STM JOURNALS

Journal of
Polymer & Composites

ISSN: 2321-2810 (Online)
ISSN: 2321-8525 (Print)
Volume 13, Special Issue 2, 2025
DOI (Journal): 10.37591/JoPC

https://journals.stmjournals.com/jopc

Research JoPC

Numerical Investigation on Concrete Filled Steel Tube Composite Circular Columns Under General Loading

Singamsetti Mohan Sai[1]*, P. Poluraju[2]

Abstract

Concrete-filled steel tube (CFST) composite columns are extensively utilized in civil engineering constructions because of their numerous structural advantages, such as superior seismic performance, high load- bearing capacity, fire resistance, remarkable ductility, and ability to absorb energy effectively, especially in areas prone to seismic activity. CFST columns are employed in tall buildings and bridges to enhance rigidity and increase bearing capacity, but their behavior can be affected by buckling. There is a critical necessity to investigate the performance of these columns under diverse conditions. The numerical method serves as a valuable tool to complement experimental studies and is utilized to examine the impact of various parameters due to constraints related to cost, equipment, and time associated with experimental programs. The present study considers various parameters including different slenderness ratios (expressed as the ratio of column height to cross-section dimension, H/D and varying steel tube thickness to column dimension ratios D/t), and different compressive strength of concrete and different yield strength of steel tube under concentric axial, uniaxial, and biaxial loading conditions. First, the software package "ABAQUS/CAE 2017" was utilized to create a finite element model for this project. In order to greatly expand the field of study, extensive numerical models were conducted. 144 specimens were used in the numerical work. In addition, the numerical results were validated with the analytical computations from the various international codes/standards to provide the accuracy of the predictions for the final carrying loads. Two distinct international codes and standards, the American Institute of Steel Construction (AISC) and the Architectural Institute of Japan standards (AIJ), are validated to the measured compressive axial, uniaxial, and biaxial capacities. The comparisons also included some suggested equations from the literature. The most cautious design code for estimating the CFST columns' load capacity is AIJ.

Keywords: Numerical investigation, composite CFST, load carrying capacity, general loading, steel tube, infilled concrete

INTRODUCTION

Columns are vertical structural elements that transfer the weight from roof slabs and beams, including their own weight, to the foundation. They are mainly subjected to axial, uniaxial, and biaxial compression shown in *Figure 1:* The column has been divided into two types: short columns and (b) long columns. A column is considered short when the ratio of its effective length to its minimum lateral dimensions is less than 12, indicating that crushing is the reason for the failure. Conversely, a column is referred to as long if its ratio is larger than 12 and it fails as a result of both buckling and crushing. The construction industry has used more Concrete filled steel tube (CFST) members than just concrete columns in the last 20 years because of their high load carrying capacity, excellent seismic performance, and ease of construction [1]. CFST

***Author for Correspondence**
Singamsetti Mohan Sai

[1]PG Student, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation University, Guntur, Andhra Pradesh, India
[2]Professor, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation University, Guntur, Andhra Pradesh, India

Received Date: April 23, 2024
Accepted Date: July 30, 2024
Published Date: January 24, 2025

Citation: Singamsetti Mohan Sai, P. Poluraju**.** Numerical Investigation on Concrete Filled Steel Tube Composite Circular Columns Under General Loading. Journal of Polymer & Composites. 2025; 13(Special Issue 2): S164–S199p.

columns are the composite structures in which steel tube is filled with concrete as shown in *Fig.2:*. CFST members are one of several methods that are suggested and utilized to lower the column's cross-sectional area [2]. CFST columns are widely used in civil engineering structures [2-3].CFSTs have a steel tube at the outside perimeter that increases stiffness and has a significantly higher modulus of elasticity than the concrete, in contrast to traditional reinforced concrete columns. The concrete core is also contained, which improves the column's ductility and compressive strength. The infilled concrete not only creates a perfect core to support the compressive load but also delays and frequently stops localized buckling of the steel. For several decades, concrete-filled steel tube columns were utilized as a composite structural element because of their many structural benefits, including high strength, high ductility, fire resistance, and significant energy absorption capacities. Composite structures are now thought to be a useful method for supporting loads in a variety of building structures, including high-rise buildings, bridges, subway stations, workshop buildings, electrical pylons and poles, and other kinds of structures. Numerous scholars have examined the sustainability of this kind of building [4-7].

Numerous research projects and design processes have been improved to examine the behavior of CFST columns under various loads. Composite columns, which are made of steel tubes filled with concrete, offer greater rigidity and bearing capacities. Numerous previous studies have examined their behavior. Huang [8]. used the nonlinear finite element analysis method to analyze and verify the test results while studying the behavior of concrete-filled steel tube columns under axial load. It was observed that the strengthening plan strengthened and improved the steel tube's confinement on the concrete core. Additionally, the specifications provided by Eurocode 4 offered a preservative estimate of the ultimate strength of circular CFST columns, even for $D/t \geq 150$. According to Hsuan's research [9], concrete in circular CFST columns could be effectively restricted by the tubes if the width-to-thickness ratio was low ($D/t < 40$) and there was little chance of steel local buckling in the tube. Lai and Ho [10]. conducted an experimental study on 35 specimens to examine the behavior of uniaxially loaded concrete-filled steel tube columns that were confined by external rings. The theoretical findings were confirmed through calculations. The CFST column specimens were divided into groups based on specimens that shared similar dimensions, including the heights of the columns, the diameter and thickness of the steel tube, and the strength of the concrete. The study's conclusion was that the external stiffener could create the bonding condition while resisting the lateral CFST dilatation. The lateral deformation of the steel tube columns and core concrete was better controlled by the external steel rings. The development and use of CFST in high-rise buildings was demonstrated by Zhong and Zhang [11]. Kharoob and others [12]. conducted an experimental investigation on the compressive behavior of square steel tubular columns filled with fictional material and reinforced with glass fiber. Schnabl et al. [13] introduced an efficient mathematical model for studying the global buckling behavior of CFST columns with compliant interfaces. In Campione et al. [14] carried out experimental compression tests on steel tubular columns filled with fiber-reinforced concrete and plain concrete for three different lengths in order to highlight the impact of slenderness on ductility under compression. The ultimate strength of CFST columns, as measured by (L/D) and D/t, was examined in relation to the thickness and shape of steel tubes using fourteen different specimens tested by Stephen [15]. Susantha [16] investigated the complete stress–strain curve of concrete columns confined by different steel shapes (circular, box, and octagonal cross-sections) subjected to axial load and lateral pressure by using FEM analysis. The study showed that the circular-shaped columns were significantly confined in comparison to the box columns.

Research Significant

In this paper, the three models are simulated by using different thickness of steel to study the effect of increase in thickness of steel tube on behavior of CFST column. The three different models are analyzed by using different concrete cube strengths to study effect of grade of concrete on behavior of CFST column, two different models are created by using different steel grade to study effect of grade of steel on behavior of CFST column, three models for the effect of axial force ratio, three models for the effect of uniaxial force ratio and three models for the effect of biaxial force ratio the six different models are created by using different column to study effect of slenderness on behavior of CFST column by Fattouh M. F. Shaker [17].The study will investigate the load carrying capacity of different parameters on CFST short and long columns when subjected to axial, uniaxial and biaxial loading conditions by taking Different steel grades, different concrete grades, and taking different steel tube thicknesses i.e., the ratios of cross section dimension to thickness D/t, the ratio of height to cross section dimension i.e., H/D, and make a comparison between different design codes because the load carrying capacity vary from code to code.

Parametric Study

The simulation of the actual behavior of CFST columns, the main components of these columns have to be modelled properly. A simplified finite element modelling used in this paper for CFST circular columns under the axial, uniaxial and biaxial load loading. ABAQUS is used for finite element model to efficiently predict the axial behavior, uniaxial behavior, and biaxial behavior of the CFST column. The testing investigation used ABAQUS software to simulate the behavior of CFST columns. FE analysis using the same approaches is frequently used to investigate parameters that cannot be considered in a laboratory setting. Limited options may influence the behavior of CFST columns under different loading conditions. The column-height-to-cross-section-dimension ratios (H/D) 1200 mm for short column and 4000 mm for long column. Tables:1 and 2 gives the information about parametric study going to be done in this project. Tables 1 and 2 shows the different grades of steel tube yield strengths (275 MPa and 340 MPa) and Different grades of concrete (25, 40, and 60 MPa) the cross-section dimension to steel tube thickness (D/t), where D is fixed to 300 mm (t) is steel tube thickness varied by 6, 8, 10 and 12 mm.

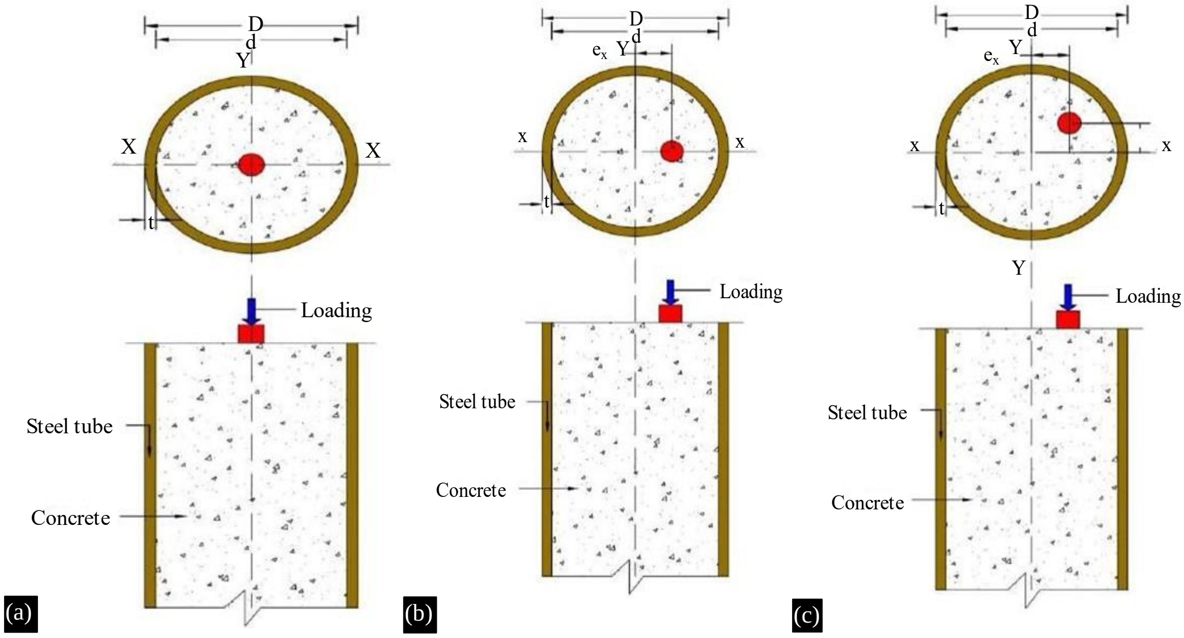


Figure 1. Showing the various loadings (a) Axial, (b) Uniaxial, (c) Biaxial Loading Conditions.

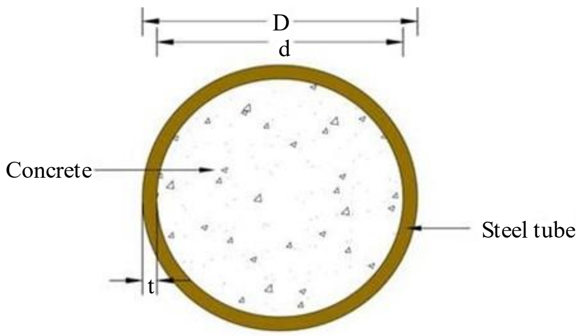


Figure 2. Cross section of composite CFST column.

Table 1. Test matrix for 275 MPa.

Steel grade	**275**																	
Concrete grade	***25***						***40***						***60***					
Type of column	***short column***			***long column***			***short column***			***long column***			***short column***			***long column***		
Loading condition	axial	uniaxial	biaxial	axial	uniaxial	biaxial	axial	uniaxial	biaxial	axial	uniaxial	biaxial	axial	uniaxial	biaxial	axial	uniaxial	biaxial
D/t ratios	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27

Table 2. Test matrix for 340 MPa.

Steel grade	**340**																	
Concrete grade	***25***						***40***						***60***					
Type of column	***short column***			***long column***			***short column***			***long column***			***short column***			***long column***		
Loading condition	axial	uniaxial	biaxial	axial	uniaxial	Biaxial	axial	uniaxial	biaxial	axial	uniaxial	biaxial	axial	uniaxial	biaxial	axial	uniaxial	biaxial
D/t ratios	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27

Analytical Model

ABAQUS is a software suite for finite element analysis and computer-aided engineering, primarily used for analyzing and simulating the behavior of structures and solid mechanics problems. It is developed by Dassault Systèmes' Simulia brand. ABAQUS provides a comprehensive set of tools for modeling, meshing, simulating, and visualizing complex engineering problems in various fields such as automotive, aerospace, civil engineering, biomechanics, and more.

The Parts module is where users create the geometric representations of the components or parts of the model they want to analyze. *Figs.3-6:* show the geometrical representation of short and long columns. The inner diameter of CFST column is set as 300 mm, The steel tube thicknesses are varying 6,8,10 and 12 mm. The lengths of short column and long column are 1200 mm and 4000 mm.

In this present study the compressive strengths of concrete are M25, M40 and M60 and the steel yield strengths of steel tube are 275 MPa and 340 MPa. Table showing the properties of concrete damaged plasticity properties, Table showing the steel tube properties. *Table.3&4:* provide the details of properties of concrete and steel tube.[18].

The Assembly module is where users assemble individual parts or components to create a complete model. It allows for the placement, orientation, and connection of parts relative to each other. *Fig.7:* showing the assembly of steel tube and infilled concrete.

In this model, coupling interaction is used; Coupling interactions represent the interaction between different physical phenomena, such as thermal-mechanical coupling, fluid-structure interaction, or electromagnetic-structural interaction and surface to surface contact property is used for steel tube and concrete column. *Fig.8:* showing the coupling interaction of steel tube and infilled concrete.

Meshing is the process of discretizing the geometric model into smaller elements (such as triangles or quadrilaterals in 2D, and tetrahedra or hexahedra in 3D) to solve the equations of motion or equilibrium numerically. The proposed FE model comprises of two fundamental parts; steel tube, concrete infill. Each part is meshed independently. The approximate global size of mesh is 50. *Figure's.9 and 10:* showing the meshin models of steel tube and infilled concrete.

In ABAQUS/CAE, a Step defines a particular stage or phase of the analysis. In a static step, the applied loads and boundary conditions remain constant throughout the analysis. This type of step is suitable for simulating static structural, thermal, or coupled-field problems where the loading does not change with time.

In the proposed finite-element model, one end is fixed, and the other end is pinned condition is used. The load and supporting conditions of the CFST column model in ABAQUS/CAE 2017 version are shown in *Figure.11:*. In this simulation three types of loading are considered, those are axial, uniaxial and biaxial loading conditions.*Figure's.12,13,14:* shows the different loading conditions (axial, uniaxial and biaxial) acting on the circular CFST column.

The Job module is where users define and manage the analysis jobs to be executed. Users specify the analysis type, solver settings, output requests, and other parameters necessary for the simulation. Once defined, jobs can be submitted for analysis, and users can monitor the progress, review results, and post-process the data generated by the solver.

After the analysis is completed, users can visualize and interpret the results using ABAQUS/CAE's post-processing tools. These tools allow for viewing various types of results such as displacements, stresses, strains, temperatures, etc., in graphical or tubular formats. *Figs.15 to 20:* show the failure conditions of short and long columns under axial, uniaxial and biaxial loading. *Table.5:* presents the results of numerical model analysis.

Table 3. Properties of Compressive strengths of concrete.

Material properties	**M25**	**Plasticity parameters**	
		Dilation angle	**40**
		Eccentricity	**0.1**
	Concrete elasticity	**fb0/fc0**	**1.67**
Young's modulus (Mpa)	***23500***	***K***	***0.6667***
Poisson's ratio	***0.2***	***Viscosity parameter***	***0.001***
Concrete compressive behavior	***Concrete compression damage***	***Concrete tension behavior***	***Concrete tension damage***

Yield stress(Mpa)	***Inelastic strain***	***Damage parametre***	***Inelastic strain***	***Yield stress(Mpa)***	***Cracking strain***	***Damage parametre***	***Cracking strain***
9.97	0	0	0	3.1	0	0	0
17.07	0.00	0.02	0.00	3.03	0.00	0.02	0.00
21.74	0.00	0.08	0.00	2.94	0.00	0.05	0.00
24.26	0.00	0.15	0.00	2.80	0.00	0.10	0.00
25.00	0.00	0.23	0.00	2.74	0.00	0.12	0.00
24.43	0.00	0.31	0.00	2.62	0.00	0.15	0.00
23.04	0.00	0.38	0.00	2.40	0.00	0.23	0.00
21.23	0.00	0.44	0.00	2.23	0.00	0.28	0.00
19.28	0.00	0.50	0.01	2.03	0.00	0.35	0.00
17.36	0.00	0.55	0.01	1.82	0.00	0.41	0.00
15.57	0.00	0.60	0.01	1.69	0.00	0.45	0.00
13.95	0.01	0.64	0.01	1.59	0.00	0.49	0.00
12.50	0.01	0.67	0.01	1.51	0.00	0.51	0.00
11.22	0.01	0.70	0.01	1.38	0.00	0.56	0.00
10.10	0.01	0.88	0.01	1.04	0.00	0.66	0.00
9.12	0.01	0.89	0.01	0.89	0.00	0.71	0.00
8.26	0.01	0.90	0.01	0.79	0.00	0.74	0.00
7.50	0.01	0.90	0.02	0.72	0.00	0.77	0.00
2.96	0.01	0.91	0.02	0.57	0.01	0.82	0.01
2.78	0.02	0.91	0.02	0.55	0.01	0.82	0.01
2.62	0.02	0.92	0.02	0.35	0.03	0.89	0.03
2.47	0.02	0.92	0.02	0.17	0.20	0.95	0.20
2.33	0.02	0.92	0.02	0.14	0.30	0.95	0.30
2.20	0.02	0.93	0.02				
2.08	0.02	0.93	0.02				
1.98	0.02	0.94	0.02				
1.88	0.02	0.94	0.02				
1.78	0.02	0.94	0.02				
1.70	0.02	0.94	0.02				
1.62	0.02	0.95	0.02				
1.54	0.02	0.95	0.02				
1.47	0.02	0.95	0.02				
1.41	0.02	0.95	0.02				
1.35	0.02	0.95	0.02				
1.29	0.02	0.96	0.02				
1.24	0.02	0.96	0.02				
1.19	0.02	0.96	0.02				
1.14	0.02	0.96	0.03				
1.10	0.02	0.96	0.03				
1.05	0.03	0.96	0.03				
1.01	0.03	0.96	0.03				
0.98	0.03	0.97	0.03				
0.94	0.03	0.97	0.03				
0.91	0.03	0.97	0.03				
0.88	0.03	0.97	0.03				
0.85	0.03	0.97	0.03				
0.82	0.03	0.97	0.03				

ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

0.79	0.03	0.97	0.03
0.76	0.03	0.97	0.03
0.74	0.03	0.97	0.03
0.72	0.03	0.97	0.03
0.69	0.03	0.98	0.03
0.67	0.03	0.98	0.03
0.65	0.03	0.98	0.03
0.63	0.03	0.98	0.03
0.61	0.03	0.98	0.03
0.60	0.03		
0.58	0.03		
0.56	0.03		
0.55	0.04		

Material Properties		**M40**		**Plasticity parameters**			
				Dilation angle			**40**
				Eccentricity			**0.1**
Concrete elasticity				**fb0/fc0**			**1.67**
Young's modulus(Mpa)		***29725.41***		***K***			***0.6667***
Poisson's Ratio		***0.2***		***Viscosity parameter***			***0.001***
Concrete compressive behavior		***Concrete compression damage***		***Concrete tension behavior***		***Concrete tension damage***	
Yield stress (MPa	**Inelastic strain**	***Damage parametre***	***Inelastic strain***	***Yield stress (Mpa)***	***Cracking strain***	***Damage parametre***	***Cracking strain***
14.04	0.00	0.00	0.00	3.92	0.00	0.00	0.00
25.71	0.00	0.03	0.00	3.83	0.00	0.02	0.00
34.03	0.00	0.09	0.00	3.72	0.00	0.05	0.00
38.65	0.00	0.16	0.00	3.54	0.00	0.10	0.00
40.00	0.00	0.24	0.00	3.46	0.00	0.12	0.00
38.99	0.00	0.32	0.00	3.32	0.00	0.15	0.00
36.59	0.00	0.39	0.00	3.04	0.00	0.23	0.00
33.54	0.00	0.45	0.00	2.82	0.00	0.28	0.00
30.34	0.00	0.51	0.01	2.57	0.00	0.35	0.00
27.25	0.00	0.56	0.01	2.30	0.00	0.41	0.00
24.41	0.00	0.60	0.01	2.14	0.00	0.45	0.00
21.87	0.01	0.64	0.01	2.01	0.00	0.49	0.00
19.62	0.01	0.67	0.01	1.91	0.00	0.51	0.00
17.65	0.01	0.70	0.01	1.74	0.00	0.56	0.00
15.92	0.01	0.88	0.01	1.32	0.00	0.66	0.00
14.41	0.01	0.89	0.01	1.12	0.00	0.71	0.00
13.09	0.01	0.89	0.01	1.00	0.00	0.74	0.00
11.92	0.01	0.90	0.02	0.92	0.00	0.77	0.00
4.87	0.01	0.90	0.02	0.72	0.01	0.82	0.01
4.59	0.02	0.91	0.02	0.69	0.01	0.82	0.01
4.33	0.02	0.91	0.02	0.45	0.03	0.89	0.03
4.09	0.02	0.92	0.02	0.21	0.20	0.95	0.20
3.86	0.02	0.92	0.02	0.18	0.30	0.95	0.30
3.66	0.02	0.93	0.02				
3.47	0.02	0.93	0.02				

3.30	0.02	0.93	0.02
3.14	0.02	0.94	0.02
2.99	0.02	0.94	0.02
2.85	0.02	0.94	0.02
2.72	0.02	0.94	0.02
2.60	0.02	0.95	0.02
2.49	0.02	0.95	0.02
2.38	0.02	0.95	0.02
2.28	0.02	0.95	0.02
2.19	0.02	0.95	0.02
2.10	0.02	0.96	0.02
2.02	0.02	0.96	0.02
1.94	0.02	0.96	0.03
1.86	0.02	0.96	0.03
1.79	0.03	0.96	0.03
1.73	0.03	0.96	0.03
1.67	0.03	0.96	0.03
1.61	0.03	0.96	0.03
1.55	0.03	0.97	0.03
1.50	0.03	0.97	0.03
1.45	0.03	0.97	0.03
1.40	0.03	0.97	0.03
1.36	0.03	0.97	0.03
1.31	0.03	0.97	0.03
1.27	0.03	0.97	0.03
1.23	0.03	0.97	0.03
1.19	0.03	0.97	0.03
1.16	0.03	0.97	0.03
1.12	0.03	0.97	0.03
1.09	0.03	0.98	0.03
1.06	0.03	0.98	0.03
1.03	0.03		
1.00	0.03		
0.97	0.03		
0.95	0.04		

Material Properties		**M60**		**Plasticity parameters**			
				Dilation angle			**40**
				Eccentricity			**0.1**
Concrete elasticity				**fb0/fc0**			**1.67**
Young's modulus(Mpa)		***36406***		***K***			***0.6667***
Poisson's Ratio		***0.2***		***Viscosity parameter***			***0.001***
Concrete compressive behavior		***Concrete compression damage***		***Concrete tension behavior***		***Concrete tension damage***	
Yield stress(Mpa)	***Inelastic strain***	***Damage parametre***	***Inelastic strain***	***Yield stress(Mpa)***	***Cracking strain***	***Damage parametre***	***Cracking strain***

Journal of Polymer & Composites
Volume 13, Special Issue 2
ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

36.28	0.00	0.00	0.00	4.80	0.00	0.00	0.00
49.89	0.00	0.03	0.00	4.69	0.00	0.02	0.00
57.71	0.00	0.09	0.00	4.56	0.00	0.05	0.00
60.00	0.00	0.17	0.00	4.34	0.00	0.10	0.00
58.33	0.00	0.25	0.00	4.24	0.00	0.12	0.00
54.43	0.00	0.33	0.00	4.07	0.00	0.15	0.00
49.63	0.00	0.40	0.00	3.72	0.00	0.23	0.00
44.70	0.00	0.46	0.00	3.46	0.00	0.28	0.00
40.05	0.00	0.52	0.00	3.15	0.00	0.35	0.00
35.84	0.00	0.57	0.01	2.82	0.00	0.41	0.00
32.11	0.01	0.61	0.01	2.62	0.00	0.45	0.00
28.84	0.01	0.64	0.01	2.46	0.00	0.49	0.00
25.99	0.01	0.68	0.01	2.34	0.00	0.51	0.00
23.50	0.01	0.70	0.01	2.14	0.00	0.56	0.00
21.33	0.01	0.87	0.01	1.62	0.00	0.66	0.00
19.43	0.01	0.88	0.01	1.38	0.00	0.71	0.00
17.77	0.01	0.89	0.01	1.23	0.00	0.74	0.00
7.54	0.01	0.89	0.01	1.12	0.00	0.77	0.00
7.12	0.02	0.90	0.02	0.89	0.01	0.82	0.01
6.73	0.02	0.90	0.02	0.85	0.01	0.82	0.01
6.37	0.02	0.91	0.02	0.55	0.03	0.89	0.03
6.04	0.02	0.91	0.02	0.26	0.20	0.95	0.20
5.74	0.02	0.92	0.02	0.22	0.30	0.95	0.30
5.46	0.02	0.92	0.02				
5.19	0.02	0.92	0.02				
4.95	0.02	0.93	0.02				
4.72	0.02	0.93	0.02				
4.51	0.02	0.93	0.02				
4.32	0.02	0.94	0.02				
4.13	0.02	0.94	0.02				
3.96	0.02	0.94	0.02				
3.79	0.02	0.94	0.02				
3.64	0.02	0.95	0.02				
3.50	0.02	0.95	0.02				
3.36	0.02	0.95	0.02				
3.24	0.02	0.95	0.02				
3.12	0.02	0.95	0.02				
3.00	0.02	0.96	0.02				
2.89	0.03	0.96	0.03				
2.79	0.03	0.96	0.03				

2.70	0.03	0.96	0.03
2.60	0.03	0.96	0.03
2.52	0.03	0.96	0.03
2.43	0.03	0.96	0.03
2.35	0.03	0.96	0.03
2.28	0.03	0.97	0.03
2.21	0.03	0.97	0.03
2.14	0.03	0.97	0.03
2.07	0.03	0.97	0.03
2.01	0.03	0.97	0.03
1.95	0.03	0.97	0.03
1.90	0.03	0.97	0.03
1.84	0.03	0.97	0.03
1.79	0.03	0.97	0.03
1.74	0.03	0.97	0.03
1.69	0.03	0.97	0.03
1.65	0.03		
1.60	0.03		
1.56	0.04		

Table.4. Properties of steel tube yield strengths.

	Yielding stress	Inelastic strain	Ultimate stress	Inelastic strain
Steel grade	275	0	380	0.158625
	340	0	450	0.1183

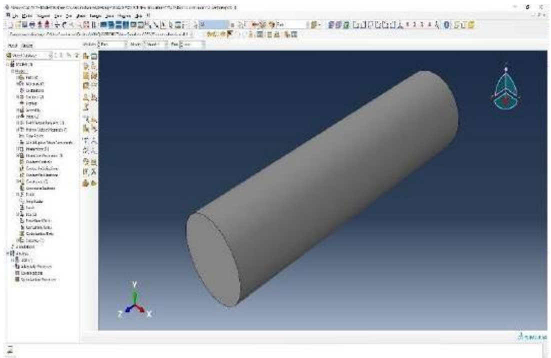


Figure3. In filled concrete for short column.

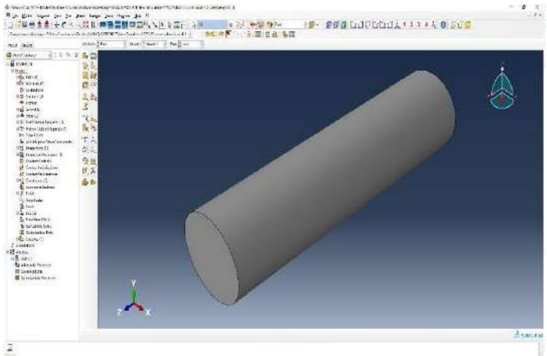


Figure 4 Steel tube for short column.

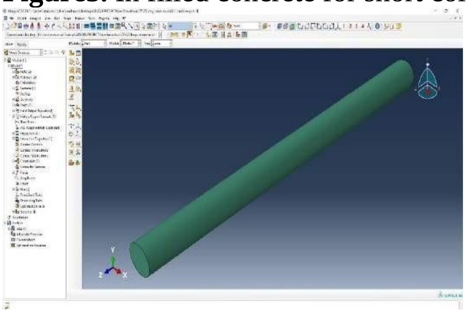


Figure 5. In filled concrete for long column.

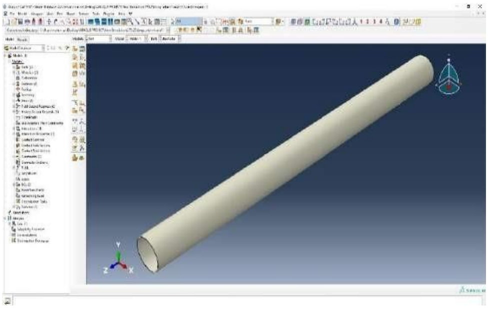


Figure 6. Steel tube for long column.

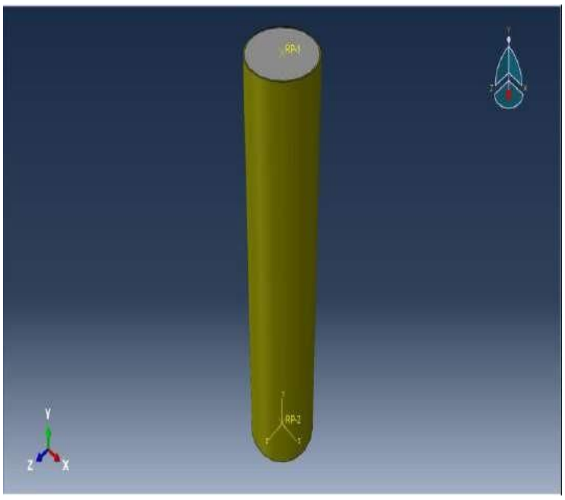


Figure 7. Assembling of Both concrete and steel tube.

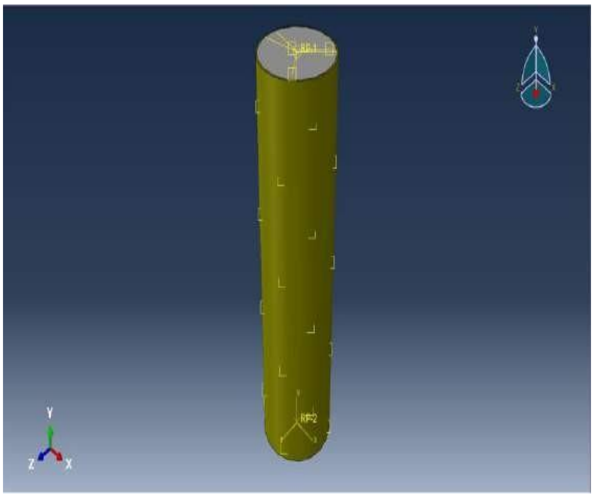


Figure 8. Interaction between concrete and steel tube.

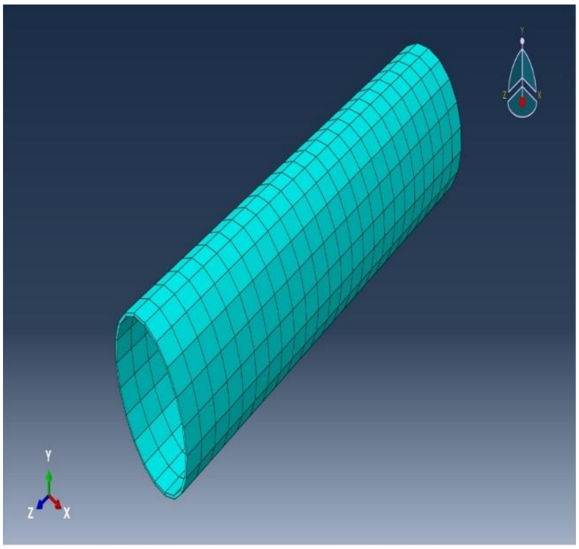


Figure 9. Meshing of steel tube

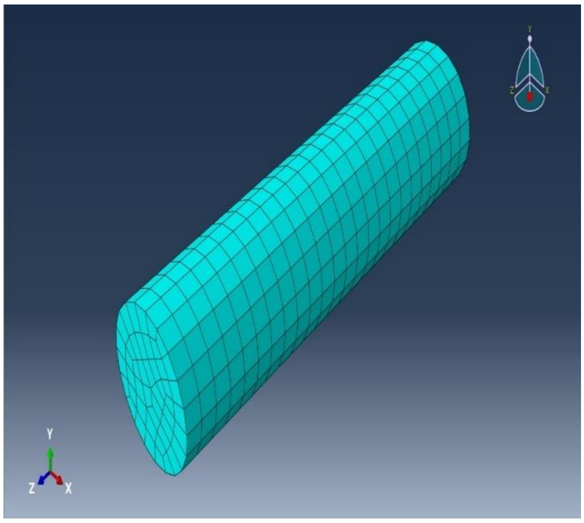


Figure 10. Meshing of concrete

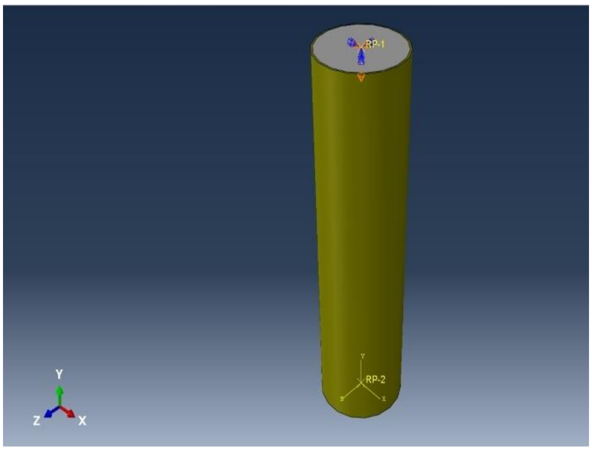


Figure 11. Load and boundary conditon

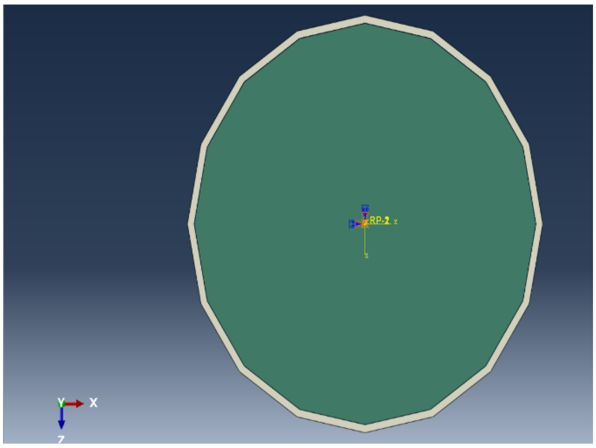


Figure 12. Axial loading condition

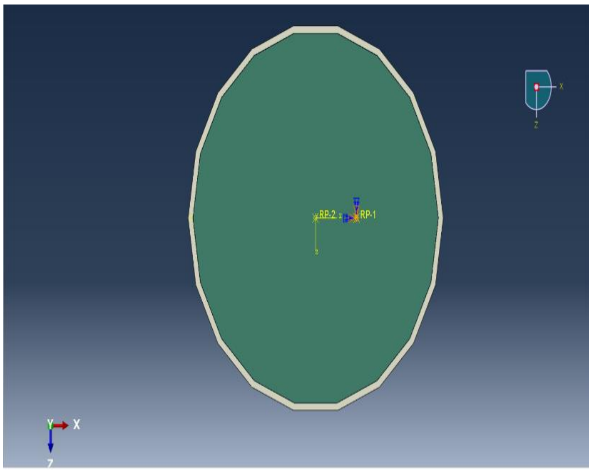


Figure 13. Uniaxial loading condition

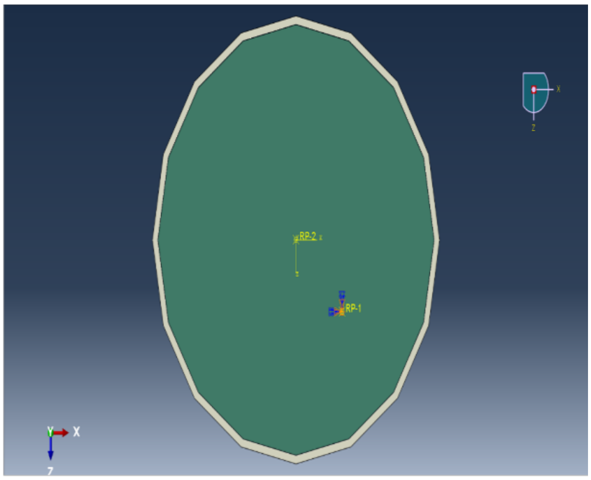


Figure 14. Biaxial loading condition

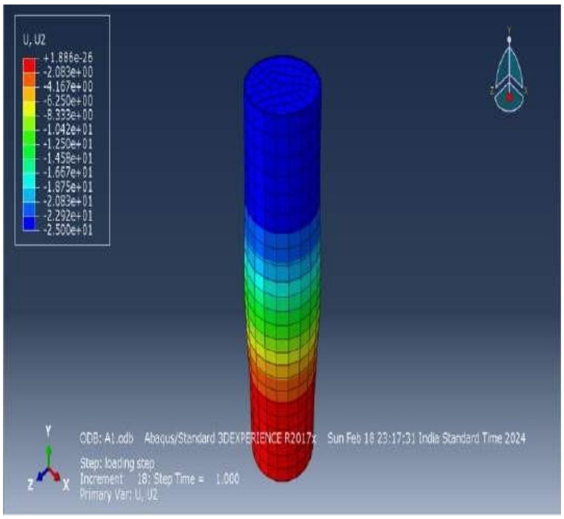


Figure15. Failure conditien of short column under axial loading.

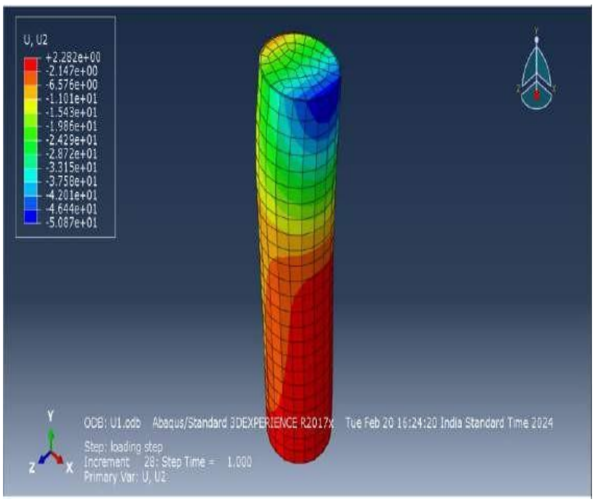


Figure 16. Failure condition of short column under Uniaxial loading.

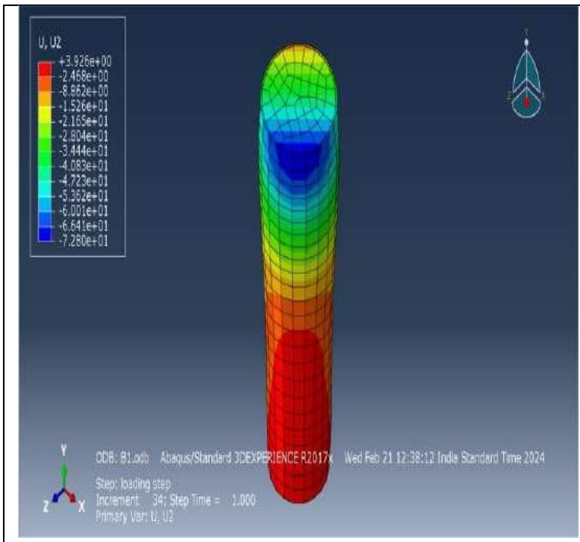


Figure 17. Failure condition of short column under Biaxial loading.

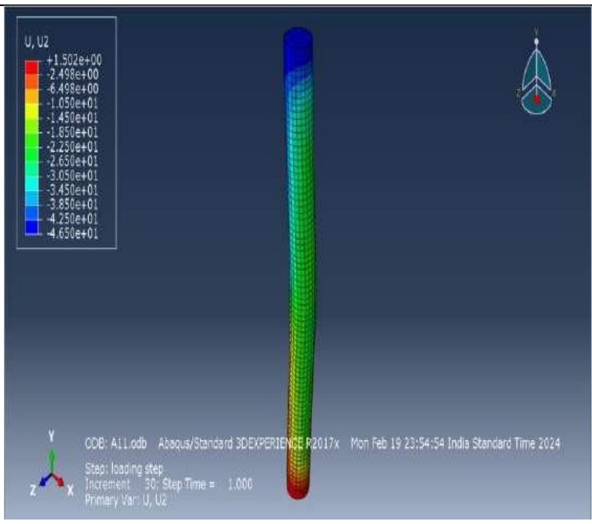


Figure 18. Failure condition of Long column under axial loading.

Journal of Polymer & Composites
Volume 13, Special Issue 2
ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

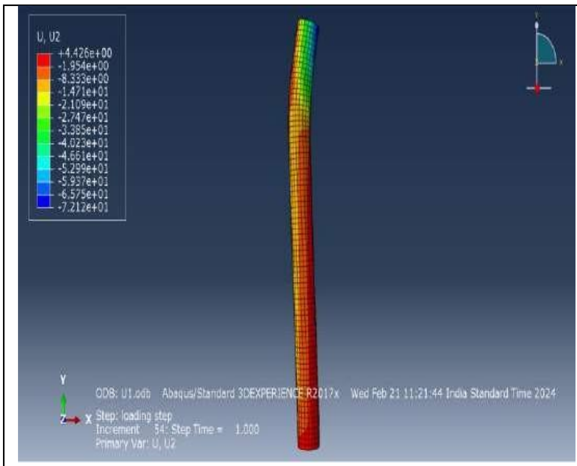


Figure 19. Failure condition of long column under Uniaxial loading.

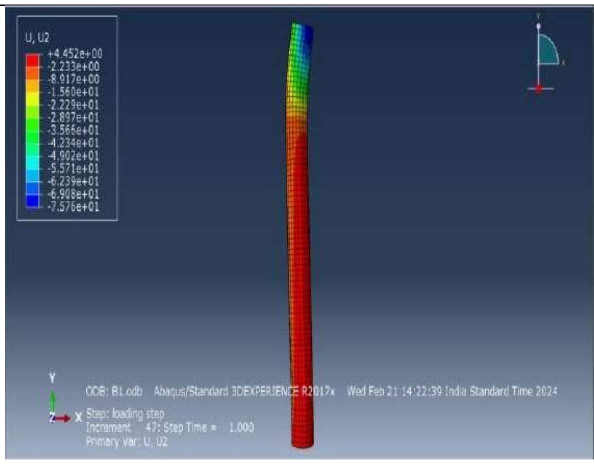


Figure 20. Failure condition of long column under Biaxial loading.

Table 5. Results of Numerical Model Analysis.

Grade of steel (N/mm^2)	**Grade of concrete (N/mm^2)**	**Type of column**	**Loading Condition**	**Thickness (mm)**	**D/t ratios**	**H(mm)**	**H/D ratio**	**Eccentricity (ex)(mm)**	**Eccentricity (ez)(mm)**	**Load 'P'(kN) ABAQUS**
275	25	short column	Axial	6	52	1200	3.85	0	0	4407
				8	40	1200	3.8	0	0	5155
				10	32	1200	3.75	0	0	5928
				12	27	1200	3.7	0	0	6582
			Uniaxial	6	52	1200	3.85	50	0	3288
				8	40	1200	3.8	50	0	3733
				10	32	1200	3.75	50	0	4218
				12	27	1200	3.7	50	0	4716
			Biaxial	6	52	1200	3.85	50	50	2923
				8	40	1200	3.8	50	50	3352
				10	32	1200	3.75	50	50	3777
				12	27	1200	3.7	50	50	4220
		Long column	Axial	6	52	4000	12.8	0	0	4358
				8	40	4000	12.65	0	0	5103
				10	32	4000	12.5	0	0	5858
				12	27	4000	12.34	0	0	6501
			Uniaxial	6	52	4000	12.8	50	0	2835
				8	40	4000	12.65	50	0	3329
				10	32	4000	12.5	50	0	3837
				12	27	4000	12.34	50	0	4295

			Biaxial	6	52	4000	12.8	50	50	2529
				8	40	4000	12.65	50	50	2995
				10	32	4000	12.5	50	50	3440
				12	27	4000	12.34	50	50	3876
	40	short column	Axial	6	52	1200	3.85	0	0	5335
				8	40	1200	3.8	0	0	5995
				12	27	1200	3.7	0	0	7366
			Uniaxial	6	52	1200	3.85	50	0	3868
				8	40	1200	3.8	50	0	4283
				10	32	1200	3.75	50	0	4722
				12	27	1200	3.7	50	0	5151
			Biaxial	6	52	1200	3.85	50	50	3492
				8	40	1200	3.8	50	50	3761
				10	32	1200	3.75	50	50	4223
				12	27	1200	3.7	50	50	4638
		Long column	Axial	6	52	4000	12.8	0	0	5169
				8	40	4000	12.65	0	0	5928
				10	32	4000	12.5	0	0	6618
				12	27	4000	12.34	0	0	7338
			Uniaxial	6	52	4000	12.8	50	0	3362
				8	40	4000	12.65	50	0	3798
				10	32	4000	12.5	50	0	4267
				12	27	4000	12.34	50	0	4675
			Biaxial	6	52	4000	12.8	50	50	2906
				8	40	4000	12.65	50	50	3266
				10	32	4000	12.5	50	50	3710
				12	27	4000	12.34	50	50	4116
	60	short column	Axial	6	52	1200	3.85	0	0	6462
				8	40	1200	3.8	0	0	7120
				10	32	1200	3.75	0	0	7738
				12	27	1200	3.7	0	0	8401
			Uniaxial	6	52	1200	3.85	50	0	4721
				8	40	1200	3.8	50	0	5104
				10	32	1200	3.75	50	0	5476
				12	27	1200	3.7	50	0	5831
			Biaxial	6	52	1200	3.85	50	50	4185
				8	40	1200	3.8	50	50	4501
				10	32	1200	3.75	50	50	4878
				12	27	1200	3.7	50	50	5218
		Long column	Axial	6	52	4000	12.8	0	0	6355
				8	40	4000	12.65	0	0	6974
				10	32	4000	12.5	0	0	7513
				12	27	4000	12.34	0	0	8316
			Uniaxial	6	52	4000	12.8	50	0	3945

				8	40	4000	12.65	50	0	4343
				10	32	4000	12.5	50	0	4750
				12	27	4000	12.34	50	0	5129
			Biaxial	6	52	4000	12.8	50	50	3444
				8	40	4000	12.65	50	50	3804
				10	32	4000	12.5	50	50	4157
				12	27	4000	12.34	50	50	4496
340	25	short column	Axial	6	52	1200	3.85	0	0	4945
				8	40	1200	3.8	0	0	5842
				10	32	1200	3.75	0	0	6684
				12	27	1200	3.7	0	0	7440
			Uniaxial	6	52	1200	3.85	50	0	3575
				8	40	1200	3.8	50	0	4196
				10	32	1200	3.75	50	0	4823
				12	27	1200	3.7	50	0	5441
			Biaxial	6	52	1200	3.85	50	50	3202
				8	40	1200	3.8	50	50	3771
				10	32	1200	3.75	50	50	4321
				12	27	1200	3.7	50	50	4884
		Long column	Axial	6	52	4000	12.8	0	0	4886
				8	40	4000	12.65	0	0	5821
				10	32	4000	12.5	0	0	6630
				12	27	4000	12.34	0	0	7416
			Uniaxial	6	52	4000	12.8	50	0	3186
				8	40	4000	12.65	50	0	3757
				10	32	4000	12.5	50	0	4330
				12	27	4000	12.34	50	0	4933
			Biaxial	6	52	4000	12.8	50	50	2807
				8	40	4000	12.65	50	50	3338
				10	32	4000	12.5	50	50	3916
				12	27	4000	12.34	50	50	4414
	40	short column	Axial	6	52	1200	3.85	0	0	5790
				8	40	1200	3.8	0	0	6622
				10	32	1200	3.75	0	0	7500
				12	27	1200	3.7	0	0	8067
			Uniaxial	6	52	1200	3.85	50	0	4168
				8	40	1200	3.8	50	0	4703
				10	32	1200	3.75	50	0	5261
				12	27	1200	3.7	50	0	5882
			Biaxial	6	52	1200	3.85	50	50	3740
				8	40	1200	3.8	50	50	4185
				10	32	1200	3.75	50	50	4698
				12	27	1200	3.7	50	50	5267

		Long column	Axial	6	52	4000	12.8	0	0	5714
				8	40	4000	12.65	0	0	6631
				10	32	4000	12.5	0	0	7481
				12	27	4000	12.34	0	0	7918
			Uniaxial	6	52	4000	12.8	50	0	3698
				8	40	4000	12.65	50	0	4274
				10	32	4000	12.5	50	0	4832
				12	27	4000	12.34	50	0	5438
			Biaxial	6	52	4000	12.8	50	50	3267
				8	40	4000	12.65	50	50	3769
				10	32	4000	12.5	50	50	4283
				12	27	4000	12.34	50	50	4789
	60	short column	Axial	6	52	1200	3.85	0	0	6901
				8	40	1200	3.8	0	0	7724
				10	32	1200	3.75	0	0	8524
				12	27	1200	3.7	0	0	9297
			Uniaxial	6	52	1200	3.85	50	0	4991
				8	40	1200	3.8	50	0	5462
				10	32	1200	3.75	50	0	5968
				12	27	1200	3.7	50	0	6457
			Biaxial	6	52	1200	3.85	50	50	4408
				8	40	1200	3.8	50	50	4856
				10	32	1200	3.75	50	50	5298
				12	27	1200	3.7	50	50	5775
		Long column	Axial	6	52	4000	12.8	0	0	6807
				8	40	4000	12.65	0	0	7673
				10	32	4000	12.5	0	0	8384
				12	27	4000	12.34	0	0	8831
			Uniaxial	6	52	4000	12.8	50	0	4299
				8	40	4000	12.65	50	0	4821
				10	32	4000	12.5	50	0	5329
				12	27	4000	12.34	50	0	5812
			Biaxial	6	52	4000	12.8	50	50	3755
				8	40	4000	12.65	50	50	4167
				10	32	4000	12.5	50	50	4668
				12	27	4000	12.34	50	50	5117

RESULTS AND DISCUSSIONS

In this section the results and discussion have been presented.

Effects of D/T Ratio

The study examines how the diameter-to-thickness (D/t) ratio of steel tubes affects the load-carrying capacity of CFST circular columns under axial, uniaxial, and biaxial loading. Columns with an inner diameter of 300 mm and D/t ratios of 52, 40, 32, and 27 were analyzed. The steel had yield strengths of 275 MPa and 340 MPa, and a modulus of elasticity of 200 GPa, while concrete grades were 25 MPa,

Journal of Polymer & Composites
Volume 13, Special Issue 2
ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

40 MPa, and 60 MPa. Columns were 1200 mm and 4000 mm long. The results showed that increasing the steel tube thickness, thus decreasing the D/t ratio, enhances the column's axial load capacity. *Figure's:21&22* displays the load-displacement curves illustrates how the diameter to thickness ratio affects the ultimate load carrying capability of CFST columns.

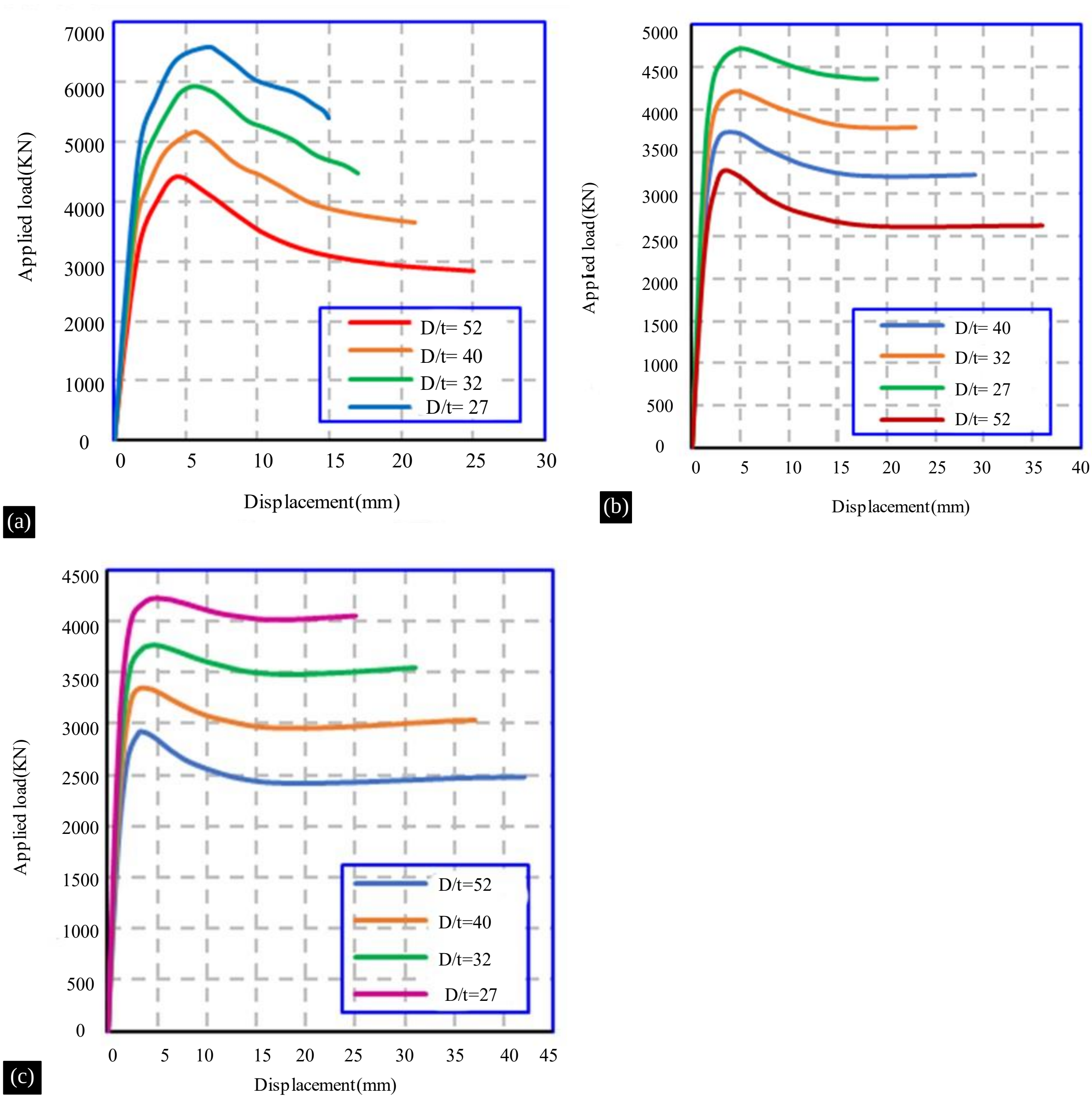


Figure 21. Applied load vs. displacement curves for short column M25 & 275 MPa (a)axial (b)uniaxial and (c)biaxial loading

Effects Of Concrete Compressive Strengths

This simulation examines circular CFST columns with a 300 mm diameter and lengths of 1200 mm and 4000 mm, filled with ordinary, standard, and high-strength concretes under axial, uniaxial, and biaxial loading. Concrete strengths of 25, 40, and 60 MPa were analyzed, alongside steel tube thicknesses of 6, 8, 10, and 12 mm (D/t ratios of 52, 40, 32, and 27) with steel yield strengths of 275 MPa and 340 MPa. The steel's Young's modulus was set at 200 GPa. *Fig's:23&24* show the load-displacement curves for the CFST circular columns filled with different concrete strengths. This indicates that increasing the concrete compressive strength significantly increases the ultimate load of circular CFST columns.

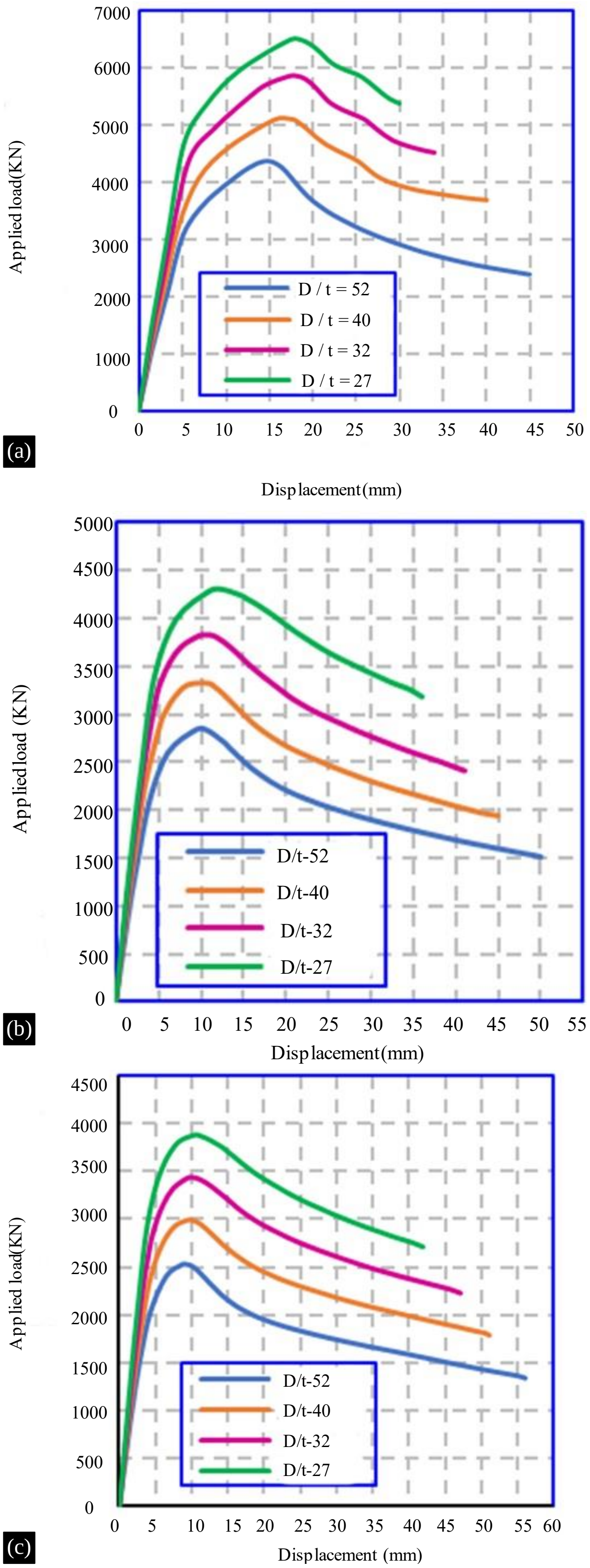


Figure 22. Applied load vs. displacement curves for long column M25 & 275 MPa (a)axial (b)uniaxial and (c)biaxial loading

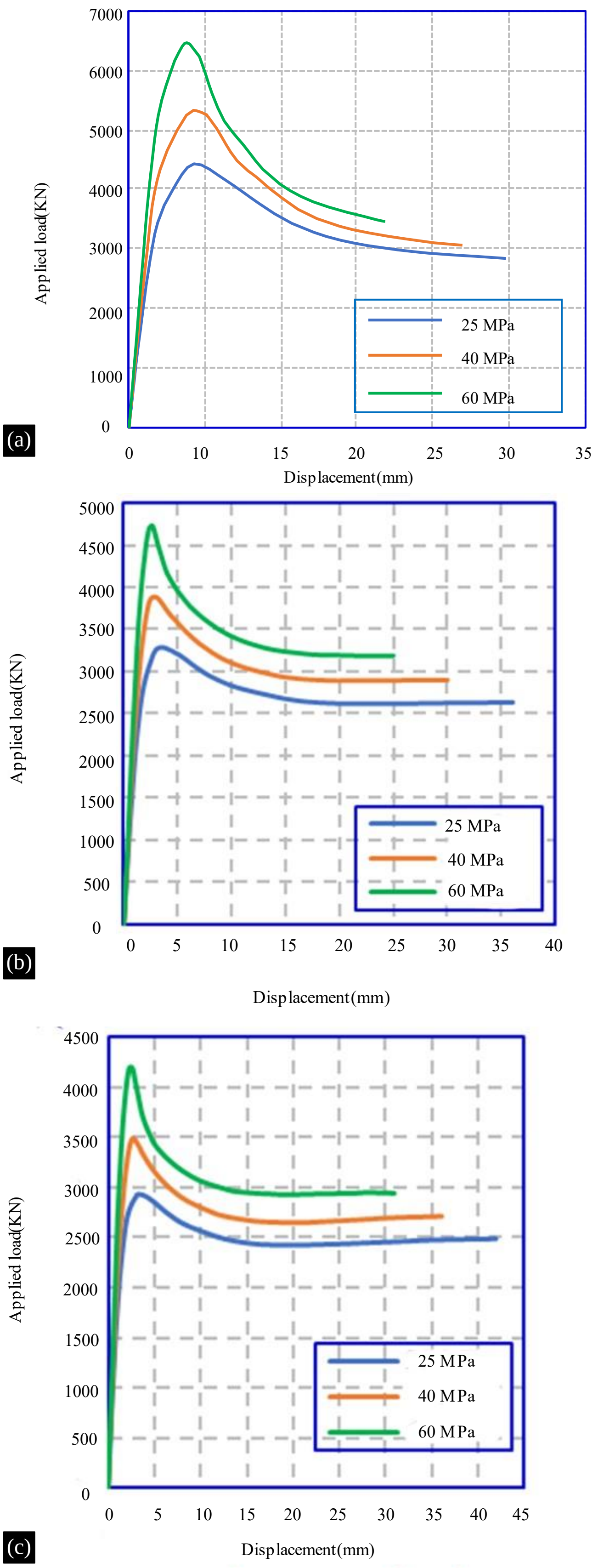


Figure 23. Applied load vs. displacement curves for short column M25, M40 and M60 & 275 MPa (a)axial,(b)uniaxial and (c)biaxial loading.

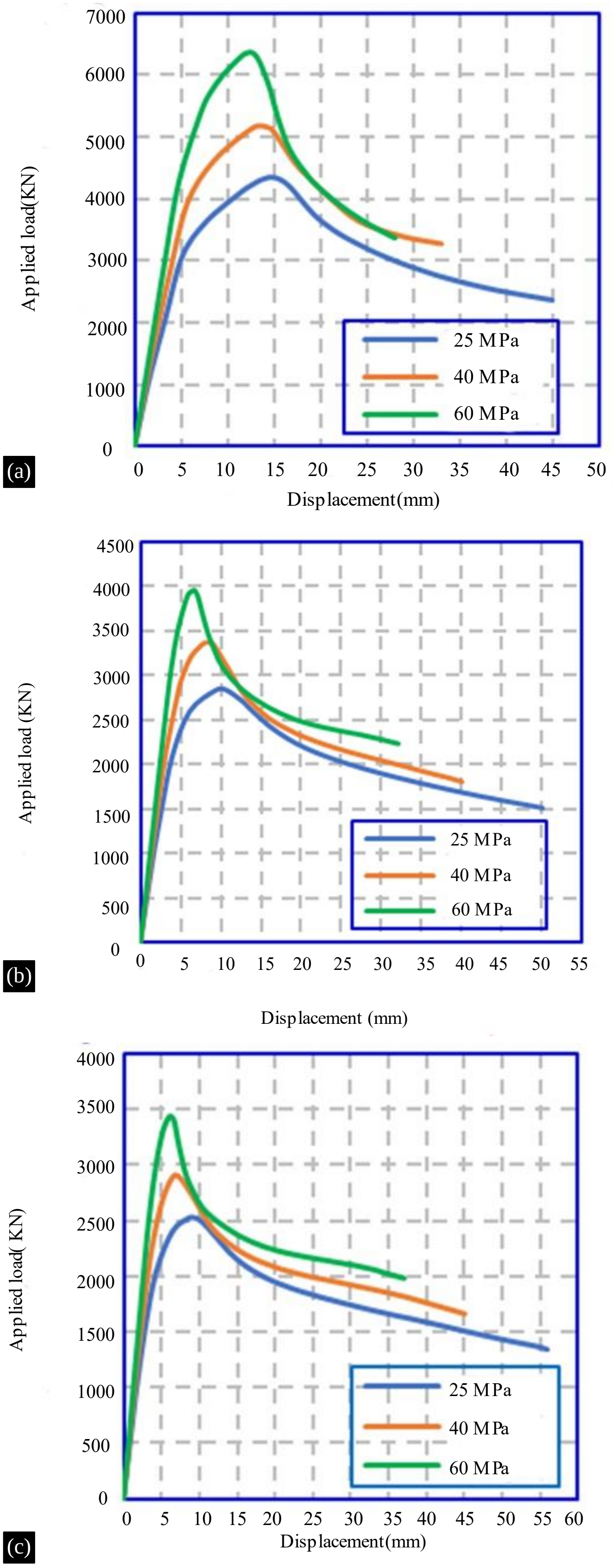
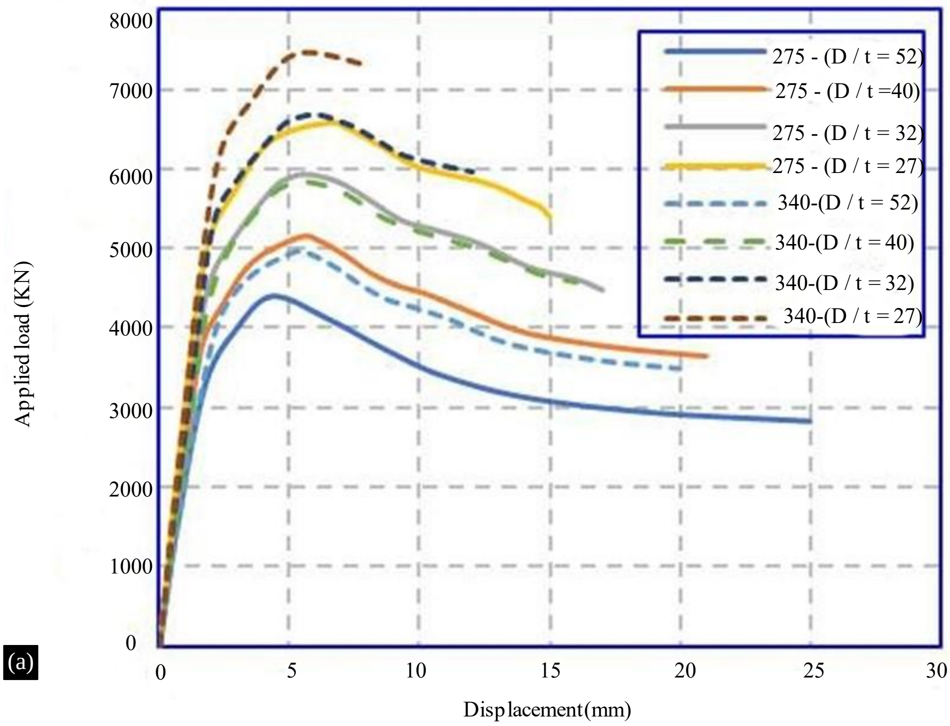


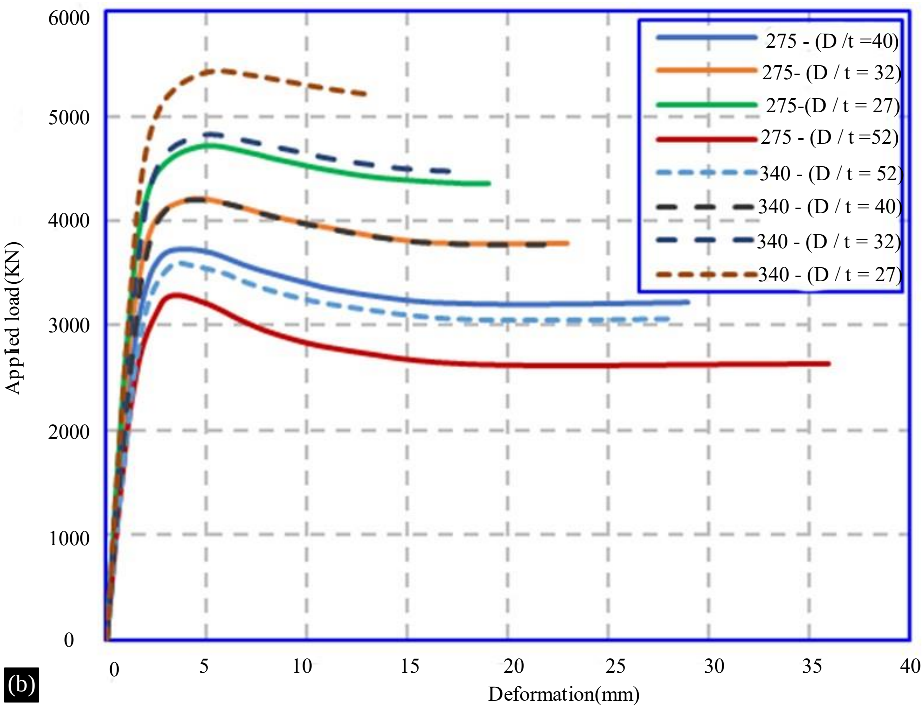
Figure 24. Applied load vs. displacement curves for long column M25,M40 and M60 & 275 MPa (a)axial,(b)uniaxial and (c)biaxial loading.

Journal of Polymer & Composites
Volume 13, Special Issue 2
ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

Effects of Steel Tube Yield Strengths

In this study, circular CFST columns with a diameter of 300 mm and D/t ratios of 52, 40, 32, and 27 were simulated to examine how different steel grades affect their load-carrying capacity under axial, uniaxial, and biaxial loading. Steel tubes had yield strengths of 275 MPa and 340 MPa, with a consistent Young's modulus of 200 GPa, and were filled with concrete compressive strengths of 25, 40, and 60 MPa. Results showed that the ultimate load capacity of CFST columns significantly increased with higher steel yield strength, highlighting the confining effect of the steel tube. Load-displacement curves *Figure's:25&26* illustrate these findings.





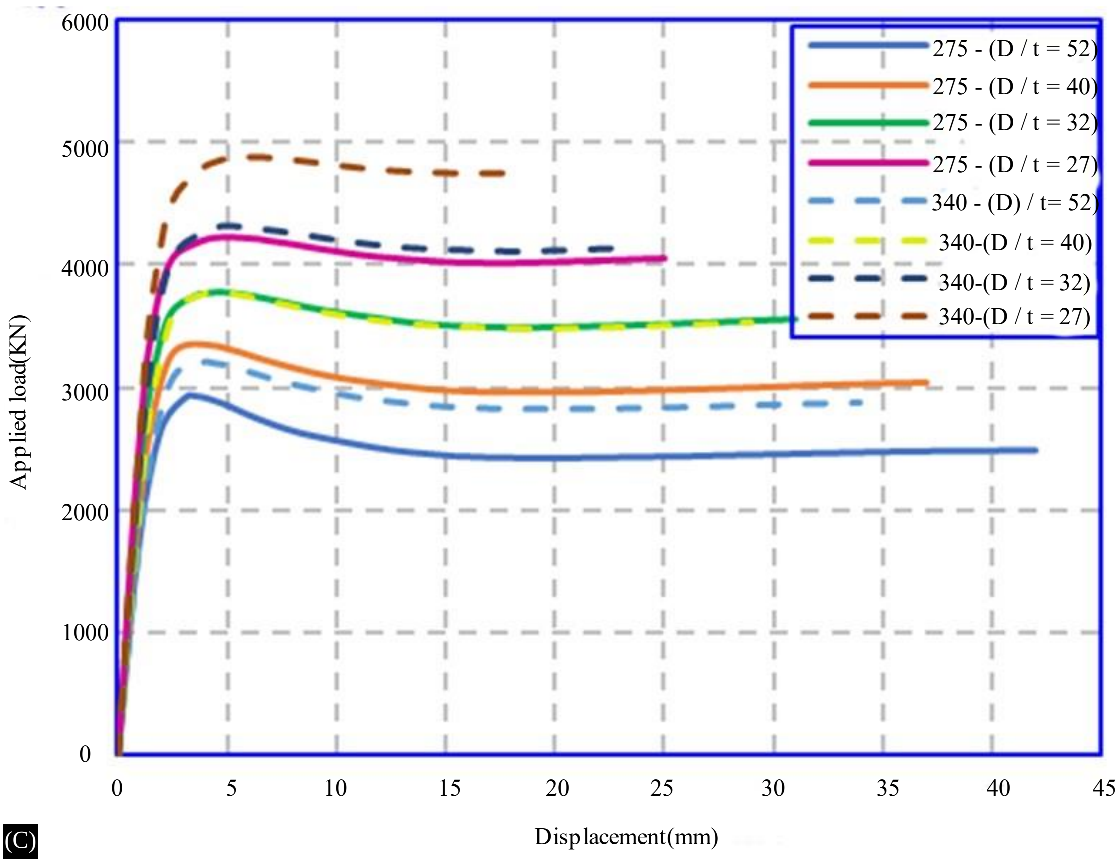
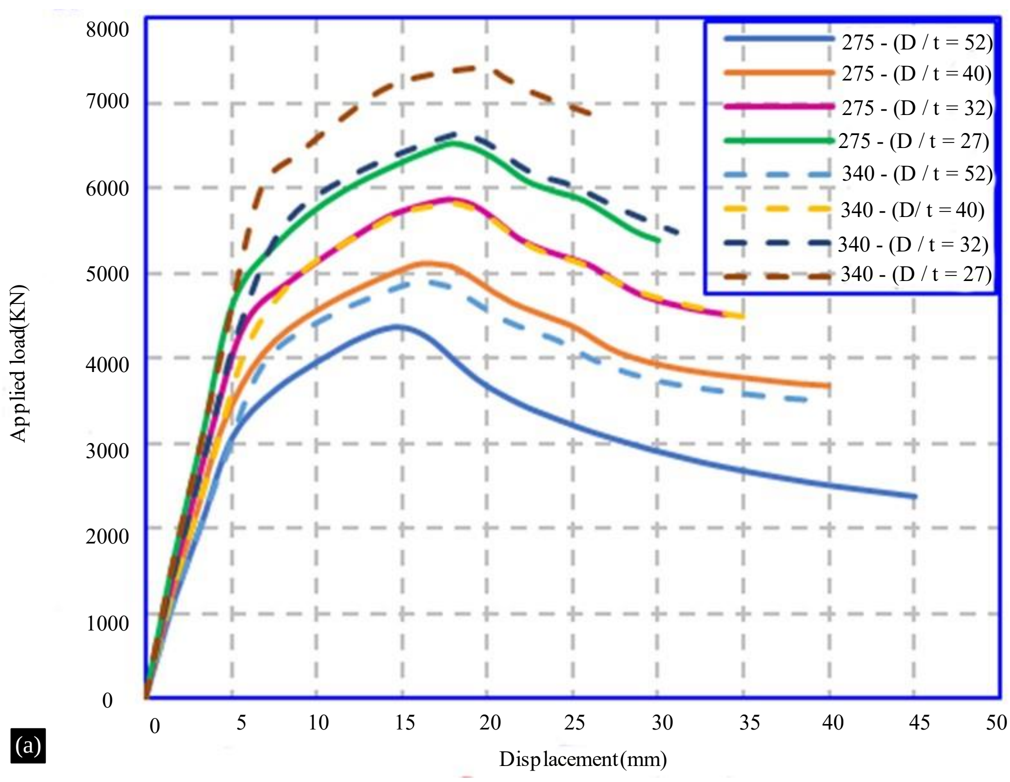
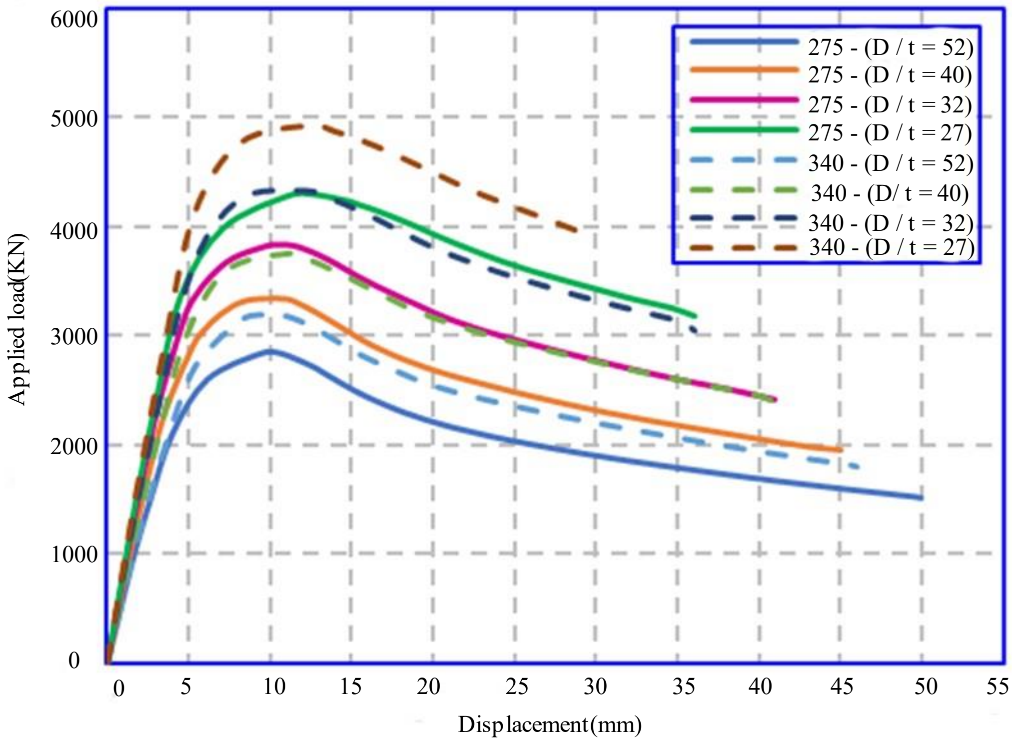
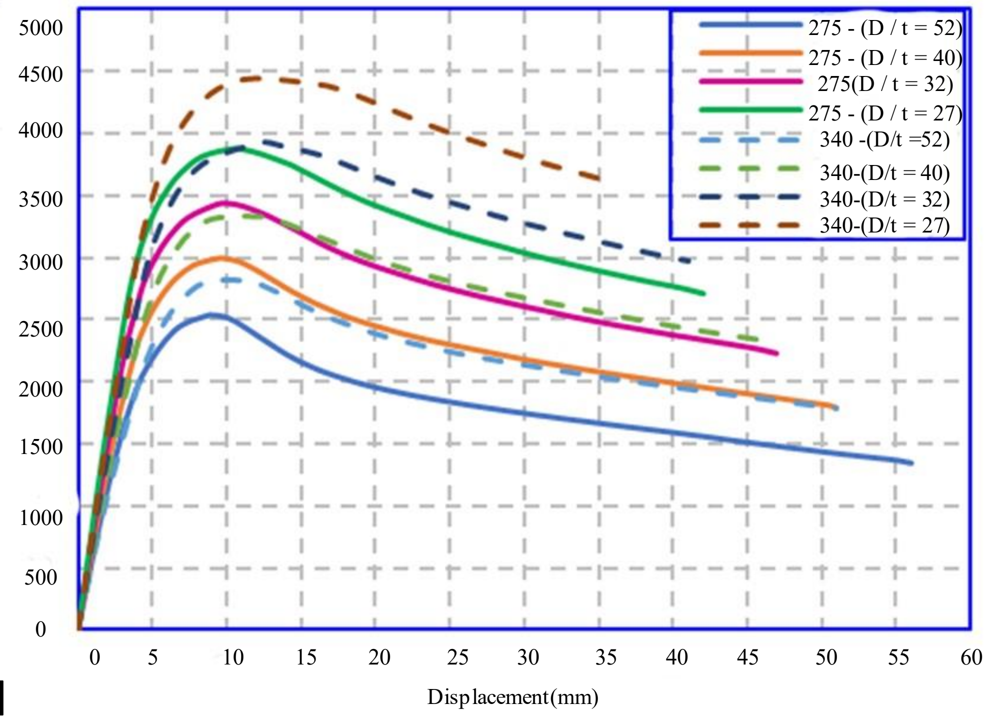


Figure 25. Applied load vs. displacement curves for short column 275 MPa and 340 MPa & M25 (a)axial,(b)uniaxial and (c)biaxial loading.





(b)

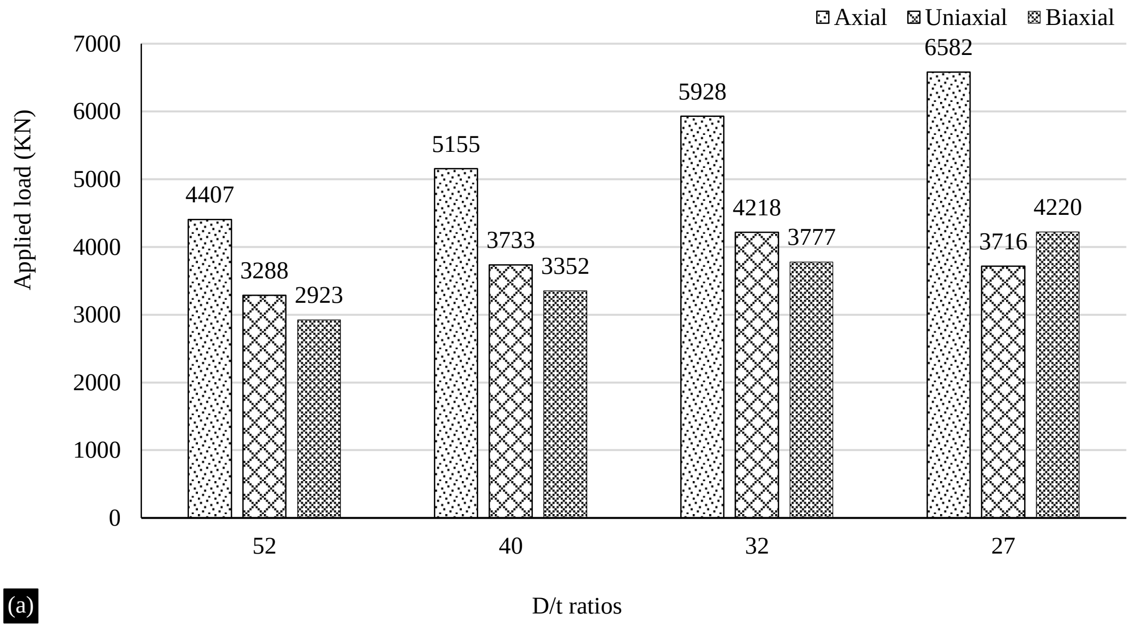


(c)

Figure 26. Applied load vs. displacement curves for long column 275 MPa and 340 MPa & M25 (a)axial,(b)uniaxial and (c)biaxial loading.

Effects of Loading Condition

The structural behavior of the various loading conditions on the load carrying capacity of circular CFST columns under axial, uniaxial and biaxial loading conditions for short and long columns were studied. The inner diameter of the circular CFST column section was set at 300 mm. The typical D/t ratios of 52, 40, 32 and 27 were considered by changing the thicknesses of the steel tube while maintaining the same cross section size. The steel tube yield strengths were 275 MPa and 340 MPa respectively. The Young's modulus of steel tube was taken as 200 GPa. The different grades of concrete were 25 MPa, 40 MPa and 60 MPa. The lengths of column were 1200 mm and 4000 mm. *Figure's.27&28:* shows the comparison of axial uniaxial and biaxial loading conditions. The investigation found that the ultimate load carrying capacity of CFST columns under axial load is high compared to uniaxial loading and the ultimate load carrying capacity of CFST columns under uniaxial load is high compared to biaxial loading for the same D/t ratio. So, we need to use the different D/t ratios for axial, uniaxial and biaxial loadings.



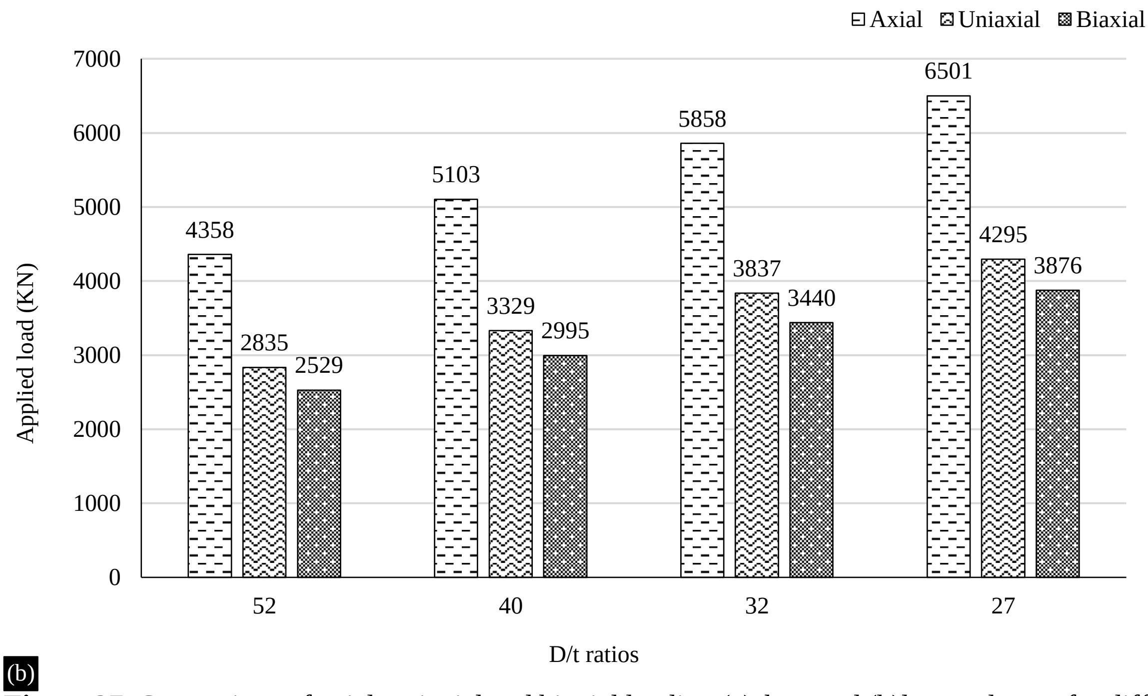
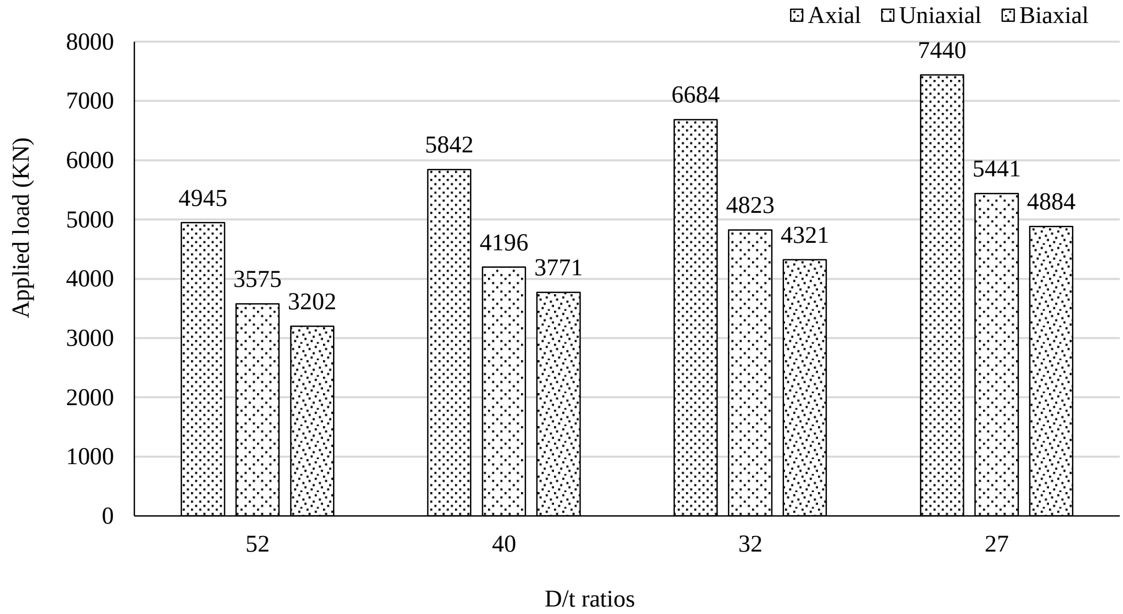
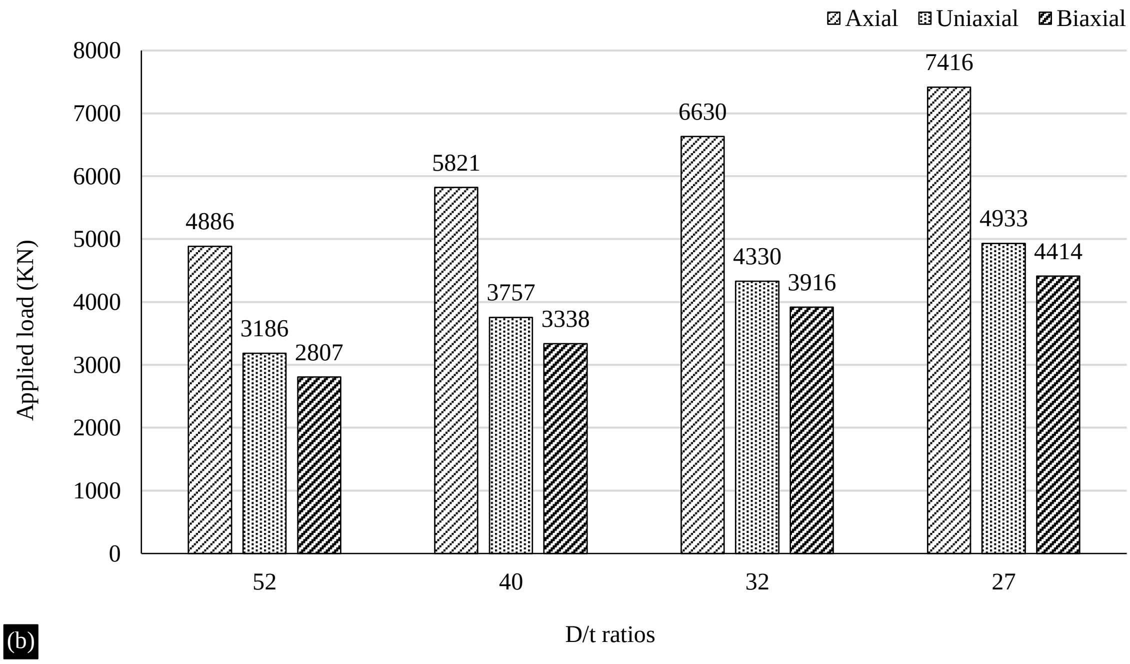


Figure 27. Comparison of axial, uniaxial and biaxial loading (a)short and (b)long columns for different D/t ratios (M25 and 275 MPa).



(a)



(b)

Figure 28. Comparison of axial, uniaxial and biaxial loading (a)short and (b)long columns for different D/t ratios (M25 and 340 MPa).

Effects of Type of Column

For this study circular CFST columns are simulated in order to investigate the effect of type of column on load carrying capacity under the axial, uniaxial and biaxial loading conditions for short and long columns. The lengths of the column were 1200mm for short column and 4000mm for long column. The diameter of the column was set at 300 mm and the D/t ratios were 52,40,32,27. Steel tubes were made of steel with yield strengths of 275 and 340 MPa respectively. Young's modulus was 200GPa for all steel tubes. The steel tubes were filled with three different compressive strength of concretes 25,40 and 60MPa.The short column taking the more load than long column, and it fails by bulging as shown in

*Figures's:*15,16,17 and long column fails by bending as shown in *Figure's:*18,19,20.Figure's:29&30 shows the comparison of short and long columns under different loading conditions, different concrete grades ,different steel grades and different D/t ratios.

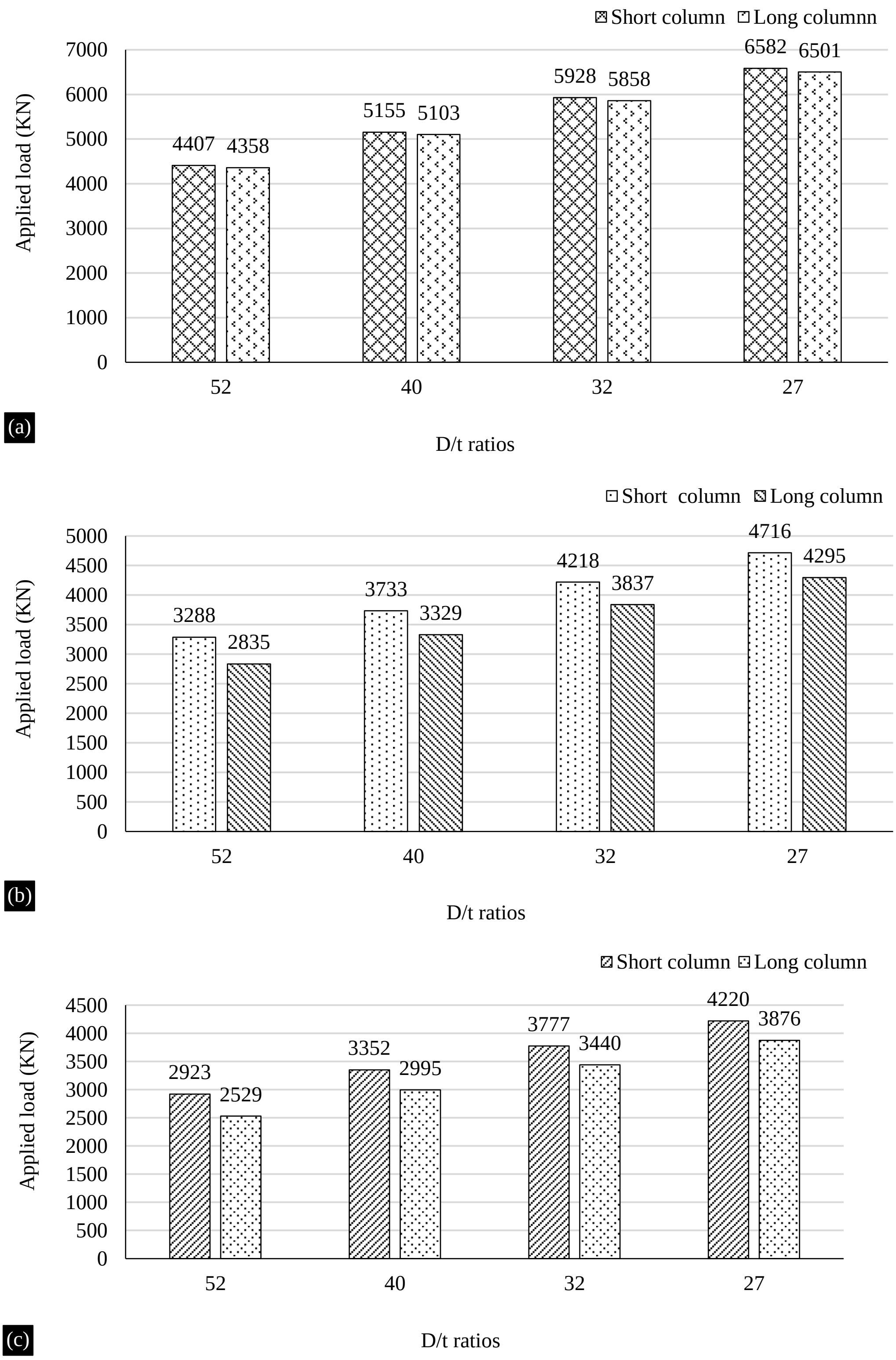


Figure 29. Comparison of short and long columns for different D/t ratios, M25 &275MPa ((a)axial, (b)uniaxial and (c)biaxial loading).

Journal of Polymer & Composites
Volume 13, Special Issue 2
ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

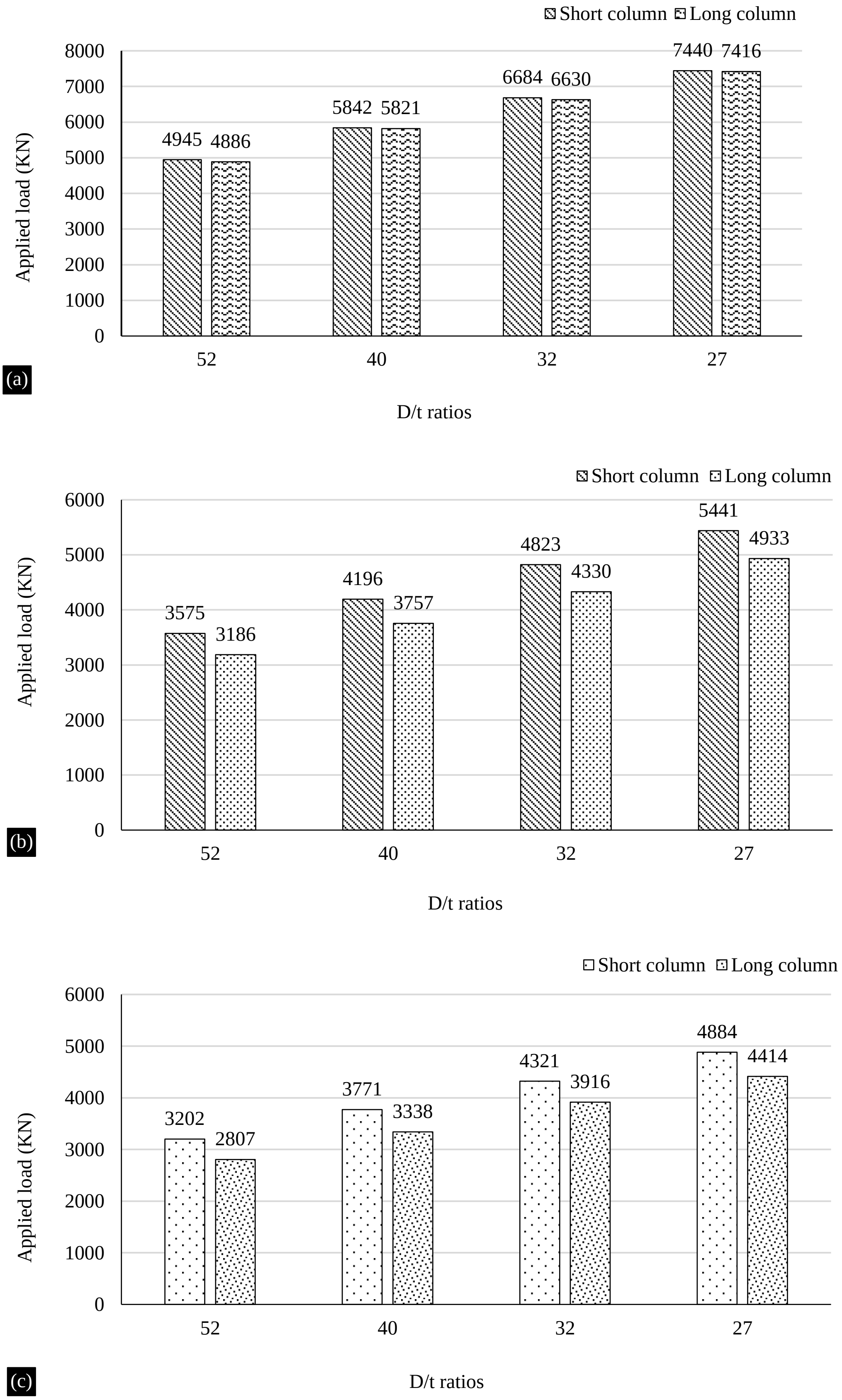


Figure 30. Comparison of short and long columns for different D/t ratios, M25 & 340MPa (a)axial, (b)uniaxial and (c)biaxial loading).

DIFFERENT CODE PROVISIONS FOR DESIGNING OF CFST COLUMNS

Two different international code provisions giving the design of CFST circular columns were used. The following international standards are considered; American standard-AISC-LRFD AISC (2010), and Architectural institute of japan standards AIJ(1997) and presented a full comparison between the results obtained by using finite element program ABAQUS/CAE version 2017 and the different design codes.

International Codes Provisions

The AISC (2010) [19] code developed a formula that can be used to design and calculate the ultimate loads of CFST columns(Pn).The ultimate load (Pn) can be calculated as follows:

$$P_e \geq 0.44\,P_o : P_n = P_o[0.658^{(P_o/P_e)}] \quad (1)$$

Where:

$$P_e \leq 0.44\,P_o : \quad P_n = 0.877\,P_e \quad (2)$$

$$P_e = \pi^2\, EI_{eff}/(KL)^2 \quad (3)$$

$$EI_{eff} = E_s I_s + 0.5 E_s I_{sr} + C1 E_c I_c \quad (4)$$

$$C1 = 0.6 + 2[A_s/(A_c + A_s)] \leq 0.9 \quad (5)$$

$$P_o = A_s F_y + A_{sr} F_{yr} + C1 A_c f'_c \quad (6)$$

In this scenario, the effective stiffness of a CFST member (measured in $N.mm^2$) is denoted as EIeff. Various parameters contribute to this calculation: Is for the moment of nertia of the steel shape, Isr for the moment of inertia of the reinforcing bars, Ic for the moment of inertia of the concrete section, Ec for the modulus of elasticity of concrete, and Es for the modulus of elasticity of steel. For instance, the area Ac of the steel section corresponds to the area of the concrete. Pn signifies the nominal axial compressive strength, Pe represents the elastic critical Euler buckling load, and Po denotes the nominal axial strength excluding length effects. The buckling length factor, K, is determined by the end conditions, while L refers to the column's length, with C1 set at 0.95 for circular section.

In AIJ(1997)[20];the compressive strength of the CFST columns is calculated as shown:
Short column H/D ≤ 4

$$N_C = {}_cN_C + (1+\eta)\,{}_sN_C \quad (7)$$

Morino and Tsuda(2003)[21], provide recommendations for design of concrete steel tubes under compression loading, for the AIJ. The recommendation considers the ultimate compressive strength for long column. Long column H/D > 12

$$N_{AIJ} = A_s.f_y\,[1+0.545(\lambda'_s-0.3)]+0.85A_c.f_c\left(\frac{2}{1+\sqrt{(\lambda'c)^4+1}}\right) \quad (8)$$

This formula applies for $0.3 \leq \lambda'_s < 1.3$ and $\lambda'_c \leq 1.0$ (9) (10)

and $\lambda'_s = \frac{\lambda s}{\pi}\sqrt{\frac{f_y}{E_s}}$, $\lambda'c = \frac{\lambda c}{\pi}\sqrt{0.93(0.85fc)^{(1/4)} * 10^{-3}}$ (11)

In the equation, the variable H/D stands for the effective length of CFST columns, while η is a constant set to zero for rectangular CFST columns and 0.27 for circular CFST columns. NC and NAIJ represent the permitted column strengths, with cNC indicating the allowable strength of the concrete column and sNC representing the allowable strength of the steel tube column. λs and λc are the slenderness ratios of the steel and concrete, respectively. Es stands for Young's modulus of the steel tube, f'c represents the compressive strength of concrete, and Fy denotes the yield strength of the steel tube.

Journal of Polymer & Composites
Volume 13, Special Issue 2
ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

Comparison of the Simulated Results with Different Codes

The varied values of axial, uniaxial and biaxial loads calculated through ABAQUS analytically, as well as those derived from various design codes, are documented in Table:6.

Table.6. Comparison of ABAQUS/CAE-2017 values with AISC and AIJ codes.

Grade of steel (N/m m2)	Grade of concrete(N/mm2)	Tye of column	Loading Condition	D/t ratios	H/D ratio	Load 'P'(KN) ABAQUS	AISCcode 'P'(KN)	Validation (AISC)% ABAQUS/AISC%Difference	Japanese code 'P'(KN)	Validation (AIJ)% ABAQUS/AIJ%Difference
275	25	shot column	Axial	52	3.85	407	3238	36	782	17
				40	3.8	5155	3777	36	4471	15
				32	3.75	5928	4324	37	5168	15
				27	3.7	6582	4877	35	5875	12
			Uniaxial	52	3.85	3288	3238	2	3782	-13
				40	3.8	3733	3777	-1	4471	-16
				32	3.75	218	4324	-2	5168	-18
				27	3.7	716	4877	-3	5875	-20
			Biaxial	52	3.85	2923	3238	-1	3782	-23
				40	3.8	3352	3777	-11	4471	-25
				32	3.75	3777	4324	-13	5168	-27
				27	3.7	4220	4877	-13	5875	-28
		Long column	Axial	52	12.8	4358	2976	46	2941	48
				40	12.65	5103	3486	46	3433	49
				32	12.5	5858	4003	46	3930	49
				27	12.34	6501	4527	44	4433	47
			Uniaxial	52	12.8	2835	2976	-5	2941	-4
				40	12.65	3329	3486	-4	3433	-3
				32	12.5	3837	4003	-4	3930	-2
				27	12.34	4295	4527	-5	4433	-3
			Biaxial	52	12.8	2529	2976	-15	2941	-14
				40	12.65	2995	3486	-14	3433	-13
				32	12.5	3440	4003	-14	3930	-12
					27	12.34	3876	4527	-14	4433 -13

40	short column	Axial	52	3.85	5335	4231	26	4842	10
			40	3.8	5995	4771	26	5531	8
			32	3.75	6702	5318	26	6229	8
			27	3.7	7366	5872	25	6935	6
		Uniaxial	52	3.85	3868	4231	-9	4842	-20
			40	3.8	4283	4771	-10	5531	-23
			32	3.75	4722	5318	-11	6229	-24
			27	3.7	5151	5872	-12	6935	-26
		Biaxial	52	3.85	3492	4231	-17	4842	-28
			40	3.8	3761	4771	-21	5531	-32
			32	3.75	4223	5318	-21	6229	-32
			27	3.7	4638	5872	-21	6935	-33
	Long column	Axial	52	12.8	5169	3832	35	3842	35
			40	12.65	5928	4350	36	4334	37
			32	12.5	6618	4874	36	4831	37
			27	12.34	7338	5403	36	5334	38
		Uniaxial	52	12.8	3362	3832	-12	3842	-12
			40	12.65	3798	4350	-13	4334	-12
			32	12.5	4267	4874	-12	4831	-12
			27	12.34	4675	5403	-13	5334	-12
		Bixial	52	12.8	2906	3832	-24	3842	-24
			40	12.65	3266	4350	-25	4334	-25
			32	12.5	3710	4874	-24	4831	-23
			27	12.34	4116	5403	-24	5334	-23
60	short column	Axial	52	3.85	6462	5551	16	6256	3
			40	3.8	7120	6093	17	6945	3
			32	.75	7738	6641	17	7642	1
			27	3.7	8401	7196	17	8349	1
		Uniaxial	52	3.85	4721	5551	-15	6256	-25
			40	.8	5104	6093	-16	6945	-27
			32	3.75	5476	6641	-18	7642	-28
			27	3.7	5831	196	-19	8349	-30
		Biaxl	52	3.85	4185	5551	-25	6256	-33
			40	3.8	4501	6093	-26	6945	-35
			32	3.75	4878	6641	-27	7642	-36
			27	3.7	5218	7196	-27	8349	-38
	Long column	Axial	52	12.8	6355	4937	29	5042	26
			40	12.65	6974	5470	27	5534	26

			2	12.5	7513	6006	25	6032	25	
			27	12.34	8316	6546	27	6535	27	
		Uniaxial	52	12.8	3945	4937	20	5042	-22	
			40	12.65	4343	5470	-21	5534	-22	
				32	2.5	4750	6006	-21	6032	-21
				27	12.34	5129	6546	-22	6535	-22
			Biaxial	52	2.8	3444	4937	-30	5042	-32
				40	2.65	3804	5470	-30	534	-31
				32	12.5	4157	6006	-31	6032	-31
				27	2.34	4496	654	31	6535	-31
340	25	short column	Axial	52	3.85	4945	3606	37	4258	16
				40	3.8	842	4272	37	5110	14
				32	3.75	6684	4947	35	5972	12
				27	3.7	7440	5630	32	6846	9
			Uniaxial	52	3.85	3575	3606	-1	4258	-16
				40	3.8	4196	4272	-2	5110	-18
				32	3.75	4823	4947	-3	5972	-19
				27	3.7	5441	5630	-3	6846	-21
			Biaxial	52	3.85	3202	3606	-11	4258	-25
				40	3.8	3771	4272	-12	5110	-26
				32	3.75	4321	4947	-13	5972	-28
				27	3.7	4884	5630	-13	6846	-29
		Long column	Axial	52	12.8	4886	3282	49	3297	48
				40	12.65	5821	3901	49	3910	49
				32	12.5	6630	4529	46	4531	46
				27	12.34	7416	5166	44	5158	44
			Uniaxial	52	12.8	3186	3282	-3	3297	-3
				40	12.65	3757	3901	-4	3910	-4

				32	12.5	4330	4529	-4	4531	-4
				27	12.34	4933	5166	-5	5158	-4
			Biaxial	52	12.8	2807	3282	-14	3297	-15
				40	12.65	3338	3901	-14	3910	-15
				32	12.5	3916	4529	-14	4531	-14
				27	12.34	4414	5166	-15	5158	-14
	40	short column	Axial	52	3.85	5790	4598	26	5318	9
				40	3.8	6622	5265	26	6170	7
				32	3.75	7500	5940	26	7033	7
				27	3.7	8067	6623	22	7906	2
			Uniaxial	52	3.85	4168	4598	-9	5318	-22
				40	3.8	4703	5265	-11	6170	-24
				32	3.75	5261	5940	-11	7033	-25
				27	3.7	5882	6623	-11	7906	-26
			Biaxial	52	3.85	3740	4598	-19	5318	-30
				40	3.8	4185	5265	-21	6170	-32
				32	3.75	4698	5940	-21	7033	-33
				27	3.7	5267	6623	-20	7906	-33
		Long column	Axial	52	12.8	5714	4128	38	4198	36
				40	12.6	631	4754	3	4811	38
				32	12.5	7481	5388	39	5431	38
				7	12.34	7918	030	31	6058	31
			Uniaxial	52	12.8	3698	4128	-10	4198	-12
				40	12.65	4274	4754	-10	4811	-11
				32	12.5	4832	5388	-10	5431	-11

Journal of Polymer & Composites
Volume 13, Special Issue 2
ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

				27	12.34	5438	6030	-10	6058	-10
			Biaxial	52	12.8	3267	4128	-21	4198	-22
				40	12.65	3769	4754	-21	4811	-22
				32	12.5	4283	5388	-20	5431	-21
				27	12.34	4789	6030	-21	6058	-21
	60	short column	Axial	52	3.85	6901	5917	17	6732	3
				40	3.8	7724	6585	17	7584	2
				32	3.75	8524	7261	17	8446	1
				27	3.7	9297	7946	17	9320	0
			Uniaxial	52	3.85	4991	5917	-16	6732	-26
					3.8	5462	6585	-17	7584	-28
				32	3.75	5968	7261	-18	8446	-29
				27	3.7	6457	7946	-19	9320	-31
			Biaxial	52	3.85	4408	5917	-25	6732	-35
				40	3.8	4856	6585	-26	7584	-36
				32	3.75	5298	7261	-27	8446	-37
				27	3.7	5775	7946	-27	9320	-38
		Long column	Axial	52	12.8	6807	5222	30	5398	26
				40	12.65	7673	5860	31	6011	28
				32	12.5	8384	6505	29	6632	26
				27	12.34	8831	7156	23	7259	22
			Uniaxial	52	12.8	4299	5222	-18	5398	-20
				40	12.65	4821	5860	-18	6011	-20
				32	12.5	5329	6505	-18	6632	-20
				27	12.34	5812	7156	-19	7259	-20

			Biaxial	52	12.8	3755	5222	-28	5398	-30
				40	12.65	4167	5860	-29	6011	-31
				32	12.5	4668	6505	-28	6632	-30
				27	12.34	5117	7156	-28	7259	-30

Comparisons of different codes provisions

Figure 31: represents the comparisons of the simulation results with the results predicted by the AISC and AIJ Codes.

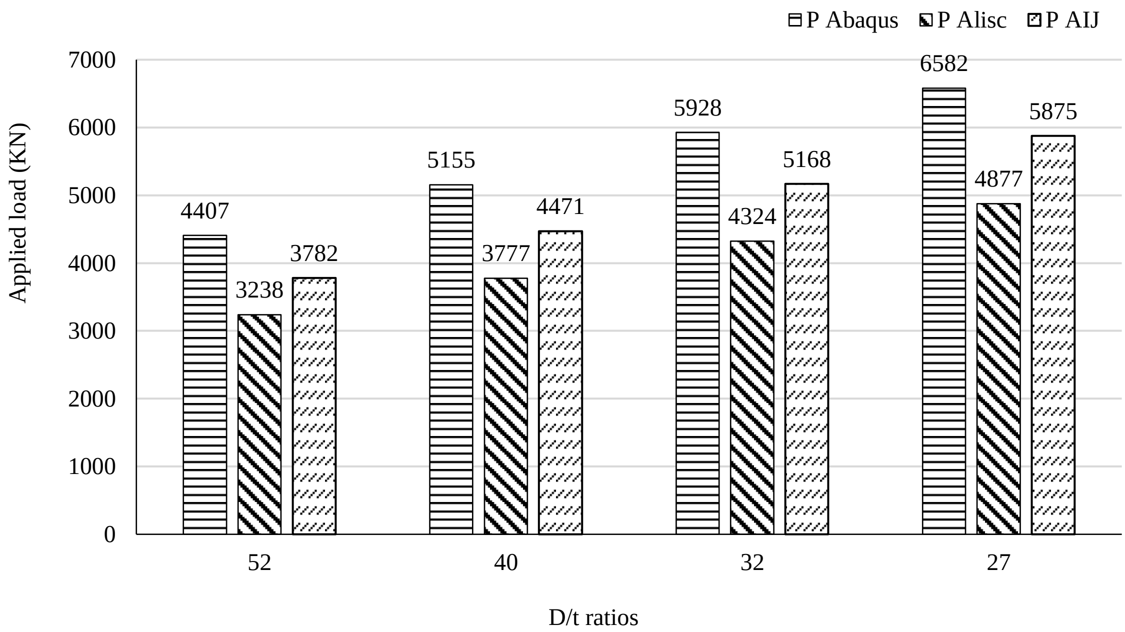


Figure 31. Comparisons of simulation results with results obtained by AISC and AIJ codes

Figure.31: demonstrates that the AIJ (1997) design code yields more accurate predictions than the AISC (2010) design code across a range of parameters, including tube-diameter-to-thickness ratios, column height-to-diameter ratios, different concrete infill material properties, steel tube material properties, and various loading conditions such as axial, uniaxial, and biaxial loading. This comparison is made against the results generated by the ABAQUS/CAE 2017 models of CFST columns. Notably, the load-carrying capacity of CFST columns calculated using the AISC (2010) design code tends to underestimate actual values.

RESULTS AND DISCUSSIONS

Discussion for Results from General Loading

For Short columns the Axial loading validation percentages for AISC range from 35% to 37%, indicating that the ABAQUS results are higher than the AISC code predictions by a significant margin. For the Japanese code, the validation percentages are slightly lower, ranging from 12% to 17%,The Uniaxial loading validation percentages for AISC are quite close, ranging from -3% to 2%, showing a good agreement. However, for the Japanese code, the validation percentages range from -13% to -20%, indicating a moderate difference, The Biaxial loading validation percentages for AISC range from -13%

ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

to -10%, indicating a reasonable agreement. For the Japanese code, the validation percentages are more negative, ranging from -23% to -28%, indicating a higher deviation.

For Long columns the Axial loading validation percentages for AISC are around 46%, showing that the ABAQUS results are significantly higher. For the Japanese code, the validation percentages are slightly higher, around 47% to 49%, The Uniaxial loading validation percentages for AISC are close, ranging from -5% to -4%, indicating a good agreement. For the Japanese code, the validation percentages are even closer, ranging from -4% to -2%, The Biaxial loading validation percentages for AISC are around -14% to -15%, showing a moderate difference. For the Japanese code, the validation percentages are slightly better, ranging from -14% to -12%.

Discussion For Results from Specified Steel Tube and Concrete Grades

For Short columns the ABAQUS load values are consistently higher than both AISC and AIJ code predictions under axial loading conditions, indicating a significant discrepancy between the finite element method (ABAQUS) and the code-based methods. The validation percentages for AISC and AIJ are notably different, with AISC showing higher differences (35%-37%) compared to AIJ (12%-17%).

Under uniaxial loading, ABAQUS values are closer to AISC values with validation differences within ±3%. However, the ABAQUS loads are lower than AIJ values, showing a consistent negative validation difference of 13%-20%. For biaxial loading, the ABAQUS loads are significantly lower than both AISC and AIJ values, with validation percentages showing a larger negative discrepancy (10%-13% for AISC and 23%-28% for AIJ).

For Long columns under axial loading, ABAQUS loads are again higher than both AISC and AIJ values, with validation differences of 44%-46% for AISC and 47%-49% for AIJ. This indicates that ABAQUS predicts higher load capacities for long columns under axial loads. Under uniaxial loading, the ABAQUS loads are close to both AISC and AIJ values, with validation differences within -5% to -2%, showing a good correlation. For biaxial loading, the ABAQUS loads are consistently lower than both AISC and AIJ values, with validation percentages showing a significant negative difference (-14% to -15% for AISC and -12% to -14% for AIJ).

CONCLUSIONS

This paper thoroughly examines the performance of concrete-filled steel tubes, focusing on key factors such as H/D and D/t ratios, the material properties of concrete and steel tubes, and different loading scenarios. It discusses the validation process using multiple code provisions The analytical investigation involved 144 specimens, yielding the following significant findings:

1. The axially loaded column taking the higher ultimate load than uniaxial and biaxially loaded columns and axially loaded column did not produce any moments.
2. The analytical models in ABAQUS closely represent the behavior and failure patterns of concrete- filled steel tube columns. These failures may include yielding failure in short columns or global buckling in large columns.
3. Infilled concrete increases column stiffness, which increases compressive strength and lowers vertical deformation while gradually improving load capacity.
4. Increased steel tube yield strength had minimal impact on CFST columns, resulting in minor variations in failure load and vertical deformation.
5. Increasing the thickness of steel tubes in CFST columns while retaining a constant column diameter reduces the D/t ratio and increases the failure load.
6. The AIJ (1997) design code accurately predicts the load capacity of CFST columns compared to other codes and standards compared to ABAQUS results. Parameters including D/t ratios, column height-to-diameter, and concrete and steel tube material qualities and various loading condition (axial, uniaxial and biaxial loading conditions)

REFERENCES

1. Dey, P., Gupta, R. K., & Laskar, A. I. (2019). Numerical and experimental investigations of different cross-sectional configuration of plain concrete and CFST short columns under axial compression. International Journal of Civil Engineering, 17, 1585-1601.
2. P.K. Gupta, S.M. Sarda and M.S. Kumar (2007), “Experimental and Computational Study of Concrete Filled Steel Tubular Columns Under Axial Loads”, J. of Const. Steel Research, 182–193
3. N.K. Brown, M.J. Kowalsky and J. M. Nau (2015), “Impact of D/t on seismic behavior of reinforced concrete filled steel tubes”, Journal of Constructional Steel Research 107, 111–123.
4. Ye, J.; Jiang, L. Simplified Analytical Model and Shaking Table Test Validation for Seismic Analysis of Mid-Rise Cold-Formed Steel Composite Shear Wall Building. Sustainability 2018, 10, 3188.
5. Kim, H.-J.; Hu, J.-W.; Hwang, W.-S. Cyclic Testing for Structural Detail Improvement of CFT Column-Foundation Connections. Sustainability 2015, 7, 5260–5281.
6. Lv, J.; Zhou, T.; Li, K. Investigation and Application of a New Low-Carbon Material (Preplaced Aggregate Concrete) in Concrete Filled Steel Tube Stub Columns. Sustainability 2020, 12, 1768.
7. Cao, B.; Zhu, L.; Jiang, X.; Wang, C. An Investigation of Compression Bearing Capacity of Concrete-Filled Rectangular Stainless Steel Tubular Columns under Axial Load and Eccentric Axial Load. Sustainability 2022, 14, 8946.
8. Huang, C.S.; Yeh, Y.-K.; Liu, G.-Y.; Hu, H.-T.; Tsai, K.C.; Weng, Y.T.; Wang, S.H.;Wu, M.-H. Axial Load Behavior of Stiffened Concrete-Filled Steel Columns. J. Struct. Eng. 2002, 128, 1222–1230.
9. Hu, H.-T.; Huang, C.-S.; Wu, M.-H.; Wu, Y.-M. Nonlinear Analysis of Axially Loaded Concrete-Filled Tube Columns with Confinement Effect. J. Struct. Eng. 2003, 129, 1322–1329.
10. Lai, M.; Ho, J. Confinement effect of ring-confined concrete-filled-steel-tube columns under uni-axial load. Eng. Struct. 2014, 67, 123–141.
11. Zhong Shan-tong, Zhang Sumei (1998) Application and development of concrete- filled steel tubes (CFST) in high rise buildings. Adv Struct Eng 2(2):149–159
12. Kharoob OF, Taman MH (2017) Behavior of fibre reinforced cementitious material- filled steel tubular columns. Steel Compos Struct 23(4):465–472
13. Schnabl S, Jelenić G, Planinc I (2015) Analytical buckling of slender circular concrete-filled steel tubular columns with compliant interfaces. J Constr Steel Res 115:252–262
14. Campione G, La Mendola L, Sanpaolesi L, Scibilia N, Zingone G (2002) Behavior of fiber reinforced concrete-filled tubular columns in compression. Mater struct 35:332– 337.
15. Schneider, S.P. Axially Loaded Concrete-Filled Steel Tubes. J. Struct. Eng. 1998, 124, 1125–1138.
16. Susantha K.; Ge, H.; Usami, T. Uniaxial stress–strain relationship of concrete confined by various shaped steel tubes. Eng. Struct. 2001, 23, 1331–1347.
17. Fattouh M. F. Shaker , Mohammed S. Daif , Ahmed Farouk Deifalla , and Nehal M. Ayash .Parametric study on the Behavior of Steel Tube Columns with Infilled Concrete-An Analytical Study.2022,14,14024.
18. M H Esfahani ; R Vaghei ; Farzad H ; Keyhan K.Simplified Damage Plasticity Model for Concrete.2017.
19. AISC360-10; Specification for Structural Steel Buildings. American Institute of Steel Construction, 2010.
20. AIJ, B. Recommendations for Design and Construction of Concrete Filled Steel Tubular Structures; Architectural Institute of Japan (AIJ): Tokyo, Japan, 1997.
21. Shosuke Morino.; Keigo Tsuda. Design and Construction of Concrete-Filled steel Tube Column System in Japan. 2003,pp.51-73.

