Glass Waste used in Production of Mortar and Concrete- A Review

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Abstract- *Disposal of waste glass produced from bottle glass, flat glass, table ware glass and filament glass fibers, etc. is one of the greater environmental problem. This problem speedily increase with increasing the amount of waste glass and decreasing the landfill space. Thus, studies have been carried out to find suitable ways to recycle waste glass in building materials like as cement, mortars, concretes and blocks. This paper presents an summary of the previous studies carried out on the use of waste glass as cement replacement and as partial or full natural fine aggregate replacement in customary mortar/concrete mixtures based on Portland cement (PC).*

Keywords- Glass Waste, concrete, compressive strength, flexure strength, split-tensile strength.

I. INTRODUCTION

Construction industries require lots of raw materials for its production and which is non- renewable today. There has been a significant emphasis on increasing sustainability in construction practices also. Environmental pollution is also increase day by day. So we require to achieve this is to increase the use of green materials in cementitious materials, which are the primary materials used in the construction industry. Lots of waste materials used in recent years like as fly ash, agriculture waste, rubber waste, etc. Glass waste has been used in recent year in cement, mortar, and concrete production also. Resource recycling techniques can be used to fully.

Convert ‘‘waste” to another ‘‘new resource”, offering environmental protection.Total production of glass will increase due to the increase in industrialization and the improvement in the standard of living, i.e. the waste glass will increase too These glass waste occupy huge parts of the landfills spaces, due to the non-biodegradable nature of glass, and causing serious environmental pollutions (air, water and soil pollutions). Also, the lack of spaces for new landfills is a problem facing the dense population cities in different countries.The best solution to overcome over the environmental impact of these glass wastes is to reuse them Construction industry,especially the cement and concrete industry, can provide a very important and useful solution for the environmental impact of glass waste, due to the chemical

composition and the physical properties of glass which are similar to that of sand and cement Crushed waste glass bottles are in environmental problem, but also provide an available resource for potential use in production of cement, mortar, and concrete by partially replacing coarse and fine natural aggregates.

Table I
Characterstics Properties of Cement

Sr. No	Characteristics	Specified values per IS:8112-1989
1	Consistency of cement (%)	---
2	Specific gravity	3.15
3	Initial setting time (minutes)	>30
4	Final setting time (minutes)	<600
5	Compressive strength (N/mm2) (i) 3 days (ii) 7 days (iii)28days	 >23 >33 >43
6	Soundness (mm)	10
7	Fineness of Cement (gm)	10

Table II
Physical Properties of Fine Aggregates

Sr. No	Physical Properties	Specified values per IS:383-1970
1	Specific gravity of fine aggregate	2.60
2	Free moisture content	2%
3	Water absorption	1.82%

Table III
Sieve Analysis of Fine Aggregate

Sr. No	IS Sieve Designation	Specified values per IS:8112-1989			
		I	II	III	VI
1	10mm	100	100	100	100
2	4.75mm	95-100	90-100	90-100	95-100
3	2.36mm	60-95	75-100	85-100	95-100
4	1.18mm	30-70	55-90	75-100	90-100
5	600 micron	15-34	35-59	60-79	80-100
6	300 micron	5-20	8-30	12-40	15-50
7	150 micron	0-10	0-10	0-10	0-15

II. LITERATURE REVIEW

Glass waste in cement, mortar and concrete was studied by many researchers for different purposes e.g. for improvement in strength of concrete, reduced the, effective utilization of glass waste, achieve economy in concrete construction etc. A few important of them has been listed the below.

Glass as a aggregate replacement material in concrete: Li-JengHunag, Her-Yung Wang, Shi-Yang Wang (2015) studied in his paper waste tire powder and waste liquid crystal display (LCD) glass sand are used as recycled materials. With a fixed water to binder ratio (W/B = 0.4), the use of fly ash and slag as cement replacement materials. waste tire powder and waste LCD glass sand, which passed the sieve screen size # 30(0.595 mm), were used to replace fine aggregates at 0%, 5% and 10% in producing lightweight aggregate concrete. .The fresh property test was processed in accordance with ACI concrete mix proportion design. Harden and durability tests were performed at 7, 28, 56 and 91 days.It was reported that the results showed that the slump increased or decreased with the addition of different types of recycled materials, but still met the design slump of 150–180 mm. Concrete workability and the unit weight decreased after adding rubber powder to concrete. As the replacement rates of waste glass sand and waste rubber powder increase, the compressive strength tends to decrease. At 56 days, the ultrasonic wave velocity of normal concrete was higher than lightweight aggregate concrete; the lightweight aggregate concrete with 10% glass sand provided the highest ultrasonic wave velocity of the lightweight aggregate concretes. Sulfate resistance tests showed that the normal weight aggregate concrete was better than the lightweight aggregate. Mixing two kinds of recycled materials also resulted in better resistance. Studies showed that adding an appropriate amount of recycled materials might improve the durability of lightweight aggregate concrete.[1]

Sara de Castro, Jorge de Brito (2012) presented in this paper the durability properties of concrete made with glass. For this, water absorption by capillarity and immersion, carbonation resistance, chloride penetration and shrinkage tests were performed. Mixes containing 0%, 5%, 10% and 20% of glass aggregates (GA) as replacement of natural aggregates (NA) were prepared. Also analyzed is the influence of the size of the replaced aggregates (fine and coarse, separately or simultaneously), in a total of 10 concrete mixes.It was conclude that the particle size strongly affects the workability of concrete. Due to the lower density of the glass aggregates, the mixes made with glass had a lighter fresh density than the reference concrete. Although there is a decrease in the compressive strength as the replacement rate increases, mixes with GA are totally feasible, even though there are some differences in performance as a function of the particle size of the GA used to replace the NA. It was found that in most cases the GA do not significantly alter the durability-related properties of concrete. In a few instances there is a variation from the reference concrete of ±15%, which is well within the expectable scatter of the results from experimental research.[2]

Nasser Almesfer and Jason Ingham (2014) focused on the study of Crushed waste glass bottles accumulating in stockpiles around New Zealand are an environmental concern, but also provide an available resource for potential use in concrete by partially replacing coarse and fine natural aggregates. The objective of this study was to test the fundamental properties of concrete that utilized 20% waste glass as a partial replacement for coarse and fine natural aggregates. It is demonstrated that the waste glass has a negative effect on concrete properties, including air content, compressive strength, and flexural strength, while also contributing to the problematic alkali-silica reaction. The use of supplementary cementitious materials such as fly ash or micro silica was found to improve the properties of concrete that utilized waste glass, especially with regards to inhibiting the alkali-silica reaction, and hence it was established that waste glass should be used with either fly ash or micro silica mainly due to concerns regarding the development of the alkali-silica reaction caused by the waste glass trialed in this study.[3]

Waste glass powder as a cement replacement material in concrete: In previous research work glass waste powder is used in concrete as a replacement of cement**.**

MahsaKamali, Ali Ghahremaninezhad (2015) studied the effect of two types of recycled glass powders with a microscale median size – one industrial by-product (GP1) and the other consumer by-product (GP2) – and fly ash on the mechanical strength and durability performance of concrete was elucidated. It was reported in his study that cementitious materials modified with glass powders showed an improvement in compressive and flexural strengths compared to the control concrete at late ages of curing. It was found that the addition of glass powders decreased alkali-silica reaction expansions of the modified cementitious materials when mixed with reactive sands and enhanced resistance to chloride permeability and electrical resistivity of cementitious materials. The improvement in the mechanical strength and durability of the cementitious materials modified with glass powders can be attributed to microstructure improvement arising from the pozzolanic property of the glass powders.[4]

KavehAfshinnia, Prasada Rao Rangaraju (2015) Studied potential synergistic role of a finely ground glass powder in binary and ternary cementitious blends with conventional SCMs such as meta-kaolin, fly ash and slag was evaluated. Strength activity index, thermo-gravimetric analysis (TGA) and mortar bar tests were conducted to study the pozzolanic behavior and ASR mitigation ability.It was reported that the ternary mixtures consisting of finely ground soda glass with either slag or Class C fly ash out-performed binary mixtures consisting of each of these SCMs at an equivalent dosage level. Binary mixtures consisting of meta-kaolin outperformed ternary mixtures consisting of ground glass powder with meta-kaolin at equivalent dosage level. Among all the binary and ternary mixtures that contained 30% level of SCMs, the maximum strength activity index and the most efficient ASR mitigation was obtained in ternary mixtures consisting of at least 10% glass powder. The results from TGA studies supported these findings.[5]

Jihwan Kim, Jae-Heum Moon, Jae Won Shim, Jongsung Sim, Hyeon-Gi Lee, GoangseupZi(2014)presented in this paper Waste glass sludge (WGS), a byproduct of glass plate manufacture, was used to improve the durability properties of concrete under an environmental condition of freezing and thawing, with the existence of de-icing salts. A total of five concrete mix proportions were prepared, by varying the amounts of WGS. In order to observe the effects and roles of WGS on the durability performances of concrete mixtures, compressive strength tests, freezing and thawing tests, chloride ion penetration and surface scaling were carried out. They founded that the test results showed that the incorporation of WGS as a partial replacement for cement has beneficial effects on the compressive strength of concrete, especially when used together with fly ash. Moreover, WGS improved the resistance of freezing and thawing with and without de-icing salts, the chloride ion penetration and the resistance of surface scaling of the concrete compared to the control mixture containing 20% fly ash as cement replacement.[6]

Waste glass powder as a cement replacement material in mortar:

KavehAfshinnia and Prasada Rao Rangaraju (2015) studied that the use of waste glass, both as a crushed glass aggregate and in a finely ground form, as a pozzolanic material in concrete has been extensively studied in the past. However, the combined use of finely ground glass powders with crushed glass aggregates has not been previously explored, as this presents a unique opportunity to not only maximize the use of waste glass in concrete but also potentially address the alkali–silica reaction issues, often associated with the use of crushed glass aggregates in concrete.This study focused on studying the influence of fineness of glass powder in mitigating alkali–silica reaction in mortar specimens containing crushed glass aggregate and a natural reactive aggregate. In these studies the glass powders were used both as a cement replacement material and as an aggregate replacement material. Two different fineness of glass powder were evaluated in this study, with an average particle size of 17 and 70 microns. Mortar bars prepared with glass powder as aggregate replacement material at 10%, 20% and 30% replacement levels were evaluated in the standard ASTM C1260 test method. Mortar bars prepared with glass powder as cement replacement material at 10% and 20% were evaluated in the standard ASTM C1567 test method.It was reported that the finer glass powder showed significantly improved ability to mitigate ASR, particularly when used as an aggregate replacement material, both in the case of crushed glass and natural reactive aggregates. This study shows that an aggregate comprised of 100% glass material can be produced without any deleterious consequences of alkali–silica reaction, provided sufficient quantity of fine glass powder is used in the mixture.[7]

III. DISCUSSION

Now a days we live in the world full of growth and enthusiastic for still more comfort and facilities. This leads to innovations and revolutions in each and every field, but on contrary it has harmful effect on environment as resources get depleted and pollution to different natural sources are occurred. Glass waste as a waste has properties which has bad impact on the environment but when mix with concrete ingredients in some proportion it helps in improving the properties of concrete mix especially its strength. By adding Glass waste it can decrease the environmental pollutions and protect natural resources. According to the researches, it shows that Glass waste is give good impact in construction line.

IV. CONCLUSIONS

1. Add recycled materials may improve the durability of lightweight aggregate concrete. The waste LCD glass sand has a smooth surface. Gaps are likely to occur in the interface, but the small waste LCD glass sand can fill the gaps between the aggregate and grout to enhance the overall compressive strength.
2. There is a clear loss of the concrete’s fresh density as glass is incorporated; this is caused by the lower particle density of the glass.Generally, there was a fall in the 28-day compressive strength because of the weak interface between the glass aggregates and the hardened cement paste, for the mixes with fine GA only and the higher w/c ratio.
3. It confirms that increasing the size of the GA is beneficial for compressive strength, water absorption by capillarity and immersion, carbonation resistance and shrinkage. The main difference between the mixes with fine and coarse GA was the significant increase of the w/c ratio in the fine GA mixes to offset workability loss. The interstitial water increases the matrix voids, which leads to these mixes performing badly.
4. The WG tested in this investigation was found to slightly increase the air content of concrete, and significantly decrease the compressive strength and flexural strength of concrete in the absence and presence of SCMs such as FA or MS. With regards to the ASR, WG was found to be a highly reactive aggregate. However, the use of FA or MS was able to decrease the ASR expansion significantly.
5. The mechanical strength and durability tests that recycled glass powders exhibited pozzolanic property, and therefore, they could be used as effective supplementary cementitious materials in formulating concrete mix designs.
6. Incorporation of glass powders as cement replacement showed an overall improvement in concrete compressive strength, mortar compressive strength and flexural strength, more noticeably, at late ages of curing. The strength performance of glass powders was shown to be slightly better or similar to that of fly ash.
7. Flow of ternary blends with glass is superior over binary blends for all SCMs. Blends of glass with slag/fly ash were superior over binary blends in all regards.
8. The hybrid-incorporation of 10% WGS and 10% fly ash enhances the compressive strength of concrete.The use of WGS improves the durability of the concrete exposed to the combined action of freeze-and-thaw and de-icing salt.
9. GP when used as an aggregate material showed significant benefits in mitigating ASR.

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