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Utilization of Glass Fibers in Concrete: A Review

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Abstract - *Abstract: Glass fiber is a substance that is produced from very fine fibers of glass. Glass fiber has tremendous high mechanical properties like high strength, flexibility, stiffness, good high temperature and resistance to chemical harm. It has similar mechanical properties like polymers and carbon fiber and it is much cheaper remarkably less brittle then other fibers, Because of this Glass Fiber have extensively high utilization in different application in the globe. In this reviewed researchers have done experimental work on glass fiber to utilize in concrete and construction material for improving the mechanical properties and durability of materials.*

Key Words: Concrete, Glass Fibre, Mechanical Properties, Tensile Strength, Flexural Strength

1. INTRODUCTION

Concrete is one of the comprehensive substance for construction industries, which is the most predominantly used material utilized in any construction or civil industries. Concrete has huge consumption in the globe which comes in the second rank after water. Concrete compound material produced by composition of coarse aggregate, fine aggregate, lime/cement, and water and some admixture, which is bonded together to produces a good strength. Concrete is very good in compressive strength also economical than other materials (Wood, Steel, Aluminum, Plastics and etc…) and also shapeable or easy to shape, good in high temperature, easy accessibility to concrete material, easy to cast. Because of consumption of natural resources like coarse and fine aggregate in concrete, to reduce these consumption some waste material like (Fly Ash, Foundry Sand, Ground granulated blast furnace slag, Silica Fume, Paper, Wood, Plastic and etc...) have been utilized in concrete for making and eco-friendly environment and also reduce utilization of natural resources. These waste materials have given a strength up to some percentage which is not desirable and also concrete will develop the cracks due to plastic shrinkage, drying shrinkage and other reasons for changes in the volume of concrete for increasing the mechanical properties and reduce these cracks. Some addition of fibers like (Steel Fiber, Polymers Fiber, Carbon fiber, Glass Fiber and etc…), Glass Fibers has similar mechanical properties like polymers and carbon fiber and it is much cheaper remarkably less brittle. Glass fiber is substance that manufactures from a very fine fibers of glass. Glass fiber has significantly high mechanical properties like high strength flexibility, stiffness and very in temperature also resistance to the chemicals harms then in this review small amounts of glass fiber have been utilized to improve the mechanical properties of concrete. Some studies have been conducted by the addition of glass fiber in concrete to improve the mechanical properties of concrete the results are desirable and acceptable. In this review percentage of addition, glass fiber is from (0 to 1.6) % of with different materials that have been utilized for improving the mechanical properties in concrete.

1.1 Literature Review 1

Teja V. Phani *et al*., 2019 have studied composite cement and glass fiber for improving the strength and durability of concrete in some areas. This experiment has been done by adding Portland cement clinker (30 to 35)% by weight, gypsum (3 to 5)%, fly ash (15 to 35)% and GGBFS (20 to 50)% it produces strength and durability on concrete, this paper carry out compressive strength and tensile strength of the concrete by adding composite cement and glass fiber and certain proportion and are tested in cube size of (150*150*150)mm and cylinders of size (150*300)mm are cast cured for (7,28, and 56) days. The results of the states show that initial strength increase for 28 days and after that the gradually decrease happened. The compressive strength shows certain development when it mixes with the 50% ordinary Portland cement, 25% fly ash, and 25% ground granulated blast furnace slag. There is a negligible change in the strength when compared to the without the glass fibers[1].

Kumar *et al.,* 2019 these experimental works show the analysis of M30 grade by internalization of glass fiber. In this experiment the used glass fibers of 14 microns diameter, indifference percentage as 0%, 0.4%, 0.8%, 1.2%, and 1.6% by the weight of cement and water-cement ratio 0.45, this experimental analysis the compressive, tensile and flexural behavior of concrete. It has been approved that by adding 1.2% glass fiber by weight of cement to concrete can increase up to 17.36% as compared to plain concrete, increase in flexural strength up to 35% and split tensile strength increased up to 40%. Shows improvement because of adding glass fiber. In this experiment, it has found that flexural strength improved compare to compressive strength[2].

Yoddumrong, *et al.,* 2019 focused and analyzed the performance of concrete with low-cost glass fiber reinforcement polymer (GFRP) in strengthening normal 15 (MPa) and low strength 5 (MPa). In this 8 cylinder have been checked. Check the capability of low-cost GFRP in improving the strength of the concrete compared to normal concrete. Specimens having compressive strength 5 (MPa) and 15 (MPa) some of these specimens have combined without GFRP and with GFRP in one, two and three layers, it has found for 5 (MPA) compressive strength increase 2.27 MPa, 3.96 MPa, and 4.13 MPa for one, two and three layers compared to controlled concrete. The compressive strength of 15 MPa has increased 1.75 MPa, 2.29 MPa, and 2.95 MPa for one, two and three layers compared to control concrete.it shows that this is an economical and effective way to improve the compressive strength of concrete[3].

Dezfouli and Rangaraju 2018 studied the effect of using (GGF) ground glass fiber as a pozzolanic in concrete with different percentages (10%, 20%, and 30%) by mass. In these studies, the durability of the properties checked for a life span of two years. For this purpose, the resistance of GGF-containing mixtures against the alkali-silica reaction, sulfate attack, and drying shrinkage was evaluated and compared with a two-year control mixture which has 100% Portland cement and a mixture which have 25% of class f fly ash. The result showed that the replacement of Portland cement with GGF has significant improvement in durability properties[4].

Mathanraj and Kumari 2016. Have done experimentally on sheet glass from cutting industries producing waste glass material, which are not recycled at current and usually deliver to the landfilling, these disposals (glass powder) used in concrete, this is economy way on waste disposal sites and conservation of natural resources. This experiment was done by the use of glass fiber 5% to 20% as a replacement of cement in concrete cube compare with conventional concrete cubes. Conventional concrete shows at 28 days compressive strength as 31.1N/mm2, split tensile strength of 2.27N/mm2 and flexural strength of 3.25N/mm2. Replacement of glass powder in cement by 0%, 5%, 10%, 15%, and 20% increase the compressive strength by 19.6%, 25.3%, and 33.7% respectively. Glass powder in cement 20% increase the split tensile strength by 4.4%, glass powder 5%, 10%, and 15% increase the flexural strength by 83.07%, 99.07%, and 100% improve in strength of concrete. Decrease 9% compressive strength after 28 days by adding 5%. Decrease 2.23% compressive strength after 28 days by 10%. Adding 15% cement replacement of fine glass powder gives as the most optimal strength results because with this replacement the decrease in strength[5].

Prasath C. *et al.,* 2014 have done experimentally on high-performance concrete by using Glass Fiber and Foundry sand. For checking mechanical properties of concrete Foundry Sand replace as fine aggregate by (10%, 20% 30%) and Glass Fiber (0.5%) for checking mechanical properties of concrete. In the age of (7, 14, 28) days compression, split tensile strength and flexural strength tests have been done on this experiment. The result shows a slight increase in concrete with Foundry Sand and Glass Fiber as compare to control concrete. After 28 days, compressive strength, split- tensile strength, flexural strength has been evaluated shows increased up to (27.15, 24.82 and 33.17) percent by 30% replacement of fine aggregate by Foundry Sand and by adding 0.5% Glass Fiber. Foundry Sand is waste sand while using it then made eco- friendly environmental structures, and also can reduce disposal problems from waste material which happens to the environment[6].

Dawood A. Eethar, 2013 has evaluated the effects of glass fiber on mechanical properties like compressive strength, workability or flow, flexural strength and density of high-performance lightweight concrete. In the experiment, Foam is used to generate a lightweight concrete. Superplasticizer added 1% by weight of cement. Glass Fibers have used in different volumes (0.06, 0.2, 0.4, and 0.6) % for Foam concrete. The result shows that an increase in Glass fiber volume can produce high-performance concrete-like by adding 0.6% of glass fiber compressive strength increased by 33.7% and flexural strength without Superplasticizer increased by 16.1% and flexural strength with Superplasticizer increased by 15.44%. But workability is decreased by 38% compared to control concrete[7].

Ravikumar and Thandavamoorthy 2013 have done an assessment on Glass Fiber in concrete to improve its mechanical properties like tensile and ductility. Glass Fiber has higher tensile strength and fire resistance properties, thus, reduction happened while firing an accident to the concrete structure. In this experiment Glass Fiber of 450mm length is added to concrete by volume fraction up to 1% of concrete. Comparison of the strength of fire resistance performance of conventional concrete and concrete with glass fiber is made, result shows, with adding 0.5% Glass fiber increase in compressive strength is 13%, increase in flexural strength 42%, and increase split tensile strength is 20% in control mixture. With adding of 1% Glass Fiber increase in compressive strength 35% shows improvement 1,78 more than normal concrete, and fire resistance shows that there is reduction in compressive strength, after giving heating to concrete at 300C for 2 hours, without the addition of the Glass Fiber the decrease is 35% from its original strength. In addition, 0.5% of Glass Fiber decreases in compressive strength by 25% from its original strength, and by adding 1% Glass Fiber the reduction in compressive strength after the fire in just 10% from its original strength. The evaluation shows that Glass Fiber has better fire resistance characteristics[8].

Kene *et al.,* 2012 Experimental studies were conducted on the behavior of steel and fiberglass. Reinforced concrete composites. This research was carried out on fiber reinforced concrete. It contains 0% and 0.5% by volume of steel fiber and alkali-resistant glass fiber 0% and 25% by weight of 12mm cut length is used with no admixture, cement result shows the addition of 0.5% by volume of steel to the concrete reduces cracks under different loading conditions. The brittleness of concrete can also be improved by adding steel fibers instead of glass fibers. Since the stretching of the concrete is very weak, the steel fiber contributes to the axial stretching, thereby increasing the tensile strength[9].

Vijai *at el.,* 2012 Have done experimental on Geopolymer Concrete, by checking mechanical properties like density, compressive strength, split tensile strength and flexural strength by adding 90% Fly ash, 10% Ordinary Portland Cement, alkaline liquids and Glass Fibers. Alkaline liquids to fly ash ratio was fixed as 0.4 with 10% of Fly Ash replacement by OPC. Glass fibers added 0.01%, 0.02% and 0.03% by volume of concrete. On the bases of the results show improvement compressive strength, split tensile, and flexural strength[10].

Rama *et al.,* 2010 Polyethylene glass fibers with different volume fractions were studied, with 25% and 40% of cement was replaced by fly ash. The effects on concrete compressive strength, splitting tensile strength and flexural strength were studied. According to Indian standards, standard sizes of cubes, cylinders, and prisms were cast according to Indian standards for each mixture and tested for 7 days, 28 days and 56 days of compressive strength, split tensile strength and flexural strength according to Indian standards. The addition of glass fibers to the fly ash concrete mixture increases the compressive strength for 28 days. The percentage of fly ash increases and the performance of concrete decreases. The split tensile strength of 25% cement instead of fly ash increased from 8.5% to 16% compared to the control mixture.

Murthy *et al.,* 2008 the compressive strength, flexural strength, and workability of concrete containing different proportions of glass fibers were studied to replace fine aggregates. It is 25 micrometers in diameter and 5 centimeters long. It is used to prepare standard M30 grade concrete and replaces fine aggregate with fiber by 1.5%. The increase in compressive strength is nominal and the bending strength increases significantly as the percentage of glass fibers increases. As the glass fiber content increases, the slump decreases. The flexural strength of a beam with 1.5% glass fiber showed an increase in strength of nearly 30% compared to a beam with 0% glass fiber[11].

2. Table

This table is the conclusion of the above literature review and the percentage of utilized glass fiber and its result.

Table -1: Literature review papers and their comparison

No	Author	Year	Utilization Area	Materials Used	Percentage of Glass Fiber	Tests	Results (Increase/Decrease/ Desirable)
1	Teja V.	2019	Concrete	OPC, FA, CA, Gypsum, Fly Ash, GGBFS, Glass Fiber	0.5%	Compressive Test, Split Tensile Test	Desirable
2	Kumar Manoj	2019	Concrete	OPC, FA, C A, Glass Fiber	(0, 0.4, 0.8, 1.2, 1.6)%	Compressive Strength, Flexural Strength, Split Tensile Strength	Increase
3	Yoddumrong Parachaya	2019	Concrete	OPC, FA, CA, GFPR(Glass Fiber Reinforced Polymer)	0.6Kg/m^3	Compressive Strength	Increase
4	Dezfouli Hassan	2018	Concrete	OPC, FA, CA, SCM (Supplementary Cement Material), GGF Ground Glass Fiber, Fly Ash	(10, 20, 30)% GGF	Compressive Strength, Split Tensile Strength, Sulfate Attack Resistance, Rapid Chloride Penetration Test	Increase
5	Mathanraj R.	2016	Concrete	OPC, FA, CA, Glass Powder,	(0, 5, 10, 15 and 20)%	Compressive Strength, Flexural	Increase

				Fly Ash	**Glass Powder**	**Strength, Split Tensile Strength, and Fire Resistance**	
6	**Prasath C.**	**2014**	**Concrete**	**OPC, FA, CA, Foundry Sand, Glass Fiber**	**0.5%**	**Compressive Strength, Flexural Strength, Split Tensile Strength,**	**Increase**
7	**Dawood Eethar**	**2013**	**Concrete**	**OPC, FA, CA, Foam Agent, Glass Fiber**	**(0.06, 0.2, 0.4, and 0.6)%**	**Workability, Compressive Strength, Flexural Strength**	**Increase**
8	**Ravikumar C.**	**2013**	**Concrete**	**OPC, FA, CA, Glass Fiber**	**(0, 0.5, 1)%**	**Compressive Strength, Split Tensile Strength, Flexural Strength, Fire Resistance**	**Increase**
9	**S. Kene Kavita**	**2012**	**Concrete**	**OPC, FA, CA, Steel Fiber, Glass Fiber**	**(0, 0.25)%**	**Compressive Strength, Split Tensile Strength, Flexural Strength, Strength of Concrete**	**Desirable**
10	**Vijai K.**	**2012**	**Concrete**	**OPC, FA, CA, Fly Ash, GPCC, Alkaline Liquids, Glass Fiber**	**(0.01, 0.02, 0.03)%**	**Compressive Strength, Split Tensile Strength, Flexural Strength,**	**Decrease**
11	**Mohan Rao Rama**	**2010**	**Concrete**	**OPC, FA, CA, Fly Ash, Polyethylene Glass Fibers**	**(0.1, 0.2, 0.3)%**	**Compressive Strength, Split Tensile Strength, Flexural Strength,**	**Desirable**
12	**Yogesh Murthy**	**2008**	**Concrete**	**OPC, FA, CA, Glass Fiber**	**(0, 0.5, 0.7, 0.9, 1.2, 1.5)%**	**Compressive Strength, Flexural Strength, Workability**	**Increase**

Note: OPC (Ordinary Portland cement), FA (Fine Aggregate), CA (Coarse Aggregate), SCM (Supplementary Cement Material), GGF (Ground Glass Fiber)

3. CONCLUSIONS

1. The small amount of addition Glass Fiber (0 up to 1.6) % has reviewed gives a desirable improvement to the mechanical properties of concrete.
2. The review has been conducted utilization Glass powder from (0 up to 30) % also good as the replacement of fine aggregate in concrete, which gives a desirable improvement to mechanical properties of concrete.
3. Utilization of Glass Fibers in concrete give desirable improvement to compressive strength as compare to conventional concrete.
4. Utilization of Glass Fiber in concrete give desirable improvement to Flexural Strength of concrete compare to conventional concrete.
5. Utilization of Glass Fiber gives desirable improvement to Split Tensile Strength of concrete compare to conventional concrete.
6. By utilization of Glass Fiber in concrete the modules elastic of concrete is increased as compared to the normal concrete.
7. By the addition of Glass Fiber cracks due to plastic shrinkage, drying shrinkage and other reasons are reduced.
8. The addition of Glass Fibers in concrete reduces the workability of concrete.
9. Utilization of Glass Fiber in concrete, while replacement of fine aggregate with some waste materials (Fly Ash, Foundry Sand, Tiles Powders, Plastics and etc..) can increase the mechanical properties of concrete.
10. Glass fiber concrete is good at hitting or against temperature as compared to control concrete.

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I am a student of M.E. Civil Engineering of Chandigarh University, I the undersigned solemnly declare that the project report **Utilization of Glass Fibers in Concrete: A Review** manuscript focus on utilization of glass fiber in concrete and construction material for improving the mechanical properties and durability of concrete. It is based on my own work carried out during the review of our study under the supervision of (Sandeep Salhotra Associate Professor, Chandigarh University.

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