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STUDY ON PARTIAL REPLACEMENT OF CEMENT WITH WASTE GLASS IN CEMENT CONCRETE PAVEMENTS

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Abstract: Many researches have been currently going to modify and improved the concrete properties by the addition of different types of materials. This paper represents the Optimum use of the glass powders with the concrete mixture and will also help in achieving the desired results. This paper shows the investigation on M30 grade due to incorporation of Glass powders . The main aim of my study is to find the utilization of waste glass as a partial replacement material for cement in concrete pavements to serve two basic purposes: A) To use the waste glass as construction material rather than disposing it to the environment and B) use the waste glass as a raw material in cement concrete pavements thereby reducing its initial construction cost. Waste glass powder of particle size less than 90 micron is used in this work. The work was divided into percentages ranging from 0%-30% with milky white glass powder. A constant water/cement 0.40 is used and grade of concrete is M30. A series of tests are conducted to study the effect of glass powder on strength of concrete. Necessary tests to be done are slump test, compression tests on concrete cubes, split tensile tests on cylinder, flexure tests on beams. Tensile and flexural strength up to different age are to be done and compared with those of conventional concrete.

Keywords: Glass Powders, Compressive Strength, Flexural Strength and Split Tensile Strength.

I. INTRODUCTION

Glass is a non bio-degradable material and is not suitable for landfills. A lot of waste glass comes from the industries which pollutes our environment. To make our environment pollution free concrete industries had used this waste glass in concrete and also as a supplementary cementing material.By using the waste glass as the replacement in concrete reduces the pollution caused by glass waste and also the pollution caused during the production of cement. A glass is an inorganic product of fusion of mixture of silica, calcium carbonate and soda ash which is cooled to a rigid condition without crystallization. The glass being mainly a silica-based material in amorphous form can be used in cement-based applications. For a long time concrete was considered to be a very durable material requiring a little or no maintenance. The assumption is largely true, except when it is subjected to highly aggressive environments. We build concrete structures in highly polluted urban and industrial areas, aggressive marine environments, harmful sub soil water in coastel areas and in many other hostile conditions where other materials of construction are found to be non-durable. The poor and unsatisfactory performance of conventional concrete under aggressive environmental conditions has necessitated the researchers and engineers to look for new concrete composites. The innovative use of concrete must contemplate explorations of areas , in use of new shapes, materials and technique of construction. Concrete is such a versatile material that such attempts of contemplation are quite possible. In modern age one cannot think of construction work without concrete. Plain concrete has two major deficiencies; a low tensile strength and allow strain at fracture. The tensile strength of concrete is very low because plain concrete normally contains numerous micro cracks. Hence Fibers are generally utilized in concrete to manage the plastic shrink cracking and drying shrink cracking In FRC, thousands of small fibers are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions.That‟s why the addition of fiber with concrete improved the concrete properties such as workability, brittleness, strength, corrosion resistance and ultimately increased life of the structure. A major advantage of using fiber reinforced concrete besides reducing permeability and increasing fatigue strength is that fibers addition improves the toughness or residual load carrying ability after the first crack. This concrete is known as Glass fiber reinforced concrete (glass powder concrete). Reinforcing capacity and proper functioning of fiber is based on length of fiber, diameter of fiber, the percentage of fiber and condition of mixing, orientation of fibers and aspect ratio. Aspect ratio is ratio of length of fiber to its diameter which plays an important role in the process of reinforcement. Glass powder concrete contains only less than 3% of fibers and aspect ratio below 100.

II. LITERATURE REVIEW

As we know the properties of concrete gets improved due to the incorporation of Glass powder. Large no. of papers have being published which tells about the compressive strength, flexural strength and split tensile strength of concrete according to their opinion.

Fabrice et al.[1] The work was divided into groups as: group 1 with 0% replacement, group 2 with 10% replacement, group 3 with 20% replacement, group 4 with 30% replacement and group 5 with 40% replacement with both green and clear glass powders. Three cubes of (15x15x15cm) were casted for each and every replacement.

Thecompressivestrengthwithgreenglasspowderupto30%replacementshowedmore strength than clear glass and normal

concrete at 7 and 28 days. Due to the higher consumption of lime/calcium oxide by green glass powder gives higher strength than clearglasswithsamereplacement.Itwasobservedthatbothgreenandclearglassoffers better results than normal concrete without any replacement and this is due to the high silica content present inglass.

Parameshwari.tetal[2]studiedtheeffectofglasspowderwhichisreplacedwith cement in concrete and the compressive strength was checked for the cubes of (150 x 150x 150) at different ages. Compressive strength was more when compared with normal concrete and was 44.9 N/mm2 after 28 days. The finely grounded glasspowder
does not contribute to alkali silica reaction and gives higher strength than large sized glass powder.

Lalitha et al. [3] studied the effects of glass powder which was used in different replacementsas5%,10%and15%withcementinconcretebyweightofcement.Cubes were casted to check the strength of waste glass concrete and then compared with the concrete with 0% replacement. Compressive strength is higher at 5% replacement of waste glass powder and is more than control concrete. Further the strength starts decreasing on increasing the glass powder content. The reason is the high magnesia content present in the glass powder which is used in this work, as excess magnesia contentmakesthestrengthdecrement.Theglasspowderusedinthisworkhasmagnesia content of 4.18% but the permissible limit of magnesia content in cement is 1-3%.

Siddeshetal.[4]studiedtheeffectdifferentparticlesizeofglasspowderincement. During the investigation cement is being replaced by 150 micron and 300 micron particle size separately for every 10%, 20%, 30% and 40% and these results are compared with normal concrete at 0% replacement. Super plasticizer(conplast430) of 0.5% by weight of cement wasused.

Compressivestrengthincreaseforparticlesizelessthan150micronupto30%andthen
decreasesbutfor300micronparticlesizethestrengthdecreasesforeveryreplacement.

Shruthietal[5]studiedtheeffectonpropertiesofconcrete.Tochecktheстrength, the glass powder is replaced by cement by 5%, 10%, 15%, 20% and 25% by weight. Strength was checked at different ages ofconcrete.

The compressive strength shows improvement due to the continuous increase of waste glasspowder.Thestrengthincreasesupto15%replacementandthenstarsdecreasing, it is due to the alkali silica reaction freed during the hydration ofcement.

Theincreaseinthestrengthupto15%isbythepozzalanicreactionandduetothefilling of voids by glass powder and giving rise to dense concretemicrostructure.

III. MATERIALS USED

Materials required for making glass powder concrete essentially consist of cement, fine sand, coarse aggregates and Glass powder. These materials are described below-

CEMENT : Ordinary Portland cement of 43 grade has been used in this experimental work. OPC 43 grade of ULTRATECH cement has been used after investigate the strength of cement at 28 days as per IS 4031-1988. The various properties of the cement are described in Table No. 1.

Table No. 1. Characteristics Properties of Cement

Sr. No.	Characteristics	Experimental value	Specified value as per IS:8112-1989
1	Consistency of cement (%)	33%	---
2	Specific gravity	2.98	3.15
3	Initial setting time (minutes)	35	>30 As Per IS 4031-1968
4	Final setting time (minutes)	282	<600 As per IS4031-1968
5	Compressive strength (N/mm^2) (i) 3 days (ii) 7 days (iii) 28days	 27.56 40.57 48.96	 >23 >33 >43
6	Soundness (mm)	1.00	10
7	Fineness of Cement	5%	10% As Per IS 269-1976.

FINE AGGREGATES: Locally available river sand passed through 4.75mm IS sieve has been used in the preparation of GLASS POWDER CONCRETE . It confirms to IS 383-1970 which comes under Zone I. The physical Properties of sand like Fineness Modulus, Specific Gravity and water absorption are 2.41, 2.65 and 1.21% respectively.

COARSE AGGREGATES: The Coarse aggregate are obtained from a local quarry has been used. The coarse aggregate with a maximum size 20mm having a specific gravity 2.89. In this experimental work coarse gravel of 20mm and crushed aggregate of 10mm are mixed in 60:40. The physical Properties of coarse aggregates like Fineness Modulus, Specific Gravity are 6.68, 2.68 respectively

GLASS POWDER: Glass is a non bio-degradable material and is not suitable for landfills. A lot of waste glass comes from the industries which pollutes our environment. To make our environment pollution free concrete industries had used this waste glass as a replacement of aggregate, fine aggregate and cement and also as a supplementary cementing material. In my research, the glass powder is being partially replaced by cement in concrete. The particle size of glass powder used for this work should pass through 90 micron sieve. White colored glass powder is used in different replacement levels.

WATER: - Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic substances that may be deleterious to concrete. As per IS 456- 2000 Potable water is generally

considered satisfactory for mixing and curing of concrete. Accordingly, potable tap water was used for the preparation of all concrete specimens.

IV. EXPERIMENTAL PROGRAMME

In this section, glass powder concrete based specimens has been tested for the compressive strength, flexural strength and split tensile strength.

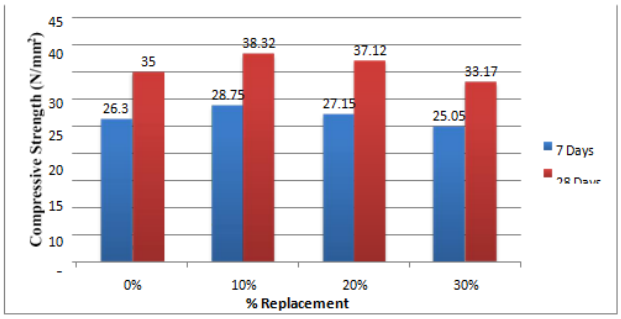
COMPRESSIVE STRENGTH TEST: To examine the compressive strength of glass powder concrete, cube of 150mm×150mm×150mm has been used in this experimental work 30-40 cubes has been casted to determine the compressive strength. firstly cement and sand are mixed uniformly in dry condition . Secondly coarse aggregates are added in this mixture. Now Glass powders also added according to mix proportion to get the resultant mixture of M30 grade. Required dosage of water was added in the course of mixing. The cube moulds were demoulded after 24 hours then they were placed in water tank containing portable water and were left for curing. After that the specimen are tested at 7 days and 28 days at compression testing machine (CTM) as per IS 516-1959. Compressive strength of concrete mixtures was measured at the ages of 7 and 28 days and shown in Table No. 2. There was an increase in compressive strength of cube concrete specimens produced with Glass powders.

Fig. 1 CUBE FILL FOR COMPRESSION TESTING MACHINE (CTM)

Table 2 (Compressive strength of concrete after 7 Days And 28 Days (in N/mm^2)

S.No	Percentage of glasspowder	7 Days Triplet sample values	Average Compressive Strength after 7 Days in N/mm^2	28 Days Triplet sample values	Average Compressive Strength after 28 Days in N/mm^2
1	0%	Sample 1= 27.2 Sample 2 =25.5 Sample 3 =26.2	26.3	Sample 1= 34.0 Sample 2 =35.7 Sample 3 =35.3	35
2	10%	Sample 1= 28.3 Sample 2 =28.9 Sample 3 =29.0	28.70	Sample 1= 38.5 Sample 2 = 37.26 Sample 3 = 39.2	38.32
3	20%	Sample1= 26.95 Sample 2 = 27 Sample 3 = 27.5	27.15	Sample 1= 37.8 Sample 2 = 37.1 Sample 3 = 36.45	37.12
4	30%	Sample 1= 25.15 Sample 2 =25.0 Sample 3 =25.0	25.05	Sample 1= 34.1 Sample 2 = 33.21 Sample 3 = 32.2	33.17

The work was divided in to 4 percentages; triplet specimens were casted for every replacement. Glass powder is replaced with cement as 0%. 10%, 20%, 30%. In table 1 the average results of compressive strength for 7 days and 28 days are summarized



GRAPH NO. 1: COMPRESSIVE STRENGTH AFTER 7 DAYS AND 28 DAYS

The above fig 1 shows the compressive strength of normal concrete and replaced concrete with glass powder at the age of 7 days and 28 days.. The highest strength was recorded at 10% replacement of glass powder with cement when compared to normal concrete. When 10% glass powder is replaced with concrete after 28 days.

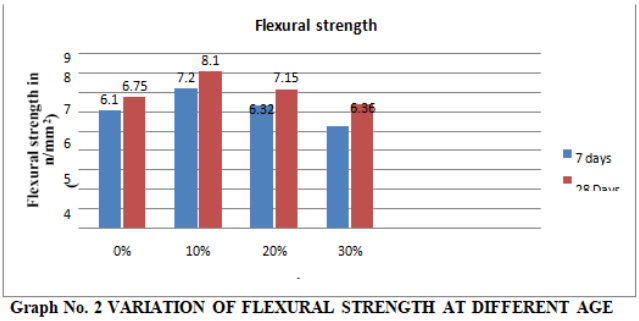
FLEXURAL STRENGTH TEST:- In table 3 the average results of Flexural strength for 7 days are summarized. Thefig 2 shows the flexural strength of normal concrete and replaced concrete with glass powder at the age of 7 days . For normal concrete the strength achieved at 7 days 6.1 N/mm. As the glass powder increases the flexural strength increases. The strength increases upto 20% replacement and then decreases. Lowest strength was noted at 30% replacement level and the maximum strength was recorded at 10% glass replacement levels. When the strength was compared with normal concrete, strength at 10% replacement levels was high. the average results of Flexural strength for 7 days are summarized. The fig 2 shows the flexural strength of normal concrete and replaced concrete with glass powder at the age of 7 days and 28 days . For normal concrete the strength achieved at 7 days 6.1 N/mm. As the glass powder increases the flexural strength increases. The strength increases up to 20% replacement and then decreases. Lowest strength was noted at 30% replacement level and the maximum strength was recorded at 10% glass replacement levels. When the strength was compared with normal concrete, strength at 10% replacement levels was high, at the age of 28 days,Glass powdered concrete shows high strength as compared to normal concrete. Strength of concrete increases as the glass powder replacement increases and also the strength increases as the age of concrete increases. When glass powder concrete is compared to normal concrete, the glass powder concrete at replacement levels 10% shows higher strength. The strength increases up to 20% and the decreases by small amount when compared to normal concrete.

Fig. 2 TEST SET UP FOR BEAM

Fig. 3 CYLINDER UNDER CTM

TABLE No. 3: Flexural strength of concrete after 7 days and 28 days in N/mm2

S.NO	Percentage of glass powder	7 Days Triplet sample values	Average Flexural Strength after 7 Days in N/mm^2	28 Days Triplet sample values	Average Flexural Strength after 28 Days in N/mm^2
1	0%	Sample 1= 2.0 Sample 2 =2.03 Sample 3 =2.07	6.1	Sample 1= 2.48 Sample 2 =2.77 Sample 3 =2.50	6.75
2	10%	Sample 1= 2.53 Sample 2 =2.57 Sample 3 =2.10	7.20	Sample 1= 2.90 Sample 2 =3.15 Sample 3 =2.05	8.1



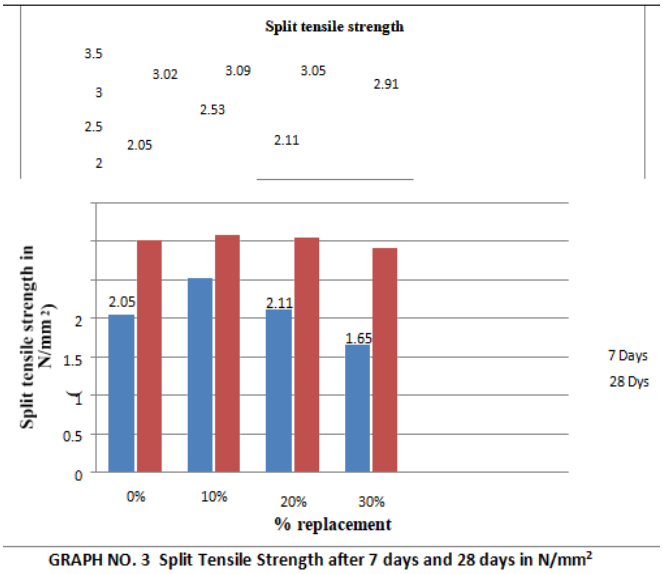
Graph No. 2 VARIATION OF FLEXURAL STRENGTH AT DIFFERENT AGE

SPLIT TENSILE STRENGTH TEST:- The work was divided into 4 percentages; triplet specimens were casted for every replacement. Glass powder is replaced with cement as 0%, 10%, 20%, and 30%. In table 4 the average results of split tensile strength for 7 days and 28 days are summarized. The strength starts increasing as the glass powder replacement increases in the concrete. For the normal concrete, the strength was recorded as 2.05 N/mm2. Maximum strength was recorded at 10% of replacement level when compared to normal concrete. levels the strength increased by 2.3%.

The maximum strength achieved at 10% replacement of glass powder was 2.53N/mm2 after 7 days and. On further increment of glass powder the strength decreases but was more as compared to normal concrete.After 28 days As the glass powder in the concrete increases the strength increases as shown in the fig. 4.3 The concrete containing 10% to 20% glass powder shows higher strength as compared to normal concrete. The maximum strength was recorded at 10% replacement of glass powder with cement in concrete.

TABLE No. 4: Split Tensile Strength after 7 days and 28 days in N/mm2

S.NO	Percentage of glass powder	7 Days Triplet sample values	Average split tensile strength after 7 days in N/mm^2	28 Days Triplet sample values	Average split tensile strength after 28 days in N/mm^2
1	0%	Sample 1= 2.1 Sample 2 = 2.05 Sample 3 = 2.0	2.05	Sample 1= 3.1 Sample 2 = 2.9 Sample 3 = 3.06	3.02
2	10%	Sample 1= 2.49 Sample 2 = 2.60 Sample 3 = 2.5	2.53	Sample 1= 3.15 Sample 2 = 3.20 Sample 3 = 2.92	3.09
3	20%	Sample1=2.18 Sample 2 =2.2 Sample 3 =2.1	2.16	Sample1=3.20 Sample 2 =3.0 Sample 3 = 2.95	3.05



GRAPH NO. 3 Split Tensile Strength after 7 days and 28 days in N/mm^2

V. CONCLUSION

The study was carried out with the aim to incorporate the waste glass,which is nuisance to the environment, in the construction of the cement concrete pavements without compromising with the quality of the concrete produced. The effect of waste glass on the compressive strength, tensile

strength, flexural strength and the workability were studied to determine the impact of waste glass if used as a partial replacement of the cement. The following conclusions were drawn from the research carried out:

- Slump of the concrete decreases as the glass powder percentage increases. The workability of concrete decreases as the replacement level of glass powder increases.
- Compressivestrengthincreasesastheglasspowderreplacementincreasesandwas found maximum at 10%. Compressive strength increases by 12% when compared to control concrete after 28 days
- Split tensile strength increased by 2.3% when compared to control concrete. The strength increases as the glass powder percentage in the concrete increases. High strength was recorded at 10%.
- Also the flexural strength increases as the glass powder replacement increases and the maximum strength was recorded at 10% replacement level.
- The increase in the strength up to 9.3% (After 7 Days) is due to the pozzolanic reaction of the glass powder. It may also be due to the filling of voids by glass powder.
- Beyond 10 % the strength starts to drop, this drop of strength may be due to the dilution effect. The pozzolanic reaction requires the hydration component CH.
- Calcium hydroxide decreases because of the reduction of This chapter deals with the conclusion of the tests done in laboratory for freshly mixed concrete and hardened concrete, the cement content and also due to the consumption of CH by glass powder.
- Beyond 10% glass replacement ,the heat of hydration decreases due to the presence of less amount of CH component. As the glass powder increases beyond 10%, the glass powder can play only the role of inert filler without being activated.

Future Scope

The project work was emphasized on use of glass materials as partially replacement of cement. The use of glass waste in construction industry may further be studied; following are the areas where the utilization of waste glass may find its scope:

- Silica fumes are also pozzolanic in character like the waste glass, the use of silica fumes alongside the waste glass may also be studied.
- The use of glass with asphalt also termed as ‘glasphalt’ may also be studies for pavement construction.
- Waste Glass may further me used as fill material in embankments.
- The further study may include analysis of the effect of glass materials on compressive strength of concrete as partially replacement of coarse aggregates and fine aggregates.

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