SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 4 | April 2020 - Peer Reviewed Journal

EXPERIMENTAL INVESTIGATION ON CONVENTIONAL CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH GLASS POWDER

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ABSTRACT

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 release large amount of carbon dioxide(CO_2) and also contributes to the green house gases. Atmospheric levels of carbon dioxide have risen by about 30 percent over the past 200 years. Each year approximately 111 million tons of controlled waste from household, commercial and industrial waste is disposed of in landfill sites in worldwide causing a rise in landfill costs and environmental problem. The use of recycled waste glass in Portland cement and concrete has attracted a lot of interest worldwide due to the increased disposal cost and environmental concern. Glass used for containers, jars and bottle is soda lime silica counts for 80 percent of the recycled glass based application. In this project the effect of the use of 'Glass Powder' as replacement of cement to assess the pozzolanic nature of fine glass powder. Number of test were conducted to study the effect of 10%,20% and 30% replacement of cement by glass powder on compressive strength and split tensile strength.

KEY WORDS: *Glass powder, recycled waste, workability, Compressive strength.*

1. INTRODUCTION

A major component of concrete is cement, which has its own environmental and social impacts and contributes largely to those of concrete. The cement industry is one of the primary industrial producers of carbon dioxide (CO2), creating up to 5% of worldwide man-made emissions of this gas, of which 50% is from the chemical process and 40% from burning fuel. 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. The interest of the construction community in using waste or recycled materials in concrete is increasing because of the emphasis placed on sustainable construction. Glass is an inert material which could be recycled and used many times without changing its chemical property. This paper reports the results of an experimental investigation on the use of glass powder in partially replacement cement in concrete applications and summarized the behaviour of concrete involving partial replacement of cement by waste glass powder 10% to 30% at interval of 10% each.

In this research, the aim is to study the usage of glass in powdered form as a partial replacement of cement and its impact on compressive strength and split tensile strength of concrete. However, most of the studies are related predominantly to the partial replacement of glass powder in cement. Use of waste and by- product as cement is of great practical significance; because of about 25% of concrete comprises cement. There are various types of waste materials that can be considered for use as cement. The experimental study for preparing nine cubes of seven different mixes using cement partially replaced by waste glass powder at varying percentage of 10%, 20%, 30%, and to study the compressive strength and split tensile properties.

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1.1 Objective of the work

- To study the existing methods of disposal of glass waste.
- To economically compare conventional concrete with the concrete modified using glass waste.
- To investigate the practicality, versatility and Feasibility of utilizing recycled glass as a partial replacement to cement.
- To identify the effects of adding waste glass powder on the fresh properties of concrete mixes such as workability by slump measures.
- To study the influence of waste glass on hardened properties of concrete mixes such as: density and compressive strength, and split tensile strength.

1.2 Scope of the Work:

- To know the effect of the different types of glass powder on concrete strength.
- Effect of glass powder on high strength concrete with various w/c ratios.
- Effect of glass powder on strength of concrete with combination of glass powder with different strengthening agent.
- To know the exact reason behind the increment in strength of concrete.
- To know the effect of glass powder on bond strength between inter-materials and between materials and steel.

2.MATERIALS USED

2.1 CEMENT

Cement is an extremely fine-grounded material with adhesive and cohesive properties and acts as a binding material in concrete.

The properties of concrete are very much influenced with the properties of cement, hence if it of worth importance to know the cement properties. Following are the main tests conducted to know the cement properties.

a. Standard consistency test.
b. Initial setting time
c. Final setting time
d. Specific gravity.

Table No.1 Properties of Cement

PROPERTY TEST	RESULTS	REQUIREMENT OFIS: 8112 - 1989	
Setting time: a) Initial b) Final	50min 10Hr	Should not be Less than Should not exceed	30 Min 600Min
Standard Consistency	32%	-	
Specific Gravity	3.15	-	
% of Fineness	6%	-	

2.2 AGGEREGATES

Aggregates are important constituents of concrete and they constitute 75 to 80% of total volume of concrete. They reduce shrinkage and effect economy to a great extent. As aggregates are main part of a body in concrete, its properties affect the economy to a great extent.

Following are the properties of aggregates, which effect concrete.

i. Size

Largest maximum size that can be under given set of conditions should be used. Using largest size will result in:

- Reduction in water content.
- Reduction in drying shrinkage.

Generally 80mm is the largest size of aggregates in concrete, which is generally used.

ii. Shape: Shape of aggregate is an important characteristic since it affects workability of concrete. As per shape they are classified as rounded irregular or partly rounded, angular, flaky. The angular aggregates are generally preferred as compared to other due to their durability and strength in concrete and good binding capacity.

iii. Texture

Generally rough texture aggregates are preferred as compared to smooth due to their good binding capacity. Rough texture increases the surface area, which increases the bonding strength of concrete.

iv. Strength

Strength of aggregates is defined as the resistance to given set of forces. It is measured as its crushing value i.e. resistance to crushing loads and impact value.

Table No.2 Properties of Aggregates

PROPERTY TEST	RESULTS	
	Coarse Aggregate	Fine Aggregate
Specific gravity	2.79	2.61

2.3 Glass Powder

Glass powder is an extremely fine powder made from ground glass. It can be used in a number of industrial and craft applications and is often available through supplier of glass and industrial supplies. High precision machining equipment is necessary to prepare it, as it needs to be very uniform, with an even consistency. Costs vary, depending on the level of grind and the applications.

Some companies use recycled glass to make their glass powders, while others may use specially made glass. The process can involve dry or wet grinding to achieve particles of the desired size. Pigments can be

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added to make coloured glass powders, and companies can also work with coloured glass if they want to make powders of a particular colour, like blue. The finished product can be hazardous and must be handled with care.

Specific gravity of glass powder = 2.31

3. EXPERIMENTAL METHODOLOGY

The following tasks are to be carried out in order to achieve the research objectives:

1. Properties of all ingredient materials cement, sand, aggregates, glass powder are studied experimentally.
2. The design of the required concrete mix is made.
3. In order to improve the performance of concrete the glass powder is partially replaced in cement.
4. For different doses of glass powders the concrete parameters such as compressive strength and split tensile strength is determined.

In this experimentation, an attempt would be made to find out the properties of concrete produced by replacing the cement with waste glass powder in various percentage ranging from 10% to 30% increments of 10% (10%, 20% and 30%).The experimental investigation would include casting and testing of cubes specimens to study the compressive and split tensile strength of concrete cubes. The Grade of concrete will be M_{20}.

3.1 Mix Calculations:

- volume of concrete=1m^3
- volume of cement=0.135m^3
- volume of water=0.1836m^3
- volume of all in aggregates=1-(.135+.186) =0.679m^3
- mass of coarse aggregate= 0.679*0.634*2.79*1000=1201.05kg
- mass of fine aggregate= 0.678*0.366*2.61*1000=647.66kg

Therefore, [C: FA: CA: W] - [1:1.42:2.58:0.43]

- Required quantity of cement = 250kg
- Fine aggregate required f a =356kg
- Coarse aggregate required C a =540kg
- Glass powder =29.52kg

Table No. 3 Mix Proportions

Ingredients	Quantity
Cement (C)	383kg/m^3
Sand (FA)	727kg/m^3
Coarse aggregate (CA)	1103kg/m^3
W/C Ratio	0.5

4. RESULTS AND DISCUSSIONS

In these concrete cubes of size 150 x 150 x150 mm, cylinders of size 150 mm diameter and 300mm length are casted ISCM moulds as per obtained mix proportions and respective grades.

The concrete cubes & cylinders are tested under Compression Testing Machine (CTM) for 7 days, 14 days and 28 days of curing to know the compressive and split tensile strengths. The results obtained of the various tests have been systematically represented in the form of tables and comparative study has been taken up at the required stages and has been indicated in the form of graphs.

4.1 Compressive strength test results:

Compressive strength = (ultimate load / area of loading) in N/mm^2

Figure 1: Compressive strength testing of a cube

Table No.4 Compressive strength test results

%Glass powder	Compressive strength for 7days	Compressive strength for 14days	Compressive strength for 28days
0	16.64	19.34	24.08
10	16.95	20.14	25.31
20	17.54	21.22	26.96
30	16.98	20.65	25.14

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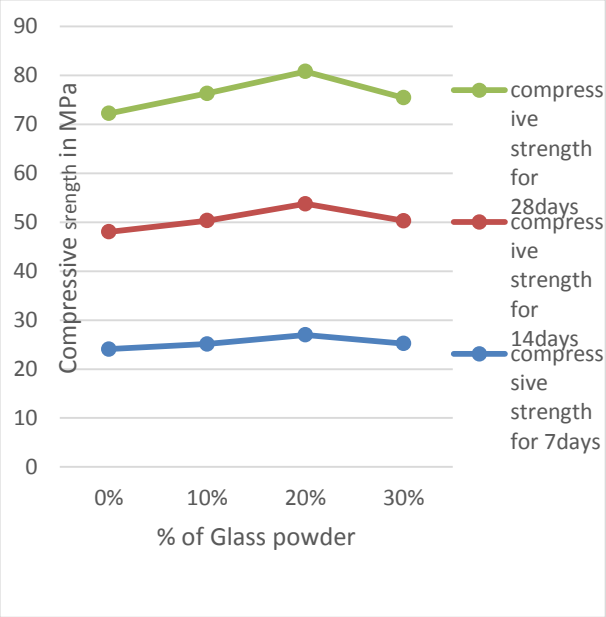

Figure.2 Graph showing compressive strength results

By comparing conventional concrete with glass powder the strength increases at some dosage. The optimum dosage of glass powder is 20% and then the strength decreases.

Table No. 5 Comparison of optimum dosage Glass powder with conventional concrete

% Glass powde	Mean compressive strength for 7days in	Mean compressive strength for 14days	Mean compressive strength for 28days
0	16.64	19.34	24.08
20	17.44	21.22	26.96

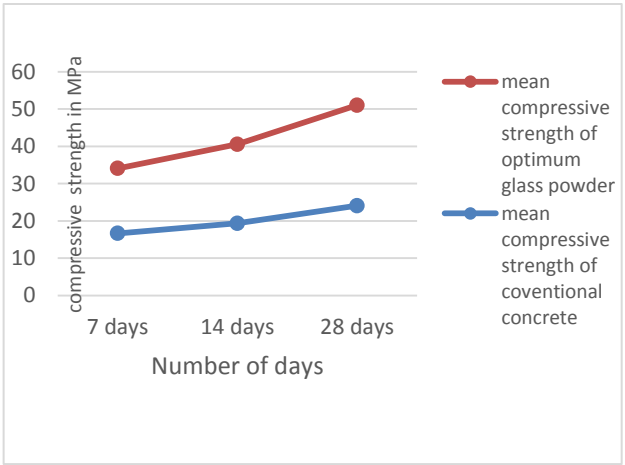

Figure.3 Graph comparing conventional concrete with optimum Glass powder

4.2 Split Tensile Strength:

Tensile strength, $f_t = (2p/\pi LD)$

Figure-4 split tensile strength testing of a cylinder

Table no.6 Split tensile strength Results

%Glass powder	Split Tensile strength for 7days	Split Tensile strength for 14days	Split tensile strength for 28days
0	1.38	1.89	2.98
10	1.44	2.02	3.42
20	1.55	2.42	3.98
30	1.47	2	3.38

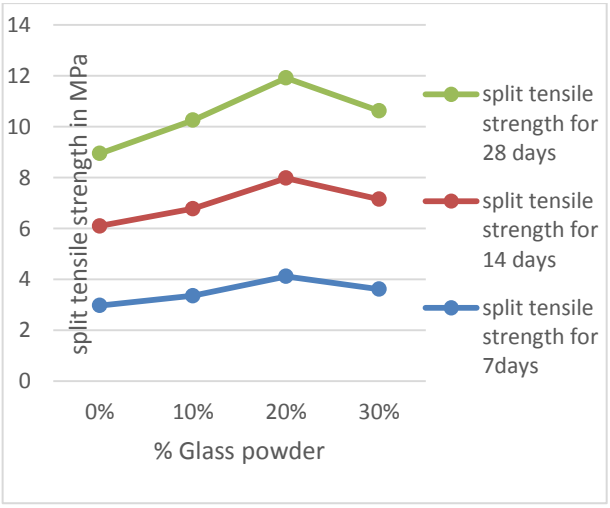

Figure.5 Graph showing Split tensile strength results

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By comparing conventional concrete with glass powder the strength will be increases at some dosage. The optimum dosage of glass powder is 20% and then the strength decreases.

Table No.7 Comparison of optimum dosage Glass powder with conventional concrete

% Glass powder	Mean Tensile strength for 7days	Mean Tensile strength for 14days	Mean Tensile strength for 28days
0	1.38	1.89	2.98
20	1.55	2.42	3.98

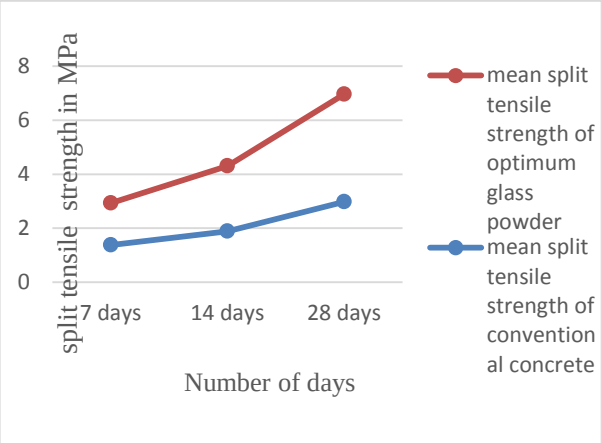

Figure.6 Graph comparing conventional concrete with optimum Glass powder

5. CONCLUSIONS

- Glass powder in concrete increase the compressive and split tensile strength effectively when compared to conventional concrete.
- The compressive strength for 28 days of conventional concrete is 24.08KN/mm2, and by the tests conducted 10% and 20% replacement of glass powder shows strength of 25.31 KN/mm2 and 26.96 KN/mm2 respectively.
- The compressive strength for 30% replacement is 25.14 KN/mm2 the compressive strength is reduced.
- The split tensile strength for 28 days of conventional concrete is 2.98 KN/mm2, and by the tests conducted 10% and 20% replacement of glass powder shows strength of 3.42 KN/mm2 and 3.98 KN/mm2 respectively.
- The split tensile strength for 30% replacement is 3.54 KN/mm2 the strength is reduced when compared to 10% and 20% replacement.
- The split tensile strength and compressive strength for 30% replacement is reduced due to hydration and binding property of concrete.
- The workability of Glass powder concrete has been found to decrease with increase in Glass powder content replacement.

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