# TAM METİN KİTABI



## 7. ULUSLARARASI
## 19 MAYIS YENİLİKÇİ BİLİMSEL YAKLAŞIMLAR KONGRESİ
## 19-20 Mayıs 2022, Samsun


**EDİTÖRLER**

Asst. Prof. Dr. Ali Mohammadi

Dr. Hakan GÖKGÖZ



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IKSAD Yayınevi ®



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19 MAYIS YENİLİKÇİ BİLİMSEL YAKLAŞIMLAR KONGRESİ

19-20 Mayıs 2022, Samsun

# BETON KARIŞIMLARINDA ATIK CAM TOZU KULLANIMININ SÜRDÜRÜLEBİLİR BİR YAKLAŞIM AÇISINDAN İNCELENMESİ

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## ÖZET

Hızlı kentleşme ve buna bağlı olarak sürekli artan nüfus artışı ve toplumların tüketim taleplerinin artması hammaddelerin hızlı bir şekilde tüketilmesine sebep olmaktadır. Bu taleplerin karşılanması için endüstriyel tesislerin ve bu tesislerde üretim sonrası atık malzemelerin hızlı bir şekilde artmasına sebep olmaktadır. Üretim sonucu ortaya çıkan bu atık malzemelerin doğada başıboş bırakılması önemli çevre sorunlarını beraberinde getirmektedir. Bu çevre sorunlarının en aza indirgenmesi için atık malzemelerin depolanması, imha edilmesi veya geri dönüşüm yoluyla yeniden değerlendirilmesi gerekmektedir. Endüstriyel üretim sonucu oluşan atık malzemelerin en önemlilerinden biriside atık cam malzemeleridir. Diğer tüm atık malzemelerde olduğu gibi atık camların geri dönüşümü çevre kirliliği ve maliyetin azaltılması için büyük önem taşımaktadır. Atık bir ürün olan atık camların hammadde olarak hiçbir koku ve tat vermemesi, şeffaf bir görünüme sahip olması ve diğer plastik veya kâğıt ambalajlar gibi kolayca deforme olmamasından dolayı çok geniş bir kullanım alanına sahiptir. Atık camların geri dönüşümde kullanımı ile ilgili en yaygın uygulama alanlarından biriside atık camların beton karışımlarında beton agregası olarak ince agregayla yer değiştirerek kullanılmasıdır. Bu sayede özellikle maliyeti düşük ve daha çevreci mimari ve dekoratif amaçlı beton uygulamaları daha etkili bir şekilde yapılabilmektedir. Bu sayede endüstriyel atıkların doğada başıboş bırakılması ve depolanması sonucu oluşan çevre kirliliğinin önüne önemli ölçüde geçilebilmektedir. Cam tozu (GP), günlük hayatta sıklıkla kullanılan pencere, kapı, ampul ve çeşitli süs eşyalarında kullanılan cam artıklarının mikron seviyesinde öğütülmesiyle elde edilen atık malzemedir. Bu çalışmada, çimento yerine %2.5, %7.5, %12.5 ve %17.5 oranında cam tozunun kullanıldığı karışımların işlenebilirliği, basınç ve yarmada çekme dayanımları incelenmiştir. Elde edilen sonuçlara göre, GP'nin belirli oranlara kadar çimento ikame edilerek kullanılmasının, numunelerin basınç ve yarmada çekme dayanımlarını bir ölçüde iyileştirdiği tespit edilmiştir.

**Anahtar Kelimeler:** Beton, atık cam tozu, basınç ve yarmada çekme dayanımı

7. ULUSLARARASI

19 MAYIS YENİLİKÇİ BİLİMSEL YAKLAŞIMLAR KONGRESİ

19-20 Mayıs 2022, Samsun

# INVESTIGATION OF THE USE OF WASTE GLASS POWDER IN CONCRETE MIXES IN TERMS OF A SUSTAINABLE APPROACH

## ABSTRACT

Rapid urbanization and the resulting ever-increasing population growth and the increase in consumption demands of societies cause immediate consumption of raw materials. To meet these demands, industrial facilities and post-production waste materials in these facilities increase rapidly. Leaving these waste materials, which are produced due to production, unattended in nature brings critical environmental problems. Waste materials should be stored, destroyed, or re-evaluated through recycling to minimize these ecological problems. One of the essential materials of waste formed due to industrial production is waste glass materials. As with all other waste materials, recycling waste glass is of great importance for reducing environmental pollution and cost. Waste glass, a waste product, has a vast usage area. It does not give any odor, tastes like raw material, has a transparent appearance, and is not easily deformed like other plastic or paper packages. One of the most common application areas related to the use of waste glass in recycling is using waste glass as concrete aggregate in concrete mixtures by replacing fine aggregate. This way, exceptionally low-cost and more environmentally friendly architectural and decorative concrete applications can be more effective. In this way, it is possible to prevent the environmental pollution caused by leaving industrial wastes unattended in nature and storing them. Glass dust (GP) is a waste material obtained by grinding glass residues used in windows, doors, light bulbs, and various ornaments, which are frequently used in daily life, at the micron level. This study investigated the workability, compressive, and splitting tensile strengths of the mixtures using 2.5%, 7.5%, 12.5%, and 17.5% glass powder instead of cement. According to the results obtained, it was determined that the use of GP by substituting cement up to specific proportions improved the compressive and splitting tensile strengths of the samples to some extent.

**Keywords:** Concrete, waste glass powder, compressive and splitting tensile strength

## I.INTRODUCTION

Cement production facilities release large amounts of $CO_2$ emissions and cause an increase in global warming. In recent years, alternative solutions have been developed to reduce the adverse environmental effects of cement production [1-4] To reduce cement production, studies on the use of pozzolan materials such as fly ash, silica fume, and blast furnace slag in concrete by partially replacing cement have become quite widespread. In this way, it is aimed to produce more economical and environmentally friendly concrete while solving the disposal problem arising from wastes [5-7]. One of the wastes that are difficult to recycle is glass waste. Because the waste glasses' colors, chemical contents, and pollution levels are very different and the recycling cost is high, very few of them can be recycled. As a result of the studies on increasing the recycling areas of waste glass, it has been revealed that using it as a binder or aggregate in concrete production can be an alternative solution both environmentally and economically. There are many studies on evaluating waste glass materials in the production of cement-based

products [8-17]. However, there are contradictions about the positive or negative effects of waste glass on cement-based materials. The types, particle sizes, and chemical contents of the waste glass used in the studies differ. In some of the studies, it is stated that waste glasses negatively affect the strength properties of concrete and cause an alkali-silica reaction in concrete [11-13]. In addition, there are many studies that the use of waste glass in concrete improves the mechanical properties of concrete [14-17]. Therefore, within the scope of this study, waste glass powder added concretes were produced, and the setting time, workability, water absorption, and concrete strength properties of the concretes were determined.

Khatib et al. [14] produced concretes using 10%, 20%, 30%, and 40% glass powder instead of cement. They stated that the use of 10% glass powder in concrete improves the compressive strength of the concrete, and if it is used above this rate, the compressive strength decreases. Aliabdo et al., [15] reported that the compressive strength of concrete with glass powder additive produced by replacing 15% with cement was improved by 6%. In another study by Ahmad et al., [16], it was determined that the 28-day compressive strength of the concretes produced using 20% waste glass powder was 24% higher than the reference concrete. However, they reported that the use of 30% glass powder caused a decrease in the workability of the concrete, an increase in the void ratio in the concrete, and thus a reduction in the compressive strength of the concrete. Gupta et al. [17] determined that replacing waste glass powder with 30% cement increased the 90-day compressive strength of concrete by 20.4%. They also stated that the use of waste glass powder above this rate causes porosity in the concrete and causes a decrease in strength.

## II.MATERIAL AND METHOD

### 2.1.Materials

CEM I 42.5 R cement, aggregate, and waste glass powder used during the production of waste glass powder added concretes were used. The size of the coarse aggregate used is a maximum 14 mm, and the fine aggregate is 4.75 mm. Waste glass powder was used after crushing and grinding below 80 microns. The fine, coarse aggregate, and waste glass powder densities are 1700, 1800, and 2500 kg/m$^3$. The appearance of ground waste glass powder is given in Fig 1. and the aggregate sieve analysis graph is shown in Fig 2.



Fig. 1. The appearance of ground waste glass powder

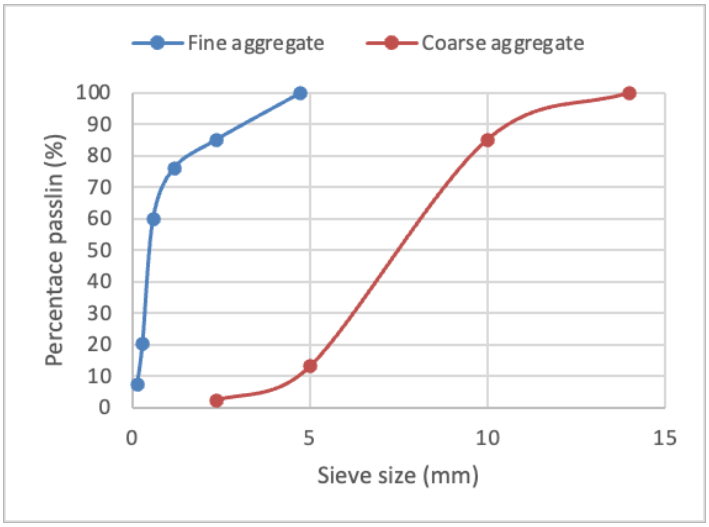


Fig. 2. The sieve analysis of fine and coarse aggregate

The chemical, physical and mechanical properties of the cement used in the study are given in Table I and the chemical composition of the recycles glass powder is shown in Table II.

Table I. The chemical, physical and mechanical properties of Cement

| The results of chemical analyses | | The results of Physical analyses | |
|---|---|---|---|
| | | | |
| $Al_2O_3$ (%) | 5.0 | Specific surface area $m^2/kg$ | 315 |
| CaO (%) | 63.6 | initial setting time (min) | 160 |
| $Fe_2O_3$ (%) | 3.7 | Final setting time (min) | 193 |
| MgO (%) | 2.8 | Mechanical analyses | |
| $SO_3$ (%) | 2.5 | Compressive Strength | |
| $Na_2O$ (%) | 0.2 | 3 day (MPa) | 20.0 |
| $K_2O$ (%) | 0.5 | 7 day (MPa) | 26.1 |
| $SiO_2$ (%) | 19.2 | 28 day (MPa) | 35.3 |
| Loss on ignition | 1.65 | | |

Table II. Chemical properties of recycles glass powder

| Composition | |
|---|---|
| $Al_2O_3$ (%) | 1.71 |
| CaO (%) | 10.04 |
| $Fe_2O_3$ (%) | 0.99 |
| MgO (%) | 2.99 |
| $SO_3$ (%) | 1.73 |
| $Na_2O$ (%) | 7.96 |
| $K_2O$ (%) | - |
| $SiO_2$ (%) | 72.90 |
| Loss on ignition | - |

**Method**

In this study, the effects of waste glass powder on the fresh and hardened properties of concrete were investigated. For this purpose, 2.5%, 7.5%, 12.5%, and 17.5% of waste glass powders were replaced with cement. The materials and proportions used in preparing waste glass powder added concrete mixtures are given in Table III.

Table III. Concrete mixing ratios

| Mix Code | C ($kg/m^3$) | GP (%) | W/C | Fine Agr. ($kg/m^3$) | Coarse Agr. ($kg/m^3$) |
|---|---|---|---|---|---|
| Plain | 390.0 | 0 | 175.5 | 692.9 | 1467.4 |
| GC-2.5 | 380.3 | 2.5 | 175.5 | 692.9 | 1467.4 |
| GC-7.5 | 360.7 | 7.5 | 175.5 | 692.9 | 1467.4 |
| GC-12.5 | 341.3 | 12.5 | 175.5 | 692.9 | 1467.4 |
| GC-17.5 | 321.7 | 17.5 | 175.5 | 692.9 | 1467.4 |

The fresh and hardened concrete properties of the prepared concrete samples were determined. Fresh concrete properties such as setting time and workability of control and waste glass powder

added concrete were determined. The properties of hardened concrete, such as water absorption, compressive strength and splitting tensile strength were investigated. Hardened concrete tests were carried out on cube samples of 100 x 100 x 100 mm dimensions. The standards used in the experiments are given in Table IV.

Table IV. Standards used in the experiments

| Analyses | Standarts |
|---|---|
| Initial and final setting time | ASTMC 191-M82 [18] |
| Workability | ASTMC143-M20 [19] |
| Water absorption | ASTMC642-M12 [20] |
| Compressive strength | ASTM C-39-M20 [21] |
| Splitting Tensile strength | ASTM C496-M17 [22] |

## DISCUSSION

### Fresh concrete properties

To determine the effect of the waste glass powder additive on the fresh concrete properties, the concretes' initial and final setting times and workability properties were determined. The test results of the fresh control and waste glass powder added concretes are given in Table V, and the initial and final setting times of control and waste glass powder added concrete mixes are shown in Fig. 3.

Table V. Fresh concrete test results

| Mix Code | Initial setting time (minutes) | Final setting Time (minutes) | Slump (mm) |
|---|---|---|---|
| Plain | 193 | 260 | 80 |
| GC-2.5 | 198 | 270 | 78 |
| GC-7.5 | 205 | 285 | 74 |
| GC-12.5 | 213 | 295 | 69 |
| GC-17.5 | 222 | 305 | 68 |

It has been observed that the mixes' initial and final setting times increase depending on the rise in the waste glass powder additive. In addition, it was observed that the workability of the concrete decreased with the increase in the waste glass powder additive ratio. Waste glass powders have reduced the workability of concrete due to their irregular and angular shapes. In addition, too much fineness of the glass powders would increase the water requirement for hydration, thus reducing the workability. This view is also supported by some researchers in the literature [1-3].

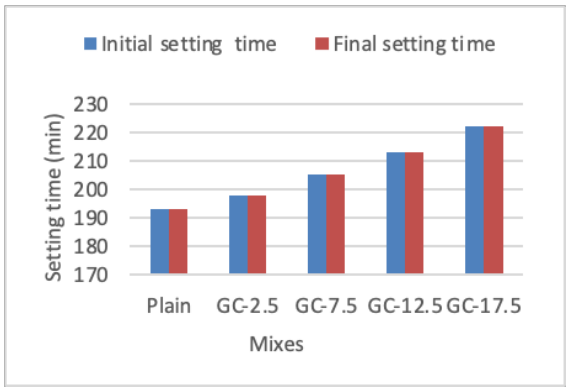


Fig. 3. Initial and final setting time of control and waste glass powder added concrete mixes

**Hardened concrete properties**

Water absorption and compressive strength tests were carried out to determine the effect of the waste glass powder additive on the hardened concrete properties. Water absorption test results of hardened concrete specimens are shown in Fig.4. Compressive strength test results of control and waste glass powder added concrete examples are given in Table VII and Fig.5, splitting tensile strength results are shown in Table VIII and Fig. 6. It was determined that the water absorption rate of the concrete decreased with the increase in the waste glass powder additive ratio. This is thought to be due to the pozzolanic effect and the space-filling effect of the glass powder. Similarly, in the study conducted by Gupta et al., they reported that the waste glass powder additive reduces the water absorption rate of the concrete.

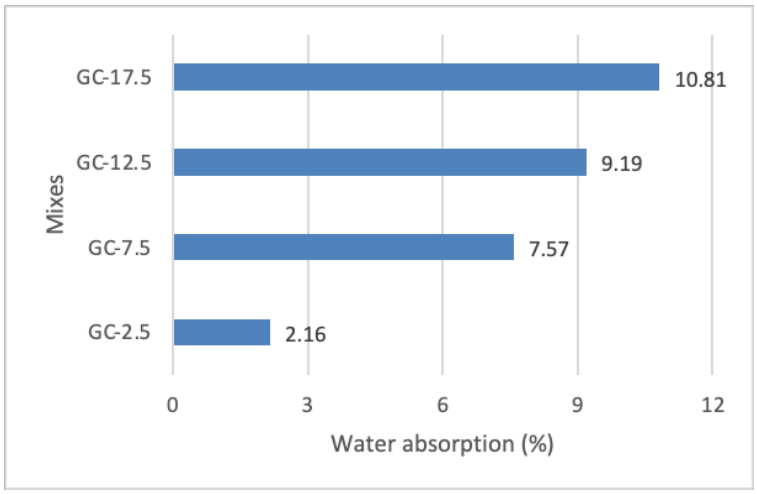


Fig. 4. Water absorption values of control and waste glass powder added concrete mixes

Table VII. Compressive strength test results of control and waste glass powder added concrete

| Mix Code | Compressive Strength (MPa) | | |
|---|---|---|---|
| | 7 day | 14 day | 28 day |
| Plain | 18.25 ±0.90 | 23.01 ±1.45 | 28.35 ±0.99 |
| GC-2.5 | 19.35 ±1.06 | 24.25 ±1.30 | 29.75 ±1.52 |
| GC-7.5 | 22.25 ±1.21 | 27.50 ±1.39 | 34.24 ±1.59 |
| GC-12.5 | 21.7 ±1.62 | 26.30 ±1.37 | 33.13 ±2.07 |
| GC-17.5 | 20.6 ±1.12 | 25.25 ±1.51 | 31.50 ±1.32 |

When Table VII was examined, it was determined that the use of waste glass powder at the rate of 2.5%, 7.5%, 12.5%, and 17.5% compared to the control concrete increased the 28-day compressive strength of the concrete by 4.93%, 17.20%, 16.86%, and 11.11%, respectively. The increase in the strength of the concretes with the waste glass powder ratio is the reaction of the glass powder with the calcium hydroxide (CaOH) that occurs during the cement hydration. In addition, glass powders increased compressive strength by showing the effect of filler, except pozzolanic active, on the aggregate-cement interface. The results were found to agree with the literature [14-18].

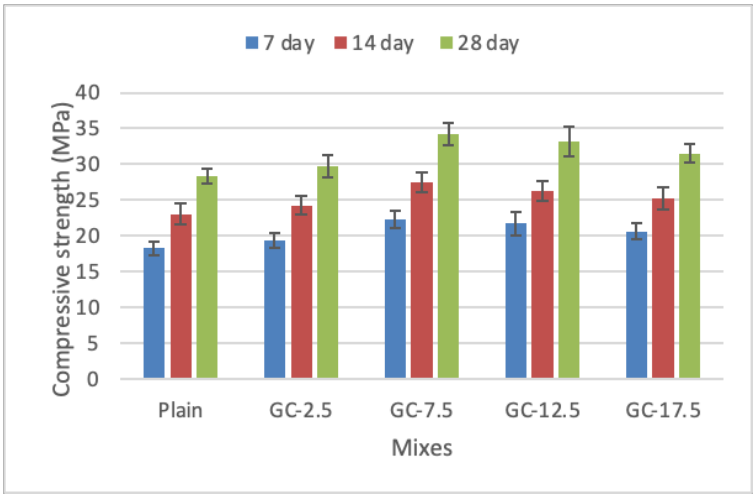


Fig. 5. The compressive strength of control and waste glass powder added concrete specimens

Table VIII. Tensile strength test results of control and waste glass powder added concrete

| Mix. Code | Splitting tensile strength (MPa) | | |
|---|---|---|---|
| | 7 day | 14 day | 28 day |
| Plain | 1.75 ±0.20 | 2.15 ±0.30 | 2.70 ±0.26 |
| GC-2.5 | 1.85 ±0.13 | 2.28 ±0.19 | 2.85 ±0.37 |
| GC-7.5 | 2.10 ±0.08 | 2.59 ±0.37 | 3.25 ±0.31 |
| GC-12.5 | 2.08 ±0.07 | 2.56 ±0.20 | 3.21 ±0.36 |
| GC-17.5 | 2.05 ±0.08 | 2.53±0.07 | 3.16±0.29 |

When Table VIII was examined, it was determined that the use of waste glass powder at the rate of 2.5%, 7.5%, 12.5%, and 17.5% compared to the control concrete increased the 28-day tensile strength of the concrete by 5.55%, 20.37%, 18.88%, and 17.03%, respectively.

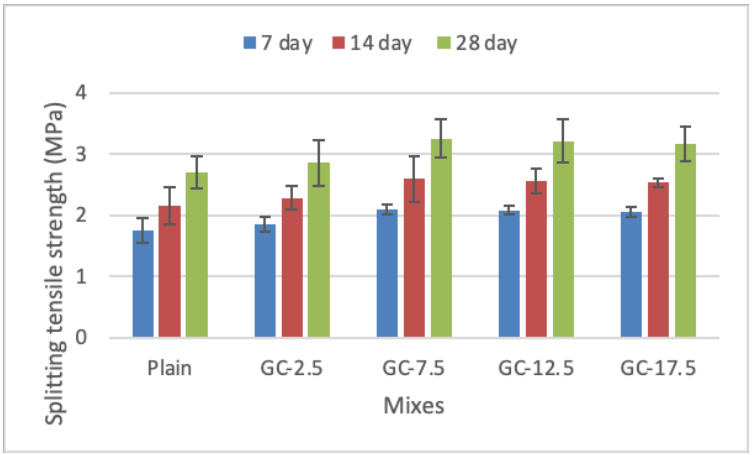


Fig.6. The splitting tensile strength of control and waste glass powder added concrete specimens

## CONCLUSION

- • It has been observed that the use of waste glass powder as an additive material in concrete mixes causes an increase in compressive and splitting tensile strength.
- • It is thought that as the glass powder ratio increases, the strength properties of concrete improve, which is caused by pozzolanic activity and filler.
- • It has been determined that the optimum use of waste glass powder at the rate of 12.5% in concrete improves the strength properties of concrete.
- • It has been determined that using waste glass powders by replacing cement in concrete has a positive contribution to concrete strength. At the same time, the widespread use of waste glass in concrete will significantly reduce environmental impacts and energy consumption resulting from cement production.

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