The Effect of Stirrup Spacing on the Elasticity of Reinforced Cement Concrete Beam

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Abstract

The elasticity of the material plays very important role in design and analysis of structures. In evaluation of deformation of members the magnitude of flexural rigidity plays very important role. The flexural rigidity depends upon elasticity of material and size of section used for particular member. Flexural rigidity increases as increase in the elasticity and size of the section.

Time period of vibration structure affects the whole seismic design of structure. In seismic analysis the stiffness of structure affects the time period of vibration of structure. Stiffness depends upon the elasticity of material used in particular member.

Hence elasticity of material used in member should be perfectly evaluated. Evaluation of elasticity of homogeneous material can be easily calculated by developing the stress – strain curve. But evaluation of elasticity of heterogeneous material is enough complicated to establish a standard mathematical expression.

Reinforced Cement Concrete (RCC) is widely used construction material which is heterogeneous in nature. Many of the standard codes considers elasticity of concrete in design and analysis of RCC structure. Such codes neglects the effect of reinforcement on the elasticity of concrete. Considering only elasticity of concrete only in design and analysis of RCC structure will not give the exact value of deformations under loading as well as time period of vibration for seismic analysis. Underestimation of magnitude of elasticity may also increase the overall cost of structure. Hence there is an urgency to evaluate the elasticity of RCC precisely.

Keywords - *Elasticity, Concrete, Reinforced Cement Concrete*

I. INTRODUCTION

The modulus of elasticity is the most important parameter fordetermining the strain behaviour of concrete. Many studies havebeen made to investigate the elastic behaviour of different concretetypessuch as dam concrete, rubberized concrete,ordinary concrete containing different types of aggregatesand cements, slag concrete, and structural lightweight aggregateconcrete. Other studies, using different parameters, havealso been reported in order to estimate or predict the modulus ofelasticity of different cement, mortar and concrete composite materials.

The aim of present study is to evaluate the elasticity of RCC used for beam subjected to the concentrated load at centre. Depending on design load percentage of longitudinal reinforcement will vary for given section. The present study is aimed to incorporate the effect of reinforcement on the elasticity of RCC. Reinforced Cement Concrete (RCC) is widely used construction material which is heterogeneous in nature. Many of the standard codes considers elasticity of concrete in design and analysis of RCC structure.Considering only elasticity of concrete only in design and analysis of RCC structure will not give the exact value of deformations under loading as well as time period of vibration for seismic analysis. Underestimation of magnitude of elasticity may also increase the overall cost of structure. Hence there is an urgency to evaluate the elasticity of RCC precisely.

II. EXPERIMENTAL PROGRAM

A. Material properties

Sr. No.	Test	Results
1	Consistency Test on Cement	0.29 %
2	Initial Setting Time of Cement	32 minutes
3	Final Setting Time Cement	610 minutes
4	Grading of sand	ZONE II
5	Grading of CA	Single Sized
6	Specific Gravity of Sand	2.74
7	Specific Gravity of CA	2.74
8	Water absorption of CA	2%

Table 1Properties of Cement

For casting of RCC columns, concrete is designed for M25. IS 10262:2009 is used for mix design. All the ingredients required for concrete are tested as per Indian Standard Codes. Ordinary Portland cement of 43 grade used. Angular crushed stones of maximum nominal size 40 mm are used for concrete manufacturing. The casted concrete is tested with standard cylindrical specimen to check target strength as well as elasticity of concrete. For longitudinal as

well as transverse reinforcement steel of grade Fe 415 is used.

B. Test specimens

To evaluate the effect of longitudinal reinforcement on elasticity of RCC used in beam, different beam specimens are casted with varying the percentage of longitudinal reinforcement. The overall depth of beam is taken as 300mm. The width and length of beam is taken as 230 mm and 1000 mm respectively. The concrete used for casting of all column specimens is designed for M25.Casted beams specimen are cured for 28 days with water sprinkling method. Three specimens of beams are casted for particular percentage of longitudinal reinforcement.

Sr. No.	Beam	Stirrup Spacing
1	B1	300 mm
2	B2	300 mm
3	B3	100 mm
4	B4	100 mm
5	B5	50mm
6	B6	50 mm

Table 2 Beam Specimen Details

2 bars of 16 mm diameter are provided on bottom side and 2 bars of 16 mm diameter are provided on bottom side. Steel used of grade Fe415.

C. Test Setup

IS 516:1959 *Code for compression testing of concrete*is used to find out the flexural strength of concrete. Similar analogy is used to find out the elasticity of RCC beam. RCC beams are tested under three point loading. Beam were simply supported on two steel supports as shown in following photograph. 10 cm support was provided at each end of the beam. Gradually increasing load is applied at centre of the beam. The capacity of jack used for test was 40 tonne.

Figure 1 Tree Point Loading Test on Beam

The deflection of beam at particular load measured with help of dial gauge with the least count of 0.001 mm.

III. TEST RESULT & DISCUSSIONS

The elasticity of simply supported RCC beam carrying concentrated load at centre can be found out by using following expression.

$$E = \frac{wl^3}{3\Delta I}$$

Where,
w: Concentrated load at centre of the beam
l: Effective span of beam
Δ: Deflection of beam
I: Moment of inertia of beam

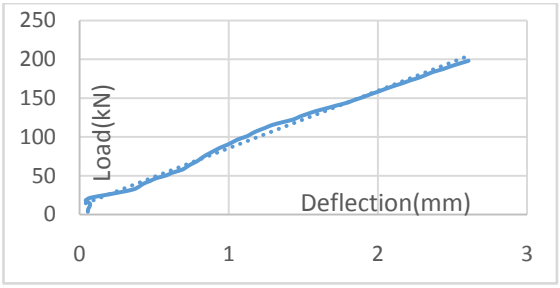

Figure 2 Load - Deflection Curve for RCC Beam Having Stirrup Spacing of 50 mm

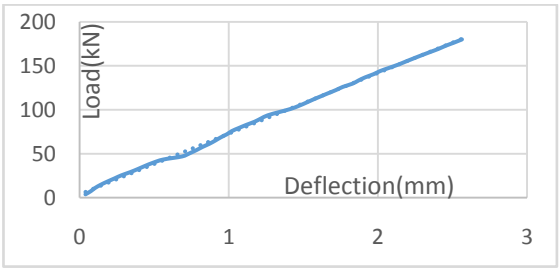

Figure 3Load - Deflection Curve for RCC Beam Having Stirrup Spacing of 100 mm

Figure shows the relationship between load and deflection for simply supported RCC beam having stirrup spacing of 300 mm, under concentrated load at centre. Similarly all RCC beam specimens are tested for three point loading and load – deflection curve is drawn. Table number 3 gives the value of elasticity for beams having variable spacing of the stirrups.

Sr. No.	Beam	Stirrup Spacing	Elasticity (GPa)
1	B1	300 mm	28
2	B2	300 mm	27
3	B3	100 mm	30
4	B4	100 mm	31.5
5	B5	50mm	34
6	B6	50 mm	33.6

Table 3 Elasticity of RCC Beam Specimens

IV. CONCLUSIONS

Following conclusions are drawn from present study.

1. The modulus of elasticity of RCC beam is significantly increased as decrease in the spacing of stirrups.
2. Load carrying capacity of the beam is increased as decrease in the spacing of the stirrups.
3. The magnitude of deflection remains almost same at ultimate load carrying capacity of RCC beam specimens having different spacing of stirrups.
4. The RCC beam having lowest spacing of stirrup shown early initiation of crack.

RECOMMENDATIONS

Present study comes up with following recommendations

1. Bureau Indian standard should develop the method to test RCC members.
2. Bureau of India standards should consider the effect of stirrup spacing on the elasticity of RCC beam.

ACKNOWLEDGEMENT

Authors express energetically thanks to management board, director and head of civil engineering department from Sanjay Ghodawat Group of Institutions, Atigre for their technical and financial support.

REFERENCES

[1] S. K. Kulkarni, M. R. Shiyekar and B. Wagh (2012) "Elastic properties of RCC under flexural loading" IJMER Vol.2, Issue.6, Nov-Dec. 2012 pp-4022-4025
[2] ASTM C39/C39M. "Standard test method for compressive strength of cylindrical concrete specimens" Annual Book of ASTM Standard 04; 2002.
[3] IS 10262: 2009 "Recommended guidelines for concrete mix"
[4] IS 456: 2000 "Plain and reinforced concrete – Code of practice"
[5] IS 383: 1970 " Specification for coarse and fine aggregates from natural sources for concrete"
[6] IS 516: 1959"Methods of tests for strength of concrete"
[7] IS 4031:1996 "Methods of physical tests for hydraulic cement" Part 1,2,3,4,6
[8] IS 516:1959"Code for compression testing of concrete".