16



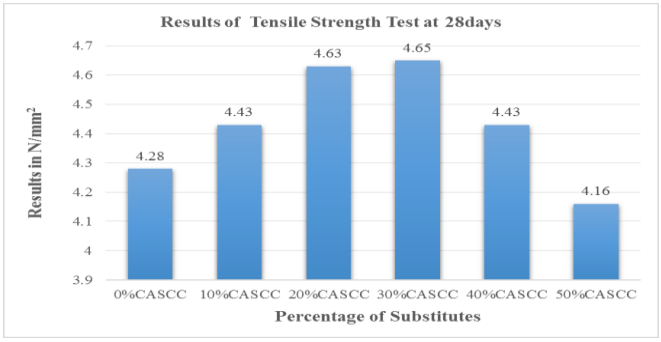
Graph -12: Results of Split Tensile Strength at 7days

Graph represents the split tensile strength test results at 7days, it is seen that higher value of tensile strength at 30%CASCC.



Graph -13: Results of Split Tensile Strength Test at 14days

Graph represents the split tensile strength test results at 14days, it is seen that higher value of tensile strength at 30%CASCC.



Graph -14: Results of Split Tensile Strength Test at 28days

Graph represents the split tensile strength test at 28days, it is seen that higher value of tensile strength at 30%CASCC.

4. CONCLUSION

After thorough study on literature, experimental investigations and discussions of outcomes; following conclusions on drown.

1) The rodded density of coarse aggregate is very high at 0%CA and voids ratio of is very lowest at 0%CA.
2) The results of fresh concrete satisfy the limits of test for all percentage of substitute of 20mm coarse aggregate, except 0%CASCC for V-T5 minutes and 50%CASCC for Orimet test.
3) The 30%CASCC of partial replacement of coarse aggregate gives the good range of compressive strength of specimens after curing period of 7days, 14days and 28days, compared with other percentage of substitutes.
4) The 30%CASCC of partial replacement of coarse aggregate gives the good range of split tensile strength of specimens after curing period of 7days, 14days, and 28days and compared with other percentage of substitutes.

5. SCOPE FOR FUTURE STUDY

1) A partial substitute is 12.5mm aggregate by 20mm aggregate along with rice husk ash in SCC.
2) A partial substitute is 10mm by 20mm aggregate utilization through GGBFS and rice husk ash.

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BIOGRAPHIES

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