Experimental Investigation on Partial Replacement of Concrete in Flexural Member below Neutral Axis

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Abstract— Beam is an important structural member that exists in RC structure. Normally two zones arise in beam, i.e. compression zone at top and tension zone at bottom of simple sup-ported beam. As concrete is weak in tension, steel is introduced in the tension zone to take the tension, so logically no concrete is required in tension side. But concrete is to be provided on tension side to act as a strain transferring media to steel and may be called as 'sacrificial concrete'. Partial replacement of the concrete below the neutral axis is an idea that can create reduction in weight and savings in materials. In this paper, an experimental investigation on partial replacement of concrete in the tension zone that is be-low the neutral axis by creating air voids. Air voids were created using thermocol. Beams were cast using different percentage of thermocol. The results obtained for control specimens and beams with thermocol are compaired.

Key words: Neutral Axis, Thermocol, Sacrificial Concrete, Tension and Compression, Center Point Loading

I. INTRODUCTION

Reinforced cement concrete is one of the important components in the construction industry. Now a day use of concrete increased in every infrastructure projects such as residential building, commercial building, roads, railway, and much more. There is acute shortage of raw materials for its preparation. Lot of researches were carried out for the investigation of alternative material that can be used in concrete and also to reduce the production of carbon dioxide by reducing the use of concrete. Locally available materials thermocol is use below neutral axis zone which does not take any tension hence the replacement of this concrete can reduce the material used in concrete.

According to the natural behavior of the concrete, it is strong in compression and weak in tension. Our assumption to design the R.C beams is the contribution of tensile stress of the concrete is neglected. The total replacement of transferred media below neutral axis is not possible hence efficient use the concrete materials can be done by replacing the concrete below the neutral axis with certain percentage.

II. RESEARCH SIGNIFICANCE

A. *Scope of the work*

According to various literature review it is observed that there is a problem related to the depth and continuity of hollow core but initially at time of design we assume that concrete is homogenous even thoe it is heterogeneous material. So design of this hollow core beam is same as that of the conventional beam as stress distribution diagram is same as shown below fig 1 hence we can remove of concrete in sacrificial zone.

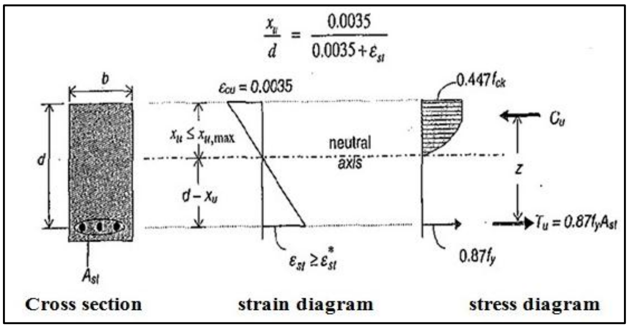

Fig. 1: Stress and strain block for a singly reinforced beam

B. *Objective of Work*

The objective is to introduce a new method of replacing some amount of concrete in sacrificial zone with thermocol below neutral axis without affecting flexural property of member, also to reduce the amount of material, cost, weight of Reinforced Concrete structure.

C. *Methodology of work*

1) Selection of concrete grade M30
2) Mix design of M30 grade concrete
3) Casting beam specimen of normal R
4) Beam
5) Casting 8, 10, and 12% of replacement of concrete beam using thermocol.
6) 5. Conducting center point loading test on all beams using UTM.

III. EXPERIMENTAL INVESTIGATION

A. *Material test*

Test	Material	Equipment Used	Values Obtained
Specific Gravity	Fine Aggregates	Pycnometer	2.55
Specific Gravity	Coarse Aggregates	*Wire basket*	*2.63*
Water absorption	Fine Aggregates	*vessel*	*1.40%*
Water absorption	Coarse Aggregates	*vessel*	*0.21%*
Workability	M30 concrete	*Slum cone apparatus*	*75mm*

Table 1: Results of test conducted on material

B. *Mix Design:*

Content	Quantity
Cement (Kg/m3)	438.13
Fine aggregate (Kg/m3)	643.41
Coarse aggregate (Kg/m3)	1083
Water (li/m3)	197.16
Mix ratio	1:1.468:2.471

Table 2: Mix design

C. *Beam Specimen*

The twelve beam specimens of 1000x150x250 mm were cast. Three beam B1, B2 and B3 are total solid beam with designed reinforced material of 10mm dia-3 nos placed at bottom and 2 nos -of 8 mm are at top is placed with minimum shear reinforcement of 8mm dia with spacing of 200 mm is provided. Three beam of B4, B5 and B6 are of 8% replacement with same reinforcement and geometry. Beam B7, B8 and B9 are of 10% replacement. Also Beam B10, B11 and B12 are of 12 % replacement of concrete with thermocoal is casted. All this hollow core beam is same reinforcement as provided in solid beam as shown in fig 2, fig 3.

Fig. 2: reinforcement and thermocol used (10% reduction)

Fig. 3: Detail for mould with reinforcement and thermocol

D. *Test Procedure*

The flexural strength of the specimens were tested using a 100T loading by (UTM); where determine the deflection at the center of the beam. The effective span of the test specimen is taken as 9000mm which achieved by using cast iron support. The flexural strength of the beam is found by single point loading. The behavior of beam is keenly observed from beginning to the failure. The loading was stopped when the beam was just on the verge of collapse. The first crack propagation and its development and propagation are observed carefully. The values of load applied and deflection are noted directly by graph which is taken as the output. The load in KN is applied with uniformly increasing the value of the load and the deflection under the different applied loads is noted down. The applied load increased up to the breaking point or till the failure of the material.

IV. EXPERIMENTAL RESULTS

A. *Load carrying capacity*

Ultimate strength of beams under central point loading was recorded the maximum load indicating on graph as below.

It was found that there is not such a high variation in the load carrying capacity of the original specimens and that of partial replacement beams. As shown in fig 4.

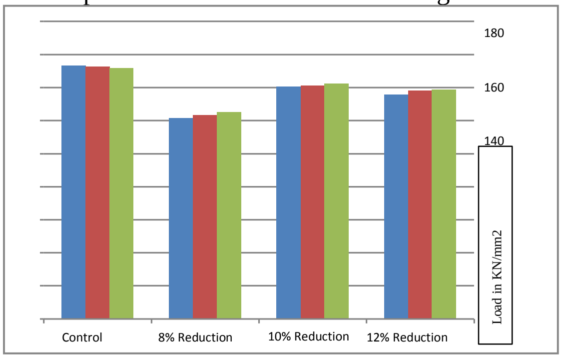

Fig. 4: Load carrying capacity

B. *Crack pattern*

Mainly shear cracks were developed from the supporting points and widened up as the load increased. At failure, the concrete in the compression region crushed. The cracks continued to widen as the load increased, and failure occurred soon after depicting a typical sudden type of shear failure. The crack pattern of test specimen beams is similar to that of control specimen.

Cracks are as shown in fig 5, fig 6, fig 7.

Fig. 5: crack pattern (control beam)

Fig. 6: Crack pattern for control beam

Fig. 7: crack pattern of test specimen (8% reduction)

C. Load v/s Deflection graph

The deflection of the beam starts, with increase in the load up to a certain level the load v/s deflection graph is linear. Due to further increase in the load, the graph is not linear, since the C.H.travel (deflection) values goes on increasing, strength of the material also increases and material loses its elasticity undergoing plastic deformation. Hence from graph strength of the material by knowing the deflection at the corresponding load values. The load vs CHT graph as shown in fig 8, fig 9, fig 10& fig 11.Also comparison of all load vs deflection given in fig 12.

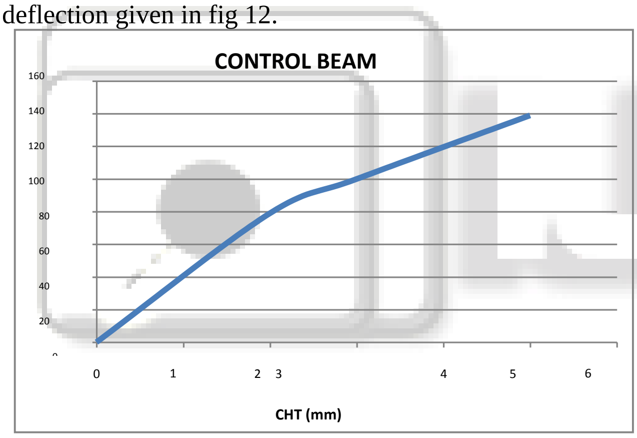

Fig. 8: Load vs CHT for control beam

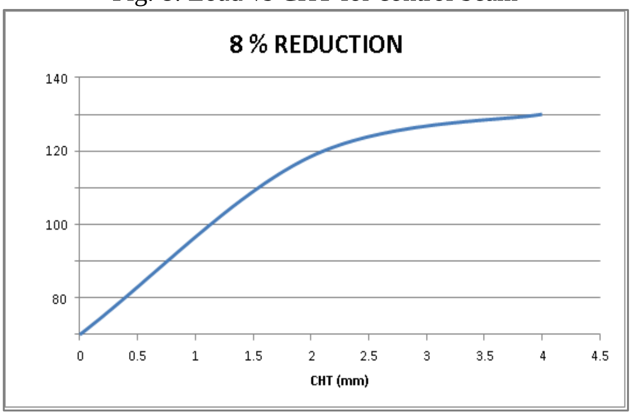

Fig. 9: Load vs CHT graph for 8%

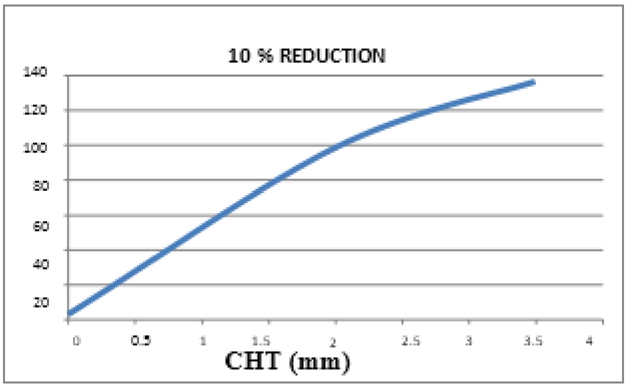

Fig. 10: Load vs CHT graph for 10% Replacement

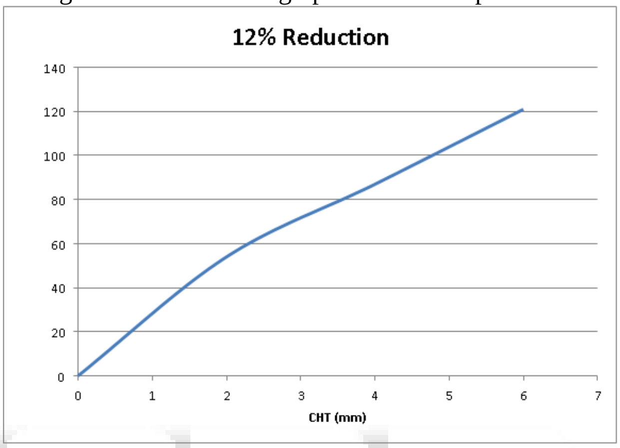

Fig. 11: Load vs CHT graph for 12% replacement (reduction)

V. RESULTS DISCUSSION

A. Load-deflection relationship

From Fig 8, fig 9, and fig 10 and fig11, it is found that the load deflection relationship of control beam and that of partially replaced beams, obtained from experimental evaluation are found to be similar which is nearly equal to 5mm.

B. Concrete Saving

Concrete is one of the most versatile building materials. Material cost is a main component to be considered while construction, mainly this varies from 25 to 75%. Therefore, in order to control the cost, it is necessary to pay maximum attention for controlling the material cost. It should be made sure that the right quantities of materials are consumed with less wastage. This issue can be minimized by avoiding concrete below the neutral axis without bearing significant strength.

C. Labor Reduction

Labors are one of the major resources in construction industries. From the study it is clear that the total volume saving in concrete is directly proportional to the percentage reduction in labor. When the volume of concreting works reduce, the need for labor also get decreased simultaneously, which in turn minimize the production cost.

D. Cost Reduction

In current days the entire field is filled with competition, and it is necessary that a business concern should have utmost efficiency and minimum possible wastages to reduce the cost of production. From the study conducted, we can conclude that by partial replacement below neutral axis in beams, significant amount of concrete can be saved without affecting the strength.

E. Applications

From the results evaluated, it is observed that the reinforced beam with region below the neutral axis replaced with voids can be applied to various fields of constructions such as:

- Raft foundations
- Piers
- Similar other works

VI. CONCLUSION

Behavior of reinforced concrete beams with region below the neutral axis with voids created using thermocol is similar to that of control specimen. Presence of voids instead of concrete in the low stressed zone has not caused significant reduction in strength of reinforced concrete beams.

The 10 percentage of voids in beam gives maximum result of load carrying capacity as compare to 8 and 12 of voids using thermocol. As we can see first breaking point load for control beam is 139 KN and first breaking point for 10% reduction it is 133 KN, so there is no significant changes in load carrying capacity.

It is observed that the replacement of concrete by voids in reinforced concrete beams does not require any extra labor or time. The concrete saving will be more effective as the length and depth of the beam increases.

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