Usage of Waste Glass as a Sand Substitution in Concrete Mortar

Dr. Kuldeep Singh Kulhar[1], Saurabh Meena2, Harsh Jangid3, Prashant Sehra[4], Pramod Meena[5]
[1]Professor, [2-5]UG Scholar
Department of Civil Engineering,
Vivekananda Institute of Technology, Jaipur, Rajasthan, India

Abstract: In this review, mortar made with squander glass as fine totals was explored for its appropriateness for development use. A reference mortar blend was proportioned by ASTM C 109 and the fine totals were supplanted by squandering glass particles by 0%, 25%, half, 75%, and 100 percent, by mass, to concentrate on its impact on the properties of mortar. For every combination, four sorts of glass sand, specifically, brown, green, clear, and blended variety glass, were utilized. Test results showed that utilization of waste glass particles as fine totals would lessen the flow ability and thickness of mortar, however, increase its air content. Aside from drying shrinkage, the mechanical properties were compromised because of miniature breaking in glass sand and debilitated bond with the concrete glue. Notwithstanding, strength was upgraded, particularly with regards to the protection from chloride particle infiltration. Sped-up mortar bar tests to ASTM C 1260 showed that green and earthy colored glasses were non-receptive while the clear glass was possibly harmful, with respect to antacid silica response.

Keywords: ASR Expansion, Flexural Strength, Compressive strength, Waste Glass, Concrete, Cement

I. INTRODUCTION

The reusing of waste glass is a significant issue for districts overall because of high removal costs and natural worries. Reusing glass from the metropolitan strong waste stream for use as a natural substance in new glass items is restricted because of significant expenses, debasements and blended variety. Albeit boring waste glasses have been reused successfully, hued squander glasses with their low reusing rate have been unloaded into landfills destinations. The use of waste glass in development has drawn in a ton of interest overall because of the huge amount utilizations and far reaching building destinations. As of late, many examinations have zeroed in on the purposes of waste glasses as fractional substitution of normal totals in concrete. The utilization of waste glasses as substantial totals didn't essentially affect the usefulness and strength however diminished the rut, air content and new weight of concrete1. Finely ground glass powders displayed exceptionally high pozzolanic activity 2,3. A main pressing issue for involving waste glass in concrete is the soluble base silica response (ASR) that happens between the salts in concrete and the receptive silica in glass. This response can be exceptionally hindering to the strength of cement. Ongoing examinations have shown that there are a few methodologies that can successfully control the development of ASR because of glass total. It has been accounted for that the utilization of side-effects and squanders, for example, fly debris, silica rage and granulated impact heater slag diminished the extension from ASR. The consolidated use of waste glass with modern side-effects can be more appropriate as opposed to utilizing it single-handedly in mortar 4,5. Lithium salt likewise can be an exceptionally powerful added substance in diminishing ASR development of cement containing waste glass6. The ASR development is straightforwardly relative to the substance of waste glasses no matter what their type7. The molecule size of glass total was found to affect ASR extension. As referenced, ASR extension increments with expanding fineness of glass in a measured way and afterward diminishes afterwards 8,9. That's what additional ongoing investigations revealed assuming the waste glass is finely ground under 100 µm ASR extensions doesn't occur10. The sorts of glass were found to altogether affect the ASR extension. Glasses containing boron, for example, Pyrex glass were viewed as more responsive than soft drink lime silica glasses11. The glass tone likewise affects ASR extension. For example clear soft drink lime glass was viewed as most responsive followed by earthy colored glass. The fact that green glass was more makes it in like manner demonstrated

II. LITERATURE REVIEW

1) M. Mageswari and B. Vidivelli (2009) have concentrated on the inventive substantial utilizing fly ash furthermore, squander sheet glass. In this examination paper squander Sheet Glass Powder

utilized as fine total what's more, Portland concrete with 20% ideal substitution of fly ash utilized as cementitious fastener offers a financially high worth use of modern waste glass. In this examination 10%, 20%, 30%, 40% and half sheet glass powder was utilized as a halfway substitution of normal sand. What's more, Portland concrete was supplanted by 20% fly ash. Minimal expense substantial assembling is conceivable as per testing result. Up to 30% substitution of normal sand by sheet glass powder and 20% substitution of concrete by fly ash gives ideal outcome.

2) M. Mageswari and Dr. B. Vidivelli (2010) have concentrated on the utilization of sheet glass powder as fine total substitution in concrete. This examination shows the chance of utilizing Sheet Glass Powder as a swap of fine total for another kind of cement. In this research normal sand was to some degree supplanted 10% to half by Sheet Glass Powder. Compressive strength test, Tensile strength test and Flexural strength test were performed up to 180 days old enough and contrasted an ordinary substantial blend. As indicated by this exploration concrete containing Sheet Glass Powder as halfway substitution of normal sand totals is conceivable. Furthermore, 10% to 20% Replacement of regular sand by Sheet Glass Powder provider higher strength

3) A. Khmiri, B. Samet and M. Chaabouni (2012) have concentrated on the assessment of the waste glass powder pozzolanic movement by various techniques. In this study squander glass powder is utilized as pozzolanic material in Portland pozzolanic concrete. Squander glass powder is acquired from building destruction and squashed holder. In this examination hued and clear glass of size 100 and 80 µm, 80 and 40 µm and lower than 40 µm are utilized. By this review, it was reasoned that the utilization of waste glass powder as fractional substitution of Portland pozzolanic concrete requires the crushing of waste glass powder is lower than 40 µm.

4) Dhirendra Patel, R. K. Yadav and R. Chandak (2012) have concentrated on the strength attributes of concrete cement containing coarse and fine waste glass powder. In the 21st century non-degradable squanders has been a significant issue. Presently these squanders are being arranged of in landfill regions without being reused. The decay of squanders take up an extremely lengthy time. This examination had been done to completely use these losses as the end results like cement and mortar. In this examination concrete was supplanted by 5% to 20% by glass powder which is utilized in mortar and cement and at 10% supplanting concrete with glass powder gives adoptable compressive strength.

III. METHODOLOGY OF PROPOSED SURVEY

Material Properties

Concrete utilized in the mortar blend was normal Portland concrete (CEM I) had a strength class 42.5 N as per Turkish standard TS EN 197-115. The salt substance of this concrete (Na_2O_{eq}) was 0.83%. Limestone total (LS) adjusting to TS 706 EN 1262016 was utilized in this review for getting ready concrete mortars. Actual properties of LS are given in Table 1. Squander glasses (WG) were utilized as substitution of LS sand with various tones (white, green and brown) and content. WG utilized in the trials were soft drink lime glasses that have been broadly utilized for bottles. The substance properties of Portland concrete (PC) and WG are given in Table 2. After the gathering process, these jugs were kept in water to eliminate natural foreign substances and were then dried also, squashed in the lab to five unique sizes. The reviewing of LS sand and WG totals are given

ASR Expansion Test

RILEM AAR-2, the super sped up mortar test (AMBT) was utilized to decide the ASR extension of mortar bars. The proportion of concrete, sand and water was 1:2.25:0.47, respectively. WG were used as replacement of LS sand with different colors and contents. In all mixtures, three different colors of WG were substituted in weight ratios of 10%, 30% and 100% of each LS size fraction, respectively. The mixtures were designated as weight ratio-glass color, e.g., 10 white; the mixture containing no glass is designated as 100 LS. Three 25×25×285 mm mortar bars were cast for each mixture. After 24 h curing the mortar bars were placed in water at 80oC for another 24 h to measure the reference length. Then the mortar bars were transferred to a solution of 1 M of NaOH at 80oC for the following test period. The length differences of the mortar bars were compared to the reference bars at 14 and 21 days, respectively.

Table1—Some important physical properties of LS

Aggregate property	Relevant standard	Obtained value
Loose bulk density	TS EN 1097-3	1.639 Mg/m^3
Void content	TS EN 1097-3	40.42 %
SSD particle density	TS EN 1097-6	2.754 Mg/m^3
Water absorption	TS EN 1097-6	0.25 %
Fines content <63μm	TS 3530 EN 933-1	32 %

Strength Test

For strength tests, mortar examples were ready as per technique portrayed in TS EN 196-117.In any case, the mortar blends were proportioned in agreement with AAR-2 test strategy. The reviewing ofLS was kept consistent while each size part of WG was supplanted with the relating size part of the LS. The explored mortar examples were projected into three-pack (40×40×160 mm) crystal shape and compacted as depicted in the related standards17 After the compaction method, the molds were put in a dampness bureau for 24 h (21±2oC, 95% RH). Following this period, the examples were eliminated from the molds and kept in water until the testing time. Compressive strength and flexural strength of the mortar not entirely set in stone in agreement with TS EN 196-117. Flexural strength of the not entirely set in stone by utilizing three 40×40×160 mm kaleidoscopic examples. Compressive strength test was applied on six broken parts of flexural test examples. Strength tests were conveyed out at 7, 28 and 90 days. The compressive strength results demonstrated the normal of six qualities and flexural strength results are the normal of three qualities.the development values were noticed for whiteWG bearing combinations. 21-day development of 100 percent whiteWG containing blend is significantly over the ASR development limit.

Table 2—Chemical composition of PC and WG

Chemical composition (%)	PC	WG		
		White	Green	Brown
SiO_2	18.80	69.72	64.03	57.41
Al_2O_3	5.13	1.02	1.6	1.68
Fe_2O_3	2.78	0.55	0.52	0.86
CaO	63.31	8.76	12.41	4.83
MgO	1.58	3.43	3.31	2.75
Na_2O	0.25	8.42	7.76	6.42
K_2O	0.88	0.13	0.32	0.60
SO_3	2.63	0.20	0.11	0.16
Total	95.36	92.55	94.14	94.08
LSF*	---	4.45	6.84	9.08
MS**	---	44.44	30.1	22.56
AF***	---	1.88	3.06	1.95
LOI****	3.91	0.31	4.07	9.37

*Lime saturation factor, ** Modulus of silica, *** Alumina factor
**** Loss on ignition

Table 3—Grading of LS sand and WG aggregates for ASR expansion and strength tests

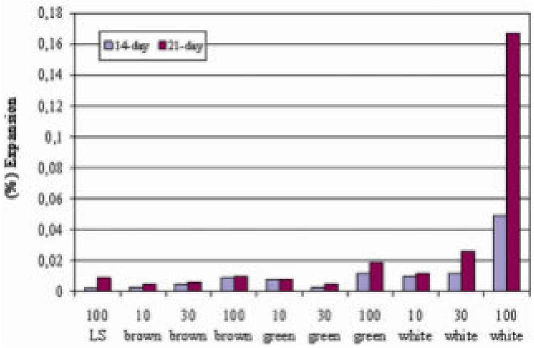
Sieve size (mm)		Mass, %
Passing	Retained	
4	2	10
2	1	25
1	0.5	25
0.5	0.25	25
0.25	0.125	15

The mortars containing 100 percent white-WG displayed development under 0.10% at 14 days anyway surpassed as far as possible at 21 days. This worth was somewhere in the range of 0.10% and 0.20% at 21 days thus this extension is characteristic of possibly inconvenient development. Map breaking was too noticed for these examples. The ASR extension results uncover that white-WG fills in as a slowly expanding total in the blend. It ought to be noticed that, the extension period for sped up mortar bar test ought to be modified for white-WG containing blends.

IV. RESULT AND DISCUSSION

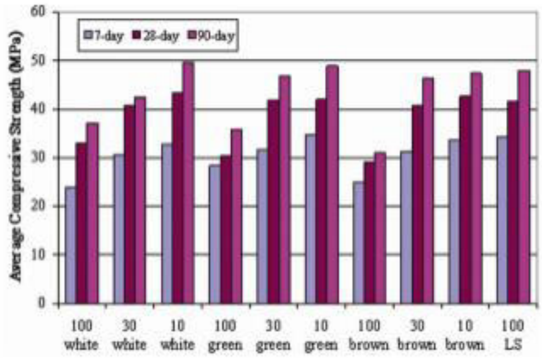
ASR Expansion

ASR extensions of the blends are given in Fig. 1. The 14-day extensions of all blends are underneath as far as possible (0.10%) by numerous normalization organizations for the example aspects utilized in this study 18,19. ASR extensions of under 0.10% are characteristic of non-injurious development. Taking into account all of the glass types utilized in this review, for the most part there is a rising pattern of development by expanding measures of WG utilized in the blend. White-WG containing blends uncover the most noteworthy development values when contrasted and different combinations having the same measure of green or brown-WG. ASR extension readings were required past 14-days, an expansion in the development values were noticed for white-WG bearing blends. 21-day extension of 100 percent whiteWG containing combination is impressively over the ASR development limit. The mortars containing 100 percent whiteWG displayed development under 0.10% at 14 days anyway surpassed as far as possible at 21 days. This value was somewhere in the range of 0.10% and 0.20% at 21 days thus this development is characteristic, possibly impeding extension. Map breaking was likewise noticed for these examples. The ASR development results uncover that white-WG fills in as a gradually extending total in the blend. It ought to be noticed that, the development period for sped up mortar bar test ought to be amended for white-WG.



COMPRESSIVE AND FLEXURAL STRENGTH

In the current examination, WG was utilized as supplanting of LS sand with various varieties and items underway of the concrete mortar. In all combinations, three unique shades of WG (white-WG, green-WG, and brown-WG) were subbed in weight proportions of 10%, 30%, and 100 percent of every LS sand size part. The Portland concrete, limestone sand and water blending extents were 1:2.25:0.47, separately. Figure 2 shows the test consequences of the compressive strength relying upon the progressions in the blending pace of the WG and the time of testing. The pace of compressive strength relies on the fair and square of WG substitution and restoring age. True to form, the compressive strength expanded with restoring age. The strength improvement of the concrete mortar containing WG was contrasted and that of the mortar containing 100 percent LS sand at a similar age. It wasINDIAN J. ENG. MATER. SCI., AUGUST 2011 306 saw that with increment of the WG content, the compressive strength of the mortars diminished. This impact is very impressive at 100 percent WG containing combinations. Brown-WG consolidation diminishes the compressive strength of blends more than different combinations. Nonetheless, there are a few excellent outcomes, for example, the outcomes got for 10% WG substitution level. The most extreme compressive strength values were estimated at 10% WG swap level for all restoring days. The mortar containing 100 percent LS displayed commonly a higher compressive strength than different combinations particularly at early ages. As found in Fig. 2, the mortar containing 100 percent LS accomplished a compressive strength of 34.23



At 7 years old, the mortars containing 100 percent white-WG, 100 percent green-WG and 100 percent brown-WG accomplished the compressive qualities of 23.89 MPa, 28.42 MPa and 25.07 MPa, individually. Likewise, the mortars containing 30% white-WG, 30% green-WG and 30% brown-WG totals accomplished the compressive qualities of 30.68 MPa, 31.71 MPa and 31.37 MPa, separately at 7 days. At 7 days, the mortars containing 10% white-WG, 10% green-WG and 10% brown-WG accomplished the compressive qualities of 32.75 MPa, 34.75 MPa and 33.74 MPa, separately. The most extreme compressive strength esteem was gotten at 10% green-WG swap level for 7 days. The compressive strength worth of the mortar 100 percent LS containing was 41.60 MPa at 28 days though the mortars containing 100 percent white-WG, 100 percent green-WG and 100 percent brown-WG accomplished the compressive qualities of 33.03 MPa, 30.47 MPa and 29.05 MPa, separately. The mortars containing 30% white-WG, 30% green-WG and 30% brown-WG accomplished the 28-day compressive qualities scope of 40.74 MPa, 41.87 MPa, and 40.82 MPa, individually which are near or better than the strength of 100 percent LS mortar. The mortars containing 10% white-WG, 10% green-WG and 10% brown-WG accomplished the compressive qualities of 43.27 MPa, 42.01 MPa, 42.61 MPa, separately, at 28 days. At 10% substitution of WG the compressive strength upsides of the WG containing mortars were higher than that of the 100 percent LS mortar. The greatest compressive strength esteem was gotten as 43.27 MPa at 10% white-WG substitution level for 28 days. Contrasted and results at 90 days, the 100 percent LS mortar accomplished a compressive strength of 48.00 MPa while mortars containing 100 percent white-WG, 100 percent green-WG and 100 percent brown-WG accomplished the compressive qualities of 37.14 MPa, 35.81 MPa and 31.01 MPa, individually. Additionally, the mortars containing 30% white-WG, 30% green-WG and 30% brown-WG totals accomplished the compressive qualities of 42.49 MPa, 46.90 MPa and 46,36 MPa, separately at 90 days. The mortars containing 10% whiteWG, 10% green-WG and 10% brown-WG accomplished the compressive qualities of 49.56 MPa, 48.88 MPa, and 47,38 MPa, separately. The mortars containing 10% white-WG and green-WG displayed higher strength values than that of 100 percent LS mortars. The level of WG affects compressive strength. With high substitution rates of LS sand by WG, the WG containing mortar showed more vulnerable upsides of compressive strength. The diminishing in strength improvement could be ascribed the abatement in glue strength between the outer layer of the WG totals and the concrete glues. The smooth and plane surface of the enormous WG particles could essentially debilitate the connection between the concrete glue and the WG particles. In any case, the white-WG containing mortar showed commonly high compressive strength at all ages, the shade of the WG small affects the compressive strength which could be overlooked. The mortars containing 10% WG showed the best compressive strength. Following 28 days of relieving the compressive strength of the mortars containing 10% white and brown-WG was generally higher than the base required limit (42.5 MPa) given in TS EN 197-1 for concrete mortar. For 30% substitution, the compressive qualities of the mortars with WG were the same as or near 100 percent LS mortar. It is presumed that up to 30% WG substitution of sand, the WG containing mortars can accomplish improved or identical strength execution contrasted with mortars made with 100 percent LS. Normal flexural rigidity results for 7, 28 and 90-day old combinations are given in Fig. 3. Flexural rigidity of the examples were diminished by expanding WG substitution level, the abatement in strength becomes extensive for 100 percent WG containing tests. The 100 percent LS mortar accomplished a flexural strength of 7.08 MPa at 7 days though the mortars containing 100 percent white-WG, 100 percent green-WG and 100 percent brown-WG accomplished the flexural qualities of 5.05 MPa, 4.23 MPa and 3.41 MPa, separately. The mortars containing 30% white-WG, 30% green-WG and 30% brown-WG total.

V. CONCLUSION AND FUTUREV WORK

In the current review, antacid silica response (ASR) development and strength attributes of mortar containing waste glasses were examined as far as waste glass content and glass tone and in view of the trial results, the accompanying ends can be made.

1) AMBT test results uncover that the combinations utilized in this review didn't show an extensive ASR development. All clusters tried had the option to relieve ASR developments to beneath 0.10% and thus as per ASTM 1260-01, the extensions were inside as far as possible

2) The expansion in extension of 100 percent white-WG containing tests past 14-days makes the time of test technique sketchy for combinations containing glass.

3) The level of WG significantly affects compressive strength. With high supplanting rates of LS sand with WG, the glass containing mortar showed lower compressive and flexural strength than those made with 100 percent LS sand. The reduction in strength becomes significant for 100 percent WG containing tests. It is accepted that such a reduction in strength is because of the decline in cement strength between the outer layer of the waste glass and concrete glue.

4) However, the decrease in flexural and compressive strength of brown-WG consolidating blends is higher than that of tests containing white-WG and green-WG, the shade of the waste glass small affects the compressive strength which could be overlooked.

5) The decrease in flexural strength of tests is by

and large higher than the decrease in compressive strength of similar examples. This might be ascribed to the adjustment of the interfacial progress zone properties of glass containing blends.

6) The 10% WG substitution created higher strength than different blends. yet, they additionally showed that the mortar containing waste glass kept on growing further with age. Following 28 days of restoring the compressive strength of the mortars containing 10% WG was near or higher than the base required limit (42.5 MPa) given in TS EN 197-1 for concrete mortar.

7) At 10% substitution glass total the flexural strength worth of the mortar was near or higher than that of the 100 percent LS mortar.

8) The mortars containing up to 30% waste glass as sand can accomplish the practically identical qualities to that of 100 percent limestone sand. It very well may be seen that when 30% fine total was supplanted by squander glass, the multi day strength was same as that of 100 percent LS mortar

REFERENCES

[1] Topcu I B & Canbaz M, Cem Concr Res, 34 (2) (2004) 267-274.

[2] Shi C, Wu Y, Reifler C & Wang H, Cem Concr Res, 35(5)(2004) 987-993.

[3] Karamberi A & Moutsatsou A, Cem Concr Compos, 27 (2)(2005) 319-327.

[4] Yuksel I, Ozkan O & Bilir T, ACI Mater J, 103 (3) (2006) 203-208.

[5] Ozkan O & Yuksel I, Constr Build Mater, 22 (6) (2008) 1288-1298.

[6] Topcu I B, Boga A R & Bilir T, Waste Manage, 28 (2)(2008) 878-884.

[7] Park S B & Lee B C, Cem Concr Res, 34 (7) (2004) 1145-1152.

[8] Shao Y, Lefort T, Moras S & Rodriguez D, Cem Concr Res, 30 (1) (2000)91-100.

[9] Shayan A & Xu A, Cem Concr Res, 34 (1) (2004) 81-89.

[10] Corinaldesi V, G Nappi G, Morricone G & Montenegro A, Waste Manage, 25 (2) (2005) 197-201.

[11] Jin W, Meyer C & Baxter S, ACI Mater J, 97 (2) (2000) 208-213.

[12] Xi Y, Li Y, Xie Z & Lee J S, Proc Int Workshop on Sustainable Development and Concrete Technology, Beijing, China, 2004, 45-54.

[13] Zhu H Y & Byars E A, Proc 12th Int Conf on Alkali-Aggregate Reaction in Concrete, Beijing, China, 2004, 811-20.

[14] Byars E A, Zhu H Y & Morales B, Final report, The University of Sheffield, Published by The Waste & Resources Action Programme, 2004, ISBN:1-84405-115-3.

[15] TS EN 197-1, Cement: Compositions, Specifications and Conformity Criteria, Part I: Common Cements. TSI, Ankara, Turkey, 2002.

[16] TS 706 EN 12620+A1, Aggregates for Concrete, TSI, Ankara, Turkey,2009.

[17] TS EN 196-1, Methods of Testing Cement - Part 1: Determination of Strength, TSI, Ankara, Turkey, 2002.

[18] ASTM C1260-01, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method), Annual Book of ASTM Standards, West Conshohocken USA, vol.04.02, 2002, 684- 688.

[19] Canadian Standard , Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete. CAN/CSA-A23.1-04/A23.2-04