Reliability Analysis of CFST Column by Form and Orthogonal Latin Hypercube Method

Keerthana V1, Khalid Nayaz Khan2, Dr. N S Kumar3

1Student, Department of Civil Engineering, Ghausia College of Engineering, Affiliated to VTU, Belagavi, Ramanagaram-562159, Karnataka, India
2Asst. Professor, Dpt. of Civil Engineering, Affiliated to VTU, Belagavi, Ramanagaram-562159, Karnataka, India
3Prof. & Director (R&D), Dpt. of Civil Engineering, Affiliated to VTY, Belagavi, Ramanagaram-582159, Karnataka, India

Abstract: In this study, analysis of CFST column is done with the assistance of ABAQUS software. The models are analyzed in ABAQUS software to establish the failure loads for various length, thickness and slenderness ratio of CFST columns. The analytical values compared with codal provisions corresponding to ACI-318 and BS 5400 code. And graphs are plotted to know the distinction between analytical and codal values. The Reliability analysis is carried to know the design goals therefore on accomplish the normal load carrying capability with less deflection. The Reliability analysis is carried out with the assistance of 2R software and also the results corresponding to reliability index and probability of failure are measure tabulated for every CFST model. The reliability analysis is performed by FORM method. Simulation techniques specifically ORTHOGONAL HYPERCUBE technique is utilized in this work. The Taguchi's approach is adopted to spot and decide the combination of parameters that yield the simplest reliability index.

Keywords: CFST, ABAQUS, Reliability, Orthogonal Latin Hypercube, FORM, 2R rel

1. Introduction

In the advance amount, concrete-filled steel cannular (CFST) columns have gained pleasant look for building and different kinds of structures. CFST columns become fashionable designers and structural engineers. They assist to extend the speed of construction whereas the steel tube acts sort of a shoring through the concrete running, afterward leads toward economy within the concrete running technique by eliminating the need of formwork. Feature scopes square measure the high strength and increase the structural inflexibility.

1.1 Concept of Reliability

Every real-life system has a capacity (or resistance) for doing something and is subjected to some sort of demand (or load). Both capacity and demand may change depending on various factors and those factors can be viewed as random variables. When demand exceeds the capacity of the system, a system failure is reached, given that the system cannot offer the service that it was designed to provide. While some system’s failure can be permanent, other system’s failure can be only temporary. Here are a few examples of real-life systems and some of the factors that could influence their capacities and demands:

- Capacity may depend on the weather.
- Capacity may depend on the quality of construction process.
- Demand may depend on the distribution of loads.

1.2 First Order Reliability method

The first order reliability technique (FORM) makes utilization of the primary and second snapshots of the irregular factors. This strategy incorporates 2 methodologies. There area unit 1st order moment (FOSM) and Advanced 1st order moment (AFOSM) approaches. In FOSM, the information on the conveyance of irregular factors is disregarded. In any case, in AFOSM, the spatial arrangement knowledge is befittingly used.

1.3 Orthogonal Latin Hypercube Method

This algorithmic program refines the sampling method of conventional Latin Hypercube by dividing the sampling house into subspaces with an equivalent likelihood, wherever the quantity of sampling taken from every of these subspaces is the same. If every variable’s sampling house is split into 2 section (upper and lower), there'll be 2m equally probable subspaces to be monitored, being the quantity of variables being employed.

2. Material and Methodology

2.1 Material Properties

- STEEL
  - a) Material: Structural Steel Fe 310 Mpa
  - b) Young’s Modulus = 200Gpa
  - c) Poisson’s ratio = 0.3
  - d) Density = 7850kg/m3.

- CONCRETE PROPERTIES
  - a) Grade of Concrete: M30
  - b) Young’s Modulus = 27386.13 Mpa
  - c) Poisson’s ratio = 0.2
  - d) Density = 2400kg/m3
2.2 Section Properties

Table 2.1: Details of Section properties

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Diameter (mm)</th>
<th>Length Based on Slenderness Ratio (L)</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>i=4</td>
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<td>241.2</td>
<td>428.4</td>
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<td>7</td>
<td>70.1</td>
<td>304.4</td>
<td>608.8</td>
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<td>8</td>
<td>80.9</td>
<td>355.6</td>
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<td>9</td>
<td>91.4</td>
<td>427.2</td>
<td>914.4</td>
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3. Results and Comparison

3.1 Design Codes

- **ACI-318:**

According to the ACI rules for composite columns follow an equivalent procedure as for concrete columns. The ultimate load carrying capacity of column is calculated by using below equation

\[ P_u = A_s f_s + 0.85 A_c f_c \]

- **BS 5400:**

According to the British Standard code ultimate load carrying capacity by using the equation as

\[ P_u = 0.67 A_c f_c + f_y A_s \]

3.2 Comparison between the Analytical and Codal values

Table 3.1: Results obtained for dia. 60.3 mm by analytical and codal provision

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>Thickness (mm)</th>
<th>L/d ratio</th>
<th>f_y (N/mm²)</th>
<th>f_c (N/mm²)</th>
<th>Pu (kN) Analytical</th>
<th>Pu (kN) ACI-318</th>
<th>Pu (kN) BS 5400</th>
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</thead>
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<tr>
<td>60.3</td>
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<td>4</td>
<td>110</td>
<td>30</td>
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<td>194.00</td>
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<td>30</td>
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<td>211.24</td>
<td>243.302</td>
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<td>3.6</td>
<td>8</td>
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<td>4</td>
<td>110</td>
<td>30</td>
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<td>297.249</td>
<td>380.088</td>
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<td>332.45</td>
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<td>30</td>
<td>342.13</td>
<td>297.249</td>
<td>380.088</td>
</tr>
</tbody>
</table>

Figure 1: Ultimate load v/s L/d ratio for Diameter 60.3 mm

Figure 2: Ultimate load v/s thickness for L/d ratio of 4

Figure 3: Ultimate load v/s thickness for L/d ratio of 8

Figure 4: Ultimate load v/s thickness for L/d ratio of 12
4. Taguchi’s L9 Orthogonal array

Table 4.1: Taguchi’s L9 Orthogonal array for Orthogonal Latin Hypercube Method

<table>
<thead>
<tr>
<th>EXP. NO.</th>
<th>T (mm)</th>
<th>D (mm)</th>
<th>L/D ratio</th>
<th>fty</th>
<th>fdk</th>
<th>Pu (kN)</th>
<th>O.H/M</th>
<th>Pi</th>
<th>R</th>
<th>K/in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.6</td>
<td>213</td>
<td>4</td>
<td>310</td>
<td>30</td>
<td>36.60</td>
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<td>0.5931</td>
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<td>310</td>
<td>30</td>
<td>4000.1</td>
<td>-1.575</td>
<td>0.1448</td>
<td>0.5392</td>
<td>85.92</td>
</tr>
</tbody>
</table>

Figure 5: Reliability in % v/s No. of models

5. Conclusion

1) The number parameter influencing the behavior and constraints like member dimension, thickness of steel pipe, slenderness (L/d ratio), D/t ratio of the tube, grade of concrete and yield strength of steel.
2) As length of tube increases, load carrying capacity decreases and Reliability index additionally decreases.
3) The results show that analytical values of load carrying capacity are more compared to the ACI and BS Code (Tb.3.1)
4) Load carrying capacity of the column increase with decrease in L/d ratio (Tb.3.1)
5) Once the L/d ratio increase the strength of CFST column increase (Fig 3.2 to 3.4).
6) Load carrying capacity of column increase with increasing the diameter maintaining constant thickness.
7) The FORM provides standard results, the error kind this technique can be avoided by careful analysis.
8) The reliability analysis using FORM, are simply done manually. Whereas ORTHOGONAL LATIN HYPERBOLIC method need appropriate software.
9) The reliability index values decrease with increase in thickness of steel tubes. (Tb.4.1)

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Author Profile


Mr. Khalid Nayaz Khan, Associate Professor Dept. of Civil Engineering GCE, Ramanagaram 562159. He has a teaching experience of 32 years. Has published about 13 papers in various journals.

Dr. N.S Kumar, Prof. & Director (R&D) received the B.E. in Civil Engineering from Mysore University in 1985, M.E. and Ph.D degrees from Bangalore University in 1988 and 2006 respectively. He is associated with Ghousia College of Engineering since 1988. He has guided one Ph.D and over 25 M.tech projects including one M.Sc. Engineering (by Research). Presently he is guiding six Ph. D scholars, He has more than 29 years of teaching & 6 years of Research experience. He has published over 130 papers in National and International journals and conferences. His research interest is composite steel structures, FEM based design of structures and Seismic Design of columns and footing.

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