The Effect of Longitudinal Reinforcement on the Modulus of Elasticity of RCC used for Column under Axial Loading

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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*

1 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 columns under axial loading. 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.

2 Experimental Program

2.1 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 1 Material Properties

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.

2.2 Test specimens

To evaluate the effect of longitudinal reinforcement on elasticity of RCC used in column, different column specimens are casted with varying the percentage of longitudinal reinforcement. The cross section of column is taken as 250 mm × 250 mm. The height of column is taken as 375 mm which is 1.5 times the least lateral dimension. The concrete used for casting of all column specimens is designed for M25.Casted column specimen are cured for 28 days with water sprinkling method. Three specimens of columns are casted for particular percentage of longitudinal reinforcement.

2.3 Test Setup

It is essential to draw a stress – strain curve for evaluation of elasticity of reinforced cement concrete used for column. For capping of RCC column specimen elastomeric pads are used, for uniform stress distribution throughout the depth of column. All the column specimens are tested under the gradually increasing axial load. Contractometer to calculate the deformation to the accuracy of one micrometre. All the columns are tested up to ultimate load points. Load versus deformation data is obtained and stress – strain relationship for each column specimen is developed.

3 Test Result & Discussions

For the all the column specimens stress versus strain curve is plotted to find out the elasticity of RCC used in column.Only elastic portion of graph is considered for estimation of elasticity. Regression is done to fit the line for given values of stress and strain. The slope of the fitted line represents the elasticity of RCC used in the column. Figure 1 shows the stress strain curve for the RCC used in column. Slope of the line is 28.341 GPa which is represents the magnitude of elasticity of RCC used in column. Similarly stress strain curve for all the column specimen is plotted to find out the elasticity of RCC. Table 2 represents the values of average elasticity for all column specimen having different longitudinal reinforcement.

IS 456: 2000 gives following expression to calculate the modulus of elasticity of concrete

$$Ec = 5000\sqrt{fck} \qquad \text{……Equation 1}$$

Where,
Ec: Modulus of elasticity of concrete
fck: Characterised strength of concrete

By using above formula the modulus of elasticity of concrete having grade of M25 comes as 25 GPa. Same expression is used to design and analysis of RCC structure as per IS 416:2000. All the RCC column specimens are showing elasticity more than 25 GPa. Hence, above expression underestimates the strength of RCC used for columns.

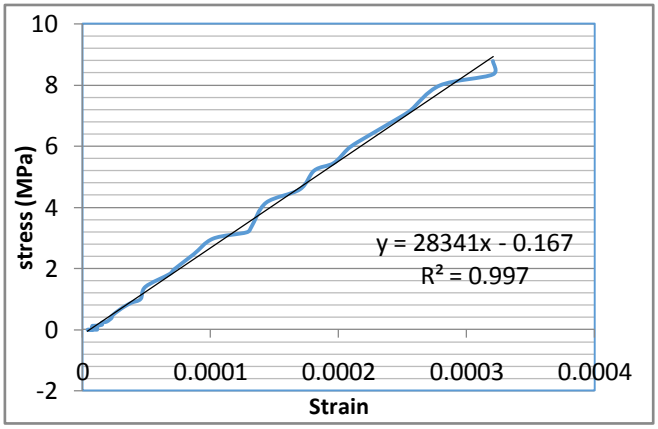

Figure 1Stress - Strain Curve for RCC used for Column

Column	Reinforcement Details	Percentage Reinforcement	Average Elasticity
Column 1	No Reinforcement	0.00 %	24.20 GPa
Column 2	4 Bars of Diameter 16 mm	1.28 %	28.34 GPa
Column 3	8 Bars of Diameter 16 mm	2.57 %	34.20 GPa
Column 4	4 Bars of Diameter 20 mm	4.02%	36.53 GPa

Table 2Elasticity of RCC Used in Columnunder Axial Loading

4 Conclusions

Following conclusions are drawn from present study.

1. The modulus of elasticity is significantly increased as increase in the percentage of longitudinal reinforcement of the column.
2. IS 456: 2000 code mathematical expression underestimates the value of modulus of elasticity by not considering the effect of longitudinal reinforcement on elasticity.
3. For same concrete, modulus of elasticity is observed slightly more for column specimen than standard cylindrical specimen.
4. Size of specimen affects the modulus of elasticity of concrete.

5 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 reinforcement on the elasticity of RCC

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