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EFFECT OF PARTIAL REPLACEMENT OF CEMENT WITH WASTE GLASS ON THE PROPERTIES OF CONCRETE

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ABSTRACT
Million tons of waste glass is being generated annually all over the world. Once the glass becomes a waste it is disposed as landfills, which is unsustainable as this does not decompose in the environment. Glass is principally composed of silica. Use of milled (ground) waste glass in concrete as partial replacement of cement could be an important step toward development of sustainable (environmentally friendly, energy-efficient and economical) infrastructure systems. When waste glass is milled down to micro size particles, it is expected to undergo pozzolanic reactions with cement hydrates, forming secondary Calcium Silicate Hydrate (C–S–H).However, the chemical composition and the pozzolanic properties of waste glass are encouraging for the use of this waste in the cement and concrete industries to provide an environmental friendly solution. This project work reviews the different proportion of waste glass and fly ash can be used in cement and the effect of the glass properties on the performance and durability of the produce concrete is carried out. The compressive strength test results indicated that recycled glass concrete gave better strength compared to control samples. A 20% replacement of cement with waste glass and fly ash was found to giving convincing results compare to other samples in this project we have consider M_{30} grade of concrete.

Keywords: *Waste glass, pozzolanic material, Fly ash & compressive strength.*

I. INTRODUCTION

1.0 General
Concrete is a worldwide composite material consisting of cement, Aggregates (coarse, fine) and water in suitable proportion. The chemical reaction wedged between the cement and water binds the aggregates into a hard mass. Fresh concrete will be plastic, in order that it can be moulded into require size and shape in the moulds. Water have to be applied for few days over the concrete surface soon after its setting because the hydration reactions takes place between the cement and water continue for a long period due to which hardening of concrete takes place. This period when the concrete is kept moist during which concrete gains strength is called curing period. Hence, the strength of concrete increases with age. The process of solidification of concrete from plastic stage is called setting while gaining of strength after setting is called hardening. Usually setting completes within a maximum duration of 10 hours, while about 90% hardening is completed by 28 days. Concrete is a construction material which is mainly used in the world.

The cement binds the concrete ingredients like a hard stone. The bond between aggregates and the cement paste is an important factor in the strength of concrete especially in the flexural strength. The shape of the aggregate is also an important factor in forming the bond between aggregates and cement. Angular shape aggregates gives good bond where as rounded shape aggregates gives less bond strength between aggregates and cement. In general an aggregate with high strength and high modulus of elasticity produces generally a concrete with high strength and high modulus of elasticity. The compressive strength of concrete depends on the composition of texture and structure of aggregates. The size of aggregates to be used in concrete varies from 150 microns to 75mm. according to Indian

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Standard the fine aggregates should pass through 4.75mm IS sieve and coarse aggregates must retained on 4.75mm IS sieve. According to Indian standard the maximum nominal size of coarse aggregate should not be greater than ¼ th the minimum thickness of the member. The properties and quality of cement concrete are influenced by the properties of its ingredients and quality control maintained during its making and curing.

The growing concern of resource depletion and global pollution has challenged many researchers to seek and develop new materials relying on renewable resources. These include the use of by-products and waste materials for building construction.

1.1 Scope of the Work

The main aim of this study is to assess the utility and efficacy use of waste glass and fly ash which are obtained from dumping yard and thermal plant can be used to produce superior concrete which is no way inferior to Normal concrete and by doing so to recycle the waste products and to decrease the construction cost of buildings.

1.2 Why the use of waste glass and fly ash

Glass is an amorphous solid that has been found in various forms for thousands of years and has been manufactured for human use since 12,000 BC. Glass is one the most versatile substances on Earth, used in many applications and in a wide variety of forms, from plain clears glass to tempered and tinted varieties, and so forth. Due to lack of facilities to recycle plants once the glass becomes a waste it is disposed as landfills, which is unsustainable as this does not decompose in the environment at this also lead to environmental pollution so we are use waste glass in the production of concrete so that to reduce environmental pollution and to reduce the construction cost of project.

Fly ash is a by product obtained from thermal power plants Fly ash is largely made up of calcium oxide and silicon dioxide which can be used as a substitute or as a supplent for Portland cement. Fly ash is also known as **Green concrete**.

1.3 Waste Materials in India

Approximately all over the world, various measures designed for reducing the use of prime aggregates and increasing the reuse and recycling have been introduced, where it is theoretically, economically, or environmentally suitable. As a result, in developing countries like India, the informal sector and secondary industries recycle 15–20% of solid wastes in various building materials and components.

As a part of integrated solid waste management plan that includes recycle, reuse and recovery, the disposed solid squander, representing unused resources, may be used as low cost materials. Currently in India, about 960 MT of solid wastes are being generated annually as by-products from industrial, mining, municipal, agricultural and other processes. Of this 350 MT are organic wastes from agricultural sources; 290 MT are inorganic wastes of industrial and mining sectors 10-12MT of Construction and Demolition (C&D) squander annually.

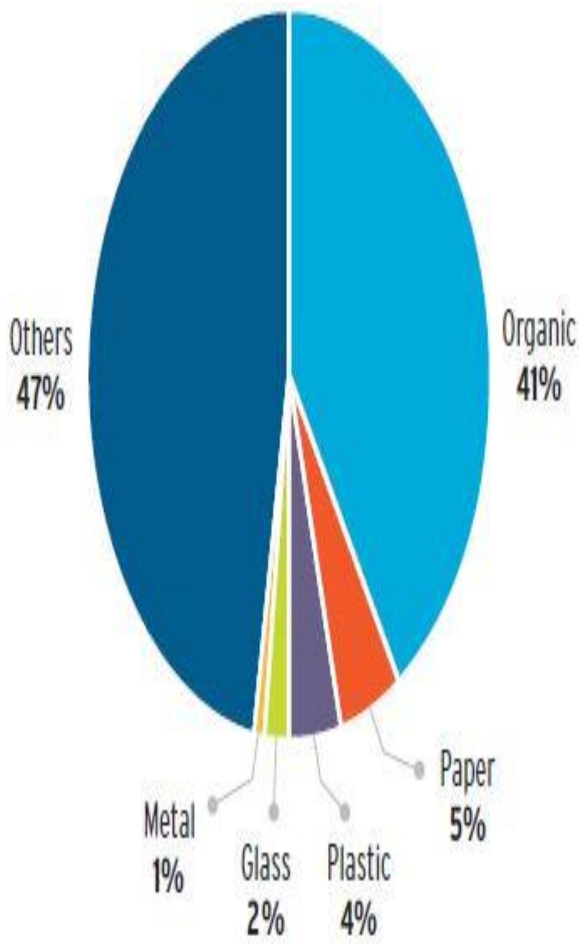

Figure 1. Waste material in India

Table 1. Quantity of various constituents generated per year.

Constituent	% of waste generated in India
organic	41
others	47
Metal	1
glass	2
paper	5
plastic	4

The above shows the percentages of solid waste generated in India the waste material are recycled by using land filling and inclination process but the material like glass cannot be decompose so alternative method should adopt to recycle the waste glass materials.

Figure 2. Waste glass bottle in dumping yards

1.4 Effect of glass utilization on compressive and tensile strength of concrete

Hence interest of the construction community in using waste or recycled materials in concrete is increasing. Many attempts have been made by various researchers to utilize waste glass as coarse aggregates, fine aggregates or as a partial replacement of cement with variation in particle size having different proportions and in various types of concretes by using the glass material they have achieved significant results when compare to normal concrete.

1.5 Objectives of the Research

Objectives of the experimental investigation are as follows:

1) To study the properties of fresh concrete this is cast by using waste glass and fly ash powder.
2) To study mechanical properties such as compressive and split tensile strength at the end of 7 and 28 days of curing by partially replacing cement waste glass powder and fly ash powder under normal.
3) To reduce environmental pollution by utilizing waste material in concrete.
4) To reduce hazardous pollution caused due to waste glass and fly ash.

II. LITERATURE REVIEW

As of 2005, the total global waste glass production estimate was 130 Mt, in which the European Union, China and USA produced approximately 33 Mt, 32 Mt and 20 Mt, respectively (IEA, 2007; Rashed, 2014).

Being non-biodegradable in nature, glass disposal as landfill has environmental impacts and also could be expensive. Sustainable construction practice means creation and responsible management of a healthy built environment considering resource efficiency and ecology .

Being versatile and economical, concrete became prime construction material over the world; however, it has impacts on the environment Manufacturing of cement (key ingredient used for the production of concrete) is a major source of greenhouse gas emissions. The use of supplementary cementitious materials (SCMs) to offset a portion of the cement in concrete is a promising method for reducing the environmental impact from the industry. Several industrial byproducts have been used successfully as SCMs, including silica fume (SF), ground granulated blast furnace slag (GGBS) and fly ash. These materials are used to create blended cements which can improve concrete durability, early and long term strength, workability and economy.

Another material which has potential as a SCM, however, has not yet achieved the same commercial success is waste glass. Researches indicated that glass has a chemical composition and phase comparable to traditional SCMs (Ryou et al., 2006; Binici et al., 2007; Nassar and Soroushian, 2012). It is abundant, can be of low economic value and is often land filled.

Milling of glass to micro-meter scale particle size, for enhancing the reactions between glass and cement hydrates, can bring major energy, environmental and economic benefits when cement is partially replaced with milled waste glass for production of concrete. Studies also focused on used of waste glass as aggregate in concrete production (Rashed, 2014; Taha and Nounu, 2009). Study on durability of concrete with waste glass pointed better performance against chloride permeability in long term but there is concern about alkali-silica reaction. Deleterious chemical constituents include sulfides, sulfates, and alkalis (which add more alkali to concrete) create higher risk of ASR over the life of the concrete. A good pozzolan functions both to mitigate ASR and to consume the lime to greatly reduce efflorescence (Matos and Sousa-Coutinho, 2012; Rashed, 2014). Utilization of waste glass in ceramic and brick manufacturing process is discussed in a recent study (Andreola et al., 2016).

The properties influence the pozzolanic behavior of waste glass and most pozzolans in concrete, are fineness, chemical composition, and the pore solution present for reaction (Imbabi et al., 2012; Rashad, 2015). The pozzolanic properties of glass were first notable at particle sizes below approximately 300 lm, and below 100 lm, glass can have a pozzolanic reactivity at low cement replacement levels after 90 days of curing (Shi et al., 2005). This size can be achieved by using a grinding operation with the help of ‘‘Ball Mill” which is generally used in cement industry to grind cement clinker.

Several researches show that, at the higher age recycled glass concrete (15% to 20% of cement replaced) with milled waste glass powder provides compressive strengths exceeding those of control concrete (Nassar and Soroushian, 2011). However, review study by Rashed (2014) showed that previous studies with glass addition were not conclusive considering workability and strength while the chloride resistance of glass added concrete was found to be similar with control condition. This research examined the potential of waste glass powder to produce sustainable concrete. Experimental work was carried out on the performance of glass in mortar and concrete. Mortar samples were prepared to evaluate the flow and strength properties. Furthermore, compressive strength of concrete cube samples was also determined by crushing it. In addition, the study discussed the packing and pozzolanic effect of glass by using super plasticizer in selected mortar samples.

III. MATERIAL AND METHODOLOGY

The materials used in this experiment were Cement, fly ash, Sand, coarse aggregate, coconut shell and water.
Cement: OPC 53 grade cement from a single batch will be used throughout the course of the project work. The properties of cement used are shown in table below.

Table 2. Physical Properties of O.P.C (Ordinary Portland cement)

S.No.	Property	Test Method	Test Result
1	Initial Setting time	Vicat apparatus (IS 4031-Part 5)	42 min
2	Normal Consistency	Vicat apparatus (IS 4031-Part 4)	33 %
3	Fineness	Sieve test on sieve no.9 (IS 4031-part11)	7% Residue
4	Specific Gravity of Cement	Specific gravity bottle	3.05
5	Final setting time	Vicat apparatus	308min

Fine aggregate: Fine aggregate used in the experiments was locally available river sand conforming to IS 383-1970(6). The physical properties of the fine aggregates were tested in accordance with IS 2386(10).

Table 3. Physical properties of Fine Aggregate

S. No.	*Property*	Test Method	Value
1	Fineness modulus	Sieve analysis (IS 2386-1963 Part 2)	3.13
2	Specific gravity	Pycnometer (IS 2386-1963 Part 3)	2.6
3	Bulk density (kg/m^3)	(IS 2386-1963 Part 3)	1830
4	Water absorption	(IS 2386-1963 Part 3)	1.02%

Coarse Aggregate: The coarse aggregate used in this study was crushed granite of maximum size 20 mm obtained from the local crushing plant. The physical properties of the coarse aggregate were tested in accordance with IS 2386(10).

Table 4.Physical properties of Coarse Aggregate (20mm)

S.No.	Property	Test Method	Value
1	Fineness modulus	Sieve analysis (IS 2386-1963 Part 2)	4.23
2	Specific gravity	Pycnometer (IS 2386-1963 Part 3)	2.73
3	Bulk density (kg/m3)	(IS 2386-1963 Part 3)	1340

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Glass Powder

Glass powder is obtained from the waste glasses bottle and pieces from the dump yard. The collected waste glasses are to be crushed in to powder to get the particle mix passing through 75 micron sieve to get the grading of cement.

Figure 3. Waste glass bottles

Table 5. Properties of Waste glass

Properties	Glass powder
Specific gravity	2.52
Bulk density	970kg/m3
Colour	white
Fineness modulus	<75um

 ISSN 2348 – 8034
Impact Factor- 5.070

Figure 4. Glass powder

Table 6. Chemical constituents of glass powder

Minerals	Percentage
Silica (Sio2)	50-80%
Alumina(Al_2O_3)	1-10%
Iron oxide(Fe_2O_3)	< 1%
Calcium oxide(Cao_3)	5-15%
Magnesium oxide	<1.5%
Sodium oxide	1-1.5%

Fly Ash: Fly ash or pounded fuel-ash is a build up from the ignition of pummelled coal gathered by mechanical separators, from the fuel gasses of warm plants. comprises generally of silicon dioxide (SiO2), aluminium oxide (Al2O3) and iron oxide (Fe2O3), and is henceforth a reasonable wellspring of aluminium and silicon for geo polymers. They are additionally pozzolanic in nature and respond with calcium hydroxide and soluble base to shape Calcium Silicate Hydrates (C – S – H).The normal molecule size of fly ash is around 20 microns, which is like the normal molecule size of Portland bond. Particles below10 microns give the early quality in concrete, while particles in the vicinity of 10 and 45 microns respond all the more gradually. Fig.1.1 demonstrates the SEM micrograph of fly ash particles. The particular gravity of fly ash particles extends between 2.0 to 2.4 contingents upon the wellspring of coal. The fineness of fly ash is in the scope of 250 - 600 m2/kg.

ISSN 2348 – 8034
Impact Factor- 5.070

Table 7: properties of Fly ash

S.NO	PHYSICAL PROPERTIES	TEST RESULTS	Specification As per IS: 3812-1981
1.	Bulk density(Kg/M^3)	1010	1120
2.	Specific gravity	2.22	to 2.42

Water: Normal portable water obtained from Municipal water supply was used for the experiment.

Chemical admixture

Cemcrete SP25:

The basic components of CEMCRETE SP are synthetic polymers, which allow mixing water to be reduced considerably and concrete strength to be enhanced significantly, particularly at the early ages. CEMCRETE SP is chloride free product.

Table 8. Properties of admixture

Colour	Brown
Specific gravity	1.20+0.035
Chloride content	Nil to BS 5075 to I.S:456-78
Nitrate content	Nil
Freezing point	0°C
Air entrainment	Maximum 0.5%

Dosage:

0.2 to 0.5% by weight of the cement depending upon the situation of the materials and conditions. Trail mixes are recommended prior to production of concrete.

IV. NORMAL CONCRETE MIX DESIGN

Concrete mix design is defined as the appropriate selection and proportioning of constituents to produce a concrete with pre-defined characteristics in the fresh and hardened states.

In the present study M_{30} grade concrete is used for the water cement ratio of 0.45

Following are the mixes considered for the study

NC - 100% Cement
GFC1 - 5% glass powder + 5% Fly ash+ 90 % cement
GFC2 - 10% glass powder + 5% Fly ash + 85 % cement
GFC3 - 10% glass powder + 10% Fly ash + 80 % cement
GFC4 - 15% glass powder + 5% Fly ash + 80 % cement
GFC5 - 15% glass powder + 10% Fly ash + 75 % cement

4.1 Compressive strength: results of cubes for 7 & 28 days

Table 9 Mix details for m30 concrete (1:1.58:2.85)

Sample	7days compressive strength KN/m^2	28 days compressive strength KN/m^2
NC	23.52	34
GFC1	24.91	35.24
GFC2	26.18	38.69
GFC3	29.40	42.44
GFC4	26.12	37.28
GFC5	24.64	32.13
GFC6	20.94	28.85

Figure 5. Compressive strength of samples at 7 & 28 days

The following bar chart showing the values of normal and different replaced proportions of Compressive strength of concrete for 7 & 28 days and it shows that sample GFC4 which is 10 % Glass + 10 % fly ash replaced for cement gives high strength when compare with the rest of the samples.

4.2 Split Tensile Strength

Tensile strength is one of the basic and important properties of concrete. Knowledge of its value is required for the design of concrete structural elements subject to transverse shear, torsion, shrinkage and temperature effects. Its

ISSN 2348 – 8034
Impact Factor- 5.070

value is also used in the design of pre-stressed concrete structures, liquid retaining structures etc. The cylindrical specimen shall have diameter not less than four times the maximum size of the coarse aggregate and not less than 150 mm. The length of the specimens shall not be less than the diameter and not more than twice the diameter.

Table 10.Split Tensile Strength of different proportional's of concrete for 7 and 28 days

Sample	7days compressive strength (KN/m^2)	28 days compressive strength (KN/m^2)
NC	1.29	3.18
GFC1	1.64	3.28
GFC2	2.27	3.48
GFC3	2.62	4.23
GFC4	1.84	3.02
GFC5	1.44	2.48
GFC6	1.07	2.18

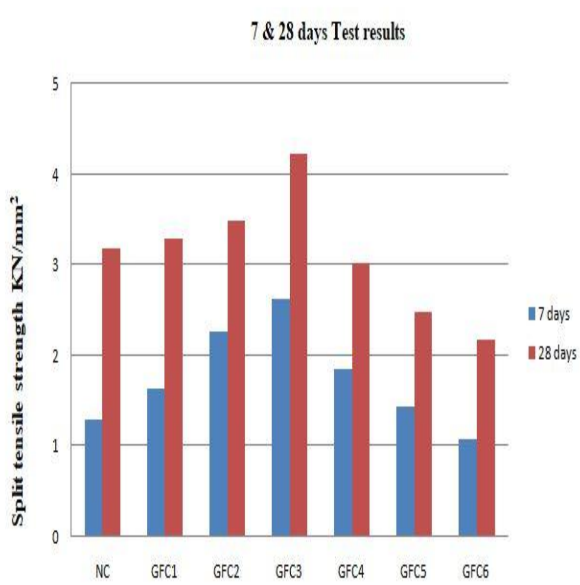

Figure 6. Split Tensile strength of samples at 7 & 28 days

The following bar chart showing the values of normal and different replaced proportions of Split Tensile strength of concrete for 7 & 28 days and it shows GFC4 sample which is 10% glass + 10% fly ash replaced for cement gives high strength when compare with the rest of the samples.

Result

The Test results shows that the values of normal and different replaced proportions of Compressive strength of concrete for 7 & 28 days and it shows that sample GFC4 which is 10% glass + 10% fly ash replaced for cement gives high strength when compare with the rest of the samples.

V. CONCLUSION

The purpose of the research is to determine the mechanical properties of concrete specimens in which and cement is replaced with waste glass and fly ash. So that to utilise the waste product and to reduce the construction cost of buildings.

The following conclusions are made based on the above study:

- The 7 days and 28 days compressive strengths of concrete increase initially as the replacement percentage of cement with glass powder and fly ash increases, and become maximum at about 10% glass and 10% fly ash sample and later decreases.
- The split tensile strength of concrete increases initially as the replacement percentage of cement with glass powder increases, and becomes maximum at about 10% glass and 10% fly ash sample and later decrease.
- The present study shows that there is a great potential for the utilization of glass powder in concrete as partial replacement of cement. About 20% of cement may be replaced with glass powder and fly ash size less than 70 µm without any sacrifice on the compressive strength.

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