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Experimental Investigation of Partial Replacement of Cement in Concrete using Waste Glass Powder

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Abstract: ***The construction industry is the second largest industry in the world & concrete is prime material used in it [5]. The use of concrete generates lots of heat during hydration process. It directly contributes to global warming. Also cement is costly material & its storage is also difficult. The cement plays important role of binding in concrete. It contains lime as main constituents. So to reduce this ill effect of cement one must find the alternatives for cement which can perform the same role in concrete. This study represents the experimental investigation of effect of partial replacement of cement by glass powder on strength of concrete & other factors like workability, water cement ratio, and heat of hydration. Glass contains lime as its one of main constituent. The cement was replaced with glass powder by 5%, 10%, 15%, and 20%. The compressive strength, flexural strength & split tensile strength are tested for these replacements. Also economical aspect is observed along with. It is observed that physical & chemical properties of glass are almost similar to cement. So in this study an attempt is made to investigate the effect of partial replacement of cement by glass powder in concrete to make it as a special concrete.***
Keywords: Special Concrete, Global warming, Cement, Glass powder

I. INTRODUCTION

The global warming is biggest challenge in front of today's world. It has made very drastic effect on the life of human being. The rise in temperature causes melting of glaciers on large amount. Increase in water level in oceans in not a good sign for cities situated nearby oceans. Also climate change is biggest problem human being is facing all over the world. This climate change has disturbed the balance of nature. The problems like draught, floods, forest fires, heat waves, storms are ill effects of climate change. It has affected human life in many ways. The cropping pattern is also changed due to climate change [2]. This is really very dangerous scenario in front of all over the world & upcoming generations. The various efforts are taken to reduce these problems. The green solutions are being discovered in every field by various scientists. The construction industry is second largest industry in the world. It has huge use of concrete as construction material. The concrete is a homogeneous mixture of cement, sand & aggregate plus water. The cement plays role of binding in concrete. It is prime ingredient of concrete. But cement has lime as its main chemical constituent. The amount of lime in cement is varies from 60-70% [1]. This lime when comes in contact with water causes a reaction called as 'hydration'. Due to hydration concrete achieve its desired strength and becomes stronger & harder. But during process of hydration large amount of heat is evolved which is called as 'heat of hydration'. The amount of heat generated during this hydration process is 500j/g as per study [4]. After water, cement is second largest material consumed in the world. One study suggests that there is about 30billion tons of concrete is consumed in the world per year [1]. This data is enough to predict the amount of heat evolved by construction industry. Another study says that construction industry contributes 8-10% in global warming. This is large figure. So we should try to reduce these ill effects by trying alternative materials & without compromising the quality needs of work. Another important aspect of the study is to find economic solutions. The increase in the population has tremendous needs of housing & infrastructure. The megastructures are created on large scale day by day. Also demand of affordable residential housing projects is also increasing. So attempt must be made to reduce the construction cost & produce affordable construction in budget of everyone. This study also aims to find economic & practicable solution for construction industry.

II. OBJECTIVE

1) To check the compressive strength of concrete mix at 0%, 5%, 10%, 15% & 20% replacements of cement by glass powder.
2) To check the split tensile strength of concrete mix at 0%, 5%, 10%, 15% & 20% replacements of cement by glass powder.
3) To check the flexural strength of concrete mix at 0%, 5%, 10%, 15% & 20% replacements of cement by glass powder.
4) To make cost comparison between normal & special concrete.

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III. MATERIALS

1) Cement-Cement of OPC-43 grade is used for study. Specific gravity of cement is 3.2.
2) Aggregate-Fine aggregate passing through 2.36mm sieve size is used & coarse aggregate passing through 20mm sieve size is used.
3) Waste Glass Powder-Though glass is 100% recyclable material but the amount of production of glass all over the world is tremendous that it is not possible to recycle the glass completely so large amount of glass is remaining un-recycled [3]. The glass powder used for this experimental investigation is waste glass collected from scrap of demolished construction site; it is then crushed & sieved through 90 micron sieve to get desired value of fineness. The fineness property is important as specific surface area plays important role in binding the materials together.

TABLE I
COMPARISON BETWEEN CHEMICAL PROPERTIES OF CEMENT & GLASS POWDER

Sr. No.	Comparison between Chemical Properties of Cement & Glass Powder		
	Composition	*Cement*	*Glass Powder*
1	SiO_2	38.06	64.32
2	Al_2O_3	8.88	2.90
3	CaO	40.92	18.18
4	Fe_2O_3	2.83	-
5	SO_3	2.33	-
6	K_2O	1.62	1.53

TABLE II
COMPARISON BETWEEN PHYSICAL PROPERTIES OF CEMENT & GLASS POWDER

Sr. No.	Comparison between Physical Properties of Cement & Glass Powder		
	Physical Property	*Cement*	*Glass Powder*
1	Colour	Lithish-grey	Mixed
2	Particle Size	< 45 micron	< 45 micron
3	Specific Gravity	3.15	2.7
4	Consistency	28%	30%
5	Initail Setting Time	30 min	45 min
6	Final Setting Time	178 min	210 min

Source-American Concrete Institute (ACI)

By comparing both chemical & physical properties of cement & glass powder we can use glass powder as a partial replacement of cement.

IV. METHODOLOGY

The mix design of M20 grade is prepared by using IS: 456:2000 & IS 10262. The proportion of mix was 1:1.8:3.8 with 0.45 water cement ratio. The cement is then partially replaced by glass powder by weight 5%, 10%, 15 % & 20% by weight batching. The molds of cube is prepared of (15cm x 15cm x 15cm) size to test compressive strength of concrete, molds of cylinder (15cm x 30 cm) is prepared to test split tensile strength & beam (15cm x 15cm x 70cm) is formed to test flexural strength of each proportion. The tests are performed at 7 days, 14 days & 28 days for compressive strength test; as compressive strength is main characteristic strength of any type of concrete. Concrete is supposed to be good in compression strength.

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The split tensile strength & flexural strength tests are taken at 28 days. The results are observed & then compared for verifying the objectives of experimental investigation of the study

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V. RESULTS

The results of compressive strength is tabulated as below

TABLE III
COMPRESSIVE STRENGTH TEST RESULTS AT 7, 14 & 28 DAYS

Replacement Levels / Age of concrete	0%	5%	10%	15%	20%
7 days	12.25 MPa	11.89 MPa	12.37 MPa	11.90 MPa	11.85 MPa
14 days	17.33 MPa	16.22 MPa	17.95 MPa	16.96 MPa	12.39 MPa
28 days	19.50 MPa	17.89 MPa	21.12 MPa	19.13 MPa	18.30 MPa

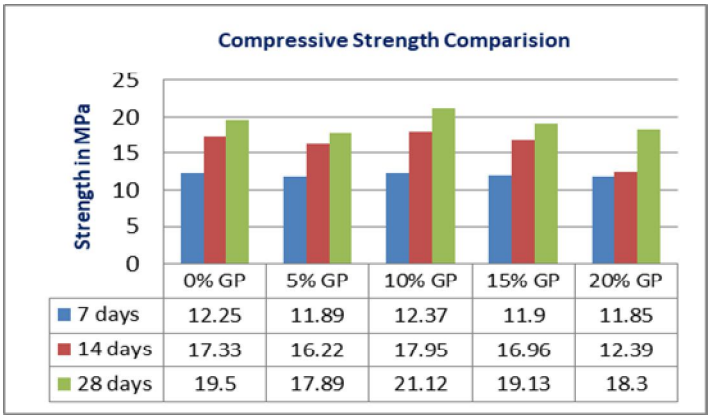


FIG1. Comparison between Compressive strength at 7days, 14 days & 28 days with 0%, 5%, 10%, 15 % & 20% replacement of cement by waste glass powder in concrete.

TABLE4
SPLIT TENSILE STRENGTH TEST RESULTS AT 28 DAYS

Replacement / Age of concrete	0%	5%	10%	15%	20%
28 days	3.2 Mpa	2.9 Mpa	3.3 Mpa	3.1 Mpa	2.7 Mpa

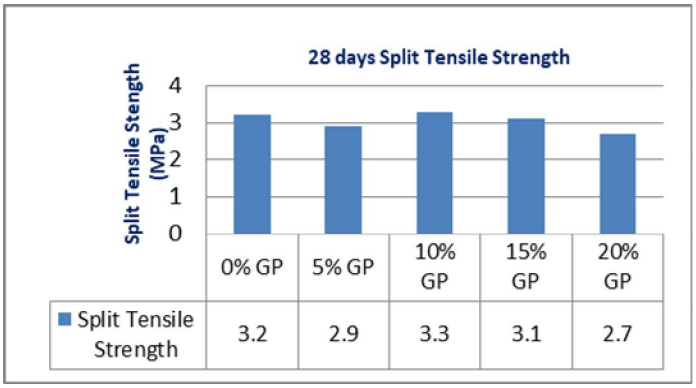


FIG2. Comparison between Split tensile strength at 28 days with 0%, 5%, 10%, 15 % & 20% replacement of cement by waste glass powder in concrete

TABLE V
FLEXURAL STRENGTH TEST RESULTS AT 28 DAYS

Replacement / Age of concrete	0%	5%	10%	15%	20%
28 days	2.8 Mpa	2.6 Mpa	2.7 Mpa	2.3 Mpa	2.4 Mpa

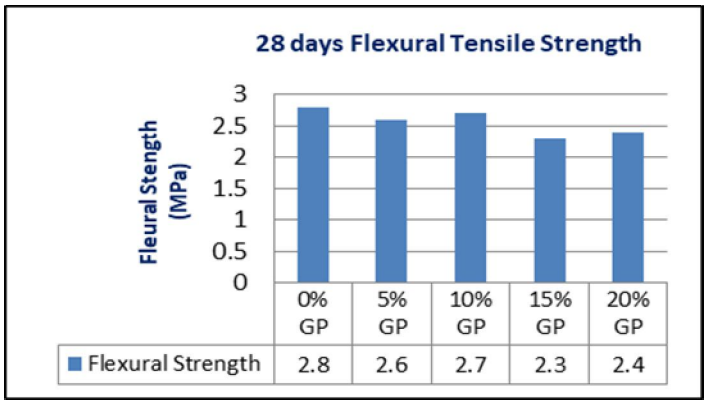


FIG3. Comparison between Flexural strength at 28 days with 0%, 5%, 10%, 15 % & 20% replacement of cement by waste glass powder in concrete.

VI. CONCLUSIONS

A. Compressive Strength Results

From above seen results in table no.3 it is clear that the compressive strength of M20 grade concrete is highest at 10% replacement of cement by glass powder in concrete. It has been seen that results are improved by 8%. So we can conclude that we can replace cement by 10% weight with waste glass powder.

B. Split Tensile Strength Results

From above seen results in table no.4 it is clear that the split tensile strength of M20 grade concrete is highest at 10% replacement of cement by glass powder in concrete. It has been seen that results are improved by 0.5%. So we can conclude that we can replace cement by 10% weight with waste glass powder.

C. Flexural Strength Results

From above seen results in table no.5 it is clear that the Flexural strength of M20 grade concrete is highest at 0% replacement of cement by glass powder in concrete. It has been seen that results are not improved at any stage of replacement. So we can conclude that there is no any advantage of replacing cement with waste glass powder.

D. Cost Analysis

From above all conclusions it is clear that the compressive & split tensile strength of concrete is improved at 10% replacement of cement by waste glass powder & there is no positive effect in flexural strength of concrete. But as we all know that compressive strength is main characteristic strength of concrete we can replace cement by 10% weight with waste glass powder in concrete.
If we consider $1m^3$ of M20 grade concrete, we requires around 7 bags (each of 50kg) of cement for it. So we can replace about 35kg of cement by waste glass powder per m^3. So overall there is saving of around 300-350Rs/ m^3 while doing construction.

VII. ACKNOWLEDGMENT

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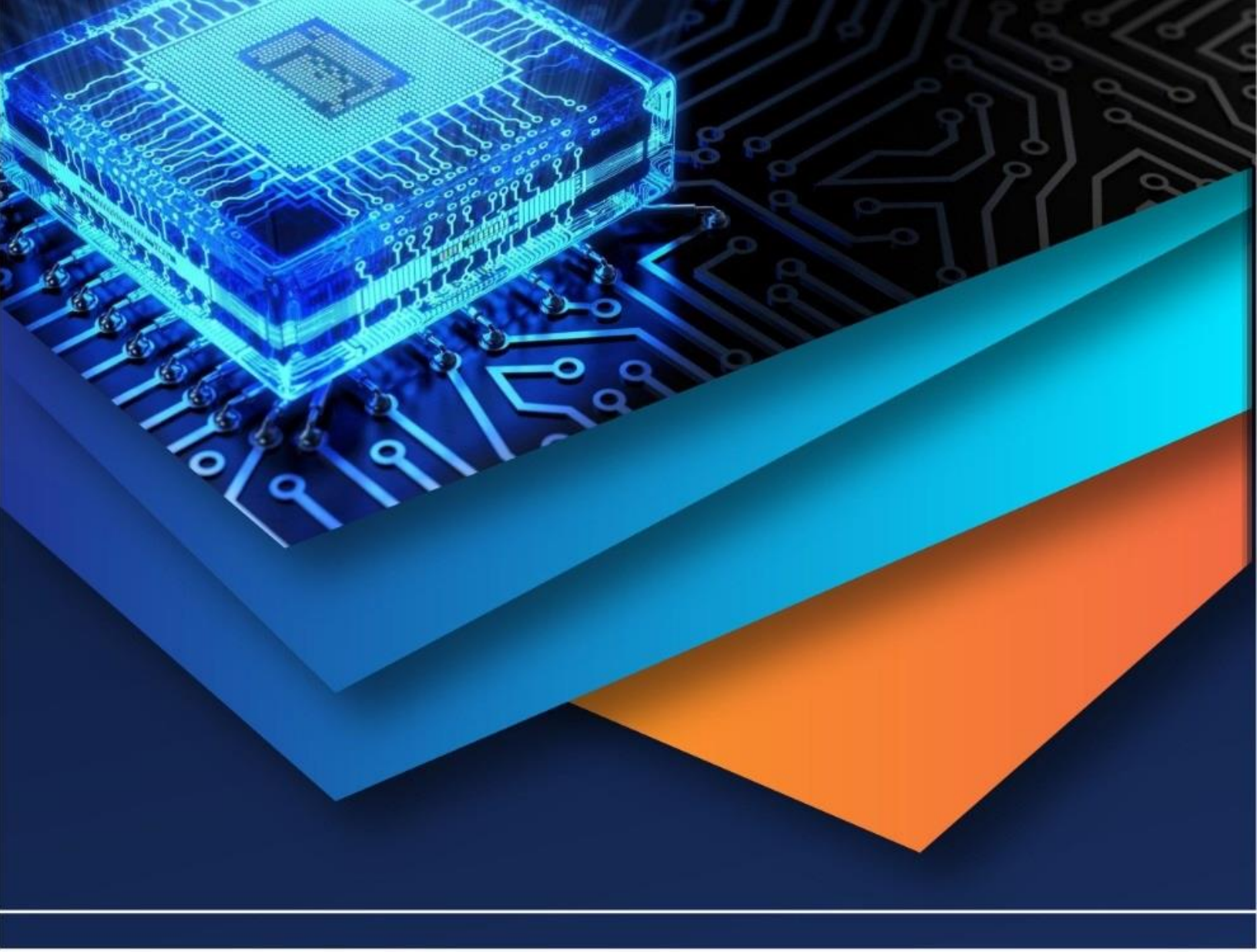
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