



Experimental Study On Mechanical Properties Of Concrete With Fibers Using Glass Powder As Replacement Of Fine Aggregate With Conventional Concrete

¹G.Srikanth, ²Mohd Mahboob Hussain Aiyaz

¹Assistant Professor, ²M.E Student

¹Civil Engineering,

¹Lords Institute of Engineering & Technology, Hyderabad, Telangana

ABSTRACT: Utilizing alternative materials has become more popular in the construction sector in recent years to reduce the impact on the environment and mitigate pollution effects. One such material is glass powder, which can be used as a partial replacement for fine aggregate in concrete. Another trend is the use of basalt fiber, in particular, has gained popularity due to its eco-friendly manufacturing process and excellent mechanical properties. Although relatively new in the construction industry, basalt fibers are cheaper than other fibers and have been studied by researchers for their effect on compressive strength, flexural strength, and splitting tensile strength of fiber concrete.

Similarly, poly vinyl alcohol fiber is a suitable polymeric fiber for use in concrete and has unique microstructure characteristics that present challenges in material design. In this project, the effect of adding basalt fiber and poly vinyl alcohol fiber on the compressive strength, flexural strength, and splitting tensile strength of fiber concrete was studied. Different volumes of fibers were added to the concrete and compared with conventional concrete.

The results of the experiment showed that the addition of up to 0.3% volume of basalt fiber and poly vinyl alcohol fiber individually improved the compressive and flexural strength of the concrete. However, there was negligible influence of fiber addition on the splitting tensile strength. Basalt fiber and poly vinyl alcohol fiber could be utilized in concrete to improve its mechanical properties, and the test results showed that poly vinyl alcohol fiber had a higher splitting tensile strength and flexural strength than basalt fiber in the corresponding mix proportion.

Overall, the study demonstrated the potential of alternative materials such as basalt fiber and poly vinyl alcohol fiber to improve the sustainability and strength of construction materials

I. INTRODUCTION

As a composite material, concrete is formed of cement, water, coarse aggregate and fine aggregates and sometimes additional materials like admixtures or fibers. It is a versatile and a popular building material because of its strength, durability and ability to be shaped and molded into various forms

The basic components of concrete are cement, water and aggregates. Cement is a binding agent that reacts with water to assemble a paste that hardens over time along with and binds the combined aggregates. Water is added to the cement to create a workable paste, aggregates are added to mix to provide bulk and strength to the concrete. Coarse aggregates such as gravel or crushed stone, are used to provide structural support, while fine

aggregates Fillers, like sand, are employed. The voids among the coarse aggregate and helps the cement paste bind to the aggregates

The qualities of concrete, including its sturdiness and durability and workability can be modified by adding various materials like admixtures, fibers, or pigments to the mix the concrete is given admixtures mix to enhance its attributes, such as setting time, workability and strength. Fibers such as steel, synthetic or natural fibers may be included in the mixture. Increasing the concrete strength in tensile, toughness and resistance to breaking. Pigments can be added to the mix to give the concrete a specific color or texture

II OBJECTIVES AND SCOPE

2.1 OBJECTIVES

1. To investigate the mechanical strength of the concrete by the substitution of glass powder along with hybrid fiber
2. To analyze the effects of glass powder as a substitute for fine aggregate in part with poly vinyl alcohol fiber (PVA) and basalt fiber
3. To investigate and compare the behavior of the conventional concrete beam and glass powder with polyvinyl alcohol fiber and basalt fiber concrete beam
4. To investigate the use of basalt fibre as a concrete reinforcing material through different experimental projects
5. To compare the analyzed results with experimental results

2.2 SCOPE

The scope of the present investigation includes:

1. By partially substituting the fine aggregate with glass powder and hybrid fiber, the flexural strength of the beam is assessed.
2. To create a mathematical model for forecasting the flexural strength of glass-powder concrete.
3. To compare the experimental work with the analytical model to determine the impact of glass powder.

2.3 NEED FOR THE PROJECT

1. To assess the effectiveness of basalt fibre and polyvinyl alcohol fibre as partial replacements for fine aggregate in concrete beams.
2. To know the effectiveness of glass powder in strength improvement
3. To examine the impacts of waste glass on characteristics of concrete containing recycled glass
4. To examine the impact of compressive durability of concrete to improve serviceability
5. To improve the long period deflection of the concrete

III.METHODOLOGY

Methodology is a systematic approach to conduct research, Methodology describes the complete procedure from surveying of literatures to comparison of results of conventional mix and mixes with partial replacement of glass powder as fine aggregate with varied proportional of hybrid fibres

IV.Mix design for M40 grade as per IS 10262:2009 & IS 456:2000

Table 4.1 Mix design of M40 grade

Cement (kg)	Aggregate(kg)	Coarse aggregate (kg)	Water (lit)
394	744	1121	157.6
1	1.88	2.84	0.4

Table 4.2 Materials required for the M40 mix for the casting specimens

MATERIALS	CUBE	CYLINDER	BEAM
CEMENT	63.84kg	100.23kg	125 kg
WATER	25.43lit	39lit	49.83 lit
GLASS POWDER	18.14kg	28.8kg	26.6kg
M-SAND	102.32kg	160.8kg	200.59kg
COARSE AGGREGATE	181.44kg	285.18kg	355.8kg
PVA FIBER	0.548kg	0.861kg	1.075kg
BASALT FIBER	0.548kg	0.861kg	1.6131kg

4.1 PREPARATION OF SPECIMENS

4.1.1 Size of the specimens

- Size of cube:150x150x150mm
- Size of cylinder:150x300mm
- Size of beam:1500x230x230mm

4.1.2 Casting of moulds

Casting of cement mixes typically involves the use of moulds to create objects or structures out of cement based mixtures. The process is similar to other casting processes in that a liquid material is poured into a moulds and allowed to solidify, taking on the shape of the moulds cavity.



Fig.4.1 casting of moulds

4.2 TESTING OF SPECIMENS



Fig.4.2 Compression and tensile strength testing machine

Samples and specimen details are mentioned below

The No. of. Cube specimen, Cylinder specimens and reinforced concrete Beams to be casted with each combinations

MIX-A: - 0% of glass powder, 0% polyvinyl alcohol fiber (PVA) and 0% basalt fiber (conventional)

Cubes: 6 Nos

Cylinder: 6 Nos

Beam: 1 No

MIX-B: - 15% Glass powder without polyvinyl alcohol fiber (PVA) and basalt fiber

Cubes: 6 Nos

Cylinder: 6 Nos

MIX-C: - 15% Glass powder with 0.1% polyvinyl alcohol fiber (PVA) and 0.1% basalt fiber

Cubes: 6 Nos

Cylinder: 6 Nos

MIX-D: - 15% Glass powder with 0.1% polyvinyl alcohol (PVA) and 0.3% basalt fiber

Cubes: 6 Nos

Cylinder: 6 Nos

Beam: 1 No

MIX-E: - 15% Glass powder with 0.2% polyvinyl alcohol (PVA) and 0.1% basalt fiber

Cubes: 6 Nos

Cylinder: 6 Nos

MIX-F: - 15% Glass powder with 0.2% polyvinyl alcohol (PVA) and 0.3% basalt fiber

Cubes: 6 Nos

Cylinder: 6 Nos Beam: 1 No

MIX-G: - 15% Glass powder with 0.3% polyvinyl alcohol (PVA) and 0.1% basalt fiber

Cubes: 6 Nos

Cylinder: 6 Nos

MIX-H: - 15% Glass powder with 0.3% polyvinyl alcohol (PVA) and 0.3% basalt fiber

Cubes: 6 Nos

Cylinder: 6 Nos

Beam: 1 No

Table 4.2 Specimen designation of cube and cylindrical samples

SPECIMENS	GLASS POWDER (%)	PVA FIBER (%)	BASALT FIBER (%)
TEST MIX (A) CONVENTIONAL	0	0	0
TEST MIX (B) GLASSPOWDER	15	0	0
TEST MIX (C)	15	0.1	0.1
TEST MIX (D)	15	0.1	0.3
TEST MIX (E)	15	0.2	0.1
TEST MIX (F)	15	0.2	0.3
TEST MIX (G)	15	0.3	0.1
TEST MIX (H)	15	0.3	0.3

Table 4.3 Details of the test and specimens

SI NO	NAME OF THE TEST	DURATION OF CURING	NO OF SPECIMENS	TOTAL NO OF SPECIMENS
01	Compressive strength	7 days	24	48
		28 days	24	
02	Split tensile strength	7 days	24	48
		28 days	24	
03	Flexural strength	28 days	4	4



Fig.4.3 casted specimens

4.3 Compressive strength

TABLE 4.4 COMPRESSIVE STRENGTH OF THE CUBIC SPECIMEN FOR 28 DAYS

CUBIC SPECIMEN LABEL	DURATION OF CURING (DAYS)	STRENGTH (Mpa)			AVERAGE
		SAMPLE 1	SAMPLE 2	SAMPLE 3	
TEST MIX (A)	28	39.1	39.5	40.2	39.6
TEST MIX (B)	28	30.2	32.0	33.3	31.83
TEST MIX (C)	28	31.5	33.5	34.6	33.2
TEST MIX (D)	28	34.6	38.55	38.55	37.2
TEST MIX (E)	28	34.6	35.1	38.2	35.96
TEST MIX (F)	28	36.8	38.5	38.5	37.6
TEST MIX (G)	28	35.5	36.8	37.7	36.66
TEST MIX (H)	28	38.7	40.8	40.96	40.1



Fig.4.4 compression testing on cube specimen

4.4 Splitting Tensile Strength Test



Fig.4.5 splitting tensile strength test on cylindrical specimen

TABLE 4.5 SPLITTING TENSILE STRENGTH OF THE CYLINDRICAL SPECIMEN FOR 28 DAYS

CYLINDRICAL SPECIMEN LABEL	DURATION OF CURING (DAYS)	STRENGTH (Mpa)			AVERAGE
		AMPLE 1	AMPLE 2	AMPLE 3	
TEST MIX (A)	28	3.39	3.46	3.60	3.48
TEST MIX (B)	28	3.18	3.25	3.32	3.25
TEST MIX (C)	28	3.32	3.32	3.46	3.36
TEST MIX (D)	28	3.60	3.60	3.74	3.64
TEST MIX (E)	28	3.60	3.74	3.89	3.74
TEST MIX (F)	28	3.74	3.81	3.89	3.81
TEST MIX (G)	28	3.74	3.81	3.96	3.83
TEST MIX (H)	28	3.96	4.0	4.0	3.98

TABLE 4.6 SPECIMEN DESIGNATION OF THE BEAM SPECIMEN

BEAM SPECIMENS	GLASS POWDER (%)	PVA FIBER (%)	BASALT FIBER (%)
TEST MIX (A)	0	0	0
TEST MIX (D)	15	0.1	0.3
TEST MIX (F)	15	0.2	0.3
TEST MIX (H)	15	0.3	0.3

4.5 Flexural strength test



Fig 4.6 Flexural testing machine

TABLE 4.7 FLEXURAL STRENGTH OF THE BEAM SPECIMEN FOR 28 DAYS

Sl. No	Mix Details	Glass Powder Replacement	PVA Fiber (%)	Basalt Fiber (%)	Load at Failure @ 28 days (kN)	Flexural Strength @ 28 days (MPa)	Remarks
1	Conventional (Control Mix) (OR) MIX-A	0%	0%	0%	9.45 kN	4.6 MPa	Plain concrete
2	15% Glass Powder + 0.1% PVA + 0.3% Basalt Fiber (OR) MIX-D	15%	0.1%	0.3%	11.40 kN	5.2 MPa	Increased strength
3	15% Glass Powder + 0.2% PVA + 0.3% Basalt Fiber (OR) MIX-F	15%	0.2%	0.3%	12.30 kN	5.6 MPa	Further improvement
4	15% Glass Powder + 0.3% PVA + 0.3% Basalt Fiber (OR) MIX-H	15%	0.3%	0.3%	13.20 kN	6.0 MPa	Highest strength observed

V.RESULTS AND DISCUSSIONS

5.1 COMPRESSION STRENGTH OF HYBRID FIBERS REINFORCED CONCRETE

The mean compressive strength of hybrid fiber reinforced concrete with certain proportion of test mix on 7 days and 28 days test

Table 5.1 Average Compressive strength of 7 days and 28 days test

CUBIC SPECIMEN LABEL	GLASS POWDER(%)	POLYVINYL ALCOHOL FIBER PVA(%)	BASALT FIBER (%)	STRENGTH (Mpa)	
				7 days	28 days
TEST MIX (A)	0	0	0	20	39.6
TEST MIX (B)	15	0	0	15.21	31.83
TEST MIX (C)	15	0.1	0.1	16.7	33.2
TEST MIX (D)	15	0.1	0.3	19.7	37.2
TEST MIX (E)	15	0.2	0.1	20	35.96
TEST MIX (F)	15	0.2	0.3	20.28	37.6
TEST MIX (G)	15	0.3	0.1	19.9	36.66
TEST MIX (H)	15	0.3	0.3	21.17	40.1

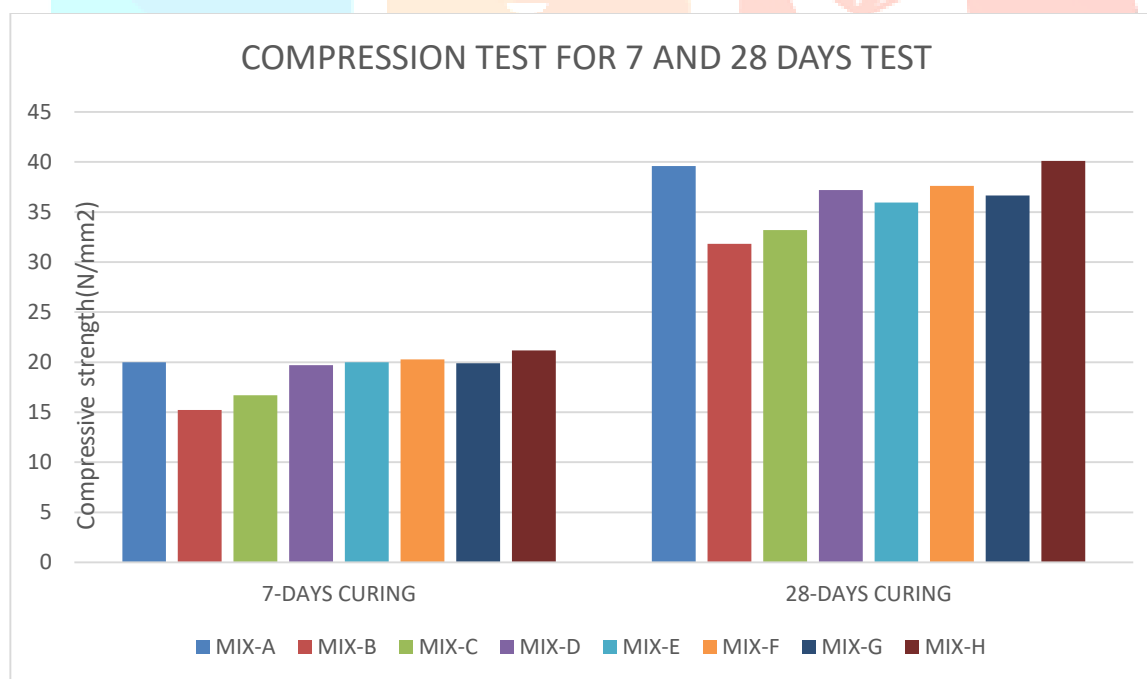


Fig.5.1 Compression test for 7 and 28 days test

The compressive strength results shows that the compressive strength generally increases with time, as expected, with higher values recorded after 28 days compared to 7 days. The exact values of compressive strength will depend on various factors such as the type of materials, curing conditions and testing method used

The fig.6.3 clearly shows the compressive strength of the conventional mix and other seven mixes of 7 and 28 days of curing, by comparing the compressive strength of the conventional mix with other mixes, the mix 8 has the maximum compressive strength of 40.1Mpa and the mix 2 has the minimum compressive strength

of 31.83 Mpa. While comparing the mix 1 with the conventional mix it shows decrease in the compressive strength ranges from 2.40 Mpa to 7.77 Mpa for other six mix proportions of 28 day testing of compressive strength.

As seen from above table, the compressive strength test for 28 days average compressive strength is maximum when 0.3% of polyvinyl alcohol fiber, 0.3% of basalt fiber and 15% of glass powder is used. The maximum compressive strength obtained from the compressive strength test for 28 days test is 43.89Mpa and compressive test on 28 days test shows that concrete of 0.3% of poly vinyl alcohol fiber (PVA) and 0.3% basalt fiber with 15% of glass powder as a partial replacement of fine aggregate has been significantly increased by 1.25% as compared to the conventional mix of M40 mix.

5.2 SPLIT TENSILE STRENGTH OF HYBRID FIBERS

The average split tensile strength of hybrid fiber reinforced concrete with certain proportion of test mix on 7 days and 28 days test

Table 5.2 Average split tensile strength for 7 and 28 days test

CYLINDRICAL SPECIMEN LABEL	GLASS POWDER (%)	POLYVINYL ALCOHOL FIBER (%)	BASALT FIBER (%)	STRENGTH	
				7 days	28 days
TEST MIX (A)	0	0	0	2.97	3.48
TEST MIX (B)	15	0	0	2.64	3.25
TEST MIX (C)	15	0.1	0.1	2.75	3.36
TEST MIX (D)	15	0.1	0.3	2.87	3.64
TEST MIX (E)	15	0.2	0.1	2.81	3.74
TEST MIX (F)	15	0.2	0.3	2.96	3.81
TEST MIX (G)	15	0.3	0.1	2.86	3.83
TEST MIX (H)	15	0.3	0.3	3.04	3.98

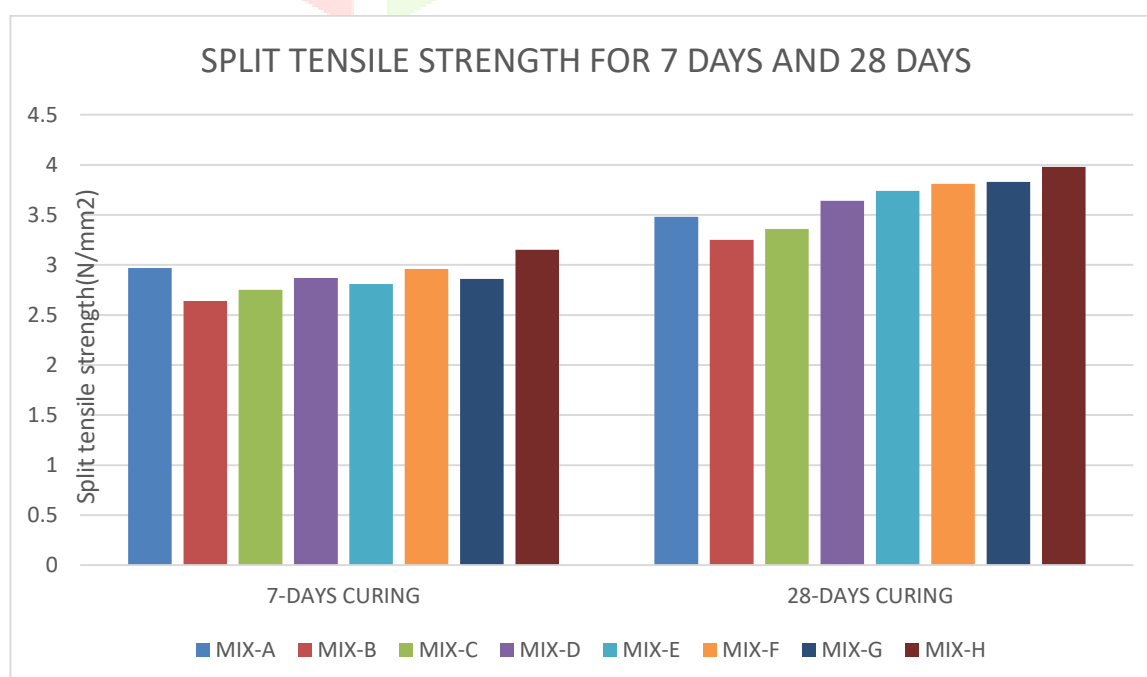


Fig.5.2 Split tensile strength for 7 and 28 days test

The fig.6.6 clearly shows the split tensile strength of the conventional mix and other seven mixes of 7 and 28 days of curing, by comparing the compressive strength of the conventional mix with other mixes, the mix 8 has the maximum compressive strength of 3.98 Mpa and the mix 2 has the minimum compressive strength of 3.25 Mpa. While comparing the mix 1 with the conventional mix it shows decrease in the split tensile strength ranges from 0.23 Mpa to 0.35 Mpa for other six mix proportions of 28 day testing of compressive strength.

From the above graph, the split tensile strength test for 28 days have been determined. We can see that, when the concrete with 0.3% of basalt fiber, 0.3% polyvinyl alcohol fiber with the partial replacement of 15% glass powder has increased. The maximum split tensile strength obtained for 28 days test is 3.98 Mpa. The split tensile strength on 28 days test shows that concrete of 0.3% of poly vinyl alcohol fiber (PVA) and 0.3% basalt fiber with 15% of glass powder as a partial replacement of fine aggregate has been significantly increased by 13.4% as compared to the conventional mix of M40.

5.3 FLEXURAL STRENGTH OF HYBRID FIBERS

The average split tensile strength of hybrid fiber reinforced concrete with certain proportion of test mix on 7 days and 28 days test

TABLE 5.3 FLEXURAL STRENGTH OF THE BEAM SPECIMEN FOR 7 DAYS & 28 DAYS

Sl. No	Mix Details	Glass Powder Replacement	PVA Fiber (%)	Basalt Fiber (%)	Flexural Strength @ 7 days (MPa)	Flexural Strength @ 28 days (MPa)	Remarks
1	Conventional (Control Mix) (OR) MIX-A	0%	0%	0%	3.1 MPa	4.6 MPa	Plain concrete
2	15% Glass Powder + 0.1% PVA + 0.3% Basalt Fiber (OR) MIX-D	15%	0.1%	0.3%	3.7 MPa	5.2 MPa	Increased strength
3	15% Glass Powder + 0.2% PVA + 0.3% Basalt Fiber (OR) MIX-F	15%	0.2%	0.3%	4.0 MPa	5.6 MPa	Further improvement
4	15% Glass Powder + 0.3% PVA + 0.3% Basalt Fiber (OR) MIX-H	15%	0.3%	0.3%	4.2 MPa	6.0 MPa	Highest strength observed

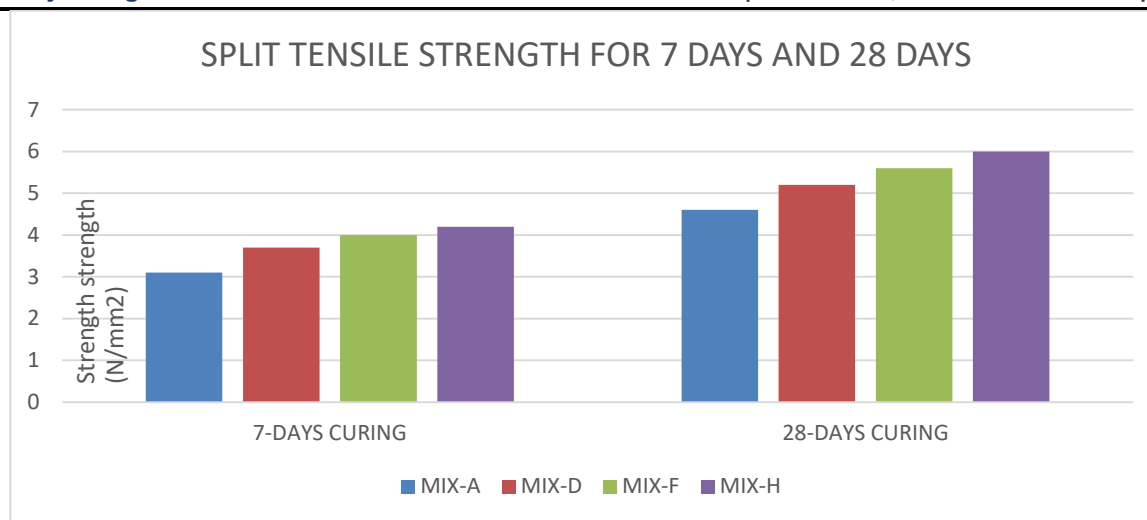


Fig.5.3 Flexural strength for 7 days and 28 days test

Strength Comparison

7 Days:

- **Lowest Strength:** MIX-A (Conventional concrete) with **6.75 KN** load and **3.1 MPa** strength.
- **Highest Strength:** MIX-D (15% Glass + 0.3% PVA + 0.3% Basalt) with **9.45 KN** load and **4.2 MPa** strength.
- **Improvement:**
 - MIX-B → 20% higher than MIX-A.
 - MIX-C → ~30% higher.
 - MIX-D → ~40% higher.

28 Days:

- **Lowest Strength:** MIX-A with **9.45 KN** load and **4.6 MPa** strength.
- **Highest Strength:** MIX-D with **13.20 KN** load and **6.0 MPa** strength.
- **Improvement:**
 - MIX-B → ~13% higher than MIX-A.
 - MIX-C → ~22% higher.
 - MIX-D → ~30% higher.

Final Summary:

- Increasing the **PVA fiber content** from 0.1% to 0.3% led to **progressive improvement** in both **load carrying capacity** and **flexural strength**.
- **Glass powder (15%)** enhanced matrix density and strength over time, benefiting 28-day strength particularly.
- **Basalt fibers (0.3%)** provided consistent crack resistance throughout.

The combination effect of glass powder, PVA fibers, and basalt fibers greatly improved the flexural behavior compared to conventional concrete

VI.SUMMARY AND CONCLUSION

6.1 SUMMARY

- The various literature reviewed related to the partial replacement of glass powder as a fine aggregate in the construction industry
- Various literature reviewed related to the
- After conducting the literature survey, the objective, scope and need for this project are formulated
- Mix design was prepared for both conventional concrete grade of M40 and hybrid fiber reinforced concrete
- The physical properties of the materials used in the research was analysed
- The compressive strength and split tensile strength of hybrid fiber with partial replacement of fine aggregate with glass powder
- The process of selection of materials for the partial replacement of fine aggregate and the fibers utilized in the concrete specimen
- The flexural behavior of hybrid fiber reinforced concrete beam with partial replacement of fine aggregate with glass powder were studied by the and experimental method

6.2 CONCLUSION

- The chapter describes a study that compared the properties of polyvinyl alcohol fiber, basalt fiber and the glass powder as a partial substitute for fine aggregate. The study examined the properties, compressive strength, tensile strength and flexural behavior
- The study also concluded that replacing of 15% of glass powder resulted in a 21.8% decreased when compared to conventional concrete of grade M40
- The compressive strength test for 28 days average compressive strength is maximum when 0.3% of polyvinyl alcohol fiber, 0.3% of basalt fiber and 15% of glass powder is used. The maximum compressive strength obtained from the compressive strength test for 28 days test is 43.89Mpa and compressive test on 28 days test shows that concrete of 0.3% of poly vinyl alcohol fiber (PVA) and 0.3% basalt fiber with 15% of glass powder as a partial replacement of fine aggregate has been significantly increased by 1.25% as compared to the conventional mix of M40.
- The split tensile strength test for 28 days have been determined we can see that, when the concrete with 0.3% of basalt fiber, 0.3% polyvinyl alcohol fiber with the partial replacement of 15% glass powder has increased. The maximum split tensile strength obtained for 28 days test is 3.98Mpa. The split tensile strength on 28 days test shows that concrete of 0.3% of poly vinyl alcohol fiber (PVA) and 0.3% basalt fiber with 15% of glass powder as a partial replacement of fine aggregate has been significantly increased by 13.4% as compared to the conventional mix of M40.
- Increasing the PVA fiber content from 0.1% to 0.3% led to progressive improvement in both load carrying capacity and flexural strength.
- Glass powder (15%) enhanced matrix density and strength over time, benefiting 28-day strength particularly.
- Basalt fibers (0.3%) provided consistent crack resistance throughout.

- The combination effect of glass powder, PVA fibers, and basalt fibers greatly improved the flexural behavior compared to conventional concrete.
- Further, the study suggested that the strength development in conventional concrete of grade M40 may be a reason for its superior performance in testing process while compared to the other mix proportions.

REFERENCES

1. Asha, P., & Bhavana, G. (2017). "Experimental Study on Glass Powder as Partial Replacement for Fine Aggregate in Concrete." *International Journal of Engineering Research & Technology (IJERT)*, 6(5), 263–266.
2. Vijayakumar, G., Vishaliny, H., & Govindarajulu, D. (2013). "Studies on Glass Powder as Partial Replacement of Cement in Concrete Production." *International Journal of Emerging Technology and Advanced Engineering*, 3(2), 153–157.
3. Afshoon, I., Sharifi, Y., & Shad, M. (2018). "Flexural Behaviour of Concrete Beams Reinforced with Steel–Polypropylene Hybrid Fibers." *Construction and Building Materials*, 180, 115–122.
4. John, S., & Gupta, R. (2020). "Effect of Hybrid Fibers on Mechanical Properties of Concrete." *Materials Today: Proceedings*, 32(3), 482–489.
5. Patel, V., & Shah, D. (2016). "Glass Powder as Partial Replacement of Fine Aggregate and Cement in Concrete." *International Journal of Innovative Research in Science, Engineering and Technology*, 5(5), 8234–8239.
6. Sadrmomtazi, A., Sobhani, J., & Mirgozar, M.A. (2012). "Modeling the Compressive Strength of EPS Lightweight Concrete Using Regression, Neural Network and ANFIS." *Construction and Building Materials*, 42, 205–216.
7. Parveen, & Singh, S.P. (2019). "Experimental Study on Hybrid Fiber Reinforced Concrete." *Materials Today: Proceedings*, 17(3), 960–966.
8. Suresh, P., & Yogeshwaran, N. (2015). "Study on Partial Replacement of Fine Aggregate by Waste Glass Powder." *International Journal of Engineering Science and Computing*, 5(6), 5711–5713.
9. Arivalagan, S. (2014). "Sustainable Studies on Concrete with Waste Glass Powder as Partial Replacement of Cement." *International Journal of Engineering Trends and Technology (IJETT)*, 7(6), 292–295.
10. Sivakumar, A., & Santhanam, M. (2007). "Mechanical Properties of High Strength Concrete Reinforced with Metallic and Non-Metallic Fibers." *Cement and Concrete Composites*, 29(8), 603–608.
11. Prem, P.R., Antony, J., & Verma, B.P. (2015). "Flexural Behavior of Hybrid Fiber Reinforced Concrete Beams." *Journal of Civil Engineering and Management*, 21(4), 537–547.
12. Prakash, R., & Thenmozhi, R. (2018). "Use of Glass Powder as Partial Replacement of Fine Aggregate in Concrete." *International Research Journal of Engineering and Technology (IRJET)*, 5(5), 1526–1529.
13. Bentur, A., & Mindess, S. (2006). *Fiber Reinforced Cementitious Composites*. CRC Press.
14. Bala, P., & Sharma, A.K. (2020). "Experimental Study on Hybrid Fiber Reinforced Concrete with Steel and Polypropylene Fibers." *Materials Today: Proceedings*, 28, 1190–1195.

15. Vijayalakshmi, M., & Sundararajan, R. (2018). "Flexural Strength of Hybrid Fibre Reinforced Concrete Beam with Partial Replacement of Cement with Glass Powder." *International Journal of Civil Engineering and Technology (IJCET)*, 9(11), 2955–2961.
16. Ramesh, D., & Sathish, V. (2017). "Partial Replacement of Fine Aggregate by Glass Powder and Steel Slag in Concrete." *International Journal of Engineering Research and Applications*, 7(5), 35–40.
17. Li, V.C. (1992). "Post-Crack Scaling Relations for Fiber Reinforced Cementitious Composites." *Journal of Materials in Civil Engineering*, 4(1), 41–57.
18. Dharmaraj, S., & Kandasamy, S. (2017). "Behavior of Hybrid Fiber Reinforced Concrete Beams under Flexural Loading." *International Journal of Civil Engineering and Technology*, 8(5), 642–648.
19. Halicka, A., Ogrodnik, P., & Zegardlo, B. (2013). "Using Ceramic Sanitary Ware Waste as Concrete Aggregate." *Construction and Building Materials*, 48, 295–305.
20. Gowri, R., & Tamilselvi, M. (2016). "Flexural Behavior of Hybrid Fibre Reinforced Concrete Using Glass and Polypropylene Fibres." *International Journal of Innovative Research in Science, Engineering and Technology*, 5(3), 3566–3571.

