EXPERIMENTAL AND ANALYTICAL STUDY ON PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH BROKEN CLAY TILES

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Abstract - *This paper studied the possibility of using broken clay tiles as partial replacement of coarse aggregate in concrete. Experimental studies were conducted on fresh and hardened concrete made with partial replacement of crushed granite coarse aggregate with broken tile. The experimental results showed that 20% and 25% tile aggregate concrete attains 98% and 95% compressive strength of natural aggregate concrete. This paper presents a detailed study of experimental and analytical investigation of the flexural behavior of the small-scale beam specimen of dimension 100X150X750 mm using 25% replacement of broken clay tile concrete.*

***Key Words*: R C C flexural beam, crack pattern of flexural beam, R C C Shear beam, crack pattern of shear beam, ANSYS analysis, etc.**

1. INTRODUCTION

Concrete has several appealing characteristics that have made it as a widely used construction material. It is the material of choice where strength, performance, durability etc., are required and concrete is undoubtedly most versatile construction material. The present study aims at utilization and to ascertain the suitability of broken clay tile aggregate as partial replacement to coarse aggregate in normal blended concretes. The use of more and more concrete in construction industry not only results in scarcity of materials but also turns out to be expensive. In order to cope up with the depletion of conventional resources it would be worth to make use of suitable waste material to replace some of the conventional materials. Thus, by using these wastes instead of conventional materials would be preserving the natural resources, but also solving the problem of disposal of waste, which has become a national problem. Various mixes of partial replacement of clay tiles are studied for workability and compressive strength. Further the compatible mix proportion with controlled concrete of grade M30 is prepared for the experimental study of the flexural beam specimen.

2. PROPERTIES FRESH HARDENED CONCRETE

Evaluation of fresh concrete by testing its workability parameters leaded not only to the property of fresh concrete but indirectly to know accuracy of the mix design proportions. It is very basic step to know the mix of concrete and constituent of proportion of concrete all together is fine or not. By doing the workability tests, identified the various parameter of workability, consistency which will helps to the further experimental works. Better workability means ability of concrete to be workable. It means that it can easily flow and can be compacted in better manner. So better compaction leads to decrease in voids and that way its strength can be said to have increased. Here as percentage of the replacement of coarse aggregate increases workability decreases. Results of various study are provided here for a comparison.

Table- 2.1 workability test values

Compaction factor test result			
Sl No	Mix designation	Compaction factor value	Decrease in workability %
1	C C	0.95	-
2	BCT $_{25}$	0.85	10.52

Slump test results			
Sl No	Mix Designation	Slump Value in mm	Decrease in Workability %
1	M_{30}	60	-
2	BCT $_{10}$	58	3.33
3	BCT $_{15}$	54	10
4	BCT $_{20}$	52	13.33
5	BCT $_{25}$	50	16.33

Table- 2.2 compressive strength test values

Compressive strength of various mix ratios		
Sl No	Mix designation	Average 28 days Compressive Strength
1	M_{30}	32.74
2	BCT_{10}	32.62
3	BCT_{15}	32.22
4	BCT_{20}	32.04
4	BCT_{25}	31.77
5	BCT_{30}	28.01

3. EXPERIMENTAL STUDY ON FLEXURAL BEAM

Beam were designed as singly reinforced section under limit state design philosophy and reinforcement are bend and tie as per the IS 456 – 2000 and SP 34. Steel of grade Fe500 TMT bars are used. Compaction and placement of concrete as per the standard specification, compaction was done in manual form using compaction rod. Whereas the concrete poured in the mold at lower height level that avoid segregation. Beams of size 100 x 150 x 750mm were cast and tested under universal testing machine of capacity 600kN. Figure 3.1 shows the details of specimens used for testing the flexural behavior.

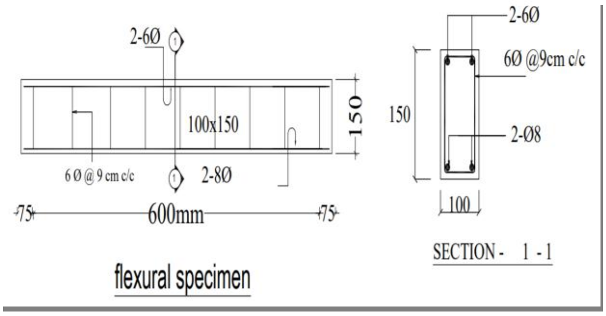

Fig -3.1: reinforcement detail

Cement, manufacturing sand, coarse aggregate, broken clay tiles after crushed and graded and water were used in preparation of specimens. Mixing of materials was carried out first in a drum type mixer; water was then added to the materials. Molds were oiled and clear cover are providing on the three side of the mold using customized cement cover block. The freshly prepared concrete layer was poured layer by layer in to the mold. After pouring the first layer up to the cover marked, the prepared reinforcement cage was placed in position and remaining concreting was completed. Each layer compacted thoroughly and bleeding of concrete in prevented. Two specimens for replaced coarse aggregate and other two for controlled concrete. Figure 3.2 shows the reinforcement tied structure.

Fig -3.2: reinforcement cage

3.1 General Behavior of Flexural Specimen

The crack pattern of beams after failure were marked and shown in the Fig 3.3. It was observed that for CC beam specimen, up to 39.5kN load the concrete was in the uncracked stage. Beyond this, the concrete started transfer load to reinforcing steel and the steel begins to resist strain. As the load increased further, along with the addition flexure cracks are developed. Further increase of load caused the widening of cracks already formed and beam failed under flexure. For BCT_{25} specimens, the cracked stage starts at 44.5 kN load. In case of broken clay tiles replaced specimens, crack propagation rate was found to be less than that of conventional concrete specimens.

Fig -3.3: Crack pattern of flexural specimen

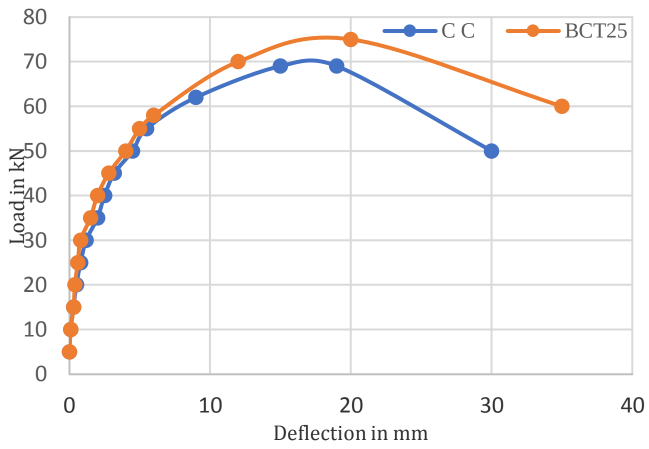

Chart -3.1: load deflection chart

4. ANALYTICAL INVESTIGATION OF FLEXURAL BEAM (ANSYS)

The model cell will be displayed for mechanical analysis systems and is used to discretize geometry into small elements. An important step in finite element modelling is a selection of the mesh density. A convergence of results is obtained when an adequate number of elements are used in a model. This properly sets the width and length of specimens in the place to be consistent with the element and nodes in the concrete portions of the model. The numbering control command is used to merge all the items to make it as a single entity. Very fine size was chosen to get more accurate results. The model of the BCT $_{25}$ beam specimen is shown in Fig 4.1.

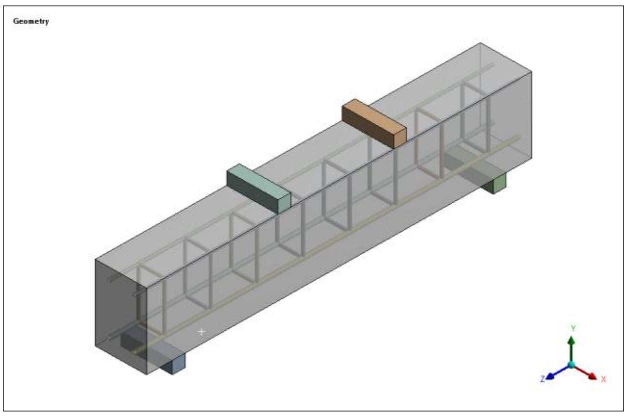

Fig -4.1: BCT $_{25}$ flexural beam model

As ANSYS is one of the best tools to find the analytical detail of the experimental works without loose the financial and time constraints, the ultimate valuation of the project done by doing the analytical work over the experimental works which carried out in the laboratory to compare the results. A typical analysis begins with providing data such as the unit system, active code, materials, element types, selection and model geometry definition. Modelling of all beams was carried out using the design modeler. It is a geometry editorm.

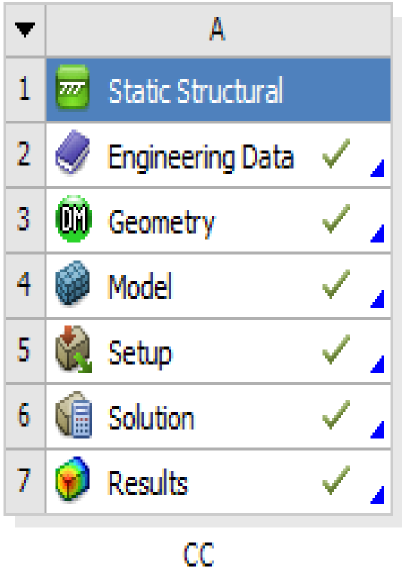

Fig -4.2: Procedure for the modelling and analysis.

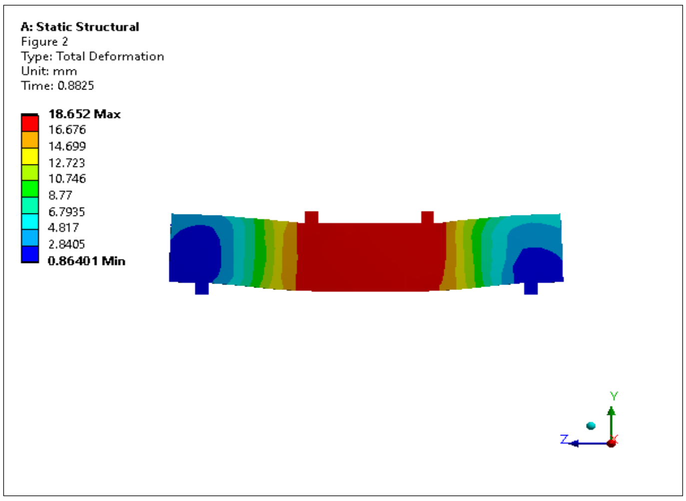

Fig -4.3: Total deformation of flexural specimen

Load deflection graph was plotted using LVDT readings at mid span of RC beam specimens. Deflection readings were taken for a load increment of 5 kN until failure of beam occur and the post peak response corresponding to ultimate load was recorded for all the beams. Vertical deflection on transverse loading over a beam reveals many engineering properties of the concrete behavior. This result will help to find the elastic modulus of concrete in the beam over a particular deflection. Crack were developed at bottom of the beam for both specimens whereas the crack propagation over the BCT $_{25}$ extended vertically up the cross section to form in the constant moment region and this crack is merely hair line thick up to the ultimate load. When compare the crack pattern in both the beam, BCT_{25} specimen undergoes for a greater number of cracks than CC specimen, these cracks extended up the member about 3/4th the height to extend diagonally toward the load point exhibiting classic diagonal tension behavior, but crack width is higher and number of cracks are minimized in the controlled concrete specimen. The comparison of load-mid span deflection curves of normal concrete and partial replaced broken clay tiles concrete were shown in Fig 4.4. it helps us to analyses the behavior of the beam subjected to unit loading. Figure 4.5 shows the compares of the analytical and experimental specimen after loading.

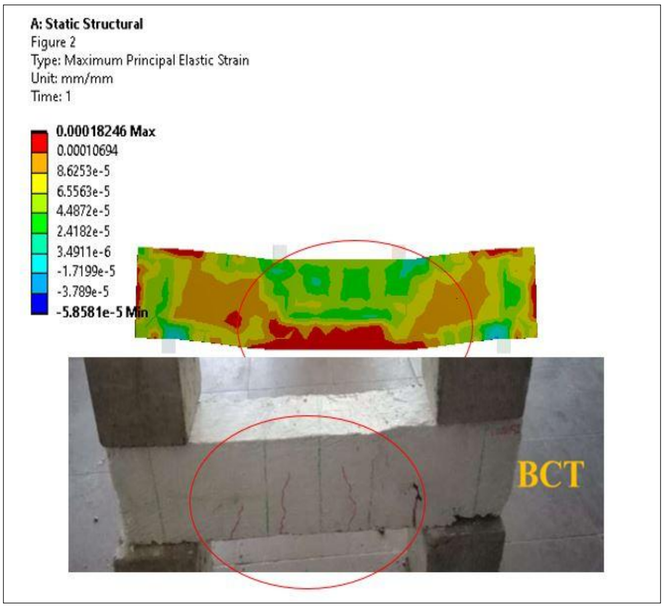

Fig -4.4: Comparison of specimen after loading

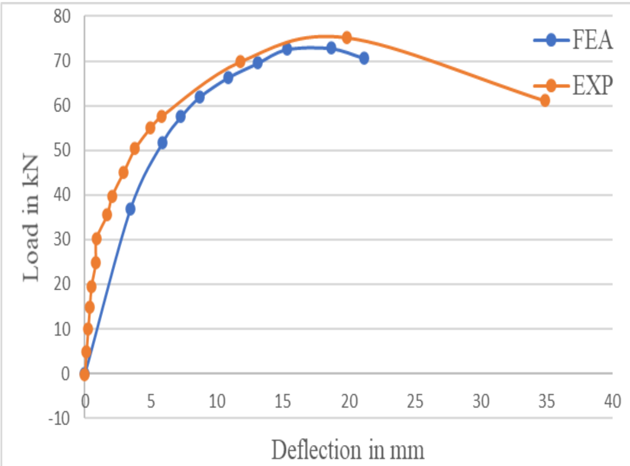

Chart -4.1: load deflection chart

5. CONCLUSIONS

With replacement of 25% broken clay tile, compressive strength of BCT_{25} shows only 3% difference with the controlled concrete, hence BCT_{25} is opted as optimum partial replacement mix proportion. The presents of broken clay tiles in the concrete delays the formation of visible cracks and the first crack load greater for $BCT_{25.}$ The ultimate load carrying capacity of BCT_{25} concrete beam was increased by 5.62% as compared to CC. Overall performance of BCT_{25} flexural specimen was found to be better in flexural behavior.

1) Analytical investigation conducted for experimental work of flexural beams in ANSYS 16.1.
2) Ultimate load carrying capacity of flexural beam is decreased 3.57% than experimental values.
3) Deformation behavior of flexural beam does not change significantly in the analytical studies.

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