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Effect of Waste Glass Powder on Properties of Concrete: A Literature Review

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ABSTRACT:- Concrete is the mixture of various materials coarse aggregate, fine aggregate, cement & water, each of them is mixed in various proportions to achieve specific strength. Cement being the most important material plays an important role in the manufacturing of concrete. The manufacturing process of cement produces a large amount Co_2 gas which is a greenhouse gas. Just like other waste products like fly ash, Silica fume etc. glass powder is also used as a partial replacement of cement. Waste glass in the form of fine aggregate or as alternative cement can be used. Researchers has investigated that glass posses a pozzolana properties due to increase in silica content, so it can be replace cement to some degree and can improve the strength and also increase the durability of concrete. According to various studies, the waste glass from door & window can be grounded fine and can be reused. The reuse of waste glass in the production of concrete can reduce the disposal problem and it can decrease the cost of concrete. This paper is a literature review, which include present & future studies on using grounded glass powder in Portland cement and in combination with other waste product.

Keywords: concrete, waste glass powder, partial replacement of cement, disposal problem

1. Introduction

Due to various factories and industries large volume of waste produced daily .The disposal of the waste generated from industries has become serious issue solid waste management is one of the major environmental concerns in the world **[Bhupendra Singh &Dr.vanita, 2014].** The recycling and reuse of the waste has become the best alternatives as their disposal problem of waste .The reuse of such waste will reduce the environment impact and is more economical the energy required to reuse the recyclable material is less than that of virgin materials **[J.M. Khatib et al, 2012].** The utilization of these waste products in construction industry is best option due to large number of construction site all over the world. 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."

Concrete is the second largest of widely used material; but there are environmental issues related with its use which are needed to be taken under considerations and cannot be ignored **[AshutoshSharma&AshutoshSangamnerkar, 2015].** One tone of Co_2 is released into the atmosphere for the production of one tone of cement, which is approximately 7% of the world's total yearly production of Co_2**[AshutoshSharma&AshutoshSangamnerkar, 2015].**

2. History

Due to use of glass products and their growing needs over the year quantity of waste glass has been increased. At the same tie today's annual global cement production has reached 2.8 billion ton per year**[R. Vandhiyan et al , 2013]** . The cement industry is facing various problems like reduce the emission co2, increase cost energy supply and requirement of natural non-renewable raw materials so attempts has been made to use recycle glass powder in Portland cement and concrete. The uses of waste glass in place of cement will reduce the usage of cement the emission of c o_2 and other greenhouse gases; emitted in the manufacturing of cement.

Glass is an amorphous material with high silica content(SiO_2) i.e.72%wate glass when grounded to very fine powder (600 micron) reacts with alkali in cement (Pozzolana reaction) &cementations product that help to contribute to the strength development **[VeenaV. Bhat, N.BhavanishankarRao, 2014]**.when glass powder is added as a pozzolana ,it provides a large volume of hydration products & uniform distribution. The added glass provider in concrete changes the cement paste structure. The resulting paste contains more of the strong calcium silicate hydrate(C-S-H) & less of the weak & easily hydroxides $(CaOH)_2$ than ordinary cement paste **[R. Vadhiyan et al ,2013] .** The micro filler effect of glass powder will reduce the permeability of concrete and impact the better paste to aggregate bond of concrete as compared to normal conventional concrete.

3. Effects of Using Glass Powder

a) Slump Test

Bajad M.N. et al [2011] studied that as we replace the cement by glass powder the workability of concrete decreases. The reduction is due to decrease in fineness modules of cementation material, which utility reduce the quality cement paste required for providing easiness per unit surface area of aggregate. **Vandhiyan R. et al [2013]** in their research presented that the workability reduces as we replace glass powder by cement. This reduction in workability is due to the shape of particles of glass powder which is angular & also due to increase surface area of waste glass powder. According to **Kumarappan N. [2013]** slump value or workability of concrete mix with varying amount of glass powder is a replacement of cement there is a systematic mix. In his test, the range of slump various 40mm

for the normal mix to 160mm at 40% waste glass powder. **Vasudevan Gunalaan & KanapathyPillay Seri Ganis [2013]**in their research showed that as compared to normal mix, if there is increase in perchance of waste glass powder as a partial replacement workability of concrete also increases**.**Above observations are summarized in following Table 1.

Table 1: Slump Value of Concrete Mix

S.No.	*% of Glass Powder*	*Author*	*Slump Value (MM)*
1.	40%	Bajad M.N. et al [2011]	66
2.	40%	Kumarappan N. [2013]	160
3.	40%	ShilpaRaju, Dr. P.R.Kumar [2014]	67
4.	20%	VasudevanGunalaan&Kanapathy pillayseriganis [2013]	70

b) Compressive Strength

Bajad M.N. et al[2011] investigated the strength of concrete containing glass powder when subjected to Sulphate attack and results concluded that highest compressive strength isachieved with 20% of replacement of cement in both the conditions and the strength decreaseswith increases in percentage beyond 20%.**Chikhalikar S.M. and Tande S.N. [2012]** studied the effect of glass powder on fiber reinforced concrete when added as a partial replacement of cement and showed that there is 30% increment in the compressive strength as compared to control mix.**Dali J.S. and Tande S.N. [2012]** concluded that the compressive strength of concrete increases at 20 % replacement of cement by glass powder either subjected to alternative wetting and drying or not.**Khatib J.M. et al [2012]** studied the utilization of glass powder in concrete production. In their research at water cement ratio 0.5 and at a replacement of cement with 10%, 20%,30%and 40% the highest compressive strength is achieved at 10% replacement and beyond 10% partial replacement it decrees & is less than the control mix.**Dhanraj Mohan Patil and Dr. KeshavK.Sangle [2013]**studied that if the size of glass powder decreases the compressive strength of concrete increases. The results concluded that particle size ranges from 90 micron gives higher compressive strength than particle size ranges from 90 to 150 micron. He also concluded that initially the increment in compressive strength is less at 7th day but it meets the required strength at 28thday. The results showed that at 20% replacement of cement by waste glass powder meets the maximum strength compare to conventional concrete**.Vijaykumar G. et al [2013]** concluded that when cement is replaced by 40% of waste glass powder, the compressive strength at 28th&60thday of curing is increased by 33.7% compared to conventional concrete.**Vandhiyan R. et al [2013]**investigated the replacement ofcement by glass powder and the result showed there is increase in the early strength at 7th days particularly at 15% glass powder gave a 29% increase in strength that of control mix of cement mortar reduces to 23% at 28 days.**Kumarappan N. [2013]**investigated that when the cement is partially replaced by 10% of glass powder the compressive strength is more as compared to control mix.**Vasudeuan Gunalaon & KanapathyPillaySeri Ganis [2013]**in their research has investigated the strength of concrete with partial replacement of cement by glass powder at 7th,14th& 28th days of specimen & the results obtained showed that at 20% glass powder mix the compressive strength of concrete mix is more than that of control mix at 28th day for the grade of 30.**ShilpaRaju and Dr.P.R.Kumar,[2014]** investigate that the compressive strength of concrete increases as the percentage of glass powderisincreasedupto 20%. The strength decreased when the percentage of glass powder is increased beyond 20%.**VeenaV.Bhat and N.BhavanishankarRao [2014]** studied the compressive strength whenglass powder replaces the cement for constant water content & for constant water cement ratio. The results showed that compressive strength decreases when water content is kept constant while the compressive strength increases at 20% replacement of cement by glass powder and is about 27% more than compared to conventional concrete mix.**JangidJitendra B.&Saoji A.C.[2014]** studies that highest strengthcan be achieved at 20% replacement of cement by glass powder.The increase in compressive strength is about 30% compared to control mix.**Ashutosh Sharma and AshutoshSangamnerkar [2015]**proposed that partial replacement of cement by 10% of glass powder will increase the compressive strength by 52.6% in 3 days.**T. Bhagyasri et al [2016]** in their research has investigated the strength of concrete at 7th& 28th days of curing specimen for M2o grade with varying percentage of glass powder such as 10%,20% and 40%. The results concluded that at 20% partial replacement the maximum compressive strength is achieved.Above observations are summarized in following Table from Table 2.1 to 2.4

Table 2.1: Compressive Strength at 3th Day

S. No.	*% Of GLP*	*Author*	*Compressive Strength (MPA)*	*Remark*
1.	10%	Ashutosh Sharma and AshutoshSangamnerkar [2015]	12.643	Glass powder particle size 600-100 micron

Table 2.2: Compressive Strength at 7th Day

S. NO.	*% of GLP*	*Author*	*Compressive Strength (MPa)*	*Remarks*
1.	20%	Bajad M.N. et al [2011]	27.30	Without sulphate attack
			26.5	With sulphate attack
2.	20%	Dhanraj Mohan Patil and Dr. KeshavK.Sangle [2013]	19.28	GLP particle size less than 90 micron
			18.49	GLP particle size 90 - 150 micron
3.	10%	Vandhiyan R. et al [2013]	30.30	-
4.	20%	VasudeuanGunalaon&KanapathyPillay Seri ganis [2013]	20	-
5.	20%	ShilpaRaju and Dr. P.R. Kumar,[2014]	27.30	-
6.	20%	VeenaV.Bhat and N. BhavanishankarRao [2014]	29.92	At constant water cement ratio
7.	20%	Raghvendra K and Virendra kumara K. N.	36.51	Mix design- 20% GLP + 40% Industrial Waste

		[2015]		
8.	20%	Bhagyasri T. et al [2016]	28.13	-
6.	20%	VeenaV.Bhat and N. BhavanishankarRao [2014]	29.92	At constant water cement ratio
7.	20%	Raghvendra K and Virendra kumara K. N. [2015]	36.51	Mix design- 20% GLP + 40% Industrial Waste
8.	20%	Bhagyasri T. et al [2016]	28.13	-

Table 2.3: Compressive Strength at 14th Day

S. No.	*% of GLP*	*Author*	*Compressive Strength (MPa)*	*Remarks*
1.	10%	Vandhiyan R. et al [2013]	33.03	-
2.	20%	VasudeuanGunalaon&KanapathyPillay Seri Ganis [2013]	29	-
3.	20%	Raghvendra K and Virendra kumara K. N. [2015]	50.55	Mix design- 20% GLP + 40% Industrial Waste

Table 2.4: Compressive Strength at 28th Day

S. No	% of GLP	Author	Compressive Strength (MPa)	Remarks
1.	10%	Khatib J.M. et al [2012]	33	-
2.	20%	Dhanraj Mohan Patil and Dr. Keshav K. Sangle [2013]	34.33	GLP particle size less than 90 micron
			32.77	GLP particle size 90 - 150 micron
3.	30%	Vijaykumar G. et al [2013]	41.96	-
4.	10%	Vandhiyan R. et al [2013]	36.18	-
5.	10%	Kumarappan N. [2013]	36	-
6.	20%	VasudeuanGunalaon&KanapathyPillay Seri Ganis [2013]	32	-
7.	20%	ShilpaRaju and Dr.P.R. Kumar,[2014]	33.50	-
8.	20%	VeenaV.Bhat and N. Bhavanishankar Rao [2014]	36.12	At constant water cement ratio
9.	20%	JangidJitendra B.&Saoji A.C.[2014]	33.42	-
10	20%	Raghvendra K and Virendra kumara K. N. [2015]	56.17	Mix design- 20% GLP + 40% Industrial Waste

c) Flexural Strength

Bajad M.N. et al [2011] through an experiment showed that 20% replacement by waste glass powder is perfect each within the case of concrete subjected to sulphate attack and once not subjected to sulphate attack. **Dali J.S. and Tande S.N. [2012]** investigated the various properties of concrete which contains mineral admixtures, once it's subjected to different wetting and drying and high temperatures and showed that 20% replacement of cement provides higher strength in each the cases once concrete not subjected to different wetting and drying, and once concrete subjected to different wetting and drying. **Chikhalikar S.M. and Tande S.N. [2012]** experimented flexural strength in his study and resulted that 20% dose of waste glass powder is perfect for replacement cement. **Vijayakumar G. et al [2013]** concluded that flexural strength is increased when 40% cement is replaced by waste glass powder. **Vandhiyan R. et al [2013]** investigated on replacement of cement by waste glass powder and ended that a substantial improvement within the flexural strength was seen at 10% replacement of cement. **ShilpaRaju, Dr. P.R.Kumar [2014] in** their research concluded that flexural strength will increase with increase in proportion of glass powder upto 20% replacement and on the far side of 20% strength will decrease.**JangidJitendra B. and Saoji A.C. [2014]** in their studies projected that flexural strength will increase when cement is replaced upto 35% of waste glass powder as compared normal mix and also the highest increment is at 20%, on the far side that it decreases.**Bhagyasri T. et al [2016]** concluded that flexural strength at the age of 7th day and 28th day is highest when cement is replaced by 20% glass powder. Above observations are summarized in table from Table 3.1 to 3.2

Table 3.1: Flexural Strength at 7th Day

S.NO.	*% of GLP*	*Author*	*Flexural Strength (N/mm^2)*	*Remarks*
1.	20%	Bajad M.N. et al[2011]	3.05	-
2.	20%	ShilpaRaju and Dr.P.R. Kumar , [2014]	3.05	-
3.	20%	Bhagyasri T. et al [2016]	3.35	-

Table 3.1: Flexural Strength at 28th Day

S. No.	*% of GLP*	*Author*	*Flexural Strength (N/mm^2)*	*Remarks*
1.	20%	Bajad M.N. et al[2011]	4.17	-
2.	10%	Vijayakumar G. et al [2013]	6.5	-
3.	10%	Vandhiyan R. et al [2013]	4.8	-
4	20%	ShilpaRaju and Dr.P.R. Kumar, [2014]	4.17	-
5.	20%	JangidJitendra B. and Saoji A.C. [2014]	3.98	-
6.	20%	Bhagyasri T. et al [2016]	8.45	-

d) Split Tensile Strength

Dali J.S. and Tande S.N. [2012] in their research on concrete containing mineral admixtures at high temperatures resulted that 20% replacement is perfect once concrete isn't subjected to various wetting and drying and as well once concrete subjected to various wetting and drying. **Vijayakumar G. et al [2013]** investigated that the glass powder in concrete will increase the tensile strength effectively in comparison with standard concrete.**Vandhiyan R. et al [2013]** presented that there was a minimal improvement within the tensile strength.**Raghvendra K and Virendra kumara K. N. [2015]** in their research concluded that when cement is

replaced by 20% waste glass powder and 40% industrial waste that is foundry sand the split tensile strength is more as compared to conventional concrete.Above observations are summarized in Table 4.

Table 4: Tensile Strength

S. No	% of GLP	Author	Tensile Strength (N/mm^2)	Remarks
1.	20%	Dali J.S. and Tande S.N. [2012	5.25	Not subjected to alternate wetting and drying after 60th day
			4.66	subjected to alternate wetting and drying after 60th day
2.	40%	Vijayakumar G. et al [2013]	3.55	At 28th day
3.	20%	Vandhiyan R. et al [2013]	3.11	At 28th day
4.	20%	Raghvendra K and Virendra kumara K. N. [2015]	3.73	At 7th day for mix-20%GLP + 40% Industrial waste
			4.81	At 14th day for mix-20%GLP + 40% Industrial waste
			5.86	At 28th day for mix-20%GLP + 40% Industrial waste

e) Water Absorption Test

Veena V Bhat, N. BhavanishankarRao [2014]concluded that water absorption decrease as the percentage of glass powder is increased. At 20% glass content the water absorption was least. **Raghvendra K and Virendra kumara K. N. [2015]** from their studies concluded that at 28 days the water absorption of concrete decreases as the percentage of waste glass powder and industrial waste increases and at 20% glass powder and 50% industrial waste that is foundry sand it is least. **Bhagyasri T. et al [2016]** studied that when cement is replaced by glass powder the water absorption at 7th day and 28th day reduces. Above observations are summarized in Table 5.

Table 5: Water Absorption

S. NO.	% of GLP	Author	Water Absorption (%)	Remarks
1.	20%	Veena V Bhat, N. BhavanishankarRao [2014]	0.516	At 28th day
2.	20%	Raghvendra K and Virendra kumara K. N. [2015]	1.5	At 28th day Mix – 20% GLP + 50% Industrial Waste
3.	40%	Bhagyasri T. et al [2016]	0.016	At 7th day
			0.023	At 28th day

f) Density

BajadM.N. et al [2011]concluded that the density of concrete with varying content of glass powder is less than the conventional concrete which is due to the fact that specific gravity of glass powder is less i.e. 2.58 while that of cement is 3.15. **J.M. Khatib et al [2012]**in their research figured out that as the percentage of glass powder is increased the density of the specimens is reduced at 40%. 2280kg/m^3 was the average density for all mixes.**Kumarappan N. [2013]** showed that as we increase the glass powder there is a marginal difference in the density of concrete as compared to conventional concrete and at 40 % the drop is observed. **VasudevanGunalaan and Pillay Seri GanisKanapathy [2013]** figured out that the concrete becomes lighter as the percentage of glass powder is increased. As compared to conventional concrete the average cube density is reduced as the percentage of glass powder is increased. **Veena V Bhat, N. BhavanishankarRao [2014]**in their research studied that density of for constant water cement decreases as the percentage of waste glass powder is increased.. Above observations are summarized in Table 6.

Table 6: Density

S. NO.	% OF GLP	Author	Density	Remarks
1.	40%	Bajad M.N. et al[2011]	2283kg/m^3	At 28th day
2.	20%	VasudevanGunalaan and Pillay Seri GanisKanapathy [2013]	2199N/mm^2	At 7th day
	15%		2087N/mm^2	At 14th day
	20%		2187 N/mm^2	At 28th day
3.	20%	Veena V Bhat, N. BhavanishankarRao [2014]	2361.48kg/m^3	At constant water cement ratio

4. Conclusions

From the above mentioned work of assorted researchers, it's clear that glass is used as a partial replacement of cement in concrete due to its enhanced workability, strength parameters like compressive strength, split tensile strength and flexural strength and also due to its enhanced durability measured by density check and water absorption check. As disposal of waste by-products drawback could be a major problem in today's world because of restricted landfill area , escalating costs for disposal, utilization of waste glass concrete won't solely offer economy, it'll conjointly facilitate in reducing disposal issues.

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