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Utilization of Waste Glass Powder as a Replacement of Cement in Concrete

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***Abstract*: A glass is defined as an inorganic product of fusion which has been cooled to a rigid condition without crystallization. From this definition, a glass is a non-crystalline product obtained by melt quenching process. Glass Wastes are produced by the industries irrespective of the nature of their products. Disposing the waste glass powder is a challenging thing for industries. Industrial wastes such as fly ash, silica fume, blast furnace slag and other wastes like plastics, glass and agricultural wastes are polluting environment. The concrete industry is making use of these industrial wastes in the production of concrete mix. Generally, waste materials such as fly ash, silica fume and blast furnace slag in concrete act like pozzolana and replace some part of cement. When waste glass material ground to a very fine powder form it shows pozzolanic properties as it contains high SiO_2 and hence to some amount can replace cement in concrete and contribute in strength development.**

The objective of this study is to analyze the effect of addition of glass powder on the various properties of concrete. The glass powder is used as alternate over cement in the concrete mix. Crumb rubber is prepared from the scraps of glass. In this study cement is replaced by 5%, 10% & 15% glass powder. The glass concrete is tested for slump and compression strength. It is found that the slump of glass concrete increases first but at certain place amount of glass increases slump start decreases. It is observed that initial compression strength of glass concrete reduced significantly but the final strength is found to be more than that of ordinary concrete.

***Keywords*: Waste glass powder, Replacement of cement.**

1. Introduction

Due to fast industrialization and urbanization in the Country, many infrastructure developments are taking place. This process has in turn led questions to mankind to solve the problems generated by this growth. The problems defined are acute shortage of constructional materials, increased dumping of waste products. Hence in order to overcome the above said problems waste products should be employed as construction material. Cement used in concrete is partially replaced by fine crushed waste glass powder in known percentages and the optimum percentage at which higher strength is obtained is being calculated because waste glass powder is widely available and not biodegradable.

The sources of production of numerous waste materials are manufacturing processes, service industries and municipal solid wastes. The Concerns deals with disposal of the created wastes have greatly increased with the increasing awareness about the environment. Solid waste management is the big environmental concerns in the world. Waste utilization has become an alternative to disposal because of the space for land filling and due to its ever increasing cost. The use of waste products in concrete not only makes it cost efficient, but also helps in reduction of disposing methods. Reuse of wet wastes is considered the best environmental alternative for resolving the problem of disposal. One such waste is plastic, which could be used in various applications According to the World Commission on Environment and Development: sustainability means “Meeting the needs of the present without compromising the ability of the future generations to meet their own needs”. Sustainability is an idea for concern for the well-being of our planet with continued growth and human development.

2. Waste Glass and its source

Due to vast and rapid industrialization in the field of glass industries, the production of aesthetic and shining glass making has increased the production of waste glass powder which remained as a precipitate. Huge amount of waste glass powder had generated from all these industries. These waste glass powder is generally of no use which has been thrown outside in the environment before a time, but recent development in the field of these waste glass powder can be utilized as a partial replacement to cement in concrete which gives better strength, durability to concrete and increase its life span and service life by increasing strength. So the glass finishing and decorative glass material industries are the major and main source of waste glass powder.

3. Experimental program

Experimentation and examination have been carried out on the waste rubber specimens to determine the workability, compressive strength, split tensile strength of the designed trial mixes.

A. Materials Used

Natural aggregates are used as per IS 383-1970 and sand is taken as per requirements of IS 383-2007. Portland pozzolona cement of 53 grade is used as per IS 1489-1991 Waste glass powder as replacement for cement.

B. *Mix Design for concrete*

Since there are various methods for mix design suitable for M25, a simplified mix design procedure, is formulated by combining available literatures on normal concrete using Waste glass powder.

For 1M³ concrete the batching is as follows.

Table 1
Mix proportion of material for M25 grade concrete

Material	Weight in Kg/m³
Cement	352
Water	165
Sand	734
Aggregate	1211

C. *Mixer Proportions and Casting of Specimens*

Mix proportions are arrived for M25 grades of concrete based on the above formulated mix design procedure by replacing 0%, 5%, 10%, and 15% of the mass of Sand by Waste Glass powder and the material requirements per m^3 of concrete. Curing was done under water for various desired periods.

4. Tests on fresh and hardened concrete

Workability tests such as slump test, compaction factor test were carried out for fresh concrete as per IS specifications, for hardened concrete cube compression strength test on 150x150x150 mm^3 size cubes at the age of 7 days, 14 days, 28 days curing were carried out using 3000kN capacity compression testing machine. Also compression strength test and split tensile strength on 150mmx300mm cylinders were carried out on 28 days cured specimens as per BIS specifications.

5. Results and discussions

A. *Test on Fresh Concrete*

The test results of workability are shown in figure 1. It was observed that the workability of concrete decreased the percentage of glass powder content was increased.

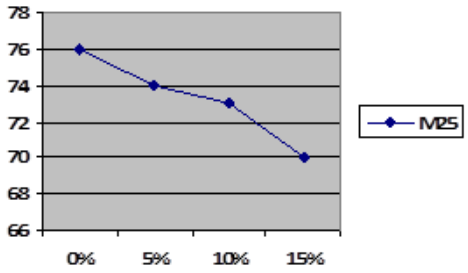

Fig. 1. Slump value of concrete

B. *Test on hardened concrete*

The results of cube compression strength, split tensile strength are shown Figure 2 & 3 and table 2 and 3 below.

1) *Compressive strength of concrete*

Table 2
Compressive strength of concrete

Sr. No.	Percentage replacement	Compressive strength in N/MM²	
		7 days	28 days
1	0%	22.12	30.56
2	5%	21.14	30.09
3	10%	23.39	31.72
4	15%	21.87	29.13

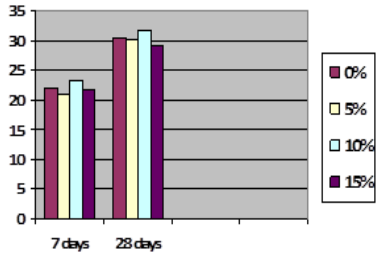

Fig. 2. Bar chart of compressive strength

2) *Split tensile strength of concrete*

Table 3
Splitting tensile strength of concrete

Sr. No.	Percentage Replacement	Split tensile strength at 28 Days in N/MM²
1	0%	9.11
2	5%	9.04
3	10%	9.58
4	15%	9.01

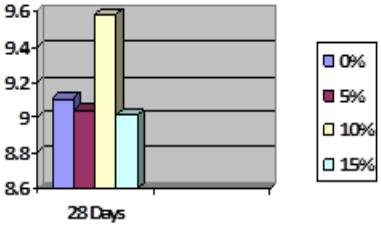

Fig. 3. Bar chart of split tensile strength of concrete

3) *Flexural strength of concrete*

Table 4
Flexural strength of concrete

Sr. No.	Percentage Replacement	Flexural strength at 28 Days in N/MM²
1	0%	48.67
2	5%	47.02
3	10%	49.83
4	15%	47.11

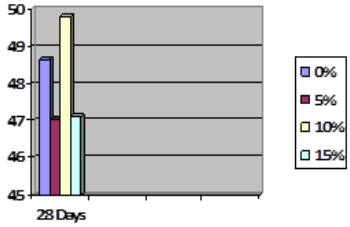

Fig. 4. Bar chart of flexural strength of concrete

6. Conclusion

Based on the investigation carried out on cement replaced waste glass powder mixes the following conclusions are drawn. The test conducted on material like coarse aggregate, river sand, cement and waste glass powder material having all the results within acceptable limit as per IS code.

1. The fresh concrete mix using waste glass powder material are gives the increase in workability as increase in % replacement of waste glass powder material so from this by using waste glass powder in concrete, the concrete mix should be more workable than conventional concrete mix.
2. The concrete for M20 grade have a nominal compressive strength is 25 N/mm2. Partial replacement of cement by waste glass powder in 5%, 10% and 15% increase in the compressive strength of concrete up to acceptable limit.
3. With partial replacement of cement by waste glass powder in concrete cylinder gives the split tensile strength of 20% should be same as traditional concrete without replacement.
4. Flexural strength of concrete with replacement by waste glass powder gives the satisfactory result up to a 5-7%. When a partial replacement of cement by waste glass powder in concrete increases above 10% then the gradual reduction in flexural strength of beam is to be noted.
5. The use of waste glass powder in concrete is relatively new development in the world of concrete technology and this research must prove that the replacement of waste glass powder in concrete is possible as cement.
6. Utilization of waste glass powder as a replacement of cement in concrete" can be conveniently used as an alternative research to the convectional concrete in the construction industry.

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