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Experimental Study on the Performance of Concrete with Partial Replacement of Fine Aggregate with Waste Glass (Powder form) in Rigid Pavements

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Abstract - *Glass are widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubes. This experimental study aimed to determine the level of waste glass (powder form) replacement resulting in optimal compressive strength and flexural strength. The mix proportion will be carried out with partial replacement of fine aggregates by waste glass i.e., 0%, 5%, 10%, and 15% by weight for M-30 mix. On mixing the concrete with the waste glass (powder form), the workability of concrete, the compressive strength and the density of concrete will becompared with conventional concrete after 7, 14 and 28 days.*

Key words: Concrete, Aggregates, Waste Glass (Powder Form), Compressive strength, Flexural strength, Workability, Glascrete.

INTRODUCTION

Rigid pavements are constructed from cement concrete or reinforced concrete slabs. The rigid pavements undergo slab action and is capable to transfer safely wheel load stresses to a wider area below. Rigid pavements are made of Portland cement concrete, reinforced cement concrete, prestressed and post-stressed concrete. Rigid pavements does not get deformed to the shape of the lower surface as it can bridge, the minor variations of lower layer. The design of rigid pavements is based on providing a structural cement concrete slab of sufficient strength to resists the loads from traffic. The rigid pavements slab as tensile strength, tensile stresses are developed due to the bending of the slab under the wheel load temperature variations. Material includes; Portland cement (Grade-53), coarse aggregate, fine aggregate which is partially replaced by waste glass (powder form) and water. Due to the use of waste glass (powder form) in concrete as it increases the compressive strength and the concrete made with the recycled glass aggregate have shown better long term strength. Providing a good base at sub base course layer under the cement concrete slab increase the pavement life considerably and therefore workout more economical in the long run.

LITERATURE REVIEW

Many researchers have investigated on various properties of concrete containing waste glass (powder form) and few are discussed below:

Craig Polley., (1996) [1] determined that the glass aggregate displays a water demand for workability greater than that of natural aggregate. By this water demand increases the water-cement ratio of the concrete, and thereby resulting in a lower strength.

ShyleshMorar., et al., (1999) [2] suggested that smaller particle size of the ground glass resulted in a higher activity of glass with lime, a higher compressive strength in concrete as well as a lower expansion.

Weihua Jin., et al., (2000) [3] pointed out that the expansion of mortar bars is directly proportional to the glass content and are strongly dependent on the color of the glass. If used in large quantities is commodity products such as concrete masonry blocks, the solid waste disposal problem faced by municipalities nationwide can noticeably be reduced.

C. Meyer., et al., (2001) [4] observed that the glass are used as an aggregate in concrete, either in commodity products, with the only objective being to utilize as much glass as possible, or in value-added products that make full use of the physical and esthetic properties of color-sorted crushed glass.

Mohamad J. Terro., (2005) [5] studied that theconcretes made with 10% aggregates replacement with waste glass possesses higher compressive strength than normal concrete at temperatures above150 degree centigrade.

Malek Batayneh., et al., (2006) [6] concluded that the strength of concrete mixes was improved by the partial replacement of fine aggregates with crushed glass aggregates, but the high alkali content of such aggregates would affect the long-term durability and strength.

S. P. Gautam., et al., (2009) [7] concluded that partially replacement of fine aggregate as waste glass (powder form) in cement concrete increases the strength in 28 days up to

20% of replacement level. The optimum replacement level of waste glass as fine aggregate is 10%.

M. Iqbal Malik., et al., (2013) [8] explained that the fine aggregates is replaced by waste glass (powder form) up to 30% by weight, it shows 9.8% increase in compressive strength at 28 days.

Kiang Hwee Tan., et al.,(2014) [9]indicated that use of recycled glass (powderform), as an alternative fine aggregate for concrete mix does not reduce the mechanical properties of the concrete up to 100% replacement as it leads to the increase in compressive strength and flexural strength.

M. Adaway., et al., (2015) [10] investigated that proportions exceeding 30% waste glass (powder form), develops negative impact on compressive strength of cement concrete. The compressive strength was found to increase with the addition of waste glass to the mix up until the optimum level of replacement.

METHODOLOGY OF THE STUDY

Waste glass (powder form) is used as fine aggregate replacement material in concrete. The waste glass are collected and are crushed into small pieces manually, then the sieve machine are used. Mix design (M30) is selected with proportion mix cement: sand: aggregate (based on design mix) by volume as per IS -specification. Concrete mixes were cured for 7 days, 14 days and 28 days. The properties of convential concrete and waste glass will be checked by different tests i.e. sieve analysis, consistency test, fineness test etc. The mix proportion will be carried out with partial replacement of fine aggregates by waste glass i.e., 0%, 5%, 10% and 15%. Specimens shall casted as per IS-specifications to find out compression strength and flexural strength with different proportion of partially replacement of waste glass (powder form) and then, compare it with conventional concrete.

Mix design: The grade generally used for this type of design mix includes, Ordinary Portland Cement (Grade-53), coarse aggregate, fine aggregate which is partially replaced by waste glass (powder form) and water. The mix design use in our investigation is the nominal mix M30 as per IS-Specification.

Mixing of Concrete: The materials used are coarse aggregate, fine aggregate and cement in a uniform layers so that when the mixing is done it can obtained a uniform color and after dry mixing, water should be done in an appropriate manner.

The methodology involved for the study are as under:

1. Mix design (M30) as per IS -specification.
2. Waste glass will be collected and converted into powder form.
3. Properties of convential concrete and waste glass will be checked by different tests i.e. sieve analysis, consistency test, fineness test etc.
4. Mix proportion will be carried out with partial replacement of fine aggregates by waste glass i.e., 0%, 5%, 10%, and 15%.
5. Specimens shall casted as per IS -specifications to find out compression strength and flexural strength with different proportion of partially replacement of waste glass (powder form) and then, compare it with conventional concrete.

EXPERIMENTATION

Sieve Analysis: It is commonly knowns as gradation test and is commonly used for determining the gradation (distribution of aggregates particles, by size) in order to determine compliance with design and verification specifications.

Sieve size	%age									
	40	**20**	**10.5**	**10**	**4.75**	**2.36**	**`1.18**	**0.6**	**0.3**	**0.15**
20mm	99	90.5	11.2	0.0	0.0	-	-	-	-	-
12.5mm	-	-	98.2	83	-	1.5	0.0	-	-	-
Sand	-	-	-	100	100	93	65.2	38.9	12.2	0.8

Consistency Test: The consistency of cement is defined as the process which permits the Vicat plunger to penetrate 5 to 7 mm from the mould when tested. As we know, the strength of materials depends upon quality of material and cement is one of them.so for more cement strength, amount of water should be right.

Fineness Test: The increase in fineness of cement is also found to increase the drying shrinkage of concrete and also in commercial cement, it is found to be about 25-30 % of particles of less than 7 micron in size.

OBSERVATIONS AND RESULTS

Water Absorption: It is carried for all mixes and by this way percentage of water absorption is measured, the percentage of water absorption decreases with increase in the waste glass content. The lowest value of water absorption is seen in 15% waste glass content because when we use excess amount of waste glass content in concrete it creates a problem in concrete due to ASR.

Light weight character: It is seen that the density decreases with increase in waste glass. The results shows 5% of reduction in dry weight of cube specimens for concrete mix with15% of replacement of waste glass, thus waste glass concrete is lighter in weight.

Flexural strength: It is seen that there should be a little reduction in the flexural strength after replacement of fine aggregates with waste glass. The slight variation in flexural strength is observed and could be explained by the weak bonding between the waste glass and the cement.

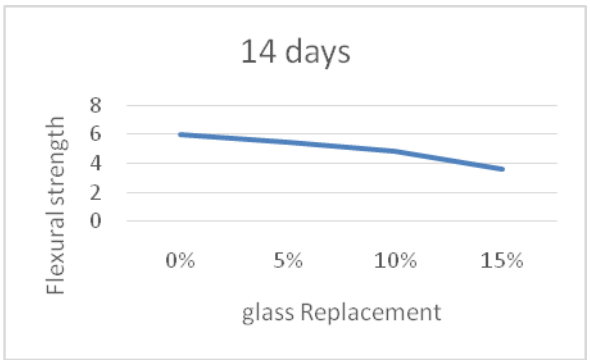

Fig.1.Flexural strength of concrete after 14 days

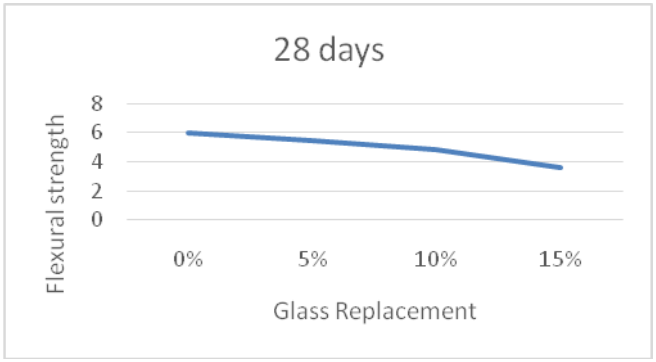

Fig.2.Flexural strength of concrete after 28 days

Compressive strength: It is observed that when the fine aggregates is replaced by 10% glass waste, the compressive strength at 14d is found to be increased by 18.99 MPa. However, it is evident that increase in compressive strength at 28 d is only 29 MPa at same replacement.

The Results for compressive strength development up to time period of 28 days is illustrated in the table.4 and expect the mix of G10%, the result shows zero significant changes between compressive strength and the concrete containing various replacements levels of glass aggregate at different ages.

14 day compressive strength: When we increase the glass aggregate, an increasing trend can be witnessed until the maximum compressive strength 18.99 MPa was developed at a replacement of 10%. By adding the glass the compressive strength gets higher and it was found that the compressive strength of concrete after 14 days of curing was found to increase with the addition of glass at lower levels of replacement.

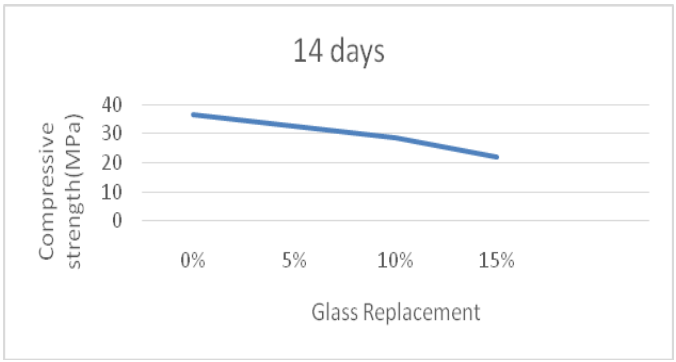

Figure 3. Compressive strength of concrete after 14 days

28 day compressive strength: The results is closely similarly as on the 14 day test with increase in addition of waste glass up to the optimum percentage of 10%. The specimen containing 15% waste glass was found to have compressive strength lower than the achieved. This resembles with the 14 day test and finally concluded that levels of glass in excess of 10% adversely affect the development of compressive strength.

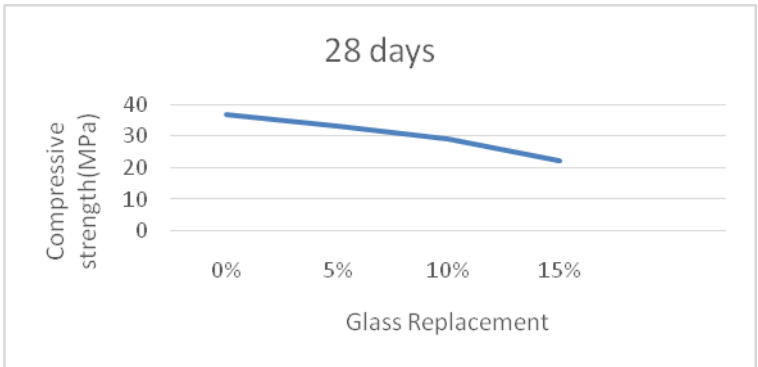

Figure 4. Compressive strength of concrete after 28 days

Conclusions:

- The compressive strength of the concrete at 14 and 28 days increased as the waste glass (powder form) replacement level increased to maximum values at 15% replacement. This means that optimum replacement of fine aggregate with waste glass (powder form) occurred at 15% replacement level.
- Compressive strength of concrete increases with the addition of waste glass to the mix up until the optimum level of replacement.
- The optimum replacement level of waste glass as fine aggregate is 10%.
- With increase in waste glass content, percentage of water absorption decreases.
- Use of waste glass can prove to be economical as it is non useful waste and free of cost.
- The glass waste (powder form) in concrete is less workable, strong, and durable as compared to sand concrete (fine aggregate).
- Waste glass can be effectively used as fine aggregate replacement.

Future Scope: To find out the changes developed by addition of some other materials like: Demolished concrete, Pulverized plastic, Foundry sand.

SCOPE OF WORK

Recent researches findings have shown that concrete made with the recycled glass aggregate have shown better long term strength.

The reusing of waste glass in concrete has significant benefits such as:

- Cutting of waste disposal costs, which are likely to rise due to landfill tax.
- Reducing the costs of producing concrete because has been replacement a part of waste rather than conventional concrete materials that have high cost.
- Conserving the environment by saving large amount of primary raw materials each year.

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