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Behaviour of Concrete with Glass Waste to an Attack from Sulphate Reagents

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Abstract - The present research deals with the incorporation of crushed beverage glass as a substitute for naturally procured river sand at a replacement percentage of 5%, 10% and 20%. The 28 days water cured specimens were placed in a sulphate environment for a period of 7 days and 28 days. Tests were conducted on the formed specimens in order to verify the change in weight and strength after comparing them with 28 days water cured specimens. The utilization of crushed waste glass up to 20% substitution level in concrete retains its strength even after 28 days of curing in sulphate medium. This study proves that the formed composite can be utilized for non-structural members up to 20% of substitution level.

Keywords: Glass waste; Compressive Strength; Sulphate Environment; Non-structural

I. INTRODUCTION

To study the resistance of concrete containing glass powder towards sulphate attack and to minimize waste age of broken glass sheets and the use of glass waste in concrete is a big opportunity from an economic point of view and useful against sulphate reagent. Today many researchers are ongoing into the use of Portland cement replacements, the usage of many waste substances like fly ash, silicon fumes, and glass waste powder are additionally used as a binder with the partial substitute of cement whilst taking some section of response at the time of hydration, additionally, it acts as a filler material [1]. Concrete produced using changing regular Portland Cement (OPC) 53-grade cement with glass waste powder (GP) in exclusive proportions has been analysed with 53 grade Cement substitute using powdered glass in the variation of 5% to 25% has been studied and carried out crushing strength (cube) for 7 days and 28 days **[2]**. It is concluded that having greater strength and most resistance against sulphate was obtained when 20% cement was once changed through the waste glass. This augmentation in the mechanical property of concrete checks is related to the pozzolanic behaviour of glass waste **[3].** In this way, utilization of glass waste is confined to up to 5% which prevents significant fall in execution under disagreeable conditions for chemical exposure concrete. To determine these regular issues, researchers have been exploring the replacement of cement with a colossal combination of green materials in concrete **[2]**. The waste glass is conveyed yearly on a big scale throughout the world, and not all of this can be reused into new glass given defilements, cost, and mixed tones. The request that must now be tended to is whether the courses of action coming about on account of the treatment of glass waste can displace ordinary water glass in the preparation of acid neutralizer cement. Thusly, the fundamental objective of the current assessment was to research the feasibility of using metropolitan and present-day waste glass as a normal dissolvable activator for sway warmer slag **[4].** The analysts affirmed that the use of waste glass in substantial upgrades its substantial and mechanical homes henceforth shows superb eventual outcome nearer to mass misfortune and power form interestingly, with reference of concrete. See table1

To solve the issue of sulphate attack as well as reduce concrete cost and reuse of waste glass we are working on replacing the waste glass with the fine aggregate at different proportions to determine the most appropriate substation level.

Author	Mix.% and Source	Chemical Composition of Glass	Binding Material	Effect
Ling & Poon (2006)**[5]**	Up to 100% Glass bottles- Large Glass(5-10mm) -Medium Glass(2.36-5mm) -Smaller Glass(<2.36mm)	MgO	Portland Cement +Metakaolin + Fly ash	+ve
Ling et (2011)**[6]**	Up to 100% Recycled Glass 22% Coarser(5-100mm)	Al2O3 CaO	White Portland Cement + Metakaolin	Ive effect at greater substitution%
Chen et (2006)**[1]**	10, 20 ,30 and 40 % Electronic Glass (38micr-300micr)	SiO2	Portland Cement	+ve

Table 1:Summary of research performed for evaluating the impact of the inclusion of glass waste in concrete

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II. Research Origination

Many researchers have observed the increase in hardened physical and mechanical properties by using glass waste in the concrete mix as a substitution for natural sand in the range of 18%-25% **[3].** However, Bisht and Ramana (2019) proved 20% replacement level as an appropriate quantity [3]. In the current study similar substation level taken in to consideration to achieve appropriate quantity of glass waste, when combination made with and without waste glass are exposed to sulphate environment. To study the decay of these formed amalgams, many tests were done which includes the examine of change in weight and strength.

III. Experimental Outline

Materials –

In modern-day work Ordinary Portland cement, 43 grade with specific gravity of 3.14 used to be in work. This cement stipulation is set through IS 1489(1991) **[7]** River sand having unique gravity of 2.65 is used which is belong to the grading curve labelled as sector two in accordance with IS383 (2016) **[8].** Coarse aggregate (10 mm and 20 mm) having a specific gravity of 2.6 is used. The beverage bottle and glass waste, which is passed through 600µ and retained on 150µ are used. After these, they had been used to change the excellent combination in more than a few percentages. The bodily and mechanical elements of uncooked substances are listed in Table2

Quantity of mixtures-

The substitute of sand with glass waste in concrete combination was once done at special share at 0%, 5%, 10%and 20% as noted in Table four having a constant water-cement ratio (0.45). The chemical composition of cement is pointed out in Table3

The notations used for glass substitution are WG0, WG5, WG10, and WG20 respectively. The substation of river sand using glass waste was once finished on a quantity basis.

Experimental Plan-

Fresh Property - Fresh Property of concrete mix. was analysed by doing a slump test according to IS1199(1959) **[9].** The test equipment contains one conical mould size of (20cm-bottom diameter,10cm-top diameter, 30cm-height) and one tamping rod. Firstly, oiling mould and then filling mould into three layers and every layer compacted by the tamping rod with 25 number of blows at every layer and smoothen the top surfaces. Then remove the mould slowly and note the reducing height of the specimen is called slump value. this slump value indicates the workability of concrete, the higher slump value higher will be workability.

Compressive Strength-

The compressive power of mix (M25) was once evaluated on three specimens of one hundred fifty mm dice at intervals of 7 days, and 28 days of water curing according to IS 516 (1995). The specimen was once examined for its compressive strength under the loading fee of 140 kg/cm^2/min until the specimen fractures.

Analysis	Properties	Result
OPC	Setting Time IS403(Part 5) (1988) **[10]** Compressive Strength IS 516(1959) **[11]**	Initial Setting time-115 min Final Setting time-248 min - 3 Day – 23.98 MPa - 7 Day – 35.45MPa - 28 Day – 44.34 MPa
Coarse aggregate	Water Absorption	0.50%
Fine aggregate	ASTM C 642(2008) **[12]**	0.51%
Glass Waste		0.31%
Coarse aggregate	Specific Gravity IS 2386**[13]**	2.59%
Fine aggregate	(Part III) (1963) **[14]**	2.67
Glass Waste Cement		2.34 3.14
Coarse aggregate	size	10 & 20 mm
Fine aggregate	IS 383 (2019) **[8]**	<4.75 mm
Glass Waste		0.15 – 0.6 mm
Coarse aggregate	Crushing Value IS 2386 (Part IV) (1963) **[15]**	24.03%
Glass Waste	Pozzolanic Activity ASTM C311 (2003) **[16]**	82%
Glass Waste	Alkali Silica Reaction IS 2386-7 (1963) **[17]**	Not deleterious

Table 2:Properties of Raw material

Compound	Percentage
Alumina	8.46
Magnesium Oxide	1.12
Free lime	0.81
Silica	32.02
Ferric oxide	3.84
Calcium oxide	44.74
Potassium oxide	0.43
Sodium oxide	0.24

Table3: -Chemical composition of cement

Fig1-Waste glass

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Resistance to sulphate Attack –

To pick a substantial example of protection from sulphate attack CTM Test was once utilized. The substantial exhibition was once assessed following 7 days, 28 days and 56 days of curing exposed to the sulphuric climate. The substantial example of 150mm aspect had been broiler dried and gauged, after which they have been situated in 3% weakened sulphuric corrosive till their looking at period **[2].** Three examples had been inspected at each evaluating stretch, and the response used to be altered in three weeks. The overall performance of the specimen towards acidic assault was once judged with the admire to variant in compressive energy as per compressive electricity test. The consequences of these found values below acidic publicity have been then in contrast with cost acquired after 28 days water curing sample.

Table 4 –

Mixes Nomination	W.G%	Cement (kg / m³)	Fine Aggregate (kg / m³)	WG (kg / m³)	Coarse aggregate (kg / m³)
WG 0	0	384	811.2	0	1122.7
WG 5	18	384	665.2	127.9	1122.7
WG 10	19	384	657.1	135	1122.7
WG 20	20	384	648.9	142.1	1122.7

Table 4 Concrete Mixture Proportions by weight at a constant water-cement ratio (0.45)

IV. RESULTS & DISCUSSIONS

Workability- In this research, the quality of chemical admixture is to be calculated at the same water-cement ratio. These tests are done precisely which can be figured out in out the workability of concrete at different substation levels of glass waste which is shown in fig2.

From this fig can see that the necessity for superplasticizer increase with increasing the WG share (superplasticizers is used to extend the usefulness of cement at an ordinary water concrete ratio). This may be due to the glass waste particles being better than the river sand, having a sharp viewpoint, and rougher in structure. Taha and Nounu (2008) **[18]** also saw a decline in compaction factor when the glass waste of size less than 5mm was used as an option for normal sand.

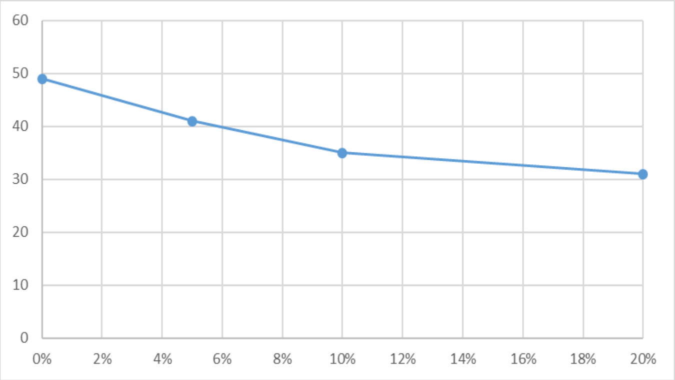

Figure 2: workability at different levels of substation level of glass waste (%).

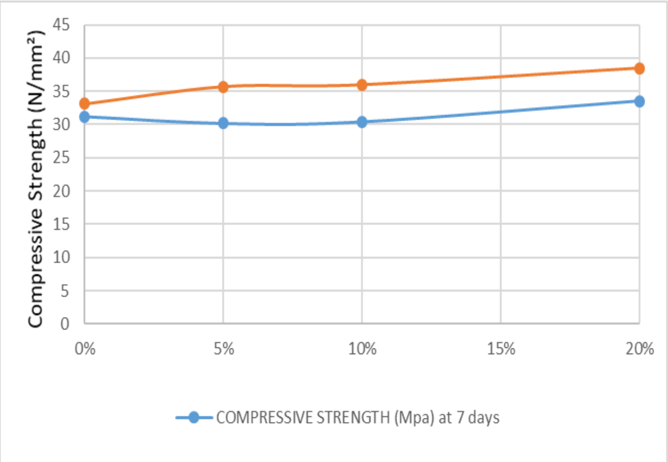

Figure 3- Crushing strength of glass waste concrete specimens before exposed to sulphate environment.

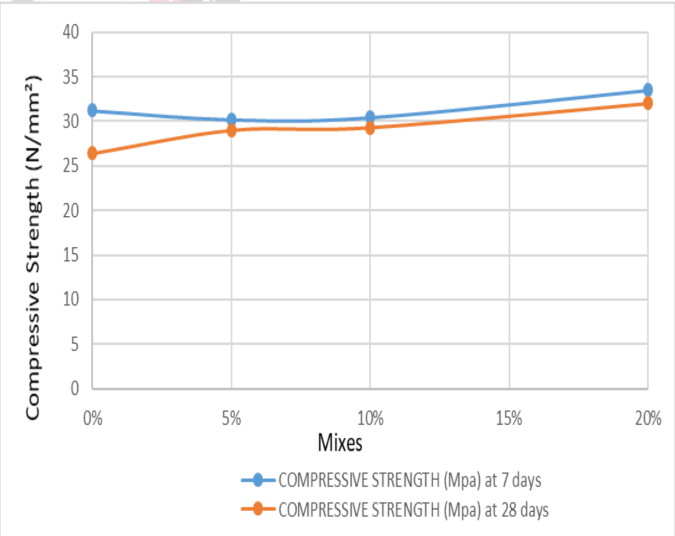

Figure 4(a)- Crushing strength of glass waste concrete specimens after exposed to sulphate environment.

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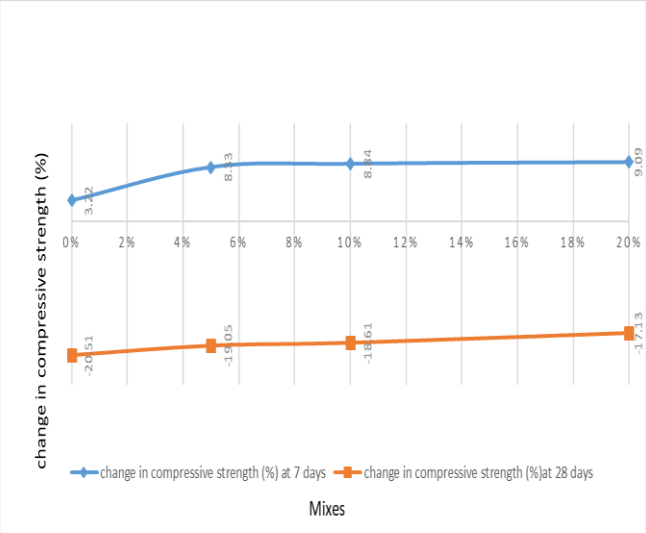
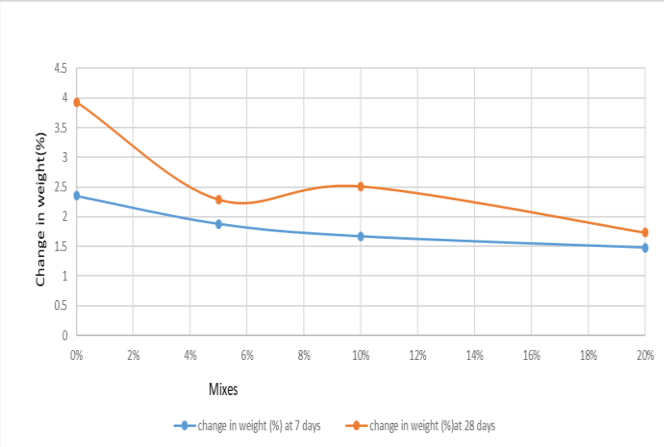


Figure 4(b): Change in compressive strength after exposing to sulphate environment (in %)



Graph 5: Variation in weight for glass waste substantial examples

Mechanical property- The crushing strength of water cured concrete samples with and without glass waste has been inspected at a time of 7 days and 28 days as mention in fig4(A). It can be said that the strength of the concrete sample increase when the glass waste substitution level increases 5 to 20% and is introduced into the concrete mix. enhance when the waste glass percent is more noteworthy than 5% in the concrete. Chen et al. (20016) [1] also present higher strength of mixture with 20% of waste glass, which associated with the pozzolanic behaviour of waste glass. Ramana and Kunal (2018) **[2]** had proved that the addition of glass waste, into the concrete mix which is based on PPC enhance its density. This enhances in the density of damp-proof voids give better resistance to crushing strength up to the substation of 20%. However, a Conclusion made by AL-Hashmi and Ismail (2009) **[4]** for 20% replacement of river sand through glass waste constituents of size 150µ - 4.75 mm point out that the reference mixture.

Sulphate attack-

Change in weight -Change in weight of significant sample when exposed to sulphate environment is given in Fig 5. With the help of fig5, it is noticed that might be seen that by use of glass waste in concrete mix reduces the weight loss. Till 28-days of sulphate curing, the weight has shown to increase for all concrete mixtures. This can be a result of engaging the destructive reaction and major to the plan of item like ettringite. As exposure increase up to 28 days weight loss was noted. The deuteriation observed is related with the removal of the extreme layer of the concrete sample. The highest deuteriation of 9.16% was seen for the control mix as compare to 3.71% at 20% substitution level. This decrease in change in weight may be a result of the sacrificial nature of glass waste which resist the decay of concrete. So there is lesser mortar past being lost on continued exposure. Also, the product formed between the reaction of waste glass and sulphate might possess better cementitious properties than ettringite. Wang (2009) **[5]** also suggested a decline in trade weight decrease when Waste glass (4.75-0.076mm) used to be utilized as a choice of stream sand in the concrete mix. IN the same way, Ling and Poon (2011) **[6]** depicted indistinguishable approaches to the acting of mortar tests when glass waste (60% < 2.36 mm and 40% 2.36 mm - 5 mm) used to be introduced has additionally been found that is calling happens more noticeable on direct tests which results into annihilation of floor layers instead of WG significant model.

Resistance to crushing strength- The variation in crushing strength after using waste glass is presented in Fig4(a) and the variation in crushing strength (in percentage) by using glass waste is given in Fig4(b). The increase and decrease of mechanical strength associated with the improvement of hazardous things like ettringite and their end to sulphate arrangement. It has been seen that when tests had been conducted for 7 days, WG20 mix show an increase (16.13%) in crushing strength as related to glass waste mix (3.21%). An increase in crushing strength for glass waste including mix can be depend upon increased voids which allowed the sulphate ions to enter the concrete specimen. The developed ettringite firstly works as a filler, thus enhancing the crushing strength of concrete. The glass waste enhances the strength due to working as a filler in concrete.

V. CONCLUSION

Slight change has been seen in weight and crushing strength when glass waste included concrete specimen have been uncovered to sulphate curing. This is related to the early response of glass waste with Na_2SO_4 consequently affecting the formation of sodium sulphate which no longer enables the deterioration of binding materials. However, extraordinary modifications have been discovered for WG0 combined concrete patterns due to the production of ettringite and gypsum. The higher the alternative vary of WG, the lesser the development of decrease-in strength in contrast to reference samples. This difficulty restricts the utilisation of WG to a most of 20% only.

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