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STUDY ON THE EFFECT OF WASTE GLASS POWDER AS A POZZOLANIC MATERIAL IN CONCRETE

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Abstract
Concrete is a construction material composed of Cement, fine aggregate, coarse aggregate, and water with or without admixtures. The concrete industry is one of the heaviest consumers of natural resources due to which sustainability of concrete industry is under threat. The environmental and economic concern is the greatest challenge the concrete industry is confronting. Cement manufacturing industry is one of the carbon dioxide emitting sources besides deforestation and the combustion of fossil fuels. The global warming is induced by the emission of greenhouse gases, such as CO2, to the atmosphere. Concrete mixtures were produced, tested and compared in terms of Compressive Strength, Split Tensile Strength and Flexural Strength of the conventional concrete at a period of 28 days. The role of GLP provides for considerable value-added utilization of waste glass in concrete and significant decreases in the output of greenhouse gases by the cement industry. This paper presents the feasibility of the substitution of waste glass powder for cement to achieve economical and environmentally friendly construction material.
Key words: Cement, Concrete, Pozzolanic Material, Strength, Waste Glass Powder

Introduction

Concrete is one of the most widely used construction materials in the world. Due to global warming, the need to cut down energy consumption has increased. The effect of global warming has impacted everyone on the planet and is a well-recognized concept. High levels of energy are needed to produce cement, which releases large amounts of carbon dioxide (CO2) and also contributes to the green house gases. Nevertheless, the production of Portland cement, an essential ingredient of concrete, leads to the release of significant amounts of CO2, a greenhouse gas; one ton of Portland cement clinker production is supposed to produce approximately one ton of CO2 and other greenhouse gases (GHGs). Atmospheric levels of carbon dioxide have climbed by nearly 30 percent over the past 200 years Environmental issues are playing an important role in the sustainable development of the cement and concrete industry. 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. Each year about 111 million tonnes of controlled waste from household, commercial and industrial waste is disposed of in landfill sites in the UK causing a hike in landfill costs and environmental problems. Recycling of construction waste helps in saving the limited landfill space and waste disposal costs. The energy needed to reuse the recyclable material is less than that of virgin materials. Use of recycled materials in construction is the most attractive option because of the large quantity due to widespread sites of construction. Recycled aggregates can be applied in as replacements in asphalt concrete, unbound base course, pipe bedding, landfill gas venting systems and gravel backfill for drains

Some of the industrial wastes like fly ash, ceramic waste, silica fume, marble dust, blast furnace slag, etc. have already established their usage in concrete. Recently, the research has recorded that the waste glass can be effectively applied in concrete either as glass aggregate or as a glass pozzolana. Efforts have been made in the concrete industry to use waste glass powder as partial replacement of cement. Today many researches are ongoing into the use of Portland cement replacements, using many waste materials like Pulverized Fly Ash (PFA), Ceramic Waste Powder, Ground Granulated Blast Furnace Slag (GGBS) and Marble Dust Powder etc. Like PFA and GGBS, Glass Powder (GLP) can also used as a binder with partial replacement of cement which take some part of reaction at the time of hydration, also it is act as a filler material Besides using waste glass as cullet in glass manufacturing, waste glass is crushed into specified sizes for use as aggregate in various applications such as water filtration, grit plastering, sand cover for sport turf and sand replacement in concrete.

LITERATURE REVIEW

Gunalaan et al.2001 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. Vandhiyan et al.2005 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 et al.2015 pre-

sented 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. Soroushian et al.2008 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. Gunalaan et al.2012 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 et al.2009 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 et al.2009 partially replaced cement by glass powder and stated that upto 10% it is feasible to replace cement as it showed higher compressive

S. No.	Parameters	Results
1.	Specific Gravity	2.62
2.	Fineness Modulus	2.52
3.	Silt Content (%)	2
4.	Water Absorption (%)	1.10
5.	Bulk Density (Kg/m3)	
	Loose	1585
	Compacted	1760

strength than the control mix. Vijayakumar et al.2012 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 et al.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.

MATERIALS USED

Cement

Commercially available Ordinary Portland Cement (OPC) of 43 grade manufactured by the JAYPEE Cement Company confirming to IS 8112:1989 was used as binder in the mixes[51] (Specification, Bureau of Indian Standards, New Delhi). The Physical Properties of OPC Cement are shown in Table 1.

Table 1 Physical Properties of Cement

Details	Normal Consistency (%)	Fineness of Cement (%)	Specific Gravity	Setting Time (min.)	
				Initial	Final
OPC (G-43)	32	6.5	3.15	49	610

Fine Aggregate

Fine aggregate normally consists of natural, crushed, or manufactured sand. Natural sand is the usual component for normal weight concrete. In some cases, manufactured light weight particles used for lightweight concrete and mortar. The maximum grain size and size distribution of the fine aggregate depends on the type of product being made. Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970 The Physical Properties of Fine Aggregate are shown in Table 2 .

Table 2 Physical Properties of Fine Aggerate

S. No.	Parameters	Results
1.	Specific Gravity	2.62
2.	Fineness Modulus	2.52
3.	Silt Content (%)	2
4.	Water Absorption (%)	1.10
5.	Bulk Density (Kg/m3)	
	Loose	1585
	Compacted	1760

Coarse Aggregate

Coarse Aggregate in concrete occupies 35 to 70% of the volume of the concrete. Smaller sized aggregates produce higher concrete strength. Particle shape and texture affect the workability of fresh concrete. Usually an aggregate with specific gravity more than 2.55 and absorption less than 1.5% (except for light weight aggregates) can be regarded as being of good quality. Where aggregates strength is higher, concrete strength

is also higher. Fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse aggregate are obtained from a local quarry, conforming to IS 383:1970

Waste Glass Powder

Waste glass available locally in Lucknow (Uttar Pradesh) market have been collected and made into glass powder. Glass waste is very hard material. Before adding glass powder in the concrete it is powdered to desired size. In this experiment, glass powder (GLP) ground in ball/pulverizer for a period of 30 to 60 minutes resulted in particle sizes less than size 150 µm and sieved in 75 µm was used. This material replaces the cement in mix proportion.

MIX DESIGN

The concrete mix design was proposed by using Indian Standard for control concrete. The mix design for M 40 grade concrete was carried out using IS 456:2000 [53], IS 10262:2009

The yielded mix proportions required as per design mix are given in Table 3.

Table 3 Mix Proportions for M-40 Grade of Concrete

Quantity of Materials (kg)					
w/c ratio	Cement	Fine Aggregate	Coarse Aggregate	Water	Chemical Admixture
0.38	414.70	617.80	1239.69	157.6	4.147

EXPERIMENTAL METHODOLOGY

The quantities of the constituents of the concrete were obtained from the Indian Standard Mix Design Method (IS: 10262- 2009)

- The study is conducted to analyze the Compressive Strength, Split Tensile Strength, Flexural Strength of concrete when the base materials, i.e. Cement is replaced with waste glass powder (GLP).
- The moulds used for cubes, beams and cylinders were of steel having an internal dimension of 150mm× 150mm × 150mm for cube, 100mm × 100mm × 500mm for beam, 150mm × 300mm for cylinder.
- The cement, coarse and fine aggregate were mixed thoroughly with the help of mechanical mixer. For all test specimens, moulds were kept on table vibrator and the concrete was poured into the moulds in three layers by tamping with a tamping rod and the vibration was effected by table vibrator after filling up the moulds.
- The moulds are kept in vibration for a minute and it was maintained constant for all specimens.
- Compressive strength tests were done on compression testing machine using cube samples.
- Split Tensile Strength Test and Flexural Strength Test were performed on Universal Testing Machine using cylinders and beams. Three samples per batch were tested with the average strength values reported in this paper.
- The waste glass powder was varied in fraction of 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45% and 50% by weight of M-40 grade concrete. In all total 33 cubes, 33 cylinders and 33 beams of OPC were examined and results were analyzed after curing the specimen for a period of 28 days.

RESULTS AND DISCUSSION

The influence of waste glass powder on the properties of concrete such as the compressive strength, Split Tensile Strength and Flexural Strength were studied. An appreciable increase in the compressive strength is observed with the increase in the percentage replacement of cement by glass powder from 5% to 15%.

The maximum values of Compressive Strength, Split Tensile Strength and Flexural Strength were found at 10% replacement of cement by glass powder. With 10% replacement of cement by waste glass powder the increase in compressive strength was 16.56%, split tensile strength was 7.16% and flexural strength was 6.57%. However, the strength increase has taken place because of pozzolanic action of glass powder. Since, the glass powder acts as a pozzolanic material the affect of carbonation is reduced and the durability of concrete increases. Therefore, the smaller particle size of the glass powder has higher activity with lime present in the cement resulting in higher compressive strength in the concrete mix. Therefore, upto 20% replacement of cement by waste glass powder the concrete gives satisfactory strength results in terms of compressive strength, split tensile strength and flexural strength for M-40 grade.

CONCLUSION

In the present research study, the influence of replacement of cement on Strength of Concrete (M-40) i.e, Compressive Strength, Split Tensile Strength and Flexural Strength by waste glass powder has been studied. Based on the results and observations of experimental work conducted, the following conclusions were drawn:

- At period of 28 days, Conventional Concrete

shows the Compressive Strength as 47.52 MPa, Split Tensile Strength as 6.42 MPa and Flexural Strength as 8.25 MPa.

- The maximum values of Compressive Strength, Split Tensile Strength and Flexural Strength were found at 10% replacement of cement by glass powder. With 10% replacement of cement by waste glass powder the increase in compressive strength was 16.56%, split tensile strength was 7.16% and flexural strength was 6.57%.
- With 20% replacement of cement by waste glass powder the compressive strength was 46.54 MPa, split tensile strength was 6.23 MPa and flexural strength was 8.35 MPa.
- However, upto 20% replacement of cement by waste glass powder the concrete gives satisfactory strength results in terms of compressive strength, split tensile strength and flexural strength for M-40 grade.

- Therefore, considering the strength criteria of concrete, the replacement of cement by waste glass powder is feasible upto 20%.
- Very finely ground waste glass powder have shown to be an excellent filler and may have sufficient pozzolanic properties to serve as partial cement replacement. Thus, reducing the use of cement and the associated energy demand and impact on air pollution and CO2 emission.
- Usage of waste glass powder in concrete can prove to be economical as it is very much cheaper than cement.
- Use of waste glass powder in concrete will reduce the disposal problem of waste glass and proves to be environmental friendly construction material.

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