



A STUDY ON MECHANICAL PROPERTIES OF A TEXTILE REINFORCED CONCRETE USING GGBS AS PARTIAL REPLACEMENT TO CEMENT

¹K.Anil Kumar, ²B.Ganesh.

¹M.Tech Student, ²Assistant Professor

^{1,2} Structural Engineering, Department Of Civil Engineering

^{1,2}Lenora College Of Engineering, Rampachodavaram – 533288, E.G. District, Andhra Pradesh

Abstract: Textile-Reinforced Concrete (TRC) is an innovative composite material that uses textiles, such as glass fiber mesh, as reinforcement instead of traditional steel bars. This approach offers several advantages, including corrosion resistance, enhanced tensile strength, high bearing capacity, and improved fracture performance, while addressing the limitations of steel reinforcement. In this study, TRC specimens will be prepared using glass fiber mesh as the textile reinforcement and Ground Granulated Blast Furnace Slag (GGBS) as a sustainable alternative to cement. The specimens will be casted with varying percentages of 10%,20%,30%,40%,50%,60% GGBS as partial replacement to cement. The mechanical behaviour of TRC is evaluated through impact and flexural strength tests. It was observed that the flexural strength were increased by 28% and impact resistance increased by up to 47% with the inclusion of 30% GGBS in GTRC as compared to the Plain cement composite. It was observed that the addition of up to 30% of GGBS in GTRC yielded better results compared to GTRC without GGBS.

Keywords: Concrete, Flexural strength, GGBS, glass fibre mesh, Impact strength, Textile-reinforced concrete.

Introduction: Concrete is a widely used construction material known for its high compressive strength but low tensile strength and brittleness. To overcome these limitations, Textile- Reinforced Concrete (TRC) has emerged as an innovative solution, offering lightweight, corrosion-resistant, and durable properties. Among various textile reinforcements, glass fibre mesh is a promising material due to its high tensile strength, flexibility, and resistance to environmental degradation. Unlike traditional steel reinforcement, glass fibre mesh enhances ductility while reducing structural weight, making it suitable for thin-walled structures, façade panels, and precast elements. This study aims to assess the mechanical properties of glass fiber mesh-reinforced concrete incorporating GGBS. Key parameters such as compressive, tensile, and flexural strength, along with durability, will be evaluated. The findings will contribute to the development of sustainable and high-performance TRC, promoting eco-friendly alternatives in modern construction while maintaining structural integrity.

Materials:

Cement: OPC is known for its versatility and strength, making it suitable for a wide range of construction applications, including residential, commercial, and infrastructure projects. It offers excellent binding properties when mixed with water and aggregates, allowing for the creation of durable concrete structures. Despite its widespread use, OPC production can contribute to carbon emissions and environmental impacts, leading to increasing efforts to develop more sustainable alternatives and practices within the cement industry.

Ground Granulated Blast Furnace Slag (GGBS): Ground Granulated Blast Furnace Slag (GGBS) is an industrial byproduct obtained from the iron and steel manufacturing process. It is produced by rapidly cooling molten blast furnace slag with water or air, preventing crystallization and forming a granulated material. This granulated slag is then dried and ground to a fine powder, which can be used as a supplementary cementitious material (SCM) in concrete. GGBS is widely

used as a partial or complete replacement for Ordinary Portland Cement (OPC) due to its numerous advantages in terms of strength, durability, and sustainability.



Fig. 1 GGBS

Glass Fibre Mesh: Glass fibre mesh is a reinforcement material made from woven glass fibers and is widely used in textile-reinforced concrete (TRC). It is produced by weaving fine glass fibre into a mesh fabric, which provides enhanced tensile strength, flexibility, and crack resistance to concrete. This mesh is typically used in applications where lightweight and corrosion-resistant reinforcement is required, offering a significant advantage over traditional steel reinforcement.



Fig. 2 Glass Fibre Mesh

Sand: Sand serves as the fine aggregate that is mixed with cement and water to form a paste-like substance used for bonding bricks, stones, and other masonry units. Sand in mortar acts to provide bulk, workability, and strength, while also reducing the cost of using cement, which is more expensive. The typical particle size of sand used in mortar is less than 4.75 mm, and it is essential for achieving the right consistency and strength.

Results and Discussion:

- i) **Flexural Strength:** The samples were cured for 28 days after they were cast. The samples were dried for 4 to 5 hours at room temperature before testing. The tests are shown here for the flexural strength after 28 days.

Table 1 Flexural strength of concrete for varying percentages of GGBS

S.No.	MIX	Flexural strength(MPa)
1	0GT	1.26
2	10GT	2.35
3	20GT	2.39
4	30GT	2.51
5	40GT	2.23
6	50GT	1.85
7	60GT	1.66

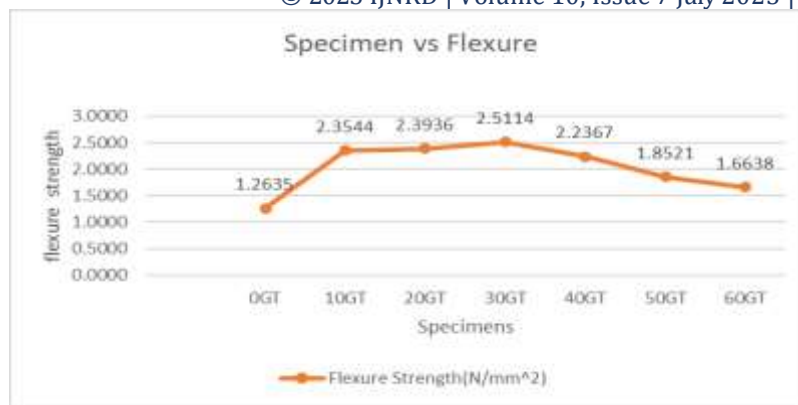


Fig 3 flexure strength diagram with respect to various ratios of GGBS

The graph titled “Specimen vs Flexure” illustrates the variation of flexural strength (in N/mm²) across different concrete or composite specimens identified as 0GT to 6GT. This graphical representation aims to evaluate how varying proportions of the GT additive influence the material's resistance to bending stress.

From the data, it is evident that the control specimen, 0GT, exhibits the lowest flexural strength at 1.2635 N/mm², suggesting a relatively brittle nature with limited resistance to bending. As GT content increases, a notable improvement is observed. 10GT shows a sharp rise to 2.3544 N/mm², and 20GT slightly improves upon that with 2.3936 N/mm². The highest flexural strength is recorded at 30GT, peaking at 2.5114 N/mm², indicating that this is the optimum GT level for enhancing flexural performance. This increase may be attributed to improved matrix cohesion, better crack bridging, or fiber distribution enhancing resistance to tensile stress during bending.

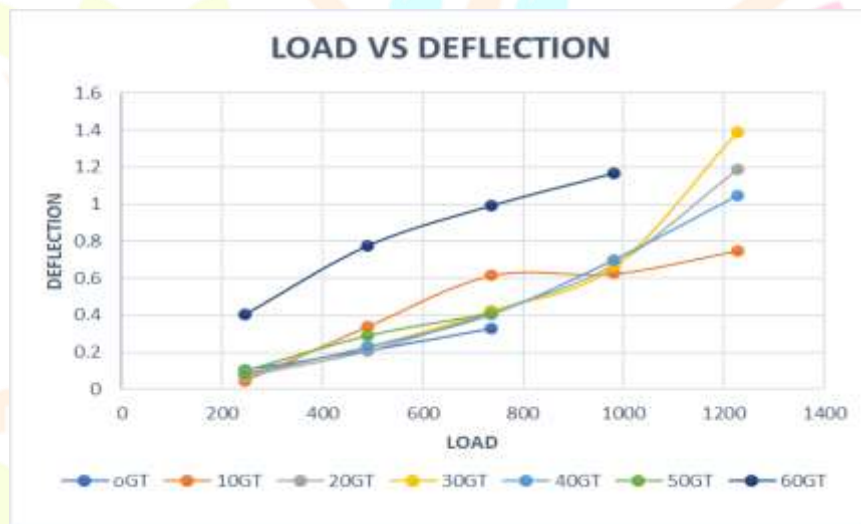


Fig 4 load vs deflection curve diagram

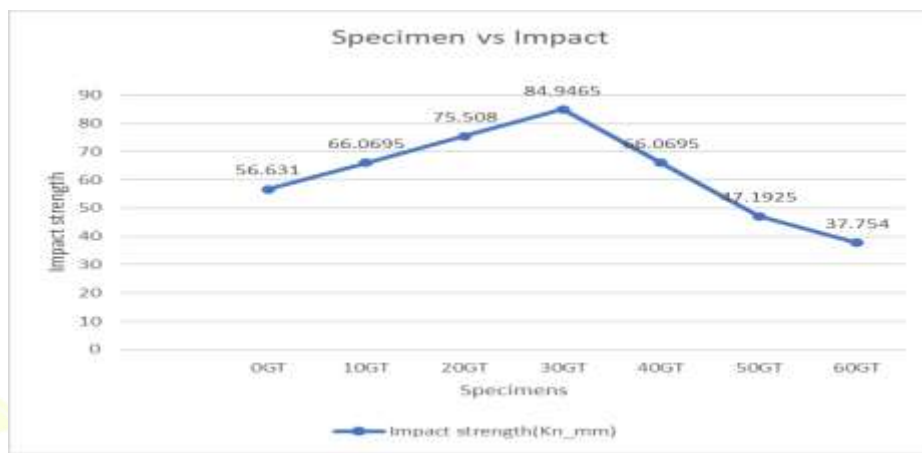
The graph titled “Load vs Deflection” presents the deflection behavior of different specimens (0GT to 6GT) under varying load conditions. The X-axis represents the applied load, while the Y-axis shows the corresponding deflection. Each colored line represents a different specimen composition based on GT content, indicating how the structural element responds to increasing load.

From the graph, it is evident that the specimen with 60GT demonstrates the highest deflection under increasing load, showing a steady and continuous rise beyond 1000 units of load, peaking above 1.2 mm of deflection. This suggests a more ductile behavior, though possibly at the cost of reduced stiffness or load-bearing strength. Similarly, 30GT also shows a sharp rise in deflection beyond 1000 units of load, eventually reaching the highest deflection of all specimens at around 1.5 mm, which indicates a flexible response under high stress.

Impact Resistance Strength: The samples were cured for 28 days after they were cast. The samples were dried for 4 to 5 hours at room temperature before testing. The tests are shown here for the Impact strength after 28 days.

Table 3 Impact strength of concrete for varying aspect ratio of GGBS

S.No	Mix	Impact resistance
1	0GT	56.63
2	10GT	66.06
3	20GT	75.50
4	30GT	84.94
5	40GT	66.06
6	50GT	47.19
7	60GT	37.75

**Fig 5 impact strength diagram with respect to percentages of GGBS**

Discussions: As per the above results we observe that :

- The GTRC of 30% Ground Granulated Blast Furnace Slag (GGBS) along with glass fibre mesh significantly enhanced the impact strength of concrete at 28 days.
- This improvement suggests the strength effect of GGBS and glass fibre mesh in resisting dynamic and sudden loading conditions with 46% of improvement in impact test at 30 percentage GGBS.
 - The same combination (30% GGBS with glass fibre mesh) also led to a 28% increase in flexural strength at 28 days.

The provided graph titled “**Specimen vs Impact**” illustrates the relationship between different specimens labeled from **0GT to 60GT** and their corresponding **impact strength measured in kN·mm**. The graph exhibits a clear trend where the impact strength increases steadily from **56.631 kN·mm at 0GT** to a **peak value of 84.9465 kN·mm at 30GT**, indicating that the modification or additive represented by "GT" contributes positively to the impact resistance of the material up to a certain point. This upward trend from 0GT to 30GT suggests that the inclusion of the GT content improves the toughness and energy absorption capability of the specimens, likely by enhancing matrix reinforcement or internal bonding.

Conclusions: From the Study on Mechanical Properties of Glass fibre mesh Reinforced Concrete based on varying percentages of GGBS the following conclusions were drawn:

- The maximum flexural strength of concrete at 28 days was obtained at using glass fibre mesh with 30 percentage of GGBS increased by 28 % as compared to conventional mix.
- The maximum impact strength of concrete at 28 days was obtained at using glass fibre mesh with 30 percentage of GGBS increased by 46% as compared to conventional mix .
- Impact resistance test and Flexural strength test results revealed a clear improvement in mechanical behaviour with increasing in replacement of cement by ggbs upto 30% and by providing glass fibre mesh while promoting environmental sustainability.

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