e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:07/Issue:02/February-2025 Impact Factor- 8.187 www.irjmets.com

MECHANICAL CHARACTERISTICS OF A MORTAR EVALUATED USING FCG AND WASTE RUBBER

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ABSTRACT

Mortar plays a crucial role in the construction industry, but it has its limitations. To address these challenges, more research is needed into durable and eco-friendly building materials. Mortar composites, created by blending different compounds, are used in a variety of cement concrete applications. Globally, mortar is the most commonly used building material. With advancements in understanding material behavior—particularly concerning admixtures, waste materials, and curing methods—high-performance or modified mortars are now being developed. Mortar is typically made by mixing sand and cement in specific proportions. It's recommended to use special mortars rather than regular cement mortar due to their added benefits. These advantages arise from challenges related to raw material collection, such as pollution and environmental impact. Additionally, the raw materials for cement and sand are finite, which has led to a growing interest in producing new materials for mortar. The properties of special mortar made with waste materials from various industries are being explored. As cement and sand consumption continues to rise, replacing these materials in mortar becomes a key focus of research. With industrialization and urbanization, the disposal and recycling of waste materials like glass and rubber have become pressing issues. Using these waste products in construction is an effective way to conserve and make use of natural resources. For instance, replacing cement with glass powder reduces mortar costs and enhances compressive strength due to its pozzolanic properties. Since much of this waste is not recycled, repurposing it in construction is a sustainable solution to both waste disposal and material conservation.

I. INTRODUCTION

Our nation is currently experiencing economic growth, leading to an increasing demand for construction materials on a daily basis. In India, concrete remains the most widely used building material. The global production of cement has reached 2.8 billion tons annually, with projections suggesting it could rise to around 4 billion tons per year. However, the cement industry is facing challenges such as rising raw material costs. Additionally, industrialization and urbanization have led to significant issues with the disposal and recycling of waste glass and rubber. Therefore, it is crucial to develop sustainable solutions, such as using these waste products as raw materials in the construction industry. This approach would help conserve natural resources, particularly glass and rubber waste.

Concrete typically contains a high amount of cement, which contributes to the release of CO_2 and negatively impacts the environment. To mitigate this, reducing the cement content by replacing it with eco-friendly, cost-effective materials such as rubber and glass is a promising solution. Domestic and industrial waste is a major source of pollution and requires urgent attention. Waste disposal, particularly in metropolitan areas, is a growing concern. With the increase in industrialization and improvements in living standards, the use of glass has surged in recent years. Unfortunately, much of this glass waste is not recycled and is discarded, leading to serious issues such as the depletion of natural resources and environmental harm.

If large amounts of generated waste were utilized in construction and industrial applications instead of relying on natural materials, there would be three key benefits:

- Preservation of natural resources
- Proper disposal of waste materials
- Liberating valuable land for other purposes

1.1 Objective of the study :

- To evaluate, through testing, how FCG & WR-based mortar compares to conventional mortar in terms of both fresh and hardened properties.
- To assess the economic feasibility of replacing a portion of the cement and sand in mortar with a combination of glass and tire waste, in the form of FCG and WR.
- To investigate the mechanical properties and behavior of mortar containing waste glass and tires (FCG and WR).
- To determine the optimal mortar proportions for varying strengths using FCG and WR.
- To identify the maximum percentage of FCG and WR that can be incorporated into mortar.
- To compare the fresh and hardened properties of mortar with FCG & WR to those of conventional mortar.

II. LITERATURE REVIEW

1. Segre & Joekes (2000) studied the surface modification of powdered tire rubber to enhance its adhesion to cement paste. Their compressive strength tests showed that adding rubber particles improved the toughness and reduced the porosity of the material specimens. Using tire rubber particles as an additive, rather than a fine aggregate, in cement-based materials appears promising for applications like driveways or road construction.

2. Ganjian (2009) found that the compressive strength of concrete depended on two factors: the grain size of the rubber used for replacement and the percentage of rubber added. Generally, compressive strength decreased as the percentage of rubber replacement increased, though a 5% replacement of aggregate or cement with rubber resulted in less than a 5% reduction in compressive strength, with minimal impact on other properties. The greatest strength reduction was observed with 10% and 15% rubber replacement for both types of rubber. When 5–10% of the aggregate was replaced with chipped rubber, the corresponding reduction in strength for powdered rubber was between 18% and 36%. The increase in rubber powder content reduced both the tensile and compressive strength of concrete, mainly due to poor bonding between the rubber and the paste matrix, which is crucial for maintaining tensile strength.

3. Bhat & Rao (2014) explored the use of waste glass powder as a partial replacement for ordinary Portland cement (OPC) in concrete. They produced concrete with 5%, 10%, 15%, and 20% cement replacement by waste glass powder and compared its properties with control concrete that contained no glass powder. Cube specimens were cast, cured, and tested at 7, 14, and 28 days for strength. The results showed that increasing the proportion of cement replaced by waste glass powder enhanced the compressive strength. This suggests that glass powder can reduce the need for cement, lower concrete weight, and decrease its porosity. Additionally, waste glass powder is both cost-effective and environmentally friendly.

III. EXPERIMENTAL WORK

In this experimental study, the compressive strength of mortar is evaluated by partially replacing cement and sand with waste glass and rubber tire powder, in the form of FCG & WR, and compared to conventional mortar. The experiment is divided into four stages:

i. In the first stage, cement is replaced with FCG, and the compressive strength of the mortar is measured at a constant w/c ratio of 0.35.

ii. In the second stage, sand is replaced with WR, and the compressive strength of the mortar is determined at a constant w/c ratio of 0.35.

iii. In the third stage, both cement is replaced with FCG and sand is replaced with WR, and the compressive strength of the mortar is measured.

iv. In the fourth stage, cement is replaced with FCG, and the compressive strength of the mortar is evaluated at varying w/c ratios, ranging from 0.35 to 0.48.

Finally, a cost analysis of the various stages is conducted at different replacement levels of FCG & WR, and the results are presented in Chapter 5. The replacement levels for the waste materials in mortar are 5%, 10%, 15%, and 20%.

IV. RESULT ANALYSIS

4.1 Compressive strength Test

Mortar specimens are tested to evaluate the compressive strength performance of cement. The test results for individual mortar samples are presented, with the mean strength, standard deviation, and coefficient of variation shown in Tables 4.5, 4.6, and 4.7. Figure 4.5 illustrates the compressive strength of standard mortar modified with 0%, 5%, 10%, 15%, and 20% glass powder as a cement replacement after 7, 14, and 28 days of water curing.

From this figure, it is evident that replacing up to 5% of cement with glass powder slightly improves the compressive strength of the mortar at the observed curing ages. Specifically, at 5% replacement, the compressive strength increases by 5.06%. However, increasing the replacement level beyond 5% (to 10%, 15%, or 20%) results in a decrease in compressive strength. For instance, after 7 days of water curing, the mortar's compressive strength increases by 5.06% at 5% replacement but decreases by 11.63%, 16.34%, and 19.34% at 10%, 15%, and 20% replacement levels, respectively, when compared to conventional mortar (0% replacement).

These results indicate that replacing 5% of cement with waste glass powder provides the best compressive strength performance in mortar.

Table 4.1 Compressive Strength Test Result of Mortar with CementReplacement by FCG

Replacement Level of Glass	Compressive Strength (MPa)		
	7 days	14 days	28 days
0%	20.9	25.8	32.2
5%	22.0	27.3	33.8
10%	18.4	23.1	30.9
15%	17.5	21.9	29.2
20%	16.9	21.1	28.1

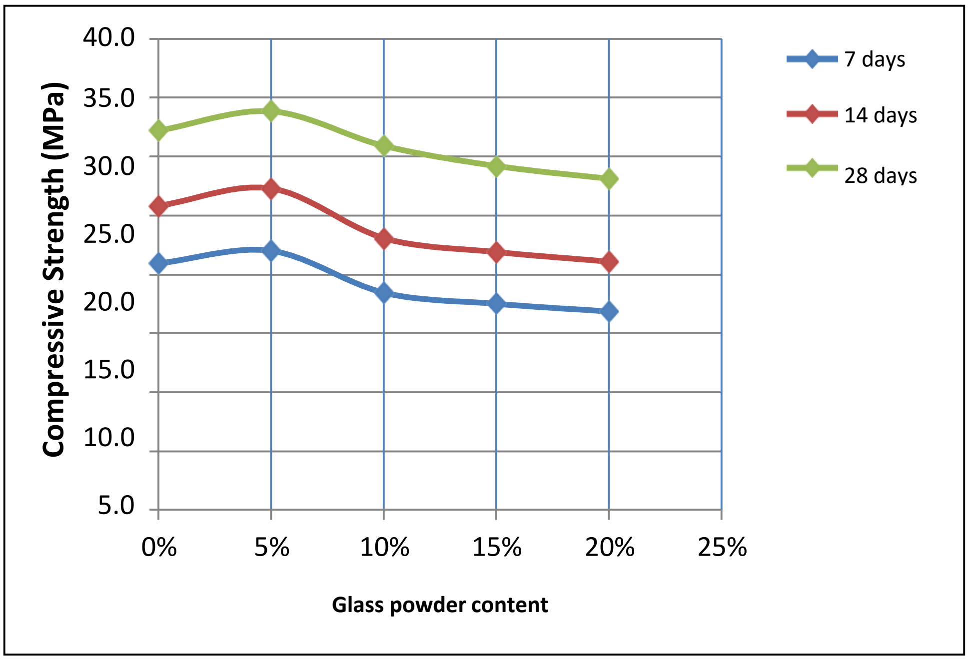

Figure 4.1 Replacement of cement by FCG

From Table 4.1 and Figure 4.1 shows that the compressive strength of glass modified mortar is increased at 5 % replacement level of cement with FCG as compared to conventional mortar and then decreases at replacement level of 10%, 15%, & 20 % at the age of 7,14 & 28 days. These results are shown that the 5 % replacement level of cement with waste glass powder in mortar gives the better compressive strength as compared to conventional mortar,

Table 4.2 Percentage variation of compressive strength at Replacement level of Glass Powder

Replacement Level of Glass Powder	Variation of compressive strength in percentage		
	7 days	14 days	28 days
5%	5.06	5.76	5.08
10%	-11.86	-10.56	-4.04
15%	-16.34	-15.13	-9.37
20%	-19.43	-18.27	-12.72

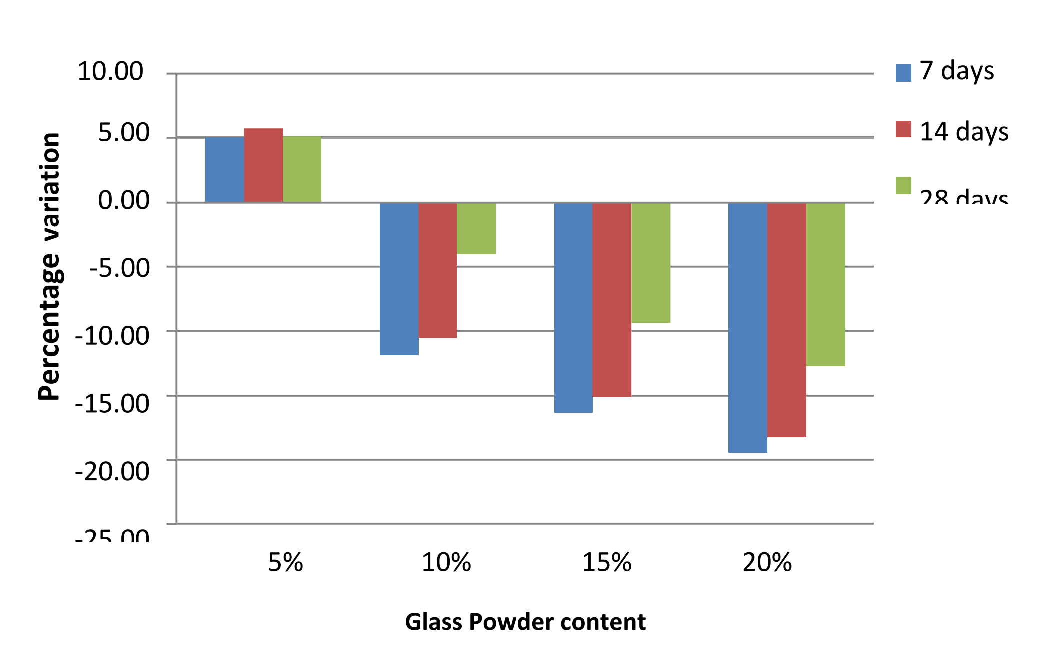

Figure 4.2 Percentage variation of Compressive strength with FCG

Table 4.3 compressive strength test result of mortar

Replacement Level of Rubber & Glass	Compressive Strength (Mpa)		
	7 days	14 days	28 days
0%	20.9	25.8	32.2
5%	18.0	21.3	24.1
10%	13.3	18.4	19.8
15%	12.5	17.3	18.9
20%	11.5	16.5	17.6

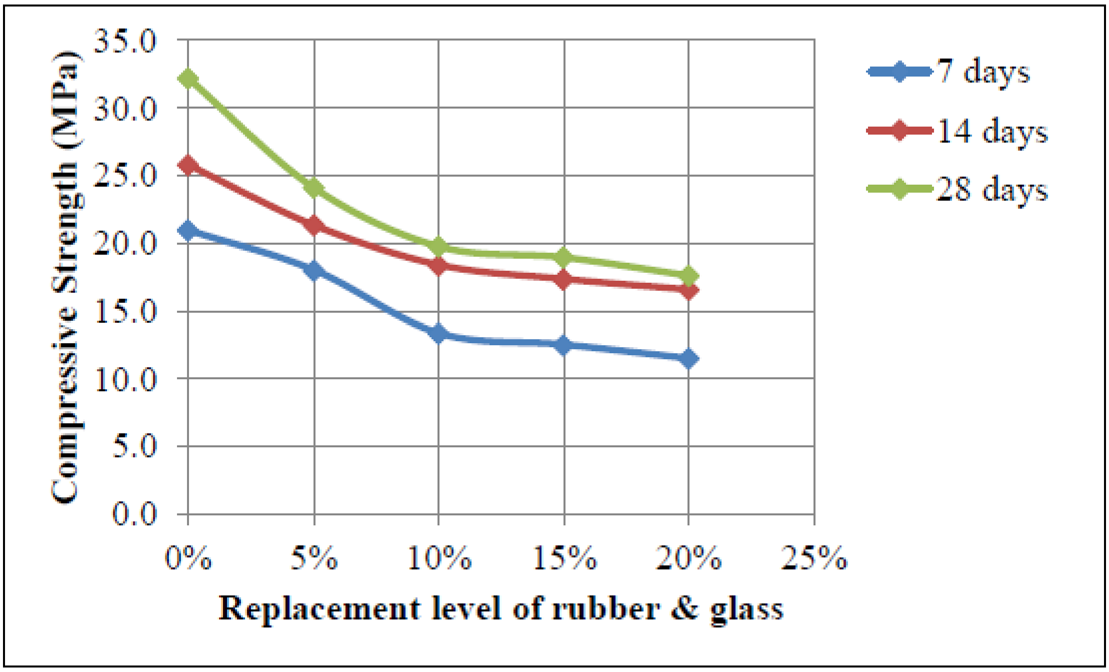

Figure 4.3 Replacement of cement & sand by FCG & WR

From Table 4.3 and Figure 4.3 shows that the compressive strength of glass & rubber modified mortar is decreases the compressive strength of the replacement level 5%, 10%, 15% and 20% as compared to conventional mortar at the age of 7,14 & 28 days. From the above research work we conclude that the glass improves the compressive strength slightly more than

V. CONCLUSION

In the present study, glass powder was used as a partial replacement for cement. The study evaluates the impact of incorporating glass powder into cement-based materials. The main conclusions are:

i. The amount of waste glass incorporated significantly affects the properties of cement mortar, with the optimal replacement level being 5% of cement with FCG.

ii. The fineness of the glass powder particles plays a crucial role. The particles must be at least as fine as cement powder for the pozzolanic activity to have a noticeable effect in the short term.

iii. While glass powder enhances the compressive strength of mortar, the addition of rubber powder tends to reduce the compressive strength of the mortar.

iv. Environmental considerations should not be overlooked. Incorporating waste glass into concrete, when done selectively, offers a solution to waste management challenges. Substituting finely ground glass powder for Portland cement can help mitigate global environmental issues, such as the high carbon dioxide emissions from Portland cement production. Additionally, it reduces the need to extract natural materials like limestone.

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