Review Paper on Sustainable Use of Recycled Glass Powder as Cement Replacement in Concrete

Jay Prakash[1] Sunil Kumar[2] Komal Singh[3] Akansha Bodwal[4]
[1,2,3,4]Department of Civil Engineering
[1,2,3,4]Rajasthan Institute of Engineering and Technology, Jaipur, India

Abstract— Cement, a key ingredient in concrete, is very energy-intensive to produce and is responsible for about 85% of the total embodied energy of concrete. The idea of replacement of cement with glass powder of particle less than 75micrometer, is a good substitute for cement and could be utilized in concrete. Cement could also be partially replaced with glass powder in concrete. Cement was partially replaced with glass powder such as 10%,20%, and 30%, and several concrete cylinders were tested for compressive strength at the gap of 7,14 and 28 days and were compared with the plain concrete i.e., concrete with cement. The use of supplementary cementitious material (i.e.; glass powder) to offset a portion of cement in concrete is a promising method for reducing the environmental impact from the industry. Researches indicate that glass has a chemical composition and phase comparable to traditional cementitious material and also glass is abundant, can be of low economic value.

Keywords: Cement, Concrete, Glass Powder, Compressive Strength

I. INTRODUCTION

Glass is a part of everyday life for the vast majority and it is essentially a transparent frozen liquid and a combination of calcium carbonate (CaCO3), soda ash, and Silica that is liquefied at extreme temperature. Glass is infinitely recyclable with no loss of quality and value. This discarded glass can be utilized as part replacement either as aggregate or cement.

Concrete is used throughout the construction industry and is widely popular. It is made by the mixing of binding materials generally cement, fine aggregate, and coarse aggregate with water. Cement is the main constituent of concrete. But, the production of cement leads to the release of various greenhouse gases such as CO2. "However, the recycling of each tonne of glass saves over 1 tonne of natural resources and recycling of every 6 tonnes of container glass results in the reduction of 1 tonne of CO2 emission. "The logical occurrence of this study shows the presence of recycled glass powder in concrete could also escalate the plastic properties of concrete. The recycled glass powder was also found to repress the alkali-silica reaction (ASR) which leads to an increment in the durability of concrete. The use of recycled glass powder represents the development of a sustainable concrete-based infrastructure system. The recycled glass powder is milled to a micrometer scale to accelerate the reactions between glass and cement brings major energy, environmental benefits, and cost benefits when cement is partially replaced with powdered glass for the production of concrete. This paper introduces a sustainable way of using Recycled Glass Powder as a cement replacement in concrete. For the successful use of recycled glass in concrete for industrial applications, it is, therefore, important to characterize the physical and chemical properties of recycled glass collected by the local council. Furthermore, the effects of replacement levels of cement with recycled glass on the strength and durability properties of concrete need to be assessed as well.

II. METHODOLOGY

A study on the durability of concrete with glass powder pointed to better performance against chloride permeability in long term but there is concern about the alkali-silica reaction. Deleterious chemical constituents include sulfides, sulfates, and alkalis (which add more alkali to concrete) creates a higher risk of alkali-silica reaction over the life of the concrete. A good pozzolan function both to mitigate alkali Silica reaction and to consume the lime to greatly reduce the efflorescence.

The properties that influence the pozzolanic behavior of waste glass and most pozzolans in concrete are fineness, chemical composition, and the pore solution present for reaction. The pozzolanic properties of glass were first notable at particle sizes below approximately 300 micrometers, and below 100 micrometers, glass can have a pozzolanic reactivity at low cement replacement levels after 90 days of curing. This size can be achieved by using a grinding operation with the help of a ''Ball Mill" which is generally used in the cement industry to grind cement clinker. Several types of research show that at a higher age recycled glass concrete (15% to 20% of cement replaced) with milled waste glass powder provides compressive strengths exceeding those of control concrete.

III. RESULTS & DISCUSSION

Our review studies show that previous studies with glass addition were not best considering workability and strength while the chloride resistance of glass added concrete was found to be similar to the control conditions. This study examined the potential of waste glass powder to produce sustainable concrete. Experimental work was carried out on the performance of glass in concrete. Concrete samples were prepared to evaluate the flow and strength properties. Furthermore, the study discussed the packing and pozzolanic effect of glass by using a superplasticizer in selected mortar samples. In addition, the compressive strength of concrete cubes was also determined by crushing them and Fig.1 is showing the comparison of compressive strength of concrete with different percentages of glass powder. Using 10% of glass powder, the compressive strength at 7 days was nearly about of plain concrete but at 14 days and 28 days, the strengths were not much increased and were remained almost the same. Using 20% of glass powder, the compressive strength at 7 days and 14 days was much lower than of plain concrete but at 28 days, the strength was increased marginally and the compressive strength was more than that of plain concrete. Using 30% of glass powder, the compressive

strength at 7 days was much lower than that of plain concrete but at 14 days, the strength was nearly about of plain concrete, and at 28 days, the strength was 15% lower than plain concrete.

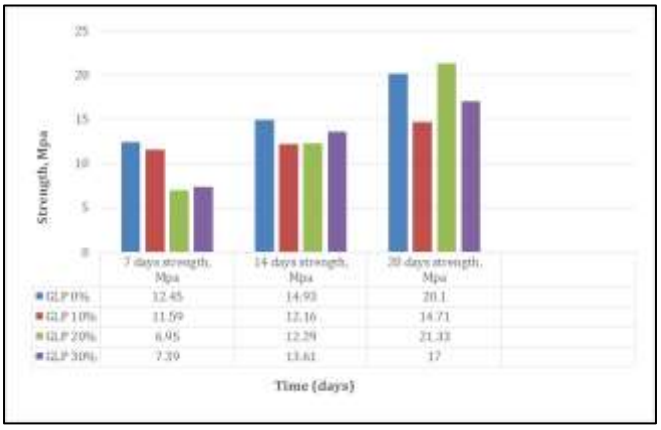

Fig. 1: Comparison of compressive strength in concrete

Fig.2 is showing the comparison of tensile strength of concrete with different percentages of recycled glass powder. Using 10% of glass powder, the tensile strength at 7 days and 14 days were nearly about of plain concrete but at 28 days, the tensile strength was slightly lower than that of plain concrete. Using 20% of glass powder, tensile strength at 7 days was slightly lower than that of plain concrete but at 14 days, the strength was increased marginally and the tensile strength was more than that of plain concrete. At 28 days, the tensile strength was slightly lower than that of plain concrete. Using 30% of glass powder, tensile strength at 7 days was much lower than that of plain concrete but at 14 days and 28 days, the strength was significantly increased and the strengths were more than plain concrete.

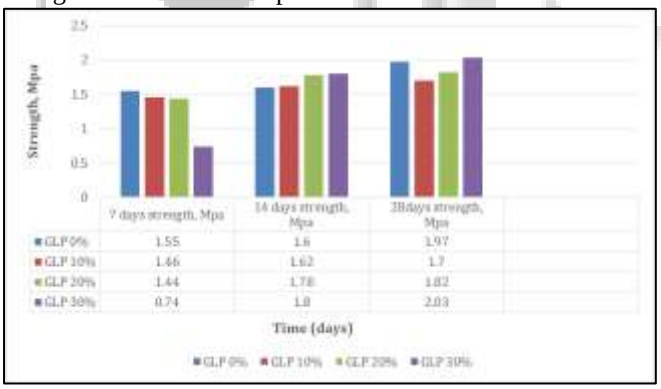

Fig. 2: Comparison of tensile strength in concrete

IV. Conclusion

Compared to plain concrete, the concrete with cement replaced by glass powder has shown better results for compressive strength when the percentages of glass powder were 20 but has shown improved results for split tensile strength for 30% glass powder. By changing or modifying the various parameters, it is possible to improve the performance of these materials, which plays an important role in eco-friendly construction.

The addition of recycled green building materials such as glass powder can increase the slump of concrete, but an excessive addition may result in surplus mixing water that could result in slight segregation that can reduce the overall strengths.

Furthermore, these concrete with glass powder utilizes the locally available materials for producing the binding material. So it can be considered as a sustainable material for green construction.

In general, considering the similar performance with replaced material glass addition can reduce significant cost of cement production and CO2 emission and save the environment by reducing greenhouse gases and particulate production.

Generally, the high surface area of milled waste glass changes the kinetics of chemical reaction toward beneficial pozzolanic reaction utilizing the available alkalis before production of a potential alkali Silica reaction gel. However, further research on durability and alkali Silica reaction aspects of glass replaced concrete is required to suggest this material for sustainable concrete practice.

V. Recommendation

1) Strength can be analyzed by partially supplanting cement and fine aggregate with waste glass powder and M-sand.
2) Utilization of waste glass powder finer than 75micron as fractional substitution with cement and analyzing strength.
3) Strength can be dissected by partially supplanting cement and fine aggregate by waste glass powder finer than 90micron and holding on 150 microns separately.

VI. Future scope

The recommendation on the use of glass powder for future studies is necessary to extend to a wider perspective to know the actual practice and effective utilization of glass powder which gives an idea to study more parameters and different conductive effects of glass powder on engineering properties of fresh and hardened concrete.

Hence future scope can be enhanced as follows:

1) To know the outcome of different types of glass powder on concrete strength.
2) Consequences of glass powder on high-strength concrete.
3) Consequences of glass powder on strength of concrete with various w/c ratios
4) Consequences of glass powder on strength of concrete with a combination of glass powder with different strengthening agents.
5) To know the exact reason behind the increment in the strength of concrete.
6) To know the effect of glass powder on bond strength between inter-materials and between materials and steel.

References

[1] K. Afshinnia, and P.R. Rangaraju, "Impact of combined use of groundglass powder and crushed glass aggregate on selected properties of Portland cement concrete",Constr. Build. Mater.,vol. 117, pp.263-272, 2016. [25] [http://dx.doi.org/10.1016/j.conbuildmat.2016.04.072]

[2] G.M.S. Islam, M.H. Rahman, and N. Kazi, "Waste glass powder as partial replacement of cement for sustainable concrete practice", Int J of Sustainable Built. Environ, vol. 6, no. 1, pp. 37-44, 2017. [http://dx.doi.org/10.1016/j.ijsbe.2016.10.005]
[3] M. Kamali, and A. Ghahremaninezhad, "Effect of glass powders on themechanical and durability properties of cementitious materials", Constr. Build. Mater., Vol. 98, pp. 407-416, 2015. [http://dx.doi.org/10.1016/j.conbuildmat.2015.06.010]
[4] N.A. Soliman, and A. Tagnit-Hamou, "Development of ultra-high- performanceconcrete using glass powder - Towards eco-friendly concrete", Constr. Build.Mater., vol.125,pp. 600-612, 2016.[http://dx.doi.org/10.1016/j.conbuildmat.2016.08.073]
[5] A. Rahma, N. El Naber, and S. I. Ismail, "Effect of glass powder on thecompression strength and the workability of concrete"C, agent Eng, vol. 4, no.1,2017.
[6] A. Arulrajah, "Kua, Teck-Ang, Horpibulsuk, Suksun, Mirzababaei,Mehdi, and Chinkulkijniwat, Avirut, Recycled glass as a supplementary fillermaterial in spent coffee grounds geopolymers",Constr. Build. Mater., vol.151, pp. 18-27, 2017.[http://dx.doi.org/10.1016/j.conbuildmat.2017.06.050]
[7] A. Scmidt, and W.H.F. Saia, "Alkali-aggregate reaction tests on glassused for exposed aggregate wall apnel work", J. Am. Concr. Inst., vol.60, pp. 1235-1236, 1963.
[8] C.D. Johnston, "Waste glass of coarse aggregate for concrete", J. Test.Eval., vol. 2, no.5,pp. 344-350, 1974.[http://dx.doi.org/10.1520/JTE10117J]
[9] İ.B. Topçu, and M. Canbaz, "Properties of concrete containing waste glass", Cement Concr.Res.,vol.34,no.2,pp.267-274,2004.[http://dx.doi.org/10.1016/j.cemconres.2003.07.003]
[10] M.J. Terro, "Properties of concrete made with recycled crushed glass atelevated temperatures", Build. Environ.,vol. 41, no. 5,pp.633-639, 2006.[http://dx.doi.org/10.1016/j.buildenv.2005.02.018]

