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

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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 this 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 that 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 E=200Gpa
c) Poison's ratio =0.3
d) Density =7850kg/m3.

• CONCRETE PROPERTIES

a) Grade of Concrete: M30
b) Young's Modulus E=27386.13 Mpa
c) Poison's ratio = 0.2
d) Density=2400kg/m3

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2.2 Section Properties

Table 2.1: Details of Section properties

Sl. No.	Diameter (mm)	Length Based on Slenderness Ratio (λ)			Thickness (mm)
		λ=4	λ=8	λ=12	
1	21.3	85.2	170.4	255.6	2.6 3.6 4.5
2	26.9	107.6	215.2	322.8	
3	33.7	134.8	269.6	404.4	
4	42.4	169.6	339.2	508.8	
5	48.3	193.2	386.4	579.6	
6	60.3	241.2	482.4	723.6	
7	76.1	304.4	608.8	913.2	
8	88.9	355.6	711.2	1066.8	
9	114.3	457.2	914.4	1371.6	

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

Pu = As fs + 0.85 Ac fc

- **BS 5400:**

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

Pu = 0.67 Ac*fc + fy* As

3.2 Comparison between the Analytical and Codal values

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

Diameter (mm)	Thickness (mm)	L/d ratio	fy N/mm²	fck N/mm²	Pu Analytical (kN)	Pu ACI-318 (kN)	Pu BS 5400 (kN)
60.3	2.6	4	310	30	216.09	206.906	194.030
60.3	2.6	8	310	30	215.68	206.906	194.030
60.3	2.6	12	310	30	213.35	206.906	194.030
60.3	3.6	4	310	30	269.50	255.260	243.302
60.3	3.6	8	310	30	263.56	255.260	243.302
60.3	3.6	12	310	30	259.89	255.260	243.302
60.3	4.5	4	310	30	315.78	297.249	286.088
60.3	4.5	8	310	30	310.45	297.249	286.088
60.3	4.5	12	310	30	304.12	297.249	286.088

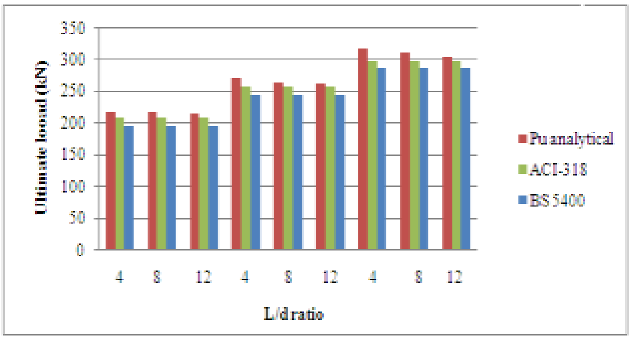

Figure1: Ultimate load v/s L/d ratio for Diameter 60.3mm

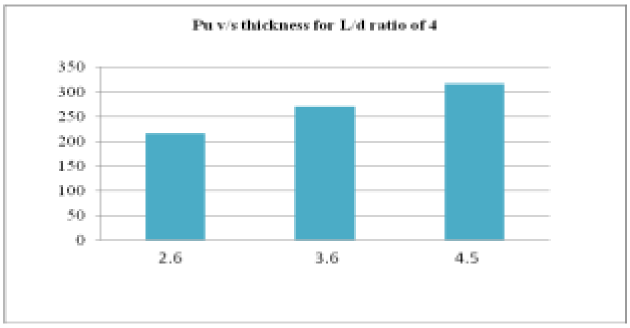

Figure 2: Ultimate load v/s thickness for L/d ratio of 4

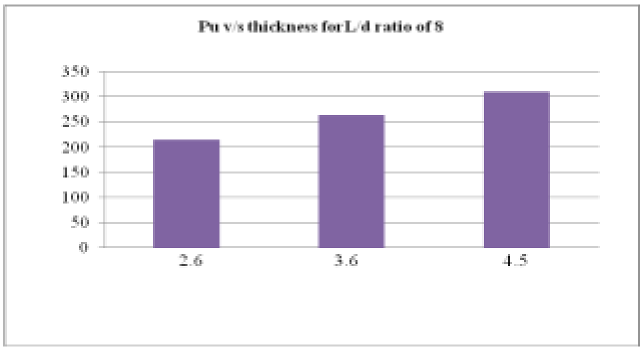

Figure 3: Ultimate load v/s thickness for L/d ratio of 8

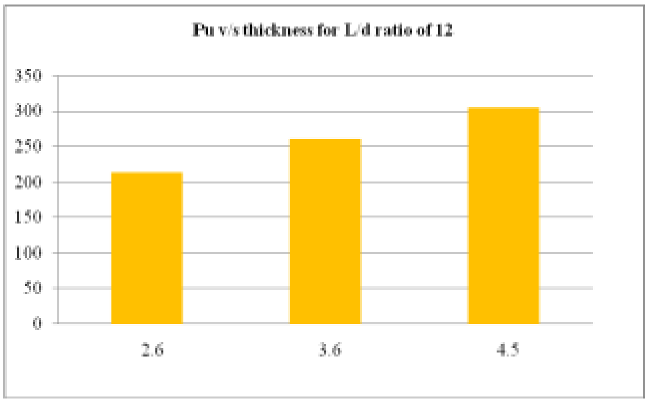

Figure 4: Ultimate load v/s thickness for L/d ratio of 12

4. Taguchi's L9 Orthogonal array

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

EXP. NO.	T (mm)	D (mm)	L/d ratio	fy N/mm²	fck N/mm²	Pu (kN)	OLHM β	Pf	R	R in %
1	2.6	21.3	4	310	30	36.80	1.0031	0.5541	0.3719	37.19
2	3.6	26.9	8	310	30	912.73	-5.332	0.5530	0.5332	53.32
3	4.5	33.7	12	310	30	2245.57	-8.686	0.6172	0.3128	31.28
4	2.6	42.4	4	310	30	558.89	-1.454	07864	0.2136	21.36
5	3.6	48.3	8	310	30	788.89	-1.870	0.8228	0.8228	82.28
6	4.5	60.3	12	310	30	3500.78	-4.940	0.4112	0.5888	58.88
7	2.6	76.1	4	310	30	1500.13	-4.349	0.1223	0.8777	87.77
8	3.6	88.9	8	310	30	3200.67	-2.643	0.5838	0.4162	41.62
9	4.5	114.3	12	310	30	4000.1	-1.373	0.1418	0.8582	85.82

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

5. Conclusion

1) The numerous 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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