ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2014

Utilisation of Waste Glass Powder in Concrete – A Literature Review

Bhupendra Singh Shekhawat[1], Dr. Vanita Aggarwal[2]

M.Tech Final Year Student, Department of Civil Engineering, MMEC, MMU, Mullana Ambala, Haryana, India[1]

Professor, Department of Civil Engineering, MMEC, MMU, Mullana Ambala, Haryana, India[2]

ABSTRACT: Concrete is one of the most widely used construction materials in the world. However, the production of portland cement, an essential constituent of concrete, leads to the release of significant amount of CO2, a greenhouse gas; one ton of portland cement clinker production is said to creates approximately one ton of CO2 and other greenhouse gases (GHGs). Environmental issues are playing an important role in the sustainable development of the cement and concrete industry **[Naik and Moriconi, 2005]** .There is a need to replace a part of cement by some pozzolanic material to reduce the consumption of cement and the environmental pollution can be checked to some extent. Some of the industrial wastes like fly ash, silica fume, blast furnace slag etc have already established their usage in concrete. Recently the research has shown that the waste glass can be effectively used in concrete either as glass aggregate or as a glass pozzolana. Waste glass when grounded to a very fine powder shows some pozzolanic properties because of silica content. Therefore the glass powder to some extent can replace the cement and contributes for the strength development and also enhances durability characteristics **[Chikhalikar S.M. and Tande S.N., 2012]**. Demand for recycled glass has considerably decreased in recent years, particularly for mixed-glass. Glass is cheaper to store than to recycle, as conditioners require expenses for the recycling process. There are several alternatives for the reuse of composite-glass. According to previous studies, all these applications, which require pre-conditioning and crushing, are more or less limited and unable to absorb all the quantities of waste glass available. In order to provide a sustainable solution to glass storage, a potential and incentive way would be to reuse this type of glass in concrete **[Idir R, 2009]**.This paper present literature review on replacement of cement by waste glass powder which includes current and future trends of research on the use of crushed glass powder in Portland cement concrete**.**

KEYWORDS: Concrete, Cement Replacement, Waste Glass Powder

I. INTRODUCTION

Manufacturing processes, service industries and municipal solid wastes are the sources of production of numerous waste materials. Concerns related with disposal of the generated wastes have tremendously increased with the increasing awareness about the environment. Solid waste management is one of the major environmental concerns in the world. Waste utilization has become an attractive alternative to disposal because of the scarcity of space for land filling and due to its ever increasing cost. The use of waste products in concrete not only makes it economical, but also helps in reducing disposal problems. Reuse of bulky wastes is considered the best environmental alternative for solving the problem of disposal. One such waste is plastic, which could be used in various applications. According to the World Commission on Environment and Development: sustainability means "Meeting the needs of the present without compromising the ability of the future generations to meet their own needs". Sustainability is an idea for concern for the well being of our planet with continued growth and human development [McDonough 1992]. For example, if we run out of limestone, as it is predicted to happen in some places, then we cannot produce portland cement and, therefore, we cannot produce concrete; and, all the employers associated with the concrete industry go out-of-business, along with their employees **[Naik and Moriconi, 2005]**.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2014

II. 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.

III. EFFECT OF USING GLASS POWDER IN CONCRETE

A. SLUMP TEST

Vasudevan Gunalaan and Kanapathy pillay Seri Ganis [2013] studied slump property in his research and resulted that compared to control mix, by using waste glass powder will give another benefit which is the workability of concrete which is much higher. **R.Vandhiyan et al[2013]** investigated that the workability was reduced due to the replacement and it reduced with increase in replacement, this is due to the increase in the surface area of the glass powder and also the angular shape of the glass particles. **Kumarappan N. [2013]** presented that there is a systematic increases in the slump as the glass powder in the mix increases. The slump ranged from around 40mm for the reference mix (i.e. 0% glass powder) to 160mm at 40% glass powder. **Khatib J.M. et al [2012]** in his study showed that there was a systematic increase in the slump as the glass powder content in the mix increases. **Jangid Jitendra B. and Saoji A.C. [2012]** resulted that the workability decreases as the percentage glass powder in the mix increases. **. Chikhalikar S.M. and Tande S.N. [2012]** studied the properties of SFRC (Steel Fibre Reinforced Concrete) containing waste glass as pozzolona and concluded that the 20% replacement of cement by waste glass powder gives better workability to SFRC. **Nassar Roz-Ud-Din and Soroushian Parviz [2012]** utilized milled waste glass in his experimentation and resulted that slump is observed to slightly increase with the introduction of milled waste glass. This could be attributed to the low water absorption of glass. The slump of recycled aggregate concrete mixes (at both levels of w/cm ratio) is higher than that of corresponding control mixes.

B. COMPRESSIVE STRENGTH

Many works have been done to explore the benefits of using waste glass powder in making and enhancing the properties of concrete. **Vasudevan Gunalaan and Kanapathy pillay Seri Ganis [2013]** investigated the test results at 7, 14, 28 days of curing of specimens containing waste glass powder as partial replacement of cement and his results showed that the 20% glass powder mix amount shows a positive value of compressive strength at 28 days compare to other ratio which 10% and 15% is not achievable even though have slight increment from 14 days results. **Vandhiyan R. et al[2013]** studied the replacement of cement by waste glass powder and concluded that the considerable increase in the early strength gain particularly at Specimen 15% GP gave a 29% increase in the strength at 7th day more than control specimen. At 28th day this difference in strength reduces to 23 %. The strength increment is optimal at 10% replacement**. Kumarappan N. [2013]** partially replaced cement by glass powder and stated that upto 10% it is feasible to replace cement as it showed higher compressive strength than the control mix. **Vijayakumar G. et al[2013]** proposed that cement replaced upto 40% by glass powder showed increment in compressive strength at both 28 days and 60 days age of curing as compared to conventional concrete**. Nwaubani Sunny O. and Poutos Konstantinos I. [2013]** concluded that increasing the amount of glass in mortar causes a general decrease of compressive strength, but the decrease becomes less evident with prolonged curing time. The particle size distribution of waste glass used was the key factor influencing the strength development. **Khatib J.M. et al[2012]** studied the performance of concrete as partial replacement of cement and concluded that the maximum compressive strength occurs at around 10% glass powder and beyond 10% it tends to decrease and is lower than that of control. **Patel Dhirendra et al [2012]** investigated the strength characteristics of pre cast blocks incorporating waste glass powder and studied that the

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2014

moderate level decrease in the compressive strength at 28 days occurs. **Jangid Jitendra B. and Saoji A.C. [2012]** concluded that the upto 40% replacement of cement, compressive strength increase upto 20% and cement replaced beyond which decreases compressive strength. **Chikhalikar S.M. and Tande S.N. [2012]** investigated on the characteristics properties of fibre reinforced concrete containing waste glass as pozzolona and showed that the compressive strength increase is achieved upto 30% as compared to control mix, but the peak % increase is at 20% replacement**. Dali J.S. and Tande S.N. [2012]** studied the properties of concrete containing mineral admixtures, when it is subjected to alternative wetting and drying and high temperature and resulted that the compressive strength increment is upto 25% replacement of cement by waste glass powder, but the peak % increment is at 20% replacement in both the cases, i.e. concrete without subjecting to alternate wetting and drying, and concrete subjected to alternate wetting and drying**. Patel Dhirendra et al [2012]** studied the properties of cement sand mortar paste containing fine and coarse glass powder as partial replacement of cement and results showed that 15% dosage for replacement is optimal. **Khmiri A. et al[2012]** proposed his experimental work containing clear and coloured glass of different sizes (100 and 80 μm, 80 and 40 μm and lower than 40 μm) and came to a result that compressive strength index of ground waste glass reaches more than 82% for sizes lower than 40 μm. **Patil Dhanraj Mohan and Sangle Kehav K. [2012]** studied the test results of waste glass powder particles ranging from size 150μm to 90μm and less than 90μm. He showed that initial strength gain is very less due to addition of GLP on 7th day but it increases on the 28th day. It is found that 20% addition of GLP gives higher strength. And also GLP size less than 90 micron is very effective in enhancement of strength**. Bajad M.N. et al [2011]** studied the strength properties containing glass when subjected to sulphate attack and showed that the peak compressive strength is achieved at 20% replacement of cement by waste glass powder both when concrete is not subjected to sulphate attack and when concrete subjected to sulphate attack and the increment continues upto 25% replacement beyond which it decreases. **Gopalakrishnan Ramasamy and Govindaraja Dharshnamoorthy [2011]** carried out tests on waste glass admixture cement and resulted that the compressive strength result is a confirmation of retarding effect of WG in the hydration of Portland cement. **Wang Her-Yung and Hou Tsung-Chin [2011]** carried out their study of Elevated Temperatures on the Strength Properties of LCD Glass Powder Cement Mortars and concluded that substituting 10% of cement by glass powder would gain a very promising compressive strength of the mortars, particularly when the added glass has a powder fineness ≥ 4500 cm2/g. In real practices, this amount of glass powder substituent could be suggestively used to replace cement. **Oliveira L.A Pereira de et al [2010]** study focused on the assessment of the pozzolanic activity of green, amber and flint color waste glass of different particle sizes(75μm – 150μm,45μm – 75μm and < 4μm) as a component of cementitious materials used as filler or binder in mortar and concrete. He concluded that 30% of 45 - 75 μm ground waste glasses size range could be incorporated as cement replacement in mortar or concrete without any detrimental effects caused by the expansivity provoked by the alkali silica reaction**. Shayan Ahmad [2002]** concluded that 30% GLP could be incorporated as cement or aggregate replacement in concrete without any long-term detrimental effects. Up to 50% of both fine and coarse aggregate could also be replaced in concrete of 32 MPa strength grade with acceptable strength development properties.

C. FLEXURAL STRENGTH

Vandhiyan R. et al [2013] experimented on replacement of cement by waste glass powder and concluded that a considerable improvement in the flexural strength was seen at 10% replacement of cement**. Vijayakumar. G et al [2013]** showed that flexural strength increment is achieved upto 40% replacement of cement by waste glass powder. **Jangid Jitendra B. and Saoji A.C. [2012]** in their work proposed that flexural strength increases upto 35% replacement of cement by waste glass powder as compared to control mix and the peak % increment is at 20%, beyond which it decreases. **Chikhalikar S.M. and.Tande S.N. [2012]** tested flexural strength parameter in his study and resulted that 20% dosage of waste glass powder is optimal for replacing cement**. Dali J.S. and Tande S.N. [2012]** studied the properties of concrete containing mineral admixtures, when it is subjected to alternative wetting and drying and high temperatures and showed that 20% replacement gives higher strength in both the cases when concrete not subjected to alternative wetting and drying, and when concrete subjected to alternative wetting and drying. **Bajad M.N. et al [2011]** experimentally showed that 20% replacement by waste glass powder is optimal both in the case of concrete subjected to sulphate attack and when not subjected to sulphate attack.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2014

D. SPLIT TENSILE STRENGTH

Vijayakumar G. et al [2013] studied that the glass powder concrete increases the tensile strength effectively when compared with conventional concrete. **Vandhiyan R. et al [2013]** showed that there was a marginal improvement in the tensile strength. **Chikhalikar S.M. and Tande S.N. [2012]** in their study on Steel Fibre Reinforced Concrete (SFRC) presented that the tensile strength attains a peak value at 20% replacement of cement by waste glass powder. **Dali J.S. and Tande S.N. [2012]** performed tests on concrete containing mineral admixtures at high temperatures and concluded that 20% replacement level is optimal when concrete is not subjected to alternative wetting and drying and also when concrete subjected to alternative wetting and drying.

E. WATER ABSORPTION TEST

Malik M. Iqbal et al [2013] in their study of concrete involving use of Waste Glass as Partial Replacement of Fine Aggregates carried out this test and resulted that the percentage water absorption decreased with increase in waste glass content. The lowest value of water absorption was found for concrete mix with 40% waste glass content. **Nwaubani Sunny O. and Poutos Konstantinos I. [2013]** in their research on the influence of Waste Glass Powder Fineness on the Properties of Cement Mortars presented that Water absorption increased with increased glass powder content. Moderate substitution levels such as Mix 2 with 5% of glass powder and Mix 3 with 20% of glass powder content achieved similar values to that of control mix. **Nassar Roz-Ud-Din and Soroushian Parviz [2012]** in their experimentation on strength and durability of recycled aggregate concrete containing milled glass as partial replacement for cement concluded that water absorption of concrete is observed to be significantly reduced with introduction of milled waste glass as partial replacement for cement in both low and high w/cm ratio mixes.

F. SORPTIVITY TEST

Nassar Roz-Ud-Din and Soroushian Parviz [2012] in their study resulted that the partial replacement of cement with milled waste glass results in significant reduction of water sorption of the concretes produced with recycled aggregates**.** **Oliveira L. A. Pereira de et al [2008]** replaced natural sand by glass powder and observed that the sand replacement by the waste glass sand reduced the concrete sorptivity coefficient. The reduction attaint a maximum of 39% for 28 days with 100% of natural sand replacement and 29% of reduction at 63 days for the same waste glass rate. This reduction can be influenced by the favourable effect of waste glass sand gradings that improve the particles packing almost certainly reducing the quantity of capillary pores.

IV. CONCLUSIONS

From the above mentioned work of various researchers and our present experimental work, it is clear that glass can be used as a partial replacement of cement in concrete because of its increased workability, strength parameters like compressive strength, flexural strength and split tensile strength and also because of its increased durability measured by water absorption test and sorptivity test. As disposal of waste by-products problem is a major problem in today's world due to limited landfill space as well as its escalating prices for disposal, utilization of waste glass in concrete will not only provide economy, it will also help in reducing disposal problems.

REFERENCES

1. Khatib J.M., Sohl H.S., H.S. Sohl and Chileshe N. (2012) "Glass Powder Utilisation in Concrete Production" European Journal of Applied Sciences 4 (4): 173-176, 2012 ISSN 2079-2077 © IDOSI Publications,
2. Patel Dhirendra, Yadav R.K. and Chandak R (2012) "Strength Characteristics of Pre Cast Concrete Blocks Incorporating Waste Glass Powder" ISCA Journal of Engineering Sciences Vol. 1(1)July, [International Science Congress Association]
3. Jangid Jitendra B. and Saoji A.C. (2014) "Experimental investigation of waste glass powder as the partial replacement of cement in concrete production" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X [International Conference on Advances in Engineering and Technology –(ICAET-2014)]
4. Idir R., Cyr M., and Tagnit-Hamou A. (2009) "Use of Waste Glass as Powder and Aggregate in Cement-Based Materials" SBEIDCO – 1st International Conference on Sustainable Built Environement Infrastructures in Developing Countries ENSET Oran (Algeria) -

5. Chikhalikar S.M. and Tande S.N. (2012) "An Experimental Investigation On Characteristics Properties of Fibre Reinforced Concrete Containing Waste Glass Powder as Pozzolona" 37th Conference on Our World in Concrete and Structures, Singapore, August.
6. Dali J.S. and Tande S.N. (2012) "Performance of Concrete Containing Mineral Admixtures Subjected to High Temperature" 37th Conference on Our World in Concrete and Structures, Singapore, August.
7. Shayan Ahmad (2002) "Value-added Utilisation of Waste Glass in Concrete" IABSE Symposium Melbourne.
8. Bajad M.N. ,Modhera C.D.and Desai A.k.(2011) "Effect of Glass on Strength of Concrete Subjected to Sulphate Attack" International Journal of Civil Engineering Research and Development (IJCERD), ISSN 2228-9428(Print) ISSN 2248 – 9436(Online), Volume 1, Number 2.
9. Malik M. Iqbal, Bashir Muzafar, Ahmad Sajad, Tariq Tabish, and Chowdhary Umar (2013) "Study of Concrete Involving Use of Waste Glass as Partial Replacement of Fine Aggregates" IOSR Journal of Engineering (IOSRJEN) e-ISSN: 2250-3021, p-ISSN: 2278-8719 Vol. 3, Issue 7 (July).
10. Nwaubani Sunny O. and Poutos Konstantinos I.(2013) "The Influence of Waste Glass Powder Fineness on the Properties of Cement Mortars" International Journal of Application or Innovation in Engineering and Management (IJAIEM) Volume 2, Issue 2, ISSN 2319 – 4847.
11. Vandhiyan R., Ramkumar K. and Ramya R.(2013)"Experimental Study On Replacement Of Cement By Glass Powder" International Journal of Engineering Research and Technology (IJERT) Vol. 2 Issue 5, May, ISSN: 2278-0181
12. Kumarappan N.(2013) "Partial Replacement Cement in Concrete Using Waste Glass" International Journal of Engineering Research and Technology (IJERT) Vol. 2 Issue 10, ISSN: 2278-0181.
13. Patel Dhirendra, Yadav R.K. and Chandak R.(2012)"Strength Characteristics of Cement Mortar Paste Containing Coarse and Fine Waste Glass Powder" International Journal of Engineering Sciences Research-IJESR Vol 03, Issue 02; ISSN: 2230-8504; e-ISSN-2230-8512,
14. Vijayakumar G., Vishaliny H. and Govindarajulu D. (2013) "Studies on Glass Powder as Partial Replacement of Cement in Concrete Production" International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 2, February)
15. Khmiri A., Samet B. and Chaabouni M. (2012)"Assessment of the Waste Glass Powder Pozzolanic Activity by Different Methods" IJRRAS 10 (2) ● February
16. Osmani M. and Pappu A. (2012) "Utilisation of Glass Reinforced Plastic Waste in Concrete and Cement Composites" Proceedings of Second International Conference on Sustainable Construction Materi als and Technologies, Ancona Italy
17. T.R. Naik and G. Moriconi (2005) "Environmental-friendly durable concrete made with recycled materials for sustainable concrete construction" CANMET/ACI International Symposium on Sustainable Development of Cement and Concrete, Toronto, Canada, October.
18. Gopalakrishnan Ramasamy and Govindarajan Dharshnamoorthy (2011) "Compressive Strength and Electron Paramagnetic Resonance Studies on Waste Glass Admixtured Cement" New Journal of Glass and Ceramics, 2011, Published Online October
19. Patil Dhanraj Mohan and Dr.Sangle Keshav K (2013) "Experimental Investigation of Waste Glass Powder as Partial Replacement of Cement in Concrete". International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 –5721, Volume-2, Issue-1, 2013.
20. Vasudevan Gunalaan and Pillay Seri Ganis Kanapathy "Performance of Using Waste Glass Powder In Concrete As Replacement Of Cement" American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-02, Issue-12
21. Roz-Ud-Din and Nassar, Parviz Soroushian (2012) "Strength and durability of recycled aggregate concrete containing milled glass as partial replacement for cement" Construction and Building Materials 29.
22. Oliveira L.A Pereira de, Gomes J.P. and Castro Santos P. (2008) "Mechanical and Durability Properties of Concrete with Ground Waste Glass Sand" DBMC International Conference on Durability of Building Materials and Components ISTANBUL, Turkey 11-14 May.
23. Oliveira L.A Pereira de, Gomes J.P. and Castro Santos P. (2010) "Optimization of pozzolanic reaction of ground waste glass incorporated in cement mortars" "Fundação para Ciência e Tecnologia" POCI/ECM/55588/2004.
24. Wang Her-Yung and Hou Tsung-Chin Hou (2011) "A Study of Elevated Temperatures on the Strength Properties of LCD Glass Powder Cement Mortars" Integrated Waste Management - Volume IISBN:978-953-307-469-6.