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Strength and Durability study on Steel Fibers Reinforced Self Compacting Concrete incorporating Sugarcane Bagasse Ash

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Abstract: The present era is "THE ERA OF CONCRETE" because concrete is the most consumed material after water in developing countries. The huge demand of concrete requires large amount of cement which is the basic necessity for strength development of concrete. Large consumption of cement forces very high production to satisfy the demand. But production of cement produces CO_2 in the atmosphere. One ton of cement produces about one ton of CO_2 and hence it creates disturbance in natural global system. So, there is need of alternative materials which can replace cement. Previous researches shows number of materials such as Fly Ash, Silica Fume, Sugarcane Bagasse Ash etc may be used as a replacement of cement. India is second largest country which produces Sugar and hence sugar waste is also produced in very large quantity. Previous researches shows that Sugarcane Ash may be replaced by cement upto certain percentages. The higher percentage may lead to the brittle failure of Concrete which has been prevented by the addition of Steel Fibers. Good range Super plasticizer is used to get Self Compacting nature of Concrete. In the present experimental work we have tried to replace cement by Sugarcane Bagasse Ash. Also the steel fibers have been used to enhance the properties of concrete using Sugarcane Bagasse Ash. Fresh properties like Workability and Hardened properties like Compressive strength, Split tensile strength, Flexural strength and Durability have been carried out. The percentage replacement of Sugarcane Bagasse Ash are 4%, 8%, 12%, 16% and 20% by weight of cement. The addition of steel fibers was 0.50% and 1% by volume of concrete. Comparative analysis of Fresh and Hardened properties of normal concrete and concrete using replacement of Bagasse Ash along with Steel Fibers has been carried out, which shows that initially the replacement of Bagasse Ash alone increases the strength and durability. The highest increment got is at 12% of replacement and the difference in strength is 11.8%. The addition of 1% steel fibers along with Bagasse Ash also increases the compressive strength upto 18%. The split tensile strength and flexural strength are also improved upto 42% and 89% respectively as compared to normal concrete. The results show that there is good scope of work to use Sugarcane Bagasse Ash in concrete industries.

Keyword: Cement, Fine Aggregate, Coarse Aggregate, Sugar Cane Bagasse Ash, Steel Fibers, Super plasticizer (Sulphonated Naphthalene Based) and Acid (HCL and H_2SO_4)

I. INTRODUCTION

Self compacting concrete (SCC) is defined as a concrete that has excellent deformability and high resistance to segregation and can be filled in heavily reinforced or restricted area without applying vibration [2,3,4,17]. SCC was developed in Japan in the 1980, and recently this concrete has gained wide use in many countries for different applications and structural configurations [2,3]. Several different approaches have been used to develop SCC. One method to achieve self-consolidating property is to incorporate a viscosity modifying admixture (VMA) to enhance stability. One method to achieve self-consolidating property is to incorporate a viscosity modifying admixture (VMA) to enhance stability. The use of VMA along with adequate concentration of super plasticizer (SP) can ensure high deformability and adequate workability, leading to a good resistance to segregation [3]. However, viscosity modifying admixtures are very expensive and can increase the cost of concrete [3]. One alternative approach to achieve self-consolidating property is to increase significantly the amount of fine materials such as bagasse ash without increasing the cost [3]. Self compacting concrete is not popular because its high cost compared to conventional concrete but now days several researcher institute and construction companies have undertaken research and development work on SCC [4].

In most of countries of the world, the construction activity is increased day by day. In most of the structure concrete plays very important role. The reason behind its popularity is its properties like durability, toughness and economy. Concrete is used

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everywhere from roads, dams, bridges, tunnel, industrial floor to parking slots, residential and commercial buildings and numerous other applications. Now as per need there is quite good quantity of concrete is available like high performance concrete, high strength concrete etc. Ordinary Portland cement is recognized as a major construction material throughout the world and in terms of its per capita consumption, it is second most consumed material in the country, next only to water. However, the production of Ordinary Portland cement, an essential basic of concrete, leads to the release of significant amount of CO_2, a greenhouse gas (GHG); production of one ton of Portland cement produces about one ton of CO_2 The objectives of this research were to make utilization of Sugar cane bagasse ash (SCBA) as replacement for cement is incorporated in concrete in order to achieve increase in strength and a better bonding between aggregate and cement paste. The environmental issues associated with GHG, in addition to natural resources issues, will play a leading role in the sustainable development of the cement and concrete industry during this century. Researchers all over the world today are focusing on ways of utilizing either industrial or Agricultural waste, as a source of raw materials for industry. This waste, utilization would not only be economical, but may also result in foreign exchange earnings and environmental pollution control.

A. Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as supplementary cement replacement materials[13]. When this bagasse is burned under controlled conditions, it gives ash having amorphous silica, which has pozzolanic properties Therefore it is possible to use sugarcane bagasse ash (SCBA)) as cement replacement material to improve quality and reduce the cost of construction materials in concrete and also reduce the environment pollution .SCBA is used as fuel in the cogeneration process to produce steam and electricity in sugar industries [8-10]. When baggase is burnt in combustion boiler under controlled burning, reactive amorphous silica is formed in the residual ashes [8-10]. After burning Bagasse ash is collected as a by-product from cogeneration boiler and directly dumped to nearest disposal area. SCBA is generated in large quantities (67,000 tonnes/day) in India, because of the extensively developed sugar industry [8-10]. The total worldwide production of sugarcane was approximately 1794 million tons [6]. Disposal of Bagasse ash is a critical issue for sugar industries because of environmental constrains and land requirement [8-10]. Good pozzolonic properties are obtained in bagasse ash heated between 700-1000 ^oC [1,2,6,12]. After the extraction of all economical sugar from sugarcane, about 40-45% fibrous residue is obtained, which is reused in the same industry as fuel in boilers for heat generation leaving behind 8-10% ash as waste, known as sugarcane bagasse ash (SCBA) [7,11]. The resulting Bagasse Ash represent approximately 0.62% of the sugarcane weight [6]. The SCBA contains high amounts of un-burnt matter, silicon, aluminum and calcium oxides [1,7]. This bagasse ash has been chemically and physically characterized replaced in different proportion with cement and incorporated in concrete. For such application, the fresh concrete must possess high fluidity and good cohesiveness [4]. The use of fine material such as three different region Sugarcane Baggase Fly Ash (SCBA) ensure the required concrete properties [4]. Fresh concrete test such as slump cone test were carried out as well as hardened concrete test like compressive strength, tensile strength and flexural strength at the age of 3, 7 and 28 days will be carried out and the optimum limit of replacement of bagasse ash as replacement for cement in concrete is conducted[1,2,3]. Fresh concrete durability carried out at the optimum limit of replacement of bagasse ash as replacement of cement in concrete is conducted[5]. The cost of self compacting concrete reduced by 36% by incorporating bagasse ash along with the standard concrete in gradients [6].

Figure 1: Sugarcane Bagasse and Sugarcane Bagasse Ash

B. Fiber reinforced concrete (FRC) has been widely used for industrial pavements and small (non-structural) precast elements or sprayed in tunnels. Besides the non-structural elements (pipes, culverts and other small components), fiber reinforcement is particularly appealing for large structural elements. Here steel fibers may be successfully adopted in substitution, at least partly, of the conventional reinforcement (bars or welded mesh) to reduce labour costs (since the conventional reinforcement is placed manually[20].

C. Similar to normal weight concrete, addition of fibers to the lightweight concrete increases the load carrying capacity and control cracks [15]. It also increases the concrete resistance to dynamic and sudden loading, reduces crack width, increase tensile strength of concrete and its resistance against deformation [15-18]. Concrete technology now includes reinforcement in the form of polymeric fibers, steel fibers and glass fibers [15]. However, there is strong negative influence on the workability of concrete with addition of fibers to it. The toughness increases substantially with the contribution of the large fibers, but the peak stress remains almost constant [15,16,19].

D. With addition of steel fibers to concrete, its properties are altered from brittle to ductile [15]. Addition of high strength steel fibers to concrete results in better ductility and higher load carrying capacity, compared to concrete with normal strength steel fibers in the absence of main reinforcement bars [15]. Use of optimal steel fiber weight ratio in high strength concrete produces high performance bending elements having elastic–plastic behavior similar to that of normal strength concrete members. In these research we have used 0.6 mm diameter and 30 mm hooked steel fibers.

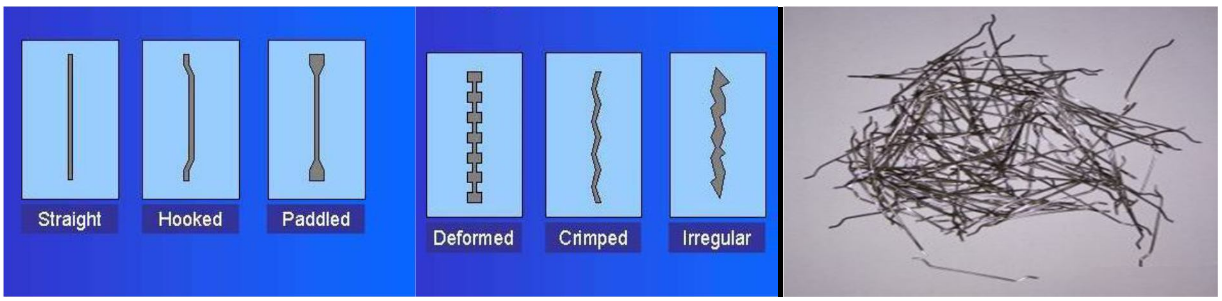

Figure 2: Steel Fiber

II. MATERIALS

The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemi cellulose and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion presents a chemical composition dominates by silicon dioxide (SiO_2) [14]. In this research I have collect the Bagasse Ash as the sugar industries Gandhra, Karajan, Vadodara. The detailed chemical and physical composition is as shown below

Table 1: Chemical Composition of SCBA

Chemical Composition	Residual Baggase Ash (%)
SiO_2	78.34
Al_2	8.55
Fe_2O	3.61
CaO	2.15
Na_2O	0.12
K_2O	3.46
MnO	0.13
TiO_2	0.50
BaO	<0.16
P_2O_5	1.07
Loss of Ignition	0.42

Table 2: Physical Property of SCB

Component	Mass (%)
Density	2.52
Blaine Surface Area (cm^2/gm)	5140
Particle size (µm)	28.9
Colour	Reddish Grey

Due to its favorable chemical composition for concrete it has been used number of times for research purpose.

III. EXPERIMENTAL WORK

A. Mix Design

1) As the development of SCC started since long no codes and standards are available for SCC particularly in India. SCC is one type of trail and error method. After few trials decide final proportion. The water-cement ratios have been varied from 0.3 to 0.5 while the rest of the components were kept the same, except the chemical admixtures, which were adjusted for obtaining the self-compact ability of the concrete.

B. Mix Design Approach

1) The recent amendment in IS 456:2000 (Annexure-1), Aug-2007, gives the guidelines about application of SCC and features of fresh SCC. However reference for the detail guidelines and specification is taken from EFNARC 2002, which says that a concrete can be classified as SCC only if it fulfils the three properties of workability.
2) Filling Ability – Ability of concrete to fill all shapes under its own weight.
3) Passing Ability – Ability to flow through right openings and spaces between steel bars under its own weight.
4) Segregation Resistances – The concrete must meet the filling and passing ability requirement with uniform composition through out the process of transportation and placing.

Table 1 :- Mix design Trial

. TRIAL							
TRIAL	% OF SCBA	Cement kg/m^3	Water kg/m^3	Sand kg/m^3	C.A Kg/m^3	SCBA kg/m^3	W/C RATIO
SCC1	0	455	204.75	820	455/455	0.00	0.45
SCC2	4	436.80	196.56	820	455/455	18.20	0.45
SCC3	8	418.60	188.37	820	455/455	36.40	0.45
SCC4	12	400.40	180.18	820	455/455	54.60	0.45
SCC5	16	382.20	171.99	820	455/455	72.80	0.45
SCC6	20	364	163.80	820	455/455	91	0.45

Table 2:- Mix design of 1 m^3

Mix	Cement (kg/m^3)	Sand (kg/m^3)	F.A (10mm) (kg/m^3)	C.A (20mm) (kg/m^3)	Water (kg/m^3)
M25	455	820	455	455	204.75
	1.0	1.80	1.0	1.0	0.45
1 Bag	50.00	90	50	50	22.5

Table 9.1 Trial Mixes

Trial	Cement (kg/m^3)	F.A (kg/m^3)	C.A (kg/m^3)	SP (%)	W/C	Slump Flow (mm)	Remark
1	542	542	1086	1.0	0.35	550	Not Accepted
2	542	650	976	1.0	0.35	565	Not Accepted
3	542	813	813	1.0	0.35	575	Not Accepted
4	455	814	904	1.0	0.35	585	Not Accepted
5	542	542	1086	1.50	0.40	560	Not Accepted
6	542	650	976	1.50	0.40	585	Not Accepted
7	542	813	813	1.50	0.40	605	Not Accepted
8	455	814	904	1.50	0.40	615	Not Accepted
9	542	542	1086	2.0	0.45	595	Not Accepted
10	542	650	976	2.0	0.45	625	Not Accepted
11	542	813	813	2.0	0.45	660	Accepted
12	455	814	904	2.0	0.45	690	Accepted

IV. SLUMP FLOW TEST

A. The basic equipment used is the same as for the conventional Slump test. The test method differs from the conventional one by the fact that the concrete sample placed into the mould is not rodded and when the slump cone is removed the sample collapses (Ferraris, 1999). The diameter of the spread of the sample is measured, i.e. a horizontal distance is determined as opposed to the vertical distance in the conventional Slump test. The Slump Flow test can give an indication as to the consistency, filling ability and workability of SCC. The SCC is assumed of having a good filling ability and consistency if the diameter of the spread reaches values between 650mm to 800mm.

Figure 3: Slump Flow Test Equipment

V. V-FUNNEL TEST

A. Viscosity of the self-compacting concrete is obtained by using a V-funnel apparatus, which has certain dimensions (Figure), in order for a given amount of concrete to pass through an orifice. The amount of concrete needed is 12 litters and the maximum aggregate diameter is 20mm. The time for the amount of concrete to flow through the orifice is being measured. If the concrete starts moving through the orifice, it means that the stress is higher than the yield stress; therefore, this test measures a value that is related to the viscosity. If the concrete does not move, it shows that the yield stress is greater than the weight of the volume used. An equivalent test using smaller funnels (side of only 5 mm) is used for cement paste as an empirical test to determine the effect of chemical admixtures on the flow of cement pastes. The SCC is assumed of having a good filling ability and consistency if the range between 6 sec to 12 sec.

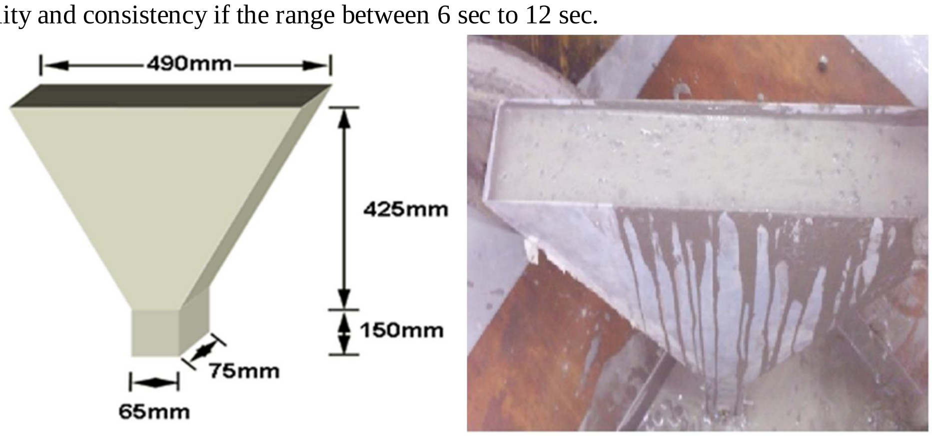

Figure 4: V-funnel Test Equipment

VI. L-BOX TEST

A. This method uses a test apparatus comprising of a vertical section and a horizontal trough into which the concrete is allowed to flow on the release of at rap door from the vertical section passing through reinforcing bars placed at the intersection of the two areas of the apparatus. The time that it takes the concrete to flow a distance of 200mm (T-20) and 400mm (T-40) into the horizontal section is measured, as is the height of the concrete at both ends of the apparatus (H1&H2). The L-Box test can give an indication as to the filling ability and passing ability. The SCC is assumed of having a good passing ability and consistency if the range (H_2/H_1) may be 0.8 to 1.

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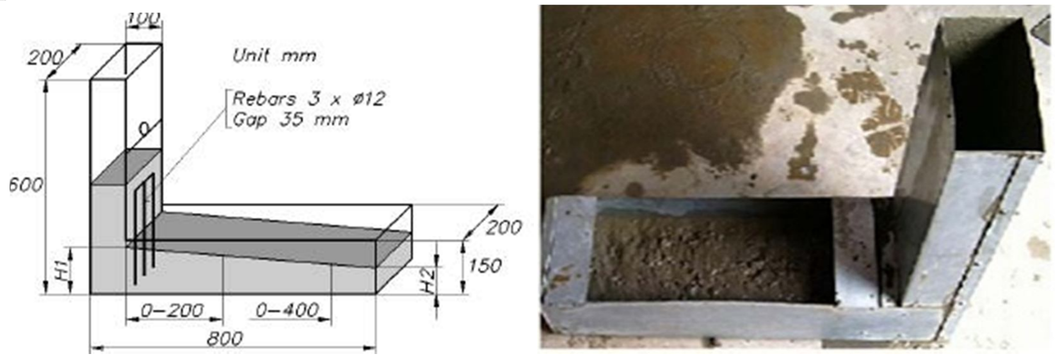

Figure 5: L-box Test Equipment

VII. J-Ring Test

A. This test (Figure 8.4) involves the slump cone being placed inside a 300 mm diameter steel ring attached to vertical reinforcing bars at appropriate spacing (the J-Ring itself). The number of bars has to be adjusted depending on the maximum size aggregate in the SCC mix. Like in the Slump Flow test, the diameter of the spread and the T-50 time are recorded for the evaluation of SCC viscosity. The Slump Flow/J-Ring combination test is an improvement upon the Slump Flow test on its own as it aims to as sessal so the passing ability of the fresh mix. In this respect, the SCC has to pass through the reinforcing bars without separation of paste and coarse aggregate.

Figure 6: J-Ring Test Equipment

Table 9.2 Workability of SCC without Steel Fiber

Mix	W /P	S.P (%)	Workability Result without SF				Workability Result with 0.50% SF				Workability Result with 1.0% SF			
			Slump flow (mm)	V-funnel (sec)	L-box (h_2/h_1)	J-Ring (mm)	Slump flow (mm)	V-funnel (sec)	L-box (h_2/h_1)	J-Ring (mm)	Slump flow (mm)	V-funnel (sec)	L-box (h_2/h_1)	J-Ring (mm)
SCC1	0.45	2	690	11.2	0.84	7	685	11.1	0.83	7	675	11.6	0.82	8
SCC2			715	10.6	0.86	5	700	10.7	0.85	6	695	11.1	0.84	7
SCC3			725	10.1	0.87	4	710	10.3	0.86	6	710	10.4	0.85	6
SCC4			745	9.8	0.89	2	725	10	0.86	5	720	10.0	0.87	5
SCC5			695	11.1	0.84	7	690	11.1	0.83	7	680	11.5	0.82	8
SCC6			635	12	0.81	9	625	12.1	0.80	10	610	12.2	0.79	10

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VIII. COMPRESSIVE STRENGTH TEST

A. Compressive strength is one of the most important engineering property of Concrete which designers are concerned of. It is a standard industrial practice that the concrete is classified based on grades. This grade is nothing but the Compressive Strength of the concrete cube or cylinder. Cube or Cylinder samples are usually tested under a compression testing machine to obtain the compressive strength of concrete. Cubes of size 150 X 150 X 150 mm were casted and cured for 28 days and tested on compression testing machine of capacity 3000kN.

B. The compressive strength of cube specimen is calculated using the following formula:

$$\sigma = P/A$$

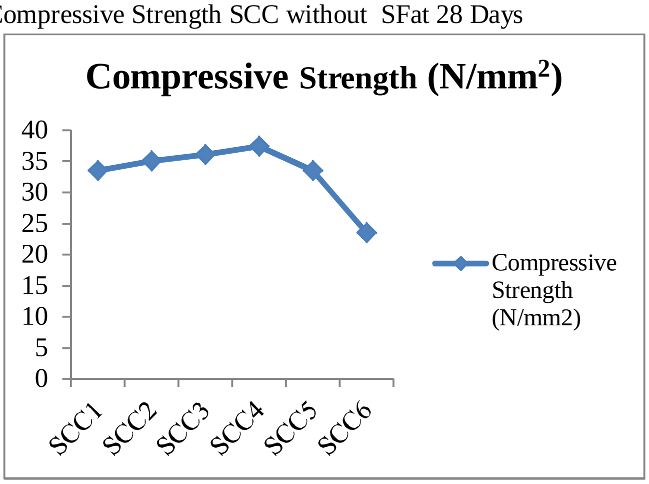
Where P = failure load

A = cross sectional area in mm

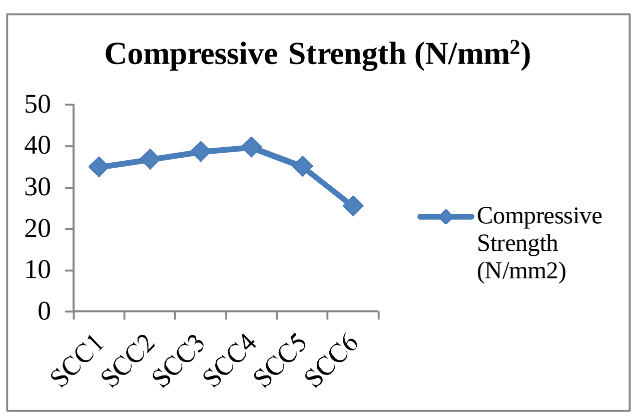
Compressive Strength test results at 28 days

Mix	% SCBA	Steel Fiber %	Water/powder ratios	Super plasticizer Dosages %	Compressive Strength (N/mm^2)					
					28 Days	Average without SF	28 days	Average With 0.50% SF	28 Days	Average With 1.0% SF
SSC1	0	1	0.45	2	33.80	33.49	34.25	34.88	35.61	35.20
	0				32.94		34.81		35.07	
	0				33.76		35.58		34.93	
- SSC2	4	1	0.45	2	34.58	35.03	36.24	36.78	37.16	37.56
	4				34.91		36.92		37.38	
	4				35.59		37.18		38.14	
SSC3	8	1	0.45	2	35.45	36.11	38.18	38.61	39.43	39.82
	8				36.08		38.91		39.84	
	8				36.11		38.73		40.18	
SSC4	12	1	0.45	2	36.94	37.44	39.27	39.73	40.93	41.34
	12				37.47		39.78		41.28	
	12				37.91		40.13		41.83	
SSC5	16	1	0.45	2	33.75	33.55	34.58	34.97	35.11	35.47
	16				33.04		34.91		35.97	
	16				33.85		35.44		35.34	
SSC6	20	1	0.45	2	24.28	23.52	25.83	25.50	28.34	28.29
	20				23.05		25.61		28.91	
	20				23.52		25.06		27.63	

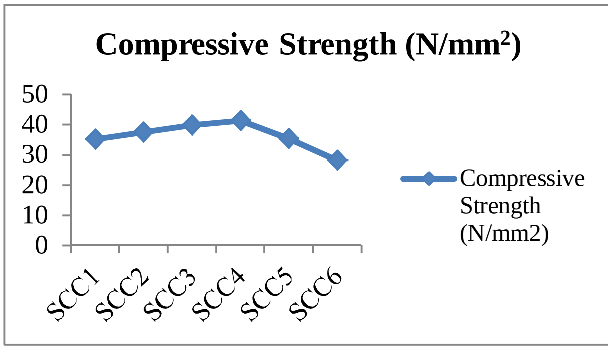
Compressive Strength SCC without SFat 28 Days



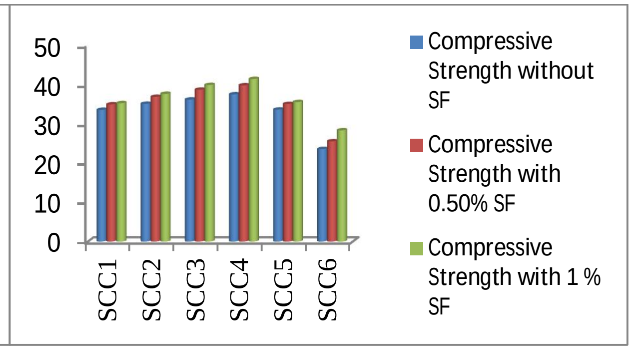
Compressive Strength SCC with 0.50% SF at 28 Days



Compressive Strength SCC with 1% Steel Fiber at 7 Days



Compressive Strength SCC with variation at 28 Days



IX. SPLIT TENSILE STRENGTH TEST

A. The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure.

B. Apart from the flexure test the other methods to determine the tensile strength of concrete can be broadly classified as (a) direct method (b) indirect method.

C. The split tensile strength tests are well known indirect tests used for determining the tensile strength of concrete. The test consists of applying a compressive live load along the opposite generators of a concrete cylinder placed with its axis horizontal 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 as elastic analysis.

D. The magnitude of this tensile stress fct (acting in a direction perpendicular to the line of action of applied loading) is given by formula (IS:5816-1970).

$$fct = 2P/ \pi DL$$

Where P = applied load (kN)

D = diameter of the specimen(mm)

L = length of the specimen(mm)

Split Tensile Strength test results at 28 days

Mix	% SCBA	Steel Fiber %	Water/powder ratios	Super plasticizer Dosages %	Split Tensile Strength (N/mm^2)					
					28 Days	Average without SF	28 days	Average With 0.50% SF	28 Days	Average With 1.0% SF
SSC1	0	1	0.45	2	3.18	3.53	4.12	4.49	4.97	4.98
	0				3.96		4.89		5.34	
	0				3.46		4.45		4.62	
-SSC2	4	1	0.45	2	3.58	3.70	4.35	4.63	5.09	5.14
	4				3.83		4.59		4.84	
	4				3.69		4.95		5.51	
SSC3	8	1	0.45	2	3.64	3.79	5.24	4.87	5.18	5.38
	8				3.81		4.79		5.65	
	8				3.93		4.58		5.32	
SSC4	12	1	0.45	2	3.59	4.01	4.73	5.00	5.48	5.67
	12				4.29		4.97		5.67	
	12				4.17		5.31		5.86	
SSC5	16	1	0.45	2	3.27	3.53	4.02	4.51	5.12	5.03
	16				3.90		4.81		4.67	
	16				3.44		4.69		5.29	
SSC6	20	1	0.45	2	3.04	2.80	3.84	3.77	3.58	3.88
	20				2.78		4.18		3.85	
	20				2.59		3.29		4.21	

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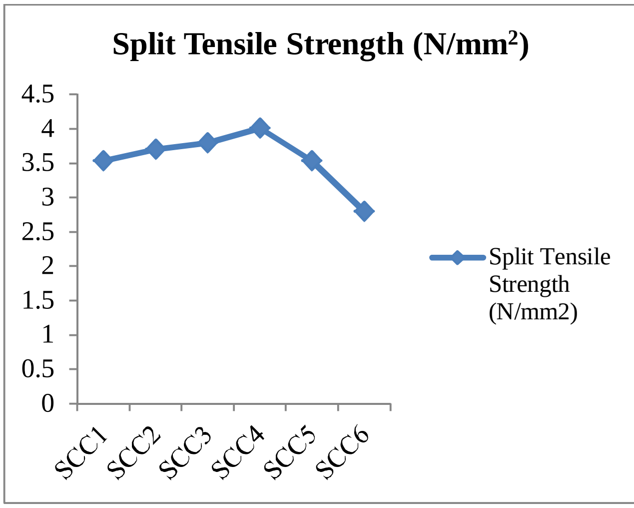
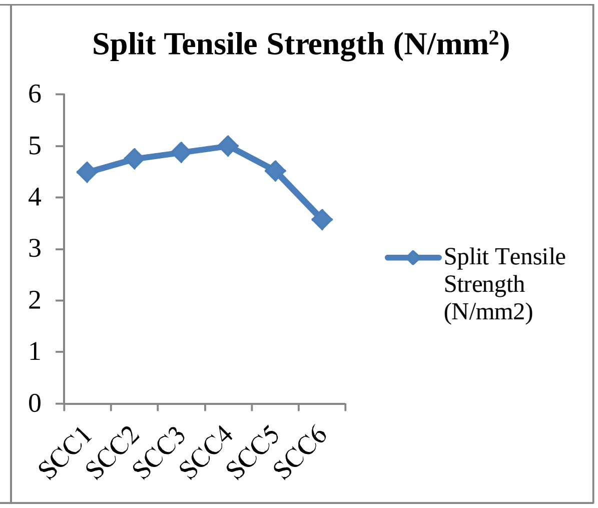
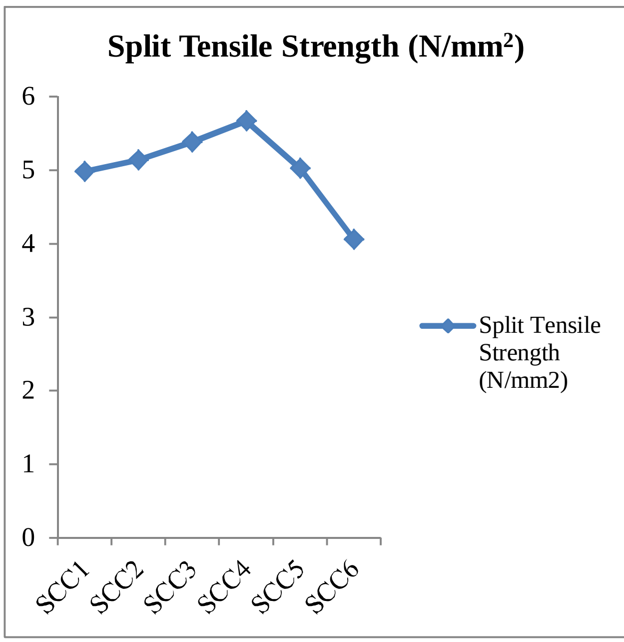
Split Tensile Strength SCC without Steel Fiber at 28 Days



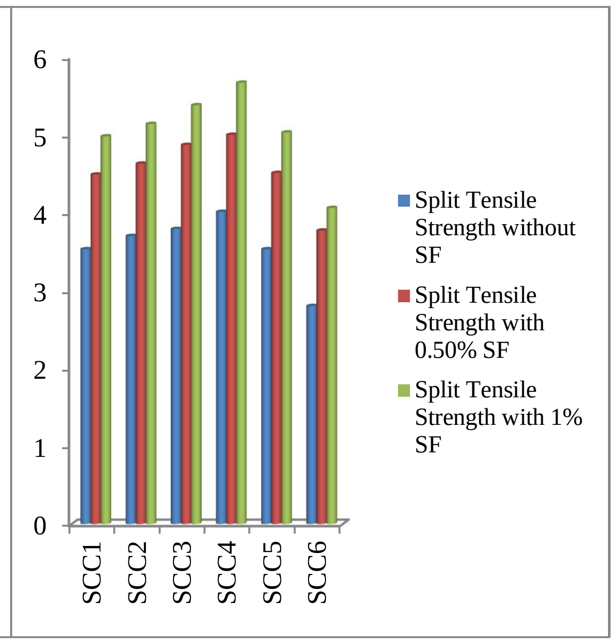
Split Tensile Strength SCC with 0.50% Steel Fiber at 28 Days



Split Tensile Strength SCC without Steel Fiber at 28 Days



Split Tensile Strength SCC variation at 28 Days



X. FLEXURAL STRENGTH TEST

A. Flexural strength also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before yields in a flexure test.

B. Flexure strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending.

C. Beam of size 700 X 150 X 150 mm were casted and cured for 28 days and tested on compression testing machine of capacity 3000kN.

D. The flexural strength of beam specimen is calculated using the following formula:

$$\sigma = PL/bd^2$$

Where P = applied load (kN)

d = diameter of the specimen (mm)

b = width of specimen (mm)

L = length of the specimen (mm)

Flexural Strength test results at 28 days

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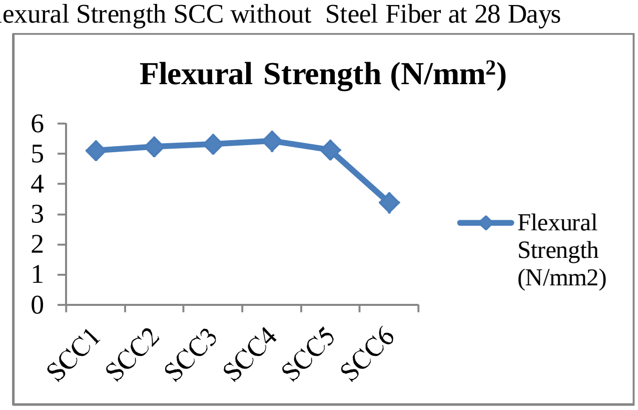
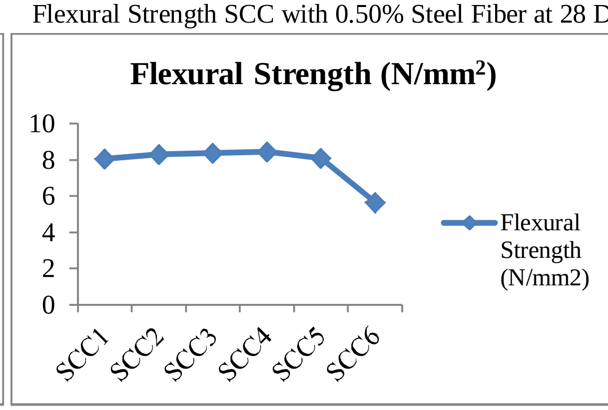
Mix	% SCBA	Steel Fiber %	Water/powder ratios	Super plasticizer Dosages %	Flexural Strength (N/mm^2)					
					28 Days	Average without SF	28 days	Average With 0.50% SF	28 Days	Average With 1.0% SF
	0				4.77		7.67		10.30	
SSC1	0	1	0.45	2	5.18	5.11	8.50	8.08	9.33	9.86
	0				5.39		8.08		9.95	
	4				4.71		7.71		10.39	
-SSC2	4	1	0.45	2	5.87	5.25	8.44	8.31	9.91	10.10
	4				5.17		8.79		10.05	
	8				4.85		7.79		10.67	
SSC3	8	1	0.45	2	5.34	5.32	8.51	8.40	10.09	10.19
	8				5.79		8.92		9.81	
	12				4.98		7.75		10.55	
SSC4	12	1	0.45	2	5.43	5.43	8.59	8.44	9.94	10.26
	12				5.89		8.99		10.31	
	16				4.65		7.70		10.17	
SSC5	16	1	0.45	2	5.27	5.13	8.39	8.10	9.65	9.90
	16				5.48		8.21		9.88	
	20				2.99		5.11		6.71	
SSC6	20	1	0.45	2	3.47	3.40	6.07	5.67	7.34	6.68
	20				3.75		5.85		6.00	

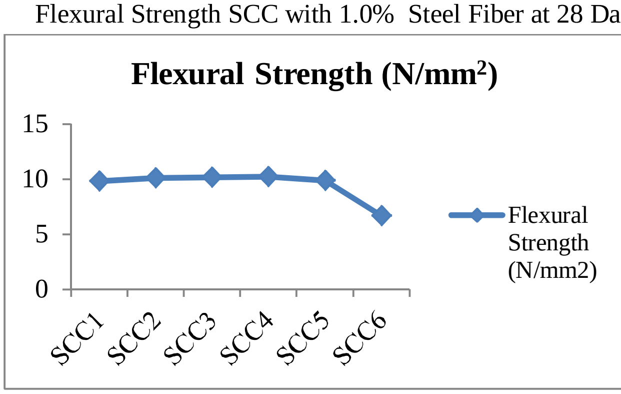
Flexural Strength SCC without Steel Fiber at 28 Days



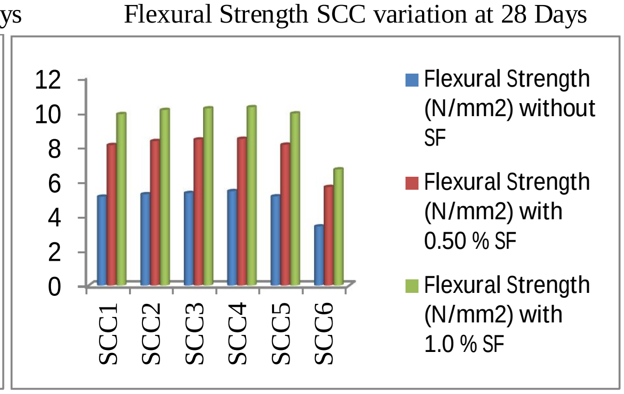
Flexural Strength SCC with 0.50% Steel Fiber at 28 Days



Flexural Strength SCC with 1.0% Steel Fiber at 28 Days



Flexural Strength SCC variation at 28 Days



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XI. DURABILITY TEST

A. Acid attack test

1) Durability is the ability to last a long time without significant deterioration. A durable material helps the environment by conserving resources and reducing wastes and the environmental impacts of repair and replacement. The production of replacement building materials depletes natural resources and can produce air and water pollution.
2) Concrete resists weathering action, chemical attack, and abrasion while maintaining its desired engineering properties. Different concretes require different degrees of durability depending on the exposure environment and the properties desired. Concrete ingredients, their proportioning, interactions between them, placing and curing practices, and the service environment determine the ultimate durability and life of the concrete.
3) Concrete is susceptible to acid attack because of its alkaline nature. During acid attack on the cement paste break down. Since concrete is an alkaline substance many of its components readily react with acid. In most cases the reaction between the attacking acid and calcium compound forms calcium salts, which can be soluble in water. Acid attack weakens the concrete structurally and reduces its durability and service life.
4) The acids most commonly attacked by concrete are carbonic acid, humic acid, and sulphuric acid. The bureau of Indian standard specified the maximum chloride content in cement as 5 percent. But it is now increased the allowable chloride content in cement to 0.1 percent. The cubes were cast of size 150 x 150 x 150 mm and kept at least 90 percent relative humidity for 24 hours. After 24 hours the cubes were unmoulded and immersed in fresh water for 28 days. After 28 day curing cubes were immersed in 5% concentrated HCL and H_2SO_4 for 56 days. After 56 days cubes were tested for compressive strength test.
5) The compressive strength of cube specimen is calculated using the following formula:

$$\sigma = P/A$$

Where P = failure load

A = cross sectional area in mm

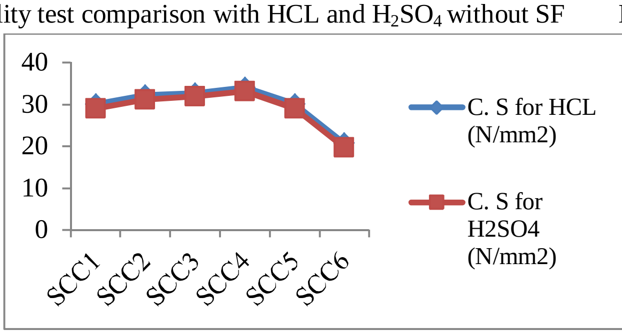
Durability results for HCL

Mix	% SCBA	Steel Fiber %	Water/powder ratios	Super plasticizer Dosages %	Compressive Strength (N/mm^2)					
					28 Days	Average without SF	28 days	Average With 0.50% SF	28 Days	Average With 1.0% SF
SSC1	0	1	0.45	2	30.61	30.15	31.61	31.23	30.95	31.24
	0				29.84		31.14		31.29	
	0				30.00		30.94		31.48	
- SSC2	4	1	0.45	2	32.19	32.21	32.94	33.44	34.34	34.27
	4				32.81		33.91		33.26	
	4				31.64		33.49		35.21	
SSC3	8	1	0.45	2	33.24	32.76	34.98	35.32	35.99	36.41
	8				32.97		35.67		36.41	
	8				32.08		35.31		36.84	
SSC4	12	1	0.45	2	33.58	34.16	35.97	35.96	37.82	38.15
	12				34.21		35.49		38.19	
	12				34.69		36.42		38.46	
SSC5	16	1	0.45	2	30.11	30.16	31.04	31.08	31.89	32.04
	16				30.54		30.76		32.94	
	16				29.85		31.44		31.28	
SSC6	20	1	0.45	2	21.59	20.78	22.21	22.32	25.21	24.85
	20				20.51		22.87		24.49	
	20				20.24		21.89		24.87	

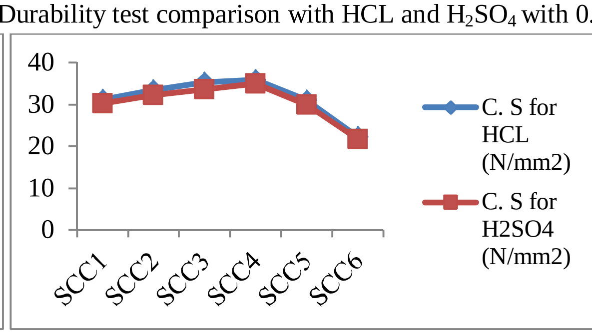
Durability results for H_2SO_4

Mix	% SCBA	Steel Fiber %	Water/powder ratios	Super plasticizer Dosages %	Compressive Strength (N/mm^2)					
					28 Days	Average without SF	28 days	Average With 0.50% SF	28 Days	Average With 1.0% SF
SSC1	0	1	0.45	2	29.58	29.12	30.29	30.32	29.97	30.39
	0				28.71		30.69		31.71	
	0				29.08		29.97		29.89	
- SSC2	4	1	0.45	2	31.29	31.17	31.89	32.22	33.18	33.02
	4				31.51		32.17		32.25	
	4				30.71		32.61		33.64	
SSC3	8	1	0.45	2	32.15	31.88	34.05	33.60	34.78	35.12
	8				32.01		33.19		35.11	
	8				31.48		33.57		35.48	
SSC4	12	1	0.45	2	32.47	33.25	35.81	35.01	36.49	37.01
	12				33.55		34.54		36.98	
	12				33.74		34.97		37.57	
SSC5	16	1	0.45	2	29.34	29.04	29.87	29.95	30.41	30.73
	16				29.03		29.41		31.59	
	16				28.77		30.59		30.19	
SSC6	20	1	0.45	2	20.47	19.77	20.99	21.70	23.97	23.58
	20				19.58		22.25		23.56	
	20				19.27		21.86		23.21	

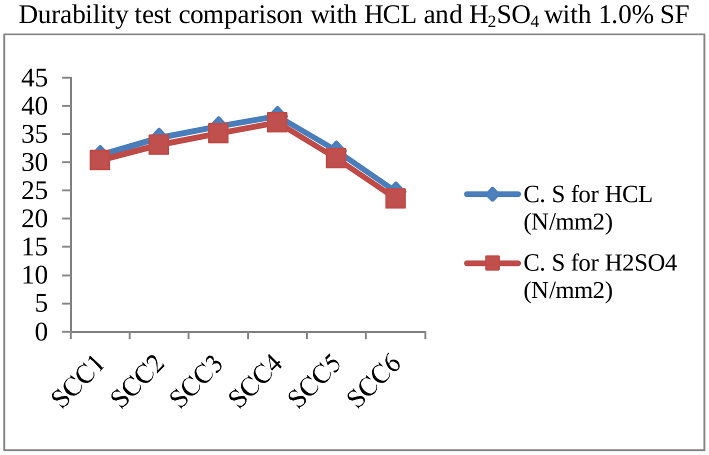
Durability test comparison with HCL and H_2SO_4 without SF



Durability test comparison with HCL and H_2SO_4 with 0.50% SF



Durability test comparison with HCL and H_2SO_4 with 1.0% SF



XII. CONCLUSION

After the detailed experimental study carried out following remarkable concluding points have been observed

A. Replacement of SCBA improved Workability as well as Strength of Self Compacting Concrete.
B. SCBA may be safely replaced up to 16% than after strength is decreased.
C. If SCBA is replaced by 12% the mix gives maximum strength along with good workability than normal concrete.
D. If SCBA is replaced by 12% the compressive strength is increased up to 12% compare to normal concrete without using steel fibers while 18% at 1% addition of steel fibers.
E. The addition of Steel Fibers improved compressive strength and durability marginally while the split tensile strength and flexural strength are improved largely.
F. The improvement of compressive strength being upto 7% at 0.50% addition of steel fibers while it is 10% at 1% addition of steel fibers.
G. The improvement of split tensile strength being upto 25% at 0.50% addition of steel fibers while it is 42% at 1% addition of steel fibers.
H. The improvement of flexural strength being upto 55% at 0.50% addition of steel fibers while it is 89% at 1% addition of steel fibers.
I. The improvement of durability being upto 6% at 0.50% addition of steel fibers while it is 12% at 1% addition of steel fibers.
J. Addition of Steel Fibers decreased workability.
K. The specimen which contains Steel Fiber gives ductile failure rather than brittle failure which is observed without Steel Fibers.
L. Durability tests show that there is large reduction in strength for normal concrete but the reduction may be controlled using Sugarcane Bagasse Ash and Steel Fibers.

Experimental result showed that Sugarcane Bagasse Ash can be successively used as cement supplementary material for achieving economical and durable concrete.

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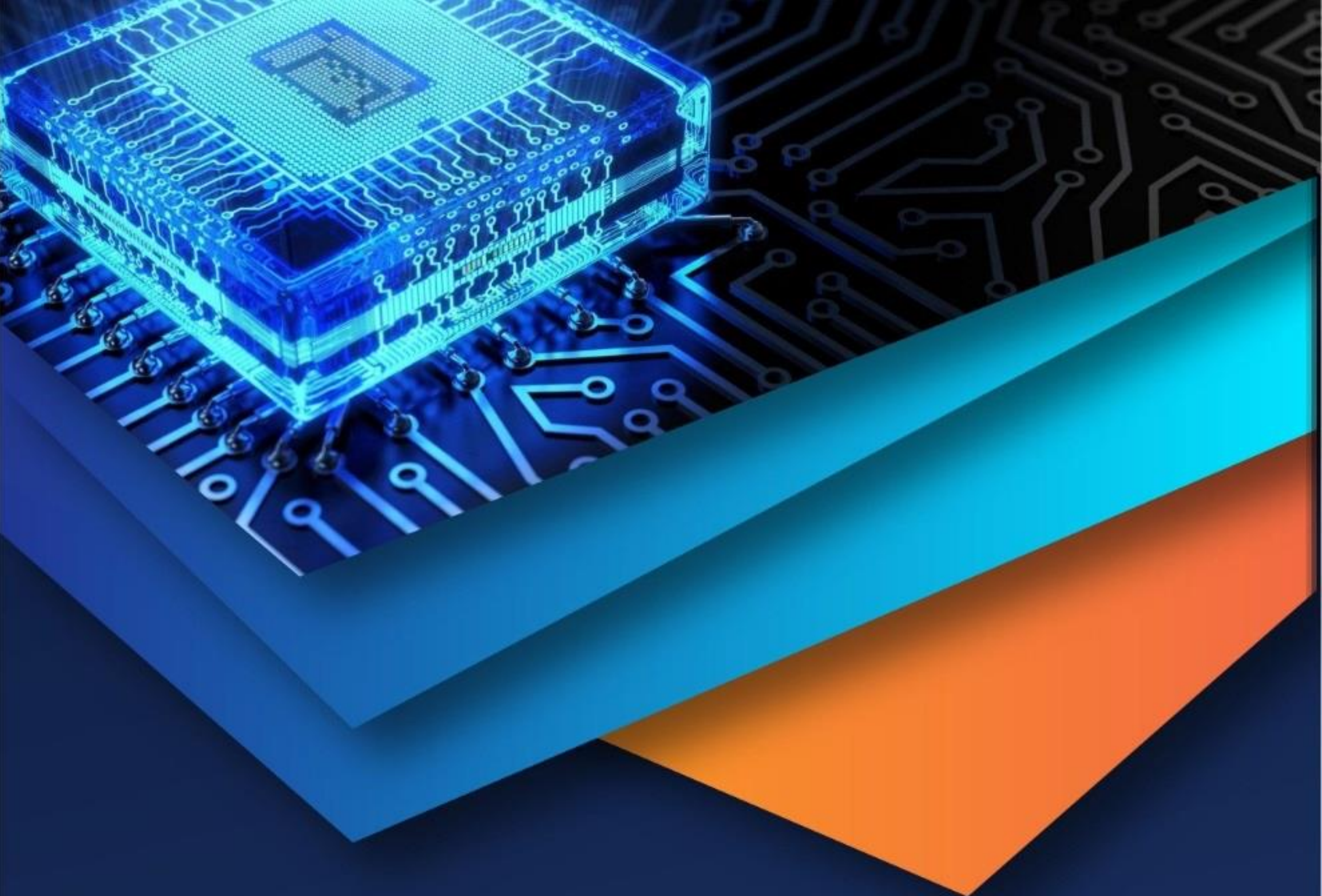

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