Analysis of Self-Compacting Concrete Using Viscosity Modifying Agent

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ABSTRACT : ***Reinforced concrete is one of the most versatile and widely used construction materials. The concrete must be able to pass the dense rebar arrangement without blocking or segregating. Self Compacting Concrete (SCC) is a latest trend in concrete technology because of ability to compact under its own weight and also due to its high resistance of segregation and bleeding; by using such kind of concrete in construction work economy can be achieved due to elimination in vibration and compaction. The results show that for constant flow ability of the SCC, replacement of cement with Guar Gum (GG) requires an increase in water/powder ratio and an increase in super plasticizer dosage. Both additions degraded the flow ability, consistence retention and hardened properties but not to a prohibitive extent. By limiting the content of guar gum not greater than 6 % of replacement of cement and by keeping Super Plasticizer (SP) content same a s 1 % gives better result than normal concrete in terms of strength, workability & durability. Grades of concrete i.e. M50 and are tested for 1 to 6 % of GG and constant 1 % of SP (Conflow-CP) and results are obtained for this thesis. Self compaction can be achieved by many ways including combination of viscosity modifying agent and super plasticizer Guar gum added in concrete by weight of cement. Result shows that by addition of both component gives better compressive strength then normal concrete.***

Key words **: *Self-compacting concrete, viscosity modifying admixtures, Slump Test, Harden property, Durability property*.**

1. INTRODUCTION

Concrete is most widely used construction material, has desirable engineering properties. Concrete plays a key role in development of our planet earth in developed, under developed and developing countries. The recent developments in the field of concrete are Self-compacting Concrete (SCC), High Performance Concrete (HPC), Compacted Reinforced Concrete (CRC) and Reactive Powder Concrete (RPC). During the last decade, concrete technology has made an enormous advance through the introduction of self-compacting concrete (SCC). Self-compacting or self-consolidating concrete is a relatively new generation of high-performance concrete that is able to achieve Impressive deformability and homogeneity in its fresh state, filling all the space around the reinforcement, passing through dense reinforcing steel bars while compacting under its own weight without any external vibration.

Also, the gradual reduction in the number of skilled workers in construction industry has led to a reduction in the quality of construction work. Therefore to ensure adequate compaction and homogeneity during placement, especially in structures with congested reinforcement and restricted areas, idea of self-compacting concrete was given by Hajime Okamura in early 1980's. Filing ability, passing ability and resistance to segregation are the main properties of self-compacting concrete which are achieved by increasing the amount of fines (i.e. particles, 0.125mm), decreasing water-powder ratio and using super plasticizer. The requirement of high fines content leads to high cement, often in the range of 450-500 kg/m^3.

Viscosity-modifying admixtures (VMA) are typically high molecular weight soluble polymers, which in aqueous medium have increased viscosity because of their interaction with water (Ramachandran, 1995). These admixtures are effective in stabilizing the rheology of fresh concrete and preventing segregation of the coarse aggregate from the other mix constituents (Okamura, 2000). VMA's change the rheological properties of concrete by increasing the plastic viscosity but usually cause only a small increase in the yield point. Admixtures which decreases the yield point are called super plasticizers and often used in combination with a VMA to optimize the yield point. In present study, an attempt is made to investigate the influence of various dosages of VMA on rheological and mechanical properties of SCC.

2. MATERIALS

2.1 Cement

The OPC 53 Grade cement of ultratech cement conforming of IS 12269-1987 was used for all concrete mixes.

2.2 Aggregates

Fine aggregates used for this work was conforming of IS 383-1987 and the size was less than 4.75mm.
Coarse aggregates used for this work was conforming of IS 383-1987 and the size was less than 20mm.

Table: 1 Properties of Coarse and Fine aggregates

Sr. no	Coarse aggregate		Fine aggregate	
1	Specific gravity	2.7	Specific gravity	2.76
2	% water absorption	0.8	% water absorption	1.10
3	Moisture contents	Nil	Moisture contents	Nil

2.3 Water

Potable water available in collage was used in casting and curing of concrete.

2.4 Guar gum powder

Guar is also known as cluster bean a drought hardy leguminous crop. It is primarily the ground endosperm of guar beans which is galactomannan. The guar seeds are dehusked, milled and screened to obtain guar gum. Is reduced crystal formation, act as a binder, thickening agent and stabilizer. In this study, the powder which we are used is purchasing from Swastik gum industries ltd., Ahmedabad.

Table: 2 Properties of Guar gum powder

Chemical composition	Polysaccharide based
Particle size (µm)	300
Viscosity	4987 cps
pH	4.52
Appearance	Off-white powder

Figure:1 Guar Gum Powder

2.5 Superplasticizer (Conflow-CP)

Superplasticizer is a chemical compound used to improve workability of concrete without adding more water. Superplasticizer improves better surface expose of aggregates to cement gel. SP act as a lubricant among the materials. In present work we are using Conflow-CP a polycarboxylic based superplasticizer which is purchased from Contech chemicals, Ahmedabad.

Table: 3 Properties of SP

Appearance	Dark Brown liquid
Specific gravity	1.110 ± 0.02
pH value (1:10)	5.0-7.0
Chlorides	Below 0.02

Figure: 2 Conflow-CP

3. MIX DESIGN OF CONCRETE

Selection of mix design, test and target property as per IS code method and converting it into rational mix design method of SCC by Okamura and Ozawa. Various trials conducted into laboratory for that. Development of SCC by varying percentage (1 to 6%) of guar gum (VMA) and by keeping SP Constant at 1% and also measurement of flow properties of SCC.

Mix design for M50 Grade of concrete according to IS 10262:2009 as shown in table-4.

Table: 4 Trial mix for M50 grade of concrete

Sr. No	Type of Mix	W/C ratio	Cement (kg/m^3)	C.A. (kg/m^3)	F.A. (kg/m^3)	SP (kg/m^3)	Water (kg/m^3)
1	TR1	0.4	492.9	1168	627.66	4.92	197.16
2	TR2	0.4	492.9	1168	745.71	4.92	197.16
3	TR3	0.38	480	1168	745.71	4.8	182.44
4	TR4	0.38	480	1118.5	870.0	4.8	182.4

As per IS code method For TR1, the 0.4 W/C ratio was used and also used 47% & 25.25% of C.A and F.A respectively but did not get the expected slump flow than increase the F.A content from 25.25% to 30% but it was also cause the segregation in TR2. After that lower the W/C ratio from 0.4 to 0.38 that gives the 480 kg/m^3 cement and 182.44 Water content than make a trial but did not get the results. After all those things I should try to limiting the C.A. content at 45% by the total weight of volume and increase the F.A. content from 30% to 35% by the weight of volume and I get the SCC flowing property by the slump flow test in TR4. Than prepared the concrete mix design for M50 which is given below in table 5.

Table: 5 Final mix design for M50 grade of concrete

Sr.No	Type of Mix	W/C ratio	Cement (kg/m^3)	C.A. (kg/m^3)	F.A. (kg/m^3)	GGP (kg/m^3)	SP (kg/m^3)	Water (kg/m^3)
1	TR4	0.38	480	1118.5	870	-	4.8	172.8
2	GG1	0.38	475.2	1118.5	870	4.8	4.8	172.8
3	GG2	0.38	470.4	1118.5	870	9.6	4.8	172.8
4	GG3	0.38	465.6	1118.5	870	14.4	4.8	172.8
5	GG4	0.38	460.8	1118.5	870	19.2	4.8	172.8
6	GG5	0.38	456	1118.5	870	24	4.8	172.8
7	GG6	0.38	451.2	1118.5	870	28.8	4.8	172.8

4. EXPERIMENTAL PROGRAMMES:

4.1 Fresh properties:

SCC has three main required fresh properties filling ability, viscosity, passing ability and segregation resistance. This tests are performed as per EFNARC February 2005 guidelines shown in below table6.

Table: 6 fresh property tests as per EFNARC

Sr. no	Method	Characteristic	Unit	Typical range of values	
				Minimum	maximum
1	Slump flow test	Flowability	Mm	650	800
2	T50cm slump flow test	Viscosity	Sec	2	5
3	L-box	Passing ability	Ratio (H2/H1)	0.8	1

a.) Sump flow & T50 Test:

The slump-flow and T50 time is a test to gives the values of flowability and the flow rate of self-compacting concrete in the absence of obstruction. The SCC assumed as a good filing ability if its Flow dia. reaches between 650 to 800mm. T50 time is also a measure of the speed of flow to reach the diameter of 500mm. It ranges between 2 to 5 sec.

Figure: 3 Flow dia. For T50 time

Figure:4 Slump flow

b.) L-Box Test:

The L-box test is used to assess the passing ability of self-compacting concrete to flow through tight openings including spaces between reinforcing bars without segregation or blocking. For the two bars test the reinforcement bars shall have 2 bars of 12mm with a gap of 59 mm and for the three bars test there shall be 3 bars with the gap of 41 mm. measured volume of fresh concrete is allowed to flow horizontally through gaps between vertical smooth reinforcing bars and height of the concrete beyond the reinforcement is measured.

Figure : 6 L-box test

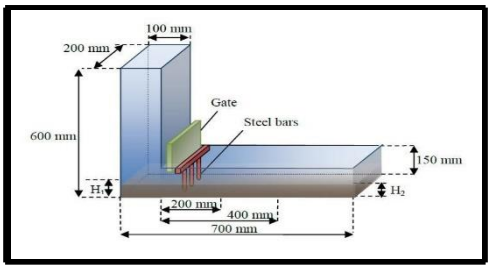


Figure: 7 L-box test apparatus

4.2 Hardened Properties:

a.) Compressive strength test:

Compressive strength of concrete is define as the load, which causes the failure of cubes. The test of strength should be made on 150mm×150mm×150mm size cube. Place the cube on the base plate of compression testing machine and start the machine. When the load is applied gradually, the bottom plate lifted up by the force of piston and thus the load applied on the cube which should be 300 KN per minutes and controlled by load rate controlled knob. Ultimate load is noted for each specimen.

Figure:8 Cube testing

Figure:9 Cube after testing

b.) Splitting tensile test:

The split tensile test is conducted by loading a cylindrical concrete cube along with its length. The results in the development of the tensile stresses along the diameter in the heading. When these stresses go upon limits the cube were split into two halves. The tensile strength calculated as split strength = $2P/(\pi LD)$. Where P is the failure load, L and D are the length and diameter of the cylinder respectively.

4.3 Durability properties:

a.) Hydrochloric Acid (HCL) attack test:

Concrete is sustainable to acid attack because of its alkaline nature. The components of the cement paste break down during contact with acids. HCL attack is typical acidic corrosion. So here, We make a solution of HCL (5%) in a laboratory. And then we are checked standard specimen after 28 days curing. The result shows compressive strength of SCC in HCL solution curing are partially less than normal water curing.

b.) Sulphuric acid (H_2SO_4) attack test:

The cubes are casted with the size of 150mm x 150mm x 150mm and kept at ambient temperature for 24 hours. After 28days, the cubes are immersing in a solution of Sulphuric Acid (H_2SO_4). After 28 of curing, the specimens has taken and are washed in water. During sulphate attack test, it can observe that there was less effect on the concrete cube surface and the top surface of cube remained same as before. The Sulphuric Acid solutions readily react with the calcium hydroxide present in Portland cement pastes to form soluble salts of calcium. There is surface cracking due to action of sulphate acting on the surface of concrete hence good resistance to sulphate.

Figure:10 Acid Curing

Figure: 11 Acid cured cube

Figure: 12 Strength test of Acid cured cube

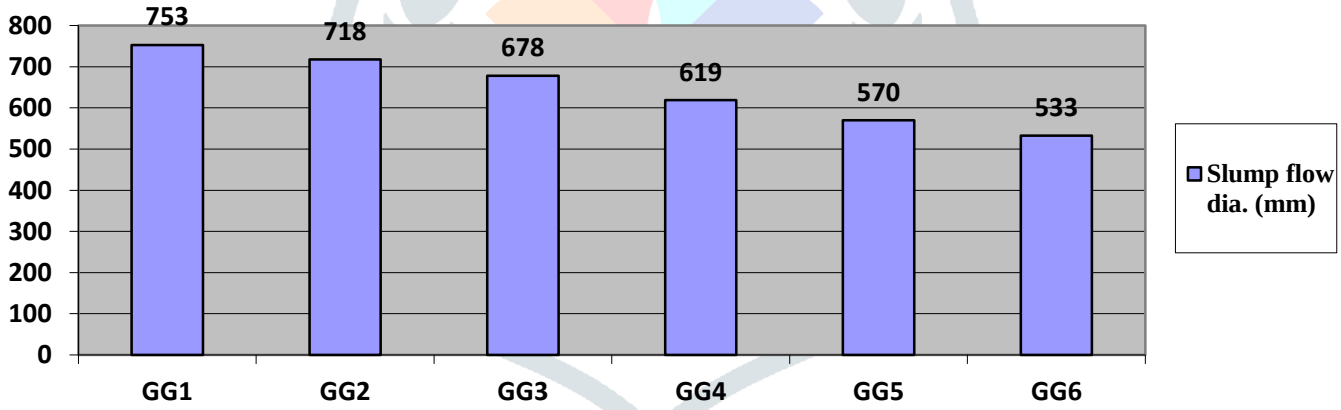
5. RESULTS AND DISCUSSION

5.1 Fresh properties test results:

Concrete Mix	T50 (Seconds)	Maximum Spread Dia. of Flow (mm)	L-Box (H2/H1)
GG1	2.07	753	0.95
GG2	2.89	718	0.89
GG3	3.015	678	0.87
GG4	4.05	619	0.83
GG5	4.68	570	0.78
GG6	5.39	533	0.68

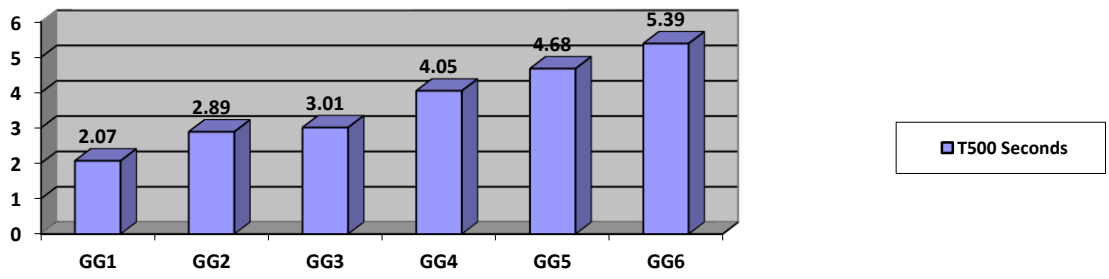
a.) Slump flow test:

As we can see here, an increase in the dosage of Guar gum powder the flow of SCC is decreases. Shown in below graph chart.



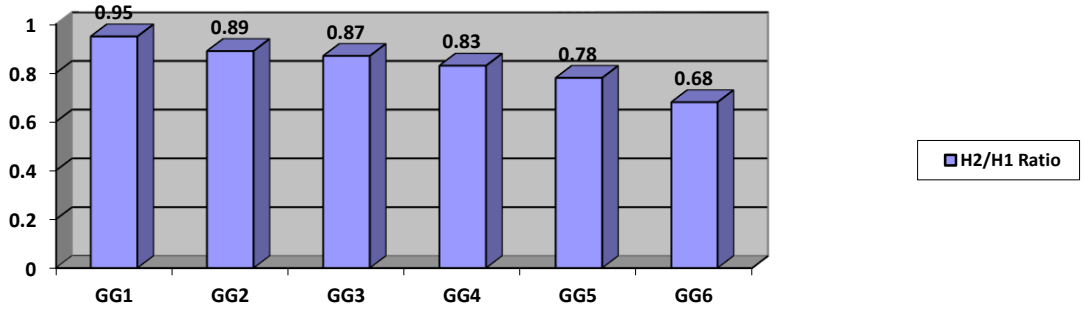
b.) T50 test:

As we can see here, an increase in the dosage of Guar gum powder the speed of flow of SCC is decreases and it increases the time of flow to reach the diameter of 500mm. Shown in below graph chart.



c.) L-box h2/H1 ratio:

As we can see here, an increase in the dosage of Guar gum powder the H2/H1 ratio of SCC is decreases. Shown in below graph chart.

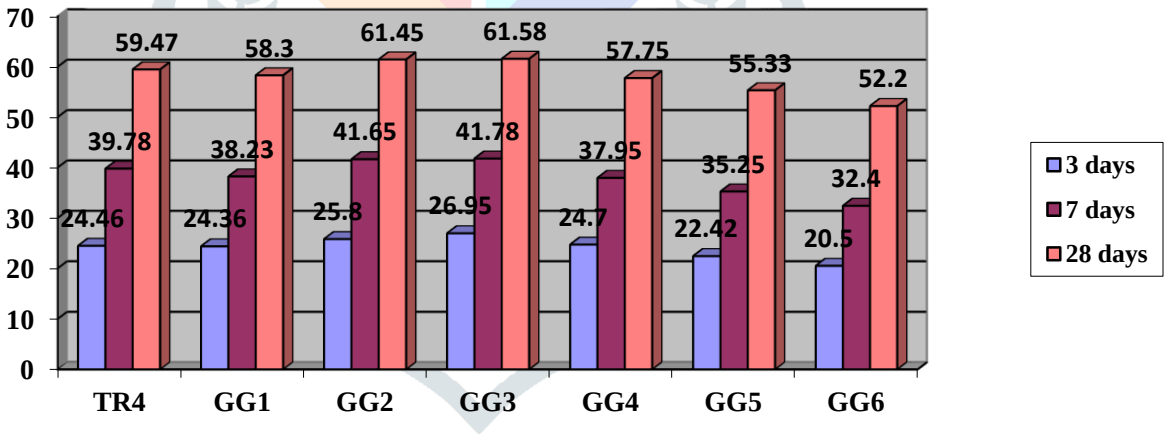


5.2 hardened properties test results:

Mix	Compressive strength (MPa)			Split tensile strength (MPa)		
	3 Days	7Days	28 Days	3 Days	7 Days	28 Days
TR4	24.46	39.78	59.47	2.64	4.36	6.55
GG1	24.36	38.29	58.30	2.17	3.60	5.42
GG2	25.80	41.65	61.45	2.70	4.55	6.77
GG3	26.95	41.78	61.58	2.56	3.67	5.67
GG4	24.70	37.95	57.75	2.50	3.85	5.40
GG5	22.42	35.25	55.33	2.10	3.40	4.90
GG6	20.50	32.40	52.20	1.86	2.94	4.74

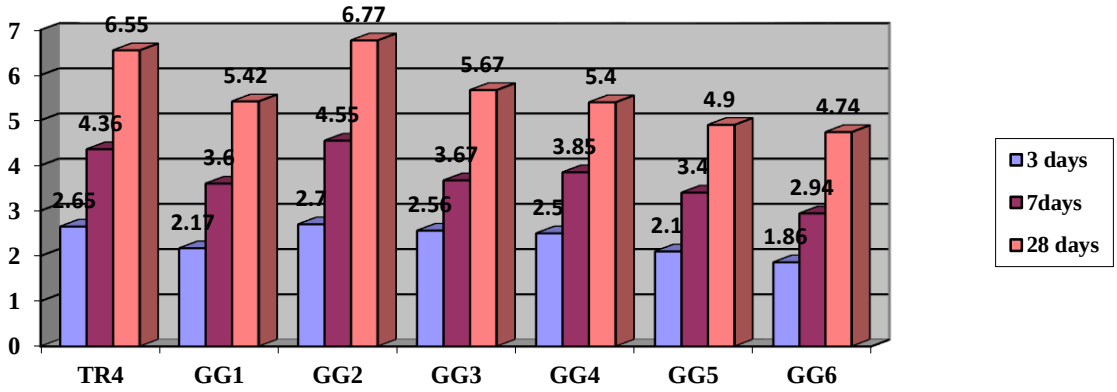
a.) Compressive strength test:

After experimental test results obtained from compressive strength at 3, 7 and 28 days; we can see here, an increase in the dosage of Guar gum powder the strength of SCC is further gradually increases from 1% to 3% dosage and then it was decreases at 4%, 5% and 6% dosage. Shown in below graph chart.



b.) Split tensile strength test:

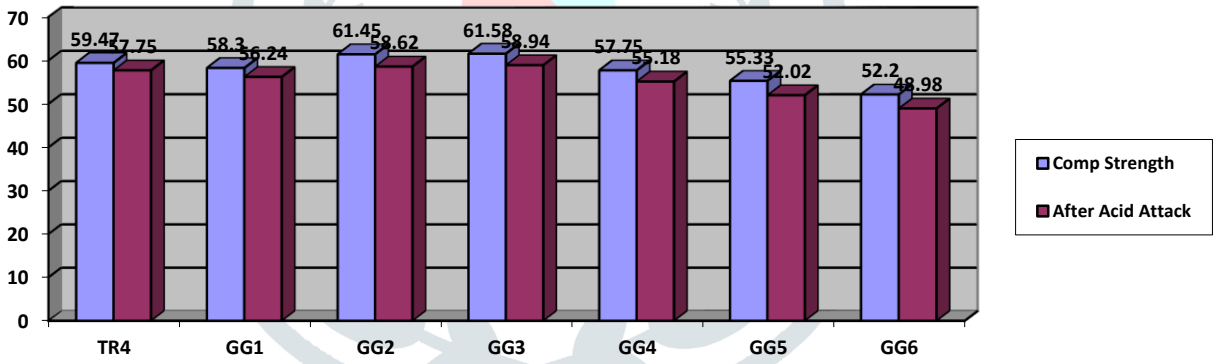
After experimental test results obtained from compressive strength at 3, 7 and 28 days; we can see here, an increase in the dosage of Guar gum powder the strength of SCC is further gradually increases into 1% and 2% dosage and then it was decreases from 3% to 6% dosage. Shown in below graph chart.



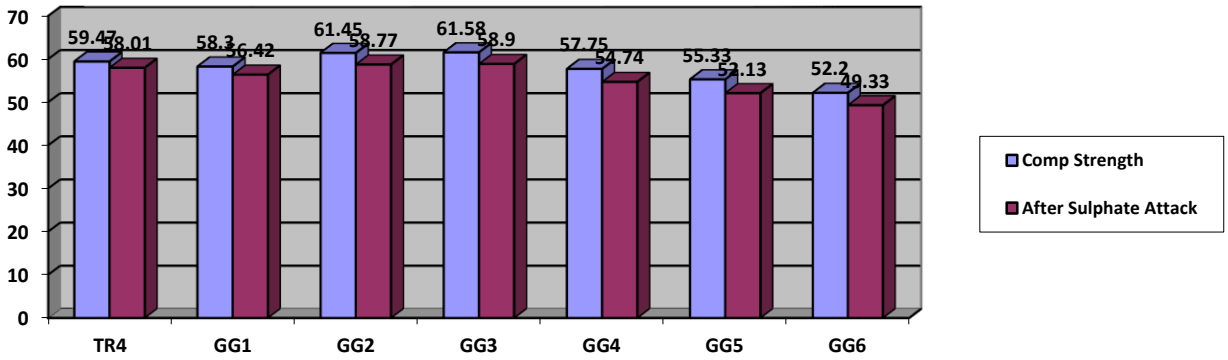
5.3 Durability Properties tests:

Mix	Comp. strength (MPA)	Comp. Strength after HCL attack (MPa)	Avg. loss of comp. strength (%)	Comp. Strength after H_2SO_4 attack (MPa)	Avg. loss of comp. strength (%)
TR4	59.47	57.75	2.88	58.01	2.45
GG1	58.30	56.24	3.53	56.42	3.21
GG2	61.45	58.62	4.60	58.77	4.35
GG3	61.58	58.94	4.28	58.90	4.20
GG4	57.75	55.18	4.45	54.74	5.20
GG5	55.33	52.02	5.97	52.13	5.78
GG6	52.20	48.98	6.16	49.33	5.48

a.) Compressive strength after HCL attack test:



b.) Compressive strength after H_2SO_4 attack test:



6. CONCLUSION:

a) By replacing of guar gum powder to cement there was has no negative effect in properties of SCC.
b) In the increment of dosage of guar gum powder, it shows the increment in fresh properties of SCC.

c) In Slump flow test, the result shows that, by replacing the cement from guar gum powder with 1% to 6% there is decrease in the slump flow up to 29.2%.

d) In L-Box Test, The result shows that, replacing the cement from guar gum powder by 1% to 6% by there will be decreases the ratio (H2/H1) of L-box test 28.42%.

e) In T50 Time test, results shows that as the dosage of guar gum powder increases then also increases the plastic viscosity.

f) In Hardened property such as Compressive strength results shows that guar gum powder can be used up to 3% to achieve target mean strength of concrete for M 50 grade. It was 3.54% higher than the target mean strength at 28 days of casting.

g) In Compressive strength test results shows that guar gum powder can be used up to 2% to achieve tensile strength of concrete for M 50 grade. It was 3.33% higher than the tensile strength of TR4 at 28 days of casting

h) In Durability test using HCL solution and H2So4 Solution in M50 grade of concrete, Results shows that there is **minimum** % loss in HCL was 3.53% at GG1(1% GGP & 1% SP) and in H2So4 was 3.21% at mix GG1(1% GGP & 1% SP).

i) In Durability test using HCL solution and H2So4 Solution in M-30 grade of concrete, Results shows that there is **maximum** % loss in HCL was 6.16% at mix GG6 (6% GGP & 1% SP) and in H2So4 was 5.78% at mix GG5 (5 % GGP & 1% SP).

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