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Conventional Concrete and Fine Glass Reinforced Concrete (Glascrete): A Study on Strength Gain and Mechanical Properties of Different Curing Periods

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Abstract

Glass is a common waste generated in our everyday life. Incorporating fine glass as a complete replacement in fine aggregate in a concrete mixture helps to promote sustainable construction. This experimental study investigated the effects of curing periods on strength gain in conventional concrete and glasscrete if it extends up to 35 days of curing period. Eighteen (18) concrete samples of rectangular prisms and eighteen (18) samples of cylindrical specimens were tested using the universal testing machine. The result showed that the compressive and flexural strength of glasscrete declines due to the alkali-silica reaction when it is cured in less than 28 days. In terms of workability, concrete with glass shows a lower slump than in conventional concrete, which means that the workability of concrete decreases if it is incorporated with glass.

Keywords: Fine glass, Curing Period, Compressive Strength, Flexural Strength, Workability

Introduction

Glass is a standard material that is made from raw materials like sand. Even though most waste glass is recycled to make new glass products, much of it is still disposed of in landfills. According to Pasana et al. (2022), approximately 48.5% of waste glass is recycled in the Philippines. This raises a concern about effectively recycling the waste glass generated daily in the Philippines. Waste glass can substitute the fine aggregates in a concrete mixture, possibly reducing the cost of producing concrete (Guatam et al., 2017). Recent studies showed the potential of replacing fine aggregates with crushed waste glass in a concrete mixture and showed positive results on the mechanical properties.

According to the research of Harrison et al. (2020), due to the chemical composition and potential pozzolanic activity exhibited by the glass, waste glass can be utilized as a partial replacement or a cement additive to produce Portland cement blends. Shi et al. (2018) discovered that compared to concrete containing waste glass with coarse particle distributions, those with finer particle distributions produce better compressive strengths after 28 days of curing. This research investigates the concrete with a curing period of 35 days for both glass-reinforced concrete and conventional concrete mix based on the American Society for Testing and Materials (ASTM). This study aims to identify how the various curing period of 7, 28, and 35 days affects the compressive strength, flexural strength, and workability of concrete mixture with 100% waste glass as a substitute for fine aggregates and compare it to the conventional concrete mixture. This study will give further information to the Architecture, Engineering, and Construction professionals (AEC) by discovering how to apply and use waste glass to innovate the construction industry and help the environment by reducing waste glass.

Review of Related Literature and Study

Fine Glass as a Substitute for Fine Aggregates

The strength gain of concrete is significantly influenced by its concrete mix design and curing period. Several studies have analyzed the effects of incorporating raw materials under different curing periods on the mechanical properties of concrete, specifically compressive strength and flexural strength. Adaway and Wang (2015) study the effects of incorporating glass in concrete, using crushed glass as a partial replacement for fine aggregates. The research emphasizes the impact on compressive strength and the environmental benefits of using waste glass in concrete. Removing 15%, 20%, 25%, 30%, and 40% of fine aggregates and replacing them with fine glass shows that the compressive strength developed increased by 9% and 6% compared to the conventional concrete. Similar research by Leron et al. (2021) investigated the incorporation of crushed glass in a concrete mixture. The result showed that the compressive strength on the 28th day was 17.10 MPa, which was the desirable safe strength design. Also, the flexural strength reached 3.548 MPa, slightly lighter than conventional concrete. They also conclude that fine glass can replace fine aggregates as a full replacement.

Mustafa et al. (2022) explored the potential of using waste glass (WG) as a sustainable material in reinforced concrete (RC) beams. The research focuses on assessing the flexural behavior of RC beams when WG is partially substituted for cement and fine aggregates. The experimental program involved testing ten RC beams, including a control beam, alongside beams incorporating WG at varying replacement levels. Cement was replaced with WG at 10% and

20%, while fine aggregates were replaced at 10% and 15%. The study also examined the effect of different longitudinal steel ratios on the structural performance of the beams. Various tests were conducted, including slump tests, compressive and tensile strength assessments, crack pattern analysis, and load-deflection and load-strain behavior evaluations.

The findings revealed that concrete mixes containing WG exhibited similar performance to the control mix in slump, compressive strength, and tensile strength, demonstrating the feasibility of using WG without significant material property compromises. Structurally, beams with 10% WG replacement for cement showed a 29% increase in cracking load and a 6.9% increase in ultimate load, reflecting enhanced structural performance at this replacement level. However, higher WG replacement ratios, such as 20%, resulted in slight cracking and ultimate load reductions, indicating diminishing returns when excessive WG content is used. Analyzing this research showed the potential of using fine glass as a substitute for fine aggregates in a concrete mixture that can promote sustainable construction and help reduce glass waste.

Strength Gain on Different Curing Periods

American Concrete Institute (ACI) defines curing as maintaining the temperature and moisture content of concrete until it reaches its desired properties. Also, proper curing of concrete can maximize the strength gain and durability of concrete. According to Hamada et al. (2022), environmental conditions such as temperature, humidity, wind, and other factors can affect the curing process, such that it can accelerate water evaporation and cement hydration. These factors proved that the curing of concrete plays a vital role in the strength gain of concrete.

Shah and Patil (2015) investigated the strength development of concrete under variations of curing time. They cured the concrete for 7, 14, 21, and 28 days and tested the compressive strength. The result showed that the strength of concrete relatively improved based on the curing time. In 7 days of curing, the compressive strength concrete developed 85% of its strength; in 14 days, it created 94%; in 21 days, its strength attained 108%; and when it was cured for 28 days, the compressive strength improved up to 124% of its design strength. A similar study was performed by Sun et al. (2024), which showed that curing time is the most critical factor that can influence the development of concrete compressive strength. The study also highlighted that relative humidity significantly affects strength development compared to temperature. This research shows that curing time plays a crucial role in developing the strength of concrete. Proper curing ensures the concrete will achieve its maximum potential strength and durability. The study recommended that different curing methods and temperatures must be considered to reach its maximum strength.

Another factor that can play a vital role in the curing period of concrete is the chemical reaction that happens while the concrete is cured on various days. In the study of Duraman and Li

(2021), when Ground Glass Cullet (GGC) was used as a 30% cement replacement for both the designed mix of the Department of Environment (DoE) and the Alkali-Silica Reaction (ASR) mix, the development of strength was initially lower and only increased after 1 week of curing. GGC requires Calcium Hydroxide (CH) produced from cement hydration, resulting in slower strength development. Microstructural analysis of specimen micrographs taken in Secondary Electron Imaging (SEI) mode with a Scanning Electron Microscope (SEM) revealed that cullet-based mortars exhibited more cracking after more extended curing. SEM micrographs were taken at 200x magnification for 10-day and 100-day cured specimens.

The comparison shows that cracks were more evident for specimens cured to 100 days of age. After ninety days, the compressive strength dropped from 77 MPa to 73 MPa when glass aggregate replaced 100% sand. Though porosity increased by 1.5% to 13% when employing 25% to 100% glass aggregate, reductions were noted in drying shrinkage, sorptivity, and chloride permeability. The glass aggregate's more negligible permeability and uneven form are responsible for the slight variances in mortar characteristics. When mortars containing glass aggregate were exposed to temperatures between 200 and 800 degrees Celsius, their residual strength trends were comparable to those utilizing natural sand.

Workability of Raw Materials on Concrete

The incorporation of raw materials such as recycled glass, fly ash, and bamboo fibers in concrete has been studied based on their potential as a substitute for additives in concrete mixture to enhance its mechanical properties and promote sustainability. Adding these raw materials affects the workability of the concrete mix. Factors such as the type of concrete mixture and the proportion of raw materials used affect its workability. The research of Shah et al. (2022) investigated the mechanical properties of concrete made with recycled aggregates and coconut fibers. They incorporated 1-2% of coconut fiber into the concrete mixture, and the result showed improved compressive strength and splitting tensile strength of concrete. However, this negatively affects workability, and plasticizers were used to avoid this adverse effect.

Another study by Ahmed et al. (2023) about the replacement of waste glass as fine aggregate (GWA) and tin can fiber (TCF). The study investigated the effects of these two raw materials on the concrete's workability, fresh density, compressive, and splitting strength using the Artificial Neural Network (ANN) approach. The results showed that the workability of concrete mix decreases when the quantity of GWA and TCF contents increases (Ahmed et al., 2023). Based on the results, the concrete slump shows a relative pattern of decreasing slump height depending on the quantity of GWA and TCF. The reduction in workability may be caused by the physical properties of GWA, which have sharp edges that can lessen the consistency of a concrete mixture with GWA and TCF (Ahmed et al., 2023). Incorporating raw materials can enhance the

mechanical properties of concrete; however, consider that the workability of a concrete mixture is affected, and it can alter the water-cement ratio compared to a conventional concrete mixture. It is suggested that adding superplasticizers can be considered to lessen the decrease in its workability.

Fine glass can be used in cementitious formulations in place of natural sand (Kim & Park, 2018). Over the past several years, there has been an increase in the number of studies examining the viability of replacing natural fine aggregate with waste glass. In the study conducted by Wang et al. (2021), using unwashed waste glass fines (U-WGF) might affect the workability of the concrete because of the number of contaminants in the glass. Due to exposure to the environment, it is guaranteed that waste glass has clay and silt content that can increase the demand for water while mixing concrete. The research stated that using U-WGF in the concrete mix would be better since additional workforce and energy will be required to wash the waste glass. It is not economical to add water to the mix, so tests were conducted with three concrete batches (with unwashed waste glass fines, washed waste glass fines, and control or concrete mix with 10 wt% glass replacement). The test results show a 5mm workability reduction in U-WGF, which can be understood because U-WGF has more clay and silt content. On the other hand, washed waste glass fines (W-WGF) have the highest workability, with a slump test value of 90mm. This study shows that the incorporation of fine glass in a concrete mixture significantly affects the workability of the concrete and takes into consideration the amount of water that is going to be added to the mixture.

Methodology

This research adapted the true experimental quantitative method approach to identify the difference in behavior between conventional concrete and fine glass-reinforced concrete during the different curing periods of 7, 28, and 35 days. The preparation of specimens began with the careful selection and processing of materials. Clear float glass, which is primarily composed of silicon dioxide (SiO_2), was sourced from window glass manufacturers. The researcher used concrete mix proportion based on ACI 211.1-91, the standard practice for selecting proportions for normal, heavyweight, and mass concrete, to achieve a 20.7 MPa (3000 psi). Concrete mix proportion includes Type I Portland cement, 3/4" size of coarse aggregates, fine aggregates, and water cement ratio of 0.43 to achieve M20 grade concrete. However, glasscrete mix proportion was the same as the conventional concrete mix proportion but fine aggregates (sand) were replaced by fine glass which passed through the sieve 3/8 inch to sieve no.200.

Table 1.*Mix Proportions of Conventional Concrete and Fine-Glass Reinforced Concrete*

| Concrete Mix | Cement | Coarse Aggregate | Sand | Fine-Glass |
|------------------------------------|--------|------------------|--------|------------|
| | Kg | Kg | Kg | Kg |
| Conventional Concrete Mix | 43.56 | 123.42 | 101.64 | 0 |
| Fine-glass Reinforced Concrete Mix | 43.56 | 123.42 | 0 | 101.64 |

Once the materials are prepared, the mixture of conventional and fine glass-reinforced concrete takes place. After mixing concrete, the mixture is tested for its workability by performing the slump test using the slump cone in each concrete mix design. The researcher provided 18 samples of 100 mm x 200 mm cylindrical molds for compressive strength testing and 18 samples of 150 mm x 150 mm x 530 mm rectangular molds for flexural strength testing. After allowing the concrete to cure for at least 24 hours, the molds were carefully removed, and the specimens were stored under identical conditions until they were ready for mechanical testing. Upon completion of the curing period, the specimens underwent compression and flexural testing using a Universal Testing Machine (UTM) to determine the maximum force they could support, with recorded forces converted into newtons (N).

The researcher used the T-test as an inferential statistic to determine the significant differences between the two groups. Bevans (2023) averred that a t-test is used in hypothesis testing to determine the effect of a process or treatment on the sample or in two groups, and it was interpreted through t-distribution values. The result was in the form of a percentage, which is commonly used to determine the percent of increase or decrease of strength gain of the discrete compared to the conventional concrete.

Results and Discussion

A. Mechanical Properties of Conventional Concrete and Fine-Glass Reinforced Concrete in Different Curing Days

Some factors can affect the strength of concrete; one of these factors is the curing period. According to Captain (2024), the strength of concrete can improve significantly over time, especially in the first 28 days of its curing period. Meanwhile, in the research of James et al. (2017), when the concrete is cured in 35 days, the concrete continues to gain strength as long as

all the factors are explicitly considered moisture content, which is crucial for the proper hydration of the concrete. It is also said that most of the time, the concrete has reached 95% of its strength in the first 28 days of its curing period. The results obtained by curing the samples on various days show their compressive and flexural strength differences. This value shows that there is a change when the concrete is cured under various curing periods.

Table 2.

Conventional and Glascrete Compressive Strength

| Curing Periods, (days) | Conventional Concrete | | Curing Periods, (days) | Glascrete | |
|------------------------|-----------------------|-----------------------------|------------------------|-----------------------|-----------------------------|
| | Machine Reading, (kN) | Compressive Strength, (MPa) | | Machine Reading, (kN) | Compressive Strength, (MPa) |
| 7 | 115.30 | 14.70 | 7 | 81.65 | 10.40 |
| | 115.60 | 14.70 | | 104.30 | 13.30 |
| | 127.90 | 16.30 | | 95.10 | 12.10 |
| 28 | 127.39 | 16.20 | 28 | 193.70 | 24 |
| | 150.19 | 19.20 | | 187.90 | 23 |
| | 163.55 | 20.80 | | 277.50 | 34 |
| 35 | 165.25 | 21 | 35 | 135.34 | 17.2 |
| | 170.49 | 21.70 | | 112.50 | 14.30 |
| | 148.89 | 19 | | 145.19 | 18.50 |

The result in compressive strength between conventional concrete and glascrete is shown in Table 2. The compressive strength of conventional and glass-reinforced concrete at various curing durations across three trials shows that conventional concrete has an average compressive strength of 15.23 MPa after 7 days, 18.7 MPa after 28 days, and 20.57 MPa after 35 days of curing. In contrast, glass-reinforced concrete exhibits an average compressive strength of 11.93 MPa after 7 days, increases to 27 MPa after 28 days, and drops to 16.67 MPa after 35 days of curing. Based on the result, glascrete declines its strength after 35 days. These results are similar to the research of Pulusan et al. (2024), who investigated the compressive strength of load-bearing paving blocks mixed with crushed glass as a partial substitution for fine

aggregates. Their results show that when the concrete is cured for more than 28 days, its compressive strength will decrease, and its compressive strength will not reach its desired value.

Another consideration in the decrease in compressive strength is the brittleness of the glascrete. Glass fiber enhances the cracking resistance of the concrete. However, it makes the glascrete brittle, compromising its compressive strength, especially when the glascrete is subjected to high stress or impact (Ali, 2025). Glass is commonly made up of silica. The chemical properties undergo a pozzolanic reaction that causes concrete binding (Islam et al., 2016). However, silica interacting with alkali results in an alkali-silica reaction (ASR). It is a chemical interaction between the silica and alkali in the mixture that leads to internal stresses and cracking (Wang, 2021). The alkali-silica reaction can absorb water, and it causes swelling in the specimen, which leads to a decrease in the compressive strength of glascrete. Another effect caused by the alkali-silica reaction is cracking. This cracking and expansion can be mitigated by correctly processing the fine glass before it is applied to the concrete. According to Fanijo et al. (2021), ASR persists in a moist environment, which results in concrete expansion over time or harms the strength of concrete.

Figure 1.

Comparison of Compressive Strength of Conventional Concrete and Glascrete

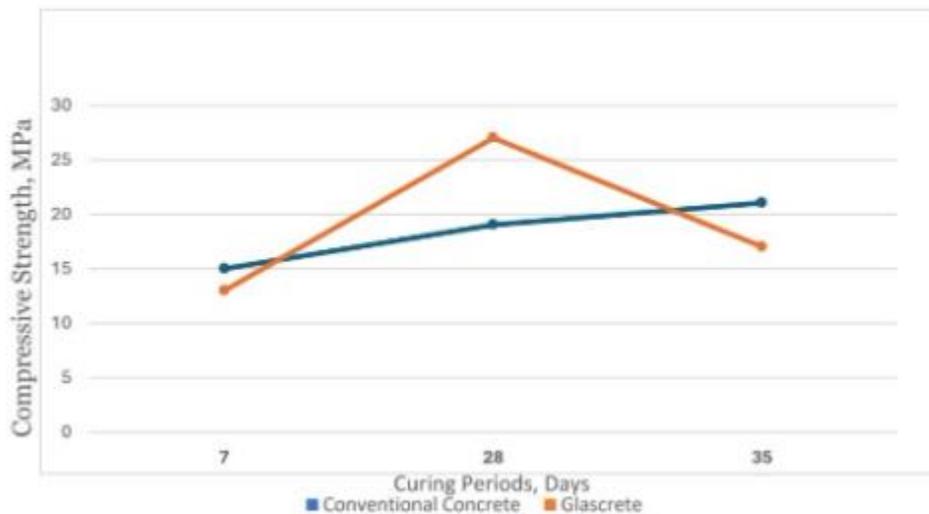


Figure 1 compares the compressive strength between conventional concrete and glascrete at various curing periods. It shows that in 7 days, conventional concrete has a 21.67% increase compared to glascrete. By 28 days, glascrete's compressive strength increases by 44.39%. However, after 35 days, the compressive strength of glascrete drops by 18.96%. This

demonstrates that glasscrete can surpass conventional concrete in compressive strength after 28 days of curing. Manzoor et al. (2022) stated that studies have shown that while fine glass concrete mix gains compressive strength at a slower rate than conventional concrete mix, recycled glass concrete has the potential to achieve comparable strength over time. In addition, Otunyo and Okechukwu (2017) expressed that at a 25% substitution level, there was a 14.73% decrease in compressive strength at 7 days and a 23.50% diminishment at 28 days. The ponder credited this decrease to the diminished grip between the glass particles and the cement glue, driving the arrangement of infinitesimal voids unfavorably influencing concrete quality. In addition, the study of Malek et al. (2020) substitution levels of 40%, 60%, and 80% led to diminishes in compressive strength by 9.6%, 23.6%, and 14.5%, respectively. The decrease in strength at higher substitution levels refers to the smooth surface of fine glass, which diminishes the bond quality between the cement paste and aggregates, leading to expanded inside pores and diminished compressive strength.

Table 3.

Conventional and Glascrete Flexural Strength

| Curing Periods, (days) | Conventional Concrete | | Curing Periods, (days) | Glascrete | |
|------------------------|-----------------------|--------------------------|------------------------|-----------------------|--------------------------|
| | Machine Reading, (kN) | Flexural Strength, (MPa) | | Machine Reading, (kN) | Flexural Strength, (MPa) |
| 7 | 23.40 | 3 | 7 | 22.50 | 3 |
| | 23.50 | 3 | | 25.70 | 3 |
| | 22.60 | 3 | | 25.10 | 3 |
| 28 | 61 | 8 | 28 | 57 | 7 |
| | 67 | 9 | | 52.20 | 7 |
| | 70.20 | 9 | | 60.20 | 8 |
| 35 | 47.70 | 6 | 35 | 43.70 | 6 |
| | 45.20 | 6 | | 43.80 | 6 |
| | 42.60 | 6 | | 43.50 | 6 |

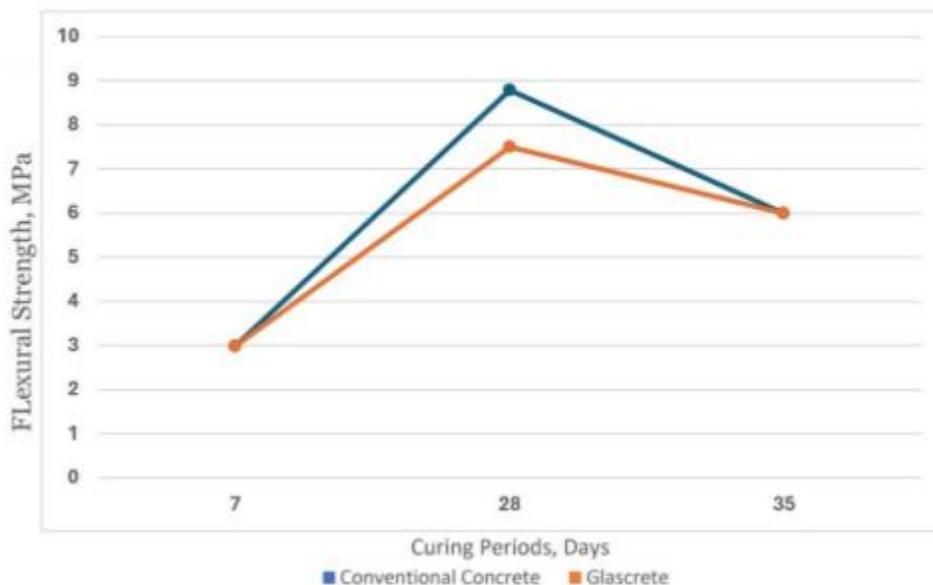
The values obtained on the flexural strength of conventional and glass-reinforced concrete at different curing times across three trials are presented in Table 3. The data reveals that conventional concrete averages 3 MPa for 7 days, 8.67 MPa for 28 days, and 6 MPa for 35 days of curing. On the other hand, the glass-reinforced concrete shows a flexural strength average of 3 MPa for 7 days, a somewhat lower flexural average of 7.33MPa for 28 days, and 6 MPa for 35 35-day curing period. Ubeid et al. (2020) computed the flexural strength based on the ACI 318

Code equation $0.62 \sqrt{f_c}$. When comparing the two concrete mixes for the 28 and 35-day curing periods, both met the minimum flexural strength for normal-strength concrete, which is 2.89 MPa.

Leron et al. (2021) state that using crushed glass in concrete for beams is permissible as it achieves the acceptable range for beams. The glascrete used in this research applies fine glass as a complete replacement for the fine aggregates of a concrete mixture. Gayathri and Malikarjuna's (2024) research investigated the optimal percentage of fine glass to be applied in a concrete mixture with silica fume and without silica fume. Their research shows that the optimal amount of fine glass that can be substituted for fine aggregates is 15%, which will reach its maximum strength of up to 4 MPa. When the replacement is increased to 20%, the flexural strength of glascrete begins to decrease. In contrast with the 100% replacement of fine aggregates, the result shown in Table 4 justified these claims. The difference in flexural strength between conventional concrete and glascrete illustrates that there is an optimal amount of fine glass that can maximize the flexural strength of concrete.

Figure 2.

Comparison of Flexural Strength of Conventional Concrete and Glascrete



The comparison of the flexural strength of conventional concrete and glascrete at different curing periods is shown in Figure 2. It shows that in 7 days, the average flexural strength of both concretes is 3 MPa, which shows no increase in flexural strength. In 28 days, conventional concrete increased by 15.46% in flexural strength compared to glascrete. It shows that conventional concrete can achieve higher flexural strength than glascrete within 28 days of

curing. Based on the study of Leron et al., conventional concrete is 11.05% higher than glascrete in terms of flexural strength. At 35 days, both concrete decreases, resulting in the same average flexural strength. It is rare, but new concrete can lose flexural strength during aging (Zhu et al., 2023). According to their study on the flexural strength of the interface between full lightweight ceramsite concrete and ordinary concrete, as the curing period continues, flexural strength may decrease until it becomes stable. It is because of the water penetration into the voids of concrete specimens that may result in weakened flexural strength.

B. Workability of Fine-Glass Reinforced Concrete

A slump test measures the workability. This is the most commonly used and simple method that can identify the workability of a concrete. In this research, the researcher used two separate mixtures. One mixture is used on the compressive strength test, and the other is used on the flexural strength test. The results in this section describe how the incorporation of fine glass in a concrete mixture alters the workability of concrete. As shown in Table 4, the workability of the two mixed concrete variations was evaluated using the slump cone test. After two trials, the slump test data for the fine glass concrete mix is lower than the conventional concrete mix. Finer Glass particles tend to increase density but also need more water or admixture to be workable. According to Shi et al. (2018), the irregular form of the particles and the glass' inability to absorb water are the reasons for the slump to decrease. Therefore, the conventional concrete mix is more workable than the fine glass mix, and maintaining the same w/c ratio as conventional concrete typically results in a lower slump value, suggesting that additional water or chemical admixtures are needed to achieve comparable workability. This indicates that the workability likely declines when exposed to fine glass with a 100% replacement.

Table 4.

Slump Test of Conventional Concrete and Glascrete

| Trial | Slump, (mm) | |
|---------|-----------------------|-----------|
| | Conventional Concrete | Glascrete |
| 1 | 80.01 | 78.74 |
| 2 | 76.20 | 71.12 |
| Average | 78.11 | 74.93 |

C. Significant Difference of Strength Development Between Conventional Concrete and Fine-Glass Reinforced Concrete Under Various Curing Periods.

The table compares concrete's compressive strength and flexural strength between conventional and fine glass-reinforced concrete across different curing periods. The values show that the computed T-value remains below the critical value, which suggests that the difference in compressive strength and flexural strength between conventional concrete and glascrete is not statistically significant.

Table 5 tests significant differences in compressive strength of conventional concrete and glascrete 7-day, 28-day, and 35-day curing periods. The computed values of t, which are all less than the tabular or critical value of t (3.472, 3.078, 1.947 <4.3027), and the obtained p-values of 0.07, 0.09, and 0.19 which are all greater than the 0.05 level of significance, indicating that the differences between the compressive strength of conventional concrete and glascrete are statistically not significant. Similarly, Table 6 presents the test of significant difference in the machine reading under flexural strength of conventional concrete and glascrete in 7-day, 28-day, and 35-day curing periods. The computed values of t, which are all less than the critical value (-1.384, 3.072, 1.058 <4.3027), and the obtained p-values of 0.30, 0.09, and 0.40, which are all higher than the 0.05 level of significance, also indicating that the difference in the machine readings across the three curing periods is not significant.

Table 5.

Test of Significance in Compressive Strength of Conventional Concrete and Glascrete Under Various Curing Periods

| Curing Periods | T-stat | T-crit. (two-tail) | P-value | Decision | Interpretation |
|-----------------------|---------------|---------------------------|----------------|------------------------|-----------------------|
| 7 days | 3.472 | 4.3027 | 0.07 | Accept Null Hypothesis | Not Significant |
| 28 days | -3.078 | 4.3027 | 0.09 | Accept Null Hypothesis | Not Significant |
| 35 days | 1.957 | 4.3027 | 0.19 | Accept Null Hypothesis | Not Significant |

Conclusion and Recommendation

The study found that the compressive and flexural strength of glascrete decreases over a more extended curing period. According to flexural strength results, conventional concrete has the same value as glascrete at 7 days of curing. Both concretes reach their maximum strength at 28 days but decline at 35 days, suggesting that fine glass aggregate may affect long-term strength. The compressive strength of conventional concrete increases gradually, but glascrete shows a

late but significant improvement at 28 days, surpassing conventional concrete before it starts to decrease at 35 days.

Slump test results show that the glasscrete has less flowability than conventional concrete because of the increased surface area and friction between the cement paste and fine glass particles, which result in a stiffer mix. However, the slight difference in the slump test result suggests that the fine glass aggregate has a negligible impact on the overall workability of the glasscrete. Based on the compressive and flexural strength testing results during the curing periods (7, 28, and 35 days), the data shows no significant differences between the two concretes. The null hypothesis was accepted, indicating that the addition of fine glass aggregate did not significantly impact the strength development of concrete within the tested curing periods. Therefore, there is no significant change between fine glass-reinforced concrete and conventional concrete in terms of strength growth and curing times, as observed in this study.

Glascrete shows comparable strength to conventional concrete within the given curing periods, so it can still be used in precast concrete products. This includes items like paving stones and other non-structural elements. In these applications, glasscrete can help promote sustainable building methods by utilizing discarded glass as a key component. The researcher recommends increasing the water-cement ratio and mixing time to enhance workability, given the observed decrease in the slump for glasscrete. This approach directly addresses the problem of high water demand and increased compaction effort that may affect the concrete strength. Since there is no significant difference in strength between glasscrete and conventional concrete, glasscrete can still be used in non-structural applications. This might include sidewalks, driveways, or other applications for which the primary focus is not on a load-bearing member. When using waste glass in concrete as a substitution material, the researcher recommends testing the material properties, particularly for glasses of varying colors, to ensure optimal performance. Different colors of glass impact heat absorption when incorporated into the concrete mix. Although the study notes a slight reduction in flowability, future research could focus on how different glass sizes and shapes affect the workability of the concrete. Research recommends adding silica content analysis of glass and cement in concrete mix for future researchers to determine the optimal usage of glass in concrete to lessen or avoid the loss of strength that causes ASR after a more extended curing period.

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