SIMULATION OF CFST FINITE ELEMENT MODELS TO STUDY ITS BEHAVIOUR

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ABSTRACT – *In recent times, engineers have increasingly utilized composite members of concrete-filled steel tubes (CFST) in modern projects such as buildings and bridges. Concrete-filled steel tubes (CFST) offers wide benefits of steel and concrete. Numerous size effect laws of concrete materials have been proposed by scholars, while the size effect laws for CFST members are still under study. The behavior of CFST columns subjected to axial compression will be study using ANSYS software. Also, Scale Effect on the compression strength of circular CFST column will be observe. In the present study, it may be focus on mechanical properties of CFST column & compares it with the model test results conducted in R & D department of civil engineering, Ghousia College of Engineering. The software results are well agreed with experimental results.*

Key Words: Concrete Filled Steel Tubes (CFST), Scale effect, ANSYS Software, Deformation, Stress and Strain.

1.INTRODUCTION

Cities have grown at an extremely rapid rate in recent generations, lack of available of land for domestic applications, resulting in an increase in high-rise, large-span, and large-scale building structures. To reduce the cross-sectional area of the column, various techniques are proposed and used, one of which is Concrete filled steel tubular (CFST) members. This building structure requires large column sizes (due to large axial loads) in the lower floors of the structure, which leads to under actualization of space. Due to the combined qualities of steel and concrete materials, concrete filled steel tubular (CFST) members are well known for their high performance. As a result, concrete-filled steel tubes are becoming more common in high-rise buildings and large-span structures. The behavior and strength capability of CFST on steel profile bonding and local buckling, concrete confinement, and material strength are also investigated.

2.CONCRETE FILLED STEEL TUBE

Concrete filled steel tubes (CFST) columns are widely used in the construction of high-rise buildings, bridges, subway platforms, and barriers. Use of CFST columns as composite columns is widely spread around the world. The basic concept of CFST column is that when the tube made of steel is provided as a casing outside the concrete filling, its properties are modified by the combined effect steel as well as concrete. They possess both static plus the earthquake resistant properties.

2.1 Advantages of CFST columns system

The occurrence of the local buckling of the steel tube is delayed, and the strength deterioration after the local buckling, is moderated, both due to the restraining effect of concrete.
Construction site remains clean.
Concrete improves the fire resistance performance, and the amount of fireproof material can be reduced or its use can be omitted.
Steel of the CFST section is well plasticized under buckling since it is located on the outside the section.
Because of the material listed above, a better cost performance is obtained by replacing a steel structure by CFST structure.
Steel tube of CFST column are generally less than 40mm thick, it is easily available, cheap and can be conveniently fabricated and assembled.
The cost of transportation and assembly of column can be reduced because they built by hoisting the empty steel tube first, then pour concrete on it.
It is about 55% lighter than that of RC. Hence, the foundation cost can be reduced. The force resulting from earthquake is smaller.
CFST columns used concrete 62% less and steel 5% - 10% less than that of RC column.

2.2 Advantages of CFST column applied in residential buildings

1. The span of frame beam reaches 7-8m even more. Hence, steel beam should be used, but it should take welding I-beam for save steel and construction cost. The SRC beams can be adopted also.

2. The seismic, corrosion and fire resistant behavior of CFST column are better than that of steel column.

3. The dimension of CFST column is nearly with the outline dimension of steel column. Hence, the space occupied by CFST column does not more than that of steel column. As everyone knows, the volume of core concrete of CFST

column is about 10% of total volume of column. And the density of concrete is one third of the density of steel. Then, the weight of CFST column does not more than that of steel column.

2.3 ADVANTAGES OF CFST COLUMN IF IT USE FOR BRIDGES

1. The load carrying capacity of compression is high and the seismic behavior is very good.

2. The empty steel tube forms arch rib at first, whose weight is light. Hence, the bridges can leap over a very large span.

3. The problem of concrete cracking does not exist

3. SCALE EFFECT

There will be some disparity between the results acquired from model tests and those reported by the prototype after its creation if perfect similitude does not exist between a model and its prototype. The scale effect refers to this disparity or dispersing influence.

4. TEMPERATURE LOAD

These loads result from temperature changes in the entire model, individual components of an assembly or an individual region of model. Structural temperature loads can be uniform over the entire entity, function of coordinates, or based on an externally specified temperature field.

5. OBJECTIVES

1. To study the behavior of CFST column with different l/d ratio.

2. To understand behavior of CFST of various size and geometry under temperature load.

3. To study SCALE EFFECT between lab test samples (models) and prototype models using ANSYS package.

6. METHODOLOGY

Static Structural Analysis:

1. Creating the geometric CFDST model of required dimensions using Design Modeller.

2. Defining the materials such as the structural steel and concrete with desired properties in engineering data.

3. Assigning the materials.

4. Meshing the model with desired mesh size.

5. Defining and assigning the support or boundary conditions (Fixed at bottom and free at top).

6. Defining and assigning the pressure of desired magnitude.

7. Solve for the static structural analysis.

8. Obtain the total deformation, maximum shear elastic strain and maximum shear stress as results.

9. Tabulate the results.

7. MODELLING

The model description and the properties of material are shown in the table 4.1 and table 4.2 respectively.

Table -7.1: Details of model

Type of Geometry	Solid circular section
Type of Structural Element	Column
Concrete grade	M25
Mesh size	20mm
Analysis type	Static Structural

Table -7.2: Material properties details

Type of material	Concrete	Steel
Yield strength	-	393 Mpa
Tensile strength	-	438 Mpa
Young's modulus	25 GPA	210 Gpa
Poisson's ratio	0.15	0.3
Compressive strength	28.5Mpa	-

Details of models for Parametric Study

Table 7.3 Normal model details

DIAMETER (mm)	L/D RATIO	LENGTH (mm)	TEMPERATURE (Degree)
50	8	400	30^{0}
			200^{0}
			400^{0}
			600^{0}
60	10	600	30^{0}
			200^{0}
			400^{0}
			600^{0}
75	12	900	30^{0}
			200^{0}
			400^{0}
			600^{0}

Table 7.4 Proto type model details

DIAMETER (mm)	L/D RATIO	LENGTH (mm)	TEMPERATURE (Degree)
300	8	2400	30^0
			200^0
			400^0
			600^0
400	10	4000	30^0
			200^0
			400^0
			600^0
500	12	6000	30^0
			200^0
			400^0
			600^0

8. MODELING PROCEDURE AND ANALYSIS IN ANSYS

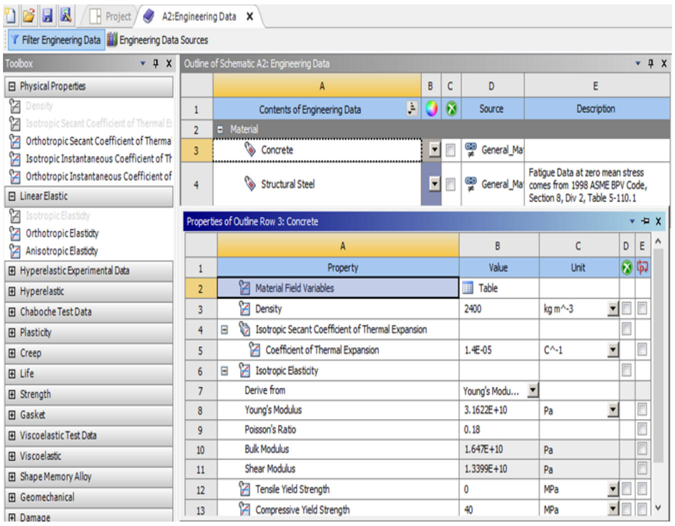

Fig -1: Ansys engineering data sources

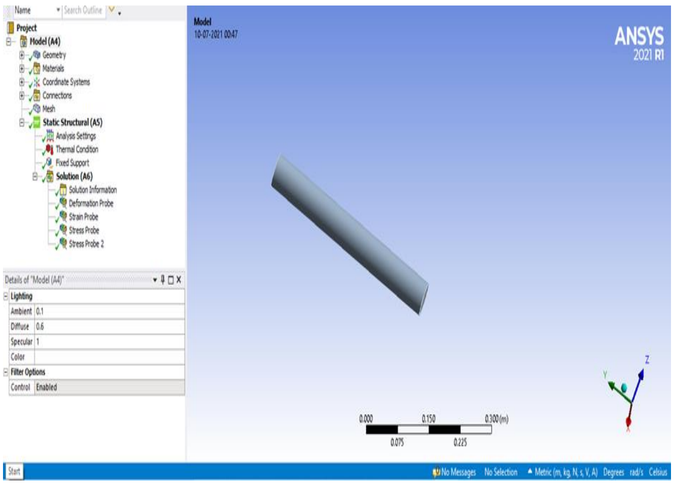

Fig -2: Ansys circular model

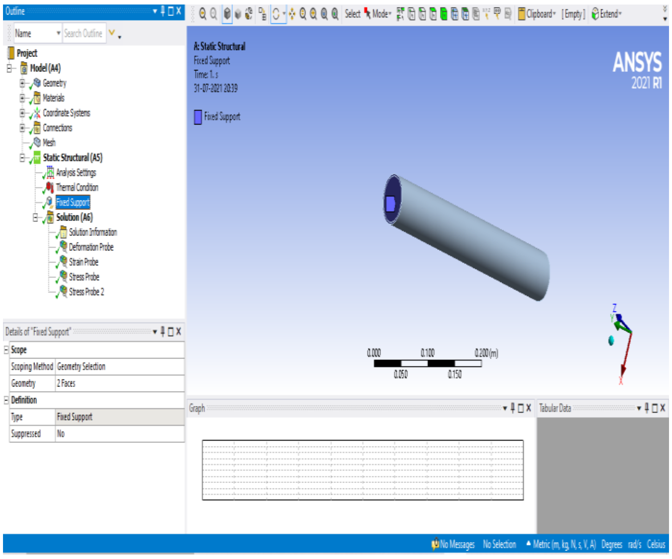

Fig -3: Applying fixed ends.

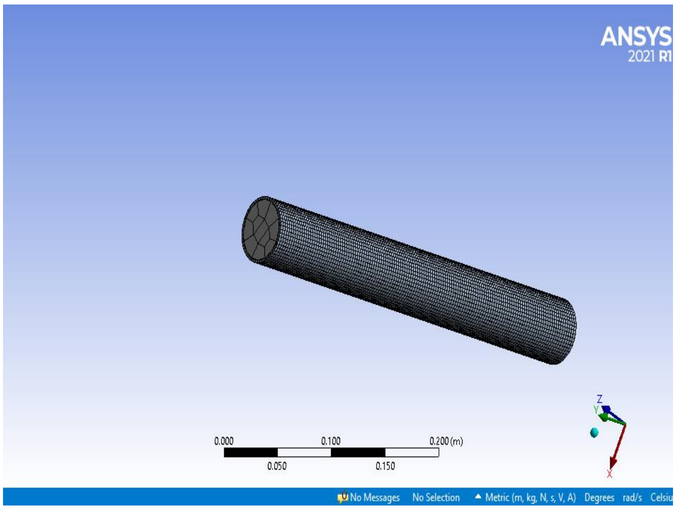

Fig -4: Set the Hyper mesh interface for Ansys User profile.

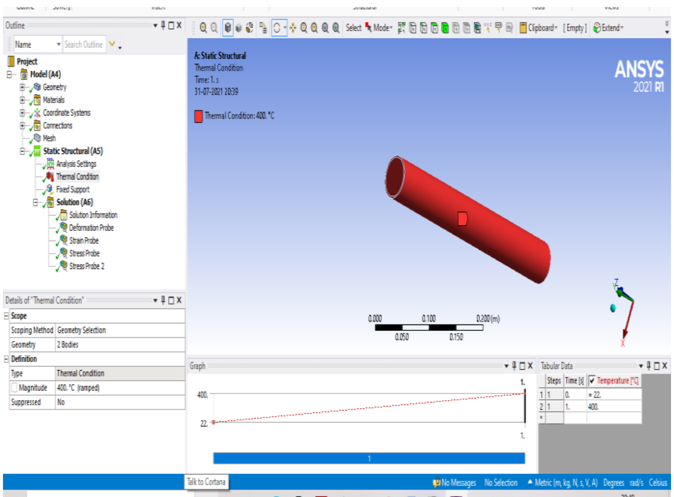

Fig -5: Applying temperature

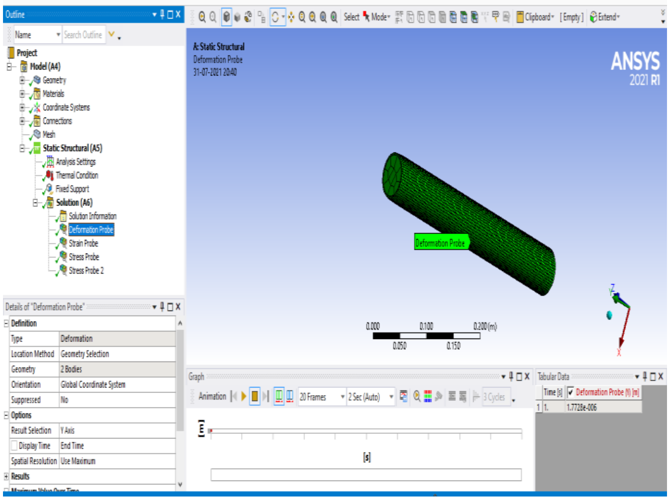

Fig -6: Deformation probe

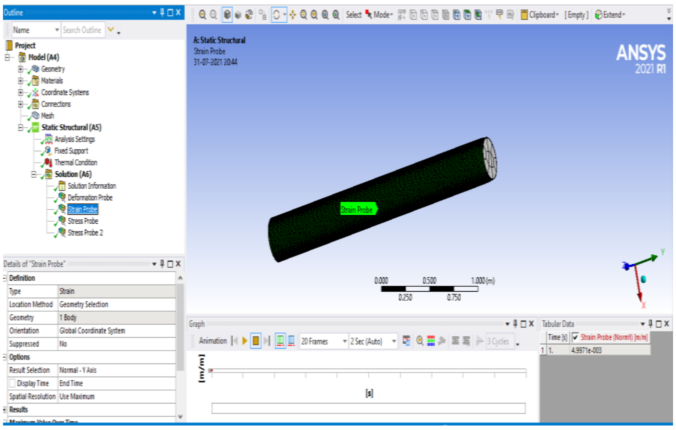

Fig -7: Strain Probe

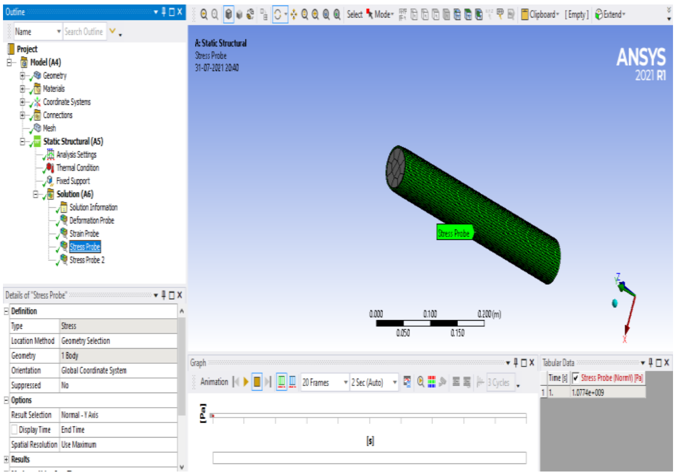

Fig -8: Stress Probe

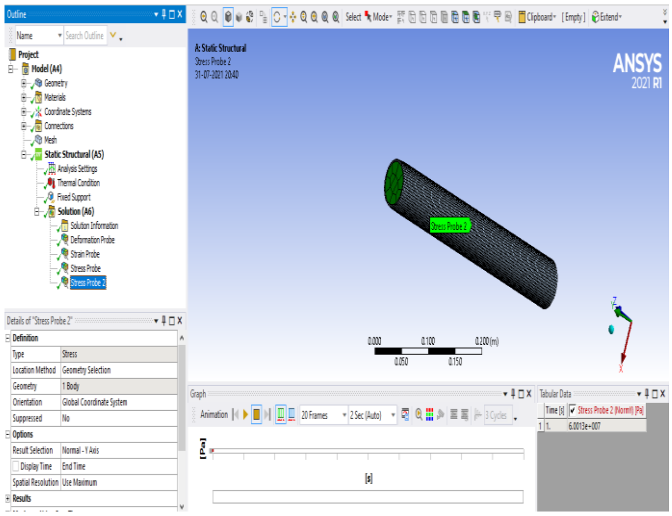

Fig -9: Stress probe 2

9. RESULTS AND DISCUSSION

9.1 Deformation

The maximum values of deformation are tabulated by comparing normal and proto type of model. The values of deformation of different models are obtained by subjecting the models to temperature loads.

1.Comparison of Diameter of outer CFST steel tube 50mm and 300mm, L/D ratio 8 with length of tube 400mm and 2400mm at 30^0, 200, 400, 600 temperature results

Table 9.1.1.: Max Deformation of CFST

SL NO	TEMPRATURE	MAX DEFORMATION FOR NORMAL MODEL (m)	MAX DEFORMATION FOR PROTO TYPE MODEL (m)
1	30^0	$3.75X10^{-8}$	$1.41X10^{-7}$
2	200^0	$8.34X10^{-7}$	$3.15X10^{-6}$
3	400^0	$1.77X10^{-6}$	$6.60X10^{-6}$
4	600^0	$2.71X10^{-6}$	$1.02X10^{-5}$

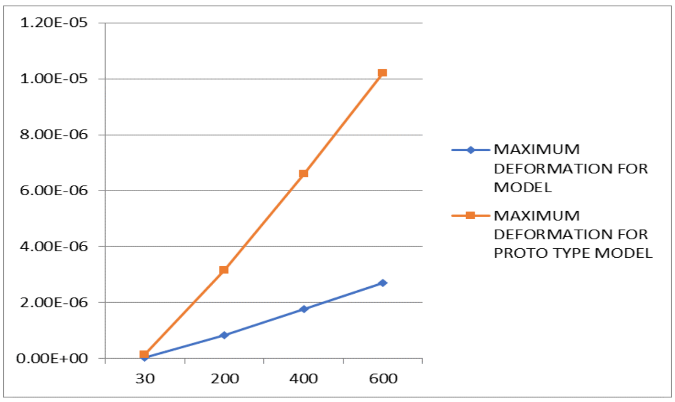

Chart -9.1.1: Graph of deformation variation

Table 9.1.2: Max Strain of CFST

SL NO	TEMPRATURE	MAX STRAIN FOR NORMAL MODEL	MAX STRAIN FOR PROTO TYPE MODEL
1	30^0	$1.47X10^{-4}$	$1.05X10^{-4}$
2	200^0	$3.27X10^{-3}$	$2.35X10^{-3}$
3	400^0	$6.95X10^{-3}$	$4.99X10^{-3}$
4	600^0	$1.06X10^{-2}$	$7.64X10^{-3}$

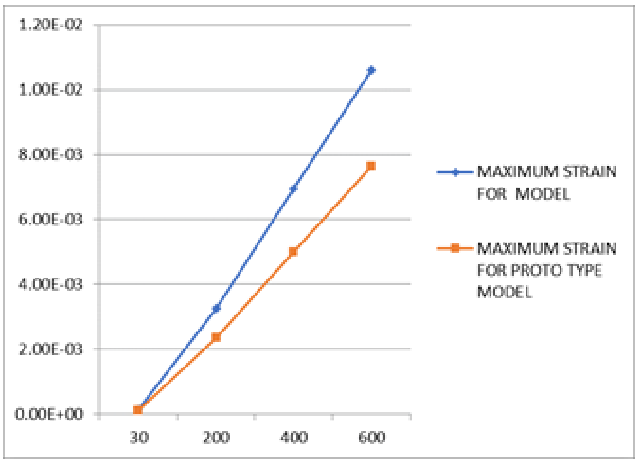

Chart -9.1.2: Graph of strain variation

Table 9.1.3: Max stress of outer steel tube

SL NO	TEMPRATURE	MAX STEEL SRESS FOR MODEL (N/mm²)	MAX STEEL SRESS FOR PROTO TYPE (N/mm²)
1	30^0	22.80	18.76
2	200^0	507.33	417.54
3	400^0	1077.4	886.69
4	600^0	1647.40	1355.8

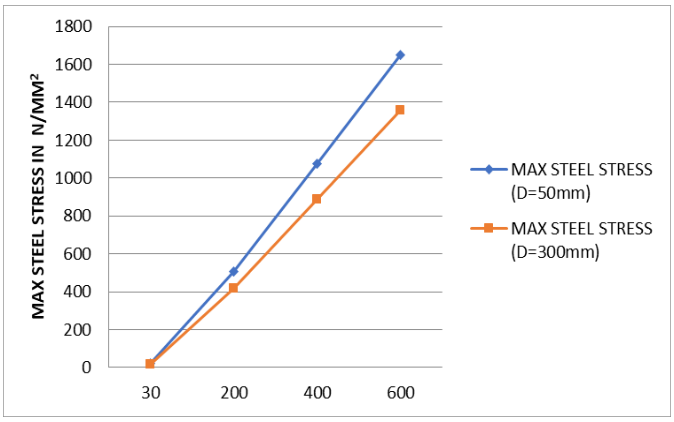

Chart -9.1.3: Graph of stress variation

Table 9.1.4: Max stress of inner concrete tube

SL NO	TEMPRATURE	MAX CONCRETE SRESS FOR NORMAL MODEL (N/mm²	MAX CONCRETE SRESS FOR PROTO TYPE MODEL (N/mm²)
1	30^0	1.27	1.73
2	200^0	28.26	38.5
3	400^0	60.01	81.77
4	600^0	91.76	125.03

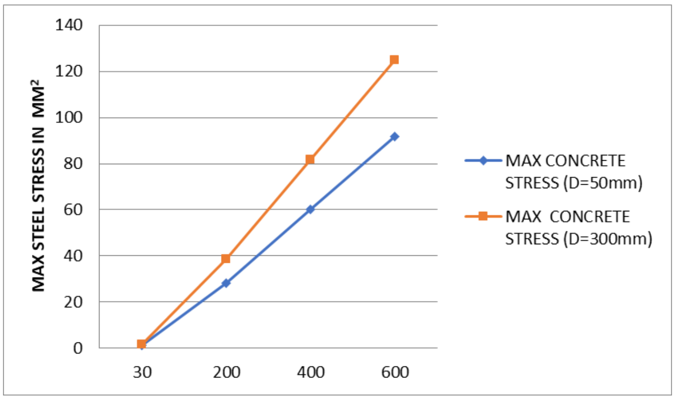

Chart -9.1.4: Graph of stress variation

Similarly, comparison of diameter of outer CFST steel tube 60mm and 400mm, l/d ratio 10 with length of tube 600mm and 4000mm at 30⁰, 200°, 400°, 600 temperatures and comparison of diameter of outer CFST steel tube 75mm and 500mm. l/d ratio 12 with length of tube 900 and 6000mm at 30°,200°,400° temperatures are studied.

9.2 Discussion of result

In this study a different diameter and different L/D ratio CFST round columns were analysed for analysed for different temperature 30^0, 200^0, 400^0, 600^0.

1. Comparison of normal model (50mm dia and 400mm length) with proto type model (300mm dia and 2400mm length)

a. Deformation

From the results of deformation, it is noted that deformation of normal model decreased by 73.40%, 73.52%, 73.1%, 73.43% for 30^0, 200^0, 400^0, 600^0 temperature compared to proto type model

b. Strain

Strain in normal CFST increased by 40%, 39.14%, 39.27%and 38.74% for 30^0, 200^0, 400^0, 600^0 temperature compared to proto type model.

c. Stress for outer steel tube

Maximum stress in normal model outer steel tube is increased by 21.53%, 21.50%, 21.50 and 21.50% for 30^0, 200^0, 400^0, 600^0 temperatures compared to proto type model.

d. Stress for inner concrete tube

Maximum stress in inner concrete tube is decreased by 26.66% for all temperature.

Similarly, the results of comparison of normal model (60mm dia and 400mm length) with proto type model (600mm dia and 4000mm length), normal model (75mm dia and 500mm length) with proto type model (900mm dia and 6000mm length) are calculated.

10. CONCLUSIONS

1. Total maximum deformation of CFST is decreases for normal model compared to proto type model.

2. Total maximum strain for CFST in increases for normal model compared to proto type model.

3. Maximum stress for outer steel tube in CFST increases for normal model compared to proto type model.

4. Maximum stress for inner concrete tube in CFST decreases for normal model compared to proto type model.

11. REFERENCES

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BIOGRAPHIES

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He has successfully guided 30 students at UG and PG level. He has published 10 papers at the National and International level. His areas of interest are composite columns.

Dr. N S Kumar, Graduated in the year 1985 from Mysore University, M.E. in Structural Engineering., in the year 1988 from Bangalore University and earned his PhD from Bangalore University during the year 2006 under the guidance of Dr. N Munirudrappa, the then Chairman and Prof. UVCE, Faculty of Civil Engineering, , Bangalore University. Presently, working as Prof. & HoD, Department of Civil Engineering, Ghousia College of Engineering, Ramanagaram and completed 31 years of teaching. He is involved in the Research field related to the behaviour of Composite Steel Columns and Nano Materials for a decade. To his credit, over 150 publications, and travelled abroad for his research presentations including world conferences too. Also, more than 3PhD's completed and ongoing 5 are working under his guidance. Also, authored more than 8books to his credit.