Comparative Study of Young's Modulus of Elasticity For Plain Cement Concrete And Reinforced Cement Concrete By Using ABAQUS Software

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Abstract- *The modulus of elasticity is the most important parameter for determining the strain behaviour of concrete and also shows the effect of strength and stiffness. 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 in design and analysis of RCC structure will not give the exact value of deformations under loading. Present paper is an attempt to study the comparative values of PCC and RCC with varying percentage of steel. The column of two cross sections 250 x 250 x 3000 and 350 x 350 x 3000 is considered with varying percentage of reinforcement ranging from 0.72% to 2.01% for M20, M25 and M30 grade of concrete. The analysis work is done with FEA software ABAQUS.*

Keywords- concrete, elasticity, reinforced cement concrete, young's modulus of elasticity.

I. INTRODUCTION

Young's Modulus of Elasticity play's very important role in designing of structure. For homogeneous material such as steel, Young's Modulus of Elasticity remains same i.e.200GPa but for heterogeneous material like concrete magnitude of Young's Modulus of Elasticity

changes depending on grade or strength i.e. $E_c=5000\sqrt{f}_{ck.}$ Also, during designing and analysis of RCC structure Young's Modulus of Elasticity is given as $Ec=5000\sqrt{f}$ ck, which does not consider effect of reinforcement on Young's Modulus of Elasticity which may under estimate strength and stiffness.

There is no expression which gives the Young's Modulus of Elasticity considering effect of RCC. Hence, it's really important to understand behaviour of reinforcement in consideration of values for Young's Modulus of Elasticity.

Finite Element Analysis will help to analyse and design number of reinforcement cement concrete model as it converts the member in small element which provide better result.

To study Young's Modulus of Elasticity of RCC many different parameters related to RCC, Cement and Steel are to be determined. The detailed study of the software ABAQUS used for designing and analysing the different models of RCC with different properties.

II. RESEARCH SIGNIFICANCE

The basic significance of the study is to show that the elasticity plays very important role in the stain as well as strength behaviour of any material. Previously the elasticity of concrete was considered as the elasticity of Reinforced Cement Concrete which underestimate the strength of RCC. Hence this work is done to consider the effect of reinforcement on values of Young's Modulus of Elasticity in reinforced cement concrete.

III. ANALYTICAL INVESTIGATION

The reinforced cement concrete column specimen with different parameter is analysed with the help of ABAQUA software. Size of specimen, shape of specimen, grade of concrete, grade of steel, percentage of steel are some parameters which usually affect the Modulus of Elasticity of Reinforced Cement concrete. To evaluate the Young's Modulus of elasticity for RCC, different column specimens are designed in ABAQUS software with varying the percentage of reinforcement. For this study we have considered two RCC column of cross section 250 x 250 mm and 350 x 350 mm. The height of column is 3000 mm. The RCC ABAQUS model is in

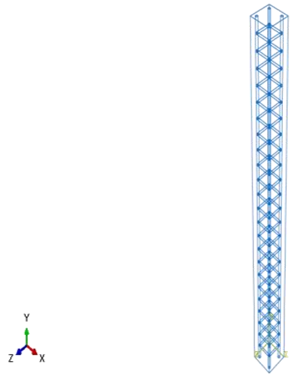

Fig 1.RCC model for specimen 250 x 250 mm

The displacement is applied on the RCC column specimen with variation of time at top surface and the bottom is kept fixed. Due to this variation of displacement with respect to time we can get load values for different values of deformation. With the use of these different load and deformation values we can calculate stress and strain values for a particular specimen, whichcanleadusforcalculationof Young's Modulus of Elasticity for different percentage of steel.

The ABAQUS model for undeformed model is in **Fig2.**

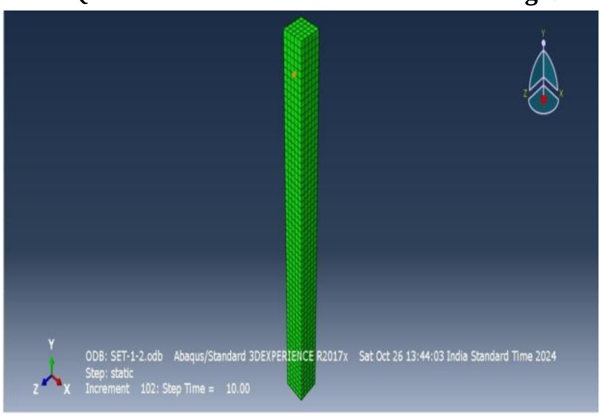

Fig. 2 - Undeformed model

After the application of displacement, deformed specimen with cross section 250 x 250 mm is in **Fig 3.**

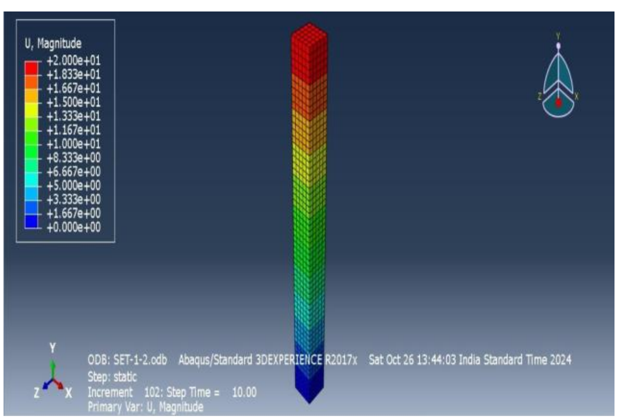

Fig 3 - Deformation in column

Materials

The material used in Reinforced Cement Concrete have different properties. The properties like Modulus of Elasticity for concrete, Modulus of Elasticity for steel, Poisson Ratio for concrete and steel, Density of concrete and steel are useful for determination of Young's Modulus of Elasticity. The properties for material mention are used as input data for ABAQUS software.

The properties are mentioned in **Table 1 and Table 2.**

DENSITY	7850Kg/m^3
ELASTICITY (Fe 415)	210000MPa
POISSONS RATIO	0.3

DENSITY	2400Kg/m^3
ELASTICITY (M20)	22360.6MPa
POISSONS RATIO	0.2

IV. RESULTS AND DISCUSSION

The values for Elasticity of RCC columns are compute with different cross section, different grade of concrete, different percentage of steel and with grade of steel FeA415 with the help of ABAQUS software and are listed in **Table 3.**

Table 3

Size of Specimen	**Grade of Concrete**	**Grade of Steel**	**Percentage Steel**	**No. of Bar**	**Elasticity**
(mm)	**(MPa)**	**(MPa)**			**(MPa)**
250x250	M20	415	0	0	23232
		415	0.72	4#12mm	24940
		415	1.28	4#16mm	25868
		415	1.93	6#16mm	27395
		415	2.01	4#20mm	27572

250x250	M25	415	0	0	25840
		415	0.72	4#12mm	27569
		415	1.28	4#16mm	28734
		415	1.93	6#16mm	30131
		415	2.01	4#20mm	30306
250x250	M30	415	0	0	28456
		415	0.72	4#12mm	29986
		415	1.28	4#16mm	31207
		415	1.93	6#16mm	32729
		415	2.01	4#20mm	32777
350x350	M20	415	0	0	23247
		415	0.72	8#12mm	24819
		415	1.28	8#16mm	26065
		415	1.93	6#20mm+2#16mm	27267
		415	2.01	8#20mm	27668
350x350	M25	415	0	0	25992
		415	0.72	8#12mm	27573
		415	1.28	8#16mm	28801
		415	1.93	6#20mm+2#16mm	30004
		415	2.01	8#20mm	30404
350x350	M30	415	0	0	28473
		415	0.72	8#12mm	29973
		415	1.28	8#16mm	31274
		415	1.93	6#20mm+2#16mm	32477
		415	2.01	8#20mm	32877

Table 3

The approximate expression for the RCC column specimen of cross section 250 x 250 mm for different percentage of steel and different grade of concrete is derived with the help of following values listed in **Table 4.**

Table 4– Data for specimen 250 x 250 mm

	M20	M25	M30
Percentage of steel	**Elasticity**		
0	23232	25840	28456
0.72	24940	27569	29986
1.28	25868	28734	31207
1.93	27395	30131	32729
2.01	27572	30306	32777

The linear expressions with percentage of steel and elasticity are:

E = 2128.9x + 23272 (For M20)
E= 2203.1x + 25899 (For M25)
E2184.7x + 28436 (For M30)
Where, E=Elasticity of RCC
x = factor for percentage of steel

Similarly, the approximate expression for the RCC column specimen of cross section 350 x 350 mm for different percentage of steel and different grade of concrete is derived with the help of following values listed in **Table 5.**

Table 5– Data for specimen 350 x 350 mm

	M20	M25	M30
Percentage of steel	**Elasticity**		
0	23247	25992	28473
0.72	24819	27573	29973
1.28	26065	28801	31274
1.93	27267	30004	32477
2.01	27668	30404	32877

The linear expressions with percentage of steel and elasticity are:

E= 2143.2x + 23267 (For M20)
E= 2136.8x + 26016 (For M25)
E= 2145.4x + 28466 (For M30)

Where, E=Elasticity of RCC
x = factor for percentage of steel

V. FURTHER RESEARCH

In present study we have developed the specimen of size 250 x 250mm and 350 x 350mm in the software ABAQUS/CAE with taking grade of steel constant as Fe415 and the variable as grade of concrete M20, M25 and M30 and the different percentage of steel.

Through this study we define approximate expression for elasticity in terms of grade of concrete and percentage of steel.

In future this study can be modified for generation of accurate expression of Young's Modulus of Elasticity for RCC by considering all parameter in one expression. The parameter are:

1. Grade of concrete.
2. Grade of steel.
3. Different No. of reinforcing bar.
4. Cross section of specimen.
5. Shape of specimen

VI. CONCLUSION

Aim of the present study was to compare Young's Modulus of Elasticity for Reinforced Cement Concrete and Plain Cement Concrete. In present days there is no formula or expression which define the Young's Modulus of Elasticity for RCC, which results in the consideration of Modulus of Elasticity of concrete as Modulus of Elasticity of RCC.

Present study come to following conclusions

1. Elasticity of RCC is greater than Elasticity of Plain concrete ($E_{RCC} > E_c$)
2. Bureau of Indian Standard code formula i.e. $E_c = 5000\sqrt{f_{ck}}$ which underestimate the elasticity of RCC.
3. Elasticity of RCC increases with increase in percentage of reinforcement.
4. If the specimen size increases, the elasticity also increases.
5. The expression developed in this study has variable (percentage of steel, grade of concrete) on basis of which the value of elasticity can calculated.

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