An Experimental Study on Partial Replacement of Cement with GGBFS and Fine Aggregate with BFS in Concrete Contains Acrylic Fibre

Nil J. Lunagariya[1], Chetan G. Solanki[2]

[1]*Research Scholar, Department of Civil Engineering, DIET-Rajkot, Gujarat, India*

[2]*Assistant Professor, Department of Civil Engineering, DIET-Rajkot, Gujarat, India*

ABSTRACT

The present day world is observer the construction of very challenging and difficult Civil Engineering structures. 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. In this paper, the two Materials are replacing with Fine aggregate and Cement with addition of the Fibre. This paper focuses on the mechanical properties of concrete incorporating mixture of Acrylic Fibre with partial replacement of cement by GGBFS and Fine Aggregate by BFS. Twenty Four mixes were containing cement replacement by GGBFS as 0 to 35%, Fine Aggregate Replacement by BFS as 0 to 35% and mixture of Acrylic fibre 0%, 0.1% and 0.2% by volume for M35 grade of concrete. The mechanical properties investigated in current study include compressive strength, splitting tensile strength and modulus of rupture also study on durability.

Keyword :- Granulated Ground Blast Furnace Slag, Blast Furnace Slag, Acrylic Fibre; Mechanical properties of concrete.

---

1. INTRODUCTION

In our world today, concrete has become ubiquitous. It is hard to imagine modern life without it. Approximately five billion tones of concrete are used around the world each year. 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. GGBFS 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.

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.

2. EXPERIMENTAL PROGRAM

2.1 Material Used

In this various materials used for the study, their properties, test conducted and results are discussed. This section also explains the mix proportions used for the study.

2.1.1 Cement

Cement was used to work according to IS: 12269 – 2013 – Ordinary Portland Cement, 53 Grade –Specification.

Table – 1: Physical Properties of Cement

Sr. No.	Property	Test Result
1	Specific Gravity	3.15
2	Fineness Test	1.65%
3	Consistency Test	34%-136ml water in 400 gm cement

2.1.2 Fine Aggregate

Fine aggregate was used to work according to IS: 383 – Specification for Coarse and Fine Aggregate from Natural Sources for Concrete which fraction is from 4.75 mm to 150 µ. Some basic test conducted on F.A. in lab oratory. Which results are given below.

Table – 2: Physical Properties of Fine Aggregate

Sr. No.	Property	Test Result
1	Specific Gravity	2.66
2	Water Absorption of Fine Aggregate (%)	0.122
3	Surface Moisture of Fine Aggregate (%)	0.137

2.1.3 Coarse Aggregate

Coarse aggregate was used to work according to IS:383 – Specification for Coarse and Fine Aggregate from Natural Sources for Concrete which fraction is from 20 mm to 4.75 mm. Some basic test conducted on C.A. in laboratory which results are given below.

Table – 3: Physical Properties of Coarse Aggregate

Sr. No.	Property	Test Result
1	Specific Gravity	2.66
2	Water Absorption of Fine Aggregate (%)	0.028
3	Surface Moisture of Fine Aggregate (%)	0.04

2.1.4 Super Plasticizer

In modern concrete practice, it's essentially impossible to make high performance concrete at adequate workability In the field without the use of super plasticizers. The super plasticizer used in the study was Conplast P211.

2.1.5 Granulated Blast Furnace Slag

Ground-granulated blast-furnace slag (GGBS or 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. Blast Furnace Slag are Shown in Figure 1.

2.1.6 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. Blast Furnace Slag are Shown in Figure 2.

2.1.7 Acrylic Fibre

The fibres used were Acrylic fibres which are randomly distributed in the concrete mix. The fibre content were chosen 0% to 0.2% by volume. Acrylic fibres are shown in figure 3.

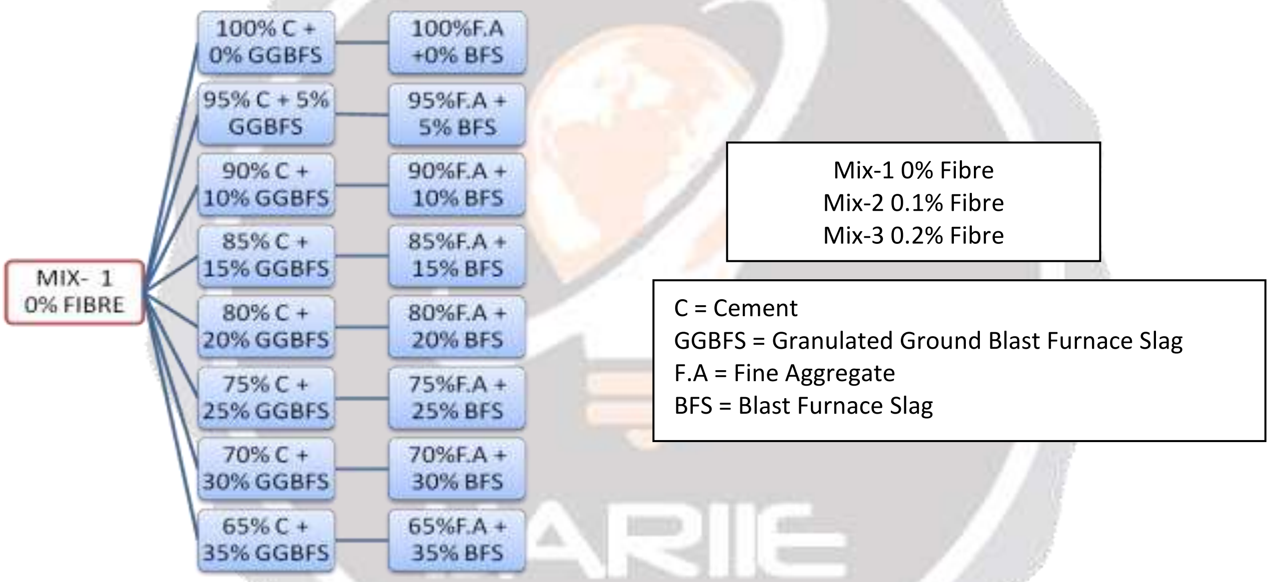
Table – 4: Properties of Acrylic Fibres

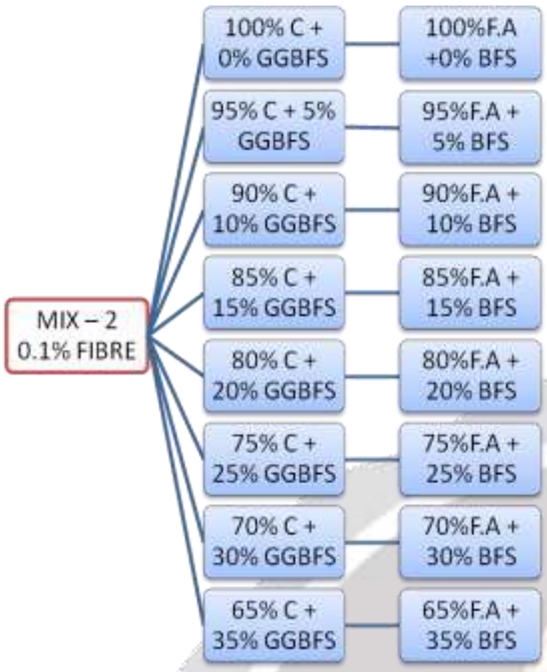
Sr. No.	Test Description	Acrylic Fibre
1	Length	11 mm
2	Color	White

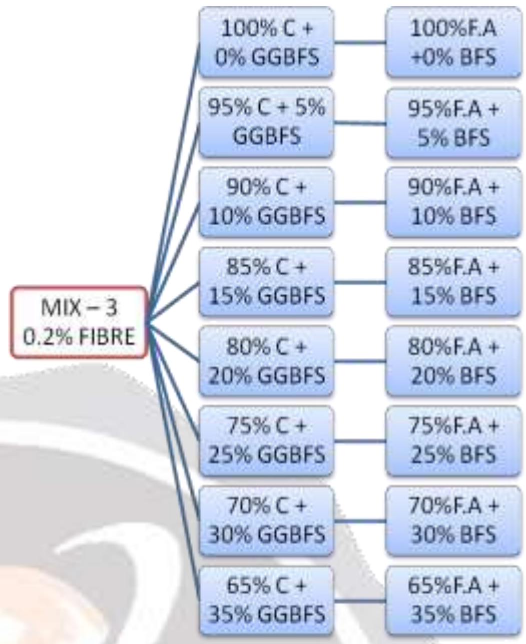
3	Specific Gravity	121 gm/cm^3
4	Density	1.10 gm/cm^3
5	Tenacity	Dry 4.12 gm/den Wet 42 gm/den
6	Surface Moisture	0.97%
7	Elongation of Break	13.67%

2.2 Concrete Mix Proportions

The mixture proportioning was done according the IS Method IS:10262 – 2009. The target mean strength w as 35 Mpa for the control mixture, the total cement content was 403 kg/m3, F.A. and C.A. content was taken 674 kg/m3 and 11800 kg/m3 respectively, the W/C ratio was kept 0.40, the super plasticizer content was 5 kg/m3.150 mm x 150 mm x 150 mm cube, 500 mm x 100 mm x 100 mm beam 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, 28, 56 days.




MIX – 2
0.1% FIBRE
100% C +
0% GGBFS
100%F.A
+0% BFS
95% C + 5%
GGBFS
95%F.A +
5% BFS
90% C +
10% GGBFS
90%F.A +
10% BFS
85% C +
15% GGBFS
85%F.A +
15% BFS
80% C +
20% GGBFS
80%F.A +
20% BFS
75% C +
25% GGBFS
75%F.A +
25% BFS
70% C +
30% GGBFS
70%F.A +
30% BFS
65% C +
35% GGBFS
65%F.A +
35% BFS


MIX – 3
0.2% FIBRE
100% C +
0% GGBFS
100%F.A
+0% BFS
95% C + 5%
GGBFS
95%F.A +
5% BFS
90% C +
10% GGBFS
90%F.A +
10% BFS
85% C +
15% GGBFS
85%F.A +
15% BFS
80% C +
20% GGBFS
80%F.A +
20% BFS
75% C +
25% GGBFS
75%F.A +
25% BFS
70% C +
30% GGBFS
70%F.A +
30% BFS
65% C +
35% GGBFS
65%F.A +
35% BFS

3. RESULTS AND DISCUSSION

3.1 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 0.1% of Acrylic Fibre. After 30% Workability is decreasing. Show in the Figure.

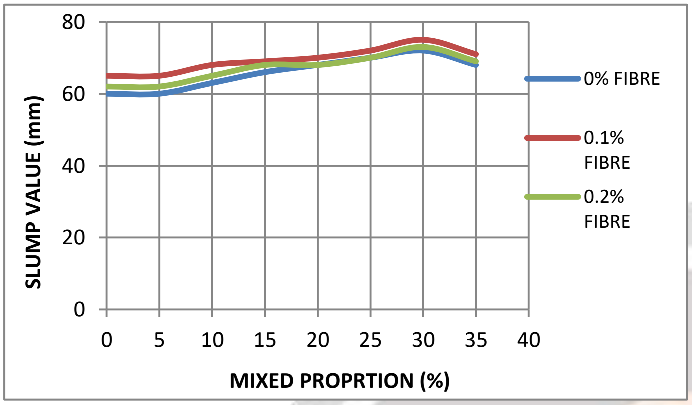


Chart-1 Mix Proportion vs. Slump Value

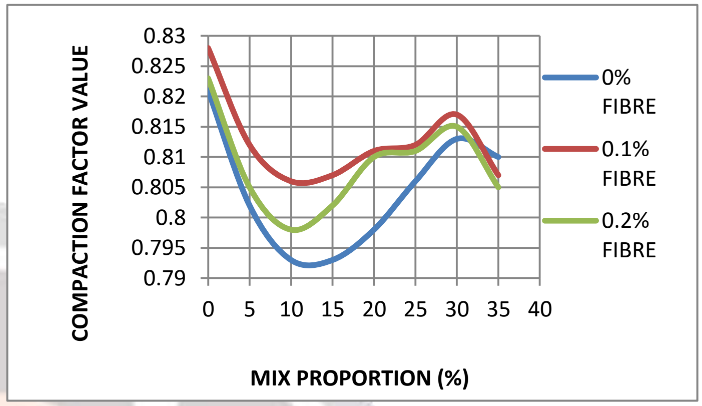


Chart-2 Mix Proportion vs. Compaction Factor

3.2 Compressive Strength

The Compressive Strength of 7 Day is Increasing 5 to 30% Replacement of GGBFS & BFS with Cement & F.A Respectively with 0.1% Acrylic Fibre Addition.

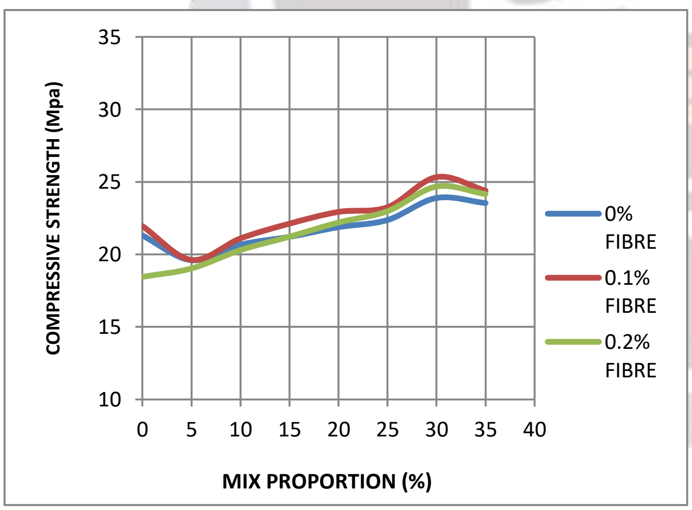


Chart-3 Mix Proportion vs. Compressive Strength (7 day)

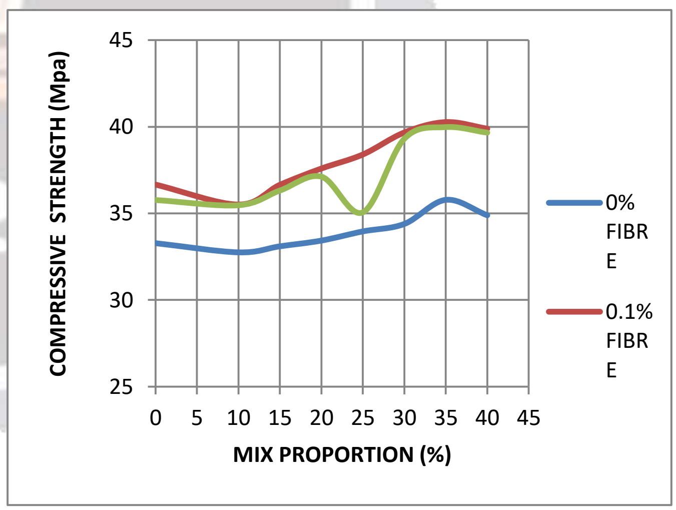


Chart-4 Mix Proportion vs. C.T. (28 day)

Compressive Strength is found at 30 % Replacement of GGBFS with Cement & BFS with Fine Aggregate addition of 0.1% of Acrylic Fibre. Compare to the 0% fibre, 0.1% content of fibre found maximum Compressive Strength which is 12% more to the Normal Concrete.

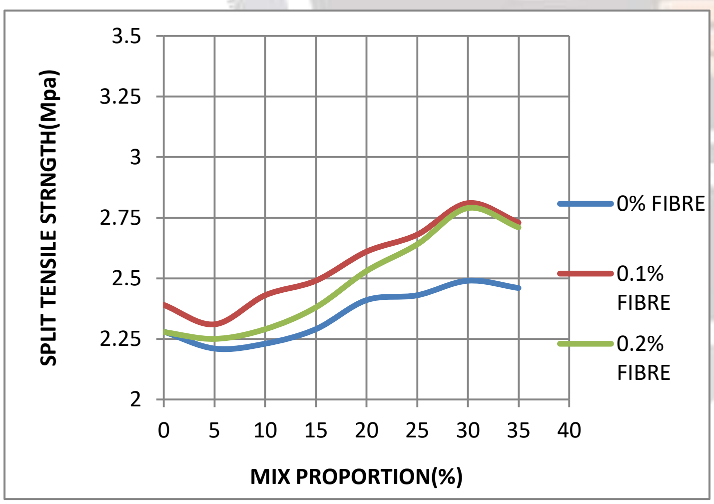
Table shows the 7 days & 28 days compressive strength, splitting tensile strength and flexural strength of the specimen fibre reinforced with 0%, 0.1% and 0.2% of Acrylic fibres (add by volume of concrete).

Sr.	GGBFS	BFS	0% Fibre				0.1% Fibre				0.2% Fibre			
	(%)	(%)	7D C.T	28 C.T	F.T	S.T	7D C.T	28 C.T	F.T	S.T	7D C.T	28 C.T	F.T	S.T
1	0	0	21.30	33.28	3.25	2.28	21.95	36.66	3.55	2.39	18.45	35.77	3.47	2.27
2	5	5	19.6	32.75	2.76	2.21	19.62	35.51	3.6	2.31	19.03	35.47	3.35	2.25
3	10	10	20.67	33.10	2.98	2.23	21.1	36.65	3.8	2.43	20.3	36.32	3.52	2.29
4	15	15	21.21	33.43	3.12	2.29	22.12	37.59	4.03	2.49	21.22	37.12	3.97	2.38
5	20	20	21.88	33.96	3.28	2.41	22.93	38.4	4.1	2.61	22.2	36.55	4.03	2.53
6	25	25	22.37	34.39	3.55	2.43	23.25	39.67	4.37	2.68	22.98	39.31	4.3	2.64
7	**30**	**30**	**23.89**	**35.78**	**3.78**	**2.49**	**25.33**	**40.27**	**4.61**	**2.81**	**24.68**	**39.98**	**4.57**	**2.79**
8	35	35	23.54	34.89	3.57	2.46	24.4	39.89	4.54	2.73	24.16	39.66	4.49	2.71

All the Strength is in Mpa

3.3 Split Tensile Strength & Flexural Strength

The flexural strength at 28 days for M35 grade of concrete, when 5 to 30 % of Replacement used the compressive strength increased. In the 30% of Replacement, Flexural strength is found maximum which 15.17% is more than 0% Replacement of GGBFS & BFS addition of 0.1% of Acrylic Fibre.



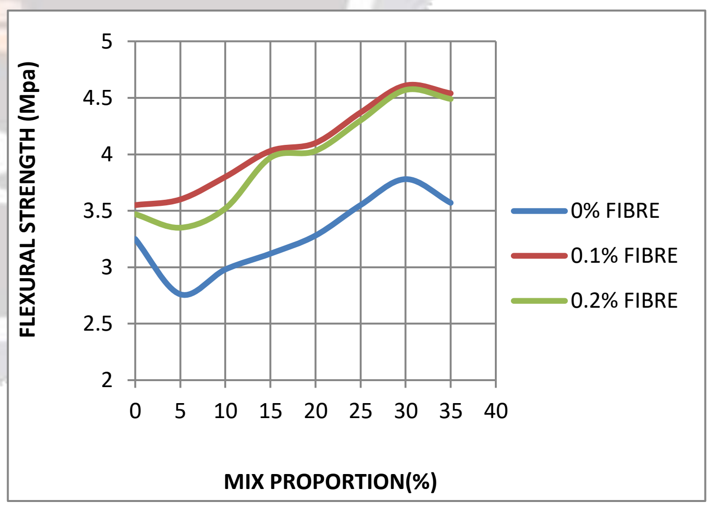


Chart – 5 & 6: Splitting Tensile Strength & Flexural Strength at 28 Day Respectively

Split Tensile strength at 28 days for M35 grade of concrete, when 5 to 30 % of Replacement used the compressive strength increased. In the 30% of Replacement, Flexural strength is found maximum which 29.85% is more than 0% Replacement of GGBFS & BFS addition of 0.1% of Acrylic Fibre.

3.4 Durability Test

The compressive strength after sulphate attack for M35 grade of concrete, when M1 used the compressive increase about 6.59, 3.91, 6.20, 3.18, 3.78% of GGBFS 10 to 50% replacement respectively compared to normal curing. When M2 used the compressive strength increase about 4.29, -2.83, 2.21, -6.33, 6.25% of GGBFS 10 to 50% replacement respectively compared to normal curing. When M3 used the compressive strength increase about 5.22, 0.91, 1.88, 4.20, 5.89% of GGBFS 10 to 50% replacement respectively compared to normal curing. The compressive strength after sulphate attack for M50 grade of concrete, when M1 used the compressive strength increase about 8.83, 9.86, 10.59, 8.68, 8.54% of GGBFS 10 to 50% replacement respectively compared to normal curing. When M2 used the compressive strength increase about 8.88, 10.79, 8.20, 6.77, 7.57% of GGBFS 10 to 50%

c	GGBFS Proportion	Blast Furnace Slag Proportion	56 Day Durability Compressive Strength for Diff. Fibre Content		
			0%	0.1%	0.2%
1	100% C + 0% GGBFS	100% F.A + 0% BFS	31.68	34.03	33.83
2	95% C + 5% GGBFS	95% F.A + 5% BFS	30.98	33.87	33.49
3	90% C + 10% GGBFS	90% F.A + 10% BFS	31.38	34.1	34.22
4	85% C + 15% GGBFS	85% F.A + 15% BFS	31.69	35.7	34.98
5	80% C + 20% GGBFS	80% F.A + 20% BFS	31.92	36.33	33.83
6	75% C + 25% GGBFS	75% F.A + 25% BFS	32.25	36.98	35.68
7	**70% C + 30% GGBFS**	**70% F.A + 30% BFS**	**33.57**	**37.23**	**36.23**
8	65% C + 35% GGBFS	65% F.A + 35% BFS	32.79	36.99	35.91

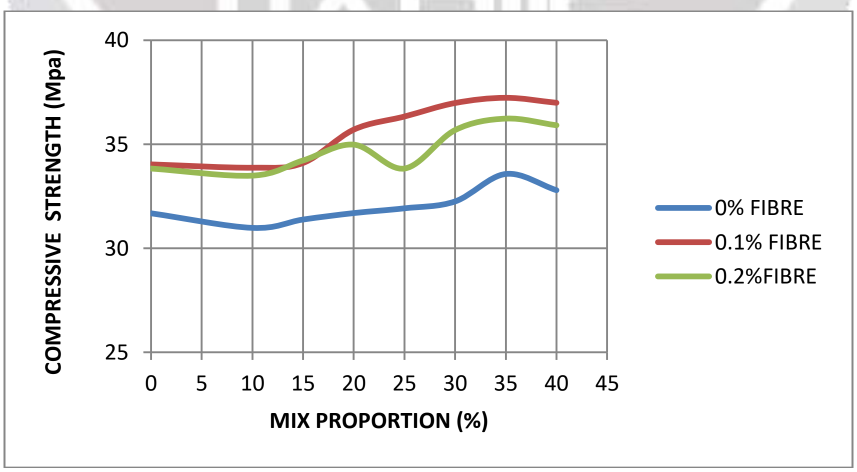


Chart – 7: Durability Compressive Strength vs. Mix Proportion

In the Durability test, Compressive Strength is decreasing 4 to 10% of the Normal 28 Compressive Strength of Concrete. Compare to the 0%, 0.1% & 0.2% fibre Content Compressive strength, Durability Strength is decreasing 6.58%, 8.1% and 10% respectively.

4. CONCLUSION

Based on the research studies the following conclusion can be made:

- The Compressive Strength at 7 & 28 day for M35 grade of concrete, when MIX-1, MIX-2 and MIX-3 used the compressive strength are decreased in 0 to 5% replacement of GGBFS & BFS but when Replacement 5% to 30% compressive Strength are gradually Increasing. For 35% replacement compressive strength is decreasing.
- For 28 day result maximum found out at 30% replacements of GGBFS & BFS with 0.1% Acrylic Fibre.
- Compare to the 0% fibre and 0.2% fibre the strength is increasing at 0.1% Fibre addition in the mix Proportion of Concrete.
- From the result of the 7 day and 28 day, the optimum fibre content found at 0.1% 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 0.1% of Acrylic Fibre.
- The maximum Compressive Strength is 40.27 Mpa at 28 day.
- In the Durability test, Compressive Strength is decreasing 4 to 10% of the 28 day Compressive Strength.

5. ACKNOWLEDGEMENT

This project consumed huge amount of work, research and dedication. Still, implementation would not have been possible if i did not have a support of many people. Therefore i would like to extend my sincere gratitude to all of them.

Prof. C. G. Solanki and Prof. Yogesh V. Akbari has support, advice, guidance, valuable comments, suggestions, and provision that benefited his much in the completion and success of this project. Who gave his love, care shelter in doing this project. Sharing his knowledge and helped to complete the project. Once again thanks a lot both of you.I am also grateful to Principal Dr. R.G. Dhamsaniya and Head of Department Prof. M.D. Barasara.

I express my sincere gratitude to all the lab staff members of strength of materials lab and extend my thanks to all the faculty members of Civil Engineering Department and to all my friends for their guidance Last but not the least; I thank God, the almighty for his blessing without which nothing would have been possible.

6. REFERENCES

[1]. “Contribution of Acrylic Fibre addition and GGBs Furnace slag on the properties of Lightweight Concrte “ - Kim Hung Mo , U. Johnson Alengaram , Mohd Zamin Jumaat , Michael Yong Jing Liu

[2]. “Experimental Studies on Concrete Replacing Fine Aggregate with Blast Furnace Slags ” - J. Selwyn Babu, Dr. N. Mahendran

[3]. “Mechanical and fracture characteristics of Eco-friendly concrete produced using coconut shell, ground granulated blast furnace slag and manufactured sand ” - A. Jaya prithika , S.K. Sekar

[4]. “Effect of acrylic fibres geometry on physical, mechanical and durability properties of cement mortars ” - Luiz A. Pereira-de-Oliveira , João P. Castro-Gomes, Miguel C.S. Nepomuceno

[5].On the use of blast furnace slag and steel slag in the preparation of green artificial reef concrete - Xiaoyan Huang, Zhongjie Wang, Ying Liu, Wentao Hu, Wen Ni

[6] M.S. Shetty. “Concrete Technology – Book”.

[7] IRICE. "Hand Book of Material Testing".

[8] NRMCA Guidelines – www.nrmca.com

[9] Design Of Pervious Concrete www.perviousconcrete.org

[10] IS: 4031 (Part 1 to 5) – 1996. "Method of Physical Tests for Hydraulic Cement" – for Fineness, Soundness, Consistency, Initial & Final Setting Time.

[11] IS: 2386 (Part – 1 & 3) – 1963. "Methods of Test for Aggregates for Concrete" – Partical Size, Specific Gravity, Water Absorption.

[12] IS: 1199 – 1959. "Methods of Sampling and Analysis of Concrete". [15] IS: 516 – 1959. "Methods of Tests for Strength of Concrete".

[13] IS: 3085- 1965. "Method of Test for Permeability of Cement Mortar And Concrete".

[14] IS: 5816 – 1999. "Splitting Tensile Strength of Concrete - Method of Test".

[15] IS: 9013 – 1978. "Method of Making, Curing and Determining Compressive Strength of Accelerated - Cured Concrete Test Specimens".

[16] Stallion Energy Pvt. Ltd., Lafarge Building Better Cities , Ultratech Cement and YOR Lab Rajkot.