Comparative Study of Retrofitted Columns Using Abaqus Software

Geeta Singh, Tarun Shokeen, and Vidrum Gaur

Abstract In the present study, coating of different materials has been done on a concrete column. The coating is being carried out using the ABAQUS software. The displacement values are obtained after applying 100 kN of force. In this study, we observed that how ABAQUS performs analyses of retrofitting column under transverse load and seismic load. The size of column used for analysis is 300 mm × 300 mm × 1200 mm. The load used is 100 kN. In this study, we design the columns of different materials and compare them with standard RCC column using ABAQUS software. The work involves calculating the maximum deflection produced in different columns and determining the most suitable material for retrofitting. Materials used for coating are carbon fibre, steel, aluminium, e-fibre glass, Douglas fir wood, Teflon. ABAQUS modelling and analysis involve pre-processing, simulation, post-processing. According to the results obtained from ABAQUS, the load resisting property observed in decreasing order is Douglas fir wood > E-fibre glass > Aluminium > Steel > Teflon > Carbon fibre > Composite of Aluminium and Steel. Douglas Fir wood is found to have best load resisting property with minimum deflection of 5.422 mm. E-fibre glass is found to have the second best load resisting property with deflection of 6.536 mm.

Keywords Retrofitted · Columns · Douglas fir wood · ABAQUS

1 Introduction

The buckling of column can be reduced by retrofitting column by the carbon fibre. Carbon fibre winding method is superior to steel plate jacketing in cost and simplicity of structures, and carbon coating method is superior to carbon fibre winding method.

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Carbon fibre has used in aircraft and sports goods because of high strength, high elastic modulus, lightweight and high durability. However, transverse reinforcement of ordinary concrete members does not need to be ductile. So that brittle carbon fibre can be applied for transverse reinforcement.

The merits of coating are.

1. The coating protects the column from rusting.
2. Increase the life and load-carrying capacity of the column.
3. Also enhance the aesthetic value of the structure.

Considering the above-mentioned facts in view a study was being planned to study the buckling of column by retrofitting the column with various materials by fixing the column from both ends and using 100 KN transverse uniform distributed loading on 300 $\times$ 300 mm size column.

2 Objective of the Study

To design the columns by retrofitting different materials and compare it with standard RCC column using ABAQUS software and to determine the most suitable material for retrofitting.

3 Literature Review

Abrams [2] studied the effect of axial load on the reversed lateral cyclic loading of columns and found that the additional axial loading creasers the stiffness, flexural strength and shear capacity. He found that the flexural capacity of columns increases with axial load but ductility reduces. Mo and Wang [3] conducted experiments on reinforced cement column by doing reverse cyclic loading. They introduced alternate ties to enhance seismic performance. He concluded that the lateral displacement of reinforced cement column is directly proportional to spacing of transverse reinforcement. Montes et al. [4] conducted experiment to calculate the ductility capacity of the column. He introduced reinforcement sizing diagram to determine acceptable reinforcement. He also introduced conjugate gradient search method for finding optimal reinforcement of RCC column.

4 Materials Used

In this study, six types of materials were used for retrofitting the column and the property of each material is given below.

4.1 Carbon Fibre

- Poisson's ratio: 0.24
- Young's Modulus: 228,000 MP

4.2 Steel

- Poisson's Ratio: 0.28
- Young's Modulus: 210,000 MPA

4.3 Aluminium

- Density is 2.7 g/cm^3.
- It increases aesthetic value.

4.4 E-Fibre Glass

- Tensile strength—3445 MPA
- Poisson's ratio—0.22
- Density: 258 g/cc
- Compressive strength—1080MPA
- Young's Modulus—78,500

4.5 Douglas Fir Wood

- It is used in veneer, plywood and construction lumber.
- It is found in Western North America
- Young's modulus: 13,000 MPA
- Specific Gravity (Basic, 12% MC): 0.45, 0.51
- Poisons Ratio—0.376
- Modulus of Rupture: 86.2 MPa
- Elastic Modulus: 12.17 GPa
- Crushing Strength: 47.9 MPa

4.6 Polytetrafluoroethylene (Teflon)

- Young's Modulus: 450 MPA
- Poisson's Ratio: 0.46
- Melting point—327 °C
- Density—2200 kg/m^3

5 Methodology

ABAQUS completes all its process in three phases. Pre-processing, simulation and post-processing are the three phases of ABAQUS.

5.1 Design Steps in ABAQUS [1]

ABAQUS consists of the following ten steps in complete analysis.

5.1.1 Creating Parts

- This is the first step in designing of column.
- It involves creating the column and its shell.

5.1.2 Assigning Property

- This step involves assigning properties to the created column.
- The properties assigned are elasticity of the material, Young's modulus and Poisson's ratio of the material.

5.1.3 Assembly of Parts

- In this step, both column and shell are assembled together.
- Type of interaction between the parts is provided.

5.1.4 Creating Steps

- Creation of steps occurs here.
- Steps are created to increase the efficiency of the output.

5.1.5 Creating Interaction (i.e. Assigning Friction Coefficient)

- Interaction between the column and shell is given to provide the amount of friction between the two surfaces.
- Here interaction property-1 is given to the column.

5.1.6 Assigning Boundary Condition

- Encastre boundary condition is applied to the column, i.e. (U1 = U2 = U3 = UR1 = UR2 = UR3 = 0).

5.1.7 Assigning Loads

- In this step, loads are assigned to the column.
- 100 kN load is applied to the column which is uniformly distributed to the column.

5.1.8 Creating Mesh

- Meshing is done to reduce the size of the smallest unit of the column.
- It is done to increase the efficiency and accuracy of the output.
- The approximate global size provided here is 100.

5.1.9 Creating and Submitting Job

- This is the final step in designing of column.
- The created work is submitted to check the errors.

5.1.10 Stress–Strain Curve

- Stress–strain diagram of the chosen node is displayed in the result.
- The red colour shows maximum deflection, and blue colour shows minimum deflection.

6 Results and Analysis

6.1 Standard Column

- Maximum deflection in standard column of Length = 300 mm, Breadth = 300 mm, Height = 1200 mm is 1.563e + 4 mm (Fig. 1).

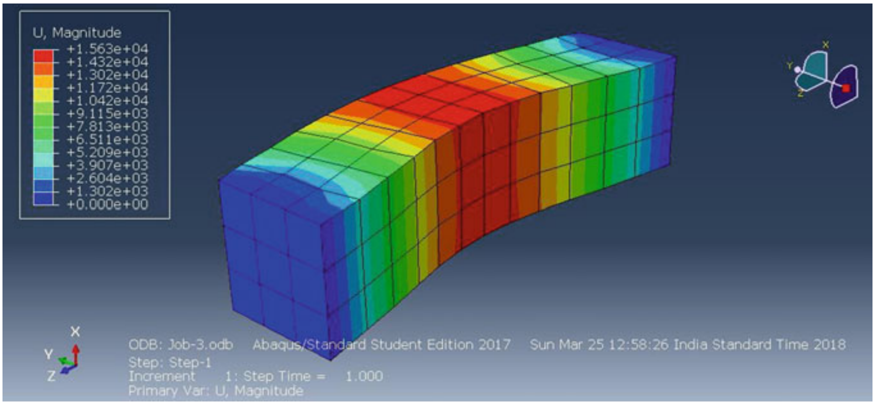

Fig. 1 Image of deflection of standard column in ABAQUS

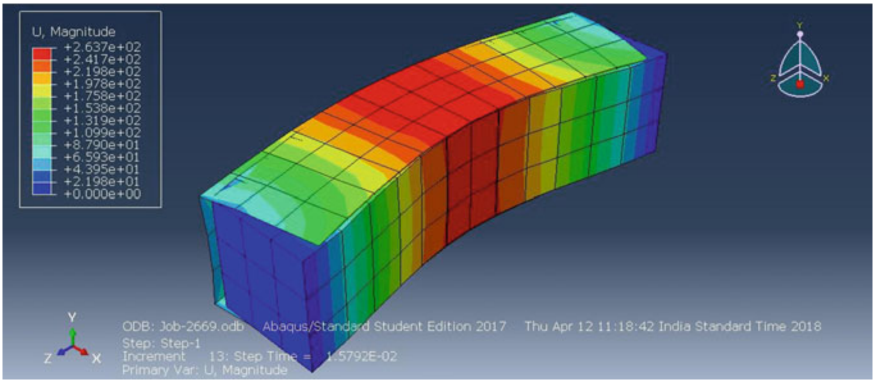

Fig. 2 Image of deflection of carbon fibre column in ABAQUS

6.2 Carbon Fibre

- The maximum deflection observed in the column after coating with carbon fibre is 2.637e + 2 mm.
- The reduction in deflection observed is 1.53e + 4 mm (Fig. 2).

6.3 Steel

- The maximum deflection observed in column after coating with steel is 2.063e + 1 mm.
- The reduction in deflection observed is 1.56e + 4 mm (Fig. 3).

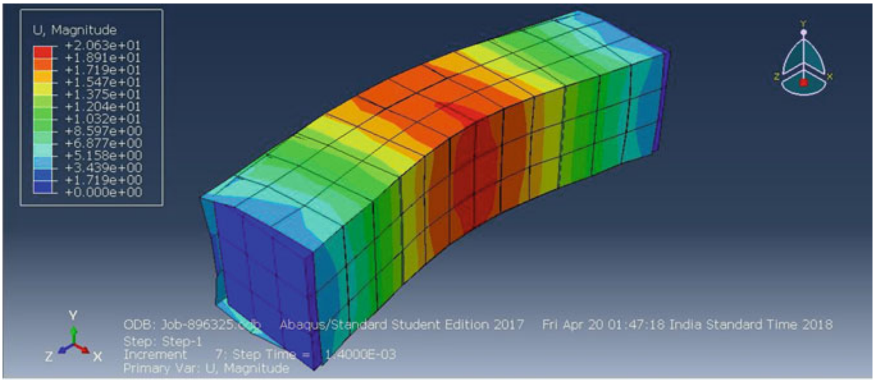

Fig. 3 Image of deflection of steel column in ABAQUS

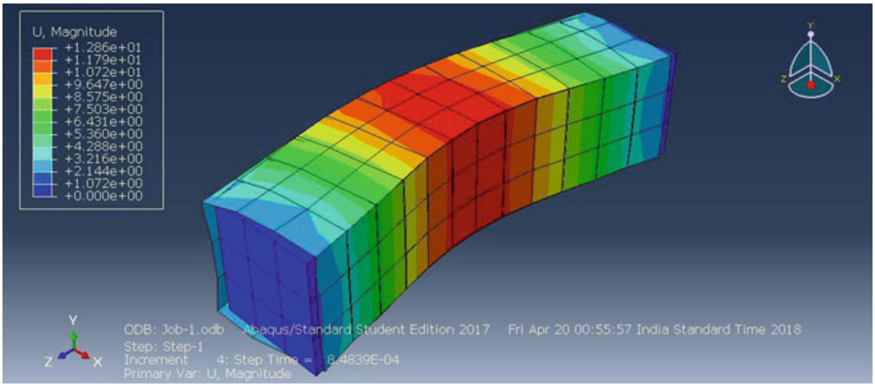

Fig. 4 Image of deflection of aluminium column in ABAQUS

6.4 Aluminium

- The maximum deflection observed in column after coating with aluminium is 1.286e + 1 mm.
- The reduction in deflection observed is 1.56e + 4 mm (Fig. 4).

6.5 Composite of Aluminium and Steel

- The maximum deflection observed in column after coating with composite of aluminium and steel is 1.344e + 4 mm.
- The reduction in deflection observed is 2.1e + 3 mm (Fig. 5).

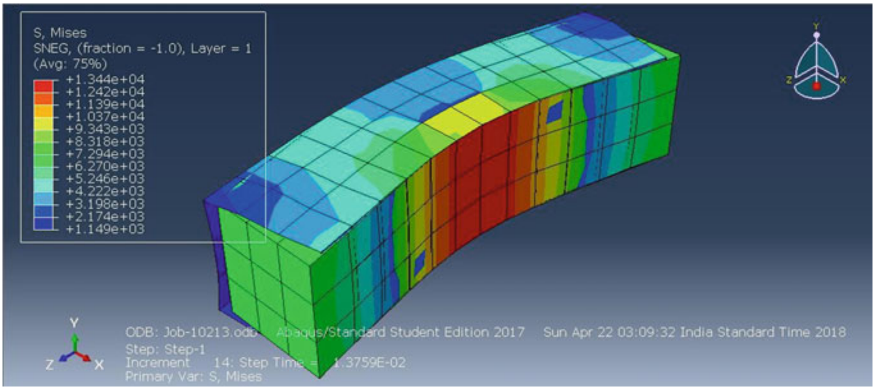

Fig. 5 Image of deflection of composite of aluminium and steel column in ABAQUS

6.6 E-Fibre Glass

- The maximum deflection observed in column after coating with e-fibre glass is 6.536 mm.
- The reduction in deflection observed is 1.56e + 4 mm (Fig. 6).

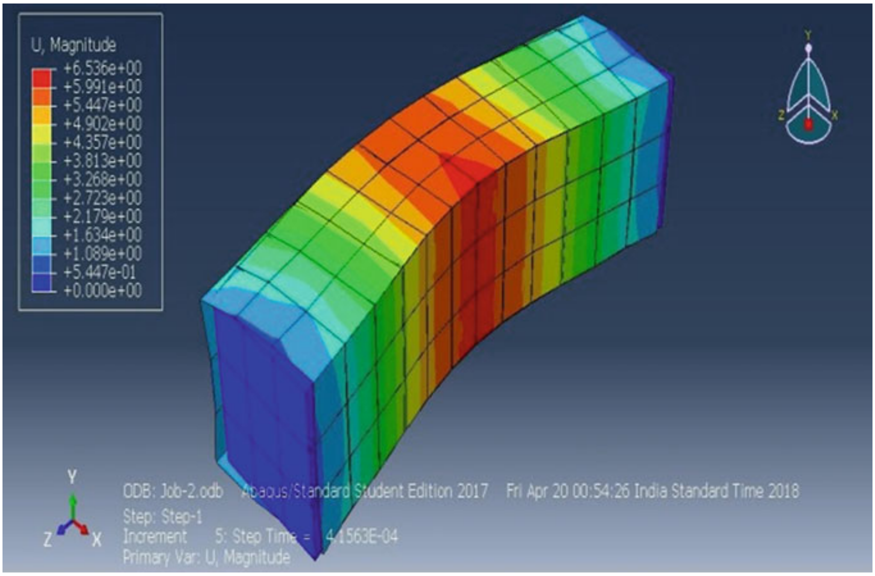

Fig. 6 Image of Deflection of E-Fibre Glass Column in ABAQUS

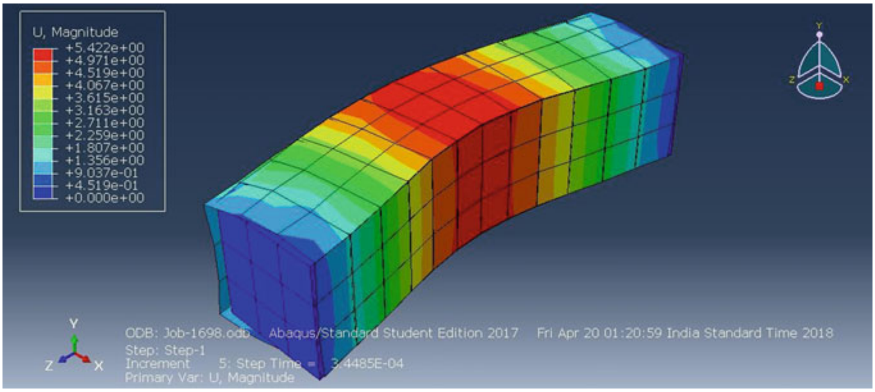

Fig. 7 Image of Douglas Fir wood column in ABAQUS

6.7 Douglas Fir Wood

- The maximum deflection observed in column after coating with Douglas fir wood is 5.422 mm.
- The reduction in deflection observed is 1.56e + 4 mm (Fig. 7).

6.8 Polytetrafluoroethylene (Teflon)

- The maximum deflection observed in column after coating with polytetrafluoroethylene is 6.278e + 1 mm.
- The reduction in deflection observed is 1.55e + 4 mm (Fig. 8).

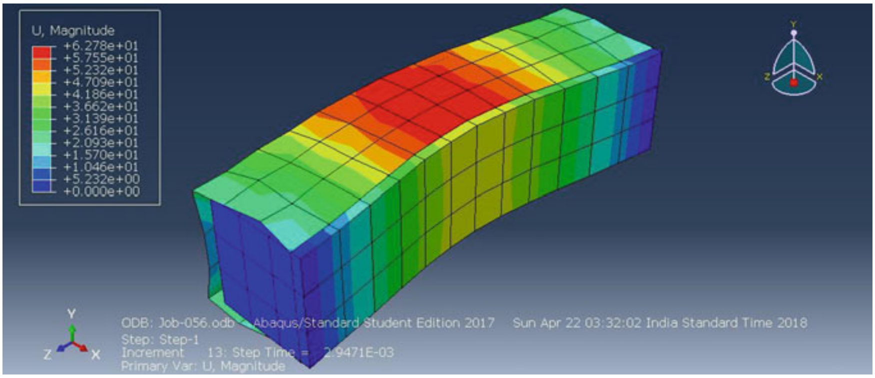

Fig. 8 Image of deflection of polytetrafluoroethylene column in ABAQUS

Table 1 Decreasing order of load resisting property of materials

S. No.	Material	Displacement before Coating (mm)	Displacement after Coating (mm)
1.	Douglas FIR wood	1.563e + 4	5.422
2.	E-Fibre glass	1.563e + 4	6.536
3.	Aluminium	1.563e + 4	1.286e + 1
4.	Steel	1.563e + 4	2.063e + 1
5.	Teflon	1.563e + 4	6.278e + 1
6.	Carbon fibre	1.563e + 4	2.637e + 2
7.	Composite of aluminium and steel	1.563e + 4	1.344e + 4

The columns of same dimensions were analysed with shells of different materials by ABAQUS software. The variations were observed in terms of deflection of columns. The comparison of deflections observed is given in Table 1.

7 Conclusion

The conclusions drawn from the present study are.

- According to the results obtained from ABAQUS, the load resisting property observed in decreasing order is

Douglas Fir Wood > E-Fibre Glass > Aluminium > Steel > Teflon > Carbon Fibre > Composite of Aluminium and Steel.

- **Douglas Fir Wood** is found to have best load resisting property with minimum deflection of 5.422 mm.
- **E-fibre glass** is found to have the second best load resisting property with deflection of 6.536 mm.

Reference

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