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AN EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT WITH GGBFS AND FINE AGGREGATE WITH BFS IN CONCRETE CONTAINS USING GLASS FIBER

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Abstract — *The increasing popularity of concrete as a construction material is placing a huge burden on the natural sand reserves of all countries. In view of the environmental problems faced today considering the fast reduction of natural resources like sand and crushed granite aggregate, engineers have become aware to extend the practice of partially replacing fine aggregate with waste materials. GGBFS is used to make durable concrete structures in combination with ordinary Portland cement. In this present study Ground Granulated blast furnace slag were replaced with Cement and the properties of concrete were studied. Blast furnace slag is a by-product from blast furnaces which is used to produce iron. Blast furnace slag has been used extensively as a successful replacement material for Portland cement in concrete materials to improve durability, produce high strength and high performance concrete, and brings environmental and economic benefits together, such as resource conservation and energy savings. In this study attempt made by the two Materials are replacing with Fine aggregate and Cement with Ground Granulated blast furnace slag and Blast furnace slag with addition of the glass fiber. This study is focuses on the mechanical properties of concrete incorporating mixture with partial replacement of cement by GGBFS and Fine Aggregate by BFS. Twenty mixes were containing cement replacement by GGBFS as 0 to 40%, Fine Aggregate Replacement by BFS as 0 to 40% and mixture of Glass fiber 0.4%, 0.5% by volume for M30 grade of concrete. The durability test is focus on same as above replacement and fiber content for M30 grade of concrete. The mechanical properties investigated in current study include compressive strength, splitting tensile strength, durability test.*

Keywords- *GGBFS, BFS, Glass Fiber, Compressive strength and Spilt tensile strength, durability test*

I : INTRODUCTION

The cement concrete has been the best building material for all types of buildings. In closely spaced designed of reinforcement fair as applied to concentrating in congested areas, decrease the strength of concrete. Structures contain micro cracks develop even before loading connected to plastic and hardened states, drying shrinkage and other causes of volume change and brittleness, higher water permeability, lower flexural strength and toughness, limited resistance to impact and poor tensile strength. So Additional ingredient are required to improve the properties of concrete.

1.1 Ground granulated blast-furnace slag

Ground-granulated blast-furnace slag (GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. The glass content of slags suitable for blending with Portland cement typically varies between 90-100% and depends on the cooling method and the temperature at which cooling is initiated.

1.2 Application of Ground Granulated Blast Furnace Slag (GGBFS)

GGBS is used to make durable concrete structures in combination with ordinary Portland cement and/or other pozzolanic materials. GGBS has been widely used in Europe, and increasingly in the United States and in Asia (particularly in Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years. Two major uses of GGBS are in the production of quality-improved slag cement, namely Portland Blast furnace cement (PBFC) and high-slag blast-furnace cement (HSBFC), with GGBS content ranging typically from 30 to 70%; and in the production of ready-mixed or site-batched durable concrete. Use of GGBS significantly reduces the risk of damages caused by alkali–silica reaction (ASR), provides higher resistance to chloride ingress — reducing the risk of reinforcement corrosion — and provides higher resistance to attacks by sulfate and other chemicals. Use of GGBS significantly reduces the risk of damages caused by alkali–silica reaction (ASR), provides higher resistance to chloride ingress — reducing the risk of reinforcement corrosion — and provides higher resistance to attacks by sulfate and other chemicals.

1.3 Blast Furnace slag

Blast furnace slag is a by-product from blast furnaces which is used to produce iron. Blast furnace slag has been used extensively as a successful replacement material for Portland cement in concrete materials to improve durability, produce high strength and high performance concrete, and brings environmental and economic benefits together, such as resource conservation and energy savings. It is economically and environmentally suitable to use these materials as aggregates in the production of more durable concrete mixtures.

The optimum percentages of replacement of these materials were found out. The result obtained encourages the use of these materials as a replacement material for fine aggregate.

II : Materials

2.1 Cement

Ordinary Portland cement 53 Grade conforming to IS 8122 – 1989 is be used.

Table 1 Physical Properties of Cement

Specific gravity	3.15
Soundness	5.2 mm
Fineness (90 um sieve)	1.7%

2.2 Coarse Aggregate

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The coarse aggregates from crushed basalt rock, conforming to IS: 383 is being use. The Flakiness Index and Elongation Index were maintained well below 15 %.

2.3 Fine Aggregate

Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand is used in combination as fine aggregate conforming to the requirements of IS: 383. The river sand is washed and screens to eliminate deleterious materials and oversize particles.

2.4 Glass Fibers

Glass Fiber: I will use Glass Fiber in my research work. It’s the latest in the legacy of innovative product. The products are ideal and effective secondary reinforcement materials. It’s unique and state of the art next generation products for rendering long lasting solutions to some of the teething problem of construction and infrastructure industries

Table 2 Properties of Glass Fiber

Sr.no	Property	Glass fiber
1.	Filament Diameter H (+10%)	13, 19, 25 6, 18, 35
2.	Zirconia Content	Min. 17% 19% or high
3.	Density (g/cm)	2.7 2.54
4.	Modulus Elasticity	72 GPA 70 GPA
5.	Resistance to Acid	Yes Yes

Fig 1 Glass Fiber

2.5 Ground Granulated Blast Furnace Slag (GGBFS)

The main components of blast furnace slag are CaO (30-50%), SiO2 (28-38%), Al2O3 (8-24%), and MgO (1-18%). In general increasing the CaO content of the slag results in raised slag basicity and an increase in compressive strength. The MgO and Al2O3 content show the same trend up to respectively 10-12% and 14%, beyond which no further improvement can be obtained.

Table 3 property of GGBFS

Sr.no.	property	GGBFS
1.	Sio2	35.47
2.	CaO	35.89
3.	MgO	8.06
4.	Fe2O3	2.41
5.	Al2O3	14.27
6.	Fineness (cm2/gm)	3820
7.	Specific Gravity	2.8
8.	SO3%	1.58
9.	MnO	0.34
10.	Alkalies	0.2

Fig 2 GGBFS

2.6 Blast Furnace Slag (BFS)

Table 4 BFS Physical Properties

Typical Physical Properties Of Blast Furnace Slag			
Slag Type and Value			
Property	Air-Cooled	Expanded	Pelletized
Specific Gravity	2.0 - 2.5	-	-
Compacted Unit Weight, kg/m3	1120 - 1360 (70 - 85)	(800 - 1040) (50 - 65)	840 (52)
Absorption (%)	1 - 6	-	-

Table 5 Typical Composition Of Blast Furnace Slag

Constituent	Mean	Range
Calcium Oxide (CaO)	41	34-48
Silicon Dioxide (SiO2)	36	31-45
Aluminum Oxide (Al2O3)	13	10-17
Magnesium Oxide (MgO)	7	1-15
Iron (FeO or Fe2O3)	0.5	0.1-1.0
Manganese Oxide (MnO)	0.8	0.1-1.4
Sulfur (S)	1.3	0.9-2.3

Fig 3 BFS

2.7 Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. It helps to from the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully.

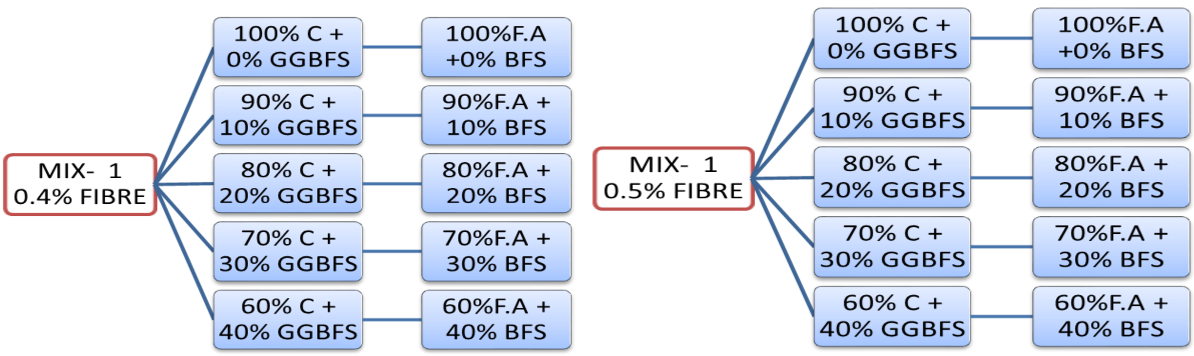
III : Concrete Mix Proportions

- Mix Proportions…

Table 6 mix design for M30

Water – Cement Ratio	0.45
Mass of Cement	380 kg/m3
Mass of Fine Aggregate	711 kg/m3
Mass of Coarse Aggregate	1283 kg/m3
Mass of Water	160 kg/m3
Chemical Admixture	5 kg/m3

- The mixture proportioning was done according the IS Method IS: 10262 – 2009. The target mean strength w as 30 Mpa for the control mixture, the total cement content was 380 kg/m3, F.A. and C.A. content was taken 711 kg/m3 and 1283 kg/m3 respectively, the W/C ratio was kept 0.45, 150 mm x 150 mm x 150 mm cube and 150 mm diameter and 300 mm height cylinder moulds were used for casting. The total mixing time was 5 minutes; the samples were then casted and left for 24 hrs before demoulding. They were then placed in the curing tank until the day of testing. The concrete specimen were cured in the tank for 7,14,28 days.



C = Cement

GGBFS = Granulated Ground Blast Furnace Slag

F.A = Fine Aggregate

BFS = Blast Furnace Slag

Mix-1 0.4% Fiber

Mix-2 0.5% Fiber

IV. METHDOLOGY

4.1 Compression Test

The compression strength of concrete is mainly defined as the load which leads to failure of the specimen divided by the area of the cross section in uniaxial compression, under a specified rate of loading. The cubes were tested in 2000KN capacity compression testing machine loaded at 140Kg/cm2/min as per standard procedure explained in IS: 516-1956(1999) to get the compression strength of the concrete. The load at which cube fail or get crack or collapse is known as ultimate load, it is noted for each specimen. The values are tabulated and calculations are done.

Comparison of compressive strength in between normal mix and green blocks after 7, 14 & 28 days curing of cube for 0.4 % glass fiber & 0.5% glass fiber.

Compression strength = Ultimate Load/Area (N/mm2)

4.2 Spilt Tensile Test

The tensile strength is one of the vital and important tests of the concrete. The concrete is not more often than not predictable to resist the direct tension because of its low tensile strength as well as harsh character. The cracking is a type of tension collapse or a type of tensile failure. The test is conducted as per IS: 58161999. A concrete cylinder of size 150mm dia×300mm height is subjected to compressive force at a rate of 4tons/min along two opposite edges. The cylinder is under compression near the loaded region across the diameter and cylinder is under to uniform tensile stress all through length.

The calculated is done using the equation given below,
Horizontal tensile stress = $2P/\pi DL$
Where, P = Compressive load on the cylinder.
L = Length of the cylinder.
D = cylinder diameter.

V. RESULT & SUMMARY

5.1 Workability

From The Result Workability of fresh concrete is increasing up to 0 to 30% Replacement of GGBFS with Cement & BFS with Fine Aggregate addition of 0.4% & 0.5% of glass Fiber. After 30% Workability is decreasing. Show in the Figure.

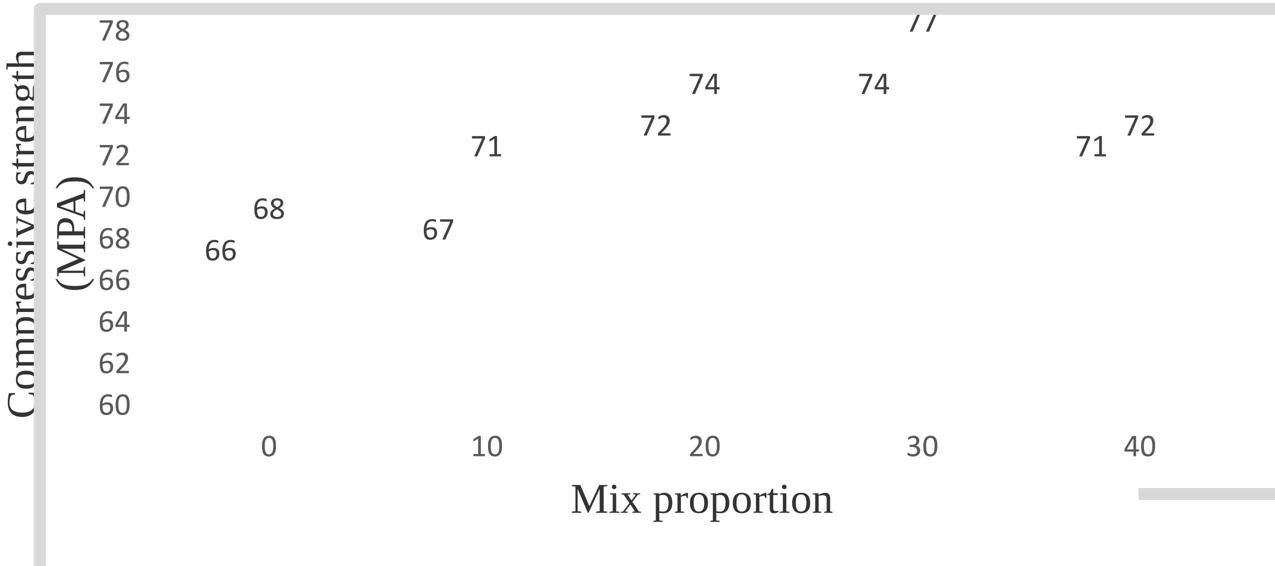


Fig 4 slump test value chart

5.2 Compressive Strength & Split Tensile Strength

The Compressive Strength of 7 Day is Increasing 10 to 30% Replacement of GGBFS & BFS with Cement & F.A Respectively with 0.4% glass Fiber Addition.

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Compressive Strength is found at 30 % Replacement of GGBFS with Cement & BFS with Fine Aggregate addition of 0.4% of glass Fiber. Compare to the 0.4% fiber, 0.5% content of fiber found maximum Compressive Strength which is 4.2% more to the Normal Concrete.

Split Tensile strength at 7, 14 & 28 days for M30 grade of concrete, when 10 to 30 % of Replacement used the compressive strength increased. In the 30% of Replacement, spilt tensile strength is found maximum which 3% , 3.5% , 4% is more than 0% Replacement of GGBFS & BFS addition of 0.4% & 0.5% fiber of glass Fiber.

Table 7 Comparison of compressive strength in between normal mix and green blocks after 7, 14 & 28 days curing of cube for 0.4 % glass fiber.

Sr.no.	GGBFS Proportion	Blast Furnace Slag Proportion	7 Days Comp. Strength In Mpa	14 Days Comp. Strength In Mpa	28 Days Comp. Strength In Mpa	7 Days Split Tensile Strength In Mpa	14 Days Split Tensile Strength In Mpa	28 Days Split Tensile Strength In Mpa
1	**100% C + 0% GGBFS**	**100% F.A + 0% BFS**	19.11	22.66	29.92	2.59	2.73	2.90
2	**100% C + 10% GGBFS**	**100% F.A + 10% BFS**	21.30	24.88	30.98	2.72	2.86	3.04
3	**100% C + 20% GGBFS**	**100% F.A + 20% BFS**	23.72	27.55	32.23	2.77	2.99	3.53
4	**100% C + 30% GGBFS**	**100% F.A + 30% BFS**	24.23	28.88	33.25	2.97	3.25	3.76
5	**100% C + 40% GGBFS**	**100% F.A + 40% BFS**	21.35	26.44	30.36	2.70	2.97	3.25

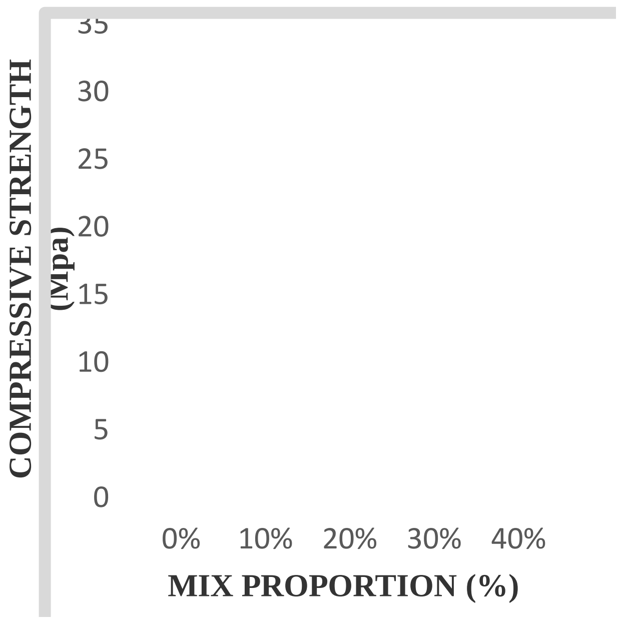

Fig 5 Comparisons of compressive strength

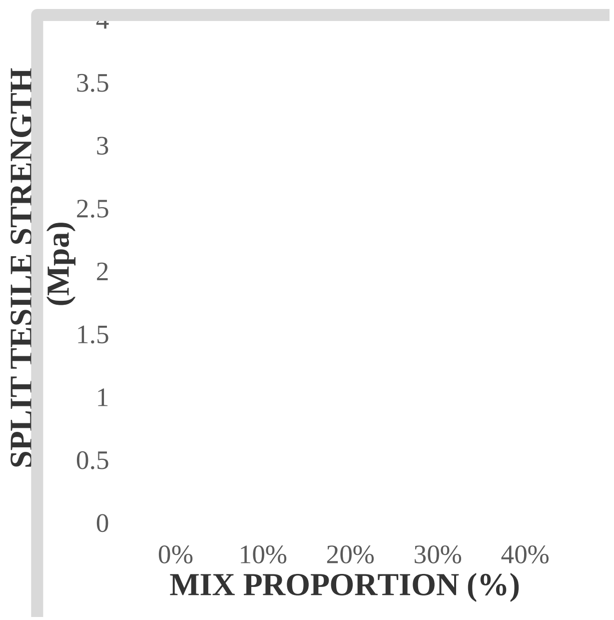

Fig 6 Comparisons of Split Tensile Strength results

Table 8 Comparison of compressive strength and split tensile strength in between normal and green blocks and cylinder after 7, 14, & 28 days curing of cube for 0.5 % glass fiber.

Sr.no.	GGBFS Proportion	Blast Furnace Slag Proportion	7 Days Comp. Strength In Mpa	14 Days Comp. Strength In Mpa	28 Days Comp. Strength In Mpa	7 Days Split Tensile Strength In Mpa	14 Days Split Tensile Strength In Mpa	28 Days Split Tensile Strength In Mpa
1	**100% C + 0% GGBFS**	**100% F.A + 0% BFS**	20.44	23.92	31.10	2.69	2.77	2.96
2	**100% C + 10% GGBFS**	**100% F.A + 10% BFS**	21.77	25.15	32.42	2.87	3.00	3.14
3	**100% C + 20% GGBFS**	**100% F.A + 20% BFS**	24.14	28.14	33.35	3.04	3.34	3.63
4	**100% C + 30% GGBFS**	**100% F.A + 30% BFS**	25.06	29.07	34.18	3.16	3.57	3.92
5	**100% C + 40% GGBFS**	**100% F.A + 40% BFS**	22.66	27.04	31.85	2.78	2.98	3.56

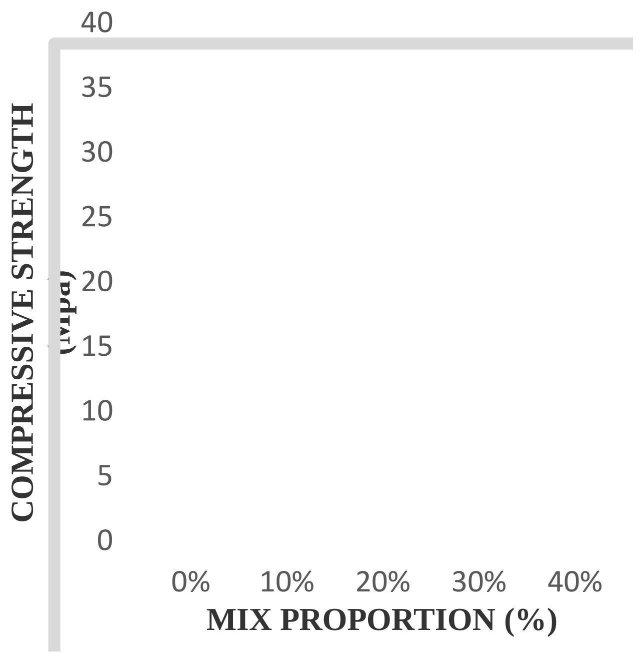

Fig 7 Comparisons of compressive strength

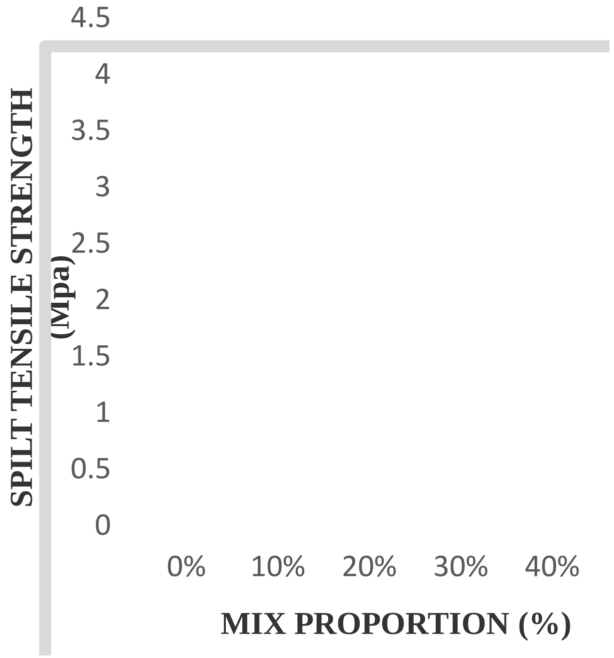

Fig 8 Comparisons of Split Tensile Strength results

4.4 Durability Test

In the Durability test, Compressive Strength is decreasing 0 to 10% of the Normal 28 Compressive Strength of Concrete. Compare to the 0.4% & 0.5% fiber Content Compressive strength, Durability Strength is decreasing 10% and 9% respectively.

Table 9 Comparison of compressive strength in between normal and green blocks after 28 days curing of cube for 0.4% & 0.5 % glass fiber.

Sr.no.	GGBFS Proportion	Blast Furnace Slag Proportion	28 days Durability Compressive Strength for Diff. Fiber Content	28 days Durability Compressive Strength for Diff. Fiber Content
			0.4% FIBRE	0.5% FIBRE
1	100% C + 0% GGBFS	100% F.A + 0% BFS	20.67	21.56
2	100% C + 0% GGBFS	100% F.A + 0% BFS	18.89	19.77
3	100% C + 0% GGBFS	100% F.A + 0% BFS	21.77	22.89
4	100% C + 0% GGBFS	100% F.A + 0% BFS	23.78	25.11
5	100% C + 0% GGBFS	100% F.A + 0% BFS	22.44	23.56

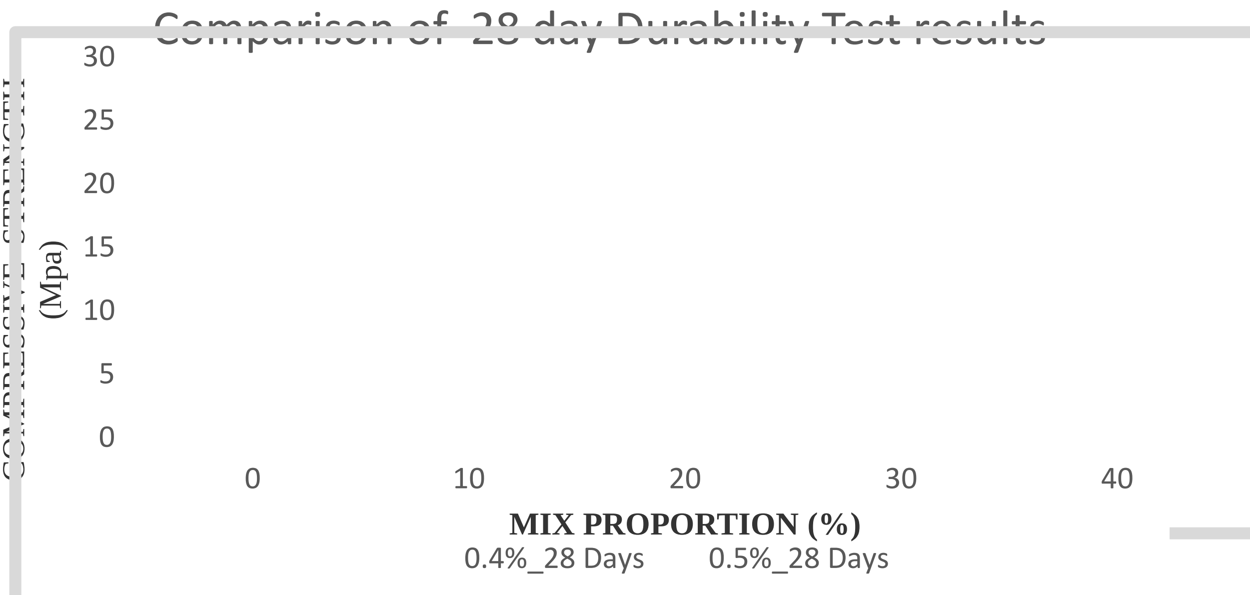

Fig 9 durability test value chart

VI : CONCLUSION

- Based on the research studies the following conclusion can be made:
- The Compressive Strength at 7, 14 & 28 day for M30 grade of concrete, when MIX-1, MIX-2 used the compressive strength are increased in 0 to 30% replacement of GGBFS & BFS. For 40% replacement compressive strength is decreasing.
- For 28 day result maximum found out at 30% replacements of GGBFS & BFS with 0.4% glass Fiber.
- Compare to the 0.4% fiber the strength is increasing at 0.5% Fiber addition in the mix Proportion of Concrete.
- From the result of the 7 day, 14 days and 28 day, the optimum fiber content found at 0.5% addition.
- In the Form, Mix Proportion the maximum Compressive Strength is Found out at 30% Replacement of GGBFS with Cement & Blast Furnace Slag with Fine Aggregate addition of 0.4% & 0.5% of glass Fiber.
- The maximum Compressive Strength is 33.25 Mpa & 34.18 Mpa for 0.4% and 0.5% fiber content at 28 day.
- In the Durability test, Compressive Strength is decreasing 0 to 10% and 10% to 30% increasing then 40% compressive strength is decreasing of the 28 day Compressive Strength

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