Utilizing Glass Fiber and Crumb Rubber for Improved Structural Performance

Manish Kumar[1], Mahendra Saini[2]
Regional College for Education Research Technology, Jaipur

Abstract: **Composite concrete is utilized as an additional building material in this case to increase the performance of building components. Aside from that, the increased demand for concrete leads to environmental degradation. Throughout its life, concrete is subjected to a variety of forces that can cause cracking and damage. Fibers are established to rise the mechanical qualities and durability of concrete when used in concrete mixes. Concrete is the most commonly used construction material. Concrete buildings generate cracks over time as a result of varied loads and external factors. Concrete has a fragile structure that can be easily cracked. Fiber reinforcement is thus utilized to improve the characteristics of concrete. The fiber becomes more ductile by transmitting the loading tension caused by adhesion behavior.In this study consider two different kinds of materials which provide tensile strength to concrete. One is glass fiber and second is crumb rubber that was replaced with fine aggregate. For this study use M25 of concrete grade. To study fresh and harden properties of sample perform experiments at different time period. At fresh stage use slump test and after samples get hard samples are test for compressive strength, flexural strength and split tensile.**

Key words: Crumb Rubber, Glass Fiber, Light weight Concrete, Compressive Strength and Tensile strength etc.

I. INTRODUCTION

Lightweight concrete is concrete that contains foaming agents that enhance the size of the mix while also offering extra qualities like cohesiveness and self-weight reduction. When poured on walls, lightweight concrete has substantial holes and fails to produce a concrete suspending or concrete covering. The properties of lightweight, porous concrete are the focus of this study. However, an appropriate water-to-cement ratio is required to provide adequate cement-water cohesion. The lack of moisture weakens the cohesive strength between the particles, lowering the strength of the concrete. Similarly, if there is too much water, the cement will separate from the aggregate and form a sticky layer, lowering its strength. Lightweight concrete can also made by mixing in air, removing finer aggregates, or substituting them by hollow, porous, or porous aggregates. Lightweight concrete is further classified into the following categories:

No-Fines Concrete

Raw concrete is formed of cement and fine aggregate and is lightweight. Create a consistent uniform everywhere. When installed on a wall, the major advantage of this lightweight concrete is that it can endure enormous voids and does not develop cement mortar or a cement layer. Figure 1.1 shows concrete without a fine grain size. Fine-grained concrete is often used for exterior walls and partitions as both bearing-load and non-bearing-load concrete. The resilience of fine concrete improves as the cement percentage increases. It is, nevertheless, vulnerable to moisture components. The lack of humidity lowers particle cohesiveness and the strength of the concrete. Similarly, too much water can cause the cement layer to separate from the aggregate, resulting in a cement layer. The lack of moisture lowers particle cohesiveness and the durability of the concrete. Similarly, excessive water may cause the cement coating to split from the aggregate, which produces a layer of slurry made from cement that seals and damages the concrete.

Lightweight Aggregate Concrete

This lightweight concrete uses low-specific gravity lightweight porous particles as a substitute for standard concrete. Lightweight aggregates include both man-made and natural materials, such as expansion blast furnace slag, vermiculite aggregates, and Gus clinker, as well as natural materials including pumice, slag, and all volcanic aggregates. The two

main qualities of this lightweight aggregate are its low density and high porosity. Lightweight concrete is classified into two types based on its intended usage. Semi-compacted lightweight concrete is one type, and structural lightweight concrete is a different one. Compacted lightweight concrete serves two functions. Cast roofs and walls, as well as reinforced concrete blocks or slabs. This type's primary demands are enough strength stability and low density for optimal enhancement, in addition to a low shrinkage increase to prevent cracks.Lightweight aggregate concrete, like traditional compact aggregate concrete, is technically fully compressed. It can form a strong connection between bars of steel and concrete when used together with steel bars. The substrate must provide appropriate corrosion protection for the steel. As a result of the shape and regularity of the aggregate bits, as well as the quality of the coarse & fine aggregate, the mixture for concrete appears to be more difficult. Only the most compact, lightweight aggregates may be used in structural concrete.

Aerated Concrete

Aerated concrete remains a permeable medium that does not contain major aggregates. Aerated concrete is made by collaborating air or other gas into a cement and fine sand solution. Ground fuel ash or other silicate minerals are used commercially instead of sand, and lime can also be used as a cement substitute. Aerated concrete can be made in two ways. The first method involves introducing gas into a plastic-state mixture via a chemical process. The second approach introduces air by combining it with a stabilizing foam or by filling it with an air-consumption substance. The first approach is frequently cast-off in precast concrete facilities, where precast parts are sterilized to generate concrete with great strength and durability. The primary technique is commonly utilized in the precast concrete industry to manufacture concrete with a comparatively high strength and moderate drying shrinkage by autoclaving precast components. The other is used mainly in cast-in-place concrete and is appropriate for roofing mortar or pipe insulation.

a) No-Fines Concrete b) Lightweight Aggregate Concrete c) Aerated Concrete

Figure 1 Different type of lightweight concrete

Applications of Lightweight Concrete

- Because LWC has low strength, it serves a purpose in the construction of smaller buildings with roofing panels and load-bearing walls.
- It's commonly employed for constructing garden boundaries, doors, stairs, and other structures.
- It is used to make walls for partitions in the construction of large buildings.

Comparison of LWC and NC

Lightweight concrete, compared to regular concrete, has an increased water content. The use of porous aggregates extends the drying time. To get around this, soak the aggregate in water while adding the cement. Regular concrete, as previously stated, weighs between 140 and 150 pounds per cubic foot due to the inclusion of denser particles in its natural state. As such, it seems that normal concrete is less expensive than LWC. Regular concrete assignments, on the other hand, necessitate further framing, cladding, and reinforcing, which raises the total expense. As a result,

LWC continues to be a cost-effective building material, especially for massive construction projects.

Figure 2Comparisons of LWC and NC

Rubber Crumb

Rubber granules are big bits of rubber derived from the tires of vehicles. This kind of rubber is made using a method known as surrounding milling. This is a multi-step process that involves the use of car or truck wheels in the form of chips, sidewalls, garbage, or tread. This method separates rubber, metal, and fiber one by one. The tires are then crushed into smaller pieces by a crushing machine. The small pieces of wood are next pelletized, which crushes them into small pieces and removes the steel and fibers.

Glass Fibre

Glass fiber, also referred to as fiberglass, and is a substance composed of extremely fine glass strands. Because of its strength, light weight, and resistance to heat and corrosion, it can be used in a variety of industries, including electronics, motor vehicles, aerospace, and construction. Glass fiber is frequently included in composite materials, such as resin, as a reinforcing ingredient to produce materials that are robust and long-lasting.

II. OBJECTIVES

- To study the effect of crumb rubber in light weight concrete.
- To identify effective amount of replacement materials used in research work.
- To make lightweight high strength concrete.
- To evaluate the compressive strength of an ordinary concrete mix after 28 days of curing with glass fiber and crumb rubber.
- To assess the flexural strength of a standard concrete mix after 28 days of curing with glass fiber and crumb rubber.
- Building sustainable and environmentally friendly materials useful in construction work.

III. METHODOLOGY

In this section consider two different kind of materials which provide tensile strength to concrete. One is glass fiber and second is crumb rubber that was replaced with fine aggregate. For this study use M25 of concrete grade. To study fresh and harden properties of sample perform experiments at different time period. At fresh stage use slump test and after samples get hard samples are test for compressive strength, flexural strength and split tensile.

Cement

In this research study OPC cement, sold under the Ultra Tech Cement brand, and was carried out for the experiment. In this order to protect concrete in closed containers from the effects of time, priority is given to finding the concrete in a single operation. The cement is then tested as on mention in to IS code: 8112-2013 and certified according to the organization requirements.

Glass Fiber in concrete

Glass fibers and cement hydration products, or cement with sand, make up glass fiber-reinforced concrete (GFRC). Glass fibers have been used in concrete as reinforcement. In Russia, glass fibers were initially utilized to strengthen concrete and cement. Nevertheless, the highly alkaline Portland cement matrix damaged them. Alkali-resistant glass fibers have been created in the UK and other nations. Glass fibers can be found in woven fabrics, chopped strand matting, wool, ropes, carnets, and continuous rovings. Portland cement's alkali attack has also been tested on glass fibers covered with epoxy-based compounds.

Figure 3Glass Fibre

Rubber crumb in concrete

The material known as crumb rubber is made by crushing recycled rubber, typically from used tires, into finer, granular fragments. It can be utilized in place of fine aggregate, like sand, in building materials like asphalt or concrete. The replacement of fine aggregate with crumb rubber has various advantages. Recycling used tires contributes to trash reduction and lessens environmental impact. It can also give the building material superior qualities, such as increased flexibility, decreased cracking, and improved vibration and noise absorption. In general, it is possible to replace fine aggregate with crumb rubber to increase the performance of construction materials while also boosting environmental sustainability, lowering waste, and being practical and sustainable.

Figure 4Crumb Rubber

Figure 5Vicat test apparatus

Figure 6Concrete cube Compressive Strength testing

Figure 7Concrete cube casting

Figure 8Concrete beam flexural strength testing

Figure 9Concrete cylinder Split tensile testing

IV. RESULT AND DISCUSSION

In this section provide details about concrete samples performed under different conditions. Prepare graphs with the help of collected experimental data. To understand the effect of glass fiber and rubber crumb in light weight concrete.

Results of Slump value test

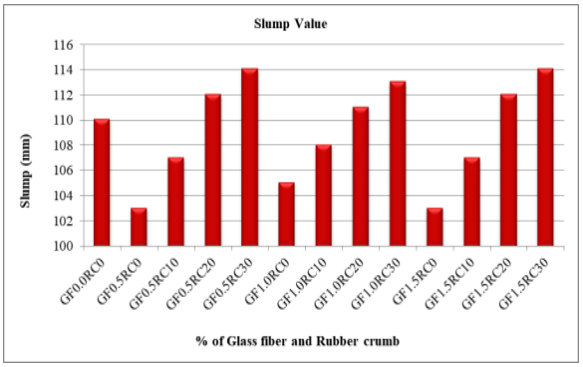

Figure 10Slump values of concrete mix samples with different amounts of rubber crumb and varying % glass fiber

Results of Compressive strength test

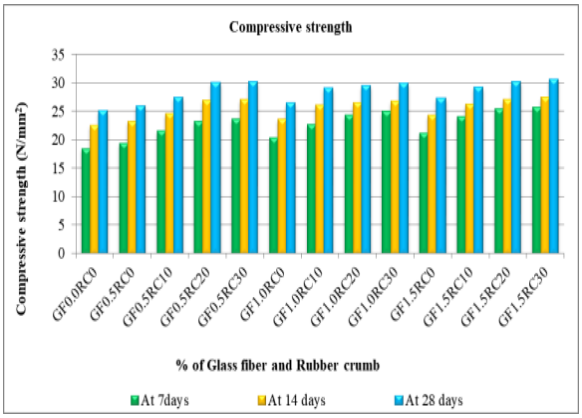

Figure 11Compressive strength test with different amounts of rubber crumb and varying % glass fiber

Results of Flexural strength test

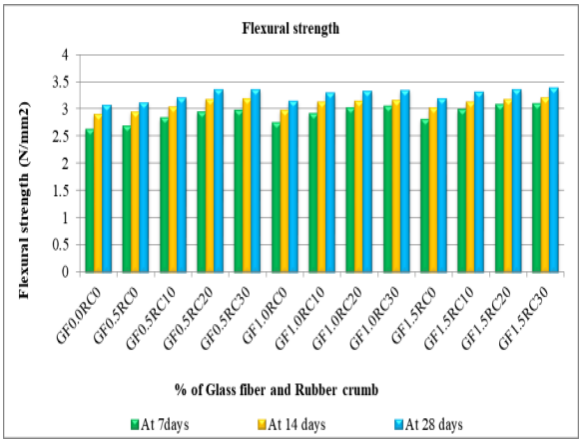

Figure 12Flexural strength test with different amounts of rubber crumb and varying % glass fiber

Results of Split tensile strength test

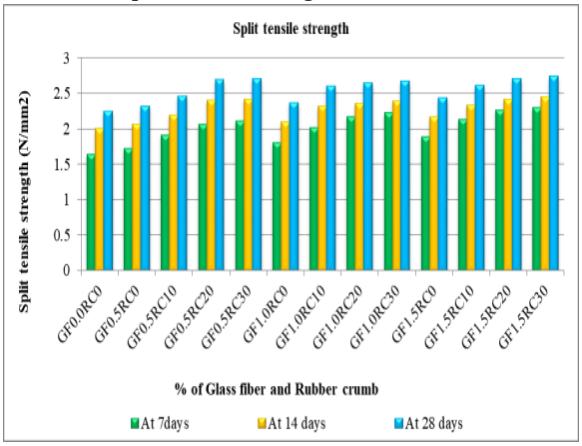

Figure 13Split tensile strength testwith different amounts of rubber crumb and varying % glass fiber

Results of Density Variation

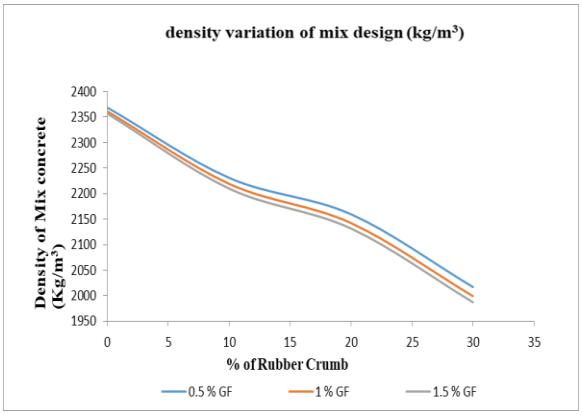

Figure 14Density variation of concrete mix prepared with different % of Glass fiber and rubber crumb

V. CONCLUSION

Slump value (mm)

- We can clearly say from this study slump value of composite concrete is decreased with increasing the percentage of glass fibre and increased when we are decreasing the percentage of glass fibre with increasing percentage of crumb rubber.
- Slump value is max. At 30% crumb rubber with 0.5% glass fibre.
- It was noticed that the addition of glass fiber reduced the slump value, but crumb rubber increases the slump value.

Compressive strength (N/mm^2)

- Compressive strength of composite concrete is increased with varying % of glass fibre and crumb rubber but rate of change of strength is decreased after 20% of crumb rubber with varying % of glass fibre.
- Max. Compressive strength of composite concrete is at 30% crumb rubber with 1.5% glass fibre.
- We can also say that mainly glass fibre imparts an important role to gain strength as compared to crumb rubber.
- But after concluding all data it was seen that after 20% addition of crumb rubber compressive strength did not change with major difference.

Flexural strength (N/mm^2)

- Flexural strength of composite concrete is increased with varying % of glass fibre and crumb rubber but rate of change of strength is decreased after 20% of crumb rubber with varying % of glass fibre.
- Max. Flexural strength of composite concrete is at 30% crumb rubber with 1.5% glass fibre.
- We can also say that mainly glass fibre imparts an important role to gain strength as compared to crumb rubber.
- But after concluding all data it was seen that after 20% addition of crumb rubber flexural strength did not change with major difference.

Split tensile strength (N/mm^2)

- Split tensile strength is maximum at mix of 1.5 % of glass fibre with 30 % crumb rubber after 28 days.
- After analyzing all the data, we can say that after 20 % addition of crumb rubber change in split tensile strength is not considerable.

Density (Kg/m^3)

- As per figure 4.21 we can say that when the glass fiber and rubber crumb is increased, the density composite concrete is decreasing.

VI. FUTURE SCOPE OF WORK

- In future work higher grade of concrete also be consider for study with same materials.
- In this study, just one type of fiber material was primarily employed for the concrete stabilization process; however, additional research can be conducted using other similar types of materials to improve the concrete's quality.
- Further research can be conducted utilizing many alternative percentages and sizes of leftover tire rubber to explore the effect in greater depth.
- Futuristic work can also be done with other waste products such as biomass ashes, non-biodegradable materials, and other environmentally harmful wastes to achieve better environmental results.

VII. REFERENCE

[1] Badawi, Moataz, et al. "The Effect of Polypropylene Fibers on the Fracture Characteristics of Lightweight Aggregate Crumb

Rubber Concrete Composites." Engineering, Technology & Applied Science Research 13.3 (2023): 10638-10645. https://doi.org/10.48084/etasr.5821

[2] Ahmad, Jawad, et al. "A study on the mechanical characteristics of glass and nylon fiber reinforced peach shell lightweight concrete." Materials 14.16 (2021): 4488. https://doi.org/10.3390/ma14164488

[3] Murali, G., et al. "Low-velocity impact response of novel prepacked expanded clay aggregate fibrous concrete produced with carbon nano tube, glass fiber mesh and steel fiber." Construction and Building Materials 284 (2021): 122749. https://doi.org/10.1016/j.conbuildmat.2021.122749

[4] Tiwari, Sachin, and Preeti Gangwar. "Evaluate the effect of acid attack on rubberised concrete using crumb tyre rubber and replacement of cement by alccofine." Materials Today: Proceedings 47 (2021): 3778-3782. https://doi.org/10.1016/j.matpr.2021.03.006

[5] Adeboje, Adeyemi Oluwaseun, et al. "Characterization of modified crumb rubber concrete." International Journal of Sustainable Development and Planning, IIETA 15.3 (2020): 377-383. https://doi.org/10.18280/ijsdp.150315

[6] Aslani, Farhad, Ayoub Deghani, and Zohaib Asif. "Development of lightweight rubberized geopolymer concrete by using polystyrene and recycled crumb-rubber aggregates." Journal of Materials in Civil Engineering 32.2 (2020): 04019345. https://doi.org/10.1061/(ASCE)MT.1943-5533.0003008

[7] Asim, Muhammad, et al. "Comparative experimental investigation of natural fibers reinforced light weight concrete as thermally efficient building materials." Journal of Building Engineering 31 (2020): https://doi.org/10.1016/j.jobe.2020.101411

[8] Del Rey Castillo, Enrique, et al. "Light-weight concrete with artificial aggregate manufactured from plastic waste." Construction and Building Materials 265 (2020)

[9] Wang, Rong, et al. "Experimental study on mechanical and waterproof performance of lightweight foamed concrete mixed with crumb rubber." Construction and Building Materials 209 (2019): 655-664. https://doi.org/10.1016/j.conbuildmat.2019.03.157

[10] Vakili, S. Ehsan, et al. "Effect of fibers and hybrid fibers on the shear strength of lightweight concrete beams reinforced with GFRP bars." Structures. Vol. 20. Elsevier, 2019.

[11] Hossain, FM Zahid, et al. "Mechanical properties of recycled aggregate concrete containing crumb rubber and polypropylene fiber." Construction and Building Materials 225 (2019): 983-996. https://doi.org/10.1016/j.conbuildmat.2019.07.245

[12] Abdelmonem, Ayman, et al. "Performance of high strength concrete containing recycled rubber." Construction and Building Materials 227 (2019): 116660.

[13] Wu, Tao, et al. "Flexural behavior of steel fiber–reinforced lightweight aggregate concrete beams reinforced with glass fiber–reinforced polymer bars." Journal of Composites for Construction 23.2 (2019)

[14] Shahjalal, Md, et al. "Experimental study on the mechanical properties of recycled aggregate concrete using crumb rubber and polypropylene fiber." CSCE Annual Conference, Canada. 2019. https://csce.ca/elf/apps/conferenceviewer/conferences/2019/pdfs/PaperPDFVersion_40_0313054319

[15] Hameed, Awham Mohammed, and Bilal Abdul Fatah Ahmed. "Employment the plastic waste to produce the light weight concrete." Energy Procedia 157 (2019): 30-38.