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Effect of Waste Glass on Properties of Conventional and Self-Compacting Concrete, Review

Elaf Khalid Dahamm[1], Ibrahim A. AL-Jumail [1], Sheelan Mahmoud Hama [1]

[1]*civil department, Engineering college Anbar University, Ramadi, Iraq*, ela20e1024@uoanbar.edu.iq, Ibrahim.aljumaily@uoanbar.edu.iq, drsheelan@uoanbar.edu.iq

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ABSTRACT

According to this study, many things designed for our luxurious lifestyle are responsible for environmental pollution as a result of poor waste management techniques.Glass is a waste that must be properly disposed of or reused in order to protect our environment.Summarise the search,Concrete making and forming is a difficult process that involves environmental, social, and economic considerations. economic and physical aspects are studied, and the possibility of partial use of waste glass powder (WGP) as an alternative to cement was investigated. Ordinary and self-compacted concrete exhibit a pozzolanic behaviour because it reacts with lime early to form a gel. The tests found that concrete samples for compressive strength at 28 days improved with cement replacement, and the results obtained compared to normal concrete were higher. Previous studies have indicated that wasted glass is an effective alternative to cement (up to 20%). WGP is used as an alternative to cement to increase the compressive strength of the mortar compared to regular concrete

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1. Introduction

At this time, engineers prefer to use concrete for several reasons, including its ease of use and its formation as a concrete structural element in any shape and size, the availability of materials included in concrete, and its good durability and resistance to water, unlike other materials. However, in recent years, several researchers have come up with the use of alternative materials for cement (Mehta and Monteiro 2014), focusing on sustainable construction and the community's interest in building and developing concrete and internal materials, whether glass or plastic waste or recycled materials (Shayan and Xu 2004).

Glass is used as a waste substitute for aggregate, a soft material substitute for sand or cement, or a substitute for gravel (Carpenter and Cramer 1999). However, since the demand in the concrete industry has increased, using natural materials in concrete, including sand, has increased, and glass powder has begun as an alternative material for sand(Lam, Poon, and Chan 2007). In addition, crushed glass is used as an alternative to coarse aggregate represented by gravel because of its flat nature, which enhances the low operating strength and thus increases the compressive strength (Cheeseman 2011).

Glass is an amorphous material with a high percentage of silica, so it can be a pozzolanic material when the particle size is less than75 micron (Federico and Chidiac 2009). The main purpose of pozzolanic materials is to reduce the reaction of alkaline silica, especially harmful to concrete structures, where these materials are cemented

* *Corresponding author*. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000.
E-mail address: author@institute.xxx

or replaced, which gives additional strength to the cement mortar, where the pozzolanic materials interact with free $Ca(OH)_2$ arising from a binder (lime, hydraulic lime) or rehydration (cement) reactions, producing calcium silicate and aluminium silicate hydrate, which contribute to building a more resistant chemical structure (Fragata et al. 2007). In addition, waste glass materials can be used as materials towards sustainability.

2. Effect of Using Glass Powder in Concrete

Many researchers carried out several experiments and research, including the researcher who found the replacement of cement with glass waste powder, which noticed a significant improvement in the bending strength when replaced by 10%(Al-Jburi Najad et al. 2019). A second study proved that By replacing 40% of the cement with glass waste, compressive strength is increased by 40%(Shekhawat and Aggarwal 2014).suggested that replacing cement with waste glass powder increases flexural strength by 35% (SAWANT 2018).He studied that replacing 20% of the cement with glass waste powder is the best, whether or not the concrete has been exposed to sulfates (MN, CD, and AK 2011) Several experiments were conducted to explore the benefits of glass powder. The researcher recommends that the test results at the age of 7, 14, and 28 days of treatment for samples containing waste glass powder as a partial substitute for cement showed that glass powder at 20% indicates the highest compressive value compared to other percentages such as 10% and 15% Although there was a slight increase in results from 14 days[9]. Compared to conventional concrete, replacing up to 40% of the cement with vitreous powder increased compressive strength every 28 days and 60 days of creasing. (Vijayakumar, Vishaliny, and Govindarajulu 2013)The researcher concluded that increasing the amount of glass in the cement mortar significantly decreases compressive strength, with the reduction becoming clearer as the curing time increases. The strength factor is affected by the size of the glass particles(kara et al in 2016) The strength characteristics of precast blocks comprising waste glass powder were investigated and studied(Patel, Yadav, and Chandak 2012).He investigated the performance of concrete made with glass powder rather than cement and discovered that the maximum compressive strength occurs at about 10% glass powder (Khatib et al. 2012). The aggregate test was conducted when replacing the aggregate with glass. It was found that the water absorption rate decreases with the increase in the percentage of waste, as the lowest absorption rate when replacing cement with glass reaches 40% (Malik et al. 2013). Researchers studied the use of waste glass and discovered that the proportion of moderate substitution levels, such as 2 to 20% glass powder content, increases water absorption.

It achieved results similar to the control mixture(kara et al in 2016).The sand was replaced with glass powder and observed to reduce the absorption coefficient of concrete. The reduction is a maximum of 39% for 28 days at 100% of sand replacement and a 29% reduction in 63 days for the same rate of glass waste(Shekhawat and Aggarwal 2014).In his experimental work, the researcher presented a study on the use of transparent and colored glass with sizes (100, 80 µm, 80, 40 µm and less than 40 µm),), yielding a compressive strength index.For sizes less than 40µm, the percentage of glass waste reached more than 82% (Kashmiri et al in 2012).

3. Waste Glasses in the Conventional Concrete

Recycling glass waste is one of the problems that are disposed of. In the United States, it was found that approximately a 2.9million metric tons of glass that are consumed is discharged into the municipal stream (Hopewell, Dvorak, and Kosior 2009).Thus, there is a growing enthusiasm for using glass waste in the usual concrete, whether these materials are broken windows or empty glass cans and others. These wastes are used in concrete as a substitute for raw materials to reduce the cost of producing these materials and to get rid of materials harmful to the environment (Deffeyes and Silverman 2004). As a result of the pozzolanic reaction and its critical importance in concrete, it was found that replacing or adding glass as an alternative to cement, many researchers have concluded its importance in concrete because it contains high amounts of silica to produce concrete(Paul, Šavija, and Babafemi 2018),Because glass contains high concentrations of alkali metal oxides present in the formation of glass (mostly in the form of calcium oxide or sodium oxide), it helps improve the performance of concrete containing waste glass due to alkaline silica reaction (Sekhavati, Jafarkazemi, and Kaya 2019)Furthermore, waste glass enhances concrete's durability and improves compressive and bending strength(Borhan 2012)

4. Waste Glasses in Self-Compact Concrete

At present, research has proven that self-compacting concrete has become a strong sign of the types of concrete that entered the construction due to the ease of pouring this type of concrete in high areas while maintaining the

fullness of the moulds regularly and without leaving spaces in the mould, because this type of concrete does not need to vibration, especially in the armed moulds, where the mixture passes easily. This need has been solved by introducing self-compacting concrete because it eliminates vibration and thus reduces the noise generated by the vibration device, providing a smooth surface for the mould. Moreover, the operability of self-compacting concrete is high, as it is easy to pour it with a few workers, which means that we do not need many workers as in ordinary concrete. That is why cement is replaced with alternative materials and is economical such as glass waste) Petean et al. 2013(,(Naik 2008),(Russell 1997). The prepared SSC mixture is screened according to EFNARC Guidelines for the Properties of Fresh Concrete. Tests include the slump flow test, the T500 slump flow, the L box test, and the V-funnel test. Performed to comment on the workability of the SSC mix (EFNARC 2002). Furthermore, the search studied the fibres that are prepared in self-compacting reinforced concrete by adding 600 g/m3 from glass fibre dispersion combined with suitable additives; The GFRSCC record showed an increase in compressive, split tensile, as well as bending strength of 2.0 to 5.5%, 3.0 to 7.0%, and 11.0 to 20.0%, respectively (Chandrasekhar, Rao, and Janardhana 2011). Compared the replacement of cement once with glass powder and once with fly ash by 10% and found that the performance of concrete in glass powder is better than fly ash and the compressive strength was higher at all ages(Schwarz and Neithalath 2008).

5. Pros and cons of adding glass to concrete

Pros

- Tons of waste that cause environmental pollution are produced annually, including glass waste that is difficult to dispose of, materials that cannot decompose, and there are no places to store them, so they are replaced as an alternative to cement to reduce pollution and reduce cement production (Khudair 2021), (Najaf and Abbasi 2022)
- Using glass waste as an alternative to cement, improved concrete is produced with new materials with improved strength and durability properties. Furthermore, using ground glass as an alternative to cement can overcome the disadvantages of recycled aggregates as the glass, when crushed into fine granules, undergoes pozzolan Secondary calcium silicate hydrate is formed as a result of reactions with cement hydrate (C-S-H).These reactions cause beneficial changes in the structure of the hydrated cement paste as well as the interfacial transition zones in recycled aggregate concrete.(Nassar and Soroushian 2012)

Cons

- The use of glass as a substitute for aggregates causes a decrease in density due to the fabrication of glass's thickness and aggregates' density (Keryou and Ibrahim 2014)
- Using waste glass as an aggregate substitute reduces compressive strength and increases the expansion of the silica alkali reaction. (Keryou and Ibrahim 2014)
- Degradation of the compressive strength, split tensile strength and flexural strength of concrete by incorporating WG. However, results regarding the modulus of elasticity of concrete have been conflicting. This reduction was necessary due to the sharp edges and smooth surface of the lost glass, which caused a weakening of the bond between the cement slurry and the lost glass particles in the ITZ (FahriyeAygün 2021)

6. The influence of glass on concrete mechanical properties

The use of glass in concrete after the grinding process into small particles, which are the size of microns, provides significant improvements in strength and durability through the pozzolanic reaction(Keryou and Ibrahim 2014). Additionally, adding WGP to SCC has been said to increase pressure, and the bending and tensile strength decrease the permeability(FahriyeAygün 2021),(Elaqra, Haloub, and Rustom 2019) Traditional blending method, compressive strength decreased with increased glazing powder at an early age. The highest compr The compressive strength of the 10 and 20% GP mixes was higher at longer ages than the control mix, which is due to the pozzolanic reactivity of the glass powder. essive strength of 20% GP was obtained after 90 days. The compressive strength of the new mixing method was higher than that of the traditional. The addition of 10% GP to the contemporary mixing method resulted in a significant increase in compressive strength, approximately 130% of the control mixture.This increase could be attributed to the hydrolysis of glass powder into free SiO2,

CaO, and Na2O ions in water, resulting in more CSH formation. In addition, the relative index demonstrates that as the amount of glass powder increases, so does the reaction(Elaqra and Rustom 2018).

7. Conclusion

- The glass powder is used as pozzolanic material from waste glass due to its high pozzolanic activity, which leads to improved mechanical properties by 10-40%
- On the contrary, it causes a decrease in mechanical strength when glass waste is added to the cement slurry due to a deficiency of calcium hydroxide.
- The results of this research aim to contribute to sustainable development,By reducing consumption as well as reducing the amount of glass waste .Going to landfills, all the results of this pilot study indicate that GP use from waste glass recycling can be processed into clay and concrete production. This is a very important fact. Because it is proposed to replace part of the cement with a substance usually taken to landfills.
- SCC with glass powder as a mineral addition instead of cement demonstrated superior mechanical properties up to 20- 30% of the powder.
- The dry densities of the glass SCC mix ranged from 2376-2523 kg/m3 for the test concrete to 2395 kg/m3 for the control concrete.
- A replacement percentage of 25% produced the greatest effect.At this percentage, increases in compressive, splitting tensile, and flexural strengths were 30, 38, and 31%, respectively.This study's findings indicate that using the optimal percentage of WG (25%) as a partial replacement for coarse aggregate has a significant economic impact.

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