ANALYSIS AND DESIGN OF GUYED TOWER USING ANSYS

A

PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision

of

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HIMACHAL PRADESH, INDIA

May-2019

STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitled **"ANALYSIS AND DESIGN OF GUYED TOWER USING ANSYS"** submitted for partial fulfillment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Mr. Kaushal Kumar**. This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **“DESIGN AND ANALYSIS OF GUYED TOWERS”** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, **Jaypee University of Information Technology,Waknaghat** is an authentic record of work carried out by **Himanshu Singh (151658)** and **Sarthak Gupta (151618)** during a period from July 2018 to May 2019 under the supervision of **Mr. Kaushal Kumar** Department of Civil Engineering, Jaypee University of Information Technology,Waknaghat.

The above statement made is correct to the best of our knowledge.

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ABSTRACT

A Guyed tower structure is a tall and thin vertical formation that depends on guy wires for its stability. The mast of the tower itself has its compressive strength to support own weight, but it does not has the shear strength to stand upright, and because of which it requires guy wires to resist the lateral forces such as wind, earthquake loads etc., to keep it upright. Guyed towers are frequently used to mount radio antennas, telecommunication satellite and in case of emergency situations as well.

Currently, the simple design methods are available for greater heights in the respective design codes. Hence, the objective of the this study is to thoroughly compare and design towers using different codal provisions and under various combination of design load using ANSYS software. Our approach will be to use different steel sections for the upper and lower parts of the Guyed tower which will serve two purposes. Firstly, Making the structure lighter so that it can withstand the forces and does not collapse under its own weight and secondly, making it cost effective.

The main advantage of guyed tower is its height which helps to cover a much larger area for communication purposes as compared to the large number of towers working in that particular area. Also if a single guyed tower is used it will automatically reduce the overall cost of installation as well as future maintenance cost is significantly reduced.

The final results are provided along with the cost estimation of installation of single guyed tower instead of providing several towers for the same purpose.

Keywords: ANSYS, Guyed tower

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LIST OF SYMBOLS

Abbreviation	Name	Page number
A_1	Probability factor	17
A_2	Terrain, height & structure size factor	17
A_3	Topography factor	17
V_Z	Design wind speed	17
P_z	Design wind pressure	17
ϕ	Solidity Ratio	19

CHAPTER 1

INTRODUCTION

India is a densely populated country and as we all know the major portion of the communication occurs with the help of cell phone devices, in which telecommunication towers play a major role. Analyzing the current scenario we get to know that the problem of connectivity is a major issue. We plan to analyze this problem by using guyed towers. A guyed tower is defined as a structure, consisting of a freely standing basement; mostly it is made of concrete or of lattice steel with a guyed mast on top. Guyed towers are used for communication purposes and structural reliability of guyed communication towers is playing an ever-increasing role in our society and the demand for reliable communication is growing. As we all know that the use of telecommunication expands, the requirement for more efficient, more reliable antenna towers and supporting structures also grows. As per our conventional codal provisions a larger number of towers are required to cover a significant area and also height restriction creates a major problem. Also, the demand for more towers to be installed in metropolitan areas has not only made it problematic to obtain building permits but also increased the need for far better dependable structures.

Fig 1.1: Fazilka TV Tower

Fig 1.2: Mumbai Television Tower

1.1 Problem Statement:

Guyed towers play a very crucial role in telecommunication purposes and as well as for transmitting radio signals. Height of the guyed towers makes it suitable for variety of purposes, even during emergency situations. So there is a need to focus the attention towards its development and improvisations.

1.2 Scope of study:

1. We aim to reduce the overall cost of making the guyed towers by using steel members of different specifications for the upper section of the tower rather than using the same member for the entire structure.
2. We aim to reduce the density of towers in a particular area by using a single guyed tower instead of using number of towers.

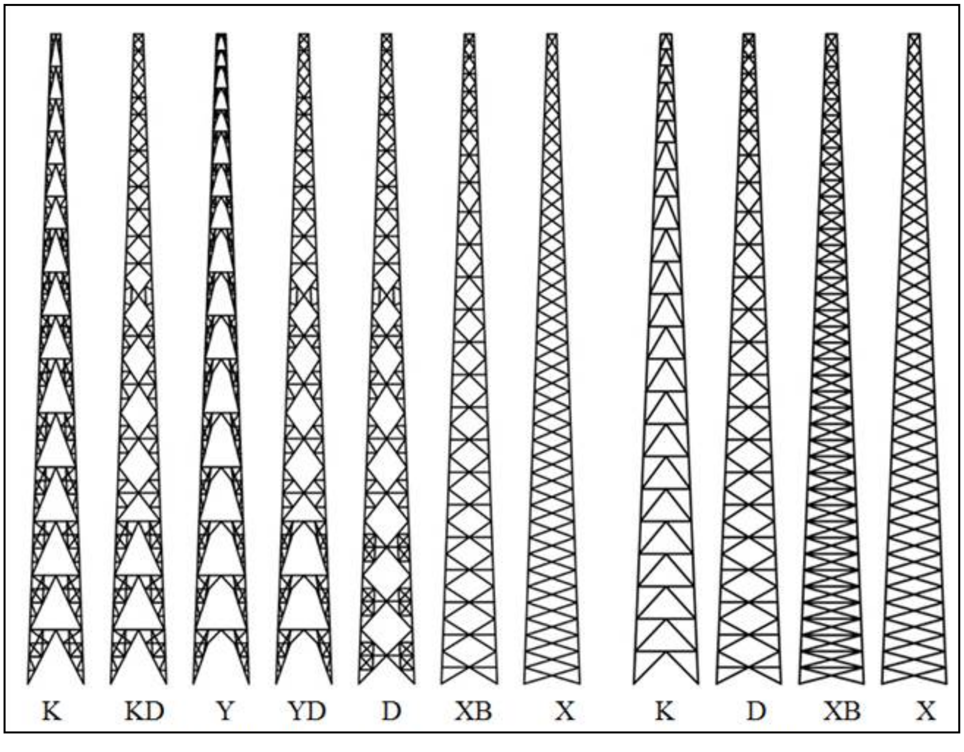


Fig 1.3: Different configurations of lattice tower

1.3 Significance of study

The major significance for carrying out this analysis is that , how a guyded mast tower with height, more than what the conventional towers are build with can incorporate the same amount of traffic as is provided by combining several telecommunications towers nowadays. The main advantage of guyed tower is the height factor which helps it to cover much larger area with a single tower. Also such towers can also be used in emergency situations as well.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction:

This chapter presents a summary of different studies on the design and analysis of guyed towers. It includes procedures and guidelines for design of guyed towers by different authors along with recently completed experimental and computational studies available in the published literature.

2.2 Previous Research:

Craig M. Snyder [1]:

Corrosion of anchors of guyed towers is an issue of importance. The age of tower is an important factor while studying the capability for structural damage because of rusting. Guyed towers nowadays should include corrosion control measures so as to increase the life of the tower. Also there is a need to check the existing towers for damage and then shoild be protected towards corrosion. Cathodic protection is tested to be the best method to reduce corrosion in the anchors of guyed towers. The benefits of controlling corrosion will automatically reduce the cost instead of choosing none. ***–Understanding and preventing guyed tower failure due to anchor shaft corrosion***.

Bibitha K Eldhose, Harinarayanan S andS.Usha [2]:

In an ever-increasing demand for wireless communication technologies, guyed towers are almost exclusively used for communication purposes and structural reliability of guyed towers is becoming an important factor. The static wind load of a 100m tall-guyed tower is statically determined. Results obtained from 3d models suggest the following conclusions. A finite element based methodology was successfully applied to determine natural frequencies and mode shapes of guyed towers ***-Linear analysis of guyed mast subjected to wind, ice and seismic loading.***

RohanManitripathi, R.Ambalvanan [3]:

Telecommunication plays an important role in today's era as it improves coverage area and network connectivity. To meet the demand of growing population and urbanization, telecommunication industry is growing enormously by installing large number of towers day by day. The steel section for the tower designed as per the IS was on the higher side as compared to the tower designed as per ANSI/TIA RS-222G. The normal wind load calculated was found to be higher for the tower designed as per IS as compared to the tower designed as per ANSI/TIA RS-222G. The American Standard code has mentioned various factors as discussed, which can be adopted by Indian Standard code in order to get an effective tower designing code -***Comparative Study of Microwave Tower as per I.S Code &ANSI/TIA/EIA/RS222-G***.

G.G. Amiri and G. McClure [4]:

The recent developments in the telecommunication industry have led to an extensive use of tall-guyed towers. Very tall towers are essential infrastructures and a fundamental component of post disaster communication system, therefore, there protection during a severe earthquake is of major importance and accordingly the seismic performance of such structures should be properly evaluated. The seismic behavior of three tall guyed towers is investigated based on detailed numerical simulations. The scope of this paper is to consider the overall seismic response of guyed towers in terms of the characteristics of their essential structural properties and the input ground motion. The results obtained from this study have so far shown that a sensitive region exists in the tower in terms of lateral stiffness, which causes some no uniformity in its seismic behavior- ***Seismic response of tall-guyed telecommunication towers***.

HarshaJatwa, VivekTiwari and SumitPahwa [5]:

Transmission line towers, nowadays plays a vital role in the operation of a dependable electrical power operating system that is the reason why it is considered as an important system for power supplies. In this study we made a companison between code IS: 802(Part l/Sec 1): 1995 and ASCE 10-98(2000) code. For this the comparative study has been carried out on the two different codes w.r.t different types of base width, height and bracing. From the various studies of these codes we can conclude that the code IS: 802(Part l/Sec 1): 1995, available for the design of tower structures requires certain modification as to made the design more structurally and economically sound as compare to the ASCE 10-98(2000) American code. Through the use of these studies certain modifications has been made to the Indian Code so as to make it updated with time - ***Comparative Study of Indian and ASCE Codes Provision for Design of Transmission Tower.***

Eric James Sullins [6]:

The objective of is to develop a systematic evaluation and assessment method that could provide necessary information for the repair and maintenance of the tower network, and the development of a condition indexing system. This system will organize the towers by importance in the network along with the condition of the tower. To be able to rank the towers with regard to structural integrity, it is important to develop a procedure for modeling and analyzing the towers using the latest codes and also under earthquake loadings. The models of the towers will be loaded with wind and ice to evaluate their performance using the new code requirements. The models will also be used to evaluate the effect of deterioration of the tower components on the overall behavior of the tower structure and its failure characteristics - ***Analysis of Radio Communication Towers Subjected to Wind, Ice and Seismic Loadings***.

Yohanna M. F. Wahba [7]:

In this investigateon, the static response of guyed communrcation towers is investigated using two different F.E.M analysis (3d truss model, and a beam model), and a beam-on-non linear springs methodology. A comparative study between the analytical techniques is undertaken for different loading levels. Various Results from analytical models are confirmed by testing four scale model tower structures to collapse. Analytical methods are extended to prototype tower structure and conclusions, recommendations are drawn regarding the aptness of the analytical models to the static analogy of such towers. The F.E.M analysis is applied to eight prototype tower structures and is subjected to free and forced vibrational motion. ***-Static and Dynamic Analyses of Guyed Antenna Towers***.

RohitKaul [8]:

The general objective of is to develop a reliable and a more efficient time domain analogy procedure for the better dynamic analysis of guyed mast towers. The magnitude of cable nonlinearity and its effect on the guyed mast is also studied as a part of the thesis. The need for dynamic analysis for the design of guyed towers has been clearly established. In the past, research in this area has mostly concentrated on frequency domain analysis with the number of approximations and assumptions. Most commonly, the mast space truss is approximated as an equivalent beam with five or six degrees of freedom at each node. For this study, a complete 3D truss model is used for the mast analysis. A computer code using object-oriented programming is assembled for time domain dynamic analysis of guyed towers- ***Dynamic Analysis of Guyed Towers Subjected to Wind Loads Incorporating Nonlinearity of the Guys***.

Y.M.F. Wahba, M.K.S. Madugula and G.R. Monforton [9]:

This paper differentiates between two different finite F.E.M models used during this analysis of guyed lattice towers. During the initial approach, three 3d truss elements are operated to model the latticed structure of tower and non linear cable elements are used for the guy wires; this automatically results in the large number of elements and their degrees-of-freedom. In the second approach, the tower mast is modeled using beam-column elements and the non-linear cable elements for the guy wires. The other computer models were assessed using six existing tower structure applied with a range of load combinations involving dead, wind and ice load. The results are equated to a basic, but widely used model in which, tower is modeled as beam on non linear elastic supports. Structural response comparesons include guy tension, axial forces of members , face shears, displacement of mast and its rotations - ***Evaluation of non-linear analysis of guyed antenna towers.***

Y. M. DESAI, N. POPPLEWELL, A. H. SHAH and D. N. BURAGOHAIN [10]:

A mathematically systematic and efficient mehod is presented for creating the stiffness of parabolic, three-nodal finite element for the static and non-linear analysis of 3d cable-supporting structures. Mathematical calculations are reduced by evaluating the wide-ranging deformation stiffness matrix w.r.t global co-ordinates while overcoming the conflicts with the existing, displacement based elements. Representative amendments are defined by using various typical geometrically nonlinear, cable aided formation. Also, an efficient methodology is put forward to calculate the self-weight profile of a pretenseon angled cable member. -***Geometric Nonlinear Static Analysis of Cable Supported Structures.***

Ayman M. Ismail, Sherif H. M. Hassnien [11]:

A nonlinear deterministic approach for predicting the wind response of guyed towers is described in this paper. The nature of wind, static and dynamic wind effect is defined. In the present approach, the time space history of wind is simulated and fed into the system's equations of motion. These are integrated in the domain of time and accordingly the response of the guyed tower is obtained. Linear and non-linear effects of a guyed tower are evaluated to obtain wind histories by a multi-regressive technique. In addition, comparative studies have been performed on the tower in order to check the effect of wind velocity and roughness length on their response. A comparison of mean and dynamic responses and a discussion of these results relative to the quasi-static analysis are presented-***Non-Linear Dynamic Analysis of Guyed Towers to Wind Loading***.

Marcel Isandro R. de Oliveira, José Guilherme S. da Silva, Pedro Colmar G. da S. Vellasco, Sebastião Arthur L. de Andrade and Luciano R. O. de Lima [12]:

The usual constructional analysis formation for communication towers and steel transmission line tower design intend to take typical truss behavior in which all the steel connections are considered pinned. Despite this fact, the most usually used tower geometry possesses structural mechanism that may mediate the assumed structural behavior. A possible reason for the structural reliability is related to the semi-rigid connection behavior in place of the initially used pinned behavior. The paper comprises a different structural analysis forming a strategy for the guyed-mast steel tower design, taking all the true structural forces and moments, by applying the beam and truss finite elements. Collations of the above taken design models with a third alternative, that forms the principle structure and the cross-bracing system with three dimensional finite beam elements and are made from three existing in-used guyed steel telecommunication towers (50m, 70m and 90m in hright). The comparisons are firstly based on the towers static and dynamic structural performance later to be followed by a linear buckling analysis to decide the mere influence of the variety of modeling strategies used on the tower stability behavior- ***Structural Analysis of Guyed Steel Telecommunication Towers for Radio Antennas.***

A. Ismail [13]:

This study proposes about the field measurements of about 138 m guyed tower in Qussia city, of Upper Egypt. In situ determinations of ambient tower the vibrations are used to calculate the natural frequencies of the guyed tower. The measurements are noted using a LMS SCADAS system and four wireless vibration sensors for the use of recording the ambient vibrations of the guyed mast. The tension in the guy cables was measured by mechanecal equipment. The dynamec properties of the guyed mast tower (natural frequenices and mode shapes) were taken from these measurements. Results of the Eagen value analysis of numeracal models of the tower were compared side by side with the natural frequenices and mode shapes extracted from the in situ measurements. The freld measurements were used to update the fenite element model. The non-linear static analyeis based on the updated fenite element model was cairred out. Seismic analysis and comparison between the oreginal and new models taking into account the detereoration in elements are presinted - ***Seismic assessment of guyed towers: A case study combining field measurements and pushover analysis.***

SeyedAli Ghafari Oskoei[14]:

Telecommunication infrastructure is an important part of the communication network and post-disaster networks and its preservateon in the case of a severe earthquake is essenteal. Telecommunicateon masts, also called guyed towers in North America, are typceally tall structures whose funecton is to support elevated antennas for rado and televison broadcasting, telcoemmunication, and two way radio systems. The current research deal with the dynamic behavior of tall guyed mast under seismic loads. Engineering literature of this feld reports that the design of tall-guyed telcommunication masts is generally operated by the serviceability criteria under severe wind conditions, typcally combined with icing in cold climate . However, there is a need for seismic desgn checks of guyed masts constructed in various zones with moderate to high seismcity. The nonlinear dynamic behavior of tall multi support telecommunication masts is extremely complex. Presently reliable seismic design of telcommunication masts requires non-linear time domain analyss based on detailed finte element models - ***Earthquake-resistant design procedures for tall guyed telecommunication masts***.

CHAPTER 3
METHODOLOGY

3.1 ANSYS

ANSYS software can be used for a vast variety of work like to design products and semiconductors, as well as to create simulations that test a product's service life, temperature distribution pattern, fluid movements, and electromagnetic properties.

ANSYS Inc. develops and markets F.E.M analysis software. It creates simulated computer formations of structural, electrical and machine components to calculate the effect of factors such as strength, toughness, elasticity, temperature distribution, electromagnetism, fluid flow, and other attributes on the structure. ANSYS is generally used to determine how a product will perform with different characteristics, without making test products or conducting crash tests. For example, ANSYS may be used to simulate how a bridge will hold up after many years of traffic and how to best operate salmon in a cannery to lessen waste, or how to design a slide that uses less material without sacrificing safety.

Many ANSYS simulatons are made using the ANSYS Workbench sofware, which is one of the company's most important and used products. Typcally ANSYS users break down larger stuctures into small elements that are each modled and tested explicitly. A user may start by defning the dimensions of an object, and then addng weight, pressure, temperature and other physcal propertes. Finally, the ANSYS software simulates and analyzs movement, fatigue, fracturs, fluid flow, temperature distrbution, electromagnetic efficency and other effects over time.

ANSYS also devlops sofware for data management and backup, academic research and teachng purposes.

3.2 Modeling considerations

The coherent non-linearity in the geometrical behavior of guyed mast towers leading to various kinds of problems in their structural analysis and it prevents, computation of a common design method. As a result of which simplified analogy assumptions, related to the load and the formation of structural behavior have to be made and estimated design method are used, which are just unjustified, and can even lead to failures.

The real structural properties of guyed mast towers is extremely complexed. The guy wires exhibit, a non-linear behavior, especially at lesser values of pretension. Exceeding the pretension loading of the guy cables lessens the non-linearity and enhances the lateral stiffness, but it also results into larger compressive loads, and hence therefore, to a more bending probability for guyed mast itself. The behavior of the guyed mast is also non-lnear due to its slenderness, and to the huge displacemnts it undergoes under substantal wind loading. Also, decisons that have been taken in the modeling phase regarding loads are also not straghtforward. Guyed mast towers have conventionally been designed for wind loadng. However, wind forces are of dynamic in nature, and consideration of similar static loading is also not always sufficient. Also in addition to wind loading, there is also ice loads. In this type of load stresses the members of the tower structure are in a fully dissimilar manner than wind and hence can be potentially critical. Concurrently ice and wind loads can commonly occur, and have been studied and found to be responsble for several disatrous failures of guyed mast towers in the past years. And along with the capability of researchers to model correctly this complexed behavior, the main attention of analysts has been dedicated on selecting cost-effective simplifications in the necessary loading and the structural formation for guyed mast towers.

A large amount of analyst has studied the structural nature of guy cables. A most commonly used technique is to take into consideration the non-linearity due to sagging of guy wires, is that of the similar cable modulus. Attractive contributions have been conducted by makers of cable design bridges, which face the same kind of problems in formation of cable behavior. The arrival of digital computers and F.E.M analysis has led to the combination of a number of numerical methods for cable wire treatment. Some of the very recent analysis provides what could be taken to be state of the art for cable formulation, nowadays and analysing more accurate numerical to approximate   results.

Fig 3.1: Sagging of Guy Wires

The speed of the wind changes with height and its change in time varies with the nature and type of ground where it is installed. The wind action is also entitled by a combined set of pressures and forces ,Whose effects are similar to the results of turbulent wind. The generalzed forces of wind on the guyed masts can be characterzed by a quasi-static and dynamic parts. Both of the forces and their displacements related, depend mainly on the important mode , frequency and its dampng. The quasi-static nature and the time-changing behavior of these pole guyed masts formations occurs along the wind and it is because of the additon of a consistant wind pressure with a non-permanent gust pressure. The purely dynamic vibratory nature of the pole masts occurs in the transverse directon of propagaton of wind and is due to the aerodynamc phenomenon of vortex shedding at the critcal wind speed.

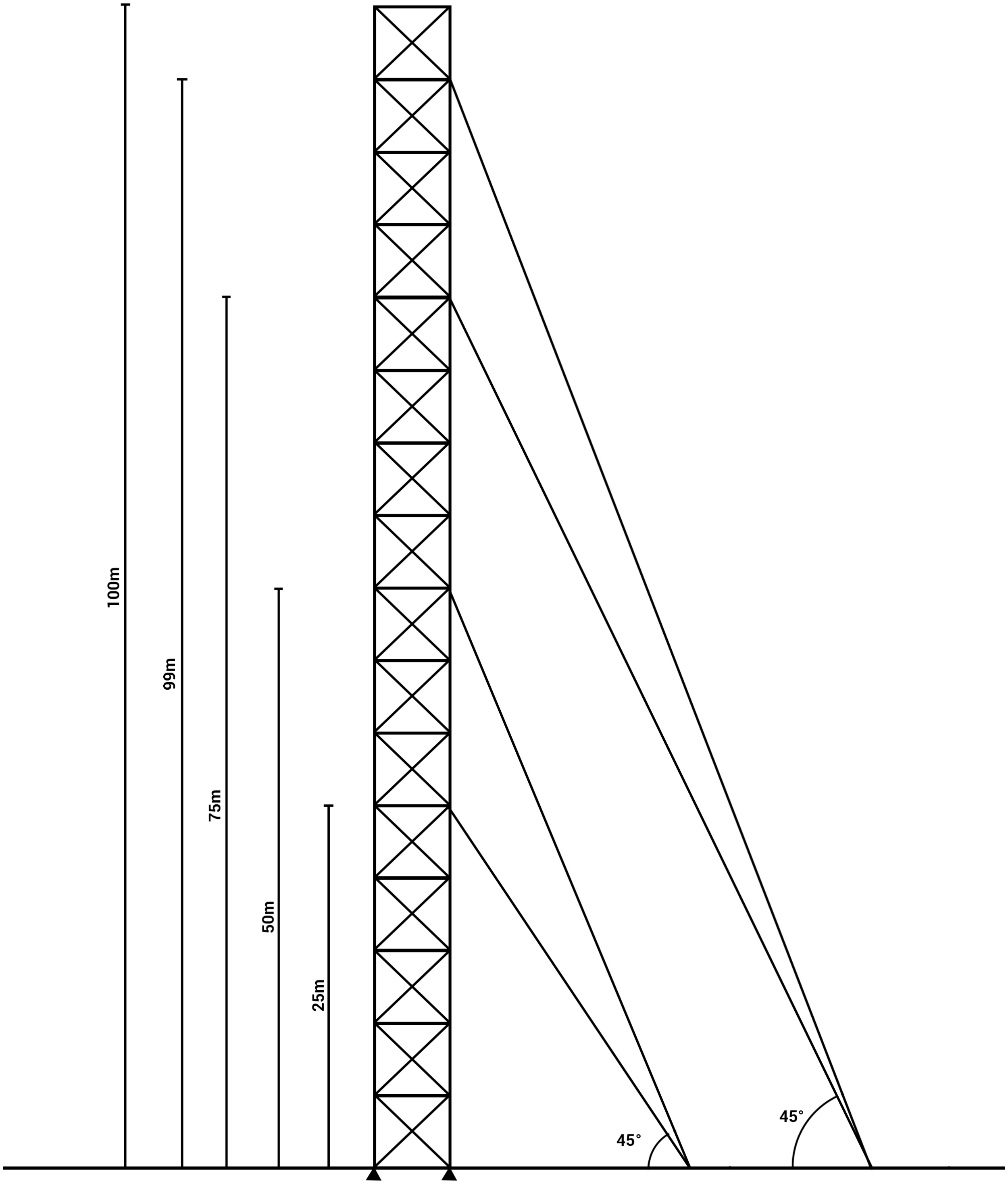


Fig 3.2: cross sectional view of geometry

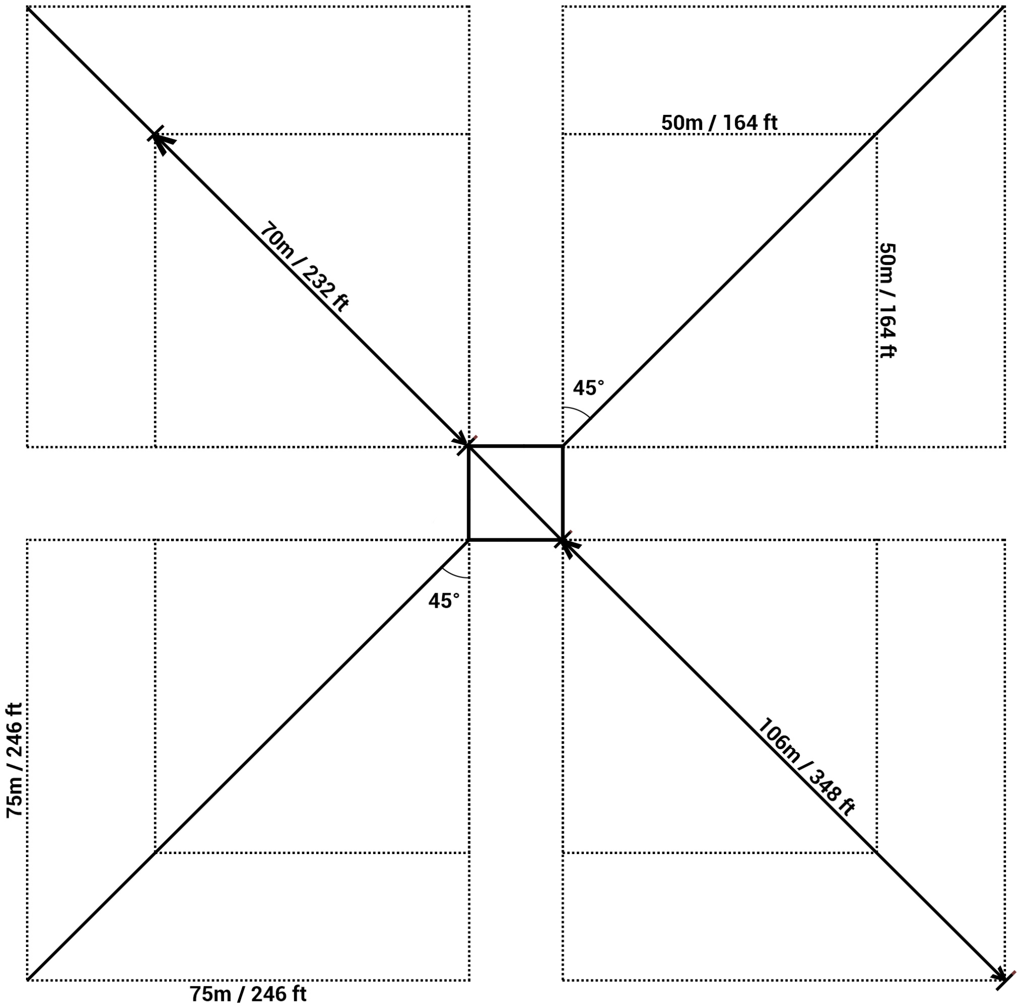


Fig 3.3: top view of guyed tower

3.3 Work Plan

The tasks undertaken to complete the stated objectives:

Task-1: Literature review

Task-2: Learning basics of ANSYS software

Task-3: Load calculations

Task-4: Basic model creation and analysis in staad pro

Task-5: Modeling of guyed tower in ANSYS along with installation of guy cables

Task-6: Analysis of the structure in ANSYS

A brief description of the work done in each task is as follows:

Task-1: Literature Review

The research activities require a thorough understanding of the literature work done so far to understand the problem, so that previous research will not be duplicated. All the objectives were formed based on the research conducted, to solve few problems.

Task-2: Learning basics of ANSYS

Learning the basic tools of the software, so as to properly model the guyed tower and analyze the structure to get the appropriate results.

Task-3: Load Calculations

Table 3.1 shows load calculation where A_1 is probability factor, A_2 is terrain, height and structure size factor, A_3 is topography factor and V_z is design wind speed at height z

Dead Load	Dead load is calculated by the software by finding the total amount of steel used multiplied by density of the steel and acceleration due to gravity
Live Load	A_1=1.07, A_2=1.2, A_3=1, A_4=1, V_z=60.348 m/sec (for Lucknow) [From: Table – 1,2 and Cl-5.3.3.1, Cl-5.3.3.2]
	Design Wind Pressure (P_z) = 0.6 x V_z^2 x (K_d x K_a x K_c) = 0.6 x 47^2 x (0.9 x 1 x 0.6) = 1179.97 N/m^2

Table 3.1: Load Calculations

Task-4: Basic model creation and analysis in staad pro

Step 1: Creation of geometry:

A single unit of the structure is made by assigning the nodes and then translational repeat is applied to construct the whole structure. Further addition of guy wires makes the structure more stable.

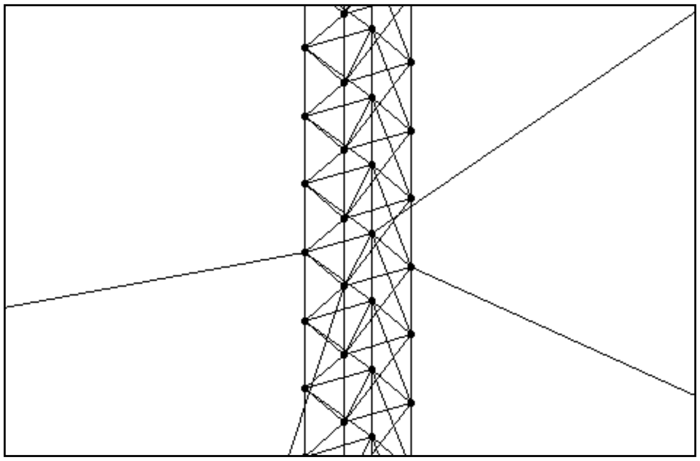


Fig 3.4: closer view of Guyed tower

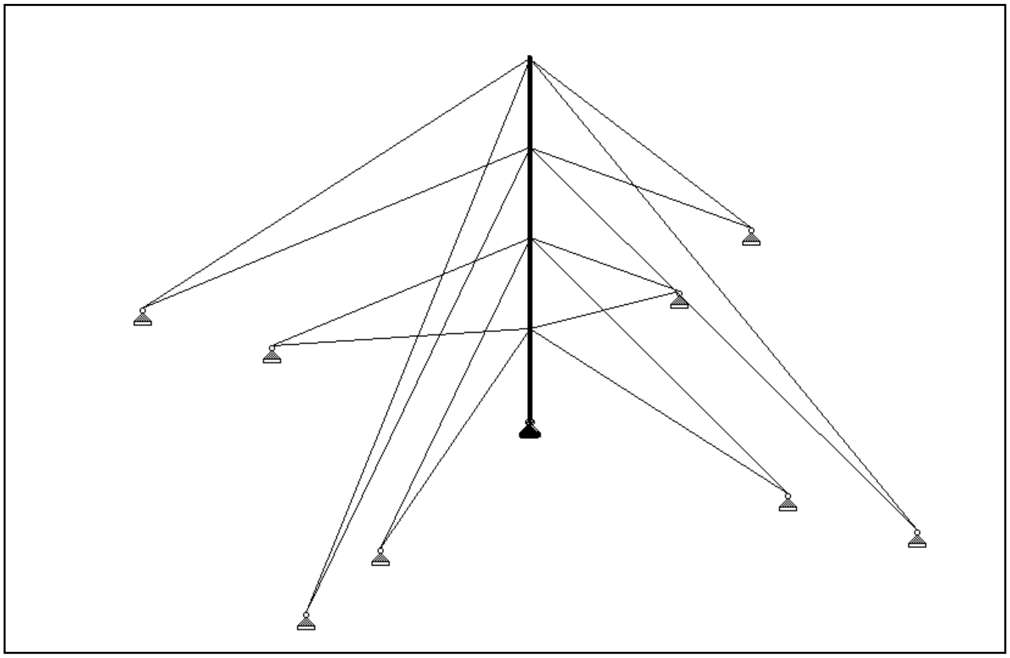


Fig 3.5: Complete view of guyed tower

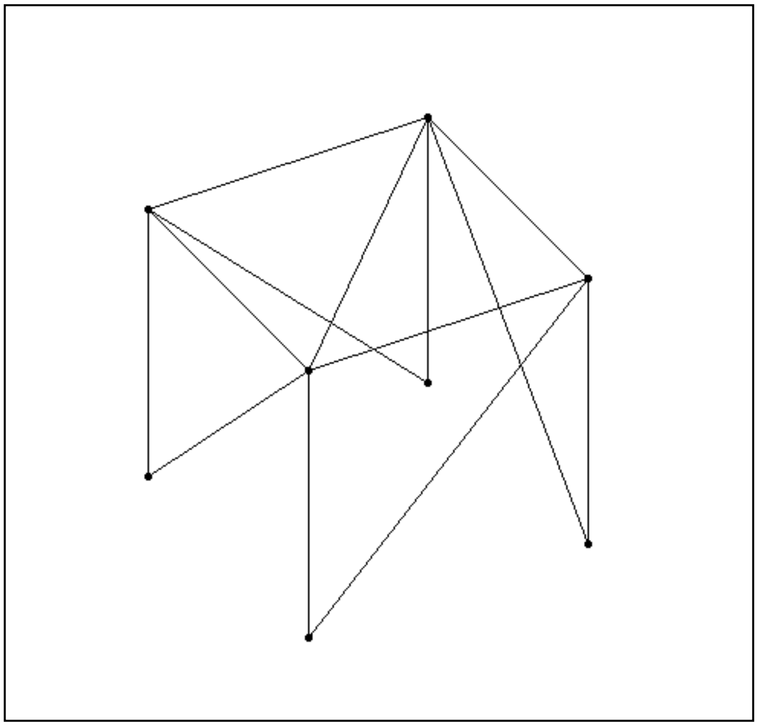


Fig 3.6: Single Unit of Guyed Tower

Step 2: Assigning supports:

Eight pinned supports are assigned, four at each end of the tower structure and four at the end of the cable where it is attached to the ground.

Step 3: Assigning material:

Two types of sections are used for the tower structure. For frames, angle section of 55x55x6 mm is used and for guy wires circular section of radius 50 mm is used

Step 4: Adding specifications to cable members:

Apply cable properties to guy wires by assigning initial tension to zero.

Step 5: Apply loading:

Various loads including self weight, wind loads are applied to the tower structure. Wind load is applied as per ASCE 7. Specifications provided for wind load calculations are:

- Design wind speed(V_z) = 60.348 m/s
- Height and width of tower is 100m and 0.609m
- Solidity ratio (ϕ) is 0.8
- K_d is 0.9

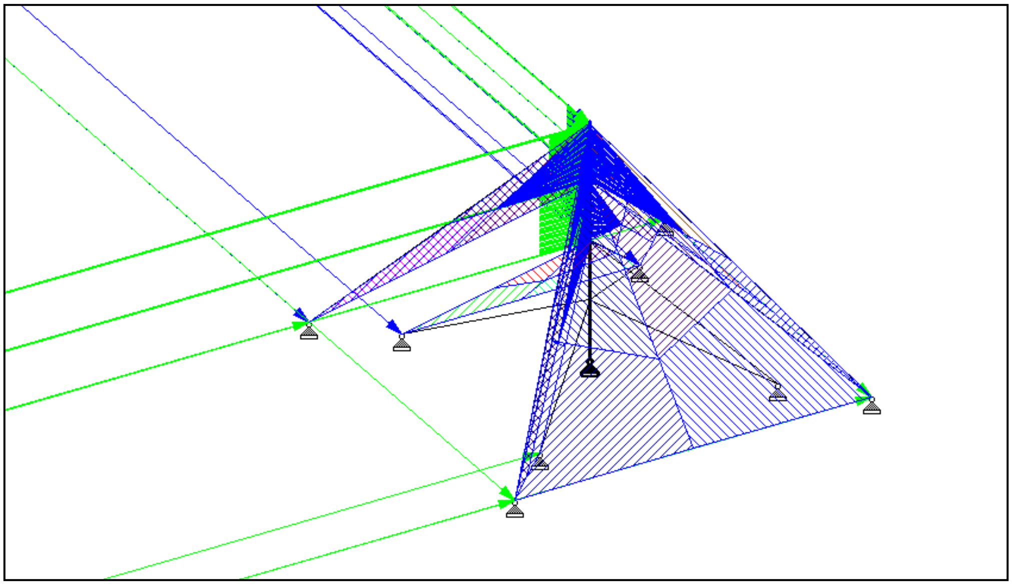


Fig 3.7: Wind load application

Step 6: Analysis:

Successful analysis with zero error and zero warning is accomplished for the entire structure.

Task 5: Modeling and analysis of guyed tower in ANSYS

Step 1: Creation of geometry

First and foremost a single unit is made and converted into a line body. By using pattern function multiple copies of the single unit is created to achieve desired height of the tower. Guy cables are added by creating construction points on the tower and ground, and connecting the points using line tool.

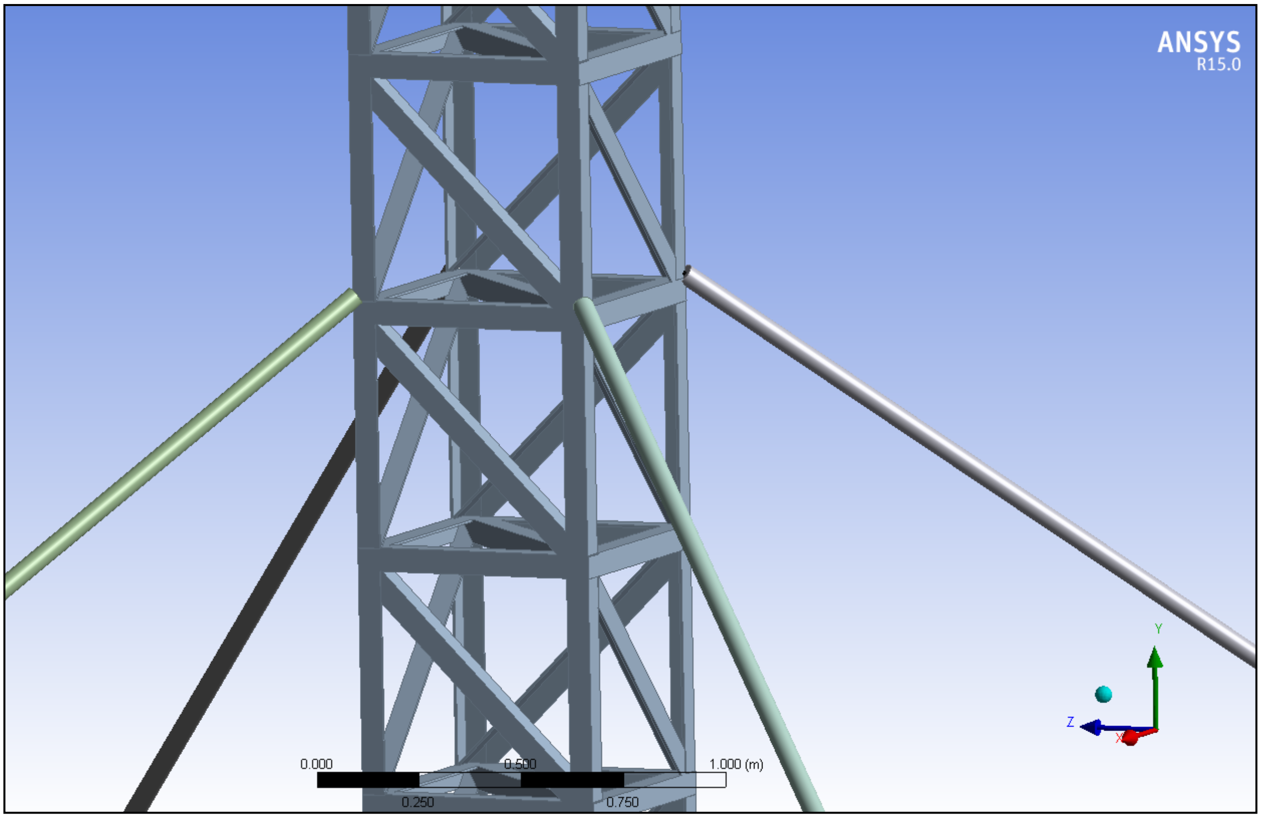


Fig 3.8: Close-up view of Guyed Tower modelled in ANSYS

Step 2: Meshing

Meshing is done by keeping the element size to default programming.

Step 3: Applying loads and supports

Pinned supports are added under the tower and guy anchors. For loading, two different types of loadings are created – dead and live. Dead load includes self weight and weight of satellites to be mounted on top. Live load includes the service load and wind load.

For wind load calculations, an envelope is created around the tower using envelope function and wind load analysis is carried out using fluent flow module.

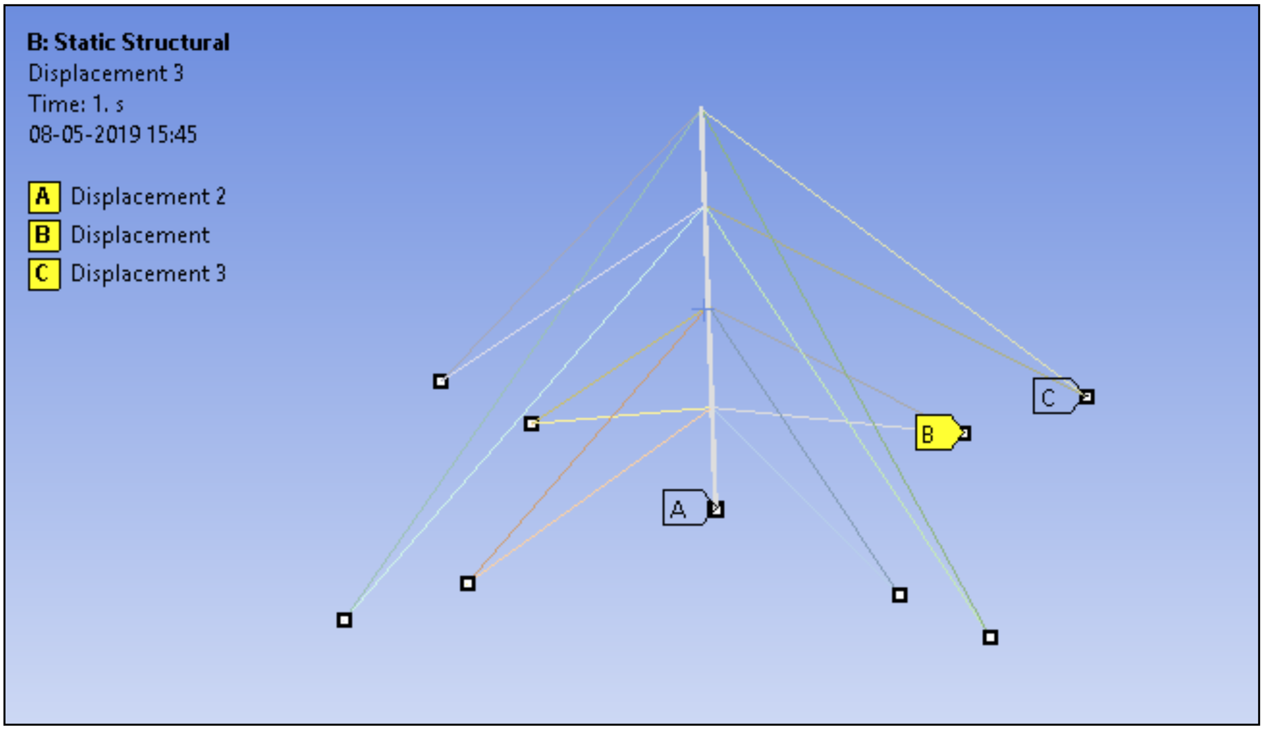


Fig 3.9: Support System in ANSYS

Step 4: Analysis

Before analyzing, the results to be displayed are selected. Dead load and service load analysis is carried out in same module and for wind load analysis we have to move to fluent flow module.

For wind load analysis, geometry is imported from the previous module. To the envelope created around the tower, opposite faces are named inlet and outlet according to the flow direction required. Rest side faces are named ‘boundary’.

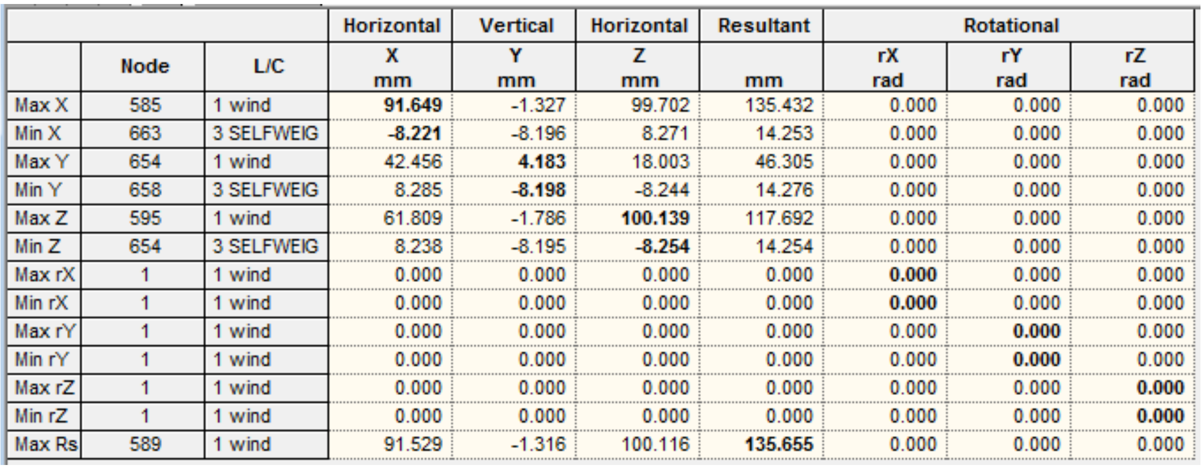
Using Boolean command, subtract the tower and enclosure from each other and then we proceed to the fluid flow simulator. Define all the variables like basic wind speed, medium etc.

Analysis is run and results are noted to produce graphs.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 STAAD Pro Analysis

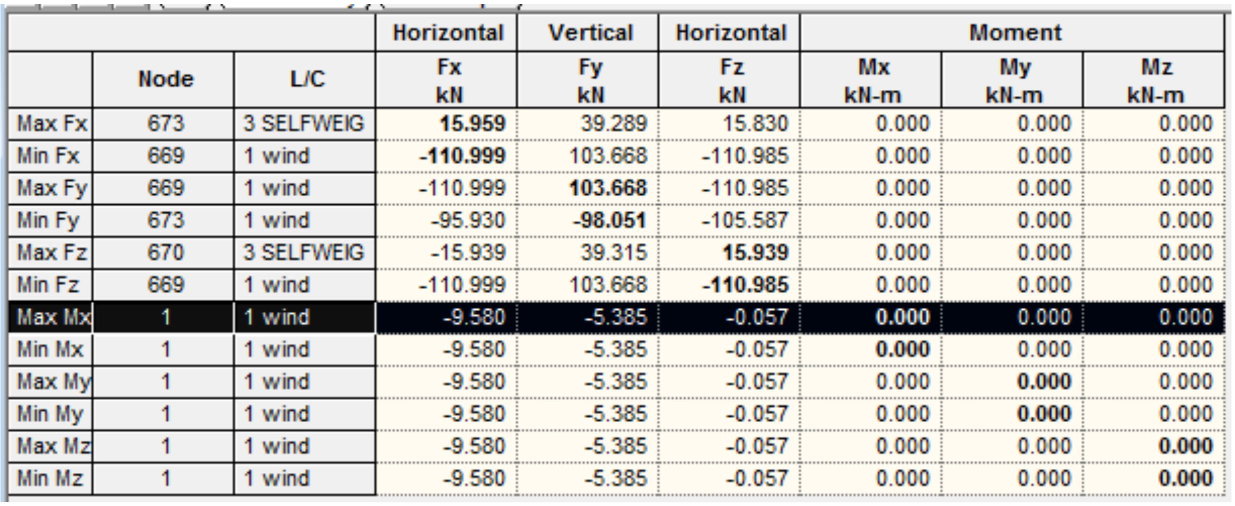


			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	585	1 wind	**91.649**	-1.327	99.702	135.432	0.000	0.000	0.000
Min X	663	3 SELFWEIG	**-8.221**	-8.196	8.271	14.253	0.000	0.000	0.000
Max Y	654	1 wind	42.456	**4.183**	18.003	46.305	0.000	0.000	0.000
Min Y	658	3 SELFWEIG	8.285	**-8.198**	-8.244	14.276	0.000	0.000	0.000
Max Z	595	1 wind	61.809	-1.786	**100.139**	117.692	0.000	0.000	0.000
Min Z	654	3 SELFWEIG	8.238	-8.195	**-8.254**	14.254	0.000	0.000	0.000
Max rX	1	1 wind	0.000	0.000	0.000	0.000	**0.000**	0.000	0.000
Min rX	1	1 wind	0.000	0.000	0.000	0.000	**0.000**	0.000	0.000
Max rY	1	1 wind	0.000	0.000	0.000	0.000	0.000	**0.000**	0.000
Min rY	1	1 wind	0.000	0.000	0.000	0.000	0.000	**0.000**	0.000
Max rZ	1	1 wind	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
Min rZ	1	1 wind	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
Max Rs	589	1 wind	91.529	-1.316	100.116	**135.655**	0.000	0.000	0.000

Fig 4.1: Nodal Displacement Summary

Observations noted:

1. Maximum displacement in x direction: 91.649 mm, because of wind loading.
2. Maximum displacement in y direction: 4.183 mm, because of wind loading.
3. Maximum displacement in z direction: 100.139 mm, because of wind loading.
4. Minimum displacement in x direction: -8.221 mm, because of self weight.
5. Minimum displacement in y direction: -8.198 mm, because of self weight.
6. Minimum displacement in z direction: -8.254 mm, because of self weight
7. Maximum resultant nodal displacement: 135.655 mm, because of wind loading.
8. All the moment of inertia are zero as it is a truss structure



			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	673	3 SELFWEIG	**15.959**	39.289	15.830	0.000	0.000	0.000
Min Fx	669	1 wind	**-110.999**	103.668	-110.985	0.000	0.000	0.000
Max Fy	669	1 wind	-110.999	**103.668**	-110.985	0.000	0.000	0.000
Min Fy	673	1 wind	-95.930	**-98.051**	-105.587	0.000	0.000	0.000
Max Fz	670	3 SELFWEIG	-15.939	39.315	**15.939**	0.000	0.000	0.000
Min Fz	669	1 wind	-110.999	103.668	**-110.985**	0.000	0.000	0.000
Max Mx	1	1 wind	-9.580	-5.385	-0.057	**0.000**	0.000	0.000
Min Mx	1	1 wind	-9.580	-5.385	-0.057	**0.000**	0.000	0.000
Max My	1	1 wind	-9.580	-5.385	-0.057	0.000	**0.000**	0.000
Min My	1	1 wind	-9.580	-5.385	-0.057	0.000	**0.000**	0.000
Max Mz	1	1 wind	-9.580	-5.385	-0.057	0.000	0.000	**0.000**
Min Mz	1	1 wind	-9.580	-5.385	-0.057	0.000	0.000	**0.000**

Fig 4.2: Support Reaction Summary

Observations noted:

1. Maximum support reaction along x direction: 15.959 KN, because of wind loading.
2. Maximum support reaction along y direction: 103.668 KN, because of wind loading.
3. Maximum support reaction along z direction: 15.393 KN, because of self weight.
4. Minimum support reaction along x direction: -110.999 KN, because of wind loading.
5. Minimum support reaction along y direction: -96.051 KN, because of wind loading.
6. Minimum support reaction along z direction: -110.985 KN, because of wind loading.

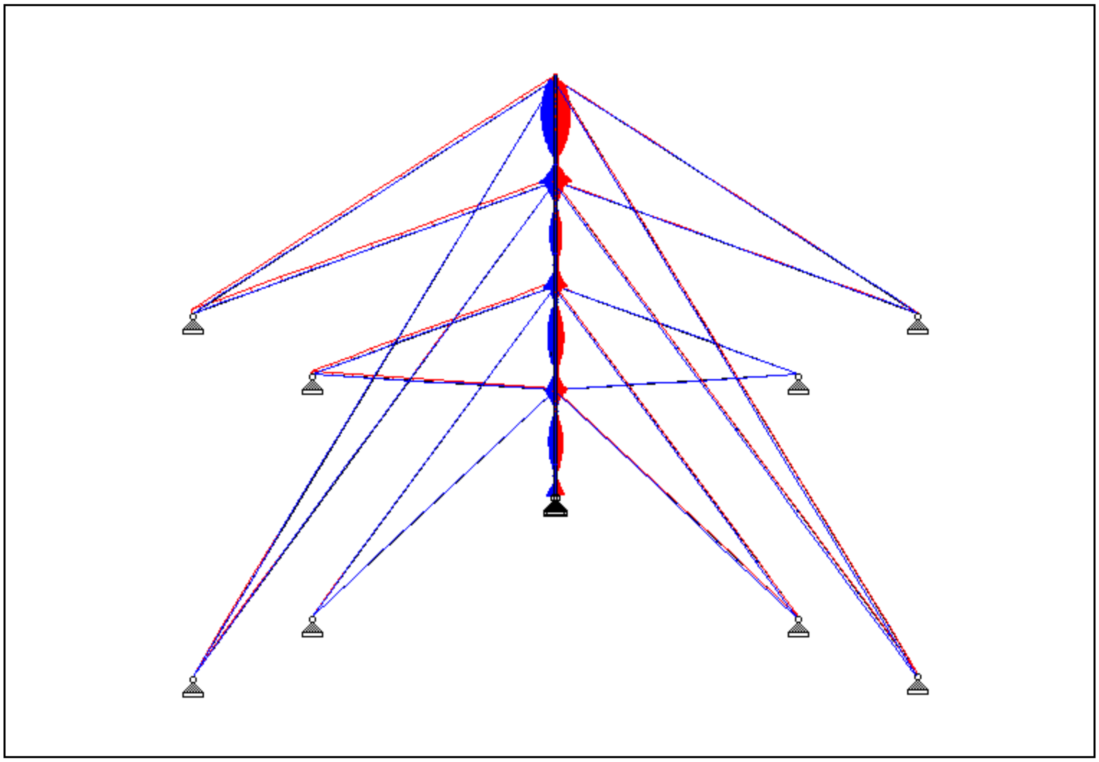


Fig 4.4: Beam Stresses Diagram

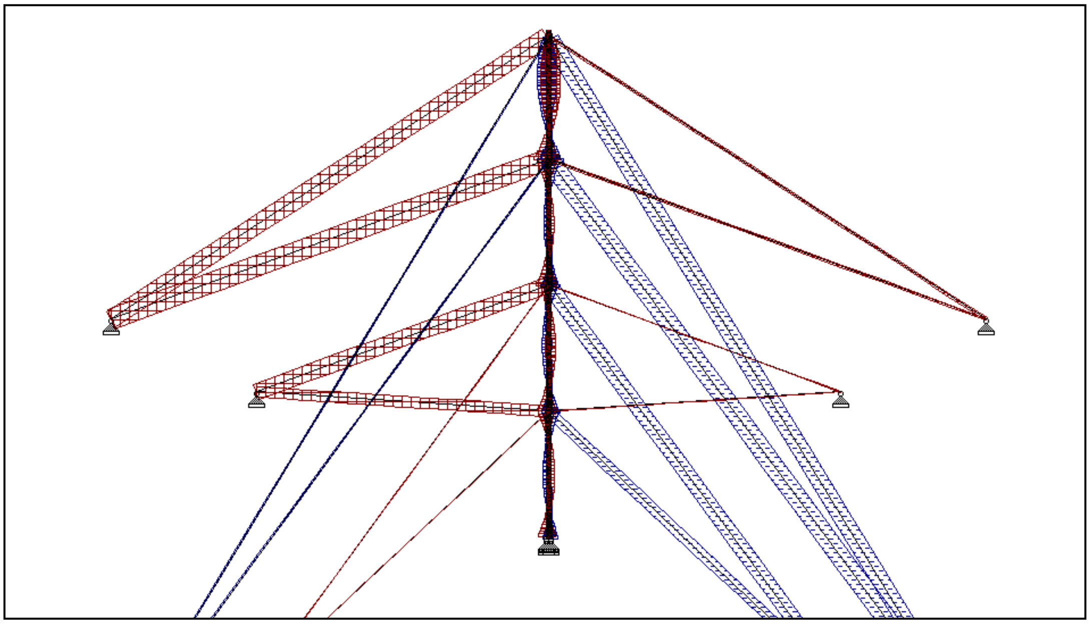


Fig 4.3: Axial Force Diagram

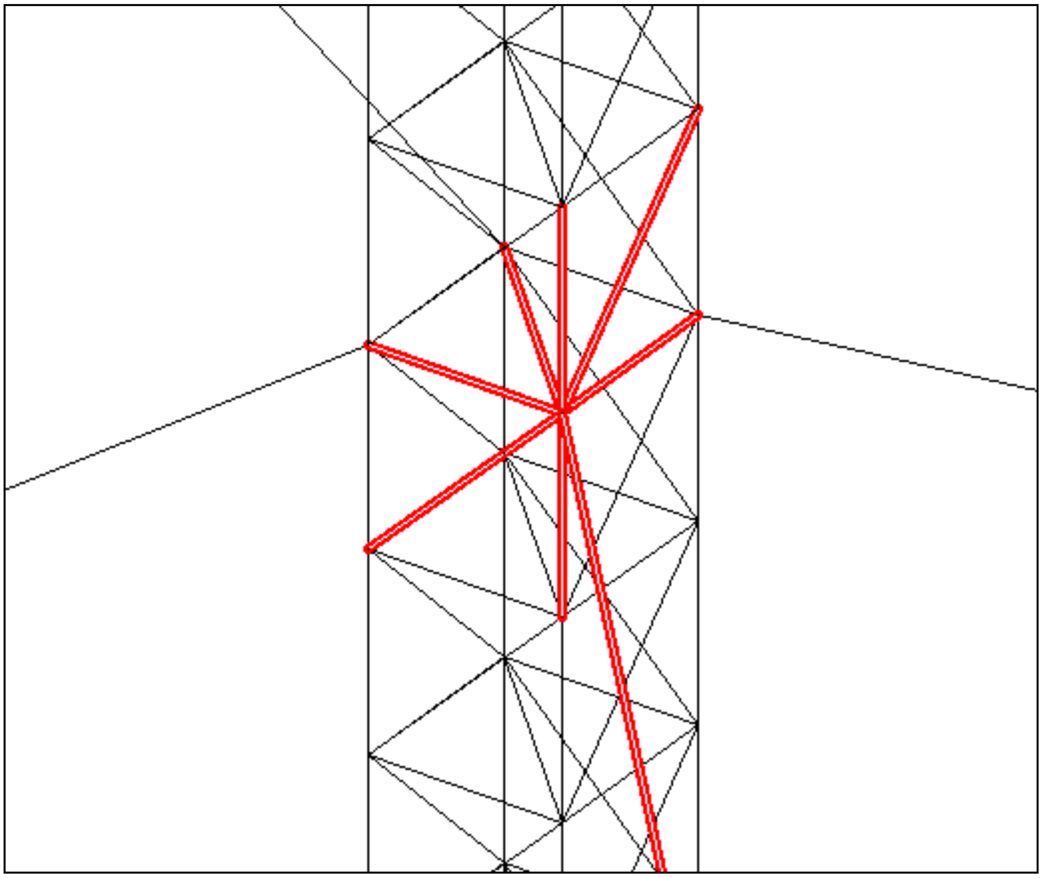


Fig 4.5: Beam stresses at the first intersection of guy cables and tower
25m from base

Observations noted:

1. Moment at the intersection of guy cables and tower, 25 m from the base: 0 KN-m
2. Beam stresses along vertical direction at the intersection of guy cables and tower, 25 m from the base: 0 KN
3. Beam stresses along horizontal direction at the intersection of guy cables and tower , 25 m from the base: 2.48 KN

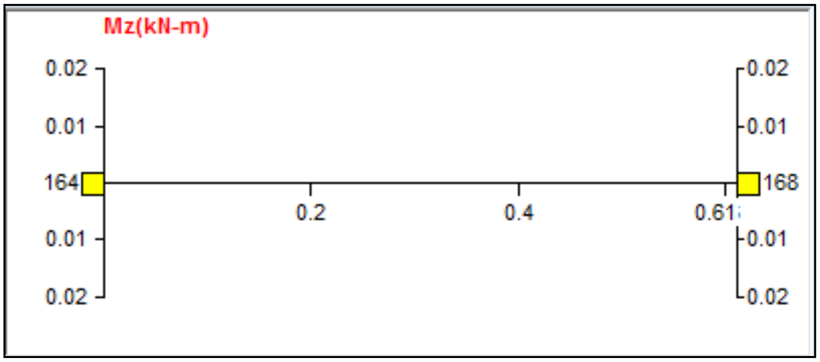


Fig 4.6: Moment at the first intersection

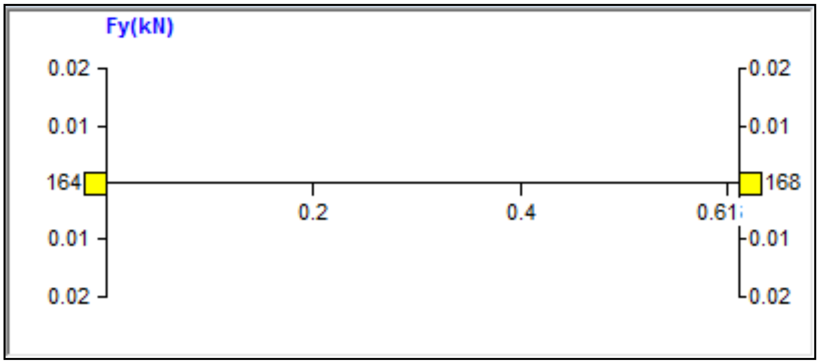


Fig 4.7: Force along vertical direction at first intersection

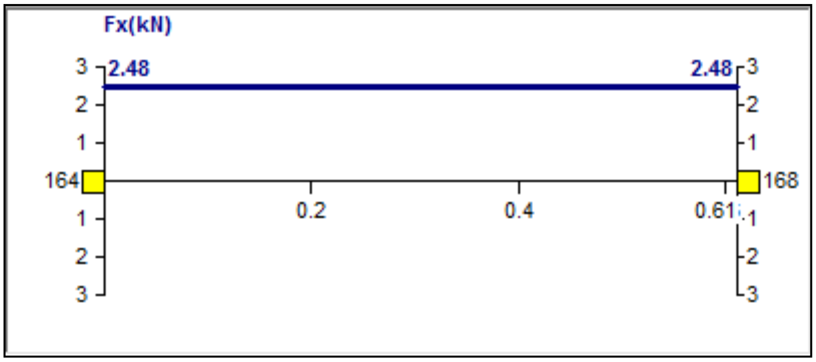


Fig 4.8: Force along horizontal direction at first intersection

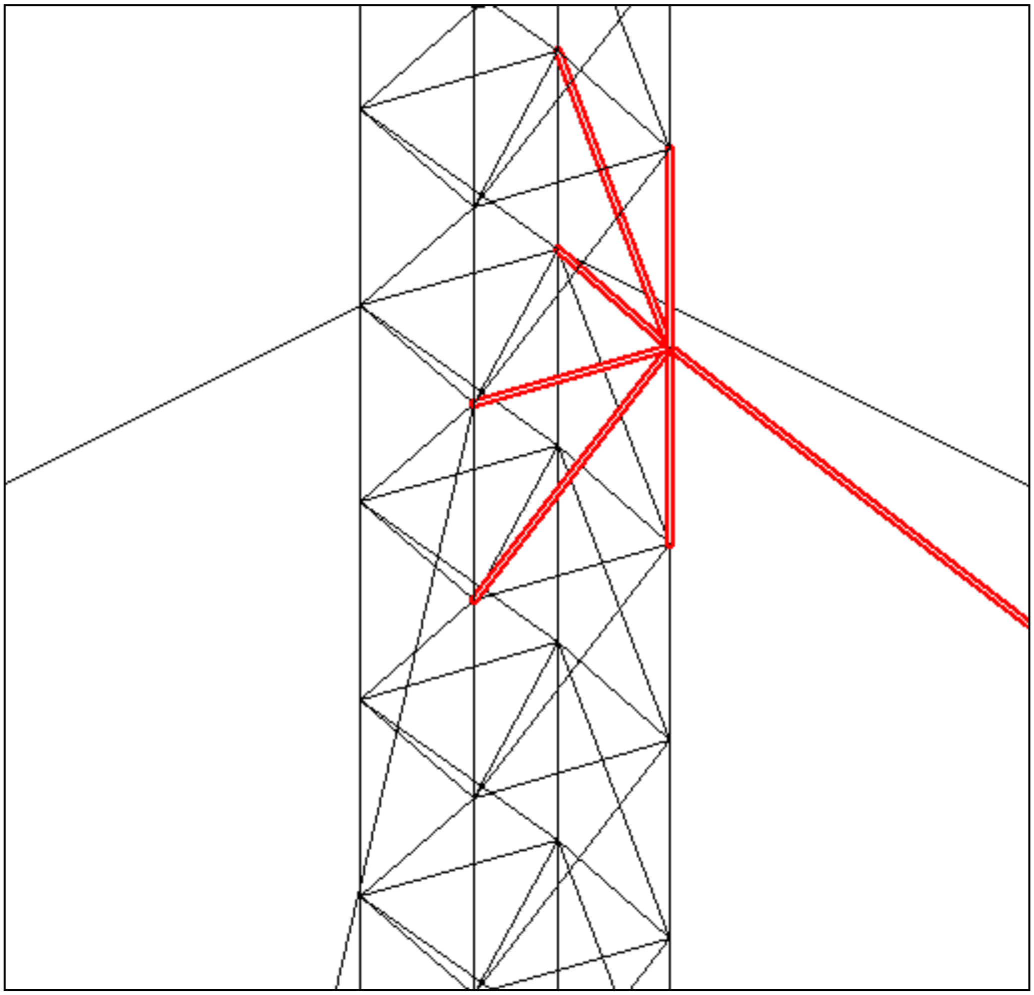


Fig 4.9: Beam stresses at second intersection of guy cables and tower 50m from base

Observations noted:

1. Moment at the intersection of guy cables and tower, 25 m from the base: 0 KN-m
2. Beam stresses along vertical direction at the intersection of guy cables and tower, 25 m from the base: 0 KN
3. Beam stresses along horizontal direction at the intersection of guy cables and tower , 25 m from the base: 2.88 KN

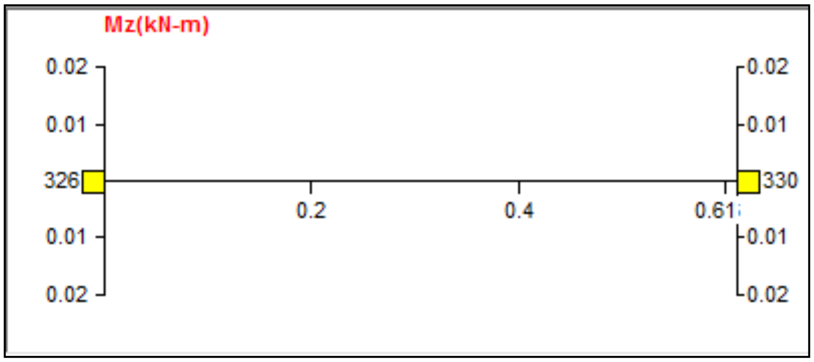


Fig 4.10: Moment at the second intersection

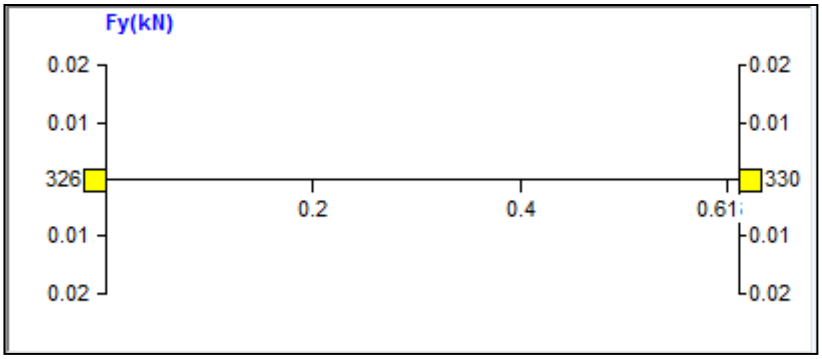


Fig 4.11: Force along vertical direction at second intersection

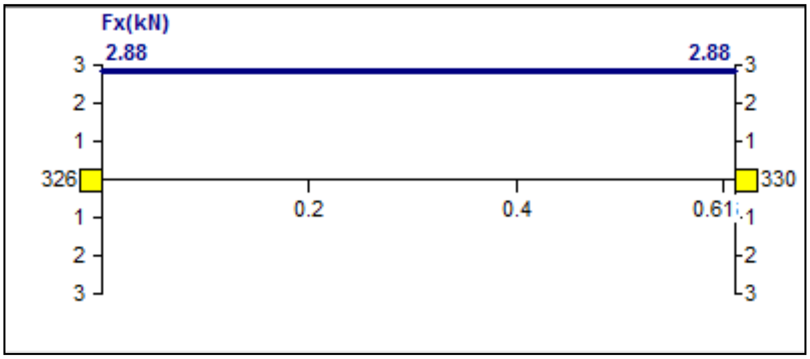


Fig 4.12: Force along horizontal direction at second intersection

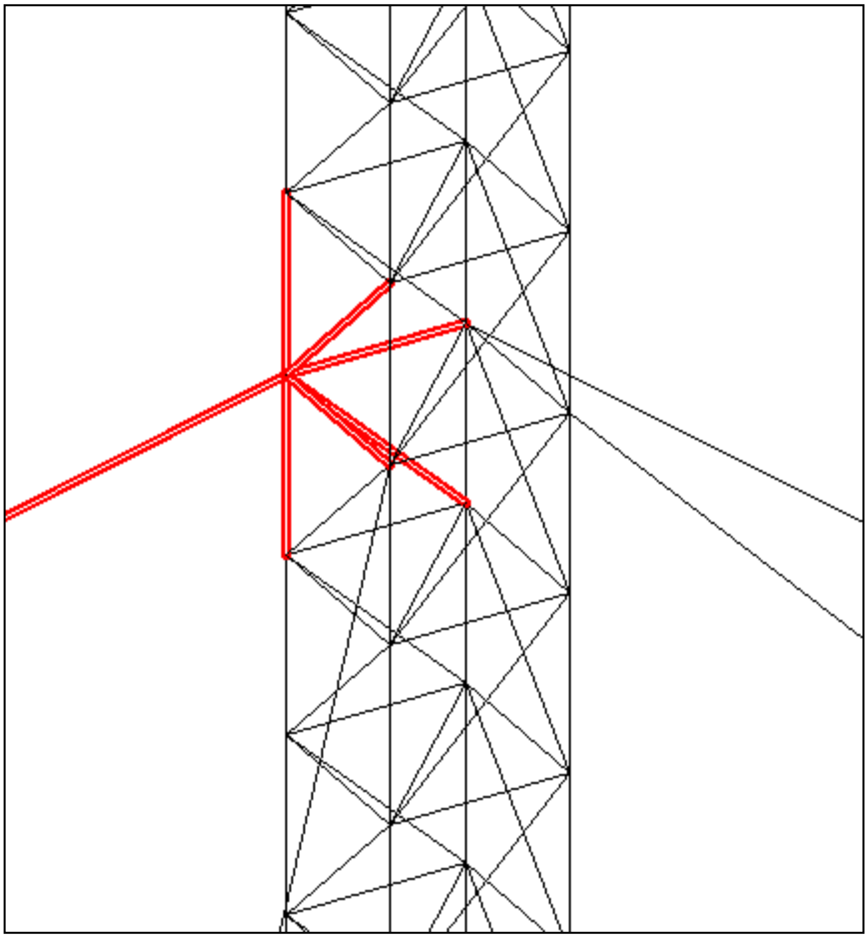


Fig 4.13: Beam stresses at third intersection of guy cables
and tower 75m from base

Observations noted:

1. Moment at the intersection of guy cables and tower, 25 m from the base: 0 KN-m
2. Beam stresses along vertical direction at the intersection of guy cables and tower, 25 m from the base: 0 KN
3. Beam stresses along horizontal direction at the intersection of guy cables and tower , 25 m from the base: 4.49 KN

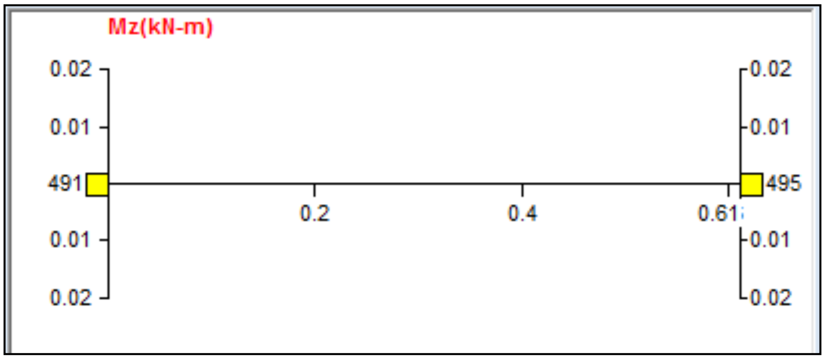


Fig 4.14: Moment at the third intersection

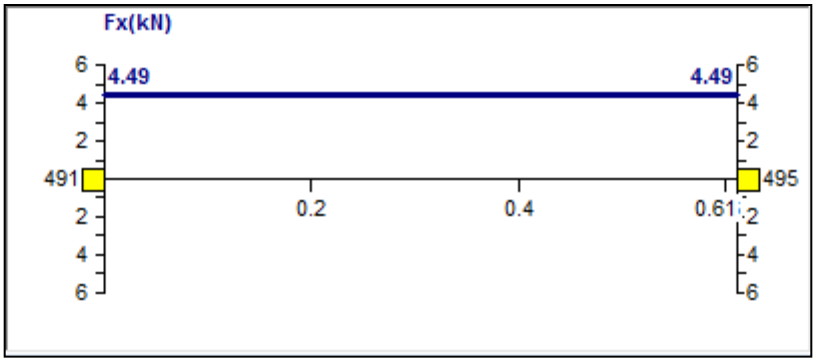


Fig 4.15: Force along horizontal direction at third intersection

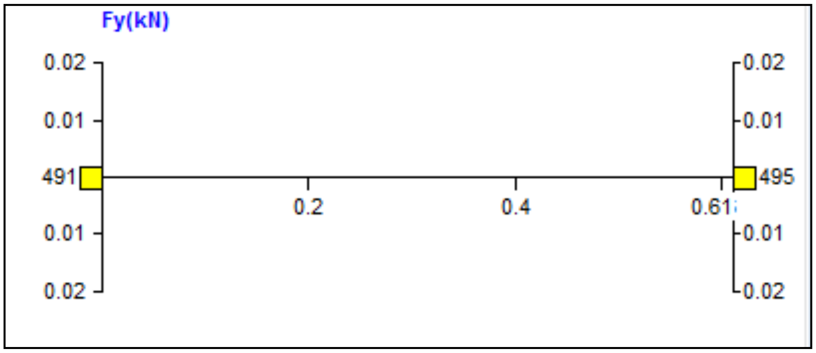


Fig 4.16: Force along vertical direction at third intersection

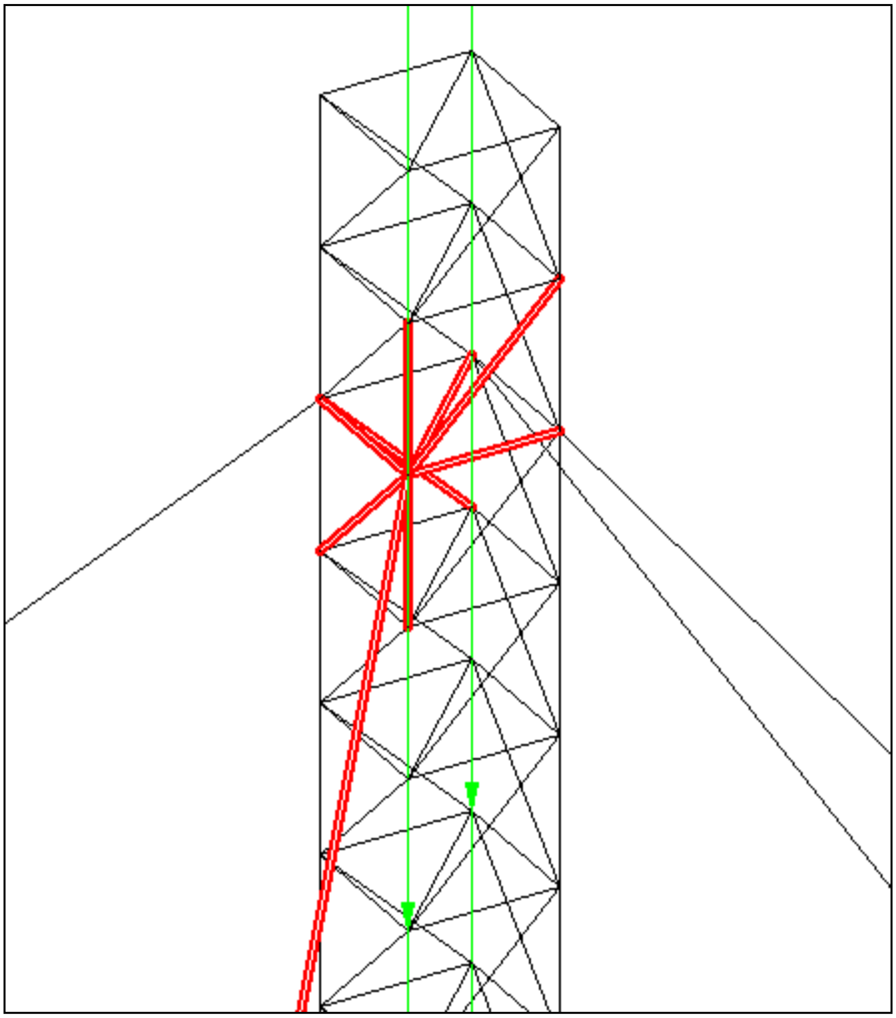


Fig 4.17: Beam stresses at intersection of guy cables and tower 1m from top

Observations noted:

1. Moment at the intersection of guy cables and tower, 25 m from the base: 0 KN-m
2. Beam stresses along vertical direction at the intersection of guy cables and tower, 25 m from the base: 0 KN
3. Beam stresses along horizontal direction at the intersection of guy cables and tower , 25 m from the base: -3.95 KN

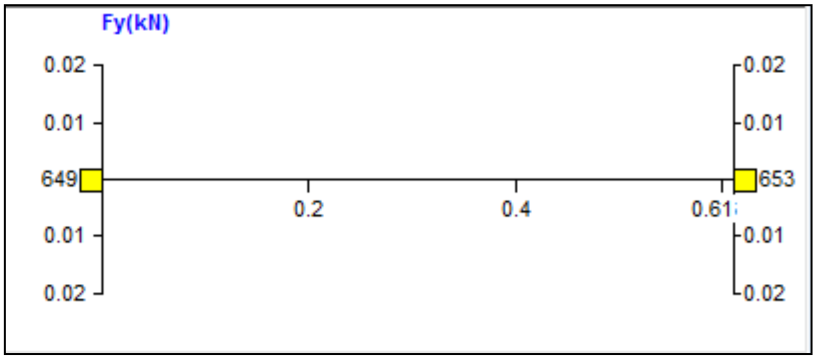


Fig 4.18: Force in vertical direction at fourth intersection

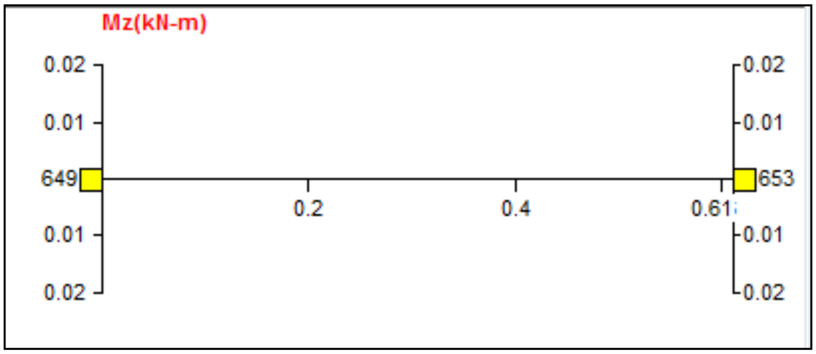


Fig 4.19: Moment at fourth intersection

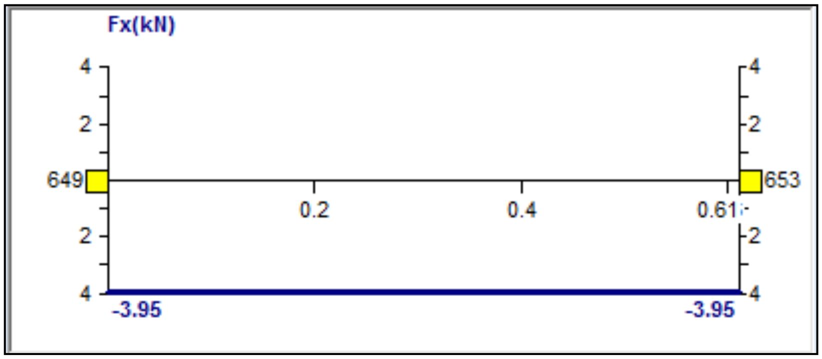


Fig 4.20: Force in horizontal direction at fourth intersection

CHAPTER - 5

CONCLUSIONS

5.1 Recommendations and Conclusions

1. Height of guyed tower makes it very suitable to overcome various difficulties that arise in the normal telecommunication towers in India. Problems such as less coverage area, high traffic issues, because of growing population in the country can be tackled much effectively with the use of guyed towers.
2. Also the cost of making a guyed tower is much less than the conventional telecommunication towers providing the same coverage area as is provided by several telecommunications towers combined.
3. The stability of guyed tower is enhanced by using guy wires all around the structure which makes it more suitable for communication in disaster as well as in emergency situations.

APPENDIX

STAAD Pro Editor File

```
STAAD TRUSS
START JOB INFORMATION
ENGINEER DATE 08-May-19
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
MEMBER INCIDENCES
DEFINE MATERIAL START
ISOTROPIC STEEL
E 2.05e+008
POISSON 0.3
DENSITY 76.8195
ALPHA 1.2e-005
DAMP 0.03
TYPE STEEL
STRENGTH FY 253200 FU 407800 RY 1.5 RT 1.2
END DEFINE MATERIAL
MEMBER PROPERTY INDIAN
1 TO 2145 TABLE ST ISA55x55x6
MEMBER PROPERTY
2146 TO 2161 PRIS YD 0.05
CONSTANTS
MATERIAL STEEL ALL
MEMBER CABLE
2146 TO 2161 TENSION 0 START
SUPPORTS
1 TO 4 665 TO 670 672 673 PINNED
DEFINE WIND LOAD
TYPE 1 WIND
<! STAAD PRO GENERATED DATA DO NOT MODIFY !!!
ASCE-7-2010:PARAMS 85.000 mph 0 1 1 0 0.000 ft 0.000 ft 0.000 ft 1 -
1 40.000 ft 30.000 ft 25.000 ft 2.000 0.010 0 -
0 0 0 0 0.761 1.000 1.000 0.850 0 -
0 0 0 0.866 0.800 -0.550
!> END GENERATED DATA BLOCK
INT 0.614555 0.614555 0.625063 0.634749 0.643753 0.652179 0.66011 -
 0.667609 0.67473 0.681515 0.688 0.694215 0.700185 0.705932 0.711476 -
```

```
HEIG  0  4.572  5.15815  5.74431  6.33046  6.91662  7.50277  8.08892 -
 8.67508  9.26123  9.84739  10.4335  11.0197  11.6059  12.192
LOAD 2 LOADTYPE Dead  TITLE SAT
JOINT LOAD
617 620 641 644 FY -10
LOAD 3 LOADTYPE Dead  TITLE SELFWEIGHT
SELFWEIGHT Y -1 LIST ALL
LOAD 1 LOADTYPE Wind  TITLE wind
WIND LOAD X 1 TYPE 1 XR -90 90 YR 0 110 ZR -90 90
WIND LOAD Z 1 TYPE 1 XR -90 90 YR 0 110 ZR -90 90
WIND LOAD -X 1 TYPE 1 XR -90 90 YR 0 110 ZR -90 90
WIND LOAD -Z 1 TYPE 1 XR -90 90 YR 0 110 ZR -90 90
PERFORM ANALYSIS PRINT ALL
FINISH
```

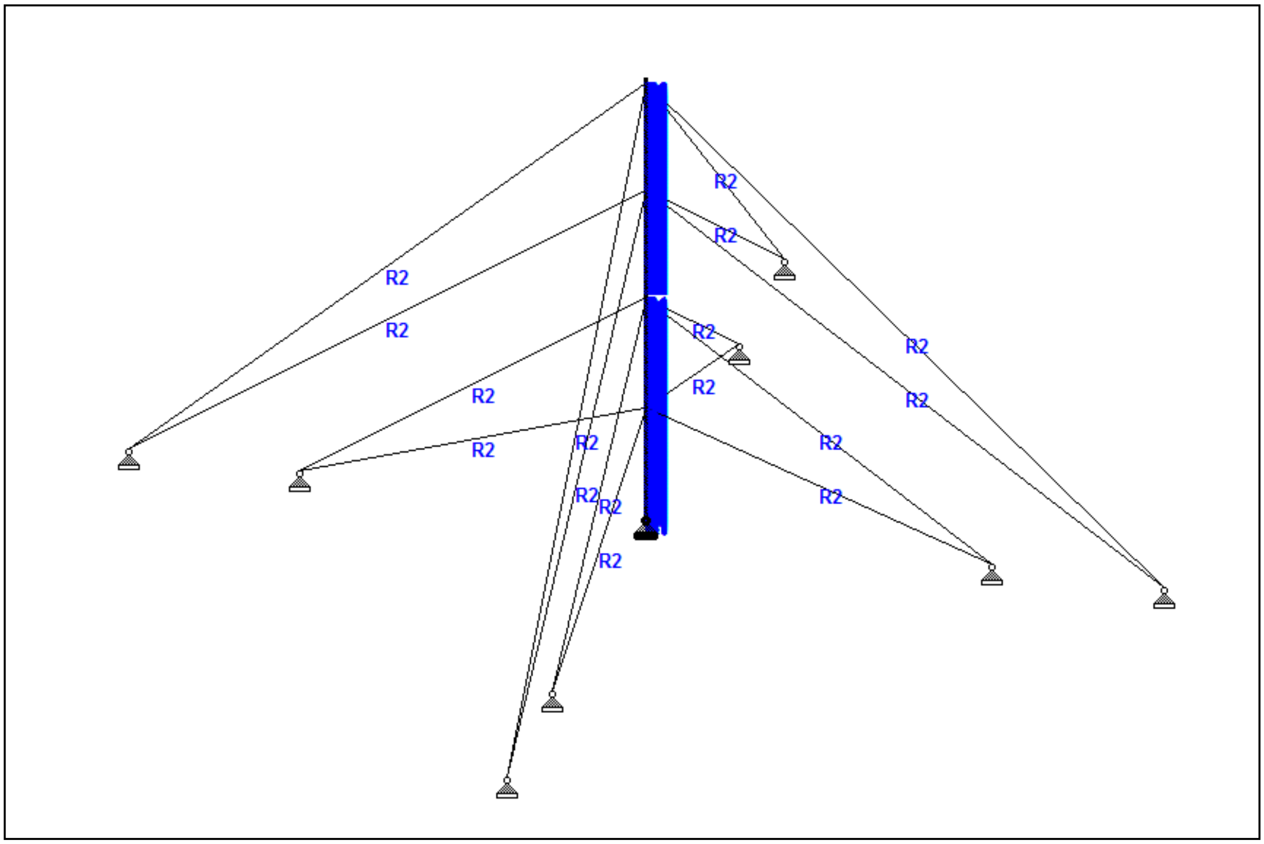
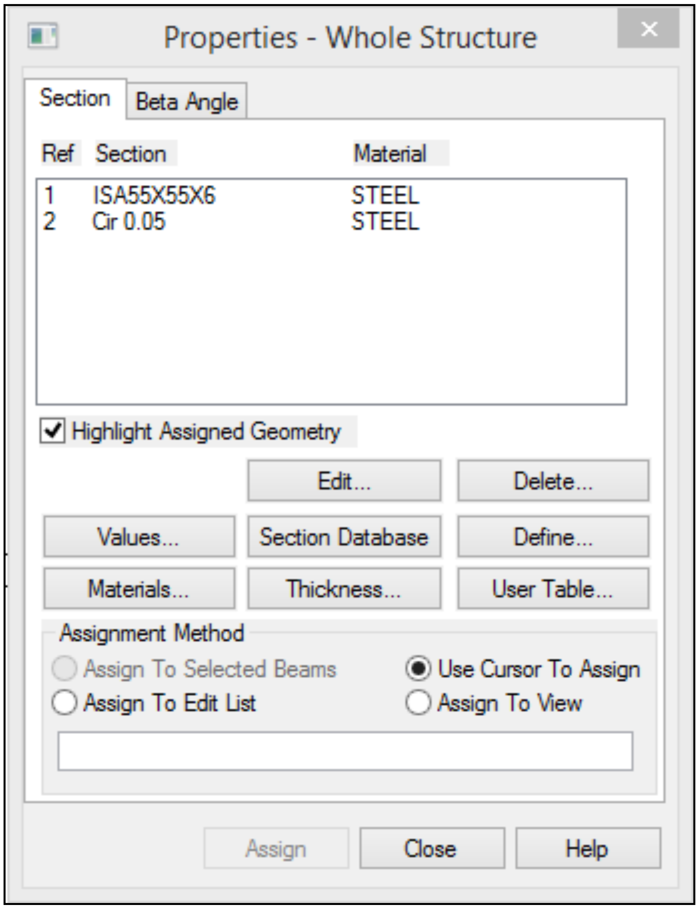


Fig A-1: Section Assignment in STAAD Pro

1. Indian standard angle section of dimension 55x55x6 are used for the tower members in the structure shown in fig
2. Guy wires attached are the cable members of diameter 50 mm in the structure as shown in the fig
3. **R1** represents the properties of the angle section used in tower members and R2 represents the properties of cable members used in guy wires.



Properties - Whole Structure

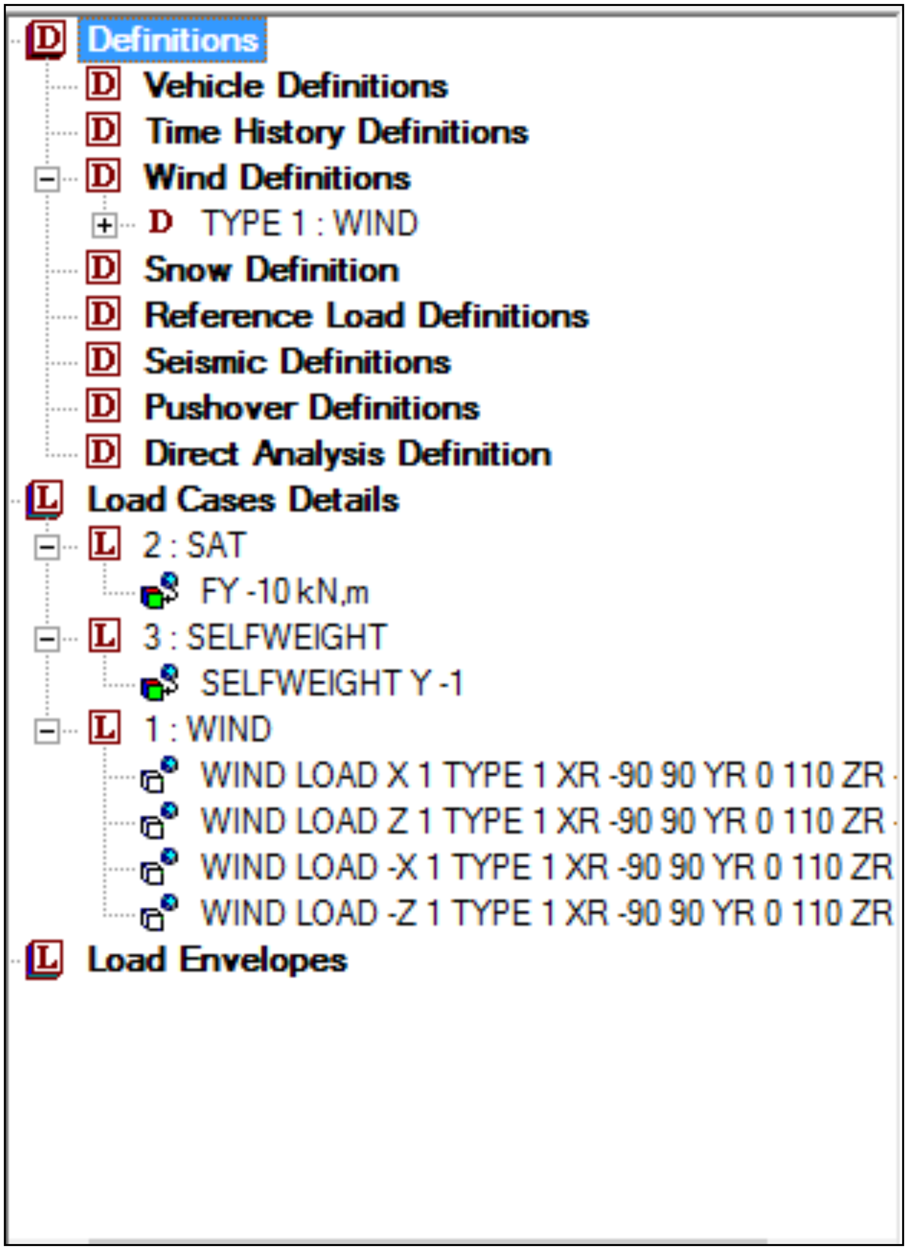
Ref	Section	Material
1	ISA55X55X6	STEEL
2	Cir 0.05	STEEL

☑ Highlight Assigned Geometry

Assignment Method

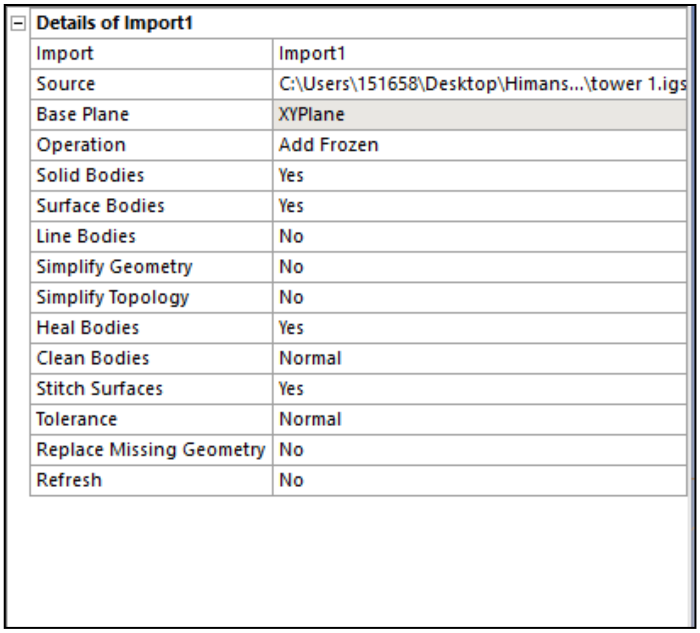
○ Assign To Selected Beams
○ Assign To Edit List
● Use Cursor To Assign
○ Assign To View

Fig A-2: Section Dialogue Box



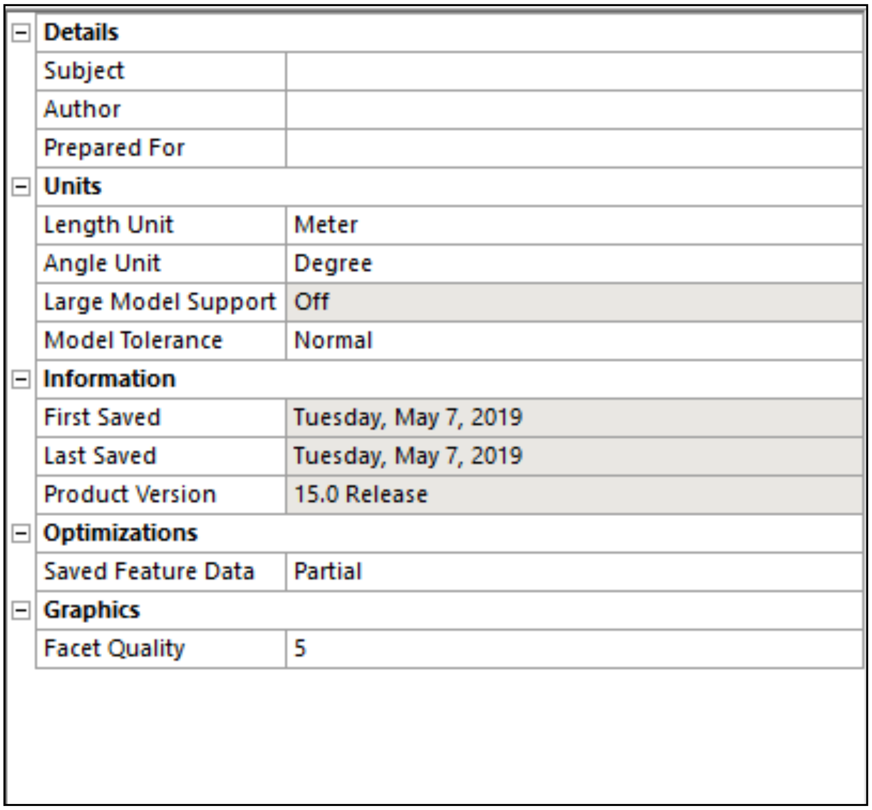
Definitions
Vehicle Definitions
Time History Definitions
Wind Definitions
TYPE 1 : WIND
Snow Definition
Reference Load Definitions
Seismic Definitions
Pushover Definitions
Direct Analysis Definition
Load Cases Details
2 : SAT
FY -10 kN,m
3 : SELFWEIGHT
SELFWEIGHT Y -1
1 : WIND
WIND LOAD X 1 TYPE 1 XR -90 90 YR 0 110 ZR
WIND LOAD Z 1 TYPE 1 XR -90 90 YR 0 110 ZR
WIND LOAD -X 1 TYPE 1 XR -90 90 YR 0 110 ZR
WIND LOAD -Z 1 TYPE 1 XR -90 90 YR 0 110 ZR
Load Envelopes

Fig A-3: Load Case Definitions



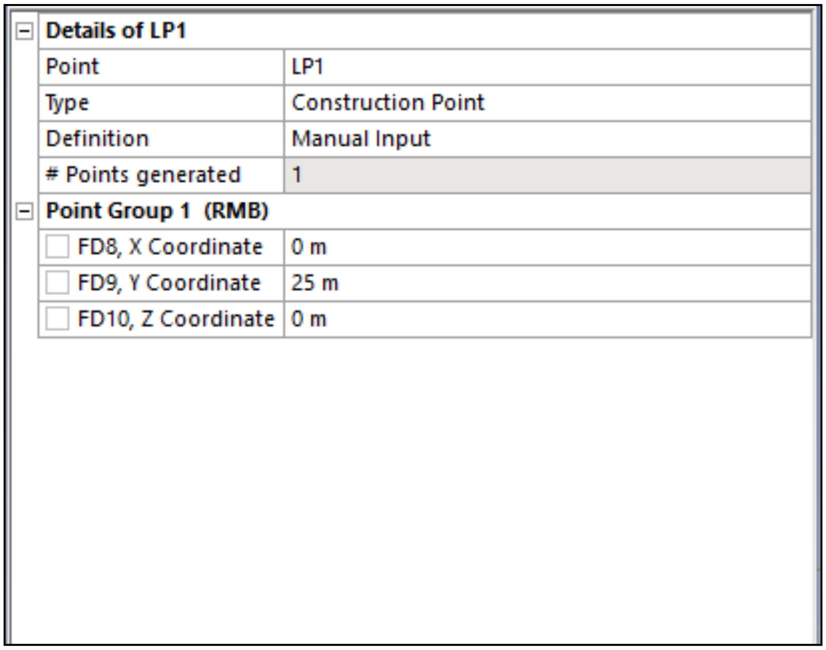
Details of Import1	
Import	Import1
Source	C:\Users\151658\Desktop\Himans...\tower 1.igs
Base Plane	XYPlane
Operation	Add Frozen
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Simplify Geometry	No
Simplify Topology	No
Heal Bodies	Yes
Clean Bodies	Normal
Stitch Surfaces	Yes
Tolerance	Normal
Replace Missing Geometry	No
Refresh	No

Fig A-4: Import details of the geometry.



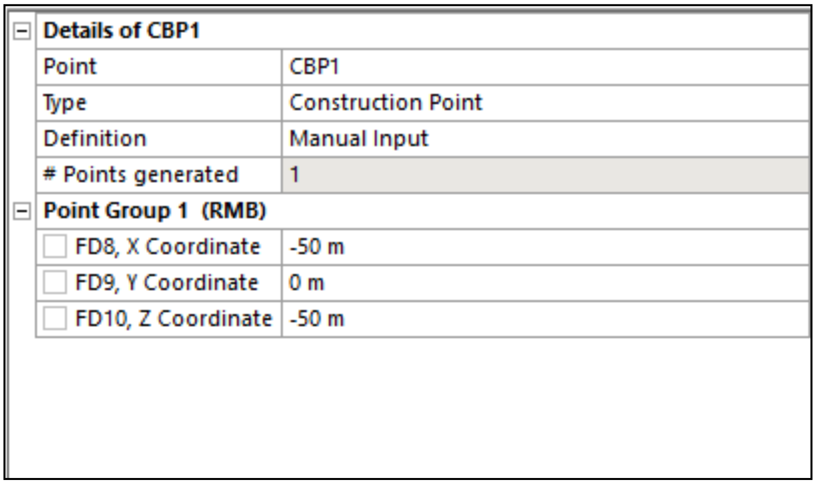
Details	
Subject	
Author	
Prepared For	
Units	
Length Unit	Meter
Angle Unit	Degree
Large Model Support	Off
Model Tolerance	Normal
Information	
First Saved	Tuesday, May 7, 2019
Last Saved	Tuesday, May 7, 2019
Product Version	15.0 Release
Optimizations	
Saved Feature Data	Partial
Graphics	
Facet Quality	5

Fig A-5: Units and Information



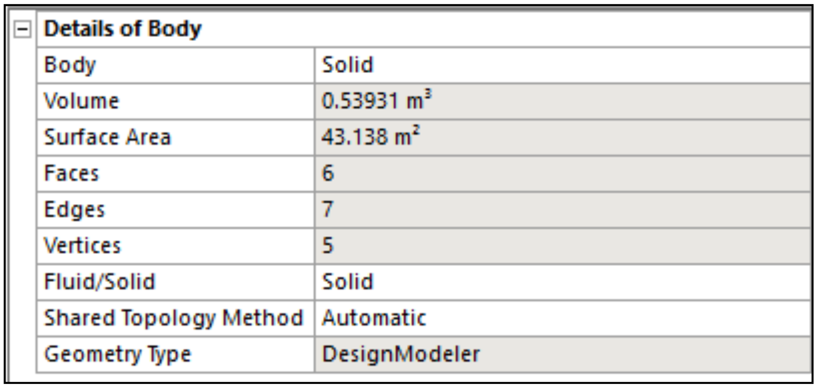
Details of LP1	
Point	LP1
Type	Construction Point
Definition	Manual Input
# Points generated	1
Point Group 1 (RMB)	
☐ FD8, X Coordinate	0 m
☐ FD9, Y Coordinate	25 m
☐ FD10, Z Coordinate	0 m

Fig A-6: Construction Point on the Tower



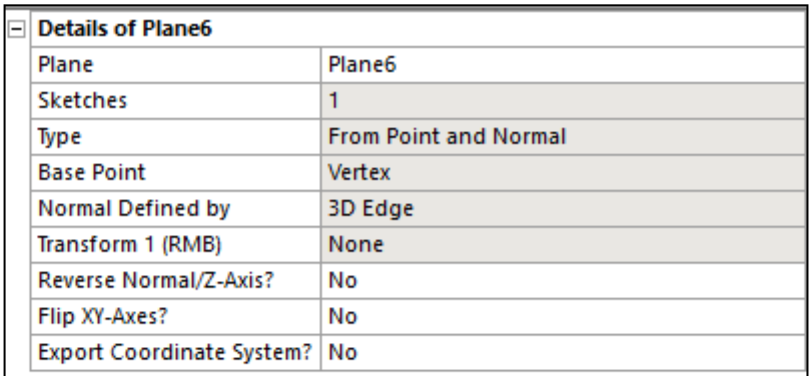
Details of CBP1	
Point	CBP1
Type	Construction Point
Definition	Manual Input
# Points generated	1
Point Group 1 (RMB)	
☐ FD8, X Coordinate	-50 m
☐ FD9, Y Coordinate	0 m
☐ FD10, Z Coordinate	-50 m

Fig A-7: Construction point on Ground



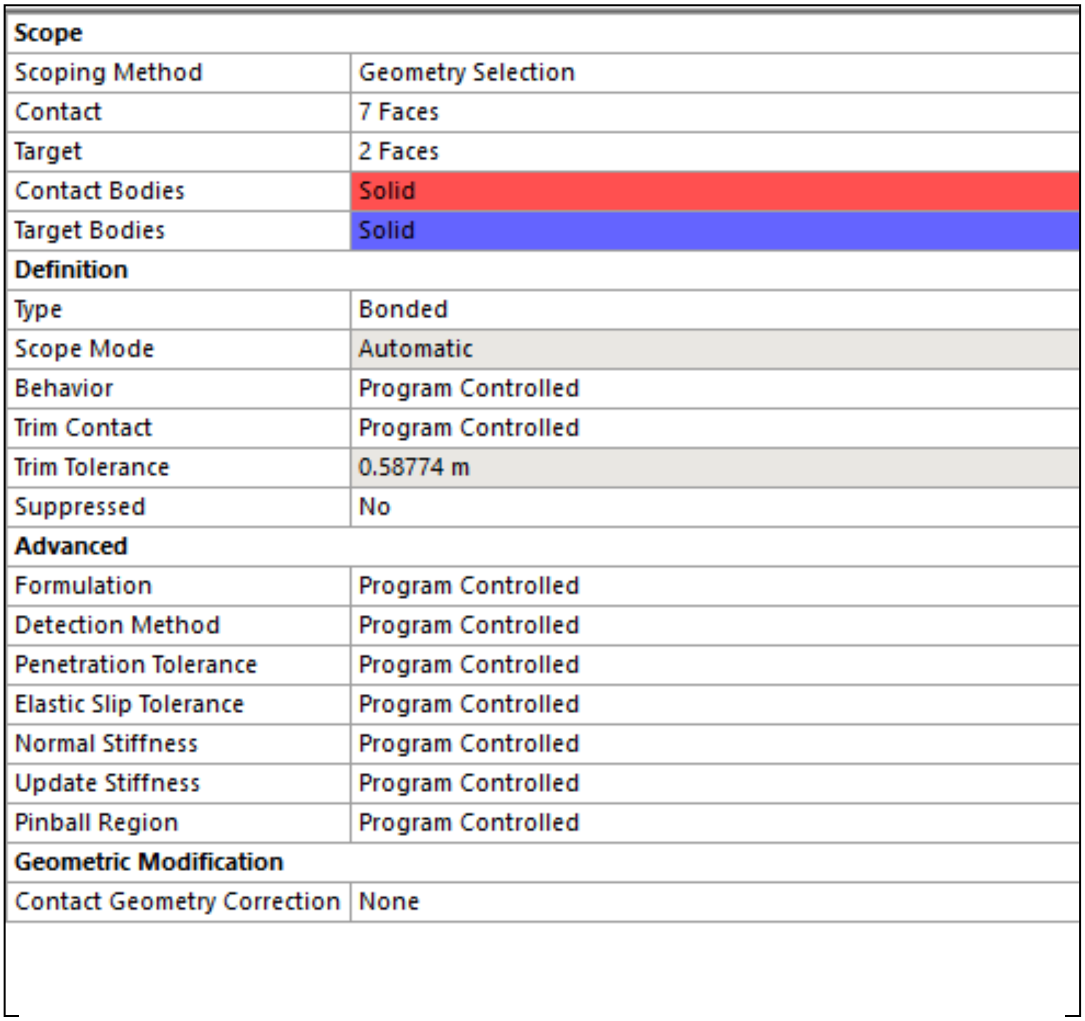
Details of Body	
Body	Solid
Volume	0.53931 m^3
Surface Area	43.138 m^2
Faces	6
Edges	7
Vertices	5
Fluid/Solid	Solid
Shared Topology Method	Automatic
Geometry Type	DesignModeler

Fig A-8: Geometric Details of Body



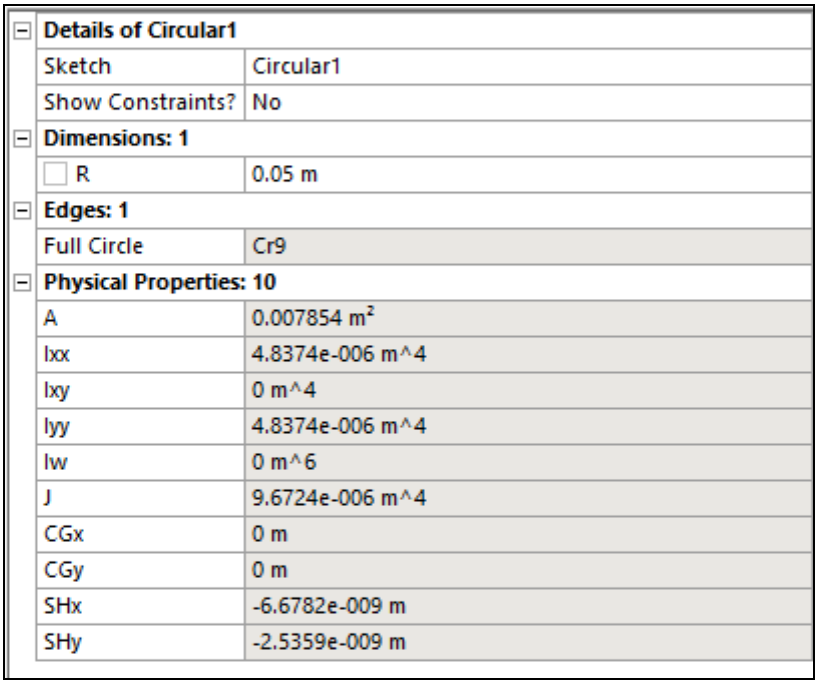
Details of Plane6	
Plane	Plane6
Sketches	1
Type	From Point and Normal
Base Point	Vertex
Normal Defined by	3D Edge
Transform 1 (RMB)	None
Reverse Normal/Z-Axis?	No
Flip XY-Axes?	No
Export Coordinate System?	No

Fig A-9: Creation of Plane for Sweep Command



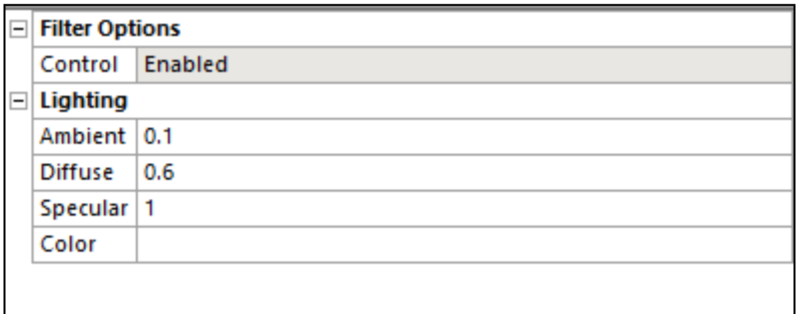
Scope	
Scoping Method	Geometry Selection
Contact	7 Faces
Target	2 Faces
Contact Bodies	Solid
Target Bodies	Solid
Definition	
Type	Bonded
Scope Mode	Automatic
Behavior	Program Controlled
Trim Contact	Program Controlled
Trim Tolerance	0.58774 m
Suppressed	No
Advanced	
Formulation	Program Controlled
Detection Method	Program Controlled
Penetration Tolerance	Program Controlled
Elastic Slip Tolerance	Program Controlled
Normal Stiffness	Program Controlled
Update Stiffness	Program Controlled
Pinball Region	Program Controlled
Geometric Modification	
Contact Geometry Correction	None

Fig A-10: Connection b/w two solid bodies at the intersection



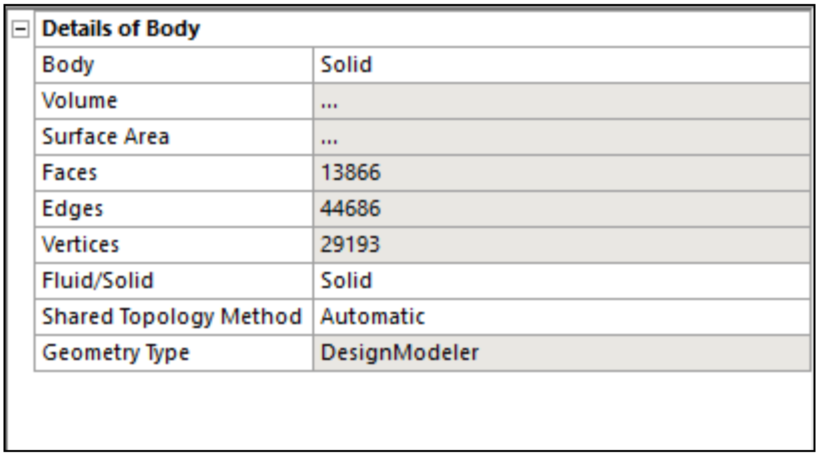
⊟ **Details of Circular1**	
Sketch	Circular1
Show Constraints?	No
⊟ **Dimensions: 1**	
☐ R	0.05 m
⊟ **Edges: 1**	
Full Circle	Cr9
⊟ **Physical Properties: 10**	
A	0.007854 m^2
Ixx	4.8374e-006 m^4
Ixy	0 m^4
Iyy	4.8374e-006 m^4
Iw	0 m^6
J	9.6724e-006 m^4
CGx	0 m
CGy	0 m
SHx	-6.6782e-009 m
SHy	-2.5359e-009 m

Fig A-11: Circular Cross-section for Sweep Command



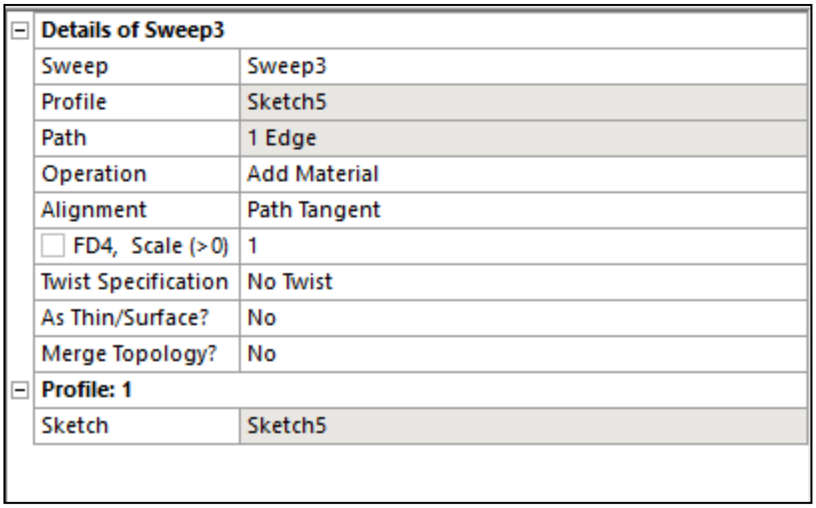
⊟ **Filter Options**	
Control	Enabled
⊟ **Lighting**	
Ambient	0.1
Diffuse	0.6
Specular	1
Color	

Fig A-12: ANSYS mechanical module



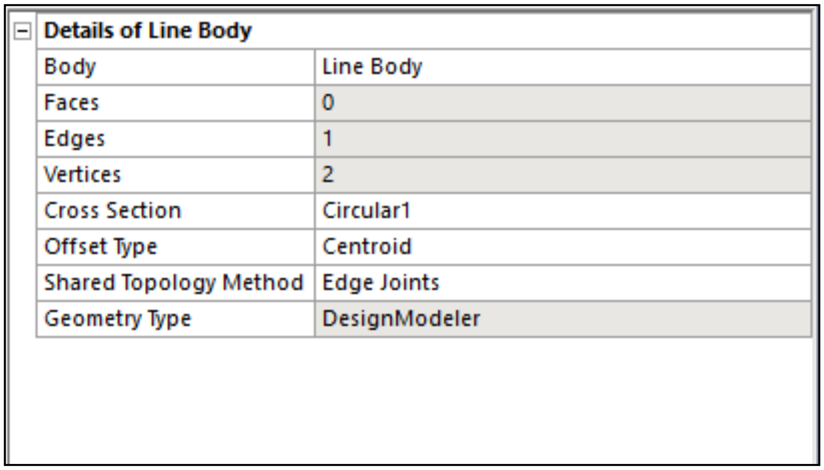
Details of Body	
Body	Solid
Volume	...
Surface Area	...
Faces	13866
Edges	44686
Vertices	29193
Fluid/Solid	Solid
Shared Topology Method	Automatic
Geometry Type	DesignModeler

Fig A-13: Solid Body details for Tower in mechanical module



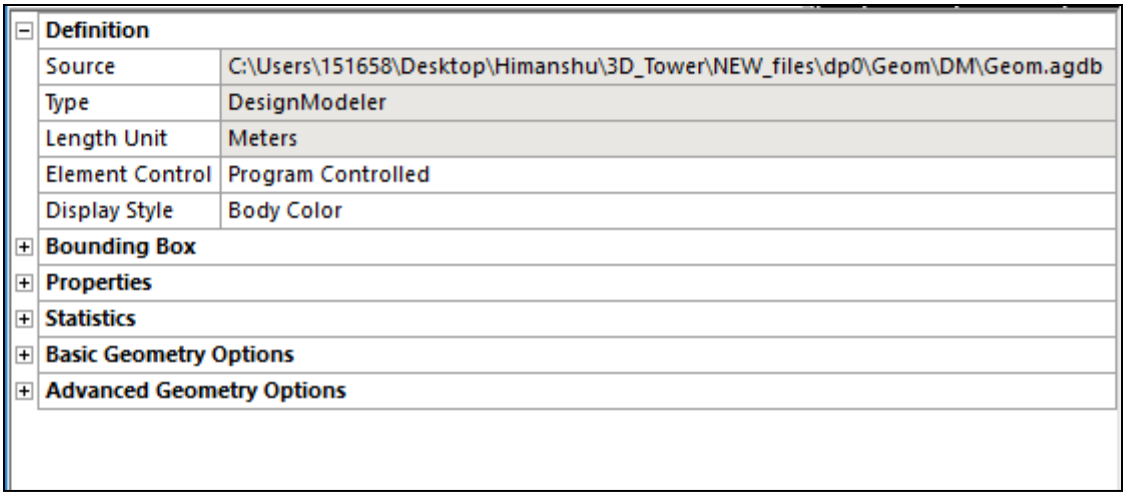
Details of Sweep3	
Sweep	Sweep3
Profile	Sketch5
Path	1 Edge
Operation	Add Material
Alignment	Path Tangent
☐ FD4, Scale (>0)	1
Twist Specification	No Twist
As Thin/Surface?	No
Merge Topology?	No
Profile: 1	
Sketch	Sketch5

Fig A-14: Sweep Command



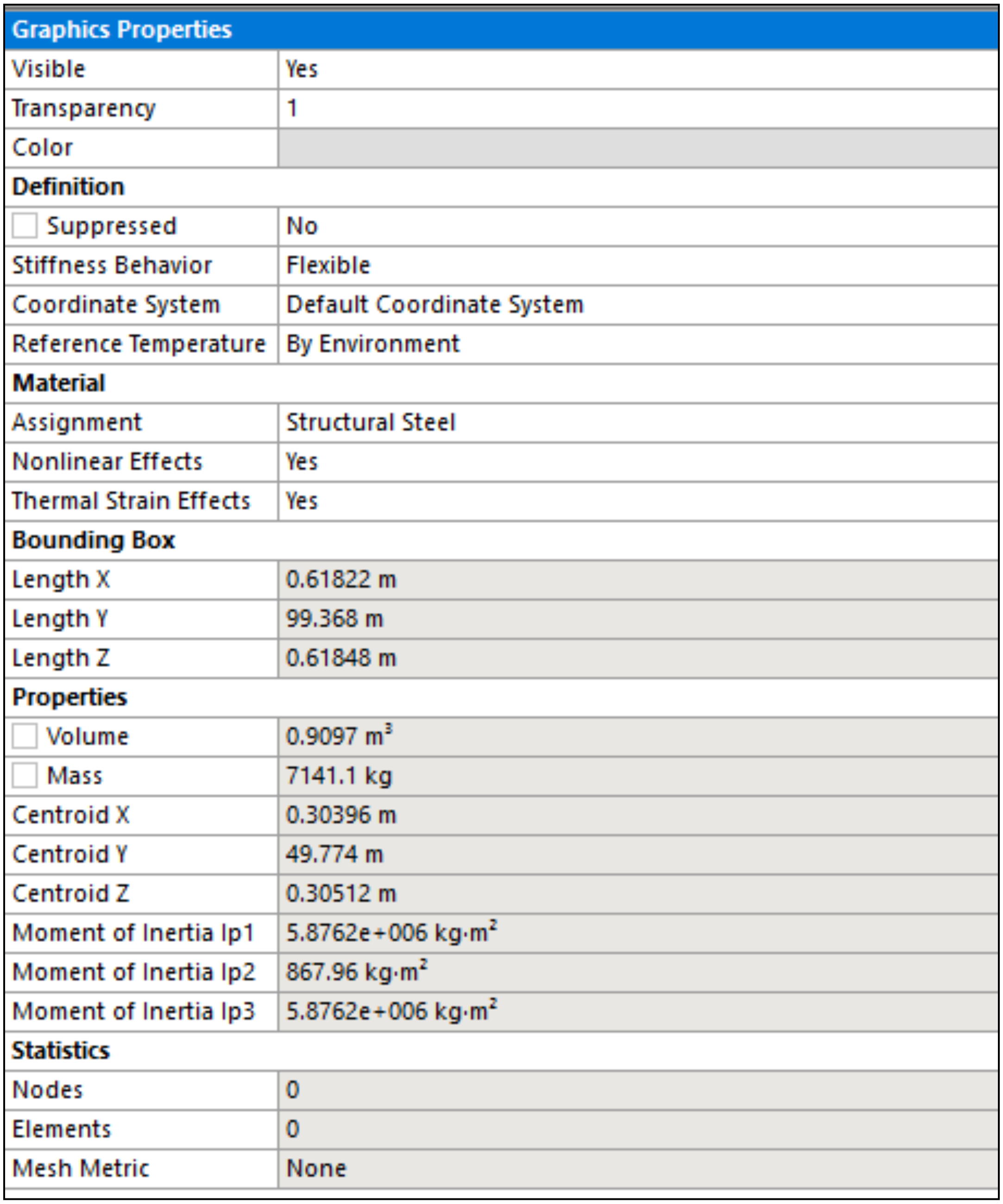
Details of Line Body	
Body	Line Body
Faces	0
Edges	1
Vertices	2
Cross Section	Circular1
Offset Type	Centroid
Shared Topology Method	Edge Joints
Geometry Type	DesignModeler

Fig A-15: Line Body for Guy wire creation



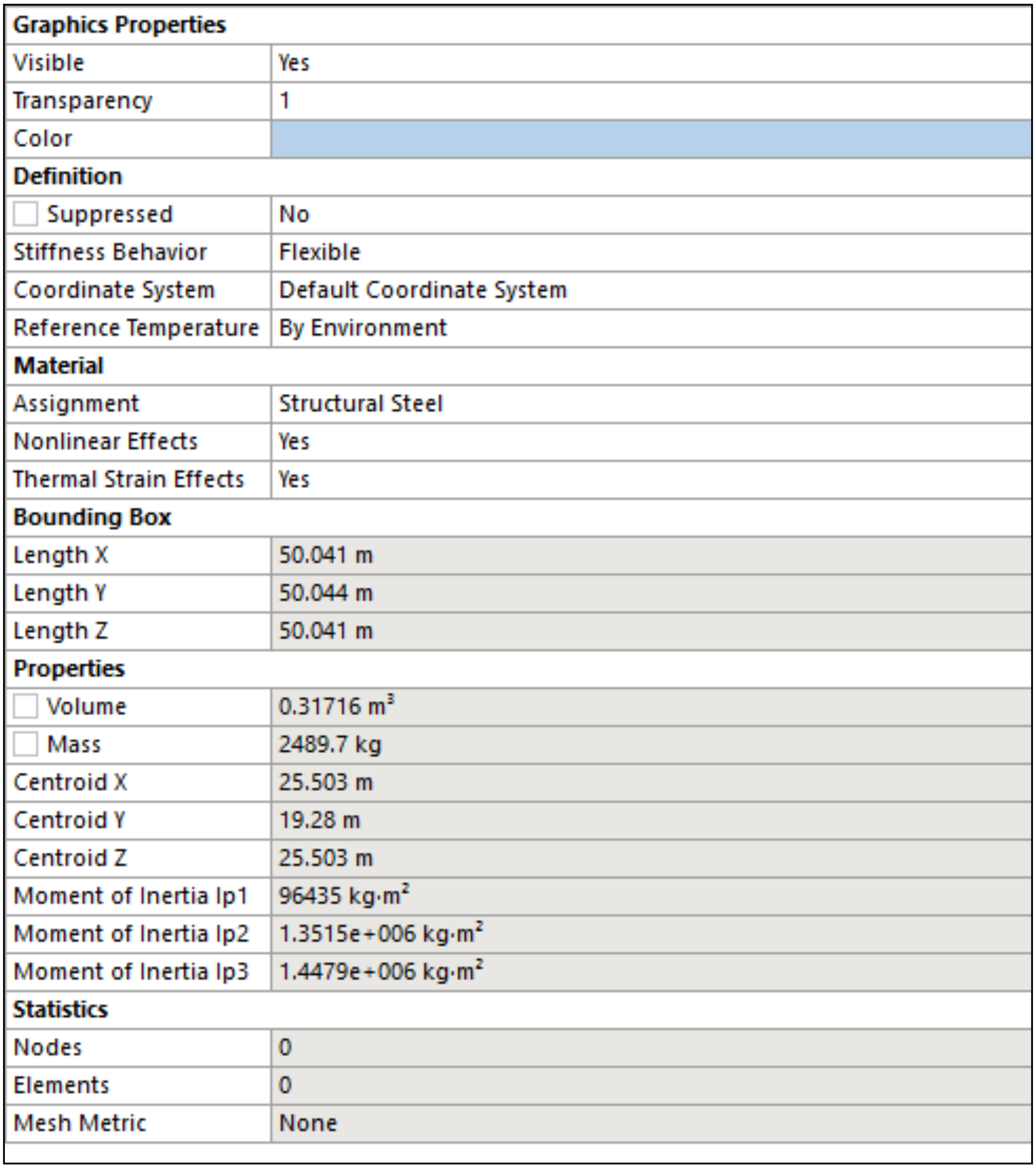
Definition	
Source	C:\Users\151658\Desktop\Himanshu\3D_Tower\NEW_files\dp0\Geom\DM\Geom.agdb
Type	DesignModeler
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Properties	
Statistics	
Basic Geometry Options	
Advanced Geometry Options	

Fig A-16: Design Modeler



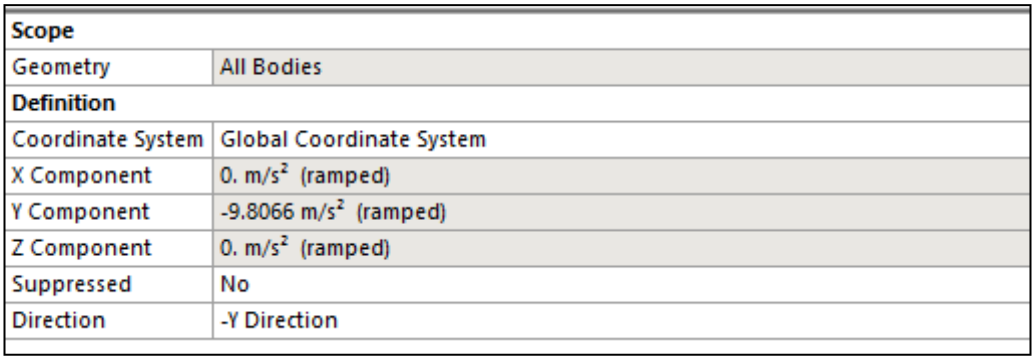
Graphics Properties	
Visible	Yes
Transparency	1
Color	
Definition	
☐ Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Material	
Assignment	Structural Steel
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	0.61822 m
Length Y	99.368 m
Length Z	0.61848 m
Properties	
☐ Volume	0.9097 m^3
☐ Mass	7141.1 kg
Centroid X	0.30396 m
Centroid Y	49.774 m
Centroid Z	0.30512 m
Moment of Inertia Ip1	5.8762e+006 $kg \cdot m^2$
Moment of Inertia Ip2	867.96 $kg \cdot m^2$
Moment of Inertia Ip3	5.8762e+006 $kg \cdot m^2$
Statistics	
Nodes	0
Elements	0
Mesh Metric	None

Fig A-17: Geometric details for Tower Construction



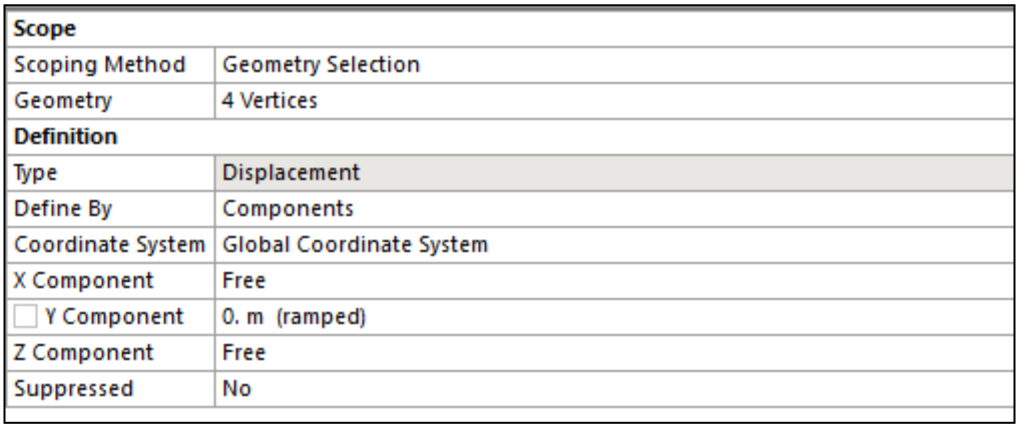
Graphics Properties	
Visible	Yes
Transparency	1
Color	🟦
Definition	
☐ Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Material	
Assignment	Structural Steel
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	50.041 m
Length Y	50.044 m
Length Z	50.041 m
Properties	
☐ Volume	0.31716 m^3
☐ Mass	2489.7 kg
Centroid X	25.503 m
Centroid Y	19.28 m
Centroid Z	25.503 m
Moment of Inertia Ip1	96435 $kg \cdot m^2$
Moment of Inertia Ip2	1.3515e+006 $kg \cdot m^2$
Moment of Inertia Ip3	1.4479e+006 $kg \cdot m^2$
Statistics	
Nodes	0
Elements	0
Mesh Metric	None

Fig A-18: Geometric Details for Guy cable Construction



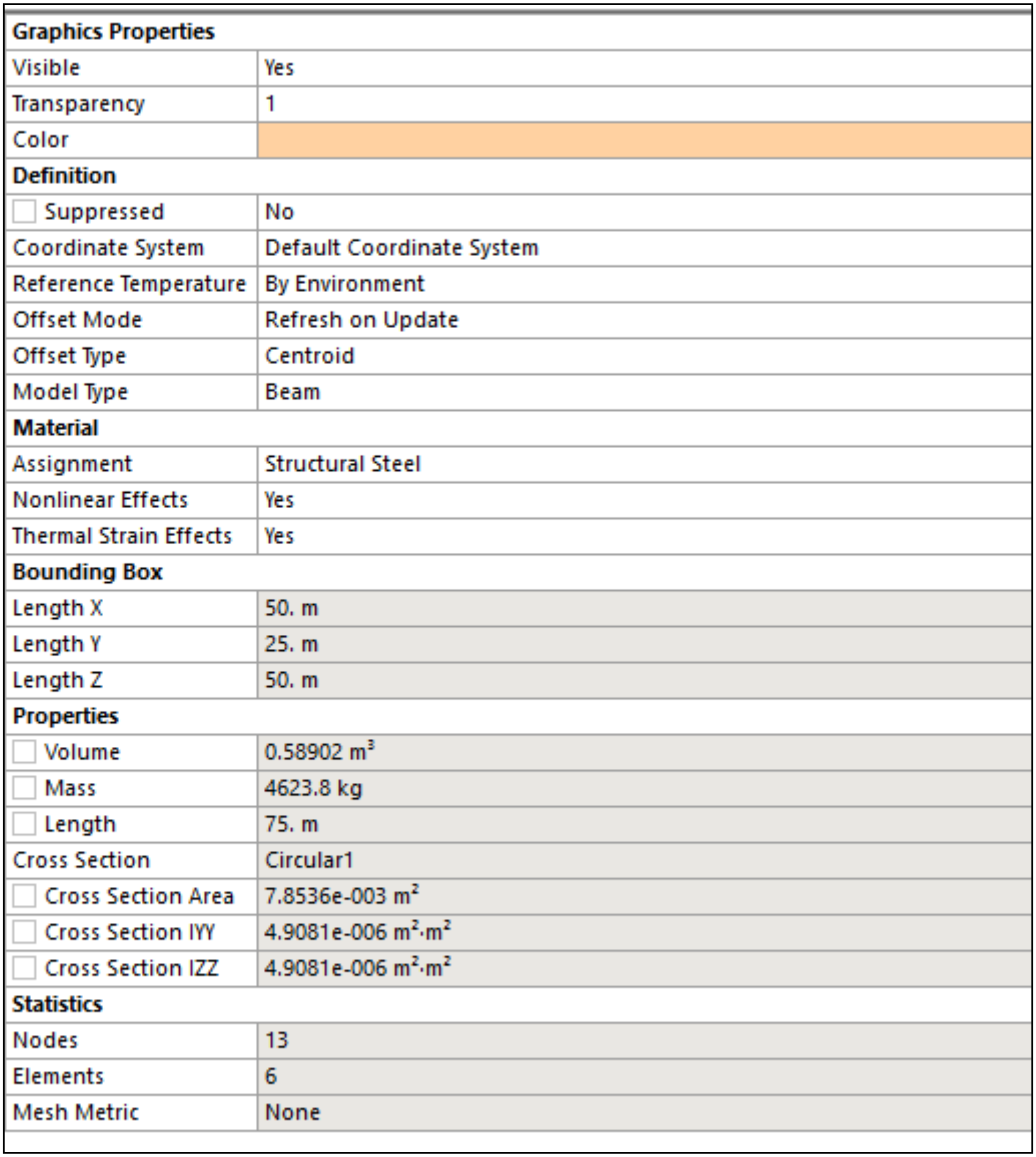
Scope	
Geometry	All Bodies
Definition	
Coordinate System	Global Coordinate System
X Component	0. m/s^2 (ramped)
Y Component	-9.8066 m/s^2 (ramped)
Z Component	0. m/s^2 (ramped)
Suppressed	No
Direction	-Y Direction

Fig A-19: Acceleration due to Gravity.



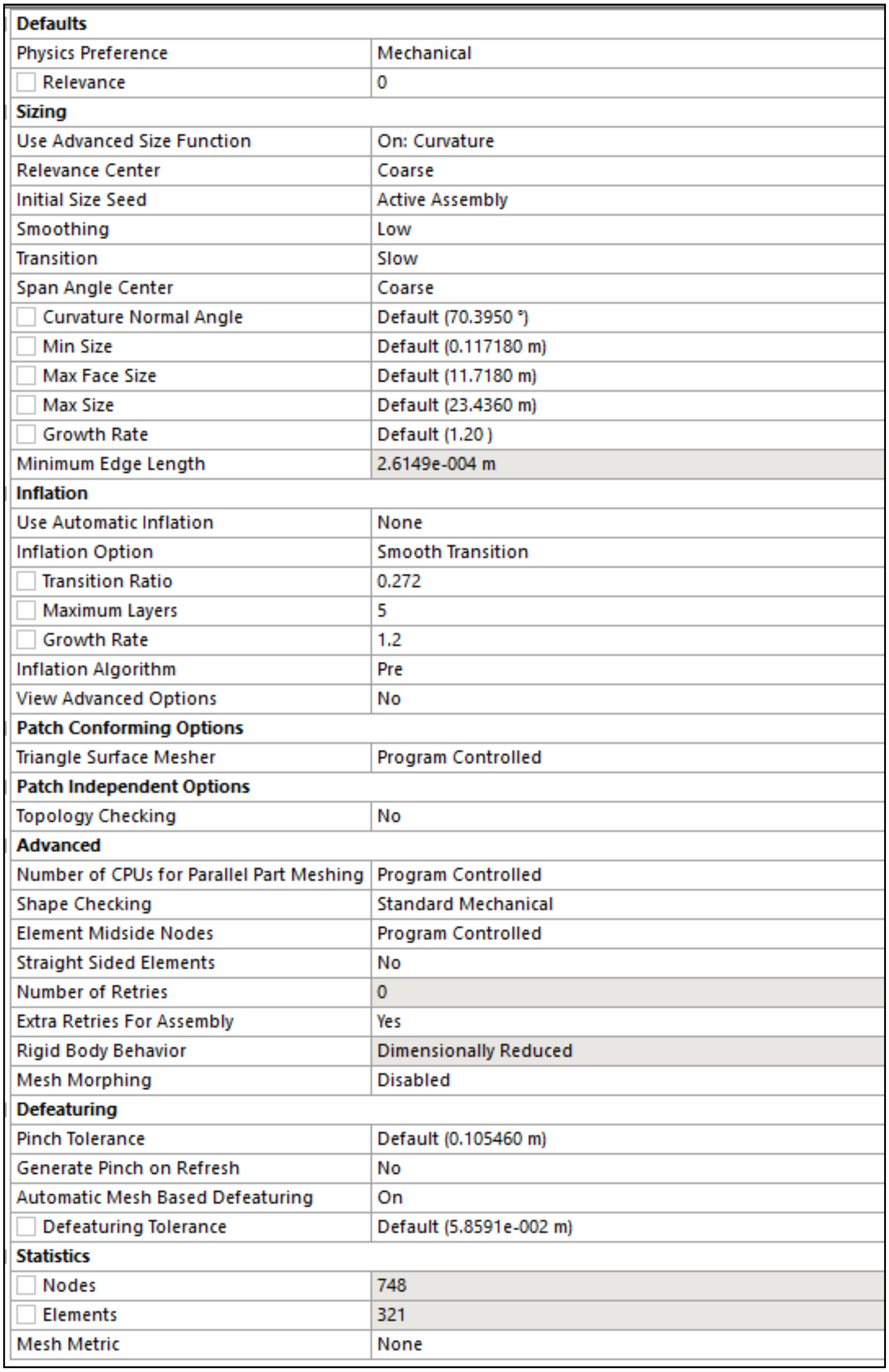
Scope	
Scoping Method	Geometry Selection
Geometry	4 Vertices
Definition	
Type	Displacement
Define By	Components
Coordinate System	Global Coordinate System
X Component	Free
☐ Y Component	0. m (ramped)
Z Component	Free
Suppressed	No

Fig A-20: Displacement Support for the Base



Graphics Properties	
Visible	Yes
Transparency	1
Color	🟧
Definition	
☐ Suppressed	No
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Offset Mode	Refresh on Update
Offset Type	Centroid
Model Type	Beam
Material	
Assignment	Structural Steel
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	50. m
Length Y	25. m
Length Z	50. m
Properties	
☐ Volume	0.58902 m^3
☐ Mass	4623.8 kg
☐ Length	75. m
Cross Section	Circular1
☐ Cross Section Area	7.8536e-003 m^2
☐ Cross Section IYY	4.9081e-006 $m^2 \cdot m^2$
☐ Cross Section IZZ	4.9081e-006 $m^2 \cdot m^2$
Statistics	
Nodes	13
Elements	6
Mesh Metric	None

Fig A-21: Guy Cables



Defaults	
Physics Preference	Mechanical
☐ Relevance	0
Sizing	
Use Advanced Size Function	On: Curvature
Relevance Center	Coarse
Initial Size Seed	Active Assembly
Smoothing	Low
Transition	Slow
Span Angle Center	Coarse
☐ Curvature Normal Angle	Default (70.3950 °)
☐ Min Size	Default (0.117180 m)
☐ Max Face Size	Default (11.7180 m)
☐ Max Size	Default (23.4360 m)
☐ Growth Rate	Default (1.20)
Minimum Edge Length	2.6149e-004 m
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
☐ Transition Ratio	0.272
☐ Maximum Layers	5
☐ Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Patch Conforming Options	
Triangle Surface Mesher	Program Controlled
Patch Independent Options	
Topology Checking	No
Advanced	
Number of CPUs for Parallel Part Meshing	Program Controlled
Shape Checking	Standard Mechanical
Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Number of Retries	0
Extra Retries For Assembly	Yes
Rigid Body Behavior	Dimensionally Reduced
Mesh Morphing	Disabled
Defeaturing	
Pinch Tolerance	Default (0.105460 m)
Generate Pinch on Refresh	No
Automatic Mesh Based Defeaturing	On
☐ Defeaturing Tolerance	Default (5.8591e-002 m)
Statistics	
☐ Nodes	748
☐ Elements	321
Mesh Metric	None

Fig A-22: Meshing Details

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