Flexural Behaviour of RCC Beams

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Abstract - Concrete is the material which is rapidly used in various conditions to sustain the compression loads and the corresponding bending and shear stress due to the applied compressive loads. The major drawback in concrete is that it is poor in tension though it is very efficient in compression. Hence to overcome this major drawback the concrete must be reinforced such that to make a homogeneous substance which can sustain both tension and compression. Steel is the material use as reinforcement for concrete. The stress strain behaviour for both concrete and steel are mostly similar. Hence in the combination of both that is in reinforced cement concrete the maximum stress point within the elastic will reach simultaneously.

Reinforce cement concrete is a general material which is widely used for various types of constructions and structural elements. For the efficient use of RCC it is necessary to know the properties and the behaviour of RCC elements under various constrains. To estimate and analyse the basic properties and behaviour of RCC an experimental study is needed. In the present study an experiment in which flexural behaviour of RCC under various constrains was the major criteria. For the experimental analysis simply supported beams of undereinforced, balanced and over reinforced sections are considered. When the beam is simply supported and is subjected to some external loading the corresponding deflections are examined such that the flexural behaviour of the RCC beams of under reinforce, balanced and over reinforced sections analysed. In order to study the flexural behaviour of any material one had need some basic constant conditions as their limitations. In the present study stress-strain behaviour of Concrete and steel are taken as a base and the flexural behaviour of the material in various fibres.

I. INTRODUCTION

RCC beam are effectively used as structural members in various constructions. RCC is a homogeneous material which is having various properties. RCC beams are classified as under reinforced, balanced and over reinforced sections on the analysis basis. In RCC both concrete and steels will reaches the stress and corresponding strains due to external subjected loads simultaneously. When in an RCC beam, if the steel tends to fail before the stress in concrete reaches the maximum permissible stress such beams are known as under reinforced sections. If both concrete and steel reaches the permissible stress values simultaneously such beams are considered as balanced sections. If the concrete tends to fail before the stress in steel reaches the maximum permissible stress such beams are considered as over reinforced sections. In the following article based on the laboratory experimental analysis the flexure behaviour of various sections are observed by destructive methods.

II. DESIGN CRITERIA

The basic design criterion for any type of structure is safety, serviceability and economy. Due to these basic esteem properties of RCC elements, they are abundantly used in all structural applications. For the structural use of RCC elements it must obey the following parameters. The structure must be safe and economical that it can perfectly resist both tension and compressive stress. The structure must be stiff and appear to be unblemished such that it should be resisted the bending moments and shear forces due to external applied loads. The structure must be economical by means of it can be able to resist all type of stress and availability of materials to make RCC.

In order to predict the safe and economic conditions of RCC it is necessary to assess the conditions of ultimate loads and corresponding deflections under particular constrains. To obtain the desirable results one had to conduct an experimental analysis. When an Rcc beam is subjected to some external loadings the beam tends to bend with some deflection due to loading. At any point in the cross section of the beam is considered the stress distribution will be such that all the fibres above the neutral axis pass through the CG are in compression, whereas all the fibres below the neutral axis are in tension.

$$\frac{X_U}{d} = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b d}$$

$\frac{X_U}{d} = \frac{X_{Umax}}{d}$ Balanced section

$\frac{X_U}{d} < \frac{X_{Umax}}{d}$ Under reinforced section

$\frac{X_U}{d} > \frac{X_{Umax}}{d}$ Over reinforced section

III. DESCRIPTION OF SPECIMENS

Two plain concrete beams, Six Reinforced concrete beams of M30 grade OPC concrete (1:1.34:2.88) used in this investigation program were it 100 mm wide x 200 mm deep x 1200 mm long. Two beams (Under reinforced) are casted with 2- 12Ø bars at bottom and 2-8Ø hanger bars, 8Ø @135 stirrups are provide, And Two beams (Balanced section) are casted with 2- 12Ø, 2-8Ø bars at bottom and 2-8Ø hanger bars, 8Ø @135 stirrups are provide, Balance Two beams (Over reinforced) are casted with 2- 16Ø bars at bottom and 2-8Ø hanger bars, 8Ø @135 stirrups are provide these details are mentioned in Table below.

Table 4.1 Details of beams geometry

Section	Mix	W/C	F_{ck} n/mm^2	F_y n/mm^2	Ast (mm^2)	Size of the beam	Design load kn
Under	1:1.34:2.88	0.41	38.24	415	226.2	1200*200*100	70.4
Balanced	1:1.34:2.88	0.41	38.24	415	326.1	1200*200*100	91.5
Over	1:1.34:2.88	0.41	38.24	415	402.6	1200*200*100	103.5
Plane	1:1.34:2.88	0.41	38.24	……	……	1200*200*100	……….

Various types of beams

IV. EXPERIMENTAL PROCEDURE

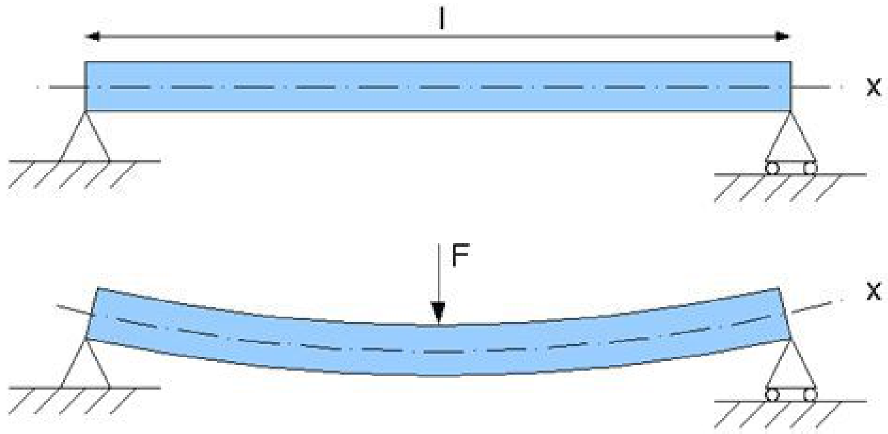
After completion of 28 days curing the beams were subjected to three point loading by using UTM. Dial gauges were arranged to the bottom of beam. And hydraulic load is applied linearly we measure the deflection of beam at each interval of 5KN load , and also observe the first crack at which load and corresponding deflection this process is continue for all beams and also note the ultimate load with corresponding deflection for all beam sections.

V. ASSUMPTION

Before conducting the experiments some assumptions are made as following:

- The planes of the cross section of the beam considered will be remains plane before bending and after bending.
- The bonding between the concrete and steel will be prefect and homogenous.

- The stress-strain behaviour of concrete and steel are mostly similar.
- The tensile strength of concrete is ignored. All the tensile stress is taken only by the reinforcement.
- The stress-strain relationship for the compressive zone in concrete is assumed to be parabolic that results in obtaining the strength.



VI. Flexural Testing Of Beam

The main objective of this study is to obtain the relation between loading and the corresponding deflection of a simply supported beam when it is subjected to a point load.

1.1 Theory

For any brittle material it is quite difficult to compute the stress-strain behaviour by means of simple compression tests, which are generally conducted on concrete blocks such that to obtain the compressive strength of concrete. In order to predict the flexural behaviour of any brittle material like concrete, load deflection method on three points was essential. The three point method is the way to compute the deflections due to applied loads in order to analyze the flexural behaviour. In this study the experimental set up was made to investigate the following:

a) Loads and corresponding deflections

b) The effect of length and cross sections on deflections per unit load.

1.2 Procedure:

Simply supported beam with central point load

For the as shown in figure 7.1 arrangement, it can be shown that the deflection under the load i.e. maximum deflection

$$\Delta = \frac{Wl^3}{48EI}$$

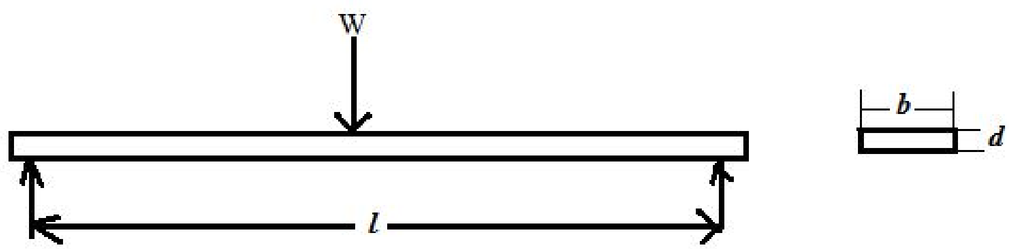


Fig: 7.1 Load on the beam for the flexural test

Where $I = \frac{bd^3}{12}$

Beam compliance $\frac{\Delta}{W} = \frac{l^3}{4Eb\,d^3}$

1.3 Apparatus and Procedure :

Universal Testing machine

To analyze the relationship between load and deflection of a beam, placed on two bear affected by a concentrated load at the centre.

1. Set the bearers so that a span of 1200 mm is maintained. The interval between each groove on the beam of the apparatus is 100 mm.
2. Place a test specimen with dimensions of 100 x 200 mm. on the bearers and mount the load device in the centre of test specimen.
3. Set the testing device so that the top of the gauge is centred on the upper plane of the load device. Lower the gauge so that its small hand is at about 10 and set the gauge to zero by twisting its outer ring. Load with weights as shown in the table below and read off the deflection. One revolution of the large hand of the gauge corresponds to 1 mm. of deflection.

Table: 7.1 Load and corresponding deflections for a balanced section

Load (kN)	Deflection (mm)
20	1.25
40	2.25
60	3.2
80	4.65
88.8 (ultimate)	5.75

Table: 7.2 Load and corresponding deflection for an under reinforced section

Load (kN)	Deflection (mm)
20	1.15
40	2.35
60	3.56
70	4.65
73.3 (ultimate)	5.2

Table: 7.3 Load and corresponding deflection for an over reinforced section

Load (kN)	Deflection (mm)
20	1.25
40	2.85
60	3.95
80	5.45
86.2 (ultimate)	5.8

4. Draw a graph of width of the deflection vs. test specimen.

The experimental program consisted of testing of eight prisms of size 100x200x1200mm of M30 grade concrete subjected to three point loading which is used two prisms of plane concrete, two under reinforced concrete beams, two balanced reinforced concrete beams and two over reinforced concrete beams UTM machine where two roller supports are used.

VII. RESULTS AND DISCUSSION

Name of Section	Deflection FEA	Deflection Exper	stress in concrete Tension	stress in concrete Compr	stress in steel Tension	stress in steel crack	1 st Crack at kn	Ultimate load FEA	Ultimate load Exper
Under	5.2	5.5	3.45	12.25	427.52	172.4	30	75.1	73.3
Balanced	6.1	5.75	3.4	11.54	402.54	142.4	34	78.4	88.8
Over	5.8	6.5	3.54	11.32	362.45	121.3	36	80.4	86.2
Plane	0.4	0.45	3.32	6.6	0	0	11	11.2	10.31

Fig: 8.1 Results of plane/over/balanced/under reinforced concrete beam

VIII. CONCLUSION

The following conclusions can be stated based on the evaluation of the analyses of the calibration model.

1. The ultimate load carrying capacity of Plane concrete beam is 0.14 times under reinforced beam
2. In under reinforced beam maximum elements reach ultimate stress compare to over reinforced concrete beam
3. From the analytical investigation it was observed that under reinforced ratio is the best type of reinforcement ratio among the others since it shows greatest warning zone before failure.
4. From the analytical investigation, it was observed that under reinforced section reinforcement reaches ultimate stress (415 N/mm^2), and over reinforced section reach 87% of ultimate stress.

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