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Using Recycled Glass Powder in Concrete: A Survey of the Literature

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Research Article
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ABSTRACT: Among the many building materials used around the globe, concrete ranks high. Nevertheless, a substantial quantity of carbon dioxide (CO2) is released during the manufacturing of portland cement, a key ingredient in concrete. It is estimated that the manufacture of one tonne of portland cement clinker results in the emission of around one tonne of CO2 and other greenhouse gases (GHGs). According to Naik and Moriconi (2005), the cement and concrete industry is focusing on environmental concerns as a means to achieve sustainable growth.Reducing cement consumption and mitigating environmental pollution can be achieved by substituting pozzolanic materials for a portion of cement. There is previously recognised use for some industrial wastes in concrete, such as fly ash, blast furnace slag, silica fume, etc. New studies have demonstrated that recycled glass may be a valuable ingredient in concrete, either alone or in combination with other materials. The silica in waste glass gives it some pozzolanic characteristics when crushed into a fine powder. Thus, glass powder can partially substitute cement, which increases strength and improves durability (Chikhalikar S.M. and Tande S.N., 2012). In recent years, there has been a significant decline in the demand for recycled glass, especially mixed-glass. Because of the costs associated with conditioning, recycling glass is more expensive than storing it. Reusing composite-glass can be achieved in a number of ways. Prior research indicates that none of these uses—which need pre-conditioning and crushing—are particularly robust and could not possibly use up the whole amount of recyclable glass. Reusing this glass in concrete might be an attractive and viable option for a long-term solution to the problem of glass storage [Idir R, 2009].In this paper, we survey the literature on the topic of using crushed glass powder in Portland cement concrete as a cement substitute. We look at both the past and the future of this field of study.

KEYWORDS: Concrete, Cement Replacement, Waste Glass Powder

INTRODUCTION

Many different types of garbage are generated by different types of activities. Some of them include manufacturing, the service industry, and municipal solid waste. Concerns regarding the correct disposal of waste have increased dramatically as people have grown more eco-conscious. All throughout the world, ecosystems are worried about how to handle solid waste. With landfill space at a premium and disposal costs on the rise, waste utilization is a viable alternative. In addition to being more economical, concrete constructed from recycled resources aids in waste management. Repurposing big pieces of waste is the greenest approach to the disposal problem. This form of waste includes plastic, which might have several use. According to the World Commission on Environment and Development, sustainability is achieved when current societal needs are met without compromising the capacity of future generations to do the same. At its core, the sustainability movement is concerned about the state of our world in relation to the continuous expansion and development of humans [McDonough 1992]. Limestone is predicted to become unavailable in specific places, which would prevent the manufacture of portland cement and, by extension, concrete. Companies making concrete would go out of business and their workers would be out of work as a result [Naik and Moriconi, 2005].

HISTORY

There has been a general perception in the concrete industry that glass aggregates should be precluded from concrete because of their potential for alkali silica reaction (ASR), even although early research did not draw definite conclusions. Recent publications, whilst not specifically supporting the use of glass in concrete, have led to a great understanding of ASR parameters and methods by which it can be suppressed and major recent research in the USA and UK has made it possible for recycled glass to be viewed as a potentially "fit-for-purpose" concrete construction material. Early researches in 1960's, 1970s and1980s on the study of ASR of glass aggregate were conducted without definite conclusions.

In parallel to these scientific advances, changes in environmental legislation are positively encouraging the use of secondary aggregates in concrete and waste glass is becoming available in larger quantities as container, end-of-life vehicle and waste electrical goods legislation take effect.

EFFECT OF USING GLASS POWDER IN CONCRETE

A. SLUMP TEST

In his study on slump property, Vasudevan Gunalaan and Kanapathy pillay Seri Ganis [2013] found that utilizing waste glass powder in concrete increases its workability compared to the control mix. Increasing the replacement lowered workability, according to research by R.Vandhiyan et al.[2013]. This is because the angular form of the glass particles and the increased surface area of the powder both contribute to this effect. According to Kumarappan N. [2013], the slump rises in a systematic fashion in relation to the amount of glass powder in the mixture. The reference mix, which had no glass powder, had a droop of about 40mm, whereas the mixture with 40% glass powder had a slump of 160mm. The slump is systematically increased as the glass powder quantity in the mix increases, according to the study by Khatib J.M. et al. [2012]. Researchers Jangid Jitendra B. and Saoji A.C. found in their 2012 study that adding more glass powder to a mixture reduces its workability. The workability of Steel Fiber Reinforced Concrete (SFRC) is improved when 20% cement is replaced with waste glass powder, according to research by Chikhalikar S.M. and Tande S.N. (2012). Using milled waste glass, Nassar Roz-Ud-Din and Soroushian Parviz [2012] found that slump marginally increases when milled waste glass is added to the mixture. One possible explanation is because glass does not absorb very much water. Slump is greater in recycled aggregate concrete mixes compared to control mixes at both w/cm ratio levels.

B. The Strength of Compression

The use of recycled glass powder in concrete production and improvement has been the subject of much research. Test results at7,14, and 28 days of curing of specimens containing waste glass powder as a partial replacement of cement were investigated by Vasudevan Gunalaan and Kanapathy pillay Seri Ganis [2013]. Their findings demonstrated that a 20% glass powder mix amount exhibited a positive value of compressive strength at 28 days, in contrast to the other ratios, which were not achievable (despite a slight increase from 14 days). Vandhiyan R. et al.[2013] investigated the effects of using recycled glass powder in place of cement and found that, compared to a control specimen, one made with 15% GP showed a 29% improvement in strength by the seventh day. By the 28th day, the disparity in strength had diminished to 23%. At 10% replacement, the strength increase is at its best. Since glass powder had a greater compressive strength than the

control mix, Kumarappan N. [2013] concluded that it is viable to substitute cement by up to 10%. When compared to regular concrete, the compressive strength of concrete that included up to 40% glass powder instead of cement increased after 28 and 60 days of curing, according to a study by Vijayakumar G. et al. (2013). Adding more glass to mortar reduces its compressive strength in general, according to Nwaubani Sunny O. and Poutos Konstantinos I. [2013], however this effect is mitigated with longer curing times. Critical to the strength development was the particle size distribution of the recycled glass employed. In their study on concrete's performance as a partial cement replacement, Khatib J.M. et al.[2012] found that the maximum compressive strength is achieved at around 10% glass powder, and that it begins to drop and is lower than the control beyond 10%. The strength parameters of pre-cast blocks containing waste glass powder were researched by Patel Dhirendra et al. [2012]. They found that the compressive strength decreases somewhat after 28 days. According to research by Jangid Jitendra B. and Saoji A.C. [2012], compressive strength increases by 20% with cement replacements up to 40%, but falls beyond that. The compressive strength of fiber reinforced concrete can be increased by up to 30% when compared to the control mix, according to research by Chikhalikar S.M. and Tande S.N. (2012), who examined the properties of this material. However, the researchers found that the highest improvement occurred at a 20% replacement rate. The compressive strength increment is up to 25% when cement is replaced with waste glass powder, according to research by Dali J.S. and Tande S.N. [2012]. However, the peak % increment is at 20% in both the case where the concrete is not subjected to alternate wetting and drying and the case where it is subjected to alternate wetting and drying. Researchers Patel Dhirendra et al. [2012] found that a dose of 15% of fine and coarse glass powder, in place of cement, improved the qualities of cement sand mortar paste. According to the experimental study given by Khmiri A. et al. (2012), which included clear and colored glass of various sizes (100 and 80 μm, 80 and 40 μm, and less than 40 μm), the compressive strength index of ground waste glass exceeds 82% for sizes less than 40 μm. In their 2012 study, Patil Dhanraj Mohan and Sangle Kehav K. examined the outcomes of tests conducted on waste glass powder particles with sizes ranging from 150μm to 90μm, with a minimum of 90μm. He demonstrated that adding GLP on day 7 results in a negligible initial strength improvement, but that by day 28, the gain had increased. An increase in strength of 20% is observed with the addition of GLP. Strength enhancement is also much improved by GLPs with a size below 90 microns. In their study on the strength properties of glass-containing materials exposed to sulfate attack, Bajad M.N. et al. [2011] demonstrated that, in both unaffected and attacked concrete, the peak compressive strength is reached at 20% cement replacement with waste glass powder. The increment in compressive strength continues up to 25% replacement before it starts to decrease. The compressive strength result confirms that WG retards the hydration of Portland cement, according to studies conducted by Gopalakrishnan Ramasamy and Govindaraja Dharshnamoorthy [2011] on waste glass additive cement. In 2011, Wang Her-Yung and Hou Tsung-Chin investigated the effects of

high temperatures on the strength characteristics of LCD glass powder cement mortars. They found that using 10% glass powder instead of cement significantly improved the compressive strength of the mortars, especially when the glass powder had a fineness of 4500 cm2/g or more. This quantity of glass powder substitute might be used as a suggestion to substitute cement in actual practice. In their study, Oliveira L.A. Pereira de et al. [2010] examined the pozzolanic activity of waste glass of green, amber, and flint colors, with particle sizes ranging from 75µm to 150µm, 45µm to 75µm, and less than 4µm. These materials are utilized as filler or binder in mortar and concrete. He arrived at the conclusion that 30% of ground waste glasses in the size range of 45 - 75 µm may be utilized as a cement substitute in mortar or concrete without causing any negative effects due to the expansivity generated by the alkali silica reaction. There would be no negative long-term impacts of using 30% GLP as a cement or aggregate substitute in concrete, according to Shayan Ahmad [2002]. Concrete with a strength grade of 32 MPa and satisfactory strength development qualities might also have up to half of its fine and coarse material changed.

C. Adaptability

Researchers Vandhiyan R. et al. [2013] found that when waste glass powder was used as a 10% replacement for cement, the flexural strength of the mixture significantly improved. Researchers Vijayakumar. G. et al. [2013] shown that by substituting up to 40% of cement with waste glass powder, flexural strength may be increased. Flexural strength improves up to 35% cement replacement using waste glass powder compared to control mix, with a peak % augmentation at 20% and a subsequent reduction, according to Jangid Jitendra B. and Saoji A.C.'s (2012) investigation. According to research by Chikhalikar S.M. and Tande S.N. (2012), the ideal dosage of waste glass powder to replace cement is 20%. This dosage was determined by testing the flexural strength parameter. Research by Dali J.S. and Tande S.N. [2012] examined the effects of high temperatures and alternative wetting and drying on the properties of concrete with mineral admixtures. The authors found that a 20% replacement increased the strength of the concrete in both the non-adversaried and altered conditions. Whether the concrete is attacked by sulphates or not, experimental results by Bajad M.N. et al. (2011) demonstrated that a 20% replacement with waste glass powder is best.

D.DIVIDEDTESSILESS STRENGTH

Researchers Vijayakumar G. et al. [2013] found that, in comparison to regular concrete, glass powder concrete significantly boosts tensile strength. A little increase in tensile strength was demonstrated by Vandhiyan R. et al. [2013]. The tensile strength reaches its maximum when waste glass powder replaces 20% of the cement in Steel Fibre Reinforced Concrete (SFRC), according to research by Chikhalikar S.M. and Tande S.N. (2012). After conducting high-temperature experiments on mineral-admixtured concrete, Dali J.S. and Tande S.N. [2012] found that, both when the concrete is not and is exposed to alternate wetting and drying, a 20% replacement level is best.

E: Testing Water Absorption

Researchers Malik M. Iqbal et al. [2013] used this test to determine that the percentage of water absorption reduced as the waste glass content increased in concrete that used waste glass as partial replacement of fine aggregates. In terms of water absorption, concrete mixes containing 40% waste glass had the best results. Water absorption rose as the glass powder content increased, according to Nwaubani Sunny O. and Poutos Konstantinos I.'s (2013) investigation on the impact of waste glass powder fineness on the properties of cement mortars. Values were comparable to the control mix in mixes with moderate amounts of substitution, such as Mix 2 with 5% glass powder and Mix 3 with 20% glass powder content. In their study on the strength and durability of recycled aggregate concrete with milled glass as a partial cement replacement, Nassar Roz-Ud-Din and Soroushian Parviz [2012] found that, in both low and high w/cm ratio mixes, the water absorption of concrete is significantly reduced.

A. SORPTIITY EVALUATION

Researchers Nassar Roz-Ud-Din and Soroushian Parviz found that recycled aggregate concretes had much less water sorption when some of the cement was replaced with milled waste glass [2012]. In their study, Oliveira L. A. Pereira de et al. [2008] found that using waste glass sand instead of natural sand decreased the concrete's sorptivity coefficient. With a 100% replacement of natural sand for 28 days and the same rate of waste glass for 63 days, the decrease reached 39% and 29%, respectively. The beneficial impact of waste glass sand gradings on particle packing, which in turn reduces the amount of capillary pores, is likely to have a role in this decrease.

CONCLUSIONS

Consistent with previous studies and our own experimental findings, glass has superior workability, strength parameters (such as compressive, flexural, and split tensile strengths), and durability (as determined by water absorption and sorptivity tests) compared to cement in concrete. Utilizing waste glass in concrete would not only offer an economic benefit, but it will also contribute to the alleviation of disposal issues, which are becoming increasingly pressing in today's world owing to the scarcity of landfill space and the ever-increasing disposal charges.

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