International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 04 | April - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Experimental Research on Concrete Strength Parameters: Glass Powder with Different Dosages Replacing Cement in M25 & M30 Concrete

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Abstract - Waste products, agricultural waste, and other natural elements are currently the focus of scientific attention as they seek to create technologies that may be used as building raw materials. On the other hand, recycling helps build a cleaner, safer environment while also boosting the economy. The purpose of this research is to find out how much stronger concrete becomes when various glass particles are used in place of cement in M25 and M30 concrete mixes. Glass bottles and other bottles that end up in landfills are a byproduct of people's daily water use and other unsanitary practices. Land filling broken glass is an environmentally harmful and unsustainable practice since the material does not biodegrade. Glass is mostly composed of silica. The primary objective of this research is to examine the potential effects of using glass powder as a partial cement substitute in two distinct concrete grades, M25 and M30, at varying percentages (5%, 10%, 15%, 20% & 25% of the cement weight). On days 7, 14, and 28, we compared the findings to those of normal concrete by testing the strength and split tensile strength.

Key Words: Cement, glass powder, natural sand, coarse aggregate, compressive strength, cracking tensile strength.

1.INTRODUCTION

Concrete is a highly prevalent substance on a global scale. The imperative to decrease energy use is growing as a result of the phenomenon of global warming. The impacts of global warming have already permeated the lives of individuals worldwide and are well recognized. The process of cement manufacture necessitates a substantial amount of energy, resulting in the emission of significant quantities of carbon dioxide (CO2) and the generation of carbon monoxide. Nevertheless, the manufacturing process of Portland cement, which is a primary ingredient in concrete, emits significant quantities of carbon dioxide, a potent greenhouse gas. Specifically, the manufacture of one ton of Portland cement clinker typically yields around one ton of carbon dioxide and other greenhouse gases. Greenhouse gasses (GHGs). The atmospheric concentration of carbon dioxide has risen by over 30 percent during the past two centuries. The cement and concrete industry's sustainable growth is significantly influenced by environmental concerns. To minimize cement usage and mitigate environmental pollution, it is necessary to substitute certain portions of cement with volcanic ash components. Approximately 111 million tons of managed trash from domestic, commercial and industrial garbage are thrown in UK landfills each year, raising waste disposal costs and environmental issues. Using recycled products will help you save landfill space and disposal expenses. Using recycled materials uses less energy than virgin resources.

Using recycled materials in building is the greatest choice owing to recycled materials since there are many construction sites. Recycled aggregate can be utilized as a substitute for asphalt concrete, baseless, pipe base, natural gas waste, and liquid trench gravel backfill. Fly ash, ceramic waste, silica powder, marble powder, blast furnace slag, etc. Some industrial wastes such as Studies undertaken in recent years have revealed that glass trash may be used efficiently as glass aggregate or glass pozzolana in concrete. The concrete industry is making efforts to partially replace cement with waste glass powder.

Considering the difficulties of cement hydrates and reactive aggregates, partial substitution of cement with glass waste also enhances the stability of cementitious materials. Colored glass mixture waste is crushed to about the size of cement particles and used to replace around 20% of the cement in concrete and boost the water resistance, durability and mechanical strength of concrete. These gains are related to the chemical features of glass waste with cement hydrates, which make the product durable and can enhance the pore system in concrete. Replacing cement with pozzolanic components such as glass powder in concrete not only enhances the strength and economy, but also increases the stability of the concrete. This study report examines the performance of concrete using glass trash as a partial replacement for cement and compares its performance with normal concrete. Additionally, waste glass may be a valuable resource and cost savings can be made by substituting cement in concrete with waste glass.

Why do you utilize discarded glass powder...?

Nowadays, several investigations are being carried out on the usage of Portland cement instead of glass powder waste by employing other waste materials and products such as fly ash (PFA) and ground granular blast furnace slag (ggBS). Like PFA and GGBS, glass powder (GLP) is also used as a material; partially substitutes cement, which partially reacts when moistened; It may also be used as packaging. The name "glass" comprises various types of substances, including binary alkali silicate glasses, borosilicate glasses, and ternary soda-lime silicate glasses. Partially substituting cement with ground glass waste leads in enhanced microstructure and stability of cementitious materials. When pulverized glass waste is partially utilized instead of cement, a denser (less porous) and better structure is created; This is efficient in limiting moisture absorption and so enhances the longevity of cementitious materials. When there are worries about the possible difficulties of cement hydrates and reactive aggregates, substituting cement with partly ground glass waste may be advantageous to the stability of cementitious materials. Mixed-coloured waste glass is crushed to nearly the size of cement particles and used to replace around 20% of cement in concrete; Thus, the water resistance, durability and mechanical strength of concrete are boosted.

These improvements originate from the utilization of chemical interactions of crushed waste glass with cement hydrates; This makes the product stable and can enhance the pore system in the stone. Replacing cement with partly crushed mixed-color waste glass can give considerable environmental, energy and financial savings. Extensive study has been done to solve the alkali silica reaction (ASR) issue. Replacing cement in concrete with pozzolanic elements such as waste glass powder not only enhances strength and economy, but also increases durability.

Scientific Research

Partial substitution of cement with glass powder can improve the chemical, mechanical and physical qualities of concrete and assure the protection of the environment for the use of glass and its disposal as trash. It also decreases the consumption of natural resources. By employing waste glass, cement output may be lowered and the cost of cement manufacturing can also be reduced.

• Control environmental pollution.
• Produce low-cost concrete.
• An inexpensive and effective alternative to trash stoves.

2. LITERATURE REVIEW

The objective of literature review is to collect published information from numerous study publications. We choose valuable data for research investigations using data analysis.

Caijun and Keren et al.; The use of glass waste in cement and concrete manufacturing has been researched and the results may be summarized as follows: First of all, the utilization of glass waste in concrete manufacturing impacts energy. and Freeze-thaw also has a modest effect. B.S. However, the fundamental concern is the expansion and disintegration of concrete containing glass aggregate. The pH of the system should be kept below 12 to prevent probable corrosion of the glass aggregate and expansion of the concrete; This may be done by substituting silicate cement with pozzolanic ingredients such as fly ash, silica powder and metakaolin. Secondly, glass trash, which is a source of silica, may be utilized as raw material in cement manufacture. However, by raising the liquid content in the clinker, it triggers the creation of certain sodium compounds and raises the alkali content in the cement. The impact depends on the amount of discarded glass utilized. If this fraction of glass trash were utilized in food, its impact would be modest. Finally, pulverized glass powder demonstrates good pozzolanic reactivity and can be utilized as a cement alternative. when predicted, when the fineness rises, the pozzolanic reactivity likewise increases. If the aggregate possesses alkaline reactivity, the alkali in the glass powder will cause the alkaline aggregate to react and expand. ASTM C-1260 test findings demonstrate that the alkali aggregate expansion response reduces as the glass change increases, and if the glass change is 50% or more, the alkali aggregate expansion reaction will fall below the negative limit. Fly ash, blast furnace slag powder, metakaolin etc. It can minimize the spread of alkaline aggregate reaction when combined with other cementing materials such as Lithium salt is an effective substance that resists the expansion of alkaline aggregates on concrete containing glass powder.

Dr. G. Vijay Kumar et al; In this study named "Glass Powder as a Partial Substitute for Cement in Concrete Production", it is pointed out that waste glass powder is employed as a cement portion in concrete and compared with traditional concrete. This study studies the feasibility of utilizing glass powder instead of cement in fresh concrete. Partially modified 10%, 20%, 30% and 40% glass powder was evaluated for 60-day compressive, tensile and flexural strength and compared to normal concrete. . The material is particle size smaller than 75um, which may inhibit alkali-silica reaction. The 28-day compressive strength of the concrete panel is 31.1 N/mm2, tensile strength is 2.27 N/mm2 and bending strength is 3.25 N/mm2. Replacing 40% of cement with glass powder was shown to boost strength by 33.7% compared to standard concrete. Tensile strength testing was also done and after substituting 40% cement, the strength rose by 4.4%. The flexural strength of concrete with partial cement substitution of 20%, 30% and 40% improved by 88.09%, 99.07% and 100%, respectively. Finally, it was found that glass powder concrete may effectively boost the compressive, tensile and bending strength compared to raditional concrete. Very finely ground materials have shown to be a very excellent material, with sufficient pozzolanic material to be employed as a semi-replacement cement.

N. Kumarappam et al. "Cement in concrete was partially replaced by glass" to evaluate the efficacy of glass powder in replacing cement concrete. Portland cement (PC) is partially modified with 0-40% glass powder. Tests include ultrasonic pulse rate, compressive strength and absorption. The findings obtained by bending the sample in water at 20°C demonstrate that a reduction in the maximum strength of the concrete and the quantity of glass powder added to the mixture is attained, around 40 mm (i.e. 0% glass) for larger slump usage. powder) up to 160 mm, with 40% glass powder. Using frosted glass decreases cement consumption and the impact of air pollution and CO2 emissions on energy demand. The glass particles in the mixed stone seems to cause the stone to crack. When the glass powder percentage is 10%, the compressive strength of the concrete is higher than the control group. When the glass powder content is higher than 20%, the strength diminishes.

J.M. Khatib et al, in their research titled "Use of glass powder in construction", pointed out that this effort should be minimized owing to global warming. The biggest issue is the rising usage of explosives. The worldwide impact of glass as a collection of Portland cement concrete heat today impacts everyone in the globe and originates from well-known notions such as the expansion and fracture of glass. A high level of durability is attained because to the alkali-silica solution. Frosted glass is regarded a pozzolanic material for carbon dioxide (CO2), also for green space, since silica is necessary to create cement and release many goods, so it may observe its resemblance with other home gases. Research articles employ glass powder instead of cement to manufacture concrete and substitute cement with 10%, 20%, 30% and 40% to prepare concrete and perform slump, compression tests and ultrasonic pulse rate testing. And compared to typical stone. It is determined that the usage of frosted glass may minimize cement use and energy demands, as well as lessen the impact on air pollution and CO2 emissions. It is noticed that when the glass powder in the concrete mixture rises, the concrete loss likewise increases. When the glass powder percentage is 10%, the compressive strength of the concrete is higher than the control group. When the glass powder content is higher than 20%, the strength diminishes.

3. MATERIALS

Concrete is a composite material composed of aggregates (aggregates or fillers) embedded in a solid matrix (cement or binder), filling the space between items gathered and linked together. In this experiment, glass powder (GLP) with a particle size of less than 90 µm was utilized instead of cement. Create a composite structure by periodically replacing 5% to 40% of the waste glass powder. M25 and M30 concrete characteristics were employed in this investigation. Mix design for M25 and M30 grade concrete as per IS 10262:2009. The primary materials are: The materials employed in this research include cement, fine aggregate, coarse aggregate, waste glass powder and water.

Class 53 Common Portland Cement, adhering to IS: 269-2015
Fine Aggregate, adhering to IS: 383-2016
Coarse Aggregate, according to IS: 383-2016
Water [Portable]
Glass waste less than 90 microns

4. EXPERIMENTAL INVESTIGATION

Normal Consistency of Cement	34%
Setting Time of Standard Cement	Intial -37 min Final - 562 min
Specific Gravity Of Cement	3.10
Fineness Test of Cement by Sieve Analysis	97%
Soundness of Cement	3 mm
Fineness Modulus of Fine Aggregate	4.07
Fineness Modulus of Coarse Aggregate	3.9
Specific Gravity of Fineaggregate	2.56
Water Absorption Test on Fine Aggregate	1.59%
Bulking of Fine Aggregate	30.73%
Specific Gravity & Water Absorption of Coarseaggregate	2.68 & 1.68%
Specific Gravity of glass powder	2.60
Fineness passing 90µ glass powder	99.5
P^H of glass powder	10.25
Colour of glass powder	Grayish White

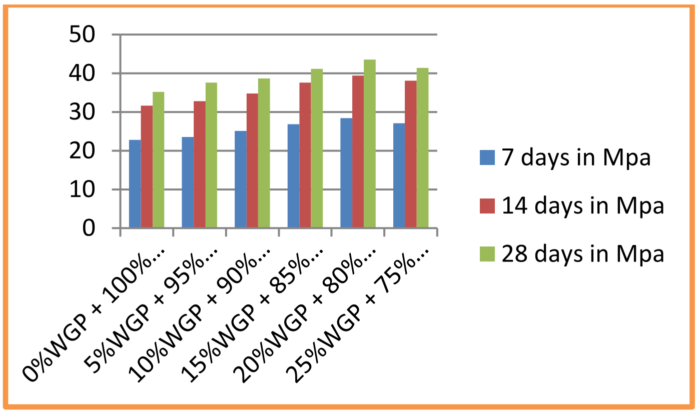
5. MIX DESIGN

Description	M25 Grade	M30 Grade
Proportion	1 : 1.76 : 2.26	1 : 1.68 : 2.11
W/C ratio	0.44	0.42
Cement	436 Kg/m^3	457Kg/m^3
Fine Aggregate	769 Kg/m^3	770 Kg/m^3
Coarse Aggregate	985 Kg/m^3	965 Kg/m^3
Water	192 l/m^3	192 l/m^3

6. PERFORMANCE TESTING & RESULTS

Table No. 6.1 Test results of Compressive Strength at 7 days, 14 days & 28 days for M25

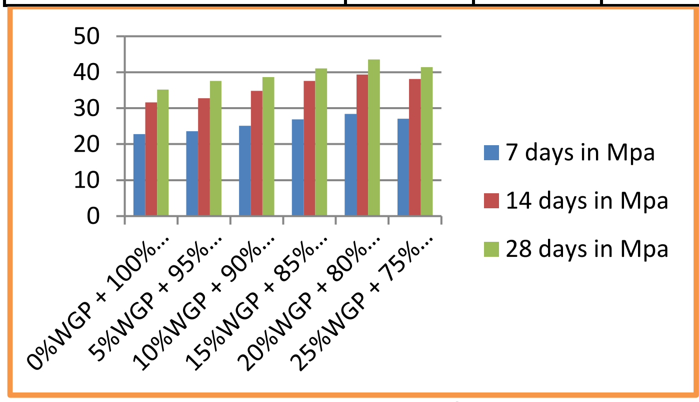
Mix % Replacement	7 days in Mpa	14 days in Mpa	28 days in Mpa
0%WGP + 100% Cement	22.83	31.62	35.15
5%WGP + 95% Cement	23.56	32.78	37.62
10%WGP + 90% Cement	25.12	34.8	38.65
15%WGP + 85% Cement	26.86	37.56	41.1
20%WGP + 80% Cement	28.45	39.4	43.56
25%WGP + 75% Cement	27.1	38.1	41.4



Graph No. 6.1 Contrast values of Compressive strength for 7 days, 14 days & 28 days for M25

Table No 6.2 Test results of Compressive Strength at 7 days, 14 days & 28 days for M30

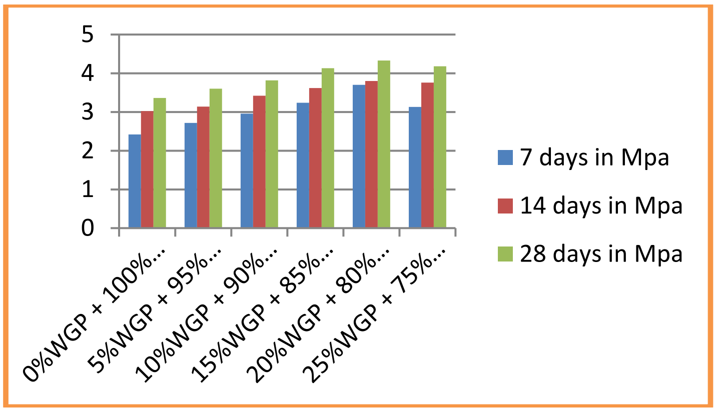
Mix % Replacement	7 days in Mpa	14 days in Mpa	28 days in Mpa
0%WGP + 100% Cement	22.83	31.62	35.15
5%WGP + 95% Cement	23.56	32.78	37.62
10%WGP + 90% Cement	25.12	34.8	38.65
15%WGP + 85% Cement	26.86	37.56	41.1
20%WGP + 80% Cement	28.45	39.4	43.56
25%WGP + 75% Cement	27.1	38.1	41.4



Graph No 6.2 Contrast values of Compressive strength for 7 days, 14 days & 28 days for M30

Table no 6.3 Test results of Split Tensile Strength at 7 days, 14 days & 28 days for M25

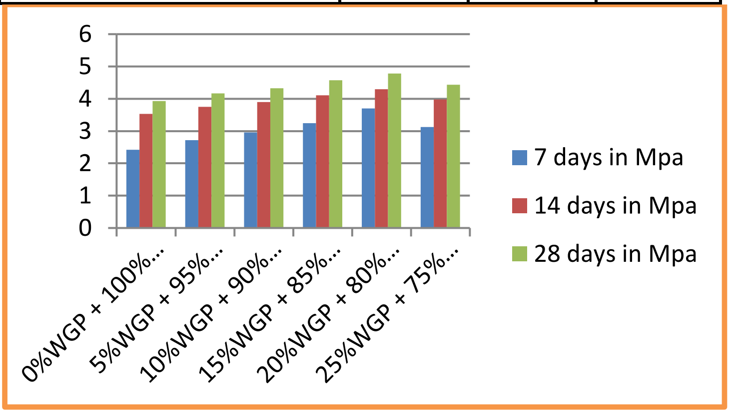
Mix % Replacement	7 days in Mpa	14 days in Mpa	28 days in Mpa
0%WGP + 100% Cement	2.42	3.02	3.36
5%WGP + 95% Cement	2.72	3.14	3.6
10%WGP + 90% Cement	2.96	3.42	3.82
15%WGP + 85% Cement	3.24	3.62	4.13
20%WGP + 80% Cement	3.7	3.8	4.33
25%WGP + 75% Cement	3.13	3.76	4.18



Graph No 6.3 Contrast values of Split Tensile strength for 7 days, 14 days & 28 days for M25

Table No 6.4 Test results of Split Tensile Strength at 7 days, 14 days & 28 days for M30

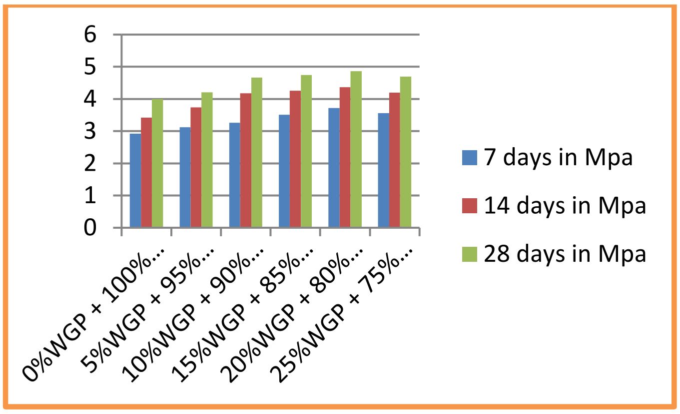
Mix % Replacement	7 days in Mpa	14 days in Mpa	28 days in Mpa
0%WGP + 100% Cement	2.42	3.53	3.93
5%WGP + 95% Cement	2.72	3.75	4.17
10%WGP + 90% Cement	2.96	3.9	4.33
15%WGP + 85% Cement	3.24	4.11	4.57
20%WGP + 80% Cement	3.7	4.3	4.78
25%WGP + 75% Cement	3.13	3.98	4.43



Graph No 6.4 Contrast values of Split Tensile strength for 7 days, 14 days & 28 days for M30

Table no 6.5 Test results of Flexural strength at 7 days, 14 days & 28 days for M25

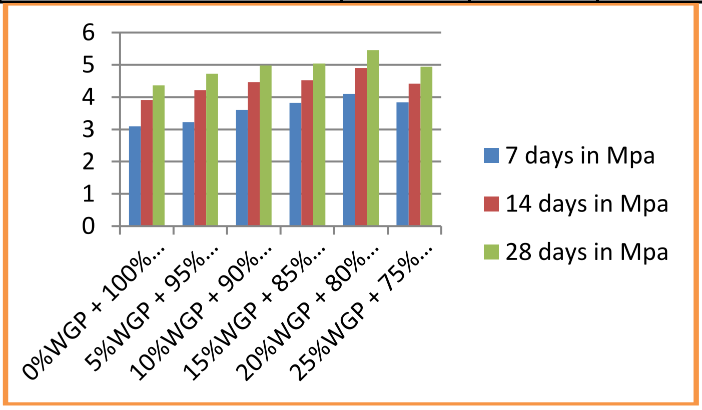
Mix % Replacement	7 days in Mpa	14 days in Mpa	28 days in Mpa
0%WGP + 100% Cement	2.92	3.42	4
5%WGP + 95% Cement	3.12	3.74	4.21
10%WGP + 90% Cement	3.26	4.18	4.66
15%WGP + 85% Cement	3.51	4.26	4.74
20%WGP + 80% Cement	3.72	4.37	4.86
25%WGP + 75% Cement	3.56	4.2	4.69



Graph No 6.5 Contrast values of Flexural strength for 7 days, 14 days & 28 days for M25

Table no 6.6 Test results of Flexural strength at 7 days, 14 days & 28 days for M30

Mix % Replacement	7 days in Mpa	14 days in Mpa	28 days in Mpa
0%WGP + 100% Cement	3.1	3.91	4.36
5%WGP + 95% Cement	3.22	4.22	4.72
10%WGP + 90% Cement	3.6	4.46	4.98
15%WGP + 85% Cement	3.82	4.52	5.04
20%WGP + 80% Cement	4.1	4.9	5.46
25%WGP + 75% Cement	3.84	4.41	4.94



Graph No 6.6 Contrast values of Flexural strength for 7 days, 14 days & 28 days for M30

7. CONCLUSIONS

In this study, the effect of glass powder on the compressive strength, tensile strength and bending strength of concrete was investigated. Tests were carried out on two classes of concrete, M25 and M30, using 5%, 10%, 15%, 20% and 25% waste glass powder without the use of cement, and the results were shown on the 7th, 14th and 28th days. day. .

1. The 7-day, 14-day and 28-day compressive strength of concrete begins to increase with the increase in glass powder replacement rate, reaches a maximum of around 20% and then decreases.
2. The flexural strength of concrete begins to increase as the substitution of glass powder and glass powder cement increases, reaching a maximum of about 20% and then decreasing.
3. As the change of glass powder cement increases, the splitting tensile strength of concrete begins to increase, reaches a maximum around 20% and then decreases. The concrete grade decreases monotonically. Workability decreases when cement is partially replaced with glass powder.
4. Current research shows that glass powder has a good ability to replace cement. About 20% of cement can be replaced by glass powder. It has been proven that the use of glass waste in concrete is cheaper than cement.
5. Using waste glass in concrete will reduce the waste glass problem and has been proven to be a household product.

SCOPE OF FUTURE RESEARCH

- ✓ Further research can be done using the difference between glass waste and the recommended amount of glass waste to achieve energy; Compressive, bending strength and splitting tensile strength can be determined.
- ✓ Instead of cement, use glass powder with different water-cement ratios.
- ✓ Other concrete performance tests of other concrete qualities can be performed.
- ✓ Research can be done on replacing coarse aggregates with glass.
- ✓ Add the activator to the waste glass powder concrete mixture and determine the consistency by analyzing the compressive strength of the concrete.
- ✓ Use waste glass powder to determine the durability of the stone.

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