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Partial Replacement of Fine Aggregate with Glass Using DIC Technique with Waste Materials for Investigation of Crack Propagation.

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ABSTRACT:
This report mainly focuses on measurements of deflection, strain and crack propagation in structures using digital image correlation (DIC) method. This is non-destructive evaluation system. In particular, monitoring the development of cracks is of large interest because their properties reflect not only the condition of concrete as material but also the condition of the entire system at structural level. In DIC sample is photographed using a high-resolution digital camera mounted on an optical microscope. The resulting displacement information reveals the average motion present from the centre of each of the small sub images used in the analysis, relative to the original position. These results show a great application potential of the DIC technique for various situations such as inspecting shrinkage-induced cracks in fresh concrete, masonry and reinforced concrete structures, and safety of bridges.
Keywords: Structural Health Monitoring; Fault detection; Identification; Crack Propagation; Digital Image Correlation Method; Concrete, MATLAB®.

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I. INTRODUCTION

The development of Digital Image Correlation (DIC) concepts in civil engineering field has become more and more attractive in the last decade and has received growing attention in academic and applied research. Digital Image Correlation (DIC) uses the principles of photogrammetry. DIC is used to track features in space and assign their position to a predetermined coordinate system. The measure is made by the comparison of an image series that is captured over fixed intervals of time. The technique can be used for many tests including compressive, tensile, torsion, bending loads for static and dynamics applications. The method can be applied from very small (micro) to large testing areas.

II. MATERIALS

Recycled waste glass is a promising material in construction due to:

- Lightweight
- Elasticity
- Energy absorption
- Sound and heat insulation
- A viable solution to cut down the carbon footprints

The following issues should be evaluated when considering the application of rubber aggregates Collection, processing and transport costs of scrap bottles. Reduction in the environmental costs of land filling and increase in landfill voids. By using, design M25 grade of concrete with an aim of maximum utilization (in percentages) of glass as aggregates with other materials. Compressive strength of concrete, split tensile strength flexural strength of concrete are important factors which assessing the suitably of using the new concrete for structural applications.

2.1 Glass :

Non-recyclable waste glass constitutes a problem for solid waste disposal in many municipalities. The current practice is still to landfill most of the non-recyclable glass. Since the glass is not biodegradable, landfills do not provide an environment-friendly solution. Consequently, there is a strong need to utilize waste glasses. Traditionally, most non-recyclable mixed-color broken glasses are coming from the bottling industry. In addition, the recently initiated business of recycling mercury-containing fluorescent lamps also produces a large quantity of non-recyclable waste glass.

The solubility of the glass is dependent on the grain size of the glass particles, increasing with the reduction of the particle size. When glass is used as finely powder material (size < 75 lm) the silica is quickly dissolved, reacting with free portlandite and acting as a pozzolanic material. On the contrary, when used as aggregate particles, glass grain suffers a partial dissolution, mainly localized in its boundaries, which causes the formation of silica gels that can expand, causing high distress. In this same study it is observed that the glass expansion has a slower initial rate, growing in later ages.

2.2Aggregate:
Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. On the bases of size aggregate can be classified as fine aggregate and coarse aggregate.

2.2.1. Fine Aggregate

Table 1: Properties of fine aggregates

PROPERTIES	FINE AGGREGATE	IS RECOMMENDATIONS
Specific Gravity	2.89	-
Fineness Modulus	3.05	Fineness more than 3.2 is not allowed for concreting
Moisture Content	2.83	-
Loose Bulk Density	1.94 kg/lit	-
Water Absorption	3.86%	0.5 To1% By weight of aggregate.
Material finer than 75µ	2.85%	-

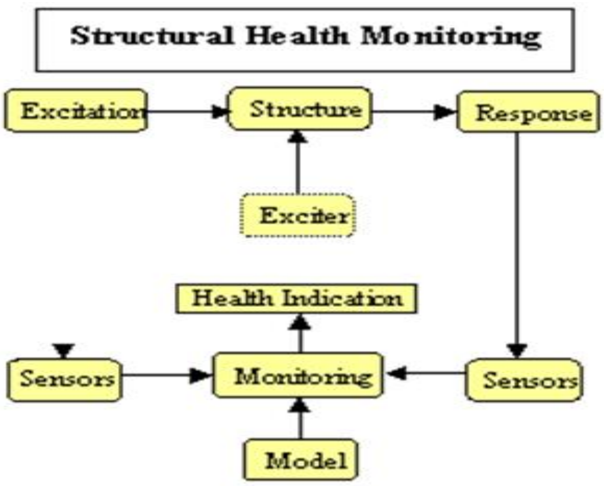
2.2.2 Coarse Aggregate

Table 2: Properties of coarse aggregates

PROPERTIES	CA: 10 - 20mm	IS RECOMMENDATIONS
Specific Gravity	2.86	
Flakiness & Elongation Index	14.7% & 34.82%	
Loose Bulk Density	1.41 kg/lit	
Water Absorption	1.37%	0.5 - 1% by weight of aggregate
Impact Value	16.22%	Impact & crushing values for concrete wearing surfaces should not exceed 30% and for other concrete works these values should not exceed 45% and 50% respectively

III. EXPERIMENTAL PROGRAMME

An experimental program was undertaken which consisted of testing glass, conventional aggregates (coarse and fine) and properties with fresh and hardened concrete specimens. The hardened concrete tests consisted of testing 100 mm × 100 mm cubes to know the compressive strength of concrete as per IS: 516 - 1959. Curing and testing of the concrete specimens were performed as per BIS guidelines. Further flexural strength of concrete will be determined as per IS: 516 - 1959 by testing beams of standard size 500 mm x 100 mm x 100 mm.



3.1 Proportion of materials

Table 3: Proportions of materials (for crumb rubber replacement)

Mix no.	Cement	Fine aggregate	Coarse aggregate	Crumb rubber by weight (%)	Water/cement ratio	Admixture (%) by weight of cement	Compaction factor
CR 0	1	2.11	2.92	0	0.40	1.5	0.9
CR 4	1	2.03	2.92	4	0.40	2	0.9
CR 5	1	2.00	2.92	5	0.40	2.2	0.9

3.2 Final value for mix design (M25)

(a) For control beam

Table 4: Mix design values

Water cement ratio	0.4
Specific gravity of cement	3.11
Specific gravity of sand	2.66
Specific gravity of coarse aggregate	2.59
Zone of sand	2nd (IS 383)
Water absorption in coarse aggregate	0.5%
Water absorption in fine aggregate	1%
Cement	385 kg/m^3
Water	154 l/m^3
Fine aggregate	990.37 kg/m^3
Coarse aggregate	890.39 kg/m^3
Admixture	7.7 kg/m^3

IV. RESULTS AND DISCUSSION

4.1 Tests Results

Digital Image Correlation were elaborated and discussed. The resolution and application of the digital-image-correlation techniques are demonstrated in this report. The results show that the how crack propagating from one place to another place during applying loads. Using our self-developed method, one can calculate the stresses, strains and also crack variation in concrete structures and the deformation evolutions can be visualized by means of the digital-image-correlation technique. The identification of crack development in structures forms an important study for investigating the earthquake resistance capability of the masonry structures.

Table 5: Comparison of stresses for beams

S No.	Beam Type	StaadPro Stress (N/mm^2)	MATLAB Stress(N/mm^2)
1	Control beam 14 days	7.707	6.5
2	Control beam 28 days	8.667	6.75
3	Beam with 25% glass waste	8.127	7.5

4.1.1 Tests Results for beam with glass.

V. CONCULSION

In this work, the fundamental principles of the structural health monitoring by the Digital Image Correlation were elaborated and discussed. The resolution and application of the digital-image-correlation techniques are demonstrated in this report. The results show that the how crack propagating from one place to another place during applying loads. Using our self-developed method, one can calculate the stresses, strains and also crack variation in concrete structures and the deformation evolutions can be visualized by means of the digital-image-correlation technique. The identification of crack development in structures forms an important study for investigating the earthquake resistance capability of the masonry structures. Traditionally, inspecting the structure and documenting the findings were done manually. The procedures are time-consuming, and the results are sometimes inaccurate. Therefore, the digital image correlation (DIC) technique is developed to identify the strain and crack propagation. This technique is non-destructive for inspecting the whole displacement and crack field.

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