Experimental Investigation on Strength and Durability Parameters of Concrete Replacing Cement by Glass Powder in Concrete

Akash Dudhat[1], Dhaval Alagiya[2], Het Hadiya[3], Dilpana Chaudhari[4], Vimal Patel[5], Sagar Naik[6]
[12345] *Student of B.E. Civil at Bhagwan Mahavir College of Engg. & Tech. Surat, Gujarat Gujarat Technological University*
[6]*Assistant Professor at Civil Department of Bhagwan Mahavir College of Engg. & Tech., Surat, Gujarat Gujarat Technological University*

***Abstract*- In a growing country like India a huge amount of industrial wastes are polluting the environment. With a view to the above, the study aims at utilization of such industrial waste by product for value added application. In addition, the waste can improve the properties of construction materials. The recycled glass has been used in the form of powder. The glass powder will tested with concrete and mortar. Cement was replaced by Glass Powder in the proportion of 0%, 10%, 15%, 20% and 25% for M30 Grade of concrete with 0.50 water cement ratio. Experimental investigation on strength properties of glass powder reinforced concrete composite is carried out and compared with normal conventional concrete. The optimum dosage of glass powder reinforced concrete for various mix designation is plotted graphically. The result showed that with increase in percentage of glass powder compressive strength of concrete is also increase. The advantages of this project are that the replacement of glass powder is economically cheap as well as a superior concrete can be made.**

Index Terms- Concrete, Cement Replacement, Waste Glass Powder, Strength, Durability, Utilization of waste glass, Environmental Friendly

I. INTRODUCTION

Construction is a general term meaning the art and science to form objects, systems, or organizations, and comes from Latin construction (from com- "together" and struere "to pile up") and Old French construction. Construction is used as a verb: the act of building, and a noun: how a building was built, the nature of its structure.

In general, there are three sectors of construction: buildings, infrastructure and industrial. Building construction is usually further divided into residential and non-residential (commercial/institutional). Infrastructure is often called heavy civil or heavy engineering that includes large public works, dams, bridges, highways, railways, water or wastewater and utility distribution. Industrial construction includes refineries, process chemical, power generation, mills and manufacturing plants. In rapidly urbanizing developing countries, both people and economic functions concentrate in major metropolises.

The income of people increase at fastest growth. Thus, can earn enough income to afford an own house, they rush to buy one. The speed of urbanization is so fast that construction cannot catch up. The urban population has grown from 10 % in 1901 to 28 % in 2001. The skewed distribution of the urban population amongst a few cities is a matter of concern to the planners and administrators of urban infrastructure. Nearly 70 % of the urban population is located in Class-I cities (population of one hundred thousand and more). Further 38 % of the total urban population is located in metropolitan cities (population of one million and more) numbering about thirty-five. This heavy concentration of population in a few centers has resulted in the expansion of cities in density as well as area. With the increase in population and economic activities the construction demand has increased many folds.

The easy availability of financing facilities for personal house have resulted in increased construction levels and their usage. Further, the increase in land use and density of population have

increase the construction. In other words the developing problems are increasing in the cities in general and the situation is becoming complex especially in core areas of the city. The uncontrolled and ill planned growth of urban centers has resulted in a number of problems like land use, shortages of water and electricity, deteriorating environment and public health.

The growing cities have generated the high levels of demand for construction by Building construction, Residential construction, industrial construction etc. in the cities. The comparison of construction method on important period of time is made and discussed in the report. Finally based on the analysis and the problem probable solutions are suggested to ease the problems.

Need For The Study

- To find an alternative solution for the ordinary Portland cement (OPC).
- To reduce CO^2 emission and produce eco-friendly concrete.
- To provide high strength concrete than ordinary Portland concrete.
- To develop a eco-friendly product at low cost.
- Optimization of waste glass in valuable product.

II. MATERIALS

General

In this chapter varies materials and method of conducting the test was discussed in detail and detailed methodology of the work was presented.

Materials Used

- Waste glass powder
- Cement
- Aggregates

- Fine aggregate
- Coarse aggregate

- Chemicals

- Magnesium Sulfate ($MgSo_4$)

Cement

Cement is one of the binding materials in this project. Cement is the important building material in today's construction world 53 grade Ordinary Portland Cement (OPC) conforming to (IS: 8112-1989). It is a mixture of calcareous, siliceous, aluminous substance and crushing the clinkers to a fine powder. Cement is when mixed with water, a chemical reaction take place as a result of which the cement paste sets and harden to atone mass.

The cement used in this experimental work is 53 grades ordinary Portland cement. The specific gravity of cement is 3.15. The initial and final setting time were found as 72 minutes and 180 minutes respectively. Standard consistency of cement was 31.25%.

Fine Aggregate

It is the aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification. The specific gravity offine aggregate is 2.75 and fineness modulus is 3.338mm. The water absorption is 1.538%.

Coarse Aggregate

20MSA & 10MSA: Crushed aggregates available from local source has been used. The coarse aggregates with a maximum size 20mm having specific gravity value of 2.885 and fineness modulus of 7.386 are used as coarse aggregates. The water absorption is 0.504%.

Glass Powder

Glass is an amorphous & transparent material, which is super-cooled liquid and not a solid. Glass can be made verity of forms and sizes from small fiber to meter-sizes pieces. Primarily glass is produced by melting a mixture of materials such as silica, CaCO3, and soda ash at high temperature followed by cooling during which solidification occurs without crystallization. Glass has been used as aggregates in road construction, masonry and building materials. Before adding glass powder in the concrete it has to be powdered to desired size. Waste glass available locally in shops is been collected and made into glass powder. Glass waste is very hard material. Glass powder is obtained from Crushing of glass Pieces. A Glass powder can be used as cement replacement material up to particle size less than 90µm.

Source of Glass

- Waste Decorative items of glass
- Old tube lights, electric bulbs etc which is use less
- Glass polishing and glass window and door manufacturing shop

Properties of Material

The physical properties, chemical properties and chemical composition of Glass Powder are presented in table 1, 2 &3.

Table 1. Chemical Composition of Glass powder

Sr.No	Chemical Composition of Glass Powder	% by mass
1	SiO_2	67.330
2	Al_2O_3	2.620
3	Fe_2O_3	1.420
4	TiO_2	0.157
5	CaO	12.450
6	MgO	2.738
7	Na_2O	12.050
8	K_2O	0.638
9	ZrO_2	0.019
10	ZnO	0.008
11	SrO	0.016
12	P_2O_5	0.051
13	NiO	0.014
14	CuO	0.009
15	Cr2O3	0.022

Table 2. Chemical Properties of Glass Powder

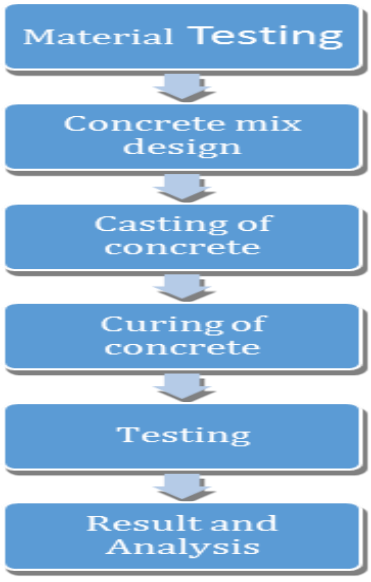
Sr. No	Chemical Properties of Glass Powder	
1	pH	10.25
2	Colour	Grayish white

Table 3. Physical Properties of Glass Powder

Sr. No	Chemical Properties of Glass Powder	
1	pH	10.25
2	Colour	Grayish white

III. METHODOLOGY

The whole process of project work is shown step by step. The methodology is explained in the following figure.



IV. MIX PROPORTION AND EXPERIMENTAL INVESTIGATION

In this chapter mix-design of concrete and the experimental investigation work carried outby help of IS 10262-2009 on the test specimen to study the strength related properties of concrete was discussed in detail.

Table 4. Mix Design

Material(Kg.)	Trail 1	Trail 2	Trail 3	Average
Cement	1	1	1	1
Fine Aggregate	1.85	1.94	1.99	1.92
Coarse Aggregate	2.89	3.02	2.74	2.88
W/C ratio	0.5	0.5	0.5	0.5

The mixing process was done using an electrically operated concrete mixer of 0.041 m3 capacity. The concrete making and mixing in the laboratory was done with accordance to ASTMC-192. The batching procedure was as follows:

1. Add coarse, fine aggregate mixing for about 2-3 minutes.
2. Add cement than mixing for about 1-2 minutes.
3. Add approximately two-thirds of water slowly and mix for 2-3minutes.
4. Add fiber with water than mixing for 2-3 minutes.

Test to be conducted on the specimens:

Compressive strength

- 7 days specimens age
- 14 days specimens age
- 28 days specimens age

Durability tests

- Alkaline attack test
- Sulphate attack test

Compressive Strength Test

Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates.

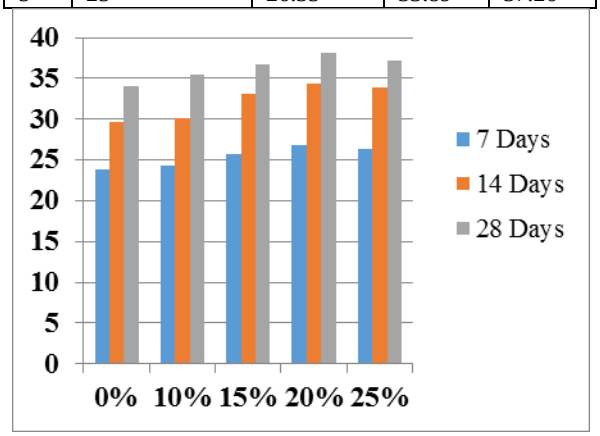
Compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.

Compressive Strength = Load / Cross-sectional Area

The test specimens for compressive strength test were made of cubes having a size of 150mm x 150mm x 150mm cast iron steel moulds were used. For each mix proportion three numbers of cubes were cast and tested at the age of 7 days, 14 days and 28 days.

Table 5. Compressive Strength Result of Concrete

Sr. No	% replacement of glass powder	Compressive strength of concrete for M30 grade concrete(N/mm^2)		
		7 day	14 day	28 day
1	0	23.82	29.61	34.04
2	10	24.38	30.14	35.47
3	15	25.72	33.07	36.75
4	20	26.76	34.41	38.09
5	25	26.35	33.89	37.26



Durability Test

Durability of concrete may be defined as the ability of concrete to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties.

Or

The ability of concrete to withstand the conditions for which it is designed without deterioration for a long period of years is known as durability.

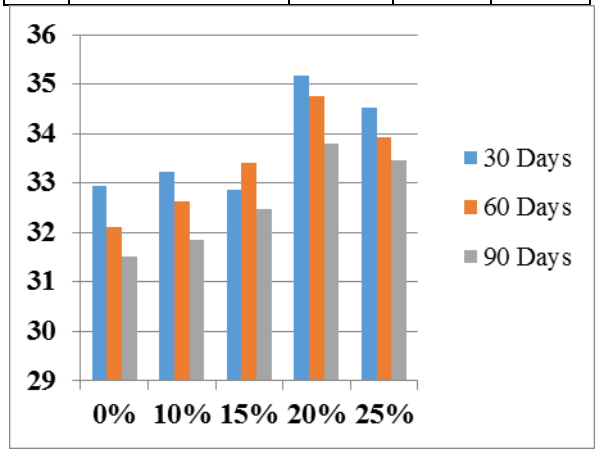
Durability is defined as the capability of concrete to resist weathering action, chemical attack and abrasion while maintaining its desired engineering properties. It normally refers to the duration or life span of trouble-free performance. Different concretes require different degrees of durability depending on the exposure environment and properties desired. For example, concrete exposed to tidal seawater will have different requirements than indoor concrete.

Sea water test

About 80 percent of the surface of the earth are covered by oceans; therefore, a large number of structures are exposed to sea water with high salinity either directly, or indirectly when winds carries sea water spray up to a few miles inland from the coast. As a result, several coastal and offshore sea structures are exposed to the continuous action of physical and chemical deterioration processes. This challenge of building and maintaining durable concrete structures in coastal environs have long become a serious issue to the people living in this areas and this provides an excellent opportunity to understand the complexity of concrete durability problems in these areas.

Table 6. Sea water test Result of Concrete

Sr. No	% replacement of glass powder	Compressive strength of concrete for M30 grade concrete(N/mm^2)		
		30 day	60 day	90 day
1	0	32.93	32.10	31.50
2	10	33.22	32.63	31.86
3	15	32.85	33.41	32.48
4	20	35.18	34.76	33.80
5	25	34.53	33.93	33.45

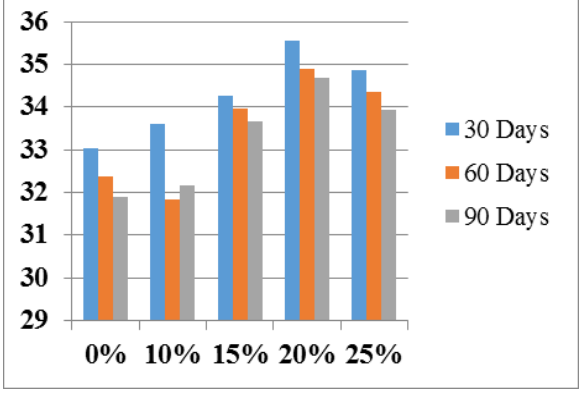


Sulphate attack test

Chemical reactions between sulfate ions and hydration products leading to ettringite and gypsum formation.

Table 6. Sulphate attack test Result of Concrete

Sr. No	% replacement of glass powder	Compressive strength of concrete for M30 grade concrete(N/mm^2)		
		30 day	60 day	90 day
1	0	33.04	32.36	31.90
2	10	33.61	32.83	32.15
3	15	34.27	33.96	33.67
4	20	35.55	34.89	34.68
5	25	34.95	34.35	33.93



V. CONCLUSIONS

Based on limited study and experimental work on concrete containing Glass powder following conclusion are made:

- The workability of concrete is increase with increase in percentage of concrete.
- The compressive strength of concrete is increase with increase in percentage of glass powder. i.e 10%,15% and 20%.
- Considering the strength criteria, the replacement of cement by glass powder is feasible upto 20%
- The durability results of weight loss and strength loss for alkaline attack and sulphate attack.
- Usage of waste glass powder in concrete can prove to be economical as it is very much cheaper than cement.
- Use of waste glass in concrete will reduce the disposal problem of waste glass and prove to be environmental friendly.
- It is recommended that of glass powder in concrete as cement replacement is possible.

REFERENCES

[1] IS 456-2000 code of practice for R.C.C. design
[2] IS 10262-2009 guidelines for concrete mix design
[3] Concrete Technology (Subject Code: 2140608)
[4] IS 383:1970; Specification for coarse and fine aggregates from natural sources for concrete
[5] IS 516: 1959; Methods of tests for Strength of concrete

BIOGRAPHIES

1. Akash A. Dudhat is a scholar in the field of Department of Civil Engineering, Bhagwan Mahavir College of Engg. & Tech., Surat, Gujarat. My current research is undertaken on Experimental Investigation on Strength and Durability Parameters of Concrete Replacing Cement by Glass Powder in Concrete.
2. Dhaval D. Alagiya is a scholar in the field of Department of Civil Engineering, Bhagwan Mahavir College of Engg. & Tech., Surat, Gujarat. My current research is undertaken on Experimental Investigation on Strength and Durability Parameters of Concrete Replacing Cement by Glass Powder in Concrete.
3. Het D. Hadiya is a scholar in the field of Department of Civil Engineering, Bhagwan Mahavir College of Engg. & Tech., Surat, Gujarat. My current research is undertaken on Experimental Investigation on Strength and Durability Parameters of Concrete Replacing Cement by Glass Powder in Concrete.
4. Dilpana B. Chaudhari is a scholar in the field of Department of Civil Engineering, Bhagwan Mahavir College of Engg. & Tech., Surat, Gujarat. My current research is undertaken on Experimental Investigation on Strength and Durability Parameters of Concrete Replacing Cement by Glass Powder in Concrete.
5. Vimal D. Patel is a scholar in the field of Department of Civil Engineering, Bhagwan Mahavir College of Engg. & Tech., Surat, Gujarat. My current research is undertaken on Experimental Investigation on Strength and Durability Parameters of Concrete Replacing Cement by Glass Powder in Concrete.
6. Sagar Naik is a postgraduate degree holder in structural engineering working as an Assistant Professor in the department of Civil Engineering at Bhagwan Mahavir College of Engg. & Tech., Surat, Gujarat. He Got university ranking in both UG and PG. He has published papers on various International journals and International conferences.