# Potential Use of Waste-Glass Powder in Concrete: State of the Art

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## Introduction

Effective substitution of building materials with cheaper and abundant substitute has been a favourite pursuit of decision makers and technologists to promote sustainability in construction field. Glass, being an abundant non-degradable waste material which requires low level technology is an ideal substitute for cement in construction industry. Similarity in chemical composition to cement makes the glass an alternative in the cementitious composites. Application of glass components in construction sector and commercial purpose has increased tremendously and in future it will be difficult to manage the non-degradable waste like glass from scrap generated from glass factories, from demolished building components and discarded bottles which cause considerable environmental pollution. Both environmental and economic advantages can be achieved by the utilisation of waste-glass in the construction industry.

Literature work pertaining towards the utilization of waste-glass as aggregate and as cement substitute in both mortar and concrete are reviewed in the present study. Related research revealed the successful transition of waste-glass usage from partial aggregate replacement to partial cement replacement in concrete. The synergistic effect of waste glass is observed in the creation of a green environment in the concrete construction sector with the proposed eco-cement. Partial substitution of cement by waste-glass powder (WGP) improves the mechanical and durability properties. The amorphous nature of glass powder causes it to fill the voids in concrete, thus making the material impermeable and more durable. The current scenario of applicability of waste-glass powder in cementitious composites and the gap area are identified in the study.

## Materials and Methods

From the overview of the previous studies on the use of *waste-glass as fine aggregate replacement*, several drawbacks like ASR expansion, decreased workability, higher bleeding and segregation was observed (Rashad 2014, Saccani and Bignozzi 2010, Park et al.2004, Naik et al.2000, Polley et al.1998). Damaging expansion due to ASR is observed when *recycled glass is substituted as coarse aggregate* (Srivastava et al.2014, Topcu and Canbaz 2004, Johnston 1974, Kou and Poon 2009, Meyer et al.1996) as well. The study revealed that mechanical properties of cementitious composites were enhanced slightly than that of conventional concrete. It is observed that the challenges due to *ASR expansion* have been overcome in the review of literature pertaining to incorporating *waste-glass into concrete as supplementary cementing material* (Federico and Chidiac 2009, Kumarappan 2013, Ashutosh and Sangamnerkar 2015, Sombir 2017, Philips et al.1972). Decrease in particle size leads to a pessimum effect in ASR expansion as well as an increase in compressive strength. The presence of milled waste-glass powder (WGP) suppresses the ASR related expansion and results in enhanced durability characteristics (Nassar and Soroushian 2012, Ahmad 2002, Dyer and Dhir 2001, Shao et al. 2000, Meyer et al.1996). Increased compressive strength and improved durability is observed with cement replacement ratio upto 45% and 60% respectively (Du and Tan 2015, Kamali and Ghahremaninezhad 2015, Schwarz et al. 2008, Shi et al. 2004). Later studies (Du and Tan 2016) proved the presence of higher porosity in the mixes with high volume WGP and concluded that better mechanical properties can be ensured with an optimum replacement of 30% WGP.

Concerned with *mortar study*, the influence of glass powder with cement replacement of 10% enhances the mortar compressive strength and setting time and soundness observed is similar to unblended Portland cement (Ali et al., 2016, Lu et al. 2017, Matos and Sousa 2012, Rajabipour et al.2010). The amorphous WGP is considered as a safe and healthy material to replace cement and quartz powder in

UHPC and the optimum replacement of cement with glass powder was 20% in terms of concrete compressive-strength development (Soliman and Hamou 2016, Siad et al 2016). Better performance in compressive and flexural strengths is obtained with the inclusion of WGP as a supplementary cementitious material with recycled aggregates and shows pozzolanic properties that increase with decrease in particle size (Letelier et al., 2016).

## Results and Concluding Remarks

A detailed review of prominent research on the use of WGP in concrete from the environmental point of view has been provided. Good agreement in results is obtained between the experimental values of waste-glass powder concrete (WGPC) with normal concrete.

Past studies revealed that, the consequences faced by glass wastes can be effectively managed by its application in concrete as an eco-cementitious material without affecting the structural integrity of concrete.The controlled production of cement and reduction in environmental contamination can be achieved by the application of WGPC, as a part of promoting green ecosystem. The social relevance of WGP lies in the mitigation of carbon emission by the partial substitution of cement in concrete and thus a measure to reduce environmental impact.

The present study concludes that crushed and reused concrete material can be effectively utilized for developing WGPC. Enhancement in mechanical and durability properties of WGPC was observed with an optimum of 30% substitution of WGP. Durability can be ensured from the past studies that WGPC has good resistance to acid/alkali attack.

According to the literature survey in the past decade, it can be concluded that the post- consumer glass in fine powdered form is a good pozzolan and exhibit competent mechanical and durability properties. Moreover, the generation of WGP neither produces any byproducts during the processing stage nor requires any sophisticated machineries and hence can be regarded as an eco-friendly material. For further consideration, an in-depth qualitative and quantitative analysis of WGPC is mandatory. The results drawn from the previous studies promote an effective foundation for future research.

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