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GLIMECRETE:An experimental study on partial replacement of cement with waste glass powder and adding lime, natural adhesive in concrete.

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ABSTRACT

Glimecrete is a concrete in which glass powder is used as a partial replacement of cement and lime and natural adhesive is added to it. The air pollution and global warming is caused due to the effect of greenhouse gases such as CO_2. Among all the greenhouse gases CO_2 contributes major role. The cement industries contributes about 7% of greenhouse gas emission globally to the earth's atmosphere. The glass is non-biodegradable material of which concentration is increasing on earth as a waste material. Glass is a material which can be used many times without changing its chemical properties. In this research effort have been made in concrete to use waste glass powder as a partial replacement of cement. Waste glass powder is a material which when grounded to a very fine particle shows a pozzolanic properties which gives strength to the concrete. The cement replacement by glass powder is in the range 10% to 30% at increment rate of 10% is has been studied. Lime is added in the proportion to provide the sufficient lime in concrete due to reduction of cement. To study this concrete cube is made and tested for compressive strength at the age of 7, 14 and 28 days and studying its economic prospects and environmental aspects and compared with those of conventional concrete. Consequently, we would like to enhance the strength by using the waste glass powder and making it eco-friendly and economical.

Keywords: - *Concrete, Glass Powder,Glimecrete, Global warming, Pozzolanic properties, Strength.*

1. INTRODUCTION

As we all know that concrete is one of the world's most used construction material due to its versatility, durability and economy. India uses about 7.3 million cubic meters of ready-mixed concrete per year. It find its application in highways, streets, bridges, skyscrapers, dams etc. Greenhouse gas like CO2 leads to global warming and it contributes to about 65% of global warming. The global cement industry emits about 7% of greenhouse gas to the atmosphere. To reduce this environmental impact alternative binders are introduced to make concrete Glass is an amorphous material with high silica content making it potentially pozzolanic when

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particle size is less than 75µm. The main problem in using crushed glass as aggregate in Portland cement concrete are expansion and cracking caused by the glass aggregate due to alkali silica reaction. Due to its silica content ground glass is considered a pozzolanic material and as such can exhibit properties similar to other pozzolanic material. In this study, finely powdered waste glasses are used as a partial replacement of cement in concrete, along with this certain proportion of lime is also added to it and compared it with conventional concrete. The concrete is made with replacing cement with waste glass powder and lime is added in the proportion to provide the sufficient lime in concrete due to reduction of cement. The excess silica in glass powder makes setting time of cement slow. But addition of lime in it maintains the setting time cement by increasing it. Along with lime, adhesive latex is added to provide bonding to the concrete. Concrete mixtures were prepared with different proportions of glass powder ranging from 0 to 30% with an increment of 10% and tested for compressive strength after 7, 14 and 28 days of curing.

2. MATERIAL AND METHODS

2.1. CEMENT

The cement used in this study was 43 grade Ordinary Portland Cement (OPC) confirming to IS 8112-1989.

2.2. FINE AGGREGATE

Locally available sand confirming to zone II with specific gravity 2.55 was used. The testing of sand was done as per Indian Standard Specification IS: 383-1970.

2.3. COARSE AGGREGATE

Coarse aggregate used was 20mm and down size and specific gravity 2.6. Testing was done as per Indian Standard Specification IS: 383-1970.

2.4. GLASS

Waste glass available locally was collected and made into glass powder. Before adding glass powder in the concrete it has to be powdered to desired size. In this project glass powder is grounded to size 75 micron as it possess pozzolanic properties. Glass Powder–Glass is an amorphous (non-crystalline) that in essence, a super cooled liquid and not a solid. Glass can be made with excellent homogeneity in a variety of forms and sizes from small fibers to meter-sizes pieces.

Primarily glass is made up of sand, soda ash, limestone and other additives (Iron, Chromium, Alumina, Lead and Cobalt). Glass has been used as aggregates in construction of road, building and masonry materials.

Applications & Properties of Glass–Glass is a uniform amorphous solid material, which is generally produced when the viscousmolten material cools very rapidly to below its glass transition temperature, without giving sufficient time for a regular crystal lattice to form. The most familiar form of glass is the silica-based material used for windows, containers and decorative objects. Glass falls in the category of biologically inactive material that can be formed with very smooth and impervious surfaces.

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TABLE I

Physical properties of glass powder

S.No	Physical Properties of Glass Powder	
1	Specific gravity	2.6
2	Fineness Passing 150µm	99.5
3	Fineness Passing 90µm	98

TABLE II

Chemical properties of glass powder

S.No	Chemical Properties of Glass Powder	
1	pH	10.25
2	Color	Grayish white

TABLE III

Chemical Composition of Glass Powder and Cement		
Item	% By Mass In	
	Glass Powder	Cement
SiO_2	72.5	20.2
Na_2O	13.7	0.19
CaO	9.79.7	61.9
Al_2O_3	0.4	4.7
MgO	3.3	2.6
K_2O	0.1	0.82
SO_3	3.0	0
Fe_2O_3	0.2	3.9

2.5. LIME

Natural Lime powder: The natural lime powder is normally available in coal seam fires and volcanic ejecta. In ancient days, this material was used to make constructions. It has a good adhesive property. In Engineering sector it has been using mortar, concrete, cement.Lime act as a flux which also results in maintaining fusion property in concrete. Natural lime can arrest the moisture content itself. So then it is reduce the curing age. In our project the lime powder contributes 20% of partially replacement of cement content and its specific gravity 2.67.

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Properties of LIME– *Calcium* hydroxide (Lime) is relatively insoluble in water, with a solubility product Ksp of 5.5 × 10−6. It is large enough that its solutions are basic according to the following reaction:

$$Ca(OH)_2 \rightarrow Ca_2^+ + 2\ OH^-$$

At ambient temperature, calcium hydroxide (portlandite) dissolves in pure water to produce an alkaline solution with a pH of about 12.4. Calcium hydroxide solutions can cause chemical burns. At high pH value (see common ion effect), its solubility drastically decreases. This behavior is relevant to cement pastes. Its aqueous solutions is called limewater and is a medium strength base that reacts.

3. EXPERIMENTAL WORK

3.1. MIX DESIGN

The concrete mix design was proposed by using Indian Standard for control concrete. The grade was M30. The mixture will be prepared with the cement content of 374.5kg/m3 and water to cement ratio of 0.40. The mix proportion of materials is 1:1.8:3.7 as per IS 10262-2009. Then natural fine aggregate was used. The replacement levels of cement, glass powder were used in terms of 10%, 20% and 30% in concrete. Chemical admixture is not used here.

3.2. DURABILITY TEST

The concrete prepared with various percentage replacement of the cement such as 10%, 20% and 30% was cured under normal condition as per IS recommendation and were tested at 7 days, 14 days and 28 days for determining the compressive strength and also compared with the test results of conventional concrete.

3.3. WORKABILITY TEST

Workability is the property of freshly mixed concrete that determines the ease with which it can be properly mixed, placed, consolidated and finished without segregation. The workability of fresh concrete was measured by means of the conventional slump test as per IS; 1199(1989). Before the fresh concrete was cast into moulds, the slump value of the fresh concrete was measured using slump cone. In this project work, the slump value of fresh concrete was maintained in the range of 70mm to 100mm.

4. DISCUSSION ON TEST RESULTS

4.1. WORKABILITY

As the glass content increases (i.e. cement content decreased) workability decreases. As there is a reduction in fineness modulus of cementitious material, quantity of cement paste available is less for providing lubricating effect per unit surface area of aggregate. Therefore, there is a restrain on the mobility.

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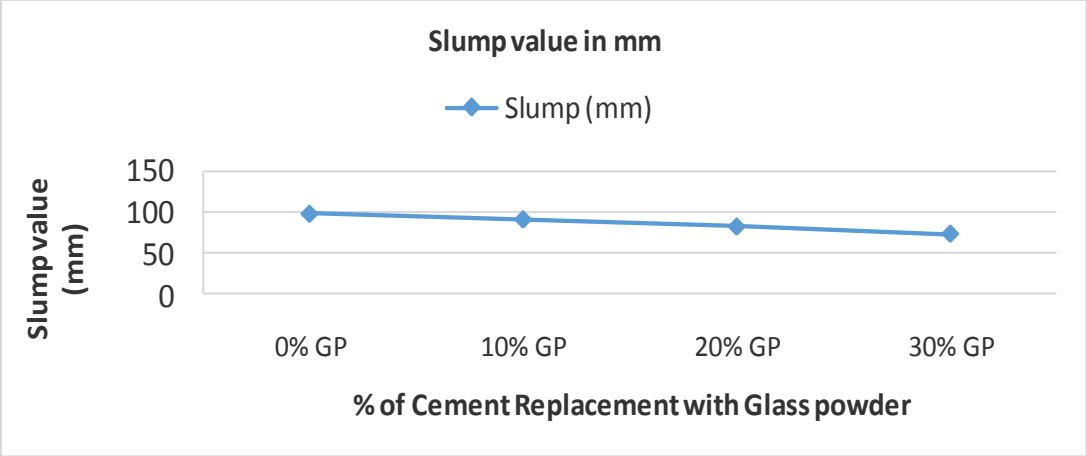
TABLE IV

Slump of Concrete With Cement Replaced Partially By Glass Powder		
Mix designation	**% of Replacement of Cement By Glass powder**	**Slump (mm)**
Mix-1	0	98
Mix-2	10	91
Mix-3	20	82
Mix-4	30	73

4.2. STRENGTH

As the percentage of replacement of cement with glass powder increases strength increases up to 20% and beyond that it decreases. The increase in strength up to 20% replacement of cement by glass powder may be due to the pozzolanic reaction of glass powder due to high silica content. Also it effectively fills the voids and gives a dense concrete microstructure. However, beyond 20%, the dilution effect takes over and the strength starts to drop. Thus it can be concluded that 20% was the optimum level for replacement of cement with glass powder. The strength improvement at early curing ages was slow due to pore filling effect. Later waste glass powder on



hydration liberates sufficient amount of lime for starting the secondary pozzolanic reaction leading to more quantity of C-S-H gel getting formed.

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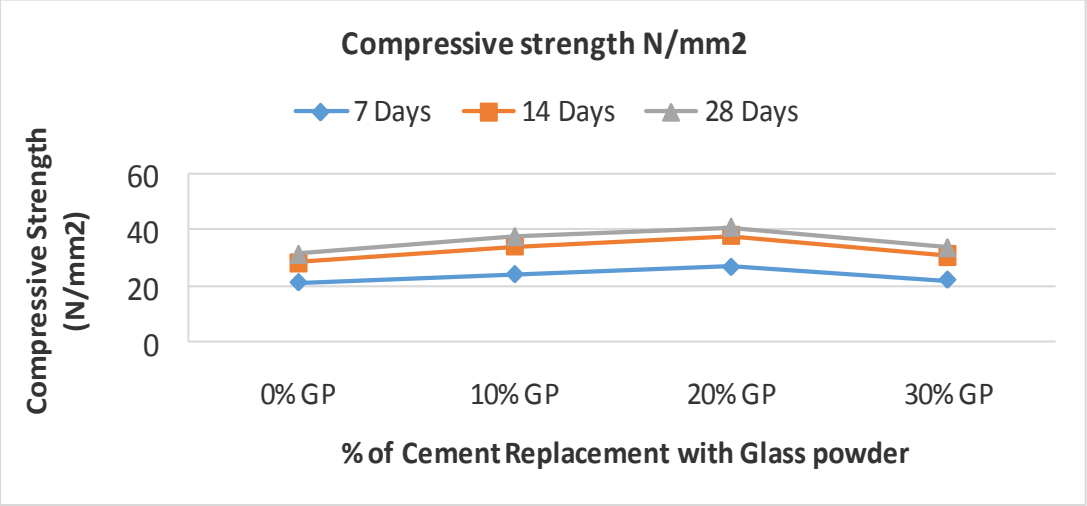
TABLE V

Compressive Strength of Concrete With Cement Partially Replaced By Glass Powder					
Mix Samples	**% of Replacement of Cement By Glass powder**	**% of lime added by weight of cement**	**7 days**	**14 days**	**28 days**
Mix-1	0	0	21.21	28.47	31.64
Mix-2	10	5	24.18	34.10	37.86
Mix-3	20	10	26.83	37.83	41.13
Mix-4	30	15	22.16	30.96	33.98



5. CONCLUSIONS

Based on experimental observations, the following conclusions are drawn:

1. As the percentage of glass powder increases the workability decreases. Use of super plasticizer was found to be necessary to maintain workability with restricted water cement ratio.
2. Compressive strength increases with increase in percentage of glass powder up to 20% replacement and beyond 20% strength decreases.
3. Considering the strength criteria, the replacement of cement by glass powder is feasible. Therefore we can conclude that the utilization of waste glass powder in concrete as cement replacement is possible.
4. Very finely ground glass has been shown to be excellent filler and may have sufficient pozzolonic properties to serve as partial cement replacement, the effect of ASR appear to be reduced with finer glass particles, with replacement level.
5. The silica in glass reduces the setting time of cement but addition of lime maintains it back.
6. Addition of lime increases workability as well as enhances compressive strength.

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7. Lime also increases the bonding property of cement.

6. FUTURE RESEARCH

1. Determine the effect of glass powder on concrete with the replacement of combination of coarse and fine aggregate.
2. Replacement of cement with glass powder in different water cement ratio.
3. In the present study the ordinary Portland cement was used. Further its mechanical properties can be compared by using different cement.
4. Study on replacing coarse aggregate with glass pieces can be carried out.

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