Journal of Advances in Civil Engineering, Vol. 5(1) 2019, pp. 28-31

RESEARCH ARTICLE

A Study on effective use of Concrete in Tension Zone of Simply Supported Flexural Member

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Received- 31 July 2018, Revised- 18 January 2019, Accepted- 22 January 2019, Published- 28 January 2019

ABSTRACT

In general, a one dimensional (which is normally horizontal) flexible member is termed as a beam that contributes support to vertical walls and the slab. The normal beam which is simply supported two zones is possible i.e. at bottom tension zone and at top compression zone. Concrete becomes weak in tension, to overcome this, steel is introduced to absorb the tension. Henceforth during the compression the concrete take the compression and the strength of concrete is ignored in tension zone. Therefore, no concrete is required in tension zone. At the instance, concrete is allowed on tension side to act as strain transferring media to steel and may be called as 'Sacrificial Concrete'. So, experimental investigation is done under three cases using the concrete in tension zone. In all the three cases the concrete in compression zone is a high grade concrete. In the first case, the tension zone is of low grade concrete. In the second case, the tension zone is of partially replaced concrete. In the third case, the tension zone is of low grade partially replaced concrete. The specimens made under the three cases are tested for flexural strength for 28 days and the results are compared with the conventional beam, which is made of high grade concrete.

Keywords: Tension zone, High grade, Partially replaced concrete, Flexural behaviour, Sacrificial concrete.

1. INTRODUCTION

Reinforced cement concrete is one of the important materials in the construction industry. Now a day the use of concrete is increasing very much. However there is acute shortage of raw materials for its preparation. Lot of researches were carried out for the investigation of alternative methods that can be used in concrete which can reduce the consumption of cement in concrete [1]. In the case of simply supported reinforced concrete beam, neutral axis splits the tension zone and compression zone. The region below the neutral axis undergoes tension and the region above neutral axis will be in compression. Since concrete is weak in taking up tension, steel reinforcements are provided at the tension zone of the beam [2]. The concrete under the neutral axis acts as the medium for transferring stress from compression zone to the tension zone. Thus, the concrete just below the neutral axis is known as sacrificial concrete. The compressive force is acting in top zone at a distance of 0.42Xu from the top of the beam section, where Xu is the distance between neutral axis and top of section [3]. At bottom of the section, tension force acts at centroid of steel reinforcement. The distance between the point of action of compressive force and tension force is called as lever arm which is directly proportional to the moment of resistance. As a structural engineer, one must

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Double blind peer review under responsibility of DJ Publications
https://dx.doi.org/10.18831/djcivil.org/2019011004

concentrate towards the structural design and functional design of the structure. In designing process, economy of the project is a major factor. Considering, economy and safety of the structure in mind, the concept of "Heterogeneous Beam" is evolved. Here three cases of heterogeneous beams are tested for flexure. The compression zone of all the three cases is made of a high grade concrete (M25). In the first case, the tension zone is of low grade concrete (M20). In the second case, the tension zone is of partially replaced concrete. In the third case, the tension zone is of low grade (M20) partially replaced concrete.

2. SCOPE

The aim of the study is the optimum use of concrete grade in tension zone. Several studies are carried out by replacing the concrete below neutral axis of beam. Also studies have been separately conducted on beams with replacing concrete in the zone below neutral axis by creating air voids. But there is no study on the combined effect of both low grade concrete in tension zone and partial replacement below neutral axis of beam. The scope of this thesis work is to fill this gap in the literature by studying the combined effect of low grade concrete below N.A. and partial replacement of concrete below N.A. by creating air voids with waste plastic bottles.

3. OBJECTIVE

The objectives of the project are as follows:

- To study a new method by replacing concrete in tension with a low grade concrete below the neutral axis of beam, thus by creating air voids with the help of waste plastic balls.
- To achieve economy in construction.
- To attain strength without affecting the serviceability.
- To avoid cracking of concrete in tension zone, as there is reduction in heat of hydration.
- To study the ultimate load carrying capacity of the beams.

4. METHODOLOGY

The methodology of work includes

- Basic tests on constituent materials of concrete.
- Design mix for M20 and M25 grade concrete.
- Allow the concrete to get required specimen.
- Preparation of beam specimens of three numbers are considered
    - 150X250X700mm size of RC-SB type beam.
    - 150X250X700mm size of RC-LGB type beam.
    - 150X250X700mm size of RC-PEB type beam.

Table 1 shows the details of specimen.

- A loading frame is developed.
- Beam specimens are tested under two points loading on loading frame to obtain sustainable and economic construction.
- Ponding method is used for testing the beams.
- Results and discussion.

Based on the basic tests and constituent material the mix proportions for M25 and M20 grade of concrete are shown in Table 2 and Table 3.

Table 1.Details of specimen

Beam	Specimen size	Properties
RC-SB	150x250x700mm	M25
RC-LGB	150x250x700mm	M25(C)+M20(T)
RC-PEB	150x250x700mm	M25(C) +plastic balls embedded(T)

Table 2.Mix design data for M25

Water	Cement	F.A.	C.A.	
180	401.75	606.58	1191.48	By mass
0.46	1	1.56	2.98	Absolute value

Table 3.Mix design data for M20

Water	Cement	F.A.	C.A.	By mass
180	372	615.58	1209.14	
0.5	1	1.65	3.25	Absolute volume

5. DESIGN

5.1. Singly reinforced section

Now for M25 + Fe 415 combination Pt limit

= 0.96 % × b × d

= 0.96 × 150 × 225

= 324 mm^2.

Thus, Pt Limit = 324 mm^2. Now by adopting steel #3-∅ 12mm,

Ast defined = 405 mm^2

We have moment of resistance as

Mu = T × L

Mu = 0.87 x 415 x 405 x (225 – 0.416 x 108)

Mu = 26.33 kNm

Xu = 0.87 fyAst/ 0.36 fckb

= 0.87 x 415 x 405 /0.36 x 25 x 150

=108.31 mm< 125 mm

Thus,

Xu = 108.31 mm which is lesser than 125mm.

The given section is Under Reinforced.

Mulim = 0.87 x 415 x 405(225-0.416×120.988)

Mulim = 25.54 kNm.

5.2. Doubly reinforced section

Assume 1 bar of 12mm dia.

For Doubly reinforced section

We have Ast2 = Asc

Ast2 = 1 bar of 12mm ∅

= ð÷4×(122)

=113.097

Asc = Ast2

Assume 10 mm dia bar for Asc

Asc ≅ 120 mm^2.

∴120 = N×ð÷4 × (102)

∴ No of bars = 1.52 ≅ 2 Nos.

Thus, the number of bars is two.

5.3. Summary

Section Size is considered as 150x250x700mm

Eff depth = 225mm

Clear cover = 25 mm Steel (tension)

= 4 – ø 12 Anchor Bar

= 2 -8 ø Stirrups

= 6∅ @ 150mm c/c

Side cover = 20mm

6. EXPERIMENTAL PROGRAM

The constituent materials are made ready as specified in the methodology. The formwork is initiated and using weight balance the ingredients are weighed accurately. By using a concrete mixer the ingredients are mixed thoroughly.

Neutral axis is embossed with the help of a string stretched between the two end plates. Concrete in the tension zone was placed in the formwork in layers of approximately 15 cm and compacted, firstly for M20 grade of concrete which were embedded with plastic balls in two cases. The layers were successively and uniformly placed one above the other and compacted. After the level of string was reached, the concreting operation was stopped with M20 grade of concrete. Then for remaining height .i.e. above neutral axis concreting was done with M25 grade of concrete. End faces were properly compacted to get smooth finish. After completion of about 12 hours, Beams where placed in a water tank for curing for about 28 days and cured using ponding method. Ponding method is basic curing method which being adopted. This method covers all the surfaces exposed concrete members even with complicated edges, corners and shapes [4].

The Universal Testing Machine was used for testing the beams. The testing of beams is performed after 28 days. Initially, a normal rectangular beam was placed on the UTM. Uniform load is applied gradually. The readings of variation in deflection and the corresponding load for each deflection is noted in detail [5-9].

7. RESULT ANALYSIS

It is observed that all the beams have more strength than the design strength from the calculations made in the design. With the varying properties, beam of 150X200X700 mm is the section size considered in Table 4.

Table 4.Ultimate load value

S. No	Beam type	Ultimate load	Depth of crack in tension zone
1	RC-SB	215.50KN	10.74mm
2	RC-LGB	206.00KN	6.82mm
3	RC-PEB	208.00KN	4.64mm

8. CONCLUSION

- Heterogeneous beam can be used for construction of large depth slabs, beams and other tension members having large depth.
- The current study assisted in knowing the effective use of concrete in tension zone of a simply supported flexural member.
- Cracking in reinforced members is minimized.
- The ultimate load carrying capacity does not vary highly for all cases.
- The cost of construction is reduced up to 5 - 6%.
- Load bearing capacity within the bars is increased.
- M20 and M25 grade concrete mix is providing the optimum result in the given test.
- Strength and serviceability of tension member is not affected in both cases.
- Tension zone is more cracks resistive. Thus by ensuring the durability and safety of the concrete.

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