Development & Strength Evaluation of Waste Glass Filled Paver Blocks

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Abstract— From past few years, there is now a significant worldwide interest to solve the environmental problems caused by industrial waste and other materials including such materials in the manufacture of concrete. This technology has been introduced in India in construction, a decade ago, for specific requirements namely footpaths, parking areas, etc. but is now being adopted extensively in different uses where the conventional pavement using bituminous mix or cement concrete technology is not feasible or desirable. The characteristics of concrete containing finely crushed glass during its process, the best ratio of finely crushed glass which leads to higher strength of concrete to produce concrete blocks, and the effect of waste glass replacement on the expansion caused by Alkali-silica reaction (ASR). This study analyzes the feasibility of waste glass inclusion as partial FA replacement systems. Properties of concrete incorporating waste glass as a partial substitution for FA amounts of 18%, 23%, 27%, and 40% were investigated. The waste glass material used was obtained from waste collectors. The results obtained show clearly that glass enhances the compressive strength properties of the final concrete product. The study indicated that waste glass can effectively be used as a fine aggregate replacement (up to 40%) without substantial change in strength.

Keywords: Glasswares, Concrete Mix and Paver Blocks

I. INTRODUCTION

Concrete paving blocks have been extensively used in many countries for quite some time as a technical problem- working technique for providing pavement in areas where conventional types of construction are less durable due to many functional and environmental constraints. This technology has been introduced in India in construction, a decade agone, for specific demands namely paths, and parking abreast. but now being adopted broadly in different uses where the conventional construction of pavement using bituminous blend or cement concrete technology isn't doable or desirable. Concrete paver blocks were first introduced in Holland in the fifties as relief of paver bricks which had come scarce due to the post-war structure construction smash. These blocks were blockish in shape and had more or less the same size as the bricks. During the once five decades, the block shape has steadily evolved from non-interlocking to incompletely interlocking to completely interlocking to multiply interlocking shapes. The main challenge before the Indian concrete assiduity now is to meet the demand of provident and effective construction materials taken by large structure requirements due to fast industrialization and urbanization. All these calls for use of good quality concrete with the use of minimal coffers (e.g., Limestone, energy & plutocrat) and achieving maximization of strength, continuity and other intended concrete parcels. In recent times there has been an adding worldwide demand of concrete paving blocks for the paths, roads and fields which has led to an original reduction of summations. In some civic areas, the enormous amounts of total that have formerly been used means that original accouterments are no longer available and the deficiency has to be made up by importing accouterments from other locales. Most metropolises have areas of land covered by loot stacks which are uncomely and help large areas of land being used for anything differently.

Concrete paving block is a versatile, aesthetically attractive, functional, and cost-effective and requires little or no conservation if properly manufactured and placed.

II. HISTORICAL REVIEW

O Sadiq, Odatoyebi - NSE Technical Transaction, 2015 - eprints.lmu.edu.ng, studied that was glass particles has been used as replacement for coarse aggregate & fine aggregate and even in this work glassware was used as a partial replacement for sand as a fine aggregate in reinforced concrete, mixes of 0%, 10%, 20 % & 30%, glass content were cast into short beams for flexural strength test.

TC Ling, CS Poon, HW Wong - Resources, Conservation and Recycling, 2013 – Elsevier, studied that was to find practical ways to recycle waste glass for the production of different concrete products such as concrete blocks, self-compacting concrete and architectural mortar. Some of these specialty glass-concrete products have been successfully commercialized and are gaining wider acceptance.

G Sharma, A Sharma - AIP Conference Proceedings, 2018 - aip.scitation.org studied that the current growth and recycling situation of waste glass and point out the direction for the proper use of waste glass as replacement of construction material. These will not only help in the reuse of waste glass but also create eco-friendly environment.

SP Gautam, V Shrivastava, VC Agarwal - J. Acad. Indus. Res, 2012 - researchgate.ne, studied that was Materials and methods In order to study the effect of waste glassware as partial cement replacement on the strength of … Cement: In this work, Ordinary Portland cement (OPC) of Birla (43 grade) brand obtained from a single batches.

EE Ali, SH Al-Tersawy - Construction and Building Materials, 2012 – Elsevier, studied that was Recycled glass as a partial replacement for fine aggregate in self compacting concrete.

P Aggarwal, Y Aggarwal, SM Gupta - 2007 - sid.ir Studied that investigate the effect of use of coal bottom ash as partial replacement of fine aggregates in percentages (10%, 20% and 30%), on concrete properties such as compressive strength, flexural strength.

KH Tan, H Du - Cement and Concrete Composites, 2013 – Elsevier, in this study, mortar made with waste glass as fine aggregates was investigated for its suitability for construction use.

III. OBJECTIVE OF STUDY

The research aims at the "Development & Strength Evaluation of Waste Glass Filled Paver Blocks".

- The following objectives are emphasised for this research work and are summarized below:
- Collection of waste glass materials from domestic households. (For e.g. Tube lights, bulbs, LEDs……. etc.)
- Casting of paver blocks by mixing glass wares into concrete mix in different proportions.
- Testing of paver blocks for different engineering properties

IV. MATERIAL

A. Cement-

In this work, Ordinary Portland cement (OPC) of UltraTech (53 grade) brand obtained from a single batch was used. The physical properties of OPC was determined. The cement is upto the requirement of IS: 8112-1989. The specific gravity was 3.15 and fineness was 2800 cm2/g.

B. Aggregate

Aggregate are the important constituents in concrete. They give body to the concrete, reduce shrinkage and affect economy. Aggregate occupy is to assist in producing workability and uniformity in mixture. The fine aggregate is also assisting the cement paste to hold the coarse aggregate in suspension. This concrete is 70-80%of the volume of concrete. To increase the density of resulting mix the aggregates are frequently used in two or more sizes. The most important function of the fine aggregate action promotes plasticity and segregation. The aggregate provides about 75% of body of. The size of aggregate bigger than 4.75 mm is considered as coarse aggregate and less as fine aggregate or sand. The nominal sizes of course aggregate are 10 mm, 20 mm and 25 mm etc. where have used. In this work fine aggregate as well as coarse aggregate were used

C. Water

The water used for mixing and curing of concrete should be free from harmful materials and objectionable strain on surface. A part of mixing water is utilised in the hydration of cement and the remaining water serves as lubricant between the fine and coarse aggregates and make concrete workable. Generally minimum 0.3 to 0.8 w/c ratios are required for hydration. But for good workable concrete additional water is required to lubricant the mix. The extra water results in formation of bleeding effects of effective water in concrete are as below:

- Less effective bond formation
- Leakage through formwork
- Honey comb formation

D. Glass-

For this work the non-recyclable glass is used. Basically, waste glass material that cannot be reused due to the high cost of manufacturing. Therefore, the manufacture will dispose in the waste landfill. Due to environmental problem, researcher tries to use the waste glass in to concrete, to create a new material to use in construction field. Researcher found that, the main material composition of glass is silica that also contain in cement production and other compound that also similarly contain in cement production.

It is crushed by using los angles abrasion testing machine up to 4.75 mm passing and 90 micron retaining glass taking for the work.

The following table no 3.3 shows Chemical composition of clear glass is as follows:

Table 3.3 Chemical Composition of Glass

Composition	Clear Glass
Sio2	72.42
Al2O3	1.44
Tio2	0..35
Cr2O3	0.002
Fe2O3	0.07
CaO	11.50
MgO	0.32
Na2O	13.64
K2O	0.35
SO3	0.21

Following figure. no. 3.4 shows crushed waste Glass material- fine and 3.5 shows Glass material- Coarse: -

Fig. 3.4:

Fig. 3.5:

E. Moulds –

The rubber moulds are used for casting paving block of Type C: Paver blocks having all faces curved or corrugated, which key into each other along all the vertical faces when paved in any pattern. They were made in such a manner as to facilitate the removal of the moulded specimen without damage.

Following figure 3.6 shows different shapesof rubber paver moulds& figure 3.7 shows Colorado block mould used in this dissertation: -

Fig. 3.7: Different moulds used in Paver Blocks

Fig. 3.8: Colorado block mould

V. METHODOLOGY

VI. OBSERVATIONS

MIX PROPORTIONS FOR M30 GRADE
Cement Content = 444.44 kg/m^3
Fine aggregate = 594.66 kg/m^3
Coarse aggregate = 570.24 kg/m^3
Water-cement ratio = 0.45
FOR 3 LITRES (0 .003 m^3) VOLUME OF MOULD

Paver Blocks	Cement (Kg)	Sand (Kg)	Aggregate (Kg)	Glass(Kg)	Water (Kg)
Plain M30 Grade	1.33	1.80	1.71	-	0.60
18% Replacement of Sand by Glass	1.33	1.46	1.71	0.35	0.60
23% Replacement of Sand by Glass	1.338	1.40	1.71	0.40	0.60
27% Replacement of Sand by Glass	1.33	1.30	1.71	0.53	0.60
40% Replacement of Sand by Glass	1.33	1.07	1.71	0.78	0.60
Plain M30 Grade	1.33	1.80	1.71	-	0.60
18% Replacement of Sand by Glass	1.33	1.46	1.71	0.35	0.60
23% Replacement of Sand by Glass	1.338	1.40	1.71	0.40	0.60
27% Replacement of Sand by Glass	1.33	1.30	1.71	0.53	0.60

Followig figure 3.17 shows compressive strength v/s method of casting Paver Block :-

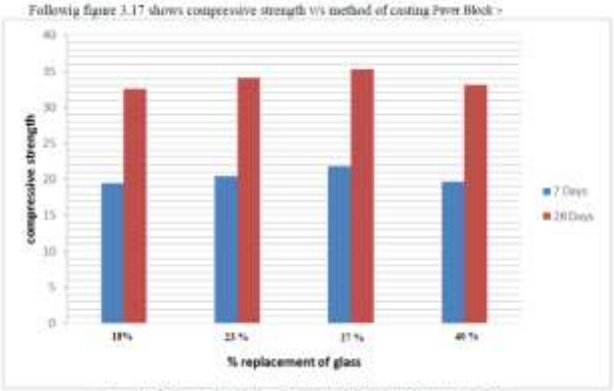
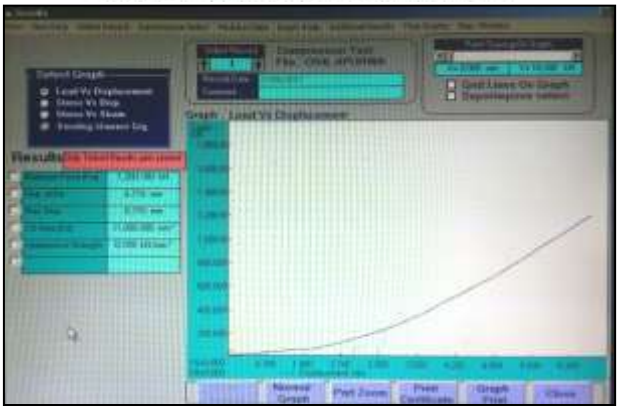


Figure 3.17 compression strength vs. % of glass replacement in cubes



VII. RESULTS

To observe the effect on compressive strength of pavers blocks and concrete cube of waste glass used as replacement with fine aggregate at 18, 23, 27 and 40% of replacement in paver blocks were used. Paver blocks and concrete cube are cast without glass also and the waste glass replacement paving block are compared with the paver blocks made without replacement of glass (Ordinary paving block). The results of compression test and flexure test are obtained that are shown below.

S.No.	Test Specimen with Markings	Cross-sectional area (mm^2)	Maximum applied Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/ mm^2)
1.	S	34155	2015.0	58.99	
2.	A	34155	1948.0	57.03	
3.	G	34155	1979.5	57.95	58.20
4.	P	34155	1999.0	58.52	
5.	R	34155	1998.0	58.49	

– An analysis made on strength characteristic by conducting test on non-recycled glass concrete. The 7 days and 28 days compressive strength result of M30 grade concrete shown in table and analysis by graphically shown in chart.

- Waste glass bas been replaced as a fine aggregate in concrete with different percentage such as 18%, 23%, 27% and 40%. The tests carried on the fine aggregate such as specific gravity, sieve analysis are also conducted on waste glass.
- Overall 16 paving blocks has been casted. In that normal blocks (Ordinary paving block and cube) casted of M30 grade concrete and compressive test conducted on paving block as well as concrete cube and the flexural test are conducted on only the paving block that after curing of 7 days and 28 days. By replacing waste glass to fine aggregate in different percentage 18%, 23%, 27% and 40% casting is done. After curing of 7 days and 28 days the compressive test and flexural test are conducted on that. By observing results of waste glass blocks that is concrete cube the strength of block is increases from 15% to 30% replacement of glass and after 45% waste glass replacement and onwards the strength is decreases. Strength reduces because of internal voids of waste glass increases. We comparing strength of waste glass blocks with normal blocks. Up to 15% and 30% is comparatively more than normal block but up to 45% strength is nearly same to normal block. So from above chart we got the optimized value as 30% replacement of waste glass as well we found that 45% replacement of waste glass is suitable for casting the paving block for light traffic.

VIII. Conclusion

The feasibility of concrete blocks with Fine Glass was shown technically in the present study. Based on the experimental investigation, the following conclusions-

- The density of concrete decreased with an increase in waste glass content thus making concrete lightweight in nature.
- The use of waste glass as fine aggregate decreases the unit weight of concrete.
- With the increase in waste glass content, the percentage of water absorption decreases.
- Workability of concrete mix increases, as well as durability of concrete, also increases with waste glass content.
- Flexural strength decreases with an increase in waste glass content.
- Compressive strength increases with increasing the glass parentage from 15% to 30% replacement of glass and after 45% waste glass replacement onwards the strength decreases. Strength reduces because of internal voids of waste glass increase.
- The cost of paving blocks decreased with an increase in glass content.
- Crushed waste glass aggregate has irregular shapes than river sand.
- A reduction in bleeding is observed by the addition of glass in the concrete mixes.
- The fluidity of the fresh concrete is inhibited.

Acknowledgement

The author are Grateful to the Department of Civil Engineering, Sagar Institute of Research & Technology-Excellence, Bhopal, Madhya-Pradesh, India for extending the facilities and support during study, and also very thankful to the project guide Sandeep Gupta (Assistant Professor) and lecturers for their guidance and support.

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