ACID RESISTANCE OF FLY-ASH –GGBS BASED GEOPOLYMER CONCRETE USING FIBRE

Abstract

Today, concrete is the second most used after water for global utilization. As concrete is formed by mixture of many chemicals which leads to many global changes in environment. Instead of cement, the waste produced from the steel and thermal industries such as ggbs, fly-ash are been replaced by cement. Such concrete is known as geopolymer concrete. This research is about study of durability properties of ggbs, fly-ash based geopolymer using fibers. Since geopolymer concrete cannot be direct mixable with water so here we have introduced water glass (sodium silicate). Water and water glass are taken in the ratio 0.3 by adding glass, polypropylene and steel fibers in 0.1%, 0.3%, 0.5% & 1.00%. These concretes are later performed durability studies acid & sulphate resistance test 7% for 28 days. The good results of highest compressive strength were obtained at 0.5% of glass fiber, 0.5% of polypropylene fiber & 1% of steel fiber.

Keywords: highest compressive strength, acid resistance test, sulphate resistance test, water / water glass (sodium silicate) = 0.3

Authors

Sri S. Rajasekhar
Assistant professor
Ced Kamala Institute of Technology & Science
Singapuram Karimnagar, India

Prof. B. Shesha Srinivas
Professor
CED Kakatiya University
Warangal, India

I. INTRODUCTION

Davidovits used the term "geopolymer" in 1978 to describe a class of mineral binders having chemical compositions similar to zeolites but with an unformed microstructure. Unlike normal portland cement, geopolymers don't use calcium-silicate-hydrates (cshs) for the conformation and also energy production, but they depend on polymerization of oxide and corundum precursors for providing the structural energy. Geopolymers are made of two major components: supply equipment and alkaline liquids. The alumino-salt source materials should be rich in siand as well as aluminium (al). They might be by-products such as cowl ash, oxide cloud, sediment, rice- cocoon ash, crimson slush, and so on. Geopolymers are also distinct from other aluminosilicate accessories (for example, aluminosilicate gels, eyeglasses, and zeolites). Geo-polymerization has a more sophisticated sight of solids than aluminosilicate gel or zeolite conflation. This concrete use helps to decrease waste stock and also reduces carbon expatriation by lowering hydraulic cement consumption. The applications include employing gpc in light pavements for casting. Water tanks and precast beams are examples of where it is used. Because geo-polymer minimises the demand for opc, it reduces co2 emissions. It creates longer-lasting infrastructure and protects water bodies and land from pollution

In this paper [1], to study the durability studies of fly-ash based geopolymer concrete which are incorporated with slag and alkaline solutions in different mix grade. The results were the mechanical properties it is observed that the concrete mixes with eighty percent fly-ash and twenty percent ggbs and little or complete portion of m-sand which used was obtained almost equal to g30 grade. So it can be used in place of traditional concrete mix. These mixes are designated g20m0, g20m50, and g20m100. Due to attacks from sulfuric acid and sulphate, traditional concrete loses weight at a higher rate than geopolymer concrete. Next after 28 days and 56 days and 90 days it is observed that the sulfuric acid effect on the geopolymer concrete is less than portland cement as the compressive strength was lost was little. Compared to other types of concrete, geopolymer concrete absorbs water at a lower percentage loss concrete made with regular portland cement at 28, 56, and 90 days.

In this paper [2], to know the durability study on high calcium fly-ash based geopolymer concrete. They have used h_2so_4 and $mgso_4$ in combination of gpc and opc, the effects observed are they have showed very little changes in strength and weight test. That means they didn't lost strength. Opc lost more strength comparatively gpc when exposed to sulphuric acid for 7 – 45 days. When exposed to magnesium sulphate, density of opc is decrease between 4% - 6% while for gpc decreased in between 2% - 3%.

In this paper [3], checked whether the durability of pumice & fly-ash based geopolymer concrete with calcium aluminate cement was decreased or increased.

In this paper [4], to know the performance of fiber ggbs based alkali – activated concrete. The microstructure of the three mixtures' specimens was also analysed and looked into using a scanning electron microscope. The following conclusions were drawn from the specimens used in this study, based on their results: 40.72% severally. The si/al ratio has a high significant impact on the high pozzolanic activity of slag, and the paste's initial and final setting times, catalyst (na content) act for reactions. Although the higher alkaline solutions' viscosity (sodium hydroxide and sodium silicates) decreased the alkali-activator mortar of flowability in comparison to opc mortar specimen. Elastic modulus, compressive strength in addition of fibres improved the mechanical properties and tensile characteristics strength. The ppf mix specimen was increased by 7.5%, 10.55% and 19.28%, by the strength of elastic modulus, compressive strength, and tensile strength. The sf mix samples were improved compared to those c mix samples, there were 6.9%, 9.11%, and 26.81% differences.

In this paper [5], the replacement of 40% of cement with ggbs in the scc2 mix resulted in better fresh properties compared to the scc1 and scc3 mixes. As a result, the scc2 mix was chosen as the optimal mix and tested for its hardened properties.

In terms of fresh properties, the scgpc mixes performed better, while the scc2 mixes showed higher strength. The scgpc mix had a slight decrease in strength compared to the conventional concrete (cc1) and scc2 mix, but it still met the strength requirements of the m40 grade. By gradually adding fibers at a rate of 0.5% of the powder content to the optimal scgpc2 mix, the fresh properties were reduced, but the maximum strength in flexure and splitting was achieved at 1.5%. The scgpfrc2 mix, containing 1.5% fibers, had better compressive strength than the other scgpfrc mixes, but not as strong as the scc2 mix.the introduction of fibers into the concrete significantly increased the flexural strength of the scgpfrc mix when compared to the scgpc mixes, and was approximately the same as the scc2 and cc1 mixes. At a fiber content of 1.5% (scgpfrc2), the flexural strength was found to be increased by 15.73% compared to the scgpc2 mix.

In this paper [6], fibre reinforced geopolymer concrete is a new form of concrete which uses fibers and geopolymer binders to increase durability & strength. D. Naveen kumar and dr. Kolli ramujee has studied the durability properties of frgpc which was mixed with fly-ash and ground granulated blast furnace slag in a recent study.The study aimed to learn about the effects of incorporating fly-ash and ggbs as substitutes in part for cement on the mechanical characteristics and durability of frgpc. The study also wanted to find out the influence of steel fiber absorption on the strength and impact resistance of the frgpc.The authors performed a study using fly-ash and ggbs as substitutions for cement in the frgpc mix. Steel fibres were incorporated in the concrete at a rate of 0.5% by volume. After 7, 14, and 28 days of curing, the compressive, flexural, and split tensile properties of the frgpc were evaluated. The frgpc's endurance was further assessed by exposing it to cycles of freezing and thawing along with a sulfuric acid attack.The results of the research demonstrated that the use of fly-ash and ggbs significantly raised the compressive, flexural, and split tensile strength of the frgpc. When compared to the control mix, the compressive strength of the frgpc increased by 12.5%, 15%, and 17.5% after 7, 14, and 28 days of curing, respectively. Similarly, after 7, 14, and 28 days of curing, the frgpc's flexural strength and split tensile strength grew by 8.33%, 11.67%, and 12.17%, and 11.11%, 12.44%, and 16.67%, respectively.

In this paper [7], the investigation focuses on the use of ground granulated blast furnace slag (ggbs) as an alternate to cement in the creation of geopolymer concrete. Researchers revealed that swapping 40% of the cement with ggbs, a blend known as scc2, increased the fresh characteristics of the concrete compared to other mixes evaluated such as scc1 and scc3. In the end, scc2 was chosen as the best integration and stiffened characteristics were reviewed. The study additionally showed that geopolymer concrete mixes (scgpc) surpassed regular concrete mixes with regard to fresh properties. Scc2 mixtures were better in terms of strength. However, when scgpc mixtures were compared to usual concrete (cc1) and scc2 mixes, there was a minor reduction in strength. Nonetheless, the strength criteria were satisfied, and the mix accomplished the m40 grade target strength.the authors further examined the effect of adding fibers to the best scgpc2 mix in increments of 0.5% powder content. They reported that while the fresh features of the concrete were lowered, the highest strengths in flexure and splitting was attained at a fiber level of 1.5% (scgpfrc2). This mix had higher compressive strength than the other scgpfrc mixtures but less strength in compression than scc2. When compared to scgpc2 combinations, adding a handful of fibers to the concrete substantially increased their flexural and splitting strength. The flexibility of the scgpfrc mix was similar to that of regular concrete (cc1) and scc2 mixes. Flexural strength has been shown to be improved by 15.73% at a fiber percentage of 1.5% (scgpfrc2) when compared to the scgpc2 mix. Similarly, the split tensile strength was found to be 25.88% higher in the scgpc2 mix and six percent greater in the conventional concrete (cc1) mix.

In this paper [8], the study participants next examined the impact of fibers on the mechanical characteristics of geopolymer concrete. The fibers were gradually added to the scc2 mix, starting at 0.5% and increasing to 1.5% powder concentration. They discovered that as the fiber level grew, the fresh characteristics of the concrete declined, but that the greatest strength in flexure and splitting was attained at 1.5% fiber concentration. The resulting scgpfrc2 mix had greater compressive strength than before scgpfrc mixes but less strength in compression than the scc2 mix. The study additionally found that adding fibers to geopolymer concrete considerably boosted its flexural strength. The flexural strength in the scgpfrc mix with 1.5% fiber content was found to be comparable to that of the typical concrete (cc1) and scc2 mixes. In fact, the flexural strength of the scgpfrc2 mix was discovered to be 15.73% higher than that of the scgpc2 mix. Similarly, when fibers were included, the capacity for splitting of the geopolymer concrete was found to be significantly improved, and it was roughly similar to that of regular concrete and scc2 mixes. The researchers also studied what effect of various curing conditions on the mechanical characteristics of geopolymer concrete. They discovered that the curing conditions had an important effect on the strength of the geopolymer concrete, with steam curing giving the greatest strength.

- Production of cement requires more energy and also releases co2, which is harmful for the environment. As waste byproducts of thermal power plant and steel industries like fly-ash has binding properties same like cement, we can use replacement of cement.
- This increases the sustainability by using and reducing waste products. It was observed that replacement of cement with fly-ash and ggbs has increased strength and durability of the concrete.
- Fly-ash and ggbs doesn't bind with the only water, it requires an activator to bind with the aggregates and form concrete.
- Before, activation of al- si reaction na_2sio_3 and naoh were used before with different molarity 8m,10m,12m etc … which leaded to quick setting time of paste and gets hardened fast.

Now in-addition to waterglass (na_2sio_3), we are adding water (w/wg=0.3) to increase the setting time, increase strength and to reduce the amount of waterglass which indirectly means cost reduction.

II. METHODOLOGY

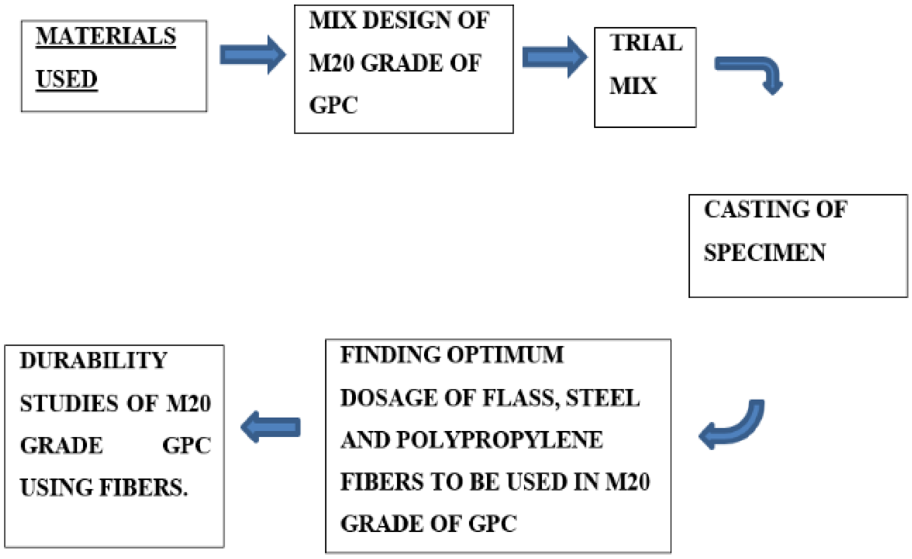

Figure 1: Methodology followed for the study

1. Trial Mix Proportions Considered For The Study

Binder content = 340kg/m^3, aggregate / binder = 5.55
Liquid/binder = 0.55 & fly-ash : ggbs ratio = 50:50

Table 2.1: Represent the quantity of material required for the study

		1-CUBE	2-CUBE	3-CUBE
	QUANTITY	1	2	3
VOLUME(M³)	0.001	0.001	0.002	0.003
DENSITY(Kg/M³)	2400	2397.8	2397.8	2397.8
WEIGHT(Kg)	2.4	2.3978	4.7956	7.1934
BINDER(Kg)	1	0.406	0.812	1.22
FLY-ASH(Kg)	0.5	0.203	0.406	0.61
GGBS(Kg)	0.5	0.203	0.406	0.61
FA(Kg)		1.028	2.056	3.085
CA(Kg)		1.028	2.056	3.085
L(ml)	0.5	0.205	0.41	0.617
WG	1.3	0.158	0.316	0.474
W	0.3	0.047	0.094	0.142

Quantity required for the mix of the geopolymer concrete are calculated by using the above reference table. On calculating we got quantities for 1, 2, 3 cubes required.

Amount of coarse and fine aggregate for 1 cube of concrete mix = 1.028kg
Amount of ggbs and flyash in ratio of 50:50 = 0.203kg

Amount of (water/water glass = 0.3)
Water quantity=0.047ml
Alkaline activator = 0.158gm. Similarly for 2, 3 cubes the estimation of quantities calculated.

Table 2.2: compressive strength of the geopolymer cubes without addition of fibers after 28 days (n/mm^2)

Polypropylene fiber percentage	After 28 days compressive strength of the cube (n/mm^2)
	(w/wg)=0.3
0.1%	32
0.3%	34
0.5%	36
1%	32

Generally, after 7 days of casting the cube, it achieves 70% of compressive strength. After 28 days it achieves 100% compressive strength i.e. 31.395 n/mm2. From table 1, after testing the test specimen, we got 30.62n/mm^2 as average compressive strength.

2. Fly-ash ggbs based geopolymer concrete introduced polypropylene fibers

- The trail mix has given the approx strength which are present in reference table. The same cubes are now introduced polypropylene fibers in 4 different percentages, that are 0.15, 0.3%, 0.5%, 1% with the total weight of the cube i.e 2.4kg.
- 3 mix trail of cubes were done for each percentage, in total 12 cubes are casted by using polypropylene fibers.
- From the table 2, we can see that optimum compressive strength achieved at 0.5% of polypropylene fibers while keeping water to waterglass ratio as constant i.e 0.3 for 28 days of ambient curing.
- Now we need to do acid resistance test and sulphate resistance test using the mix design with inducing 0.5% fibers.
- The compressive strength obtained at various percentage of fibers are 32(n/mm^2), 34(n/mm^2), 36(n/mm^2) and 32(n/mm^2) for 0.1%, 0.3%, 0.5% and 1.00% respectively.

Table 2.3: compressive strength of the geopolymer cubes in addition of polypropylene fibers after 28 days (n/mm^2)

Trial mix without fibers	After 28 days compressive strength of the cube(n/mm^2)
	W/WG=0.3
1	30
2	32
3	30

From the table 2.3 we got the compressive strength values for the 0.1%, 0.3%, 0.5% and 1.00% are 32n/mm^2, 34n/mm^2, 36n/mm^2 and 32n/mm^2 respectively. We have obtained highest compressive strength 36n/mm^2 at 0.5%

3. **Fly-ash ggbs geopolymer concrete introduced glass fibers:** The same process is repeated by introducing glass fiber to the fly-ash, ggbs based geopolymer concrete. Here we added the glass fiber in 4 different percentages that are 0.1%, 0.3%, 0.5% & 1% keeping (w/wg=0.3) and left the concrete for 28 days and it achieved the highest compressive strength at 0.5%

Table 2.4: compressive strength of the geopolymer cubes in addition of glass fibers after 28 days (n/mm^2)

Glass fiber percentage	After 28 days compressive strength of the cube (n/mm^2)
	(w/wg)=0.3
0.1%	30
0.3%	29
0.5%	32
1%	31

From the above table 2.4 we got the compressive strength values for the 0.1%, 0.3%, 0.5% and 1.00% are 30n/mm^2, 29n/mm^2, 32n/mm^2 and 31n/mm^2 respectively. We have obtained highest compressive strength 32n/mm^2 at 0.5%.

4. **Fly-ash ggbs Geopolymer concrete introduced Steel Fibers:** The same process is repeated by introducing steel fiber to the fly-ash, ggbs based geopolymer concrete. Here we added the steel fiber in 4 different percentages that are 0.1%, 0.3%, 0.5% & 1% keeping the water to water glass ratio constant i.e (w/wg=0.3) and left the concrete for 28 days and it achieved the highest compressive strength at 1% that is 38 n/mm^2.

Table 2.5: compressive strength of the geopolymer cubes in addition of steel fibres after 28 days (n/mm^2)

Steel fiber percentage	After 28 days compressive strength of the cube (n/mm^2)
	(w/wg)=0.3
0.1%	31
0.3%	32
0.5%	34
1%	38

From the above table 2.5 we got the compressive strength values for the 0.1%, 0.3%, 0.5% and 1.00% are 31n/mm^2, 32n/mm^2, 34n/mm^2 and 38n/mm^2 respectively. We have obtained highest compressive strength 38n/mm^2 at 1.00%.

5. **Durability tests performed on the geopolymer concrete using fibers are Acid resistance test:** The acid resistance test is used to determine the durability of the geopolymer concrete in acidic conditions/environments. It is a important test which is used to be for the super structures like wastewater plant treatment, industrial factories, storage tank and which are mostly exposed to the ground water as it contains different chemicals and minerals. To withstand all conditions this test is performed. Requirements of the test includes 7% sulphuric acid solution, separate curing tank, digital weighing machines. The no of cubes tested for this acid resistance test are 9 i.e [3 cubes of 0.5% polypropylene fiber, 3 cubes of 0.5% glass fiber and 3 cubes of 1% steel fiber where the highest strengths are achieved by addition of various percentages of fibers. The weights of the cubes were measured after ambient curing for 28 days and placed the cubes in a separate tank by preparing a solution of 7% sulphuric acid of 98% acidimetric or concentration. The amount of acid required for 1lt of water is calculated by using the formula

   M1v1 = m2v2
   98x = 7(1000)
   X = 71.42ml of acid for 1000ml of water.

   Here we have taken 15lt of water and added 1.07lt of acid. The cubes were placed very carefully wearing a pair of gloves. Special care should be taken while performing the test as it is dangerous. The cubes were allowed to cure in the acid tank for 28days and then later washed with the water and dried the cubes under sunlight for 24hours. Now the cubes were measured with the digital weighing guage and noted the weights of each cube. Percentage loss of cubes by taking the final reading of the average weight of 3 cube

Table 2.6: Reading of 0.5% polypropylene fiber before and after the acid test performance

S.NO	WT OF CUBES BEFORE CURING AFTER 28 DAYS OF AMBIENT CURING(Kg)	WT OF CUBES AFTER AMBIENT CURING FOR 28DAYS + CURING IN ACID SOLUTION FOR 28DAYS(Kg)	COMPRESSIVE STRENGTH OF CUBES AFTER 28 DAYS OF AMBIENT CURING(N/mm^2)	COMPRESSIVE STRENGTH OF CUBES AFTER AMBIENT CURING FOR 28DAYS + CURING IN ACID SOLUTION FOR 28DAYS (N/mm^2)
1	W1= 2.39	Y1= 2.03	36	19
2	W2= 2.4	Y2= 2.04	36	20
3	W2= 2.4	Y3= 2.04	36	18

The above tables 2.6, the readings of weights and compressive strengths before and after the test performed. After the calculations we got the highest compressive strength $20n/mm^2$ among the 3 trails mix of specimen.

Table 2.7: Reading of 0.5% glass fiber before and after the acid test performance:

S.NO	WT OF CUBES BEFORE CURING AFTER 28 DAYS OF AMBIENT CURING(Kg)	WT OF CUBES AFTER AMBIENT CURING FOR 28DAYS + CURING IN ACID SOLUTION FOR 28DAYS(Kg)	COMPRESSIVE STRENGTH OF CUBES AFTER 28 DAYS OF AMBIENT CURING(N/mm²)	COMPRESSIVE STRENGTH OF CUBES AFTER AMBIENT CURING FOR 28DAYS + CURING IN ACID SOLUTION FOR 28DAYS (N/mm²)
1	W1= 2.39	Y1= 2.1	32	20
2	W2= 2.4	Y2= 2.08	32	21
3	W3= 2.4	Y3= 2.13	32	19

The above table 2.7, the readings of weights and compressive strengths before and after the test performed. After the calculations we got the highest compressive strength 21n/mm^2 among the 3 trails mix of specimen.

Table 2.8: Reading of 1% steel fiber before and after the acid test performance

S.NO	WT OF CUBES BEFORE CURING AFTER 28 DAYS OF AMBIENT CURING(Kg)	WT OF CUBES AFTER AMBIENT CURING FOR 28DAYS + CURING IN SOLUTION FOR 28DAYS(Kg)	COMPRESSIVE STRENGTH OF CUBES AFTER 28 DAYS OF AMBIENT CURING(N/mm²)	COMPRESSIVE STRENGTH OF CUBES AFTER AMBIENT CURING FOR 28DAYS + CURING IN SOLUTION FOR 28DAYS (N/mm²)
1	W1= 2.38	Y1= 2.2	32	20
2	W2= 2.4	Y2= 2.19	32	21
3	W3= 2.39	Y3= 2.15	32	19

The above table 2.8 and graph 2.6 are the readings of weights and compressive strengths before and after the test performed. After the calculations we got the highest compressive strength 23n/mm^2 among the 3 trails mix of specimen.

% loss = (initial wt of the cube - final wt of the cube) / initial wt of the cube x 100.
%loss for polypropylene fiber = (15.03+15+15) % / 3 = 15.01%.
%loss for glass fiber = (12.1+13.33+11.25) % / 3 = 12.22%.
%loss for steel fiber = (16.66+12.60+11.66) % / 3 = 13.64%.

6. **Sulphate resistance test:** This test is important for knowing the durability of structures as sulphates can react with the hydration of products present in fly-ash and ggbs which causes cracking, expansion, detoriation of structures. It helps to determine the potential resistance to sulphate attack. These results after performing the test indicates whether it is

suitable for construction of super structures in which the sulphates are present like soil, groundwater, sea water.

Requirements of the test includes 7% sodium sulphate powder, curing tank, digital weighing machines. The no of cubes tested for this acid resistance test are 9 i.e[3 cubes of 0.5% polypropylene fiber, 3 cubes of 0.5% glass fiber and 3 cubes of 1% steel fiber

Where the highest strengths are achieved by addition of various percentages of fibers keeping water to waterglass ratio constant as 0.3.

The weights of the cubes were measured after ambient curing for 28 days and placed the cubes in a separate tank by preparing a solution of 7% sulphuric acid of 98% acidimetric or concentration. The amount of acid required for 1lt of water is calculated by using the formula

M1v1 = m2v2
98x = 7(1000)
X = 71.42grams of acid for 1000ml of water.

Here we have taken 15lt of water and added 1.07grams of sodium sulphate powder. The cubes were placed very carefully wearing a pair of gloves. No special care should be taken while performing the test as it is not dangerous. The cubes were allowed to cure in the acid tank for 28days and then later washed with the water and dried the cubes under sunlight for 24hours. Now the cubes were measured with the digital weighing guage and noted the weights of each cube.

Percentage loss of cubes by taking the final reading of the average weight of 3 cubes at the end using the formula.

Table 2.9: Reading of 0.5% polypropylene fiber before and after the sulphate test performance:

S.NO	WT OF CUBES BEFORE CURING AFTER 28 DAYS OF AMBIENT CURING(Kg)	WT OF CUBES AFTER AMBIENT CURING FOR 28DAYS + CURING IN SOLUTION FOR 28DAYS(Kg)	COMPRESSIVE STRENGTH OF CUBES AFTER 28 DAYS OF AMBIENT CURING(N/mm^2)	COMPRESSIVE STRENGTH OF CUBES AFTER AMBIENT CURING FOR 28DAYS + CURING IN SOLUTION FOR 28DAYS (N/mm^2)
1	W1= 2.4	Y1= 2.18	36	21
2	W2= 2.38	Y2= 2.20	36	20
3	W3= 2.39	Y3= 2.22	36	21

We can observer that the compressive strength after the test done is reduced as there will be losses. The highest compressive strength after the test performed is $20n/mm^2$ the weight of the concrete cube.

Table 2.10: Reading of 0.5% glass fiber before and after the test performance

S.NO	WT OF CUBES BEFORE CURING AFTER 28 DAYS OF AMBIENT CURING(Kg)	WT OF CUBES AFTER AMBIENT CURING FOR 28DAYS + CURING IN SOLUTION FOR 28DAYS(Kg)	COMPRESSIVE STRENGTH OF CUBES AFTER 28 DAYS OF AMBIENT CURING(N/mm²)	COMPRESSIVE STRENGTH OF CUBES AFTER AMBIENT CURING FOR 28DAYS + CURING IN SOLUTION FOR 28DAYS (N/mm²)
1	W1= 2.38	Y1= 2.2	32	20
2	W2= 2.4	Y2= 2.19	32	21
3	W3= 2.39	Y3= 2.15	32	19

We can observer that the compressive strength after the test done is reduced as there will be losses. The highest compressive strength after the test performed is 21n/mm^2.the weight of the concrete cube. The weights are also reduced from the original weight.

Table 11: Reading of 1% steel fiber before and after the sulphate test performance:

S.NO	WT OF CUBES BEFORE CURING AFTER 28 DAYS OF AMBIENT CURING(Kg)	WT OF CUBES AFTER AMBIENT CURING FOR 28DAYS + CURING IN SOLUTION FOR 28DAYS(Kg)	COMPRESSIVE STRENGTH OF CUBES AFTER 28 DAYS OF AMBIENT CURING(N/mm²)	COMPRESSIVE STRENGTH OF CUBES AFTER AMBIENT CURING FOR 28DAYS + CURING IN SOLUTION FOR 28DAYS (N/mm²)
1	W1= 2.39	Y1= 2.08	38	25
2	W2= 2.4	Y2= 2.1	38	24
3	W3= 2.38	Y3= 2.12	38	25

We can observer that the compressive strength after the test done is reduced as there will be losses. The highest compressive strength after the test performed is 25n/mm^2 .the weight of the concrete cube. The weights are also reduced from the original weights

% loss = (initial wt of the cube - final wt of the cube) / initial wt of the cube x 100.
%loss for polypropylene fiber = (9.16+7.56+7.11) % / 3 = 7.94%.
%loss for glass fiber = (7.56+8.75+10.04) % / 3 = 8.78%.
%loss for steel fiber = (12.97+12.5+10.9) % / 3 = 12.1%.

III. RESULTS & CONCLSIONS

- The highest compressive strength obtained among 3 fibers is for steel fibers at 1% that is 38 n/mm^2.
- The % loss of cubes after performing the 7% of acid resistance test for 28days is between 12- 16%.
- The % loss of cubes after performing the 7% of sulphate resistance test is between 7-13%.
- The highest compressive strength obtained after performing 7% acid resistance test for 28 days is 23 n/mm^2 for 1% of steel fiber and least compressive strength is 18 n/mm^2 for 0.5% of polypropylene fiber.
- The highest compressive strength obtained after performing 7% sulphate resistance test for 28 days is 25 n/mm^2 for 1% of steel and least is 19 n/mm^2 for 0.5% of glass fiber.
- We can conclude that steel fibers are used to increase the toughness and durability of structures which are suitable for the applications such as floor, bridge decks and tunnel linings etc.
- Glass fibers are used to increase the durability and strength as they are weight less and corrosion resistant and can be moulded into complex shapes.
- Polypropylene fibers are used to decrease the cracking and to improve its durability of structures as they easy to handle and available in precast products.
- Selection of fiber for construction process depends on the various factors and requirements as different fibers offers different properties and benefits. All we have to do is to add the optimum amount of fibers to the mix to gain more durability.

REFERENCES

[1] nagajothi, s., elavenil, s., angalaeswari, s., natrayan, l., & mammo, w. D. (2022). Durability studies on fly ash based geopolymer concrete incorporated with slag and alkali solutions. Advances in civil engineering, 2022.
[2] lavanya, g., & jegan, j. (2015). Durability study on high calcium fly ash based geopolymer concrete. Advances in materials science and engineering, 2015.
[3] karaaslan, c., yener, e., bağatur, t., & polat, r. (2022). Improving the durability of pumice-fly ash based geopolymer concrete with calcium aluminate cement. Journal of building engineering, 59, 105110.
[4] hammad, n., el-nemr, a., & hasan, h. E. D. (2021). The performance of fiber ggbs based alkali-activated concrete. Journal of building engineering, 42, 102462.
[5] kumar, b. N., kumar, g. V., & rajesh, v. (2021). Development of fly ash-ggbs based self compacting geo-polymer concrete with and without steel fibres. Computational engineering and physical modeling, 4(3), 1-18.
[6] kumar, n. D., & ramujee, k. (2017). Durability characteristics of fiber reinforced geopolymer concrete incorporated with fly-ash and ggbs. International research journal of engineering and technology, 4(11), 958-969.
[7] panda, r., sagarika, p., & mohanty, a. M. (2020). Geopolymer concrete: an emerging green material for modern construction. Int. J. Eng. Adv. Technol, 9, 4046-4050.
[8] prabu, b., kumutha, r., & vijai, k. (2017). Effect of fibers on the mechanical properties of fly ash and ggbs based geopolymer concrete under different curing conditions.