International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 08 | Aug 2020 www.irjet.net p-ISSN: 2395-0072

Experimental Investigation on Glass Fiber Reinforced Pervious Concrete by Partial Replacement of Cement by Glass Powder

Megha N Belagal[1], Ramya B V[2]

[1]*MTech. Structural Engineering, Dept. of Civil Engineering, Bapuji Institute of Engineering and technology, Davangere, Karnataka, India.*
[2]*Assistant Professor, Dept. Civil Engineering, Bapuji Institute of Engineering and technology, Davangere Karnataka, India*

Abstract - *Pervious concrete is a lightweight concrete which mainly is comprised of cement, water, coarse aggregates with or without fine aggregates. It is also widely known as "no-fines concrete" or "porous concrete". As we all know that concrete plays major role in the field of construction and cement is the key ingredient of the concrete mix and we are well aware of the environmental pollution that occurs due to the process of manufacturing the cement by omitting CO_2 and there are many other industrial by-products also that harm the environment by omitting the pollutants even though we are aware of all such problems we cannot do anything as residential buildings, industries etc. Ply the very important roles in our daily life, instead of adding problems by dumping the non-degradable materials such as plastic, glass, rubber waste in the landfills we can utilize these by-products in the construction fields by replacing cement with these waste products one such attempt is the replacement of cement by glass powder. This paper summarizes the benefits, properties, strength of pervious concrete by replacing glass powder by cement. This method not only proves to be a sustainable method but also proves to reduce pollution in the environment.*

Key Words: Pervious Concrete, Sustainable, Glass powder, Coarse aggregates.

1. INTRODUCTION

Glass is one of the most versatile substances used on earth which is in use since 12000 BC. The glass manufacture has increased a lot nowadays for everyday growing needs and glass is found in different forms jars, bottles, windshields, windows, cathode ray tubes, bulbs etc., this manufacturing process also leaves behind a large scale waste or by-product which has created waste product management a very big issue so why not utilize it for a good cause and this also saves a large scale natural resources untouched like lime stone used for manufacturing cement and the Co_2 gas and other green house gases will not be released into atmosphere that also reduces the risk of pollution. The glass has a lot of chemical composition similar to cement and glass is an amorphous material with high silica content (SiO_2) i.e., 72% of glass when grounded to a very fine powder reacts with the alkali in cement and cementations product. When glass powder is added as a pazzolana, it provides a uniform distribution and large volume of hydration products.

The glass powder added in concrete changes the structure of paste. The resulting paste contains less of weak and easy hydroxides $(CaOH)_2$ and strong calcium silicate hydrate (C-S-H) than that of an ordinary cement paste. There will be reduction in the permeability of concrete and better impact as well as better aggregate bond compared to the conventional concrete

Glass fibers is a material consisting of extremely numerous fine fibers of glass and the mass manufacturing of the glass fiber was made with finer machine tooling in the year 1893. Glass fibers were first used to reinforce cement and concrete in Russia. Glass fiber is used as a thermal building insulating material. The glass fiber is much cheaper and less brittle when used in composites, glass fibres are relatively light in weight and have many other properties like they are more dense, contains little or no air and no gas, much poorer thermal insulator. Glass fibers contain silica more than 50% and other components like aluminum, calcium and magnesium oxide and borate. Glass fibers are used in concrete in

order to control cracking due to plastic shrinkage and drying shrinkage, to reduce permeability of concrete and thus to reduce bleeding of water.

They are mainly used in exterior building facade panels and as architectural precast concrete. Glass fibers are available in different forms such as chopped strand mats, cranette, ropes, woven fabric, and wool.

Glass fibers of 6mm, 10mm, 12mm, 24mm to 50mm in length and a few microns in diameter can be added up to 5% by weight and premixed with cement and water in a paddle mixer or in a pan.

1.1 Objectives of the study

The investigation looks at partial replacement of cement by glass powder of size 150microns and the glass fibers are added as the strengthening material in the concrete. The mixes are 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40% by partially replacing cement by glass powder in each mix as specified above and adding glass fiber at intervals of 0%, 0.25%, 0.50%, 0.75%, 1%, 1.25%, 1.50%, 1.75% and 2% for each mixes. These results are compared with nominal concrete (0% replacement of glass powder and 0% addition of glass fiber).

1.2 Advantages and disadvantages of Glass powder

Advantages of glass powder

1. If the glass powder is finer than 150µ shows pazzolanic behavior.

2. Smaller particle size of the glass powder has the higher activity with lime resulting in higher compressive strength in the concrete mix.

3. Compared to the fly ash concrete, finer glass powder concrete had slightly higher early strength as well as late strength.

4. The durability property of concrete is improved due to the denser matrix which is produced due to the micro structural examination.

5. Glass waste is recognized to be increased year by year in a very large volume from shops, factories and construction areas and it can be used effectively.

6. The waste storage in construction sector is advantageous as it also reduces construction cost.

Disadvantages of glass powder

1. Usage of glass powder is economical only when it is used in very high quantity, for the small-scale construction it will be very costly.

2. Since the glass is non-biodegradable the material is very effective to the worker's health.

3. If grinding is done manually then it should be done with all the precautions, measures should be taken otherwise it will lead danger.

4. Finely grounded glass powder will be very light in weight it can easily mix up with air and that will lead to the respiratory problems for workers so, it should not be put from large heights and also mixed with care.

5. It reduces the flexural strength of concrete.

1.3 Applications and Benefits of Glass fibers

Applications of glass fibers

1. RMC Application.

2. Crack reduction in concrete/ plaster.

3. Durable and maintenance free concrete.

4. Industrial application.

5. Infrastructural projects

6. RCC/ PCC Road.

Benefits of glass fibers

1. It improves mix cohesion, improves pumping ability over long-distance travel from RMC to the site.

2. Improves freeze and thaw resistance.

3. Improves the resistance to fire in case of fire accidents.

4. Improves the impact resistance and resistance to plastic shrinkage during curing.

2. REVIEW OF LITERATURE

N. Bhavani Shankar Rao, et al [2] (2014)

The study has enlightened that replacement of cement by glass powder is carried out at an interval of 0%, 5%, 10%, 15% and 20% and when the compression test for cubes were carried out and the results of the test depicted that there was an increase in compression strength by 27% compared to the conventional concrete when the glass powder was replaced by cement at 20% and considering the criteria it is feasible to replace cement by glass powder only up to 20%.

Rohan Datta, et al [3] (2015)

The main objective of the research paper is to reduce pollution in the environment by using waste materials as replacement of cement such as rice husk ash(RHA), fly ash, ground granulated blast furnace slag (GGBFS), silica fume, rubber tires, glass powder, hypo sludge, ceramic powder, MSWIBA.

The conclusions drawn by the experiment were better long term compressive strength by using fly ash, 10%-12% strength increment by using RHA, GGBFS is not so ideal for pervious concrete as it may affect strength, silica fume is good for improving strength but it requires addition of super plasticizers' for improvement in workability, rubber utilization will decrease compression strength, glass powder increases strength, hypo sludge increases permeability and decreases compressive strength, ceramic powder increases permeability and durability, MSWIBA increases durability. These material usage decreases the problem of waste product management.

A.B. Khemalpure, et al [1] (2016)

In this research paper they have concentrated on the strength of plain pervious concrete when compared with pervious concrete with different materials like glass fiber and polypropylene fibers, they have used the glass fibers and polypropylene in proportion of 0.1%, 0.15%, 0.2% and 0.25% of volume of concrete. They have carried out tests at 3 days, 7 days, 14 days and 28 days. They have concluded that compression strength of glass fibers and polypropylene fiber mixed with pervious concrete gives 22.15% more strength at 28 days compared with plain pervious concrete and the permeability of pervious concrete varies on the percentage of fibers added to concrete

M. H. Rahman, et al [b] (2016)

This research paper states that chemical composition of clear and colored glass are very much similar and they could be considered as pazzolanic materials and the results of the study depicts that there is 2% increase in the strength by using 20% replacement of cement by glass powder and it has also stated that for every six ton usage of glass powder reduces up to one ton of CO_2 production which is very eco friendly as well as there will be 14% of reduction of cost it also results to be economical.

Siddesh. T.M, et al [3] (2016)

This paper focuses on the experimental investigation on partial replacement of glass powder by cement at different intervals. They have conducted the experimental different intervals of 10%, 20%, 30%, 40%. The flexural strength split tensile test and compressive strength test have been conducted. Increasing the amount of glass above 30% in mortar causes decrease in compressive strength, average compressive strength of concrete containing glass powder less than 150µ size will increases up to 30% replacement of cement but if the size of glass powder is less than 300µ size will gradually decrease. Average tensile strength of concrete containing glass powder less than 300µ will decrease gradually up to 30% replacement of cement.

M R V S G Gupta, et al [1] (2018)

The study investigates the usage of glass powder by replacing cement at different intervals i.e. 10%, 20% and 30% in two different mixes with 1:4 and 1:8 ratios and they have found out that there is 13.27% higher strength than that of conventional concrete by replacing 20% of cement by glass powder for mix ratio of 1:4 and 12.76% higher strength than that of

conventional concrete by replacing 20% of cement by glass powder for mix ratio of 1:8.

Hosana. S, et al [1] (2019)

Paper has been investigated on partial replacement of cement by glass powder at intervals of 25%, 35% and 50% and the compressive strength observed after testing the specimens, presented that there will be good development in compressive strength, flexural strength and tensile strength for replacement of 25% mix and there will be decrease in strength in the simultaneous mixes of 35% and 50% and there will be decrease in the workability also for an M20 concrete.

3. MATERIALS

Cement

Ultra-Tech Ordinary Portland cement of grade 43 is used for all concrete mixes. The cement used is fresh, uniform in colour grey with light greenish shade and had no lumps and irregularities. It was stored in a dry place free from moisture content so that it does not lead to degradation in case of moisture. Tests conducted on cement were initial setting time, final setting time, standard consistency, compressive strength and specific gravity.

Fig 1: Cement

Water

Water is an important ingredient of concrete and mortar as it is actively participates in the chemical reaction with cement. Since it helps to form strength, giving cement gel, the quantity and quality of water is to be looked very carefully.

Table: -1 Properties of cement

Sl. No	Test conducted	Results obtained	Requirement as per IS8112
1.	Initial setting time	50 minutes	Should not be lesser than 30 min
2.	Final setting time	240 minutes	Should not be more than 600 minutes
3.	Specific gravity	3.1	3.1-3.15
4.	Compressive strength	42.32 MPa	43 MPa (minimum)

Coarse Aggregate

The coarse aggregate used in this experiment is 20 millimeters downsize crushed granite stone which is obtained from locally available quarry. Properties of the material are listed according IS: 383-1970. The physical properties obtained are according to IS: 2386-1963

Fig 2: Coarse aggregate

Glass powder

Waste glass available in local shops has been collected and made into glass powder. Glass waste is very hard material. Before adding glass powder in the concrete, it must be powdered to desired size less than 150 microns and 300microns. Glass powder is added to the cement separately before dry mixing with other material. The specific gravity of glass powder was

found to be 2.69. This value is far less than 3.15 for Portland cement.

Fig 3: Glass Powder

Glass fibers

Glass fiber reinforced concrete is a type of fiber reinforced concrete. Glass fiber is mainly used in exterior building façade panels and as architectural precast concrete. This material is very good in making shapes on the front of any building and it is less dense than steel. Glass fiber material is also used in filling cracks and increasing strength of concrete.

Fig 4: Glass fiber

The specifications of the glass fiber used in this thesis are as follows:

- Length of the glass fiber used is 12mm
- Filament diameter:14µm/0.00055^0
- Specific gravity of glass fiber is 2.68g/cm^3
- Moisture (%): 0.50 max.
- Material: Alkali resistant glass
- Softening point: 860^{0}C (1580^0 F)
- Modulus of elasticity: 72 GPa.
- Cement concrete mix by volume 1:8
- Optimum W/C ratio 0.40

4. Methodology

Experiments were conducted on concrete prepared by partial replacement of cement by glass powder at different intervals of 10%, 20%, 30% and 40% and addition of glass fiber at intervals 0.50%, 1%, 1.50% and 2% of the binder mix design was prepared. These results are compared with nominal concrete (0% glass powder and 0%glass fiber replacement)

In this project various tests are conducted on cement; coarse aggregate and the observation is tabulated, and the results are calculated. Graphs are plotted if it is necessary by using suitable readings:

The tests conducted on the moulds are:

1. Compressive strength test
2. Permeability test

1. Compressive strength test

Specimens of dimensions 150x150x150mm were prepared. They are tested on compression testing machine as per IS 516-1959.

Fig 5: Compressive strength test

The compressive strength is calculated by using the equation

F=P/A---------1

Where,
F=Compressive strength of the specimen (in MPa)
P=Maximum load applied to the specimen (in N)
A= Cross sectional area of the specimen (in mm^2)

2. Permeability test

Permeability can be defined as the ability of porous mass to allow passage of the water through the medium i.e. understanding the structure of soil and how the water passes through different layers.

Permeability is very important factor for structures, and it is considered to be in a straight line at an effective velocity. The velocity of the flow depends on the size of pores.

Fig 6: Permeability test

5. Experimental results

Table 2: Compression strength test results

Sl. No	% of glass powder	% of glass fiber	Mean strength	
			7-day	28-day
1	0%	-	1.83	2.62
2	10%	0.50%	2.11	3.02
3	20%	0.50%	2.60	3.71
4	30%	0.50%	2.31	3.30
5	40%	0.50%	1.64	2.58

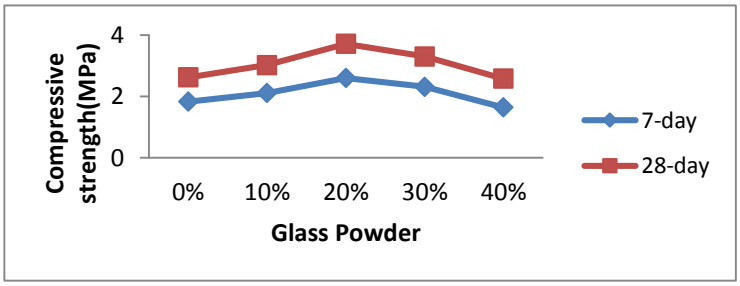

Fig 7: Compressive strength of concrete

Table 3: Compressive strength test results

Sl. No	% of glass powder	% of glass fiber	Mean strength	
			7-day	28-day
1	0%	-	1.93	2.76
2	10%	1%	2.21	3.16
3	20%	1%	2.86	4.08
4	30%	1%	2.40	3.42
5	40%	1%	2.14	3.06

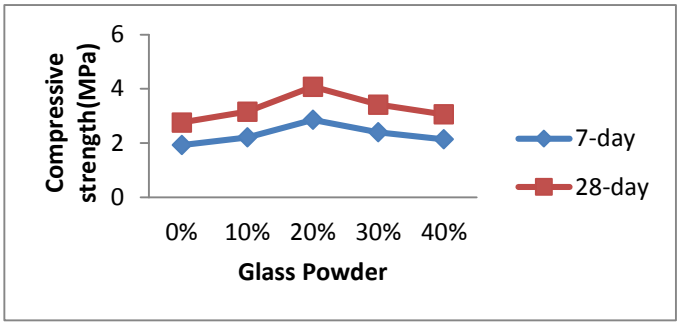

Fig 8: Compressive strength of concrete

Table 4: Compressive strength of concrete

Sl. No	% of glass powder	% of glass fiber	Mean strength	
			7-day	28-day
1	0%	-	2.27	3.24
2	10%	1.50%	2.95	4.21
3	20%	1.50%	3.45	4.90
4	30%	1.50%	2.56	3.65
5	40%	1.50%	2.42	3.45

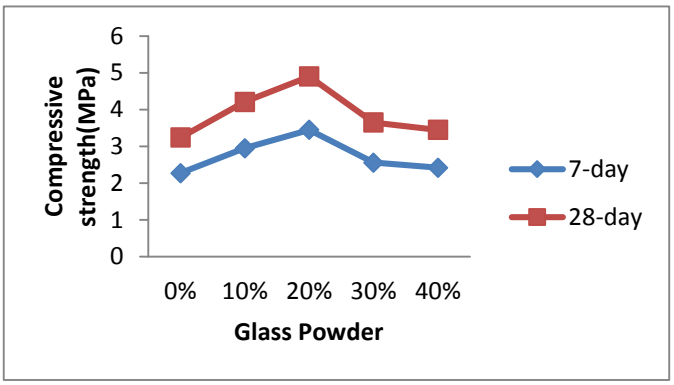

Fig 9: Compressive strength of concrete

Table 5: Compressive strength of concrete

Sl. No	% of glass powder	% of glass fiber	Mean strength	
			7-day	28-day
1	0%	-	2.65	3.78
2	10%	2%	3.10	4.42
3	20%	2%	3.50	4.99
4	30%	2%	2.85	4.07
5	40%	2%	2.60	3.65

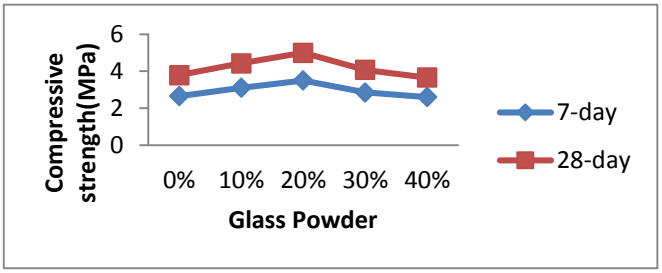

Fig 10: Compressive strength of concrete

Table 6: Permeability test results 0.50% glass fiber mix

Sl.No.	Design mix	Time in mm/sec
A1	0%glasspowder+100%cement +100% coarse aggregate	18.32
A2	10%glasspowder+90%cement +100% coarse aggregate	18.66
A3	20%glasspowder+80%cement +100% coarse aggregate	19.21
A4	30%glasspowder+70%cement +100% coarse aggregate	19.47
A5	40%glasspowder+60%cement +100% coarse aggregate	20.06

Table 7: Permeability test results 1.00% glass fiber mix

Sl.No.	Design mix	Time in mm/sec
B1	0%glasspowder+100%cement +100% coarse aggregate	19.36
B2	10%glasspowder+90%cement +100% coarse aggregate	19.54
B3	20%glasspowder+80%cement +100% coarse aggregate	20.18
B4	30%glasspowder+70%cement +100% coarse aggregate	20.76
B5	40%glasspowder+60%cement +100% coarse aggregate	21.70

Table 8: Permeability test results 1.50% glass fiber mix

Sl. No.	Design mix	Time in mm/sec
C1	0%glasspowder+100%cement+10 0% coarse aggregate	21.29
C2	10%glasspowder+90%cement+10 0% coarse aggregate	21.38
C3	20%glasspowder+80%cement+10 0% coarse aggregate	22.11
C4	30%glasspowder+70%cement+10 0% coarse aggregate	22.30
C5	40%glasspowder+60%cement+10 0% coarse aggregate	22.55

Table 9: Permeability test results 2.00% glass fiber mix

Sl. No.	Design mix	Time in mm/sec
C1	0%glasspowder+100%cement+10 0% coarse aggregate	23.06
C2	10%glasspowder+90%cement+10 0% coarse aggregate	23.19
C3	20%glasspowder+80%cement+10 0% coarse aggregate	23.48
C4	30%glasspowder+70%cement+10 0% coarse aggregate	24.02
C5	40%glasspowder+60%cement+10 0% coarse aggregate	24.15

6. CONCLUSIONS

1. Maximum strength of the concrete is attained in the mix with 20% glass powder replacement.
2. Increasing the amount of glass powder higher than 20% will show in gradual decrement in the compressive strength.
3. The permeability of the concrete is highly depended on the voids that are present in the structure of the specimen.
4. The specimens with higher percentage of glass fiber will have more voids as compared to that of lower percentages of glass fiber i.e., concrete specimen with 0.50% glass fiber allows the water to pass quickly as compared to that of specimens of mix containing 2% glass fibers.

REFERENCES

1. A.B. Khemalapure, Prof. A.R. Vasatkar (2016), "An Experimental Analysis on Strength of Pervious Concrete", International Journal of Advance Engineering and Research Development, Vol.03, Issue-7.

2. Asst.Prof. B. Radha Kiranmaye, Asst.Prof D. Tarangini, Asst.Prof K.V Ramana Reddy (2018), "Effect of glass fiber on properties of pervious concrete", Vol.09, Issue -4.

3. G. M. Sadiqul Islam, M. H. Rahman, Nayem Khazi (2017), "Waste glass powder as partial replacement of cement for sustainable concrete practice", International Journal of Sustainable Built Environment, 6.37-44.

4. Harish. B. A, Hanumesh. B. M, Siddesh. T. M, Siddhalingesh. B. K (2016), "An Experimental Investigation on Partial Replacement of Cement by Glass Powder in Concrete", International Research Journal of Engineering and Technology, Vol.03, Issue-10.

5. Hosana. S, Snega. S, Prasitha. T (2019), "Analysis of Glass Powder as a partial replacement of cement in concrete ", International Journal of Research in engineering and Technology, Vol. 07, Issue-11.

6. Jose Marcos Ortega, Viviana Letelier, Carlos Solas, Marina Miro, Glacomo Moriconi, Miguel Angel Climent, Isidro Sanchez (2018)," Influence of Waste Glass Powder Addition on the Pore Structure and Service Properties of Cement Mortars", Sustainability, 10, 842, doi:10.3390.

7. Asst. Prof. Mithun Sawant, Daksha Dande, Shivani Sabde, Rutuja Bhalsing, Praful Yadav, Nilesh Ranjan, (2017), "Pervious Concrete with glass fiber", International Journal of Research in Advent Technology, Vol.5, No.-5.

8. M R V S G Guptha, P Uma, K Santosh (2018), "Performance Evaluation on Pervious Concrete by Partial Replacement of Glass Powder", International Journal of Technical Innovation in Modern Engineering and Science, Vol. 4, Issue-12.

9. Sukamal Kanta Gosh, Ananya Chaudary, Rohan Datta, D. K. Bera, "A Review on Performance of Pervious Concrete Using Waste Materials", International Journal of Research in Engineering and Technology, Vol. 04, Special Issue-13.

10. Veena. V. Bhat, N. Bhavanishankar Rao (2014), "Influence of Glass Powder on the Properties of Concrete", International Journal of Engineering Trends and Technology, Vol. 16, No.-5

CODES OF PRACTICE

1. IS 383-1970 (Specifications for fine and coarse aggregates)

2. IS 2386(PART 3) – 1963 (Methods of aggregate testing for concrete)

3. IS 516-1959 (Specifications for compressive strength)

4. IS 12727- 1989 (Specifications for Pervious Concrete)

BIOGRAPHIES

Megha N Belagal
MTech. Structural Engineering
BIET Davangere

Ramya B V
Assistant Professor
Dept. of civil engineering
BIET Davangere