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Review on Experimental Study Work on Partial Replacement of Cement with Waste Glass in Flexible ɑrCC Pavements

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Abstract: ***Environmental issues have off late attracted many attentions worldwide. Disposal of wastes has huge environmental impacts as such; waste management and therefore the safe disposal of waste have massive and far-reaching consequences for the environment and are of vital importance.***
The concrete industry is functioning tirelessly to adopt innovative measures to adopt waste glass and use it as a construction material. Today the development industry is finding cost effective materials for strengthening the concrete. Waste management is becoming a serious issue worldwide. One option for safe environmental and economic disposal of waste is to reuse them in building materials.
Due to high material consumption of the construction industry, the use of used glass as a partial replacement for fine aggregate in structural concrete is partially attractive.
The environmental troubles that are associated with cement manufacturing makes the new studies moving forward to using materials have less environmental impact, thus, during this paper we utilized different type of recycled glass that has high percentage of silicon dioxide (SiO2) with different concentrations. the most 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 smaller than 90 micron is used in this work. The work was divided into percentages starting from 0% - 30% with milky white glass powder. a continuing water/cement 0.40 is employed and grade of concrete is M30. A series of tests are conducted to review 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: cement, Waste glass in flexible, CC Pavements, Slump Tests, compression test on concrete cube

I. INTRODUCTION

It is possible to provide door to door service only by road transport .Concrete pavement a large number of advantages such as long-life span negligible maintenance, user and environment friendly and lower cost. Keeping in this view the whole life cycle cost analysis for the black topping and white topping have been done based on various conditions such as type of lane as single lane, two lane, four lane different traffic categories deterioration of road. A highway pavement is a structure consisting of upper imposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade.

The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed bearing capacity of the sub- grade. Two types of pavements are generally recognized as serving this purpose, namely flexible pavements and rigid pavements. The initial cost of concrete overlay is 15% to 60% more than the flexible overlay. The main objective of this study is therefore to propose a construction method to decrease the construction cost of rigid pavement and thereby use of waste glass to serve this purpose without compromising the quality of the road pavement.

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A. Cement

Cement is one of the main building materials. It is a material having adhesive and cohesive properties. The cement used for making concrete is known as hydraulic cement. When water is added to the cement it starts reacting chemically in exothermic processes known as hydration of cement. In hydration of cement, cement paste is formed which covers the aggregate in concrete and also fill the voids. When the water content in cement is reduced, it starts losing its consistency. The loss of water content may be due to the adsorption, evaporation and subsequently sets transforming the mixture in a solid mass. If the consistency of cement paste is excessively high, there is a danger of segregation. It will decrease the quality of concrete. After adding water to the cement, it starts gaining strength with the time. Ultra tech brand cement of OPC 53 is being used in this research.

B. Glass

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

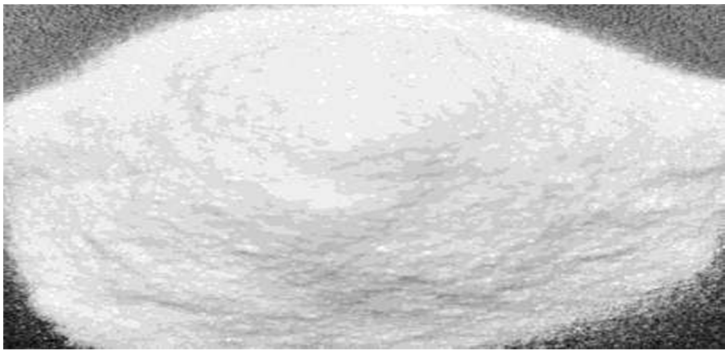

Figure Crushed Glass Powder

1) The main disadvantage of using crushed glass as a replacement of aggregate in concrete is expansion and cracking
2) This expansion and cracking are caused due to alkali silica reaction in the concrete
3) Ground glass is considered as pozzolanic materials and can exhibit properties similar to other pozzolanic materials. It has been found that using glass in mortar applications caused more expansion compared with mortars without glass particles. This expansion can in some cases cause deterioration to the material.
4) It was found that if the glass was ground to a particle size of 300 μ or smaller, the alkali-silica reaction (ASR) induced expansion could be reduced. In fact data reported shows that if the waste glass is finely ground, under 150 μ, this effect does not occur and mortar durability is guaranteed
5) Fine particles of glass usually present pozzolanic activity beneficial to the concrete, while coarse particles are usually deleterious to concrete due to alkali- silica reaction (ASR).

II. LITERATURES REVIEW

A. Review on Properties of Concrete

1) Compressive Strength

a) Fabrice et al. (2017) 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. The compressive strength with green glass powder up to 30% replacement showed more 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 clear glass with same replacement. It was observed that both green and clear glass offers better results than normal concrete without any replacement and this is due to the high silica content present in glass.

b) Parameshwari.t et al. (2017) studied the effect of glass powder which is replaced with 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 glass powder does not contribute to alkali silica reaction and gives higher strength than large sized glass powder.

c) Lalitha et al. (2017) studied the effects of glass powder which was used in different replacements as 5%, 10% and 15% with cement in concrete by weight of cement. 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 content makes the strength decrement. The glass powder used in this work has magnesia content of 4.18% but the permissible limit of magnesia content in cement is 1 -3%.

d) Siddesh et al. (2016) studied the effect different particle size of glass powder in cement. 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(compact- 430) of 0.5% by weight of cement was used. Compressive strength increases for particle size less than 150 micron up to 30% and then decreases but for 300-micron particle size the strength decreases for every replacement.

e) Shruthi et al. (2015) studied the effect on properties of concrete. To check the strength, the glass powder is replaced by cement by 5%, 10%, 15%, 20% and 25% by weight. Strength was checked at different ages of concrete. The compressive strength shows improvement due to the continuous increase of waste glass powder. The strength increases up to 15% replacement and then stars decreasing, it is due to the alkali silica reaction freed during the hydration of cement.

2) Flexural Strength

a) Fabrice et al. (2017) divided this work 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 beams of (length of 50cm and width of 10cm) were casted for each and every replacement. Rate of testing for beams was 0.1kn/sec . Flexural strength for both glass powders was done at 7 days and 28 days of age. Flexural strength starts increasing with increase in glass powder up to 30% replacement and then starts decreasing with increase in glass powder replacement. The strength was higher at 30% and was higher than both clear glass and normal concrete. Also the green glass gives more strength at 7 and 28 days at 30% replacement of glass powder. Due to the higher consumption of lime/calcium oxide by green glass powder gives higher strength than clear glass with same replacement.

b) Parameshwari et al. (2017) used glass powder in concrete in replacement of cement and determined the effects of glass powder on concrete. Cement in concrete was replaced by 10%, 15% and 20% by weight of cement. Fine aggregate of maximum size 4.75mm was used and coarse aggregate size was between 4.75 mm and 20 mm Flexural strength of the concrete with glass powder in different percentages increases with increase in glass powder replacement in concrete. By correlating the flexural strength of normal concrete with glass powder concrete, glass powder concrete shows higher flexural strength. The finely grounded glass powder does not contribute to alkali silica reaction and gives higher strength than large sized glass powder.

c) Shruthi et al. (2015) in their research used glass powder as a replacement of cement in concrete. To check the strength effect, the cement is replaced by 5%, 10%, 15%, 20% and 25% by weight. The flexural strength shows improvement due to the effect of glass powder increment. Flexural strength increases up to 15% replacement and then stars decreasing. The decrease in the strength is due to the alkali silica reaction freed during the hydration. Flexural strength was checked at 28days and 56 days with the same replacement of glass powder and the flexural strength was more at 15% of glass powder replacement. The increase in the strength up to 15% is by the pozzolanic reaction and due to the filling of voids by glass powder. Beyond 20% replacement the strength of concrete starts decreasing because of the dilution effect.

3) Durability

a) Hongjian et al. (2014) studied the effect of glass powder on concrete when cement is being replaced in different percentages. Also 15% glass powder was used as an additive to check the impermeability against chloride and water. Glass powder passed through 90-micron sieve and coarse aggregate with maximum size 10 mm was used. Grade of cement used is OPC43 and mix design to be designed is M50. Cylinders were casted to check the durability of the concrete. Rapid chloride penetration test was checked at 7 days 28 days and 91 days. Also water penetration resistance of concrete was checked at age of 28 days.

RCPT shows the total charge passed within different replacement of cement in concrete. The charge passing through the concrete sample starts decreasing increasing the glass powder content. This test basically determines the electrical conductivity of concrete instead of direct measurement of chloride permeability. Transportation of ions in the pore solution depends upon the pore structure. Increase in waste glass powder replacement decreases the charge passage in concrete. At 7 days the charge passed reduced due to the dilution of OPC in concrete. There is a reduction of total charge passed for long curing time due to the further hydration of cement. Water penetration of concrete continuously decreases as there is increase in glass powder replacement. As compared to plain concrete the concrete with replacement shows much lower water penetration and the reason for this reduction is refined pore structure and mainly the interfacial transition zone.

4) Slump Value

a) Fabrice et al. (2017) used the w/c ratio of 4.5 the max value of slump was found to be 80 mm for 20mm aggregates.
b) Parameshwari et al. (2017) used the w/c ratio of 4.4 the max value of slump was again found to be 80 mm for 20mm aggregates
c) Siddesh et al. (2016) used the w/c ratio of 4.5 the max value of slump found to be 85 mm for 20mm aggregates.
d) Shruthi et al. (2015) used the w/c ratio of 4.5 the max value of slump found to be 75 mm for 20mm aggregates.
e) Hongjian et al. (2014) used the w/c ratio of 4.5 the max value of slump found to be 100 mm for 10 mm aggregates.

According to the above papers the workability decreases as the glass powder replacement increases. Slump is decreasing as the glass powder replacement with cement increases.

5) Split Tensile Strength

a) Fabrice *et al.* (2017) studied both green and clear glass powder and their effects on concrete when partially replaced with cement in concrete. In this paper glass powder passed through 90-micron sieve is replaced in different percentages. Cylinders (diameter 10cm and height of 20cm) with replacement and without replacement of glass powder were casted to check the split tensile strength of concrete and then compared with the normal concrete. At the age of 7 and 28 days the, strength was maximum at 30% glass powder replacement for both types of glass powder. As from the table shown below it is clear that green glass shows more strength as compared to clear glass at 7days as well as 28 days of age. Due to the higher consumption of lime/calcium oxide by green glass powder gives higher strength than clear glass with same replacement. It was observed that both green and clear glass offers better results than normal concrete without any replacement and this is due to the high silica content present in glass.
b) Lalitha *et al*. (2017) studied the effects of glass powdered concrete. Glass powder was used in different replacements as 5%, 10% and 15% with cement in concrete by weight of cement. Tensile strength was higher at 5% replacement of waste glass powder and is more than control concrete. Tensile strength is more than normal concrete at 5 % replacement as the tensile strength increases by 32.3% at the same replacement. 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 content makes the strength decrement. The glass powder used in this work has magnesia content of 4.18% but the permissible limit of magnesia content in cement is 1 -3%.

III. OBJECTIVE OF WORK

The main objectives of this study are as follows:

1) To determine the suitability of Glass powder in the construction of Cement Concrete Pavement as a cost reduction measure.
2) To determine the percentage of glass powder which gives maximum strength when compared to ordinary concrete.
3) To check the workability of the concrete with glass powder.
4) To check the compressive strength of the concrete with glass powder.
5) To Determine Tensile Strength of the concrete with glass powder.
6) To Determine Flexural Strength of the concrete with glass powder.

IV. CONCLUSIONS

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:

1) Slump of the concrete decreases as the glass powder percentage increases. The workability of concrete decreases as the replacement level of glass powder increases.
2) Compressive strength increases as the glass powder replacement increases and was found maximum at 10%. Compressive strength increases by 12% when compared to control concrete after 28 days
3) 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% .
4) Also the flexural strength increases as the glass powder replacement increases and the maximum strength was recorded at 10% replacement level.
5) 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.
6) 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.
7) 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.

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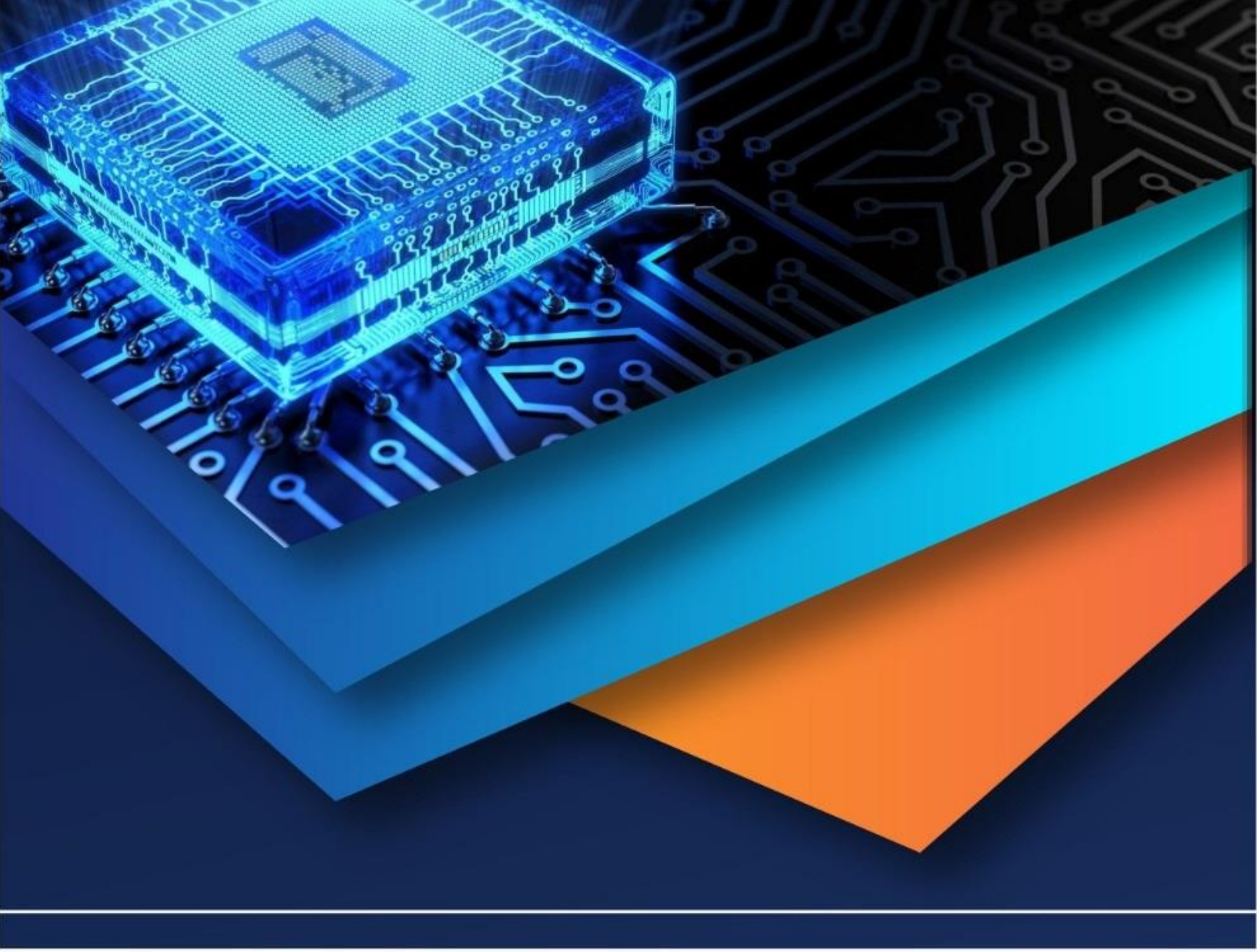

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