Analysis and Design of 765 kV Transmission Tower

A Dissertation Submitted in Partial Fulfillment

for the Award of the Degree of

Master of Technology

In

Civil Engineering

(Structures)

Submitted by

Anup Singh

Roll -2K13/STE/06

Under the guidance of:

Dr. Awadhesh Kumar

(Associate Professor)

DEPARTMENT OF CIVIL ENGINEERING

Delhi Technological University

Bawana Road, Delhi 110042

July 2015

CANDIDATE'S DECLARATION

This is to declare that the **Major Project II** on the topic **"Analysis and Design of 765 kV Transmission Tower**" is a bonafied work done by me in partial fulfillment for the requirement of the degree of Master of Structural Engineering (Civil Engineering) from the Delhi Technological University, Delhi.

This project has been carried out under the supervision of **Dr. Awadhesh Kumar.**

.

I do hereby state that I have not submitted the matter embodied in this direction for the award of any other degree.

Name: **Anup Singh**
Roll. No: 2K13/STE/06

CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Dr.Awadhesh Kumar
Associate Professor,
Civil Engineering Department,
Delhi College of Engineering,
Delhi- 110042.

ACKNOWLEDGMENT

It is a privilege to have been a student of Structural Engineering in Delhi Technological University, Delhi. It is matter of great pleasure to acknowledge a great debt of gratitude and respect to my supervisor **Dr. Awadhesh Kumar ,Associate Professor** in Civil Engineering Department for his keen interest and valuable guidance, strong motivation and constant encouragement. I want to thank him for allowing me to work on this project and for his constant help and support throughout my work. I find myself fortunate to have worked under his supervision and giving me valuable time and suggestions and increasing my knowledge through fruitful discussion

I owe my sincere thanks to **Dr. Nirendra Dev, H.O.D** in Civil Engineering Department and all the staff members and friends for all their help, time and moral support provided throughout the year, which went a long way in successful completion of my work.

Name: Anup Singh
Roll No: 2K13/STE/06
Delhi College of Engineering,
Delhi- 110042.

ABSTRACT

Considering the continually expanding interest of electricity in the nation, an effort has been made in this work to break down and improve the outline of the tower design. Transmission Line Towers costs upto 30% of the total cost of the transmission line. Therefore, it is imperative for us to economise the design of the tower, thus a cost analysis has also been done compare the effectiveness of the present transmission line for 765 kV. As the idea of high voltage is not new in the nation ,as endeavor has been made in this work to look at the adequacy and expense helpfulness of transmitting the electricity at high voltage to make the transmission line more savvy by changing the geometry (shape) and conduct (sort) of 765 kV transmission line structure. This target of the work is met by selecting a 765 kV single circuit delta configuration transmission line using Square Base Self Supporting Towers. Utilizing STAAD, Analysis of tower has been completed as a three dimensional structure and the same has been designed using the angle sections.

The compressive stresses, axial forces , maximum node displacements have been plotted and summarized in graphical manner for the configurations considering the angle and tube sections .

Table of Contents

List of Figure

Figure No. **Title**

List of Tables

Figure **Title** .

CHAPTER 1
INTRODUCTION

1.1 Present Status

India has a vast populace living everywhere throughout the nation and the power supply need of this populace makes prerequisite of an extensive transmission and conveyance framework. Likewise, the availability of the essential assets for electrical force era viz. coal, hydro potential, is truly uneven, consequently, again adding to the transmission necessities.[Ref. 12]

The increase in the demand for electrical energy can be met more economically by increasing the power transmission capacity of the transmission lines, alternatively, utilizing saving in the cost of transmission line in this connection by minimizing the cost of transmission line structures is an obvious need.

Transmission line is a coordinated framework comprising of conductor subsystem, ground wire subsystem and one subsystem for every class of support structure. They are outlined and developed in various type of shapes, sorts, sizes, setups and materials. The supporting structure sorts utilized as a part of transmission lines by and large fall into one of the three classes: grid, shaft and guyed. The supports of EHV (Extra High Voltage) transmission lines are typically steel grid towers. The cost of towers constitutes around 28 to 42 percent of the cost of transmission line and thus ideal tower outline will acquire generous reserve funds. The determination of an ideal blueprint together with right sort of supporting framework adds to a substantial degree in adding to an efficient configuration of transmission line tower. [Ref. 14]

Power Grid Corporations of India Limited has prescribed the following steps

Advanced Design of Power Transmission Lines:

1. Survey of existing framework and practices.
2. Choice of clearances.
3. Protector and encasing string outline.
4. Pack conductor studies.
5. Tower setup examination.
6. Tower weight estimation.
7. Establishment volumes estimation.
8. Line cost investigation and compass advancement.
9. Monetary assessment of line.

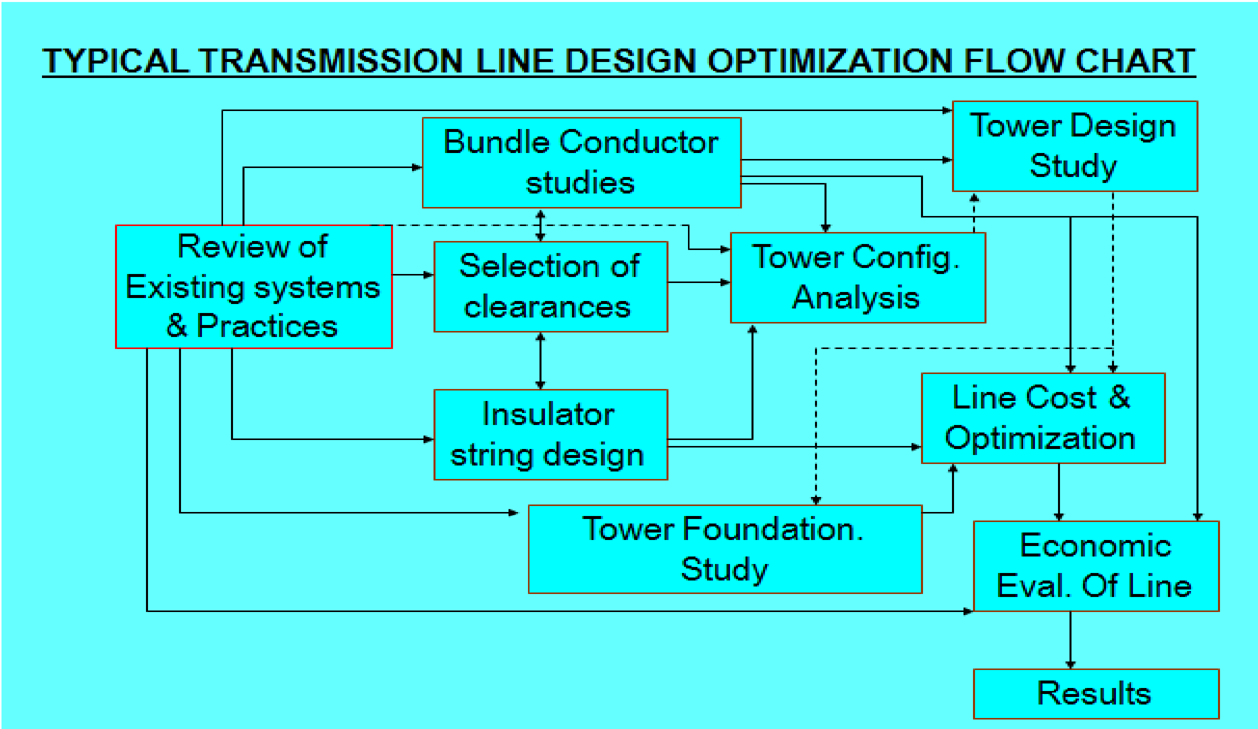


Figure 1.1: Various Steps that are to be followed for Obtaining Results

1.2. OBJECTIVES:

In analysis and design of tower for optimization, the following below mentioned parameters are constrained on the basis of electrical requirements:

1. Base Width
2. Height of the Tower
3. Outline of the Tower

Considering the above restrictions, an attempt has been made to make the transmission line more cost effective by optimizing the geometry (shape) and behavior (type) of transmission line structure. This is done as per the guidelines of Power Grid Corporation of India limited by following the IS Codes and CBIP Manuals with the latest ongoing worldwide research. [Ref. 18]

Following work has been carried to meeting the objectives:

1. Terminology of transmission line and its components have been understood.
2. Literature survey and the on going research work have been studied.
3. Different behaviors of the towers are studied i.e. the self supporting tower and the guyed mast.
4. Methodology for analysis and design of transmission line towers is studied.
5. Finally, worked is done in the direction to find out the most economical configuration/ geometry

CHAPTER 2
LITERATURE REVIEW

2.1 Definition:

Towers consist of tower body, earth wire peaks and cross arms. The transmission voltage, the number of circuits, the height of support and other aspects determine design of tower

2.2 High Voltage Transmission Advantages

High voltage transmission is utilized to exchange the bulk power from sending end to receiving end with lesser losses. EHV transmission has particular burdens, for example, Right of Way losses, protection prerequisite for conductor, radio obstruction and substantial supporting structures (clearance needed between stage to stage and stage to ground increments with increment in voltage. [Ref. 15]

Advantages:

•**No Body Effect**: In HVDC (High Voltage Direct Current) transmission current appropriates consistently over the cross segment of the conductor. Subsequently no losses because of skin impact is experienced. For the same current conveying limit HVDC lines have lesser cross area contrasted with air conditioning high voltage lines

•**Lower Transmission Losses**: HVDC (High Voltage Direct Current) transmission requires just two conductors. Hence the force losses in DC line will be lesser contrasted with air conditioning line .

•**Better voltage Regulation**: In DC lines voltage drop does not exist because of inductive reactance. Voltage Regulation will be better in HVDC transmission

•**Surge Impedance Load**: Long EHV lines are stacked to under 80% of characteristic burden. No such condition is required in HVDC transmission

•**No Line Loading Limi**t: The passable stacking breaking point on EHV AC lines are constrained by the transient strength utmost and the line reactance to very nearly 33% of the warm evaluating of the conductors. No such breaking point exist on account of HVDC line

•**Lesser Coronae Loss and Radio Interference**: Corona Loss specifically relative to recurrence. Accordingly in DC line corona losses will be lesser contrasted with AC line

•**Higher working Voltages**: Insulation design of the conductors for high voltage transmission lines relies upon the exchanging surges yet not on lightning surges (for voltages past 400 kV exchanging surges are more serious than lightning surges). The level of exchanging surge will be lesser in DC line contrasted with air conditioning line. Consequently less protection is needed in DC line

•**Reactive Power Absorption**: Unlike AC line/DC line does not require any responsive force remuneration gadgets. This is a result of the non attendance of charging streams and force variable operation.

- Short circuit streams amid issue in DC line will be lesser contrasted with air conditioning lines.

- Absence of the charging streams and confinements
- Economical and higher reliability

Table 2.1 :Real Value And Nominal Voltage Value of Various HVAC/HVDC

Voltages (kV_{rms})				
	Normal rating		Emergency rating	
Nominal	Maximum	Minimum	Maximum	Minimum
765	800	728	800	713
400	420	380	420	372
230	245	207	245	202
220	245	198	245	194
132	145	122	145	119
110	123	99	123	97
66	72.5	60	72.5	59

2.3. Types of Suspension Supports

2.3.1 Suspension Supports

Suspension Supports carry the conductor in a straight line. During normal operation, they do not transfer conductor tensile forces to the support and therefore can be designed relatively light weight.

2.3.2 Angle Suspension Supports

They serve as suspension supports for the conductors where the line changes direction at line angle deflections. In this case, the suspension insulator are used for line deflections between 0^o and 20^o .

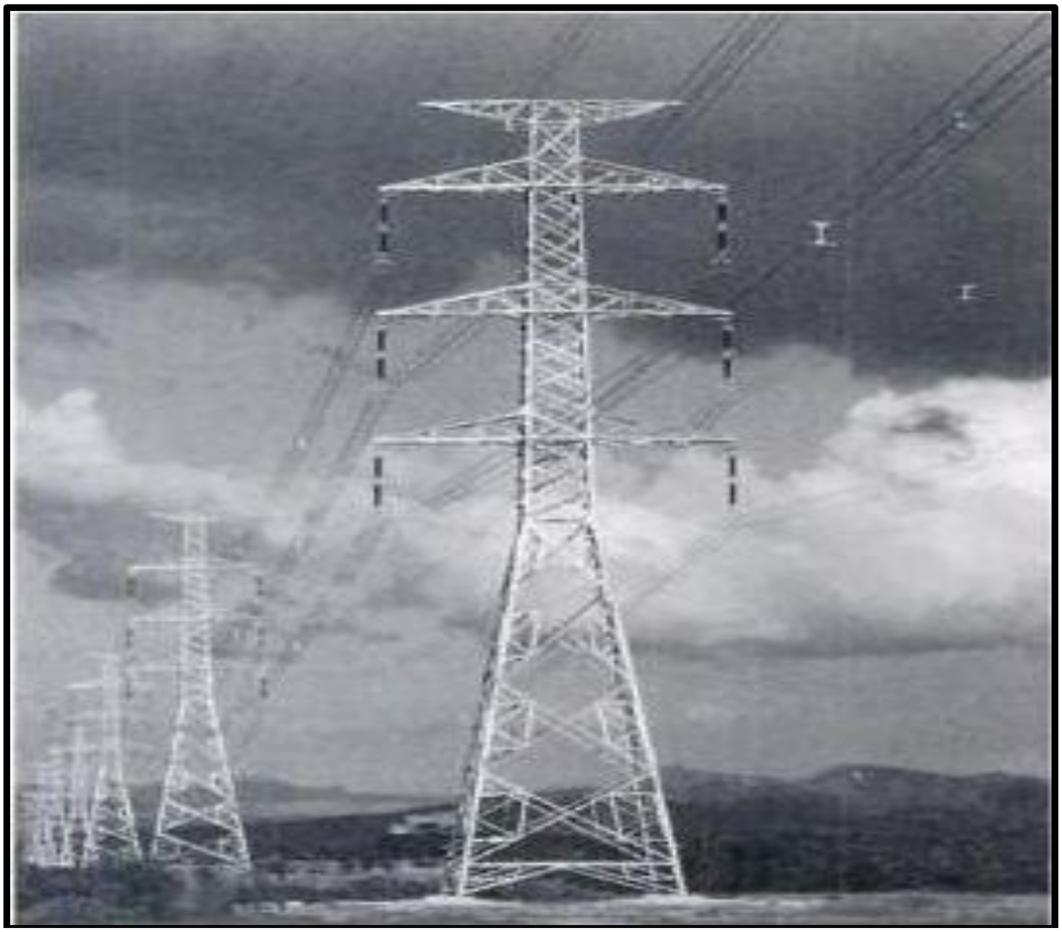


Figure 2.1 : Suspension tower with tension insulator sets

2.3.3 Angle Supports

They carry the resulting conductor tensile forces where the line changes direction at line deflections. Unlike the angle suspension supports, they consists of tension insulator sets.

2.3.4 Strain and Angle Strain Support

They carry the conductor tensile forces in the line direction or in the resultant direction. These are designed for conductor tensile forces in both line directions and secure the line against cascading failures.

2.3.5 Dead End Supports

They carry the total conductor tensile forces in line direction on one side.Thus many a times these supports are additionally loaded by the conductors (belonging to substation portals) which act often under large angle to horizontal and with conductor tensile forces caused by short distances to portal.

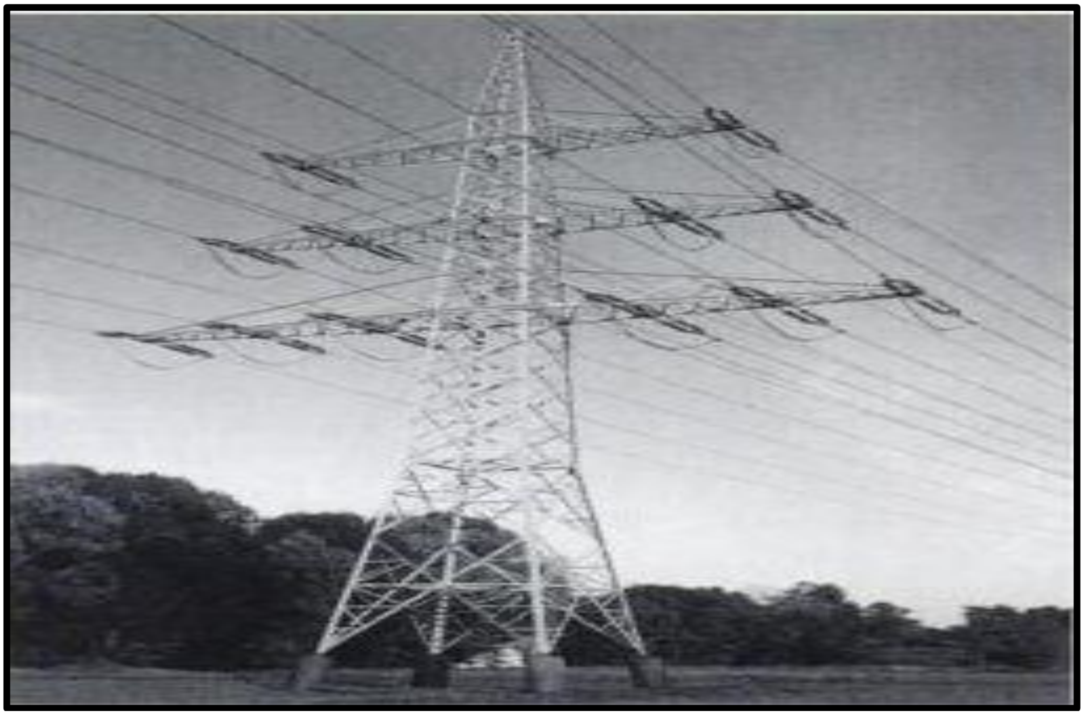


Figure 2.2 : Strain support with tension insulator support

2.4 Determination of Transmission Line System

The determination of support outline is a delicate issue, which depends upon the following parameters.

- There ought to be full usage of the privilege –of –way as the accessibility of area is dependably a problem. Thus multi circuit lines or smaller lines ought to be considered.
- Effect of electrical and attractive fields, the visual and area Impact ought to be considered.
- Number of circuits to be introduced.
- Keraunic level and the plans of earth wires.
- The Terrain and its selection for the compass lengths and support locales The transmission line is an element of the line voltage. The general execution of an overhead transmission line is an element of the execution of different segments constituting the transmission line.

2.5 COMPONENTS OF A TRANSMISSION LINE

The transmission line is considered as an incorporated framework comprising of subsystems :

- Conductor subsystem comprising of conductor and its holding clasps.
- Ground wire subsystem comprising of ground wire and its holding clasps.
- One subsystem for every class of support structure i.e. for a specific grid structure, the segments are point part, jolts, establishments.

The right determination of aforementioned segments are interrelated to each other. The determination of transmitter and ground wire is subject to the hang attributes of both furthermore reliant on the compass of the transmission line which in swings identifies with the spotting of the towers along the line. Tower spotting is itself a component of tower sort.

Tower spotting along the line further rely upon the point of line deviation. The compass of transmission line and point of line deviation can further be improve for getting the best results. Indeed, even the balance sort is additionally an element of these two parameters. The wise choice in the conduits, covers and ground wire outline of towers with there spotting and erection can bring the expense adequacy of the transmission line. [Ref. 3]

2.6. SAG TENSION CALCULATION

Proper evaluation of sags and tensions are necessary at the design stage for fixing up the ruling span and structural requirements of line supports.
During erection of the overhead lines, the sags and tensions to be allowed for various spans under the ambient conditions will also have to be properly evaluated, so that the lines may give long and trouble free service. Various methods, analytical and graphical, have been devised to determine the sags and tensions.
Sag tension calculations fix up the conductor and insulator sub system. Sag Tension are required in the decision for fixing up ruling span and in fixing up the outline of the tower, thus, indirectly also decides the tower subsystem. [Ref. 7]

The spacing required between the ground wires and conductors at null points to ensure that a lightning stroke which hits the ground wire does not flashover to the conductor is called as mid span clearance. Thus, from the protection point of view, the ground wire is strung with a lesser sag (10 to 15%) than the conductor so as to give a mid span separation greater than the supports.

Indian Standard codes of practice for Use of Structural Steel in Over Head Transmission Line Towers have recommended after conditions for the hang tension estimations for the conduit and the ground wire:

• Maximum temperature (75^{o} C for ASCR and 53^{o} C for ground wire) with outline wind weight (0% and 36%).

• Every day temperature (32^0) and configuration wind weight (100%, 75% and 0%). • Minimum temperature (0^0) with configuration wind weight (0% and 36%).
IS 802: Part 1:sec 1: 1995 states that Conductor/ ground wire strain at consistently temperature and without outside burden ought not surpass 25 % (up to 220 kV) for channels and 20% for ground wires of there extreme elasticity.

2.7 CONFIGURATION OF TOWER

A transmission line tower, similar to some other uncovered structure, has a super structure suitably molded, dimensioned and intended to maintain the outer burdens following up on the hung links (conveyors and ground wires) and the super structure itself. The super structure has a trunk and a hamper (enclosure) to which links are joined, either through encasings or straightforwardly. Suffice it to say, a tower is all that much like a tall tree.

A.S.C.E manual "Rules for Electrical Transmission Line Structural Loading" has recognized the general arrangement of a transmission line structure on the premise of taking after necessities:

• Ground clearance requirements
• Electric air gap clearance requirements
• Electric and magnetic field limits
• Insulation requirements
• Structural loading
• Number of circuits
• Right of way requirements
• Aesthetic design criteria

Bracing systems

Bracing makes the structure stable and rigid. Following are the most adopted bracing system for transmission line towers. Bracing patterns should be selected considering both economic and structural stability

2.7.1 Supporting Frameworks

Supporting makes the structure steady and inflexible. Taking after are the most received supporting framework for transmission line towers. Propping examples ought to be chosen considering both monetary and basic steadiness.

2.7.2 Single web Framework

It comprises either diagonals or struts. This supporting framework is basically utilized for little based towers, in cross-arm. This kind of supporting framework is generally used for 66 kV single circuit towers, and has little application for wide-based towers of higher voltages .

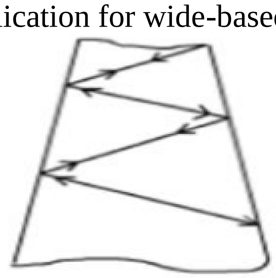


Figure 2.3: Single web Frame work

2.7.3 Double web or Warren Framework

This propping framework is of askew cross bracings. Shear is just as conveyed by the two diagonals,one in tension and the other in strain yet both the diagonals are intended for tension and strain so it won't fizzle when the heap switches. The inclined props are associated at their cross focuses. Discriminating length is more or less a large portion of that of a relating single web framework as the shear prelude is conveyed by two individuals. This arrangement of propping is monetarily received for both high and low towers.

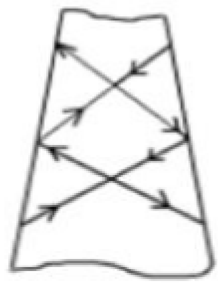


Figure 2.4: Warren Framework

2.7.4 Pratt Framework

This framework likewise has inclined cross bracings and, furthermore, it has even struts. These struts are subjected to tension and the shear is taken completely by one inclining in strain, the other slanting acting like a repetitive part. It is practical to utilize the Pratt bracings for the base and Warren bracings at the upper statures.

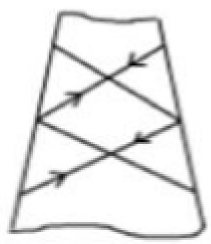


Figure 2.5: Pratt Framework

2.7.5 Portal framework

The diagonals are designed for carrying both tension and compression forces therefore its provides stiffness than the other system. For better performance both warren and Pratt system can be used with portal system.

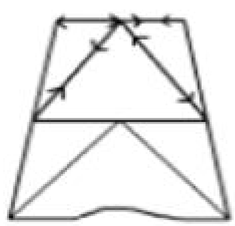


Figure 2.6: Portal framework

IS 802: Part 1: Sec: 1:1995 states that the configuration of a transmission line tower is dependant on the accompanying parameters:

• The length of the insulator assembly.
• The minimum clearances to be maintained between conductors and between conductor and tower.
• The location of ground wire or wires with respect to the outermost conductor.
• The mid span clearance required from considerations of the dynamic behavior of conductors and lightning protection of the line.
• The minimum clearance of the lowest conductor above ground level

CBIP in its "Transmission Line Manual" has summed up the total height of a transmission line tower as [Ref. 8]
:

2.8 Clearances

2.8.1 Minimum allowable ground Clearance

It is the minimum distance from the ground to the lowest point of the bottom conductor. It is fixed as per the requirement of electric air gap clearance and the electric and magnetic field limitations.

2.8.2 Maximum sag

The sag of the conductor is defined as the distance between the point of attachment of the cable to the insulator/ tower and the null point in the cable (earth wire and conductor). It is dependent on the size and type of conductor, climatic conditions (wind temp., snow) and span length.

2.8.3 Length of suspension insulator string

It is a critical parameter in choosing the stage to least ground metal clearance, which thus chooses the length of cross arms. It is an element of protection level, power recurrence voltage and administration conditions .

2.8.4 Vertical spacing between conductors

It is the minimum permissible spacing maintained between two conductors on the basis of electrical requirements

2.8.5 Vertical clearance between ground wire and top channel

This vertical clearance is decided by the requirement of the peak clearance and the mid span clearance.
Peak clearance is dependant on the angle of shielding made by the ground wire to protect the power conductors against the direct lightning stroke and to conduct the lightning current to the nearest earthed point when contacted by a lightning stroke. Mid span clearance is the spacing

required at the null points between the ground wire and the conductor to safe guard the conductor from flashover during lightning.

2.9 Loading Calculations

CBIP manual "Transmission Line Manual" expresses that Tower stacking is most vital piece of tower configuration. The transmission line tower is a pin jointed light structure for which the greatest wind weight is the boss rule for outline. Further simultaneousness of quake and most extreme wind condition is unrealistic to place together and seismic anxieties are significantly lessened by the adaptability and flexibility for vibration of the structure. This suspicion is additionally in the line with the suggestion given in cl. No. 6.2 (b) of IS-1893-1984.

The loadings which are considered during the project are as follows:

2.9.1 Dead Load

Self weight of tower members, ground wire, conductor, insulator, line man, equipments used during construction and maintenance.

2.9.2 Wind load

Tower exposed member, ground wire, conductor and insulator strings are subjected to wind pressures.

The Loading Criteria for the transmission line as given by CBIP in "Transmission Line Manual" is as follows:
i) Reliability
ii) Security
iii) Safety

Reliability of a transmission system is the probability that the system would perform its function/ task under the designed load criteria for a specified period. Thus, this covers climatic loads such as wind loads and/or ice loads.

Security of a transmission system is the capacity of the system to protect itself from any major failure arising out of the failure of its components. Thus, this covers unbalanced longitudinal loads and torsional loads due to broken wires

Safety of a transmission system is the ability of the system to provide protection against any injuries or loss of lives to human beings out of the failure of any of its components. Thus, this covers loads imposed on tower during the construction of transmission line and loads imposed on tower during the maintenance of transmission line.

Nature of Loads as given by CBIP in "Transmission Line Manual" are as follows:

2.9.3 Transverse loads

This type of load covers
Wind load on tower structure, conductor, ground wire and insulator strings. Component of mechanical tension of conductor and ground wire.

2.9.4 Vertical loads

This type of load covers
i) Loads due to weight of each conductor, ground wire based on appropriate weight span, weight of insulator strings and fittings.
ii) Self weight of the structure.
iii) Loads during construction and maintenance.

2.9.5 Longitudinal loads

This type of load covers
Unbalanced horizontal loads in longitudinal direction due to mechanical tension of conductor and/or ground wire during broken wire condition.

2.9.6 Anti Cascading checks

In order to prevent the cascading failure in line, angle towers are checked for anti cascading loads for all conductors and g. wires broken in the same span.

2.10 SUSPENSION TOWER

2.10.1 Reliability Condition

Transverse loads

These loads shall be calculated as follows:
i) Wind action on tower structures, conductors, ground wires and insulator strings.
ii) Component of mechanical tension of conductor and ground wire due to wind.

NOTE- Since mechanical tension is a longitudinal load according to is code as we have chosen on deviation line. No component will act here.

Thus, total transverse load = F_{wt} + F_{wc}, + F_{wi} + F_{wd}
F_{wt}=Wind load on tower.
F_{wc}=Wind load on conductor and ground wire.
F_{wi}=Wind load on insulator strings.
F_{wd}=Deviation Load.

Where 'F_{wc}', 'F_{wi}' and F_{wd}' are to be applied on all conductors/ground wire points and 'F_{wt}' to be applied on tower at ground wire peak and cross arm levels and at any one convenient level between bottom cross arm and ground level for normal tower.

Vertical loads

This load comprise of:
i) Loads due to weight of conductors/ground wire based on design weight span,weight of insulator strings and accessories
ii) Self weight of tower structure up to point/level under consideration.

The effective weight of the conductor/ground wire should be corresponding to the weight span on the tower. The weight span is the horizontal distance between the lowest points of the conductor/ground wire on the two spans adjacent to the tower under consideration.

Longitudinal loads

i) No longitudinal load for suspension and tension towers.

2.10.2 Security Requirement

a) Transverse loads

i) Transverse loads due to wind action on tower structures, conductors, ground wires and insulators shall be taken as nil.
ii) Transverse loads due to line deviation shall be based on component of mechanical tension of conductors and ground wires corresponding to everyday temperature and nil wind condition.
iii) For broken wire spans the component shall be corresponding to 50 percent mechanical tension of conductor and 100 percent mechanical tension of ground wire at everyday temperature and nil wind load.

a) Vertical Loads

This load comprise of
i) Normal Condition: Loads due to weight of conductors/ground wire based on design weight span, weight of insulator strings and accessories
ii) Broken wire condition : Loads due to weight of conductors/ground wire based on broken wire condition where the load due to weight of conductor/ground wire shall be considered as 60 percent of weight span weight of insulator strings and accessories.
ii) Self weight of tower structure up to point/level under consideration.

b) Longitudinal Load

i) Suspension towers: The longitudinal load corresponding to 50 percent of the mechanical tension of conductor and 100 percent of mechanical tension of ground wire shall be considered under every day temperature and no wind tension.

ii) Broken wires:Horizontal loads in longitudinal direction due to mechanical tension of conductors and ground wire .

2.10.3 Safety Consideration

a) Transverse Load

i) Transverse loads on account of wind on tower structures, conductors, ground wires, and insulators shall be taken as nil for normal and broken wire conditions.

ii) Transverse loads due to mechanical tension of conductors and ground wire at everyday temperature and nil wind condition on account of line deviation shall be taken for both normal and broken wire conditions.

b) Vertical Load

These loads comprise of

i) Normal Condition: Loads due to weight of conductors/ground wire based on design weight span, weight of insulator strings and accessories

ii) Broken wire condition: Loads due to weight of conductors/ground wire based on broken wire condition where the load due to weight of conductor/ground wire shall be considered as 60 percent of weight span, weight of insulator strings and accessories.

iii) Self weight of tower structure up to point/level under consideration.

iv) Load of 1500 N considered on each cross arm, as a provision of lineman with tools,

v) Load of 3500 N considered acting at the tip of cross arms up to 220 kV and 5 000 N for 400 kV and higher voltage for design of cross arms

vi) Following erection loads at lifting points, for 400 kV and higher voltage, assumed as acting at ocations specified below:

Table 2.1 : Load Values for safety Requirements load Values IS : 802-1995

Tension Tower	**Vertical Load, N**	**Distance from the Tip of Cross Arm,mm**
Twin bundle conductor	10 000	600
Multi bundle conductor	20 000	I 000

2.12 Longitudinal Load

i) Normal condition

Suspension Towers : Nil

ii) Broken wire conditions

Suspension towers: Longitudinal load Per sub-conductor and ground wire considered as 10000 N and 5000 N respectively.

2.13. LOADING COMBINATIONS

a) Reliability Conditions

i) Transverse loads
ii) Vertical loads .
iii) Longitudinal loads

b) Security Conditions

i) Transverse loads
ii) Vertical lauds
iii) Longitudinal loads

c) Safety Conditions

i) Transverse loads
ii) Vertical loads shall be the sum of:
- a) Vertical loads as per security considerations multiplied by the overload factor of 2.
- b) Vertical loads calculated as per security consideration safety consideration of vertical loads.

iii) Longitudinal loads

CHAPTER 3
COST ANALYSIS

3.1 General

The Main Parameters which are affecting the reliablity and cost of the transmission towers are Voltage level,Surge Impedance Loading and the Right of Way.These parameters have been summarized in the table below and also presented in a graphical form.

Table 3.1 : Tower Height in Various Transmission Lines(CEA,India)

S.No	Transmission Line	Tower Height
1.	765 kV	52.5 m
2.	400 kV	42 m
3.	220 kV	30 m
4.	132 kV	23 m

Table 3.2 : Right of Way in Various Transmission Lines(CEA,India)

S.No	Transmission Line	Right of way
1.	765 kV	85 m
2.	400 kV	52 m
3.	220 kV	35 m
4.	132 kV	27 m

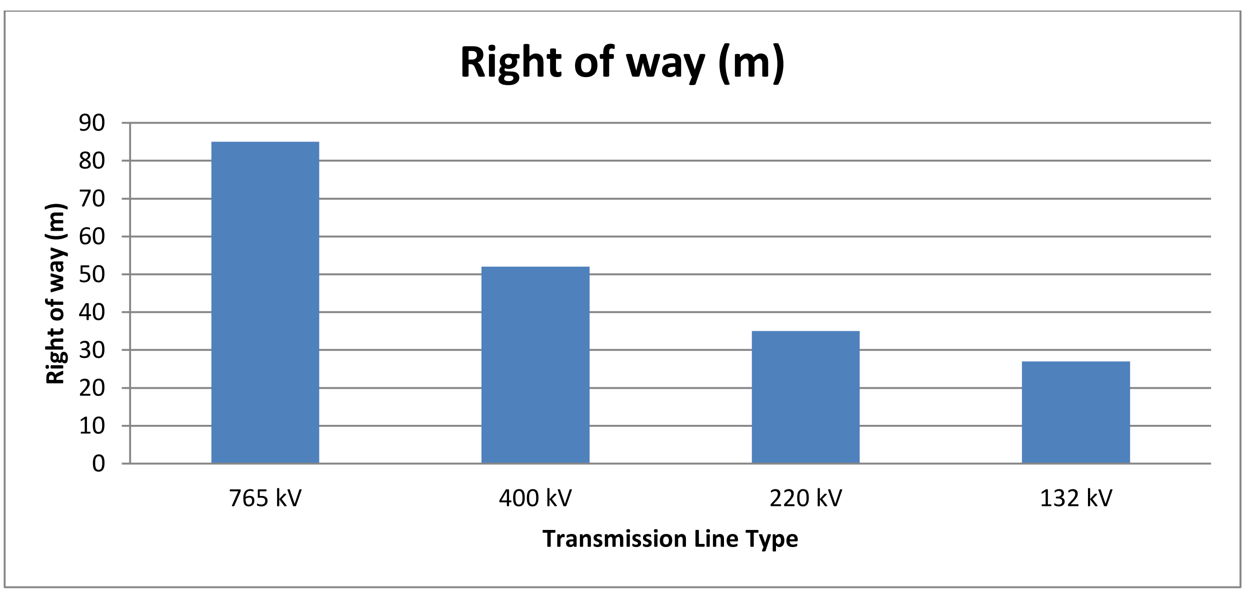


Figure 3.1 : Comparison of Right of Way in Various Transmission Lines

Surge Impedance Loading: It is the unit power factor load over a resistance line such that series reactive loss along the line is equal to shunt capacitive gain . Under these conditions the sending end and receiving end voltages and current are equal in magnitude but different in phase position.

Table 3.3 : Comparison of Power transmission Capacity (MW)

S.No	Transmission Line	Surge Impedance Loading(MW)
1.	765 kV	2200 MW
2.	400 kV	600 MW
3.	220 kV	180 MW
4.	132 kV	65 MW

Table 3.4 : Comparison of Right of Way Utilization in Various Transmission Lines.

S.No	Transmission Line	Right Of Way Utilization
1.	765 kV	25 MW/m
2.	400 kV	11.5 MW/m
3.	220 kV	5.0 MW/m
4.	132 kV	2.4 MW/m

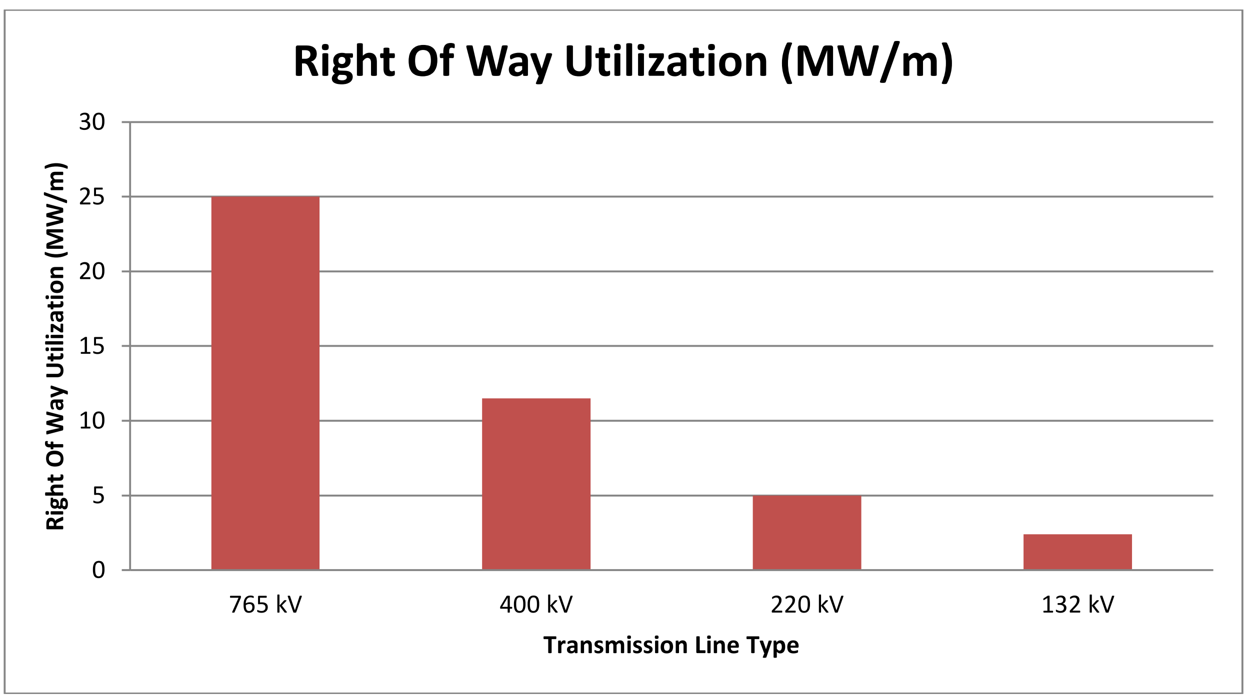


Figure 3.2 : Comparison of Right of Way Utilization in Various Transmission Lines.

Table 3.5 : MVA Capacity at Various Voltage Level, PGCIL, India

Voltage Level (A)	Transformer Capacity	
	Existing capacity (B)	Maximum Capacity (C)
765 kV	6000 MVA	9000 MVA
400 kV	1260 MVA	2000 MVA
220 kV	320 MVA	500 MVA
132 kV	150 MVA	250 MVA

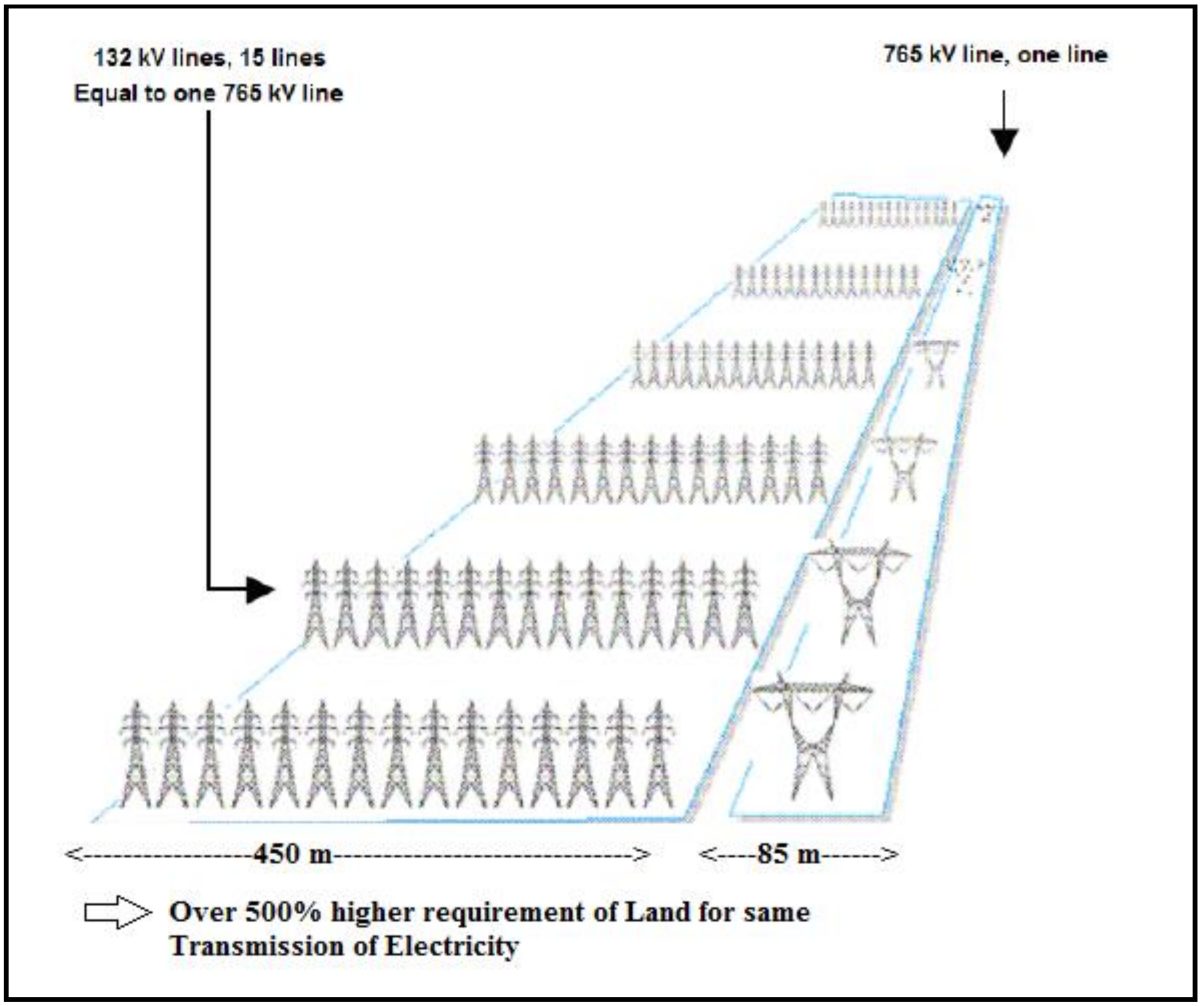


Figure 3.3 : The percentage increase in Right Of Way Requirements (Ahari,IJECE,2012)

For the transmission of the same value of power, the right of way requirements of 132 kV line is over 5 times that of 765 kV line.

765 kV line require only single installation of 765 kV tower while 132 kV line require over 15 such lines thereby covering an area of 450 m per unit length as compared to 85 m per unit length required in 765 kV line.

3. 1 Case Study:

A power of 12000 MW is to be transmitted from a power station over 800 km to a distant Place with 50% series capacitor compensation .

$P = 0.5\ E^2/Lx,\ MW$

where P = power in MW,
E = Voltage in kV,
x = positive-sequence reactance per phase, ohm/km and
L = line length, km.

$P = 0.5 \times 400^2/400 \times 0.327 = 670$ MW/Circuit at 400 kV
$P = 0.5 \times 765^2/400 \times 0.272 = 2860$ MW/Circuit at 765 kV

Table 3.6 : Computation of Power Loss as per Extra High Voltage (Ramdos)

S.No.		**400 kV**	**765 kV**
1.	Number of Circuits Required($\frac{12000}{P}$)	18	5
2.	Current Per Circuit ,kA	$667/\sqrt{3} \times 400 = 0.963$	1.54
3.	Resistance for 800 km, ohms	0.031 × 800 = 24.8	0.0136 × 800 = 10.88
4.	Loss per circuit, MW	3 × 24.8 × 0.9632 = 69 MW	3 × 10.88 × 1.542 = 77.4 MW
5.	Total power loss, MW	18 × 69 = 1242	5x77.4=387
6.	Loss in 400 kV over 765 kV =1242/387=3.2		
7.	Total Power Saved=1242-387=855		
8.	Power Saved per km=855/800=1.068 MW		

Cost Of production of 1 MW=Rs.6.5 Cr. in thermal Power Plant
Therefore, for 1.068 MW=1.068x6.5=Rs. 7 Cr.

Table 3.7 : Transmission Line Length upto 10th Five Year Plan,(CEA,India)

S.No.	Transmission Line	Transmission lines Length (Km)
1.	765 kV	2184
2.	500 kV	5172
3.	400 kV	75722
4.	220 kV and below	114629
Total Length Upto 500 kV =192535 km		

Total Money saved 1,92,535x7= Rs.13,47,745 Cr.

Table 3.8 : Capital Line Cost for setting up of Transmission Tower

Type of Transmission Line	220 kV	400 kV	765 kV
Estimated Line Cost per km	0.18 Cr.	0.65 Cr.	1.5 Cr.
Extra Cost over 400 kV line = 0.85 Cr. per km Extra Cost over 220 kV line =1.32 Cr. per km			

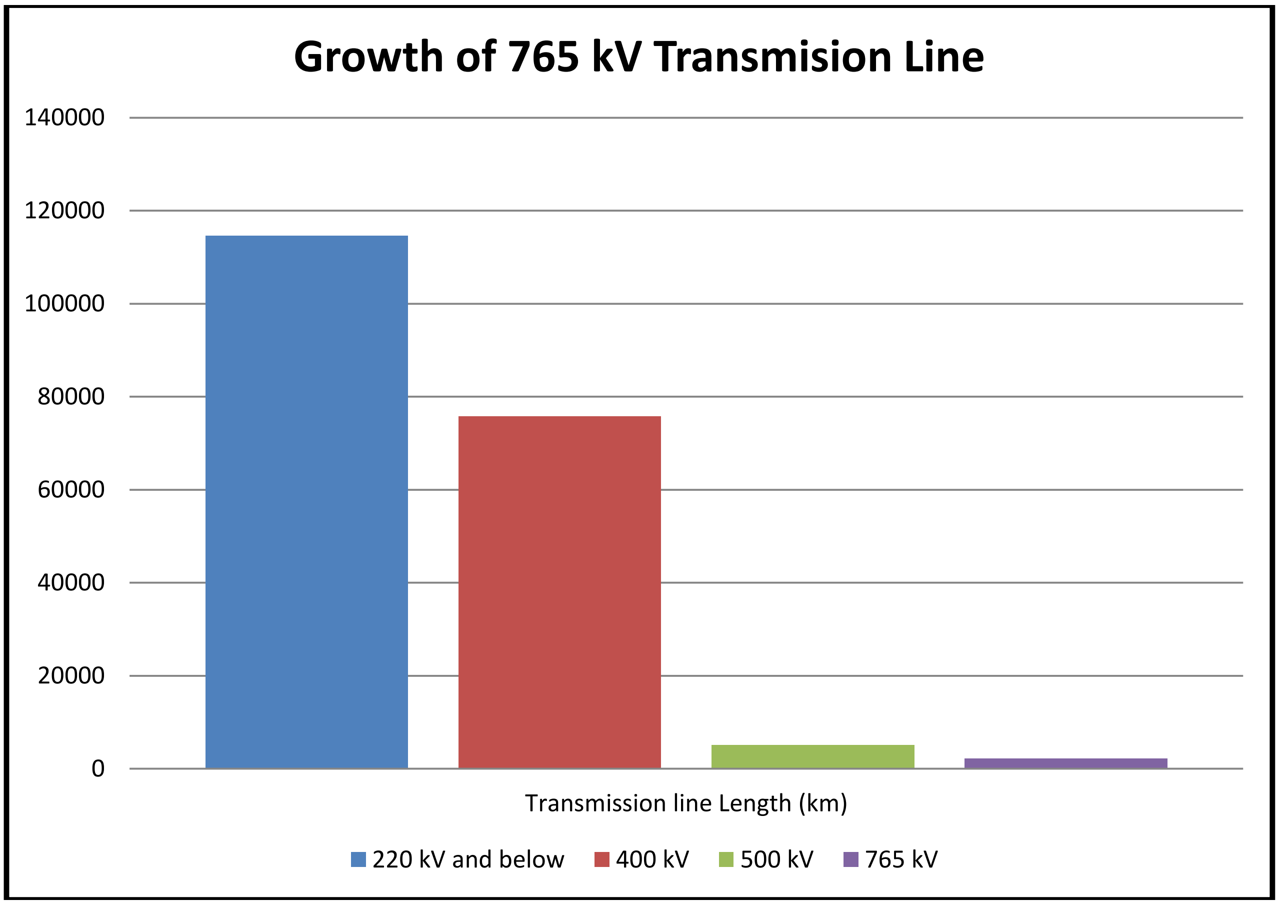


Figure 3.5 : Transmission Line Length upto 10th Five Year Plan

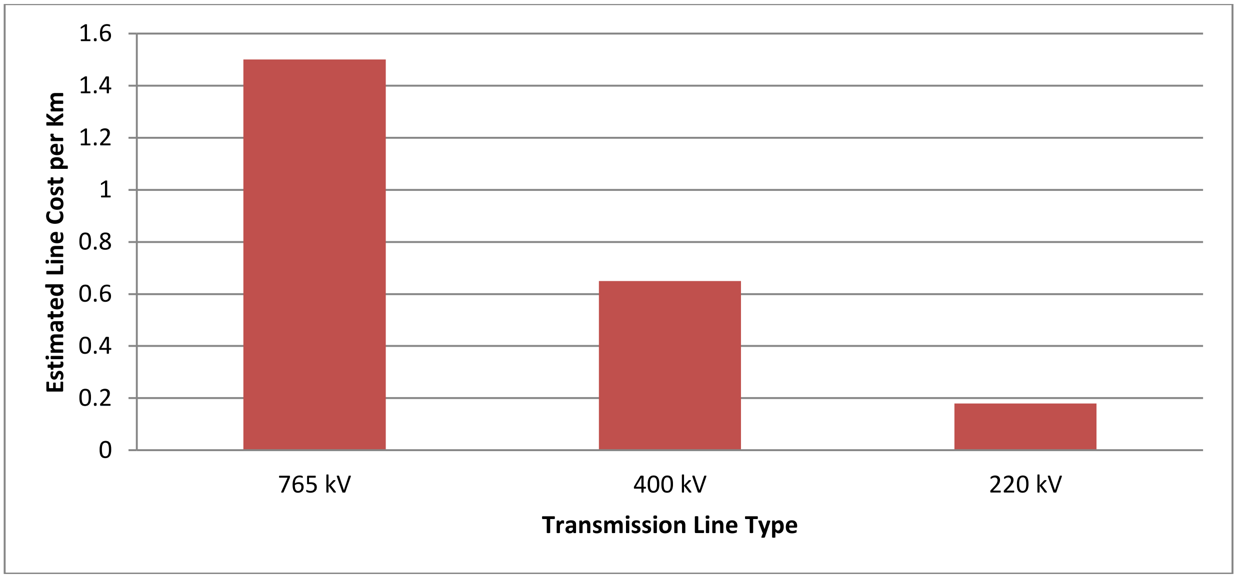


Figure 3.6 : Capital Line Cost for Different Transmission Line Types

- Cost Incurred for Upgradation From 400 kV to 765 kV =64,363.7 Cr
- Cost Incurred for Upgradation From 220 kV to 765 kV =97,434.6 Cr
- Total Cost =1,61,798.3 Cr

- Net Saving =11,85,947 Cr

Table 3.9 :Line loading limits for different voltages and lengths

S.No.	Line Length (km)	Line Loading in Surge Impedance Loading (MW)	Line loading limits (MW) 400 kV	Line loading limits (MW) 765 kV
1	100	3.0	1800	6600
2	150	2.0	1200	4400
3	250	1.5	900	3300
4	350	1.2	720	2640
5	400	1.1	660	2420
6	500	1	600	2200

Table 3.10 : Number of lines required for different voltages and lengths

Power Flow (MW)	500 MW		1000 MW		2000 MW		2500 MW	
Voltage (kV)	400 kV	765 kV	400 kV	765 kV	400 kV	765 kV	400 kV	765 kV
Line Length (km)	Number of Lines Required							
100	1	1	1	1	1	1	2	1
150	1	1	1	1	2	1	2	1
250	1	1	1	1	3	1	3	1
350	1	1	2	1	3	1	4	1
400	1	1	2	1	3	1	4	2
500	1	1	2	1	3	1	4	2

Table 3.11 : Right of Way required for different voltages and length

Power Flow (MW)	500 MW		1000 MW		2000 MW		2500 MW	
Voltage (kV)	400 kV	765 kV	400 kV	765 kV	400 kV	765 kV	400 kV	765 kV
Line Length (km)	Right of Way required in Acres							
100	1285	2101	1285	2101	1285	2101	2570	2101
150	1928	3151	1928	3151	3856	3151	3856	3151
250	3213	5252	3213	5252	9639	5252	9639	5252
350	4498	7353	8996	7353	13494	7353	17992	7353
400	5141	8403	10282	8403	15423	8403	20564	16806
500	6426	10504	12852	10504	19278	10504	25704	21008

Table 3.12 : Ratio of 400 kV/765 kV Right of Way for different voltages and length

Power Flow (MW)	500 MW		1000 MW		2000 MW		2500 MW	
Voltage (kV)	400 kV	765 kV	400 kV	765 kV	400 kV	765 kV	400 kV	765 kV
Line Length (km)	Ratio of 400 kV/765 kV Right of Way							
100	0.6		0.6		0.6		1.2	
150	0.6		0.6		1.2		1.2	
250	0.6		0.6		1.8		1.8	
350	0.6		1.2		1.8		2.4	
400	0.6		1.2		1.8		1.2	
500	0.6		1.2		1.8		1.2	

The value of the ratio being less than 1 indicates that the cost effectiveness of 400 kV is more than that of 765 kV while ratio of more than 1 indicates vice-versa. Hence the breakeven point (where installation of 765 kV line is more profitable over 400 kV line) favoring the installation of 765 kV line over 400 kV line is at 1000 MW, 250 km.

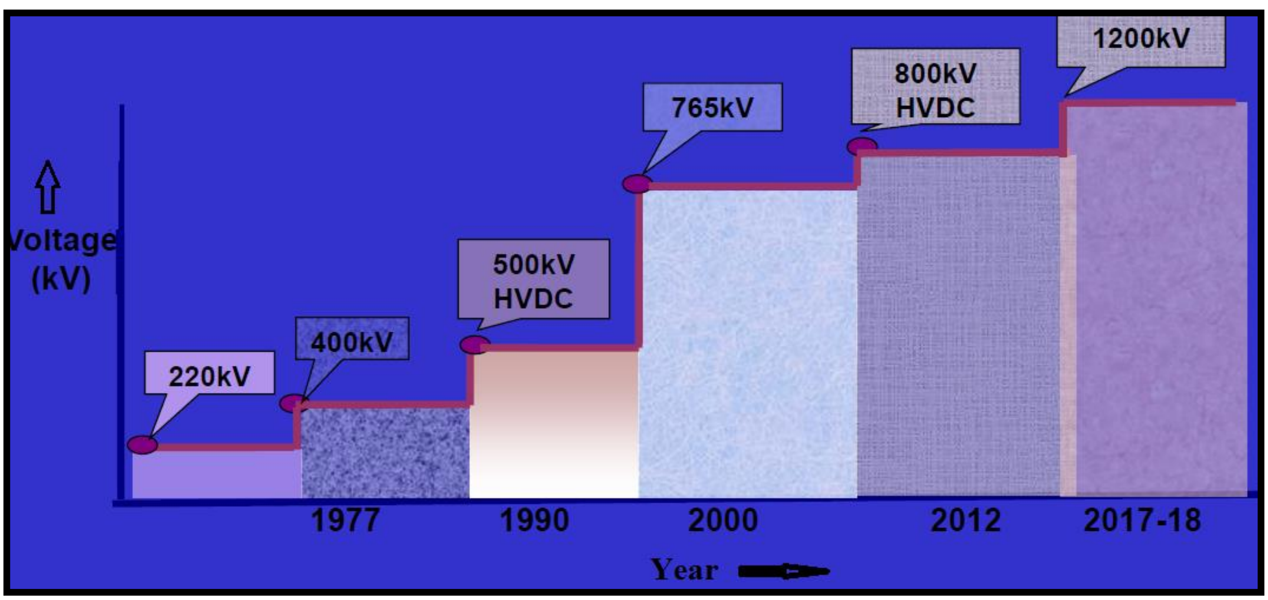


Figure 3.1 : Voltage Evolution in various years,PGCIL,India

Points of interest of 765-kV Technology

765-kilovolt (kV) transmission line offers various mechanical and operational points of interest for extension of the country's vitality network.

Resource Conservation

• A solitary circuit 765-kV line can convey as much power as three single-circuit 500-kV lines, three twofold circuit 345-kV lines, or six single-circuit 345-kV lines, diminishing generally number of lines and privileges of path needed to convey proportionate limit.

• 765-kV undertakings utilize a commonplace right-of-way width of 85 m. Standard industry right-of way width for 500-kV is likewise 52 m, and 45 m for 345-kV development. For proportionate force conveying ability, lower voltages oblige more lines and therefore all the more right-of-way effect.

Execution and Design Efficiency

Power losses in a transmission line decrease as voltage increases. Since 765-kV lines use the highest voltage available in the United States, they experience the least amount of line loss.

• The greater transmission efficiency of 765-kV can be attributed mainly to its higher operating voltage (and thus lower current flow), and larger thermal capacity/low resistance compared to lower voltage lines. This allows 765-kV lines to carry power over significantly longer distances than lower voltages.

• With up to six conductors per phase, 765-kV lines are virtually free of thermal overload risk, even under severe operating conditions.

• By shifting bulk power transfers from the underlying lower-voltage transmission system to the higher-capacity 765-kV system, overall system losses are reduced significantly.

• New 765-kV designs have line losses of less than one percent, compared to losses as high as 9 percent on some existing lines.

• The overlay of a 765-kV system allows for both scheduled and unscheduled outages of parallel lower voltage lines without risk of thermal overloads or increased congestion.

• Use of 765-kV technology allows transmission builders to take advantage of economies of scale. A 765-kV transmission line provides the same capacity as three 500-kV lines or six 345-kV lines.

• Utilizing 765-kV results in a substantial reduction in system losses. For instance, a loss reduction of 250 megawatts, equates to saving as much as 200,000 tons of coal, and 500,000 tons of CO_2 emissions on an annual basis.

• The addition of 765-kV systems relieves the stress on underlying, lower voltage transmission systems, postponing the potential need for upgrades of these networks.

CHAPTER 4
ANALYSIS AND DESIGN

4.1 Components of Transmission Line System

A Transmission Line System has following components:

i) Transmission Line Components
ii) Sag Tension for Conductor and Ground Wire
iii) Configuration of Towers

Transmission Tower Components

The following parameters for transmission line and its components are assumed from I.S. 802: Part 1: Sec: 1:1995 and I.S. 5613: Part 2: Sec: 1:1989.

1. Transmission Line Voltage	: 765 kV (A.C.)
2. Right of Way (recommended)	: 85, 000 mm
3. Angle of Line Deviation	: 0 to 2 degrees
4. Terrain Type Considered	: Plain
5. Terrain Category	: 1
6. Return Period	: 50 yrs
7. Wind Zone	: 4
8. Basic Wind Speed	: 47 m/s
9. Basic Wind Tension	: 1890 Newton per sq.mm
10. Tower Type	: Self-Supporting Tower, Suspension
11. Tower Geometry	: Square Base Tower
12. No. of Circuits	: Single Circuit
13. Tower Configuration	: Vertical Conductor
14. Tower Shape	: Barrel Shaped
15. Bracing Pattern	: Fink Fan Type
16. Cross Arm	: Pointed
17. Steel Used	: Mild Steel (IS-2062)

18. Slope of Tower Leg : 82.43º

19. Conductor Material: :ACSR(Al conductor steel reinforce)

20. Maximum Temperature : 75°C (ACSR)

21. Number of Ground Wires : Single

22. Peak Type : Rectangular

23. G.W. Type : Earth wire

24. Maximum Temperature : 75°C

25. Insulator Type : I String

26. Number of Insulator Disc : 35

27. Size of Insulator Disc : 274 x 145 mm

28. Length of Insulator String : 2,340 mm

29. Minimum Ground Clearance : 7,000 mm

30. Sag Error Considered :160 mm

31. Creep Effect : Not Considered

32. Minimum Height above G.L : 28,555 mm

33. Width at Hamper Level : 4500 mm (Square Tower)

34. Width at Base : 13000 mm (Square Tower)

35. Tower Weight (Minimum) : 465 kN

36. Minimum ThickNess of Member : 10 mm

37. Normal Span : 400 m

38. Wind span :1.0 x normal span (plain terrain)

39. Weight span

i) Suspension tower, max. : 1.5 x Normal span

,min :0.8 x Normal span (plain terrain) (For hilly terrain, the minimum weight span be fixed suitably).

ii) Angle tower, Downward : 2 x Normal span

Upward : 200m Net Span

TRANSMISSION LINE SPECIFICATIONS

Conductor:

1.	Code Name	:	ACSR Bersimis
2.	Number of sub-conductor /phase	:	4
3.	Spacing between conductors	:	450 mm
4.	Bundle Arrangement	:	Horizontal Square
5.	Nominal Aluminium area	:	690 sq.mm
6.	Stranding and Wire Diameter	:	42/4.57 mm Al + 7/2.54 mm
7.	Overall Diameter	:	35.04 mm
8.	Approximate mass	:	2187 kg /km
9.	Ultimate Tensile Strength	:	146.87 kN
10.	D.C. Resistance at 20^o C ohms/km	:	0.042
11.	Corona extinction kV(rms) voltage phase to ground	:	560
12.	Modulus of Elasticity	:	0.6320×10^6 kg/cm^2
13.	Coefficient of linear thermal expansion per degree C	:	21.5×10^{-6}
14	Maximum temperature of current carrying conductor	:	95 °C

Earth Wire :

1.	Size	:	7/3.66 mm G.S.S. wire of 95 kg f/ mm^2
2.	Number of earth wire	:	2
3.	Overall Diameter	:	10.98 mm
4.	Quality of ground wire	:	95 kg f/mm^2
5.	Ultimate Tensile strength	:	69.72 kN.
6.	D.C. Resistance at 20 C	:	2.5 ohms/km
7	Modulus of Elasticity	:	1.933×10^6 kg/cm^2
8.	Coefficient of linear thermal expansion per degree C	:	11.5×10^{-6}
9.	Maximum allowable temperature per degree C	:	53° C

Clearances:

i) Minimum ground clearances as per indian Electricity rules. : 12,400 mm

ii) As per interference : 15,500 mm

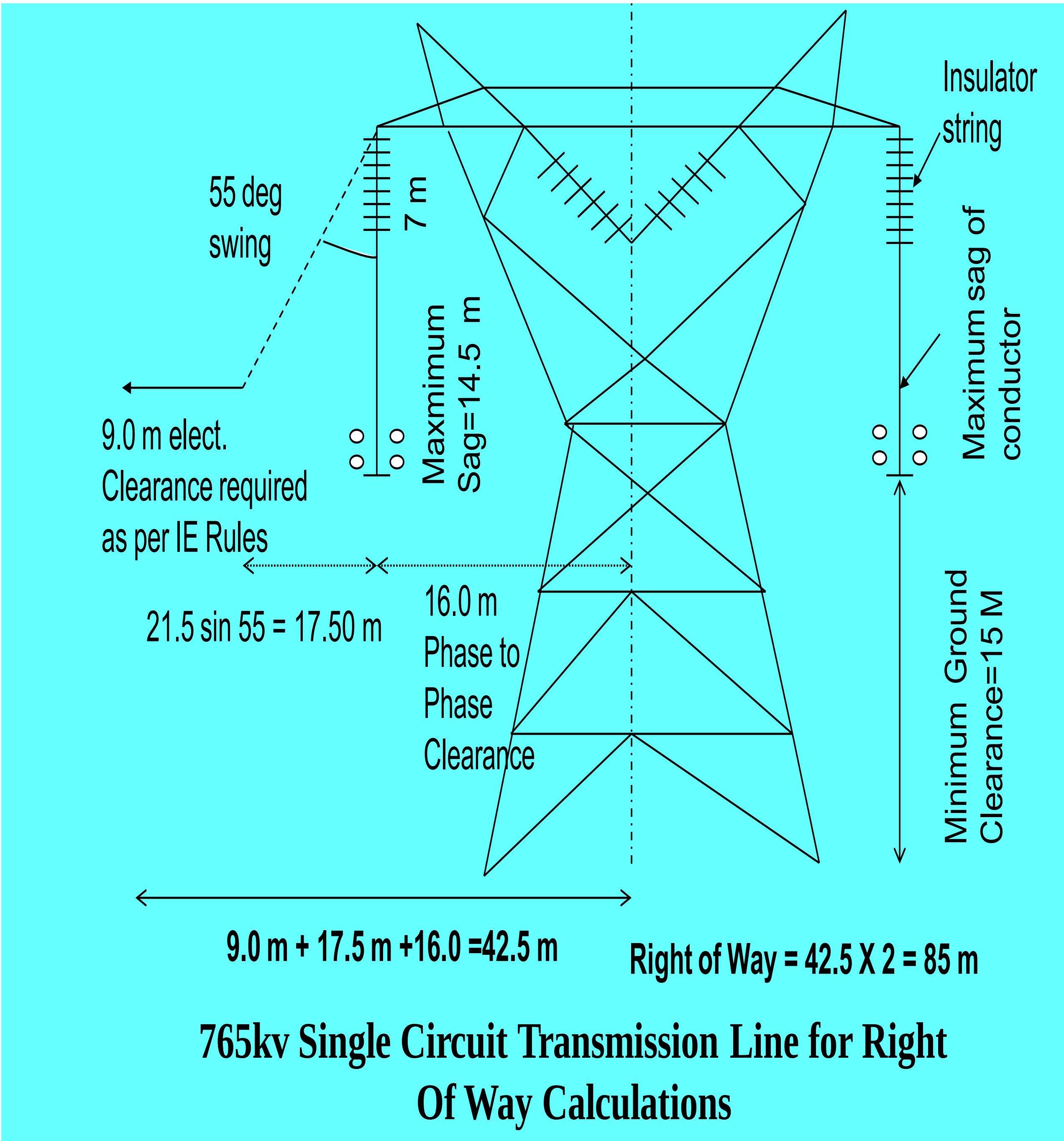
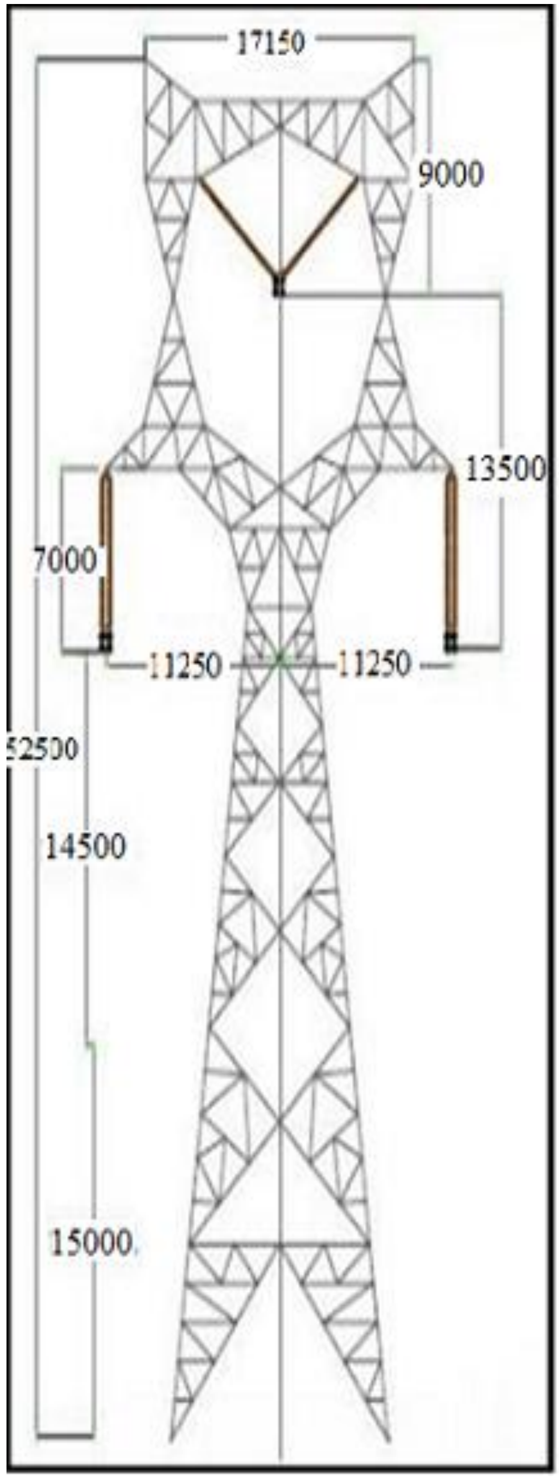


Figure 4.1 : Line Diagram of the Transmission Tower , PGCIL, India



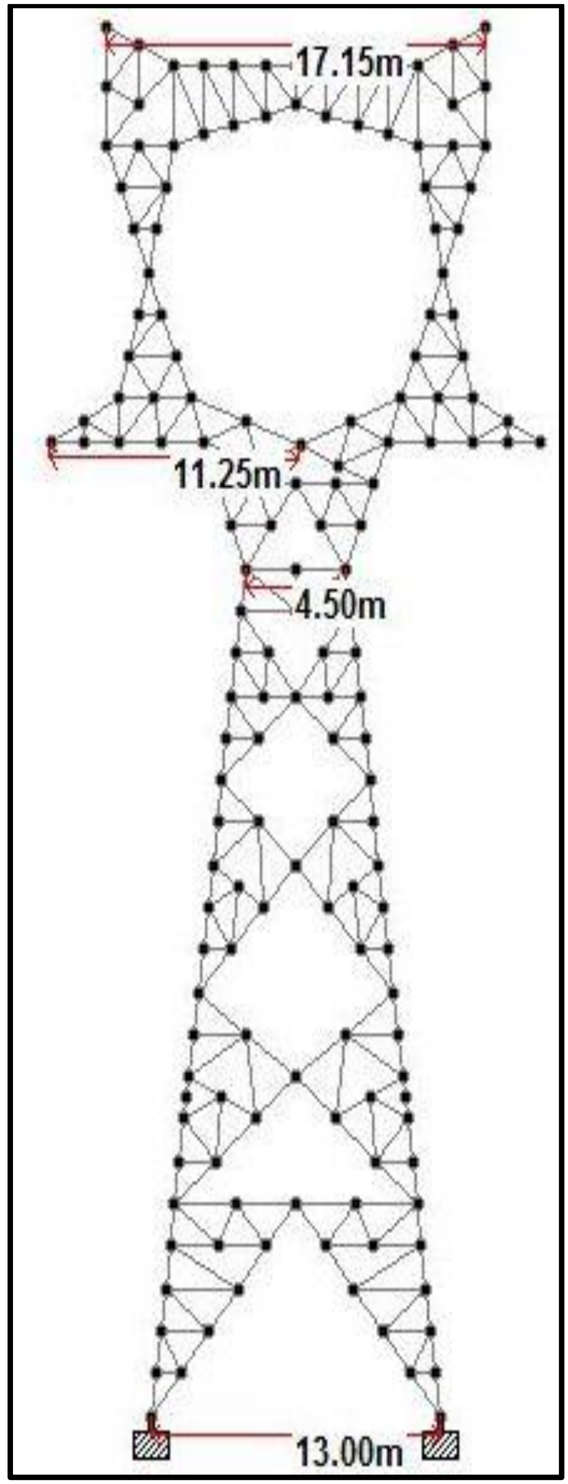


Figure 4.2 : Representative Figure of the STAAD Model showing various clearances and dimensions

Figure 4.3 :Actual 2D STAAD model

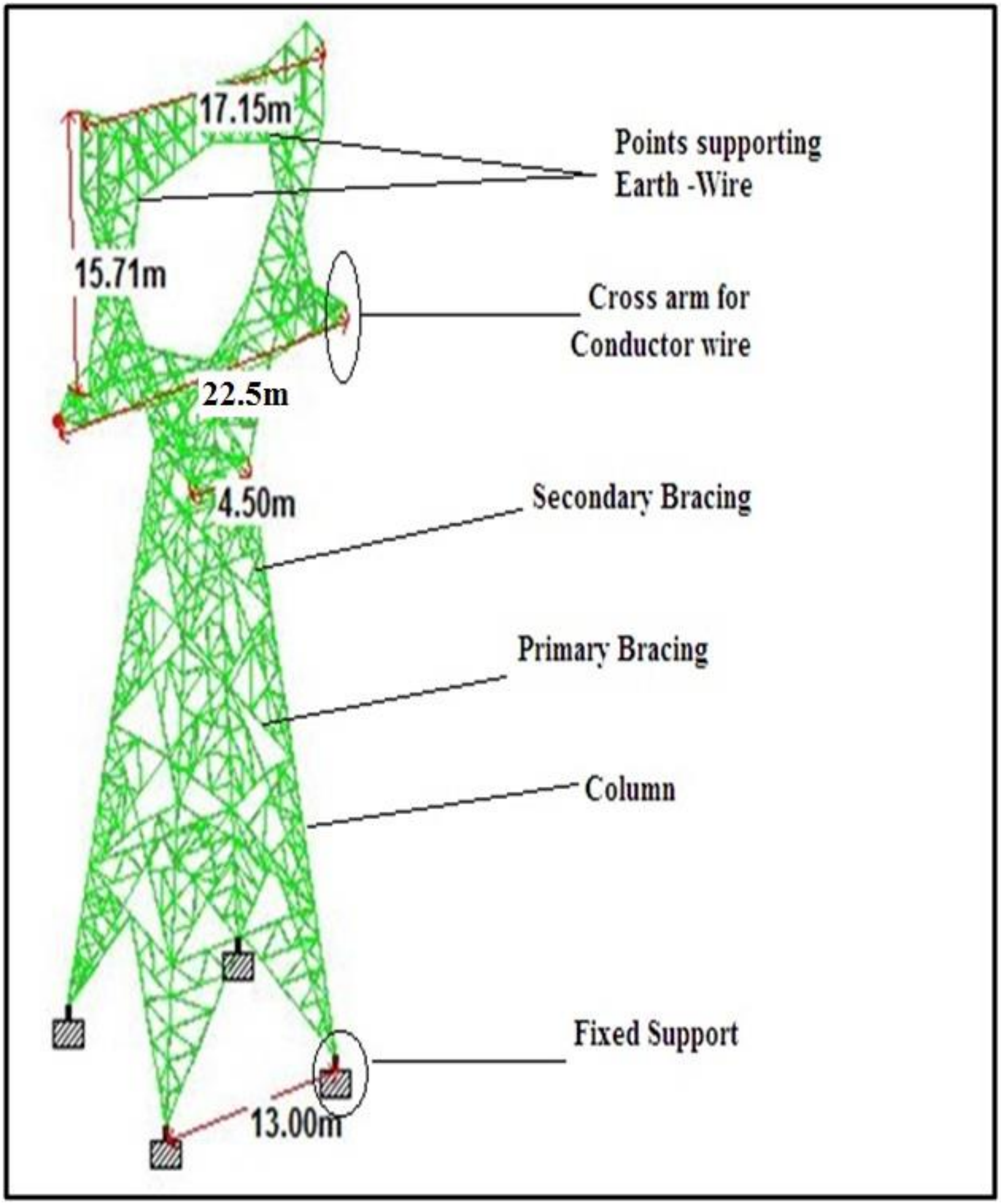


Figure 4.4 :Showing Various Elements of Transmission Line Tower

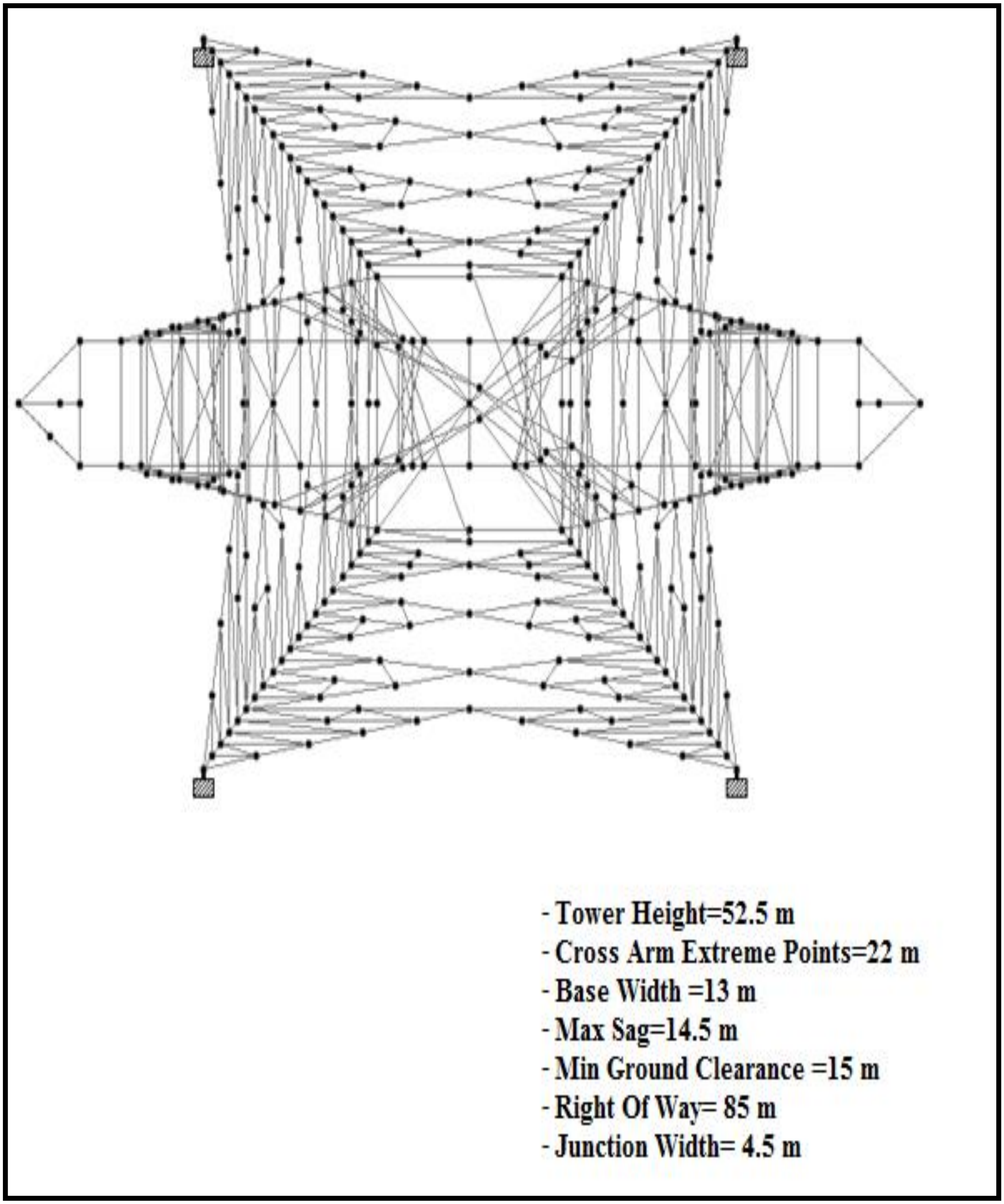


Figure 4.5 : Plan View of the STAAD Model

4.1.1 Determination of Tower Height

The factors that govern the height of the tower are:

1. Minimum permissible ground clearance (h1)

2. Maximum sag of the lowermost conductor wires (h2)

3. Insulator string height (h3)

4. Vertical distance between ground wire and top conductor (h4)

4.1.2 Determination of Base Width

1) For most towers the ratio of base width to total tower height =$\frac{1}{3}$ to $\frac{1}{6}$

from large-angle towers to tangent towers.

2) Ryle has given the following formula for determination of the economic base width:

$$B=0.42\sqrt{M} \text{ or } 0.013\sqrt{m}$$

Where B = Base width in meters,

m= Overturning moment about the ground level in tm, and

M= Overturning moment about the ground level in kgm.

4.1.3 Maximum sag of the lowermost conductor (h2).

The power carrying conductors sags due to its self-weight and the sag is maximum when the temperature is maximum and when there is no wind condition. The maximum sag occurs at the mid-section between the two towers in open country.

$$\text{Max Sag}=\frac{qWl^2}{8T}$$

$$\text{Loading factor(q)}=\sqrt{\frac{w^2+p^2}{w^2}}$$

W=weight of the conductor/m/cm^2,
l =span length in meters,
T=Tension in the conductor and
p=Wind pressure.

4.1.4 Sag Calculation of Conductor

Sag=$\frac{wl^2}{8T}$

w=weight per unit length of conductor,
l=length of span and
T=Tension in the conductor.

Table 4.1 : Design Data as per CEA guidelines, India

Weight per unit length of conductor ,W	=2187 kg/km=2.187 kg/m
Length of span ,L	=1.5x400 m=600 m
Tension in the conductor,T	=146.87 kN=14687 kg
Factor of safety for tension	=2
Safe Tension	=14687/2=7343.5 kg
Sag	$=\frac{2.187\text{x}600\text{x}600}{8\text{x}7343.5}$=13.40 m

Table 4.2 : Sag Calculation as per IS Code 802:1995

Sag Calculation	
BASIC CONDITION:	
Temperature =	=32.2 °C
Wind	= NIL
Factor of Safety	= 4
Working tension (T_1)	$=\frac{U.T.S}{FOS}.=\frac{14687}{4}$=3671.75 kg
Working Stress (f_1)	$=\frac{T_1}{A}=\frac{3671.75}{9.261}$=381.63 kg / cm^2
$\partial=\frac{W}{A}$	$=\frac{2.187}{9.261}=0.227$
Loading Factor,q_1 $=\sqrt{\frac{w^2+p^2}{w^2}}$	=1 (for no wind i.e. P=0)
The working Stress is determined by the following formula: $f_1^2(f_1-k)=\frac{l^2\,\partial^2 q_1^2 E_f}{24}$	
$k=f_1-\frac{l^2\,\partial^2 q_1^2 E_f}{24f_1^2}$	$=381.63-\frac{400^2\text{x}.227^2\text{x}12.63^2\text{x}106}{24\text{x}381.632}$
	=381.63-1490.7=-1109

Condition 2:	
Temperature	=75° C
Wind	=NIL
Loading Factor (q_2)= $\sqrt{\frac{w^2+p^2}{w^2}}$	=1 (for no wind i.e. P=0)
Difference of Temperature,t	=75-32.2=42.8^o C
Working stress is determined by following formula	
F_2^2x(F_2 – (K – α.t.E)) = $L^2.\partial^2.q_2^2$.E / 24	
$f_2^2[f_2 - \{-1109 - (11.5 \times 10^{-6}) \times 42.8 \times (0.632 \times 10^6)\}] = \frac{(400)2 \times (0.227)2 \times (1) \times (0.632 \times 106)}{24}$	
f_2	=350.07 Kg / cm^2
Maximum Sag,S=$\frac{l^2\ \partial q_2}{8f_2}$	=$\frac{400x400x.227x1}{8x350.07}$=13 m

4.2 Loading Calculations

4.2.1 Determination Of Wind Tension, P_d

Basic wind speed (V_b)	= 55m/s
Meteorological reference wind speed **(**V_R)= V_b/k_o	
Ko	=1.375
V_R	=55/1.375=40 m/s
Design wind speed, V_d =V_Rxk_1xk_2	
Risk coefficient(k_1)	=1.3
Terrain roughness coefficient (k_2)	=1.08
V_d	=40x1.3x1.08=56.16m/sec
Design wind tension, Pd=0.6xV_d^2	==0.6x56.16^2 =1890 N/m^2

Wind Load on the Tower
$F_{wt}= P_d \times C_{dt} \times A_e \times G_T$

Where,
P_d = design wind tension, in N/m^2

C_{dt} = drag coefficient for panel towards which the wind is blowing.
Values of C_{dt} depends on the solidity ratios.

A_e =Total net surface area of the legs, bracings, cross arms and secondary members of the panel projected normal to the face in m'

G_T =Gust response factor, peculiar to the ground roughness and depends on the height above ground.

Table 4.3 : Calculation For Enclosed Area for Computation of Solidity Ratio.

Enclosed Area			
S.No.	**Panel Number**	**Area Calculation**	**Computed Area**
1.	Panel 1	=0.5x(13+4.5)x30.65	=268.18 mm^2
2.	Panel 2	=2x.5x4.04x4.6	=18.58 mm^2
3.	Panel 3	=.5x8.09x1.5	=6.06 mm^2
4.	Panel 4	=2x.5x3.44x4.67x2	=32.12 mm^2
5.	Panel 5	=2x.5x(3.32+7.14)x1.63	=17.04 mm^2
6.	Panel 6	=2x.5x4.81x3.32	=15.96 mm^2
7.	Panel 7	=2x.5x5.47x3+2x.5x(3+1.5)x5.94	=43.14 mm^2
Total Enclosed Area			=401.10 mm^2

Table 4.4 : Calculation For Projected Area for Computation of Solidity Ratio.

Projected Area			
Member	**Width**	**Length**	**Area**
ISA 200x200x25	0.200	65.12	13.02 mm^2
ISA 90x90x12	0.090	408	36.72 mm^2
ISA 100x75x12	0.100	275	27.5 mm^2
Total Projected Area			=77.24 mm^2

Solidity Ratio= $\frac{77.24}{401.10}$ **= 0.1926**

IS 802.1.1.1995: Wind tension shall be calculated on 1.5 times the projected area of members on windward face

Therefore, **Solidity ratio=1.5x0.1926=0.288**

Table 4.5 :Design Coefficients from IS Code

Drag coefficient ,C_{dt}	2.5
Gust response factor ,G_T	1.7

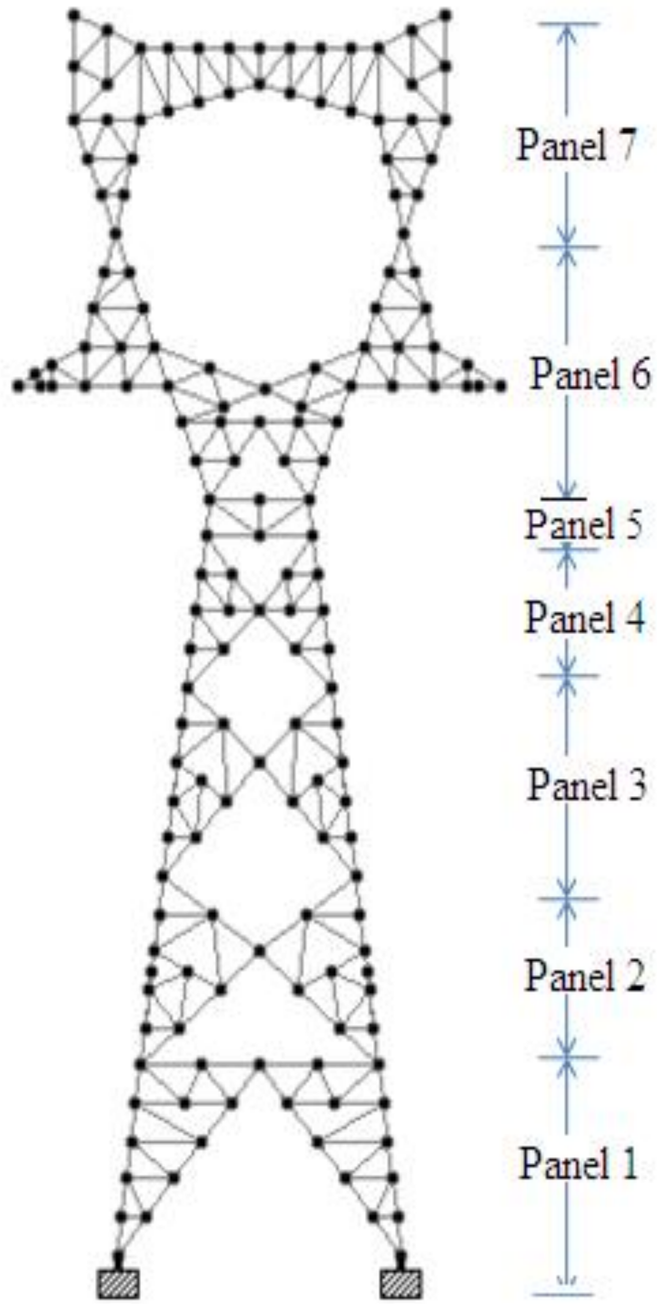


Figure 4.6 : Representative figure showing various panel members

Table 4.6 :Wind Load Calculation for Members of Panel 1

Panel 1	
Leg Members	
Number of Leg	2
Legs Length	8.14 m
Member Dimension	200x200x25
Wind Load on leg	2x8.14x.2x2.5x1890x1.7=32.6 kN
Diagonal Bracing	
Number of Bracings	36
Total Bracing Length	81.92m
Total Wind Load on Bracing	81.92x.09x2.5x1890x1.78=52.64 kN
Total Wind Load	85.3 kN

Table 4.7 :Wind Load Calculation for Members of Panel 2

Panel 2	
Leg Members	
Number of Leg	2
Legs Length	8.14 m
Member Dimension	200x200x25
Wind Load on leg	2x8.14x.2x2.5x1890x1.7=32.6 kN
Diagonal Bracing	
Number of Bracings	28
Total Bracing Length	65.82 m
Total Wind Load on Bracing	65.82x.09x2.5x1890x1.78
Total Wind Load	74.8 kN

Table 4.8: Wind Load Calculation for Members of Panel 3

Panel 3	
Leg Members	
Number of Leg	2
Legs Length	8.14 m
Member Dimension	200x200x25
Wind Load on leg	2x8.14x.2x2.5x1890x1.7=32.6 kN
Diagonal Bracing	
Number of Bracings	28
Total Bracing Length	57.74 m
Total Wind Load on Bracing	57.74x.09x2.5x1890x1.7=37 kN
Total Wind Load	69.7 kN

Table 4.9 : Wind Load Calculation for Members of Panel 4

Panel 4	
Leg Members	
Number of Leg	2
Legs Length	8.14 m
Member Dimension	200x200x25
Wind Load on leg	2x8.14x.2x2.5x1890x1.7=32.6 kN
Diagonal Bracing	
Number of Bracings	28
Total Bracing Length	40.26 m
Total Wind Load on Bracing	40.26x.09x2.5x1890x1.78=25.87
Total Wind Load	58.47 kN

Table 4.10: Wind Load Calculation for Members of Panel 5

Panel 5	
Leg Members	
Number of Leg	2
Legs Length	1.63 m
Member Dimension	200x200x25
Wind Load on leg	2x1.63x.2x2.5x1890x1.7=6.54 kN
Diagonal Bracing	
Number of Bracings	12
Total Bracing Length	22.13 m
Total Wind Load on Bracing	22.13x.09x2.5x1890x1.7=14.22 kN
Total Wind Load	20.76 kN

Table 4.11: Wind Load Calculation for Members of Panel 6

Panel 6	
Diagonal Bracing	
Total length	178.78 m
No of bracing	87
Total wind load on bracings	178.78x.012x2.5x1890x1.7=17.23 kN
Total Wind Load	17.23 kN

Table 4.12 : Wind Load Calculation for Members of Panel 7

Panel 7	
Diagonal Bracing	
Total length	158.98 m
No of bracing	82
Total wind load on bracings	158.98x.012x2.5x1890x1.7=15.32 kN
Total Wind Load	15.32 kN

Sag Tension for Conductor and Ground Wire:

Sag tensions are calculated by using the parabolic equations as discussed in the I.S. 5613: Part 2: Sec: 1: 1989 by developing integrated program on Microsoft Excel for both the conductor and ground wire.

$$f_1^2(f_1-k)=\frac{l^2\,\partial^2 q_1^2 E_f}{24}$$

$$k=f_1-\frac{l^2\,\partial^2 q_1^2 E_f}{24 f_1^2}$$

Table 4.13 Sag tension for conductor (ASCR)

Temperature Variation	0 ℃		32℃		75 ℃	
Wind Variation	0	0.36	0	0.75	1	0
Tension=FxA(kN)	77.5	93.22	T_1=63.47	T(0.75)=110.1	T=130	51.33

Table 4.14 Sag tension for ground wire

Temperature Variation	0 ℃		32 ℃		75 ℃	
Wind Variation	0	0.36	0	0.75	1	0
Tension=FxA(kN)	33.8	44.6	T_1=29.57	T(0.75)=58.6	T=69.72	27.33

Notations Used In the Below Equations:

Tensions for Conductor

- T=130 kN
- T_1(0.0)=63.47 kN
- T(0.75)=110.1 kN

Tensions for Ground Wire

- T=69.72 kN
- T_1(0.0)=29.57 kN
- T(0.75)=58.6 kN

4.3 Reliability Condition:

Table 4.14 : Various Loads Calculation of Ground Wire as per IS 802:1995

I. Ground Wire:
A. Transverse Load:

1. Wind on Wire: F_{WC} = Pd . L . d . G_C . C_{DC} 2 Due to Deviation: F_Wd = 2 . T . sin(Φ_2 / 2)	=1890x1.2x400x.01x2.12=19.22 kN =2x69.72xsin(2°/2)=2.43 kN
Total:	=21.65 kN
B. Vertical Load: 1. Weight of Wire: VR = w .L 2. Weight of Ground Wire clamp VR	 =0.6x428 kg/km=2.568 kN =50 N=.05 kN
Total:	=2.618 kN
C. Longitudinal Load: LR = 0 * T . cos(Φ_1/2)	 =0 kg

Table 4.15 : Various Loads Calculation of Conductor as per IS 802:1995

II. Conductor:	
A. Transverse Load:	
1. Wind on Wire: FWC = n . P_d . L . d . G_C . C_{DC}	=1890x1x400x.03x2.12=48.08 kN
2. Wind on Insulator: FWi = n . m . P_d . A_i . G_i . C_{di}	.2x1890x280x170x2x35 x 0.5x2=8.31 kN
3. Due to Deviation FWd = 2 . n . T . sin(Φ_2 / 2)	=2x130xsin (2°/2)=4.53 kN
Total: =	60.92 kN
B. Vertical Load:	
1. Weight of Wire Vertical load VR = w . n . (L1 or L2)	=.600x2187kg/km=13.122 kN
2. Weight of Insulator: VR = n *m *indiviual wt	=3.5 kN

Total	=16.62 kN
C. Longitudinal Load: LR = 0 *n* T . cos(Φ_1/2)	=0 kN

4.4 Security Condition:

Table 4.16 : Various Loads Calculation of Ground Wire as per IS 802:1995

I. Ground Wire:	**Normal Condition**	**Broken Wire Condition**
A. Transverse Load:		
1. Wind on Wire: $F_{WC} = P_d(0.75) . L . d . G_C . C_{DC}$ 2 Due to Deviation: $F_{Wd} = 2 . T(0.75) . \sin(\Phi_2 /2)$ $F_{Wd} = T(0.75) . \sin(\Phi_2 / 2)$	=14.41 kN =1.82 kN	=8.41 kN =0.91 kN
Total:	=16.23 kN	=9.32 kN
B. Vertical Load: 1. Weight of Wire: VR = w .L 2. Weight of Ground Wire clamp VR	=0.6x428kg/km=2.568 K N =50 N=.05 kN	
Total:	=2.618 kN	
C. Longitudinal Load: LR = 0 * T_1. cos(Φ_1/2) LR = T_1. cos(Φ_1/2)	=0 kg	=29.57 kN

Table 4.17 : Various Loads Calculation For Conductor as per IS 802:1995

II. Conductor:	**Normal Condition**	**Broken Wire Condition**
A. Transverse Load:		

1. Wind on Wire: $F_{WC} = n \cdot P_d \cdot L \cdot d \cdot G_C \cdot C_{DC}$	=36.06 kN	=21.63 kN
2. Wind on Insulator: $F_{Wi} = n \cdot m \cdot Pd \cdot A_i \cdot G_i \cdot C_{di}$	=6.23 kN	=6.23 kN
3. Due to Deviation $F_{Wd} = n \cdot T \cdot \sin(\Phi_2 / 2)$ $F_{Wd} = 0.5 * n \cdot T(0.75) \cdot \sin(\Phi_2 / 2)$	=3.39 kN	=1.69 kN
Total: =	=45.68 kN	=29.55 kN
B. Vertical Load:		
1. Weight of Wire Vertical load VR = w . n .L	=13.122 kN	
2. Weight of Insulator: VR = n *m *indiviual wt	=3.5 kN	
Total	=16.62 kN	
C. Longitudinal Load: LR = 0 *n* T . cos(Φ1/2) LR = 0.5 *n* T . cos(Φ1/2)	=0 kN	=31.73 kN

4.5 Safety Condition

Table 4.18: Various Loads Calculation For Ground Wire as per IS 802:1995

I. Ground Wire:	**Normal Condition**	**Broken Wire Condition**
A. Transverse Load:		
2 Due to Deviation: $F_{Wd} = 2 \cdot T_1 \cdot \sin(\Phi_2 /2)$ $FWd = T_1 \cdot \sin(\Phi_2 / 2)$	=1.03 kN	=0.51 kN
Total:	=1.03 kN	=0.51 kN

B. Vertical Load: 1. Weight of Wire: VR = 2.w .L 2. Weight of Ground Wire clamp VR 3. Weight of Man with Tool	 =5.12 kN =2x50 N=0.1 kN =1.5 kN	 =3.07 kN =0.1 kN =1.5 kN
Total:	=6.72 kN	=4.67 kN
C. Longitudinal Load: LR = 0 * T_1 . cos(Φ_1/2) LR = 0.5 * T_1 . cos(Φ_1/2)	 =0 kN	 =14.78 kN

Table 4.19 : Various Loads Calculation For Conductor as per IS 802:1995

II. Conductor:	**Normal Condition**	**Broken Wire Condition**
A. Transverse Load:		
Due to Deviation F_{Wd} = 2.n . T_1 . sin(Φ_2 / 2) F_{Wd} = n .(0.5* T_1) . sin(Φ_2 / 2)	 =2.19 kN	 =0.54 kN
Total: =	=2.19 kN	=0.54 kN
B. Vertical Load:		
Weight of Wire Vertical load VR = 2.w . n .L Overload factor=2	 =26.24 kN	 =15.74 kN
Weight of Insulator: VR = 2*n *m *indiviual wt Weight of Man with Tool Weight At Arms Tips	 =7 kN =1.5 kN =3 kN	 =7 kN =1.5 kN =3 kN
Total	=37.74 kN	=27.24 kN
C. Longitudinal Load: LR = 0 *n* T_1 . cos(Φ_1/2) LR = 0.5 *n* T_1 . cos(Φ_1/2)	 =0 kN	 =19.46 kN

CHAPTER 5
RESULTS AND DISCUSSION

5.1 General

The results of the analysis and design have been included. Only the critical results have been summarized and converted into graphical diagrams to present the data in meaningful form. Towers analysis is done considering the use of angle section and the tube section. Following results include axial forces, compressive stresses and the displacements.

Table 5.1 : Maximum axial forces in compression in the tower in kN in angle section configuration.

S.No	Different node points	Wind in x-direction	Wind in z-direction	Allowable compression force	Factor of safety
1.	Leg member at base	617.30	906.44	1298.00	1.43
2.	Leg member between cross arm and base	364 .22	466.16	786.00	1.69
3.	Leg member near cross arm	310.26	319.45	786.00	2.46
4.	Members at the tip	93.28	130.48	244.00	1.87
5.	Cross arms	101.57	125.71	363.00	2.89
6.	Hamp-ring	85.16	135.01	197.00	1.46
7.	Primary bracings	134.65	178.55	197.00	1.32
8.	Junction connection	91.11	135.22	256.00	1.89

The maximum axial forces in compression (Table 5.1) is found to be more with the wind acting in z-direction compared to wind in x-direction as wind forces in z-direction has a cumulative effect on the pre-existing voltage loads in the wire.

Table 5.2 : Maximum axial forces (kN) in compression in the tower in tubular section configuration.

S.No	Different node points	Wind in x-direction	Wind in z-direction	Allowable compression force	Factor of safety
1.	Leg member at base	610.26	810.12	1450.00	1.79
2.	Leg member between cross arm and base	320.41	450.12	780.00	1.73
3	Leg member near cross arm	280.10	320.1	550.00	1.72

5.	Members at the tip	90.12	120.56	450.00	3.73
4.	Cross arms	85.00	130.10	450.00	3.46
7.	Hamp –ring	120.14	74.20	350.00	4.72
8.	Primary bracings	140.40	115.10	350.00	3.04
9.	Junction connection	91.22	89.22	180.00	2.02

The maximum axial forces in tubular section (Table 5.2) also follow the similar pattern as observed in angular configuration with maximum forces exisiting due to wind in the z-direction. However, compression forces are more in tubular section compared to angular section.

Table 5.3 : Maximum axial forces in tension in the tower in kN in angle section configuration

S.No	Different node points	Wind in x -direction	Wind in z -direction	Allowable tensile force	Factor of safety
1.	Leg member at base	410.56	670.23	1411.00	2.11
2.	Leg member between cross arm and base	370.55	512.89	1411.00	2.75
3	Leg member near cross arm	151.00	298.61	1411.00	4.73
5.	Members at the tip	116.26	206.71	606.00	2.93
4.	Cross arms	143.54	130.44	484.00	3.71
6.	Hamp-ring	16.25	19.31	234.00	12.12
7.	Primary bracings	160.52	172.12	234.00	1.36
8.	Junction connection	150.12	263.89	484.00	1.83

All the maximum tensile forces (Table 5.3) generated in the members at various node members are within the safe allowable limit. The factor of safety is not high which confirms our validity of results and safe economical design.

Table 5.4 : Maximum axial forces in compression in the tower in kN in tubular section configuration

S.No	Different node points	Wind in x -direction	Wind in z -direction	Allowable tensile force	Factor of safety
1.	Leg member at base	390.12	588.22	1353.00	2.30
2.	Leg member between cross arm and base	355.40	457.11	1353.00	2.96

3	Leg member near cross arm	147.20	302.40	1353.00	4.47
4.	Members at the tip	114.00	202.17	561.00	2.77
5.	Cross arms	120.12	112.1	561.00	5.00
6.	Hamp-ring	18.25	18.45	249.00	13.50
7.	Primary bracings	102.00	154.49	249.00	1.61
8.	Junction connection	144.80	186.36	194.00	1.04

The maximum tensile here too(Table 5.4) , follow the similar trend and all maximum values have been observed in the z-direction as expected thus underlying the codal provisions of IS: 802-1995.

Table 5.5 : Maximum displacement in the tower in mm in z-direction.

S.No	Different node point	Angle section	Tube section	Permissible deflection
1	Base of tower	0.00	0.00	0.00
2	Hamp-width	46.257	57.50	282.00
3	Topmost tip	105.38	160.4	500.00
4	Ground wire point	124.25	144.45	480.00
5	Mid – junction of tip point and cross arm	130.40	140.4	434.00
6	Cross arm	261.67	352.20	360.00

Table 5.6 : Maximum displacement in the tower in mm in x-direction.

S.No	Different node point	Angle section	Tube section	Permissible deflection
1	Base of Tower	0.00	0.00	0.00
2	At Hamp-Width	46.12	78.45	282.00
3	At Topmost tip	87.47	92.90	500.00

4	At Ground Wire Point	72.00	88.14	480.00
5	Mid – Junction of Tip Point and Cross Arm	116.12	132.74	434.00
6	At Cross Arm	207.42	212.63	440.00

The maximum displacements (Table 5.6) have been observed as 352 mm and 261 mm for tubular and angular configuration respectively.both the values are well within the permissible limits, thus not permitting higher deformations. Low deformation even in zones with highest specified basic speed of 55 m/s in the IS code: 875-1987 (Part-3) makes them capable of resisting the winds of severe intensity in coastal areas and higher altitudes.

Table 5.7: Angle and tube sections

S.NO	Different node points	Angle section	Tube section
1	Leg members	ISA 200x200x25	IST 200x12
2	Cross arms	ISA 90x90x12	IST 90x12
3	Primary bracings	ISA 100x75x10	IST 90x6
4	Secondary bracings	ISA 50x50x6	IST 60x6
5	Tip members	ISA 90x90x12	IST 90x12
6	Lower bracing	ISA 75x75x10	IST 75x6

All the sections used in the both the configuration are selected considering the criteria like minimum thickness ,economical design. Built up members (with higher permissible values)are not considered due to cost constraints, as our underlying purpose of design is safety as well as economical design.

Table 5.8 : Comparison of steel weight in kN.

S.No	Angle section tower weight	Tube section tower weight	Steel saved	% saving
1	414.3	380	34	8.21 %

Table 5.9: Permissible limit of compressible and tensile forces.

S.No.	Angle section	Slenderness ratio (λ)	Permissible compressive stress (N/mm^2)	Permissible compressive force (kN)	Permissible tensile force (kN)
1	ISA 200x200x25	42-126	139-64.32	1303-600	1411
2	ISA 90x90x12	36-113	145.56-72	392-113	606
3	ISA 100x75x10	83-146	101-51	266-84	484
4	ISA 75x75x10	47-126	132-64.32	185-89	234
5	ISA 50x50x6	83-150	101-45	87-25	85

The low transmissions of electricity in India is largely attributed to the higher costs of installation of transmission towers ,with cost of steel contributing the largest factor.thus our main emphasis has been on the financial applicability of design.

Tubular sections has been found to be of greater economical feasibility without compromising the safety standards as laid down in the IS code : 875-1987(Part-3).

The practical difficulty observed during installation of towers with tubular configuration like non availability of skilled labour has made these sections unpopular but once the expertise is achieved in its installation, there can be higher cost savings in installation of tower with tubular sections.

5.2 Design of Members

- Design Of Leg Members
- Design of Cross arm
- Design Of Tip Members
- Design Of Junction Members
- Design Of Bracing Members

Design of leg members

S.No	Properties	Values	Remarks
1.	Effective length l_{eff}	1630	Effectively restrained in position at both ends but not against rotation
2.	Load in compression p_c	906.40	
3.	Load in tension p_t	670.23	
4.	Steel used	MS	Mild Steel
5.	Angle section	200x200x25	
6.	Angle	Single	
7.	$I_{yy}(cm^4)$	1411.6	Minimum
8.	R_{vv}=	38.8	Minimum
9.	Gross area(mm^2)	9380	As per IS.SP.6.1.1964 (steel table)

Check For compression

S.No.	Properties	Values	Remarks
1.	Slenderness ratio (λ)	42.23	<180 O.K
2.	Compressive stress, F_{cbc} (N/mm^2)	138.4	
3.	Ultimate compressive strength	1299.31	>906 kN OK
4.	Factor of safety	1.43	

Check For tension

S.No.	Properties	Values	Remarks
1.	Net area (mm^2)	87.50	
2.	Tensile stress ,f_{at} (N/mm^2)	150	
3.	Tensile strength(kN)	1411.5	>670 kN O.K
4.	Factor of safety	2.1	

Design of cross arm member			
S.No.	**Properties**	**Values**	**Remarks**
1.	Effective length l_{eff} (mm)	2350	Effectively restrained in position at both ends but not against rotation
2.	Load in compression p_c	125.71	
3.	Load in tension p_t	143.54	
4.	Steel used	MS	Mild Steel
5.	Angle section	Double	Used Back-to- Back
6.	Angle	90x90x12	
7.	$I_{yy}(cm^4)$	295.8	Minimum
8.	R_{vv}(mm)	27.1	Minimum
9.	Gross area(mm^2)	4038	As per IS.SP.6.1.1964 (steel table)

Check for compression

S.No.	Properties	Values	Remarks
1.	Slenderness Ratio (λ)	87.1	<180 O.K
2.	Compressive stress, F_{cbc} (N/mm^2)	90	
3.	Ultimate compressive Strength (kN)	363.4	>125 kN OK
4.	Factor of Safety	2.9	

Check for tension

S.No.	Properties	Values	Remarks
1.	Net area (mm^2)	3560	
2.	Tensile stress,f_{at}(N/mm^2)	150	
3.	Tensile strength (kN)	534	>143 kN O.K
4.	Factor of safety	3.73	

Design of tip member			
S.No.	**Properties**	**Values**	**Remarks**
1.	Effective length l_{eff} (mm)	3400	Effectively restrained in position at both ends but not against rotation
2.	Load in compression ,p_c	130.48	
3.	Load in tension, p_t	206.71	
4.	Steel used	MS	Mild Steel
5.	Angle section	90x90x12	
6.	Angle	double	
7.	$I_{yy}(cm^4)$	295.8	Minimum
8.	R_{vv}(mm)	27.1	Minimum
9.	Gross area(mm^2)	4038	As per IS.SP.6.1.1964 (steel table)

Check for compression

S.No.	Properties	Values	Remarks
1.	Slenderness ratio (λ)	125	<180 O.K
2.	Compressive stress, f_{cbc} (n/mm^2)	60.5	
3.	Ultimate compressive strength (kn)	244	>130 kN OK
4.	Factor of safety	1.87	

Check for tension

S.No.	Properties	Values	Remarks
1.	Net area (mm^2)	3230	
2.	Tensile stress,f_{at}(n/mm^2)	150	
3.	Tensile strength (kn)	484.56	>206 kN O.K
4.	Factor of safety	2.34	

Design of Hamp -ring			
S.No	**Properties**	**Values**	**Remarks**
1.	Effective length l_{eff} (mm)	1400	Effectively restrained in position at both ends but not against rotation
2.	Load in compression , p_c	135.14	
3.	Load in tension p_t	19.16	
4.	Steel used	MS	Mild Steel
5.	Angle section	100x75x12	
6.	Angle	Single	
7.	$I_{yy}(cm^4)$	48.6	Minimum
8.	R_{vv}(mm)	15.8	Minimum
9.	Gross area (mm^2)	1956	As per IS.SP.6.1.1964 (steel table)

Check for compression

S.No	Properties	Values	Remarks
1.	Slenderness ratio (λ)	88.6	<180 O.K
2.	Compressive stress, f_{cbc} (N/mm^2)	101	
3.	Ultimate compressive strength (kN)	197.55	>135 kN :OK
4.	Factor of safety	1.45	

Check for tension

S.No	Properties	Values	Remarks
1.	Net area (mm^2)	1564	
2.	Tensile stress,f_{at}(N/mm^2)	150	
3.	Tensile strength(kN)	234.72	>19.16 kN check:O.K
4.	Factor of safety	12.31	

Design of primary bracing member			
S.NO	**Properties**	**Values**	**Remarks**
1.	Effective length l_{eff}(mm)	1400	Effectively restrained in position at both ends but not against rotation
2.	Load in compression p_c	178.12	
3.	Load in tension p_t	172.00	
4.	Steel used	MS	Mild Steel
5.	Angle section	100x75x12	
6.	Angle	Single	
7.	I_{yy}(cm^4)	48.6	Minimum
8.	R_{vv}(mm)	15.8	Minimum
9.	Gross area(mm^2)	1956	As per IS.SP.6.1.1964 (steel table)

Check for compression

S.NO	**Properties**	**Values**	**Remarks**
1.	Slenderness ratio (λ)	88.6	<180 OK
2.	Compressive stress, f_{cbc} (N/mm^2)	101	
3.	Ultimate compressive strength(kN)	197.55	>178 kN OK
4.	Factor of safety	1.45	

Check for tension

S.NO	**Properties**	**Values**	**Remarks**
1.	Net area (mm^2)	1564	
2.	Tensile stress,f_{at} (N/mm^2)	150	
3.	Tensile strength (kN)	234.72	>172 kN O.K
4.	Factor of safety	12.31	

CHAPTER 6
CONCLUSION AND FUTURE SCOPE OF WORK

6.1 Conclusion

1. After consideration of the cost and losses of various transmission lines it is clear that the 765 kV transmission as huge advantage over lower voltage level as loss is over 3.2 times over 400 kV.

2. Right of Way utilization in 765kV tower is 2.17 times better than 400 kV tower.

3. Power transmission capacity of 765 kV is 3.8 times more than that of 400 kV .

4. After consideration and deductions of all losses and higher costs, it is found that installation cost of 765 kV is 60 % that of 400 kV.

5. A value of 1.6 for the ratio of 400 kV/765 kV Right of Way width requirements gives the breakeven point for setting up of 765 kV tower.

6. 765 kV transmission line clearly saves lot of land resources which is highly precious considering the shortage of level in present scenario as land required for 765 kV line is one - fifth that of 132 kV line.

7. The 765 kV tower Single circuit delta configuration has been found suitable in all the three conditions of reliability, security and safety considerations of the IS: 802-1995.

8. Maximum deflection is found at the cross arms i.e. 261 mm for angle section while for tubular section it is 352mm both values are within permissible limit.

9. Comparison of tube section and angle section shows that though former is using 8.21% less steel but the use of tube section gives higher stresses and deflections by 19.2 % ,

10. The present delta configuration has least weight to deflection ratio, thus giving economy in the design .

11. The axial forces induced in the angle section are higher than the tube sections at all heights .

12. In tower with tube section, deflection is found to increase in normal condition compared with angle sections but within permissible limit.

13. Tubular section is coming all the way more economical than the angle section tower .Even the self weight of the tower, wind loading on the tower, axial forces in the members except the node deflection, all are coming comparatively lesser.

6.2 Future Scope of Work

1. Continuous demand due to increasing population in all sectors viz. residential, commercial and industrial leads to requirement of efficient, consistent and adequate amount of electric power supply which can only be fulfilled by adopting high voltage transmission
2. Effective static loading on transmission line structure, conductor and ground wire can be replaced with the actual dynamic loading and the results can be compared.
3. Rapid urbanization and increasing demand for electricity, availability of land leads to involve use of tubular shape pole structure.
4. By 2020,the total generation capacity of India will increase from present installed capacity of 202 GW to 480 GW. To achieve this substantial growth, it requires power transfer with minimal environment impact, this necessitates development of high voltage transmission (upward of 765 kV) i.e. 1200 kV.
5. Research should be conducted on the development of 1200 kV as its power flow capacity (thermal rating) is approx. 12000 MVA while for 765 kV it is 3800 MVA ,the former is almost 3 times higher .
6. Power Flow (Surge impedance loading) for 1200 kV is 6000 MVA while for 765 kV it is 2000 MVA ,the former is 3 times that of 765 kV. Thus future of electricity transmission lies in 1200 kV.
7. Efforts for trying different structural material like aluminum should go on till some wonderful results could be achieved.
8. Attempt in changing the shape of cross arm can lead to improved results, structural optimization is already worked out that is by reconsidering the behavior of tower and geometry of tower:
9. Instead of considering wind as the prominent force seismic force (seismic zone IV and V) can be considered and the snow load in hilly region can be checked with different combinations.
10. Use of insulated cross arms should be studied in detail, as it reduce electrical clearances, thus, allowing the tower to somewhat more slender .

References

1. Albermani, F., Mahendran, M., and Kitipornchai, S. (2008). 'Upgrading of transmission towers using a diaphragm bracing system'. *International Journal of Civil And Structural Engineering*, 02(02), 112-114.

2. Baranov, E., and Zevin, A. (1998). 'The design system of a steel tower for overhead transmission lines.'. *Journal of Constructional Steel Research*, 46, 468-469.

3. Battista, R., S. Rodrigues, R., and S. Pfeil, M. (2003). 'Journal of wind engineering and industrial aerodynamics'. *Dynamic behavior and stability of transmission line towers under wind forces.*, 91, 1051-1057.

4. Da Silva, J., Ghergita, S., and Hughes,, D. (2001). 'Diaphrams for lattice steel supports'. *CIGRE,France*, 22(08), 44-53.

5. Das Begamudre, R. (2006). *Extra high voltage ac transmission engineering*. New Age Publishers Pvt Ltd, Delhi, 346-459.

6. Fossati, F., Manenti, A., Diana, G., Bruni, S., and Cheli, F. (1998). 'Dynamic analysis of the transmission line crossing'. *74*, (56) (*Journal of Wind Engineering and Industrial Aerodynamics*), 977-986.

7. Ghugal, Y., and Salunkhe, U. (2011). 'Analysis and design of three and four legged 400kV steel transmission line towers: comparative study'. *International Journal of Earth Sciences and Engineering*, 04(06), 691-694.

8. Kuzmanov, B., Thomas, F., and Willems, N. (1997). 'Automated design of three legged transmission line towers'. *Computers & Structures*, 01(01), 171-182.

9. Lakshmi, V., and Rao, R. (2002). 'Effect of medium wind intensity on 21m 132kv transmission tower'. *International Journal of Engineering Science and Technology*, 2(4), 820-824.

10. Lakshmi, V., and Satyanarayana, M. (2011). 'Study on performance of 220 kV M/C MA tower due to wind'. 03(03), 2-3.

11. Loredo-Souza, A., and Davenport, A. (2003). 'The influence of the design methodology in the response of transmission towers to wind loading'. *Journal of Wind Engineering and Industrial Aerodynamics*, 91, 991-1005.

12. Mc. Clure, G., and lapointe, M. (2003). 'Modeling the structural dynamic response of overhead transmission lines.'. *Journal of Computers and Structures*, 81, 824-835.

13. Prased Rao,, N., and Kalyanaraman, V. (2001). 'Non linear behavior of lattice panel of angle towers.'. *Journal of Constructional Steel Research*, 57, 1337-1357.

14. Punamia, B., and Jain, A. (2003). *Comprehensive design of steel structures*. Laxmi Publications, Delhi, 456-586.

15. S. Al-Ansari,, M. (2012). 'Building response to blast and earthquake loading'. *International Journal of Civil Engineering & Technology (IJCIET)*, 03(02), 327-346.

16. Selvaraj, M., Babu, R., and Kulkarni, S. (2012). 'Behavioral analysis of built up transmission line tower from FRP putruded sections'. *ISSN 2250-2459*, 02(09).

17. Visweswara Rao, G. (1995). 'Designs for transmission line towers'. *Computer & Structures*, 57(1), 81-92.

18. Yasui, H., Ohkuma, T., Marukawa, H., and Momomura, Y. (1991). 'Analytical study on wind induced vibration of power transmission towers.'. *Journal of Wind Engineering and Industrial Aerodynamics,*, 83, 441-451.

19. IS: 802 (Part 1/ Sec 1) 1995, *Use of structural steel in over head transmission line towers – code of practice (materials, loads and permissible stresses)*, section1 –materials and loads, B15,New Delhi.

20. IS: 5613 (Part 3/ Sec 1) 1989, *Code of practice for design, installation and maintenance for overhead power lines*, part 3 - 400 kV lines, section 1 - design, 1989,B15,New Delhi

21. IS: 875 (Part3) 2005, *Code of practice for design loads (other than earthquake) for buildings and structures*, part 3- wind loads, 2005, B15,New Delhi.

Appendix A

Beam no.	Wind in Z-Direction Compressive Stress N/mm²	Tensile Stress N/mm²	Wind in X-Direction Compressive Stress N/mm²	Tensile Stress N/mm²	Allowable Compressive Stress N/mm²	Allowable Tensile Stress N/mm²
1	49.398	-9.358	45.114	-15.045	140.55	-150.00
2	25.428	-26.473	26.213	-28.42	141.46	-150.00
3	48.729	-16.606	69.599	-25.696	112.24	-150.00
4	22.84	-43.29	50.49	-20.51	112.24	-150.00
5	7.21	-97.38	8.54	-92.93	105.84	-150.00
6	82.68	-23.85	76.72	-32.73	141.46	-150.00
7	18.87	-18.51	22.23	-19.98	148.70	-150.00
8	47.98	-52.32	26.12	-52.81	138.30	-150.00
9	49.83	-62.55	58.23	-90.95	138.30	-150.00
10	16.95	-14.68	15.50	-14.88	145.28	-150.00
11	56.64	-83.34	59.28	-85.78	92.07	-150.00
12	81.30	-57.91	75.32	-62.43	92.07	-150.00
13	16.42	-26.35	16.50	-20.48	145.28	-150.00
14	80.35	-115.90	83.30	-108.21	97.49	-150.00
15	113.77	-145.02	116.73	-123.91	126.74	-150.00
16	109.60	-146.38	112.55	-142.69	126.74	-150.00
17	88.38	-106.74	88.89	-105.85	119.31	-150.00
18	110.13	-91.15	111.46	-99.30	119.31	-150.00
19	106.34	-130.64	109.30	164.23	119.31	-150.00
20	102.17	-136.98	105.12	164.23	119.31	-150.00
21	73.66	-66.40	83.30	-119.47	97.49	-150.00
22	61.78	-53.36	95.35	-105.73	97.49	-150.00
23	51.39	-61.35	83.30	-101.03	97.49	-150.00
24	51.08	-49.47	79.97	-89.17	97.49	-150.00
25	47.90	-48.10	81.87	-82.73	97.49	-150.00
26	80.85	-79.74	94.38	-90.72	97.49	-150.00
27	59.79	-3.98	68.08	-7.79	118.54	-150.00
28	24.89	-34.32	31.58	-52.64	118.54	-150.00
29	80.35	-129.58	83.30	-133.82	97.49	-150.00
30	25.89	-42.55	23.45	-43.77	123.10	-150.00
31	65.72	-91.86	68.68	-90.08	78.69	-150.00
32	61.55	-102.63	64.50	-100.64	78.69	-150.00
33	46.70	-32.35	43.01	-35.41	123.10	-150.00
34	80.35	-130.64	83.30	164.23	97.49	-150.00

35	52.73	-56.60	83.89	-87.93	89.05	-150.00
36	58.30	-114.06	46.29	-105.34	120.46	-150.00
37	103.34	-66.25	89.03	-61.40	120.46	-150.00
38	6.93	-119.12	64.19	-78.28	126.74	-150.00
39	84.75	-39.74	50.00	-41.13	126.74	-150.00
40	62.72	-46.00	86.71	-58.35	102.64	-150.00
41	24.01	-34.80	23.57	-53.16	102.64	-150.00
42	7.36	-9.59	15.65	-20.47	120.08	-150.00
43	6.90	-9.49	17.49	-17.39	120.08	-150.00
44	32.81	-33.80	44.68	-45.45	102.64	-150.00
45	31.38	-32.95	42.70	-45.18	102.64	-150.00
46	78.68	-81.33	58.20	-34.13	120.08	-150.00
47	81.72	-80.02	47.38	-46.89	120.08	-150.00
48	90.83	-20.48	107.79	-38.04	118.54	-150.00
49	46.99	-74.59	53.21	-82.66	118.54	-150.00
50	35.40	-26.33	39.07	-27.06	71.55	-150.00
51	26.16	-36.98	27.24	-40.63	71.55	-150.00
52	13.94	-90.15	8.96	-84.41	120.46	-150.00
53	83.50	-23.96	70.06	-24.30	120.46	-150.00
54	63.61	-143.59	66.56	-96.77	80.75	-150.00
55	52.68	-28.49	53.90	-23.36	95.15	-150.00
56	21.57	-52.36	25.41	-40.94	95.15	-150.00
57	86.65	-109.21	82.14	-100.86	120.84	-150.00
58	99.61	-95.97	95.79	-92.56	120.84	-150.00
59	63.61	-132.05	66.56	-105.28	80.75	-150.00
60	22.48	-44.32	37.55	-19.06	108.24	-150.00
61	54.00	-7.43	67.47	-49.65	108.24	-150.00
62	31.64	-29.32	47.13	-44.46	97.49	-150.00
63	27.88	-30.16	43.27	-45.41	97.49	-150.00
64	80.35	-136.15	83.30	-123.40	97.49	-150.00
65	27.67	-38.25	24.94	-32.04	107.84	-150.00
66	37.88	-25.90	36.68	-24.02	107.84	-150.00
67	114.34	-49.21	99.62	-32.26	118.54	-150.00
68	55.93	-99.67	43.51	-84.75	118.54	-150.00
69	42.57	-47.97	48.95	-53.04	107.44	-150.00
70	48.08	-46.89	53.14	-53.36	107.44	-150.00
71	113.37	-110.64	87.34	164.23	120.46	-150.00
72	103.32	-120.91	106.27	-102.55	120.46	-150.00
73	89.33	-78.49	76.26	-67.83	97.49	-150.00
74	78.27	-89.98	67.54	-77.41	97.49	-150.00
75	17.11	-16.27	28.43	-27.24	141.46	-150.00
76	27.50	-21.92	22.70	-30.27	141.46	-150.00
77	88.72	-96.10	91.67	164.23	105.86	-150.00
78	69.67	-69.95	68.47	-68.27	103.04	-150.00

79	70.92	-71.82	69.27	-70.28	103.04	-150.00
80	87.82	-104.51	73.76	-88.11	138.82	-150.00
81	109.66	-95.88	91.17	-78.69	138.82	-150.00
82	92.15	-93.79	77.89	-80.94	99.06	-150.00
83	88.36	-95.47	73.95	-82.82	99.06	-150.00
84	68.54	-145.16	49.57	-138.79	121.22	-150.00
85	104.08	-116.89	107.03	-85.31	121.22	-150.00
86	30.27	-53.66	30.59	-48.92	68.82	-150.00
87	67.52	-28.21	58.79	-28.93	68.82	-150.00
88	51.12	-82.78	22.64	-116.10	138.08	-150.00
89	73.69	-59.38	25.75	-31.64	97.37	-150.00
90	63.48	-32.73	11.57	-21.72	97.37	-150.00
91	124.46	-13.43	65.86	-87.64	138.08	-150.00
92	105.57	-82.68	108.53	164.23	118.54	-150.00
93	101.40	-118.54	104.35	164.23	118.54	-150.00
94	5.60	-20.52	16.48	-5.19	136.77	-150.00
95	20.14	-7.59	13.03	164.23	136.77	-150.00
96	63.61	-124.32	66.56	164.23	80.75	-150.00
97	72.55	-147.21	33.39	164.23	126.74	-150.00
98	109.60	-103.65	119.01	-67.33	126.74	-150.00
99	50.48	-75.75	72.06	-43.94	102.64	-150.00
100	26.08	-22.81	21.44	-38.75	102.64	-150.00
101	91.58	-86.99	65.95	-53.74	120.08	-150.00
102	92.22	-91.71	64.19	-58.28	120.08	-150.00
103	38.16	-63.55	30.58	-57.59	121.98	-150.00
104	58.22	-76.78	52.63	-67.13	59.72	-150.00
105	42.57	-65.01	45.53	-57.55	59.72	-150.00
106	62.26	-25.16	52.62	-25.48	121.98	-150.00
107	22.37	-50.28	14.19	-79.36	138.08	-150.00
108	12.16	-12.21	16.64	-13.47	58.73	-150.00
109	72.08	-62.15	2.45	-18.62	97.37	-150.00
110	61.87	-17.55	9.87	-8.51	97.37	-150.00
111	5.78	-11.02	14.91	-12.31	58.73	-150.00
112	81.15	-137.19	0.72	-53.44	138.08	-150.00
113	3.24	-7.28	10.50	-1.60	93.15	-150.00
114	16.43	-5.34	11.96	-1.62	93.15	-150.00
115	66.82	-69.56	53.41	-61.31	69.72	-150.00
116	107.30	-145.31	85.54	-132.06	121.22	-150.00
117	104.08	-118.92	107.03	-103.85	121.22	-150.00
118	82.31	-103.45	85.26	164.23	99.45	-150.00
119	20.37	-42.76	16.99	-70.67	138.08	-150.00
120	10.15	-5.06	2.80	-9.76	34.91	-150.00
121	78.54	-64.62	4.80	-16.64	97.37	-150.00
122	68.32	-66.67	14.01	-8.08	97.37	-150.00

123	3.45	-8.13	2.85	-9.34	34.91	-150.00
124	69.80	-22.25	60.36	-46.14	138.08	-150.00
125	57.75	-70.03	46.18	-54.47	111.45	-150.00
126	74.22	-54.47	58.84	-39.63	111.45	-150.00
127	71.90	-125.47	74.86	164.23	89.05	-150.00
128	11.79	-10.05	17.90	-6.89	56.08	-150.00
129	19.25	-7.85	18.06	-7.12	56.08	-150.00
130	6.89	-21.47	18.37	-67.43	97.37	-150.00
131	31.23	-1.06	14.19	-63.81	97.37	-150.00
132	24.11	-43.62	23.76	-73.28	138.08	-150.00
133	13.89	-10.65	9.57	-14.38	20.00	-150.00
134	79.10	-67.91	7.43	-16.02	97.37	-150.00
135	68.88	-25.65	14.79	-8.45	97.37	-150.00
136	9.10	-14.15	9.45	-14.37	20.00	-150.00
137	69.12	-120.61	21.10	-47.00	138.08	-150.00
138	12.45	-131.29	6.91	-19.34	136.77	-150.00
139	119.63	-13.45	5.97	-24.72	136.77	-150.00
140	105.57	-147.75	108.53	164.23	118.54	-150.00
141	101.40	-130.64	104.35	164.23	118.54	-150.00
142	73.04	-119.08	71.04	-105.48	121.22	-150.00
143	104.08	-89.15	108.25	-93.09	121.22	-150.00
144	9.66	-5.83	11.86	-3.18	92.73	-150.00
145	4.44	-4.70	8.62	-4.29	93.15	-150.00
146	7.93	-4.14	8.39	-4.01	93.15	-150.00
147	14.99	-3.33	13.27	-3.00	92.73	-150.00
148	27.38	-11.12	12.83	-2.85	58.73	-150.00
149	17.16	-19.33	14.61	-33.62	58.73	-150.00
150	30.53	-39.78	28.02	-28.43	120.84	-150.00
151	32.30	-46.24	17.90	-27.41	120.84	-150.00
152	18.20	-50.61	21.45	-73.60	138.08	-150.00
153	7.98	-7.12	7.26	-12.52	34.91	-150.00
154	2.25	-2.37	4.07	-1.37	61.61	-150.00
155	4.90	-3.74	1.88	-4.50	46.20	-150.00
156	77.16	-66.23	6.90	-10.54	97.37	-150.00
157	66.94	-12.21	12.49	-5.04	97.37	-150.00
158	2.49	-4.94	1.97	-4.75	46.20	-150.00
159	4.36	-1.42	4.39	-1.38	61.61	-150.00
160	8.05	-8.64	6.83	-12.00	34.91	-150.00
161	87.31	-41.94	3.82	-56.80	138.08	-150.00
162	121.16	-93.14	99.04	-74.24	138.30	-150.00
163	106.89	-149.44	89.06	-95.72	138.30	-150.00
164	29.74	-74.05	37.24	-79.70	70.94	-150.00
165	64.58	-29.74	65.52	-42.24	70.94	-150.00
166	80.35	-105.77	83.30	-120.34	97.49	-150.00

167	61.04	-80.03	22.30	-6.15	72.17	-150.00
168	57.94	-135.28	15.45	-5.44	72.17	-150.00
169	10.22	-39.78	11.44	-10.18	72.17	-150.00
170	55.02	-39.63	18.37	-10.68	72.17	-150.00
171	86.70	-67.82	96.62	-53.00	103.84	-150.00
172	55.09	-123.07	38.01	-93.97	103.84	-150.00
173	76.04	-135.03	79.00	-128.31	93.19	-150.00
174	10.22	-47.97	19.99	-78.56	138.08	-150.00
175	65.77	-36.16	5.81	-19.17	82.69	-150.00
176	55.56	-54.10	8.42	-12.00	82.69	-150.00
177	79.74	-15.69	5.45	-53.56	138.08	-150.00
178	6.60	-7.67	14.65	-3.02	117.71	-150.00
179	13.25	-3.24	13.13	-1.86	117.71	-150.00
180	17.77	-41.89	18.63	-74.07	138.08	-150.00
181	7.56	-3.48	4.44	-6.82	46.90	-150.00
182	65.18	-36.65	7.68	-13.81	82.69	-150.00
183	54.97	-43.94	11.28	-8.15	82.69	-150.00
184	3.18	-6.10	3.55	-6.39	46.90	-150.00
185	66.36	-14.15	72.28	-44.32	138.08	-150.00
186	51.43	-145.78	58.09	-108.82	108.24	-150.00
187	91.10	-31.73	94.06	-9.74	108.24	-150.00
188	2.53	-4.11	3.31	-4.56	37.42	-150.00
189	2.52	-1.94	2.76	-3.34	37.42	-150.00
190	98.88	-74.53	85.52	-58.67	136.35	-150.00
191	93.84	-93.51	76.29	-82.06	136.35	-150.00
192	10.81	-2.20	2.99	-8.13	93.15	-150.00
193	7.80	-8.78	2.08	-7.65	93.15	-150.00
194	7.68	-2.82	7.78	-3.45	56.46	-150.00
195	3.97	-4.42	4.43	-3.69	65.70	-150.00
196	8.86	-10.04	4.55	-3.06	65.70	-150.00
197	7.41	-5.40	8.34	-3.16	56.46	-150.00
198	10.22	-41.65	19.04	-68.83	138.08	-150.00
199	64.87	-37.06	4.85	-13.32	82.69	-150.00
200	54.66	-21.38	13.68	-5.63	82.69	-150.00
201	64.89	-19.30	24.62	-44.67	138.08	-150.00
202	3.81	-9.16	10.44	-5.83	34.91	-150.00
203	10.35	-3.78	11.05	-4.95	34.91	-150.00
204	7.96	-9.17	8.23	-9.60	65.70	-150.00
205	6.51	-7.09	7.08	-7.11	65.70	-150.00
206	54.87	-126.54	22.63	-111.65	129.18	-150.00
207	93.85	-52.88	54.69	-42.91	129.18	-150.00
208	9.24	-34.70	28.26	-19.35	72.18	-150.00
209	6.88	-11.83	14.07	-11.63	52.19	-150.00
210	11.82	-17.96	12.88	-18.59	52.19	-150.00

211	20.29	-18.06	12.76	-7.64	72.18	-150.00
212	79.29	-12.99	107.69	-13.27	130.85	-150.00
213	37.02	-53.46	49.35	-69.23	130.85	-150.00
214	3.93	-4.61	2.73	-5.01	22.37	-150.00
215	3.19	-3.63	1.37	-4.74	22.37	-150.00
216	70.26	-97.88	85.93	-75.97	87.40	-150.00
217	1.08	-50.83	24.90	-83.65	138.08	-150.00
218	7.43	-10.31	10.71	-8.62	24.85	-150.00
219	51.88	-16.53	11.94	-8.07	72.17	-150.00
220	21.87	-37.68	6.71	-14.90	72.17	-150.00
221	11.65	-6.28	11.22	-7.87	24.85	-150.00
222	73.09	-22.36	3.30	-53.92	138.08	-150.00
223	12.76	-4.32	13.27	-7.67	83.85	-150.00
224	8.75	-9.13	13.24	-5.00	83.85	-150.00
225	11.82	-3.90	8.83	-5.83	92.73	-150.00
226	9.76	-10.16	8.49	-7.14	92.73	-150.00
227	4.53	-10.69	18.37	-69.45	97.37	-150.00
228	7.49	-3.71	18.37	-65.76	97.37	-150.00
229	3.56	-12.03	18.37	-48.08	82.69	-150.00
230	20.63	-4.92	14.19	-37.58	82.69	-150.00
231	0.65	-55.37	28.33	-83.64	138.08	-150.00
232	48.85	-19.00	14.14	-13.28	72.17	-150.00
233	55.02	-35.36	8.88	-15.66	72.17	-150.00
234	86.03	-111.74	2.87	-53.52	138.08	-150.00
235	7.14	-11.48	6.65	-8.95	34.91	-150.00
236	8.84	-6.80	8.28	-7.21	34.91	-150.00
237	118.43	-130.64	116.82	164.23	136.35	-150.00
238	119.21	-99.54	122.16	-93.22	136.35	-150.00
239	12.67	-3.50	9.76	-8.23	117.71	-150.00
240	3.90	-8.72	4.91	-9.42	117.71	-150.00
241	4.35	-5.84	7.83	-4.99	46.90	-150.00
242	7.47	-1.89	8.48	-2.81	46.90	-150.00
243	10.22	-47.54	19.87	-72.87	138.08	-150.00
244	66.13	-33.15	5.68	-14.08	92.73	-150.00
245	55.91	-23.80	17.52	-6.18	92.73	-150.00
246	76.54	-15.36	6.20	-42.09	138.08	-150.00
247	17.70	-7.40	11.56	-9.90	56.08	-150.00
248	13.76	-10.31	11.30	-10.27	56.08	-150.00
249	15.25	-11.59	30.64	-5.19	56.54	-150.00
250	13.05	-3.15	26.78	-7.78	56.54	-150.00
251	7.82	-3.23	7.77	-2.60	56.46	-150.00
252	6.69	-6.08	7.30	-3.25	56.46	-150.00
253	9.98	-14.17	14.10	-10.77	20.00	-150.00
254	13.26	-11.43	14.36	-10.51	20.00	-150.00

255	32.73	-132.76	35.68	-142.62	49.87	-150.00
256	82.08	-80.86	54.15	-54.71	97.49	-150.00
257	28.03	-21.19	23.36	-0.71	83.21	-150.00
258	9.34	-11.16	5.94	-13.13	83.21	-150.00
259	85.62	-87.85	83.30	-111.29	97.49	-150.00
260	19.39	-5.96	66.09	-5.19	72.17	-150.00
261	14.67	-8.98	64.97	-71.06	72.17	-150.00
262	19.43	-36.01	16.92	-65.87	138.08	-150.00
263	9.21	-7.62	2.73	-18.12	27.58	-150.00
264	64.20	-33.61	13.51	-18.96	92.73	-150.00
265	53.98	-20.49	28.06	-9.16	92.73	-150.00
266	3.39	-8.89	1.75	-17.22	27.58	-150.00
267	59.33	-46.32	4.36	-38.57	138.08	-150.00
268	7.25	-6.48	8.98	-11.10	65.70	-150.00
269	5.18	-8.29	8.28	-9.15	65.70	-150.00
270	10.22	-32.56	26.91	-60.25	138.08	-150.00
271	63.91	-34.12	12.72	-17.81	92.73	-150.00
272	53.70	-17.51	26.82	-7.58	92.73	-150.00
273	50.35	-16.80	1.38	-39.02	138.08	-150.00
274	124.19	-130.64	123.94	164.23	136.35	-150.00
275	119.21	-110.49	122.16	-100.13	136.35	-150.00
276	3.36	-5.30	4.43	-6.84	10.28	-150.00
277	4.30	-4.59	5.32	-6.83	10.28	-150.00
278	4.68	-11.63	18.37	-47.19	92.73	-150.00
279	19.18	-10.21	14.19	-40.42	92.73	-150.00
280	2.97	-41.21	22.53	-71.72	138.08	-150.00
281	6.67	-12.81	8.34	-13.07	15.30	-150.00
282	46.90	-15.32	19.21	-5.73	87.41	-150.00
283	22.83	-36.63	11.75	-16.36	87.41	-150.00
284	12.61	-4.82	9.21	-11.59	15.30	-150.00
285	61.56	-24.07	5.61	-43.79	138.08	-150.00
286	22.85	-3.11	19.86	-11.72	56.54	-150.00
287	28.03	-18.79	9.68	-15.10	56.54	-150.00
288	17.82	-1.08	16.36	-5.39	28.93	-150.00
289	4.45	-11.86	12.39	-7.46	28.93	-150.00
290	59.25	-130.64	62.20	164.23	76.39	-150.00
291	61.89	-95.63	69.02	-42.25	79.03	-150.00
292	36.73	-144.21	64.84	164.23	79.03	-150.00
293	10.33	-8.28	6.59	-11.34	24.85	-150.00
294	9.17	-7.65	6.58	-10.73	24.85	-150.00
295	2.78	-3.18	2.94	-5.70	37.42	-150.00
296	2.47	-0.84	2.80	-3.96	37.42	-150.00
297	51.92	-73.49	55.49	-80.40	129.18	-150.00
298	41.71	-36.95	41.30	-24.33	129.18	-150.00

299	25.70	-32.07	0.00	-29.94	82.85	-150.00
300	15.48	-11.46	23.65	-9.64	82.85	-150.00
301	87.42	-3.16	111.86	-4.30	130.85	-150.00
302	33.67	-52.82	42.41	-71.95	130.85	-150.00
303	2.62	-9.49	6.56	-6.07	27.58	-150.00
304	14.37	-12.21	8.62	-1.56	27.58	-150.00
305	2.87	-41.21	35.81	-72.56	138.08	-150.00
306	50.26	-22.82	21.62	-3.99	87.41	-150.00
307	77.90	-34.79	11.20	-14.81	87.41	-150.00
308	67.69	-15.22	5.51	-43.80	138.08	-150.00
309	13.69	-4.57	16.07	-2.31	83.85	-150.00
310	6.13	-10.61	13.29	-4.56	83.85	-150.00
311	12.56	-13.49	56.71	-5.19	72.17	-150.00
312	15.64	-3.01	53.49	-5.19	72.17	-150.00
313	9.53	-1.86	8.95	-7.69	39.28	-150.00
314	4.62	-8.05	6.88	-2.50	39.28	-150.00
315	6.83	-11.01	18.37	-71.53	97.37	-150.00
316	7.44	-7.88	14.19	-68.56	97.37	-150.00
317	2.49	-32.42	15.62	-59.03	138.08	-150.00
318	59.88	-25.73	1.43	-22.15	87.41	-150.00
319	49.67	-89.98	14.62	-9.58	87.41	-150.00
320	58.30	-18.01	6.70	-29.13	138.08	-150.00
321	105.57	-147.75	108.53	164.23	118.54	-150.00
322	101.40	-130.64	104.35	164.23	118.54	-150.00
323	31.54	-77.77	42.01	-26.00	99.85	-150.00
324	63.17	-5.80	85.67	-29.00	99.85	-150.00
325	5.75	-6.84	5.98	-10.22	47.45	-150.00
326	4.15	-4.94	5.07	-8.48	47.45	-150.00
327	7.10	-3.27	10.30	-1.77	45.34	-150.00
328	4.45	-5.43	7.84	-3.14	45.34	-150.00
329	3.84	-1.38	2.69	-2.19	61.61	-150.00
330	0.86	-2.80	1.76	-2.60	61.61	-150.00
331	2.23	-25.26	17.85	-47.32	138.08	-150.00
332	5.18	-5.87	3.66	-7.82	24.91	-150.00
333	55.40	-26.46	2.74	-21.70	87.41	-150.00
334	45.19	-28.41	17.71	-9.49	87.41	-150.00
335	5.18	-4.85	2.05	-6.34	24.91	-150.00
336	45.58	-15.43	7.94	-24.62	138.08	-150.00
337	7.45	-6.25	7.09	-3.70	124.31	-150.00
338	3.76	-16.20	12.13	-10.82	124.31	-150.00
339	18.16	-0.26	18.64	-0.12	124.31	-150.00
340	5.77	-3.23	8.68	-3.70	124.31	-150.00
341	24.51	-130.64	27.46	164.23	41.65	-150.00
342	50.17	-112.81	46.06	-55.79	79.03	-150.00

343	61.89	-28.54	64.84	-52.49	79.03	-150.00
344	2.00	-28.85	32.11	-56.19	138.08	-150.00
345	7.77	-46.74	17.92	-31.57	24.91	-150.00
346	19.70	-29.32	26.29	-14.29	36.85	-150.00
347	72.82	-12.21	49.85	-15.77	99.09	-150.00
348	10.22	-56.88	11.45	-42.33	99.09	-150.00
349	19.70	-40.40	22.66	-39.05	36.85	-150.00
350	7.77	-48.33	10.72	-34.74	24.91	-150.00
351	45.59	-12.21	7.90	-29.55	138.08	-150.00
352	0.90	-6.04	0.07	-8.54	17.66	-150.00
353	5.23	-0.12	0.79	-5.69	17.66	-150.00
354	33.69	-36.12	31.60	-31.77	97.49	-150.00
355	30.17	-16.91	23.95	-25.39	97.49	-150.00
356	12.60	-14.60	7.20	-20.20	97.49	-150.00
357	81.56	-83.73	83.30	-109.40	97.49	-150.00
358	5.10	-10.23	14.19	-46.50	82.69	-150.00
359	8.32	-4.71	17.38	-40.37	82.69	-150.00
360	9.84	-7.69	3.19	-14.32	15.30	-150.00
361	9.99	-6.46	4.14	-11.80	15.30	-150.00
362	1.40	-43.57	19.22	-29.58	45.34	-150.00
363	44.47	-25.71	42.21	-0.14	45.34	-150.00
364	89.50	-130.64	92.45	164.23	106.64	-150.00
365	112.68	-126.47	115.63	-101.45	129.82	-150.00
366	14.40	-6.78	22.00	-6.17	28.93	-150.00
367	4.27	-13.50	16.23	-0.98	28.93	-150.00
368	120.94	-113.61	123.89	164.23	138.08	-150.00
369	81.95	-1.56	79.92	-52.37	99.09	-150.00
370	6.09	-111.70	18.14	-81.39	99.09	-150.00
371	123.54	-138.45	123.89	164.23	138.08	-150.00
372	105.57	-130.64	108.53	164.23	118.54	-150.00
373	101.40	-140.32	104.35	164.23	118.54	-150.00
374	29.84	-56.19	66.69	164.23	99.85	-150.00
375	82.71	-114.90	61.38	-117.40	99.85	-150.00
376	3.81	-3.04	5.87	-5.26	65.70	-150.00
377	4.54	-7.81	4.21	-4.70	65.70	-150.00
378	15.31	-5.75	57.64	-5.19	87.41	-150.00
379	10.36	-8.50	53.08	-45.27	87.41	-150.00
380	4.68	-12.46	14.19	-40.08	87.41	-150.00
381	20.12	-7.66	73.22	-31.91	87.41	-150.00
382	68.57	-88.22	71.53	-81.23	81.54	-150.00
383	64.40	-130.64	67.35	164.23	81.54	-150.00
384	8.10	-4.40	5.29	-4.81	93.15	-150.00
385	4.15	-5.74	3.93	-5.73	93.15	-150.00
386	9.94	-3.29	9.30	-2.33	45.34	-150.00

387	28.20	-11.80	4.71	-6.11	45.34	-150.00
388	120.94	-108.86	123.89	164.23	138.08	-150.00
389	-3.29	-10.70	-0.34	-16.59	13.85	-150.00
390	20.49	-147.75	23.45	164.23	37.63	-150.00
391	136.36	-130.64	123.89	164.23	138.08	-150.00
392	7.44	-130.89	10.40	-115.75	20.41	-150.00
393	3.26	-59.37	6.22	-30.02	20.41	-150.00
394	2.89	-6.94	2.41	-7.66	24.91	-150.00
395	9.59	-2.02	4.58	-5.49	24.91	-150.00
396	76.87	-110.23	79.83	-45.22	89.84	-150.00
397	72.70	-147.75	75.65	164.23	89.84	-150.00
398	86.70	-130.64	89.65	-119.67	103.84	-150.00
399	6.85	-9.10	14.19	-45.40	92.73	-150.00
400	3.06	-10.81	21.16	-41.47	92.73	-150.00
401	8.75	-2.99	6.98	-4.59	124.31	-150.00
402	6.60	-11.71	8.39	-9.61	124.31	-150.00
403	44.96	-77.93	53.61	-77.50	129.18	-150.00
404	34.75	-33.86	39.42	-27.91	129.18	-150.00
405	34.83	-42.69	1.30	-39.76	94.37	-150.00
406	24.62	-12.93	34.30	-11.06	94.37	-150.00
407	97.03	-15.25	115.33	-77.24	130.85	-150.00
408	31.58	-51.54	33.05	-72.05	130.85	-150.00
409	7.77	-7.85	4.86	-38.28	24.91	-150.00
410	0.32	-29.05	21.34	-44.12	24.91	-150.00
411	4.52	-3.04	7.15	-3.45	47.45	-150.00
412	2.15	-8.20	4.84	-3.56	47.45	-150.00
413	2.40	-4.23	4.92	-3.85	46.20	-150.00
414	5.69	-2.20	5.99	-3.36	46.20	-150.00
415	2.15	-4.94	3.20	-5.40	22.37	-150.00
416	6.95	-2.90	5.09	-4.70	22.37	-150.00
417	-5.10	-56.95	-2.14	-47.83	7.87	-150.00
418	-9.27	-71.12	-6.32	-68.66	7.87	-150.00
419	21.40	-6.53	13.26	-35.54	45.34	-150.00
420	3.60	-21.85	18.37	-40.54	45.34	-150.00
421	7.25	-11.90	14.19	-75.54	97.37	-150.00
422	10.03	-10.34	79.61	-72.28	97.37	-150.00
423	101.40	-64.03	65.42	-56.77	118.54	-150.00
424	43.77	-111.36	44.46	-140.50	118.54	-150.00
425	21.02	-18.43	89.08	-5.19	99.09	-150.00
426	33.15	-147.75	84.90	164.23	99.09	-150.00
427	89.10	-147.75	92.05	164.23	106.24	-150.00
428	84.13	-147.75	87.09	164.23	97.10	-150.00
429	79.96	-147.75	82.91	164.23	97.10	-150.00
430	78.00	-130.64	80.96	164.23	95.15	-150.00

431	0.80	-6.66	0.24	-7.27	10.28	-150.00
432	7.52	-1.54	3.07	-4.96	10.28	-150.00
433	1.17	-149.32	6.47	-145.86	14.14	-150.00
434	-3.00	-7.55	-0.05	-24.73	14.14	-150.00
435	32.52	-27.50	38.17	-33.15	97.49	-150.00
436	39.25	-25.08	33.28	-0.04	112.24	-150.00
437	14.74	-23.55	7.97	-30.20	112.24	-150.00
438	68.02	-70.15	89.74	-91.87	97.49	-150.00
439	13.73	-5.93	62.25	-5.19	72.17	-150.00
440	13.59	-12.87	61.00	-5.19	72.17	-150.00
441	4.45	-16.45	33.10	-5.19	36.85	-150.00
442	18.53	-91.77	36.81	164.23	36.85	-150.00
443	68.57	-136.93	71.53	164.23	81.54	-150.00
444	64.40	-136.41	67.35	-142.17	81.54	-150.00
445	-13.50	-37.59	-10.55	-41.49	3.64	-150.00
446	-3.29	-79.56	-0.34	-69.34	13.85	-150.00
447	51.45	-85.41	79.83	164.23	89.84	-150.00
448	89.07	-130.64	75.65	-5.19	89.84	-150.00
449	10.38	-7.32	57.28	-5.19	72.17	-150.00
450	14.12	-4.79	56.50	164.23	72.17	-150.00
451	66.06	-128.22	69.02	164.23	79.03	-150.00
452	61.89	-130.64	64.84	164.23	79.03	-150.00
453	6.76	-7.48	14.19	-43.55	82.69	-150.00
454	9.47	-8.37	68.50	-41.22	82.69	-150.00
455	93.67	-147.75	96.63	164.23	106.64	-150.00
456	89.50	-130.64	92.45	164.23	106.64	-150.00
457	11.86	-3.33	57.72	-5.19	87.41	-150.00
458	8.80	-9.11	53.10	-45.51	87.41	-150.00
459	3.26	-12.89	18.37	-40.32	87.41	-150.00
460	8.67	-6.27	18.37	-32.99	87.41	-150.00
461	7.84	-8.53	14.19	-43.42	92.73	-150.00
462	3.17	-12.21	19.97	-41.79	92.73	-150.00
463	11.56	-2.97	5.78	-13.28	124.31	-150.00
464	2.60	-8.90	1.31	-16.14	124.31	-150.00
465	92.58	-130.64	89.84	164.23	99.85	-150.00
466	82.71	-142.98	85.67	164.23	99.85	-150.00
467	48.09	-109.94	65.71	-104.26	129.18	-150.00
468	37.88	-47.01	51.52	-33.97	129.18	-150.00
469	32.97	-40.98	0.76	-35.21	106.24	-150.00
470	22.76	-15.83	31.92	-9.48	106.24	-150.00
471	108.51	-18.04	118.74	-75.90	130.85	-150.00
472	41.37	-48.25	37.11	-70.71	130.85	-150.00
473	4.46	-7.92	14.19	-73.66	97.37	-150.00
474	7.28	-9.69	88.85	-71.74	97.37	-150.00

475	15.41	-5.83	74.66	-5.19	99.09	-150.00
476	19.08	-0.04	68.70	164.23	99.09	-150.00
477	84.13	-147.75	87.09	164.23	97.10	-150.00
478	79.96	-130.64	82.91	164.23	97.10	-150.00
479	19.03	-29.95	75.60	-101.28	117.29	-150.00
480	4.52	-81.56	7.48	-96.87	17.49	-150.00
481	0.35	-71.13	3.30	-55.78	17.49	-150.00
482	49.79	-52.13	63.85	-66.19	97.49	-150.00
483	19.70	-19.67	21.49	-23.32	126.74	-150.00
484	23.27	-22.95	25.69	-25.96	126.74	-150.00
485	39.49	-41.44	56.27	-58.22	97.49	-150.00
486	28.78	-19.17	103.10	-87.82	117.29	-150.00
487	84.13	-147.75	87.09	164.23	97.10	-150.00
488	79.96	-130.64	82.91	164.23	97.10	-150.00
489	2.66	-15.11	14.19	-61.63	99.09	-150.00
490	8.89	-12.04	91.59	-52.54	99.09	-150.00
491	10.28	-3.17	77.40	-5.19	97.37	-150.00
492	9.92	-6.49	71.62	-114.46	97.37	-150.00
493	68.16	-116.46	90.01	-109.28	129.18	-150.00
494	57.95	-46.53	75.82	-31.91	129.18	-150.00
495	21.21	-33.56	27.43	-36.85	106.24	-150.00
496	11.00	-16.47	13.24	-14.54	106.24	-150.00
497	83.86	-15.39	91.59	-53.02	130.85	-150.00
498	42.98	-29.19	36.27	-47.84	130.85	-150.00
499	11.79	-1.92	20.03	-7.70	124.31	-150.00
500	3.89	-8.96	10.38	-2.51	124.31	-150.00
501	12.04	-3.18	60.86	-5.19	92.73	-150.00
502	10.26	-6.31	57.54	-48.68	92.73	-150.00
503	7.28	-8.24	14.19	-43.49	87.41	-150.00
504	2.96	-13.97	66.52	-42.19	87.41	-150.00
505	9.54	-8.29	52.33	-5.19	87.41	-150.00
506	14.44	-14.10	50.12	164.23	87.41	-150.00
507	93.67	-147.75	96.63	164.23	106.64	-150.00
508	89.50	-130.64	92.45	164.23	106.64	-150.00
509	8.59	-5.78	59.06	-5.19	82.69	-150.00
510	15.00	-1.89	59.84	-86.46	82.69	-150.00
511	89.67	-130.64	95.89	-81.27	102.64	-150.00
512	85.50	-103.30	88.45	164.23	102.64	-150.00
513	7.02	-10.85	14.19	-44.49	72.17	-150.00
514	10.55	-9.21	57.98	-41.68	72.17	-150.00
515	-3.29	-57.25	-0.34	-86.95	13.85	-150.00
516	-13.50	-87.37	-10.55	-78.71	3.64	-150.00
517	17.81	-59.57	48.49	-71.97	89.84	-150.00
518	72.70	-22.74	75.65	164.23	89.84	-150.00

519	68.57	-134.01	71.53	-104.40	81.54	-150.00
520	64.40	-140.65	67.35	164.23	81.54	-150.00
521	0.45	-17.40	17.35	-42.12	36.85	-150.00
522	18.90	-2.62	3.16	-25.96	36.85	-150.00
523	11.14	-7.83	14.19	-43.26	72.17	-150.00
524	10.62	-14.34	57.98	-43.57	72.17	-150.00
525	66.07	-130.64	81.05	-129.99	83.21	-150.00
526	73.81	-129.81	69.02	164.23	83.21	-150.00
527	76.87	-79.11	93.16	-95.40	97.49	-150.00
528	34.50	-2.48	40.28	-4.39	112.24	-150.00
529	16.16	-25.94	18.97	-30.81	112.24	-150.00
530	29.69	-24.71	35.47	-30.50	97.49	-150.00
531	15.44	-99.53	32.49	-94.90	33.56	-150.00
532	4.56	-130.64	9.17	164.23	14.14	-150.00
533	-3.00	-0.15	-0.05	-5.19	14.14	-150.00
534	16.42	-2.01	19.37	-10.47	33.56	-150.00
535	0.87	-6.66	2.81	-5.28	10.28	-150.00
536	7.43	-1.43	6.49	-2.46	10.28	-150.00
537	84.13	-147.75	87.09	164.23	97.10	-150.00
538	79.96	-147.75	82.91	164.23	97.10	-150.00
539	89.10	-130.64	92.05	164.23	106.24	-150.00
540	3.95	-31.99	14.19	-123.06	99.09	-150.00
541	19.15	-22.65	89.86	-100.19	99.09	-150.00
542	11.70	-7.92	75.67	-5.19	97.37	-150.00
543	13.65	-5.95	73.74	-5.19	97.37	-150.00
544	21.73	-1.52	44.55	-20.92	45.34	-150.00
545	10.82	-21.45	28.40	-15.73	45.34	-150.00
546	2.13	-5.00	3.00	-3.73	22.37	-150.00
547	6.93	-2.80	5.10	-3.66	22.37	-150.00
548	8.00	-4.99	10.95	-23.17	25.14	-150.00
549	-5.10	-93.51	-2.14	-95.26	7.87	-150.00
550	-9.27	-44.70	-6.32	-41.29	7.87	-150.00
551	3.76	-122.67	9.11	-120.36	25.14	-150.00
552	2.29	-4.30	2.32	-5.95	46.20	-150.00
553	5.68	-2.20	3.00	-4.73	46.20	-150.00
554	4.53	-3.52	8.60	-10.04	47.45	-150.00
555	2.65	-8.23	7.53	-12.14	47.45	-150.00
556	7.77	-2.66	14.90	-14.62	24.91	-150.00
557	9.04	-29.80	10.72	-9.44	24.91	-150.00
558	82.01	-112.66	0.08	-108.65	129.18	-150.00
559	71.79	-32.35	91.75	-24.37	129.18	-150.00
560	21.72	-29.56	26.55	-32.42	94.37	-150.00
561	11.50	-13.44	12.36	-12.45	94.37	-150.00
562	70.53	-15.36	64.93	-36.90	130.85	-150.00

563	34.33	-25.03	27.65	-31.71	130.85	-150.00
564	8.81	-2.99	10.08	-5.72	124.31	-150.00
565	7.47	-12.06	11.91	-11.53	124.31	-150.00
566	11.20	-3.16	59.94	-5.19	92.73	-150.00
567	10.27	-4.14	57.48	-46.21	92.73	-150.00
568	79.55	-31.95	69.79	-41.02	118.54	-150.00
569	24.76	-90.17	12.81	-96.78	118.54	-150.00
570	76.87	-130.64	75.65	164.23	89.84	-150.00
571	72.70	-119.14	57.37	164.23	89.84	-150.00
572	3.03	-6.87	4.52	-6.71	24.91	-150.00
573	9.35	-2.28	8.94	-5.00	24.91	-150.00
574	7.44	-132.16	10.40	-140.62	20.41	-150.00
575	3.26	-31.80	6.22	-47.48	20.41	-150.00
576	120.94	-122.70	123.89	164.23	138.08	-150.00
577	20.49	-130.64	23.45	164.23	37.63	-150.00
578	-3.29	-64.28	-0.34	-60.38	13.85	-150.00
579	126.90	-130.64	123.89	-120.01	138.08	-150.00
580	9.50	-3.30	10.07	-5.07	45.34	-150.00
581	0.30	-11.48	4.61	-7.19	45.34	-150.00
582	8.14	-4.30	8.76	-3.84	93.15	-150.00
583	4.29	-5.73	7.45	-4.22	93.15	-150.00
584	68.57	-130.64	71.53	164.23	81.54	-150.00
585	64.40	-120.78	67.35	-103.51	81.54	-150.00
586	11.71	-9.27	14.19	-41.98	87.41	-150.00
587	5.38	-13.36	69.99	-40.69	87.41	-150.00
588	9.64	-8.82	55.80	-5.19	87.41	-150.00
589	23.70	-0.80	57.39	-15.90	87.41	-150.00
590	4.86	-3.42	9.88	-10.71	65.70	-150.00
591	5.53	-7.93	9.81	-12.15	65.70	-150.00
592	105.57	-147.75	108.53	164.23	118.54	-150.00
593	101.40	-130.64	104.35	164.23	118.54	-150.00
594	120.94	-112.27	123.89	164.23	138.08	-150.00
595	81.95	-25.70	91.51	-9.29	99.09	-150.00
596	10.37	-116.12	40.83	-94.81	99.09	-150.00
597	129.40	-148.38	123.89	-97.17	138.08	-150.00
598	14.27	-7.40	6.94	-13.44	28.93	-150.00
599	3.55	-13.49	0.65	-17.40	28.93	-150.00
600	112.68	-85.74	115.63	-102.92	129.82	-150.00
601	101.80	-133.43	88.94	-116.01	129.82	-150.00
602	2.97	-43.81	7.60	-48.19	45.34	-150.00
603	28.20	-1.01	36.78	-14.64	45.34	-150.00
604	36.05	-52.17	88.45	-128.02	102.64	-150.00
605	30.51	-77.76	66.86	-89.67	102.64	-150.00
606	10.31	-7.71	13.39	-4.47	15.30	-150.00

607	9.85	-6.06	13.52	-3.21	15.30	-150.00
608	10.99	-5.93	58.67	-5.19	82.69	-150.00
609	12.58	-1.28	59.86	-126.52	82.69	-150.00
610	80.35	-105.18	83.30	-121.33	97.49	-150.00
611	27.57	-12.21	33.34	-2.06	97.49	-150.00
612	13.32	-18.38	16.92	-23.02	97.49	-150.00
613	24.85	-27.02	28.26	-23.29	97.49	-150.00
614	0.96	-6.03	3.74	-2.24	17.66	-150.00
615	5.22	-12.21	6.27	-5.19	17.66	-150.00
616	6.59	-28.32	45.21	-56.64	138.08	-150.00
617	7.77	-47.02	10.72	-51.45	24.91	-150.00
618	19.70	-12.45	22.66	-6.64	36.85	-150.00
619	73.72	-12.21	51.83	-1.46	99.09	-150.00
620	10.22	-58.41	14.56	-48.73	99.09	-150.00
621	19.70	-42.25	10.82	-31.52	36.85	-150.00
622	7.77	-0.25	10.72	-12.64	24.91	-150.00
623	45.79	-15.40	71.41	164.23	138.08	-150.00
624	24.51	-130.64	27.46	164.23	41.65	-150.00
625	8.30	-7.67	12.88	-14.21	124.31	-150.00
626	4.74	-16.12	7.12	-17.80	124.31	-150.00
627	18.63	-3.19	17.47	-13.84	124.31	-150.00
628	6.25	-4.61	11.57	-11.72	124.31	-150.00
629	5.28	-24.72	44.02	-6.80	138.08	-150.00
630	5.13	-5.77	8.58	-1.61	24.91	-150.00
631	56.21	-27.10	8.82	-14.90	87.41	-150.00
632	45.99	-59.63	28.93	-7.04	87.41	-150.00
633	5.12	-4.60	9.94	-1.86	24.91	-150.00
634	44.36	-15.01	67.94	-97.21	138.08	-150.00
635	52.92	-114.61	64.52	-92.03	83.21	-150.00
636	66.07	-47.43	69.02	-31.53	83.21	-150.00
637	4.02	-1.36	4.83	-1.42	61.61	-150.00
638	1.04	-2.81	4.48	-2.09	61.61	-150.00
639	6.57	-3.70	0.93	-10.41	45.34	-150.00
640	3.71	-5.47	22.37	-9.70	45.34	-150.00
641	5.66	-6.87	8.19	-6.57	47.45	-150.00
642	4.24	-4.90	8.74	-7.76	47.45	-150.00
643	105.57	-147.75	108.53	164.23	118.54	-150.00
644	101.40	-130.64	104.35	164.23	118.54	-150.00
645	5.26	-32.05	50.67	-17.85	138.08	-150.00
646	61.05	-26.32	19.35	-12.67	87.41	-150.00
647	50.84	-14.41	40.39	-5.19	87.41	-150.00
648	57.27	-20.25	76.15	-5.19	138.08	-150.00
649	9.04	-8.25	72.94	-5.19	97.37	-150.00
650	13.52	-2.89	72.94	-12.28	97.37	-150.00

651	9.53	-2.21	9.47	-7.09	39.28	-150.00
652	4.85	-8.04	7.46	-9.63	39.28	-150.00
653	6.38	-14.37	14.19	-42.74	72.17	-150.00
654	11.22	-7.63	69.68	-39.25	72.17	-150.00
655	35.85	-77.27	55.49	-75.82	102.64	-150.00
656	101.88	-37.91	88.45	-44.83	102.64	-150.00
657	12.30	-8.32	6.82	-11.27	83.85	-150.00
658	8.46	-9.14	6.74	-11.65	83.85	-150.00
659	6.44	-41.20	65.10	-10.81	138.08	-150.00
660	50.56	-12.21	19.17	-5.62	87.41	-150.00
661	77.31	-35.51	4.24	-19.63	87.41	-150.00
662	67.09	-45.22	93.13	-16.89	138.08	-150.00
663	2.35	-9.44	2.34	-11.70	27.58	-150.00
664	14.26	-24.77	9.30	-7.49	27.58	-150.00
665	95.11	-115.64	11.85	-107.83	129.18	-150.00
666	84.89	-33.02	101.79	-26.44	129.18	-150.00
667	16.73	-23.65	21.81	-25.88	82.85	-150.00
668	6.51	-12.56	7.62	-10.76	82.85	-150.00
669	63.73	-20.49	57.35	-41.53	130.85	-150.00
670	28.21	-29.10	20.97	-36.34	130.85	-150.00
671	2.71	-3.26	2.65	-2.08	37.42	-150.00
672	2.48	-0.97	3.68	-2.10	37.42	-150.00
673	11.57	-8.28	13.43	-6.10	24.85	-150.00
674	10.39	-7.50	13.25	-5.36	24.85	-150.00
675	59.25	-130.64	62.20	164.23	76.39	-150.00
676	17.59	-1.11	7.98	-15.16	28.93	-150.00
677	3.79	-12.17	2.78	-17.75	28.93	-150.00
678	22.68	-2.54	20.63	-1.98	56.54	-150.00
679	39.40	-18.59	7.81	-8.65	56.54	-150.00
680	66.07	-31.49	69.02	-146.40	83.21	-150.00
681	2.88	-130.64	79.03	164.23	83.21	-150.00
682	6.53	-41.20	64.84	-14.23	138.08	-150.00
683	7.21	-12.33	1.11	-9.04	15.30	-150.00
684	47.26	-19.79	17.47	-13.53	87.41	-150.00
685	23.54	-37.35	3.60	-26.28	87.41	-150.00
686	13.33	-4.16	1.11	-6.51	15.30	-150.00
687	61.26	-16.25	92.82	-5.19	138.08	-150.00
688	9.56	-7.59	67.57	-5.19	92.73	-150.00
689	19.81	-9.29	64.96	-9.68	92.73	-150.00
690	2.94	-4.76	9.72	-4.49	10.28	-150.00
691	4.32	-4.04	8.61	-4.01	10.28	-150.00
692	120.92	-130.64	112.04	164.23	136.35	-150.00
693	119.21	-116.82	122.16	-123.06	136.35	-150.00
694	2.12	-32.50	60.09	-32.75	138.08	-150.00

695	62.25	-34.35	12.09	-27.56	92.73	-150.00
696	52.03	-48.01	20.38	-16.46	92.73	-150.00
697	50.06	-17.80	81.54	-13.00	138.08	-150.00
698	7.81	-6.62	7.17	-7.82	65.70	-150.00
699	5.65	-8.97	7.81	-10.11	65.70	-150.00
700	3.80	-35.81	61.58	-7.33	138.08	-150.00
701	9.54	-5.59	24.15	-2.15	27.58	-150.00
702	62.31	-33.62	9.02	-31.09	92.73	-150.00
703	52.09	-23.78	20.67	-14.90	92.73	-150.00
704	4.47	-6.32	25.23	-2.80	27.58	-150.00
705	58.70	-23.69	90.03	-49.22	138.08	-150.00
706	18.04	-8.69	14.19	-44.04	72.17	-150.00
707	12.24	-11.58	22.99	-42.96	72.17	-150.00
708	9.88	-14.24	8.81	-14.39	20.00	-150.00
709	13.35	-11.48	9.33	-14.04	20.00	-150.00
710	42.80	-54.93	21.54	-79.52	49.87	-150.00
711	80.35	-139.28	83.30	164.23	97.49	-150.00
712	22.81	-18.29	25.02	-20.58	83.21	-150.00
713	10.63	-12.43	11.66	-15.40	83.21	-150.00
714	34.78	-36.80	28.32	-30.31	97.49	-150.00
715	8.82	-3.64	8.25	-5.50	56.46	-150.00
716	7.25	-6.08	7.92	-6.81	56.46	-150.00
717	14.67	-12.01	14.40	-31.51	56.54	-150.00
718	10.38	-3.58	0.21	-30.06	56.54	-150.00
719	17.72	-7.34	19.88	-7.76	56.08	-150.00
720	13.94	-10.30	19.33	-8.30	56.08	-150.00
721	3.86	-47.40	70.76	-27.15	138.08	-150.00
722	70.79	-34.80	7.89	-21.97	92.73	-150.00
723	60.57	-15.15	27.77	-4.33	92.73	-150.00
724	76.05	-21.01	93.47	-12.03	138.08	-150.00
725	4.98	-6.13	3.24	-6.84	46.90	-150.00
726	8.02	-2.04	5.74	-6.29	46.90	-150.00
727	12.18	-2.95	15.39	-3.40	117.71	-150.00
728	4.02	-8.80	11.31	-4.64	117.71	-150.00
729	123.38	-147.75	126.34	164.23	136.35	-150.00
730	119.21	-130.64	122.16	164.23	136.35	-150.00
731	6.90	-11.48	8.35	-9.57	34.91	-150.00
732	9.10	-6.97	8.89	-10.00	34.91	-150.00
733	5.04	-55.48	81.20	-7.91	138.08	-150.00
734	51.71	-14.57	19.95	-2.73	72.17	-150.00
735	55.02	-34.64	14.46	-13.30	72.17	-150.00
736	85.78	-12.21	106.91	-5.19	138.08	-150.00
737	7.62	-9.90	64.02	-5.19	82.69	-150.00
738	17.41	-2.37	61.97	-5.19	82.69	-150.00

739	5.47	-8.79	67.55	-5.19	97.37	-150.00
740	11.43	-22.68	66.89	-8.32	97.37	-150.00
741	12.52	-3.72	15.61	-3.13	92.73	-150.00
742	10.07	-10.12	15.27	-6.66	92.73	-150.00
743	13.29	-3.01	8.55	-7.16	83.85	-150.00
744	5.32	-10.47	3.91	-9.73	83.85	-150.00
745	5.47	-51.21	76.47	-11.93	138.08	-150.00
746	8.30	-8.35	9.00	-6.74	61.23	-150.00
747	51.94	-63.68	18.09	-2.47	72.17	-150.00
748	19.30	-37.59	11.39	-13.24	72.17	-150.00
749	9.08	-5.88	9.10	-6.08	61.23	-150.00
750	73.14	-130.64	106.04	-30.65	138.08	-150.00
751	37.73	-51.47	40.68	-25.46	54.87	-150.00
752	4.95	-3.93	6.60	-2.20	56.34	-150.00
753	2.91	-3.53	6.22	-3.38	56.34	-150.00
754	61.25	-130.64	54.18	164.23	129.18	-150.00
755	112.03	-122.73	114.99	-95.53	129.18	-150.00
756	12.42	-35.27	33.63	-25.98	72.18	-150.00
757	20.63	-21.96	19.44	-28.10	52.19	-150.00
758	16.28	-18.23	20.72	-19.70	52.19	-150.00
759	20.87	-18.99	10.30	-7.72	72.18	-150.00
760	63.21	-0.67	53.51	-2.68	130.85	-150.00
761	30.23	-37.34	16.22	-41.08	130.85	-150.00
762	9.39	-7.56	7.11	-8.52	113.43	-150.00
763	8.99	-6.88	9.37	-9.55	113.43	-150.00
764	3.72	-9.15	3.40	-8.67	34.91	-150.00
765	10.36	-3.72	4.71	-8.39	34.91	-150.00
766	10.22	-41.94	68.81	-16.35	138.08	-150.00
767	63.40	-36.97	12.23	-11.16	82.69	-150.00
768	53.19	-21.68	18.67	-3.38	82.69	-150.00
769	65.05	-18.15	92.21	-10.16	138.08	-150.00
770	7.25	-2.44	7.32	-4.97	105.16	-150.00
771	3.00	-4.80	6.80	-6.54	113.43	-150.00
772	12.23	-9.47	8.81	-8.24	113.43	-150.00
773	6.21	-5.95	5.23	-7.30	105.16	-150.00
774	11.27	-2.15	17.15	-5.40	93.15	-150.00
775	8.16	-8.77	17.20	-7.36	93.15	-150.00
776	123.38	-147.75	126.34	164.23	136.35	-150.00
777	119.21	-130.64	122.16	164.23	136.35	-150.00
778	1.96	-3.72	2.32	-1.36	82.30	-150.00
779	2.63	-1.56	3.07	-1.40	82.30	-150.00
780	94.40	-143.90	83.22	-104.15	108.24	-150.00
781	91.10	-54.58	94.06	-103.47	108.24	-150.00
782	0.55	-41.40	70.19	-6.57	138.08	-150.00

783	7.15	-2.48	7.90	-1.39	94.83	-150.00
784	63.63	-38.05	8.74	-9.66	82.69	-150.00
785	53.42	-15.54	18.17	-7.78	82.69	-150.00
786	2.24	-5.99	6.95	-2.60	94.83	-150.00
787	66.12	-49.54	98.84	-15.02	138.08	-150.00
788	4.55	-7.97	1.36	-9.83	117.71	-150.00
789	12.23	-3.34	0.88	-8.83	117.71	-150.00
790	2.13	-49.89	85.22	-15.11	138.08	-150.00
791	70.19	-37.34	16.53	-9.92	82.69	-150.00
792	59.98	-129.96	33.29	-5.19	82.69	-150.00
793	79.55	-12.21	106.21	-130.61	138.08	-150.00
794	76.04	-144.75	79.00	-125.42	93.19	-150.00
795	86.70	-29.41	69.07	-40.22	103.84	-150.00
796	11.36	-117.75	31.72	-120.77	103.84	-150.00
797	62.76	-144.43	17.54	-8.70	72.17	-150.00
798	58.44	-130.64	17.01	-12.83	72.17	-150.00
799	10.22	-40.11	10.48	-19.47	72.17	-150.00
800	55.02	-39.97	9.30	-15.83	72.17	-150.00
801	125.33	-132.22	128.29	-117.92	138.30	-150.00
802	121.16	-130.64	124.11	164.23	138.30	-150.00
803	28.69	-56.58	40.69	-48.05	70.94	-150.00
804	52.12	-23.69	56.39	-21.23	70.94	-150.00
805	85.81	-84.39	60.19	-57.41	97.49	-150.00
806	0.94	-52.79	93.33	-11.94	138.08	-150.00
807	8.45	-7.25	8.76	-6.76	34.91	-150.00
808	1.93	-2.58	0.48	-2.95	61.61	-150.00
809	5.27	-3.32	6.13	-2.16	46.20	-150.00
810	80.23	-66.93	5.93	-16.95	97.37	-150.00
811	70.02	-12.21	17.27	-5.81	97.37	-150.00
812	2.60	-4.71	5.97	-2.18	46.20	-150.00
813	4.37	-1.56	1.29	-3.00	61.61	-150.00
814	7.86	-8.64	9.71	-8.68	34.91	-150.00
815	87.30	-12.21	115.25	-114.75	138.08	-150.00
816	77.36	-81.68	76.49	-109.56	120.84	-150.00
817	90.13	-108.14	32.45	-76.57	120.84	-150.00
818	27.29	-11.13	5.70	-12.87	58.73	-150.00
819	17.07	-15.51	12.44	-10.77	58.73	-150.00
820	9.53	-6.41	9.49	-10.77	92.73	-150.00
821	3.94	-5.13	3.21	-6.01	93.15	-150.00
822	7.55	-4.22	3.17	-6.12	93.15	-150.00
823	15.06	-3.30	10.73	-11.45	92.73	-150.00
824	105.57	-147.75	108.53	164.23	118.54	-150.00
825	101.40	-130.64	104.35	164.23	118.54	-150.00
826	58.60	-134.70	74.57	-120.33	121.22	-150.00

827	104.08	-74.79	107.03	-68.42	121.22	-150.00
828	12.33	-80.89	24.45	-8.13	136.77	-150.00
829	10.22	-13.17	14.83	-9.25	136.77	-150.00
830	24.19	-43.86	73.44	-16.28	138.08	-150.00
831	13.97	-10.53	13.64	-11.09	20.00	-150.00
832	79.84	-68.68	8.37	-15.88	97.37	-150.00
833	69.62	-13.14	20.38	-4.15	97.37	-150.00
834	9.19	-14.05	13.31	-11.26	20.00	-150.00
835	69.17	-20.07	99.70	-5.19	138.08	-150.00
836	11.51	-20.65	69.38	-5.19	97.37	-150.00
837	28.27	-0.93	76.80	-15.64	97.37	-150.00
838	11.66	-10.13	13.24	-10.46	56.08	-150.00
839	19.26	-7.87	13.78	-10.51	56.08	-150.00
840	98.48	-130.64	101.44	-133.07	111.45	-150.00
841	94.31	-140.86	97.26	-130.37	111.45	-150.00
842	71.90	-130.64	74.86	164.23	89.05	-150.00
843	20.65	-43.03	74.24	-8.27	138.08	-150.00
844	10.43	-4.94	10.90	-3.08	34.91	-150.00
845	76.99	-64.45	8.12	-12.16	97.37	-150.00
846	66.77	-63.16	17.99	-1.20	97.37	-150.00
847	3.52	-8.15	10.50	-3.75	34.91	-150.00
848	69.88	-145.38	98.11	164.23	138.08	-150.00
849	82.31	-130.64	85.26	164.23	99.45	-150.00
850	47.61	-50.96	42.97	-40.24	69.72	-150.00
851	108.25	-130.64	111.21	164.23	121.22	-150.00
852	104.08	-133.18	107.03	-117.35	121.22	-150.00
853	3.30	-7.29	7.65	-9.16	93.15	-150.00
854	16.47	-5.34	9.63	-10.21	93.15	-150.00
855	5.25	-50.58	85.92	-5.19	138.08	-150.00
856	12.99	-12.21	18.32	-13.02	58.73	-150.00
857	72.07	-61.62	7.52	-7.83	97.37	-150.00
858	61.85	-73.90	18.79	-5.19	97.37	-150.00
859	5.71	-10.66	21.88	-5.19	58.73	-150.00
860	81.01	-16.09	119.23	-40.48	138.08	-150.00
861	1.95	-63.69	28.12	-35.30	121.98	-150.00
862	42.57	-61.69	45.53	-56.71	59.72	-150.00
863	54.37	-76.77	51.76	-68.13	59.72	-150.00
864	83.22	-3.88	89.64	164.23	121.98	-150.00
865	63.61	-147.75	66.56	164.23	80.75	-150.00
866	89.75	-130.64	89.39	164.23	126.74	-150.00
867	109.60	-120.86	112.55	-100.70	126.74	-150.00
868	57.42	-34.07	46.07	-2.75	102.64	-150.00
869	25.01	-36.89	8.87	-53.03	102.64	-150.00
870	98.19	-87.00	46.24	-48.44	120.08	-150.00

871	91.64	-98.31	48.84	-49.59	120.08	-150.00
872	5.67	-21.87	14.19	-15.06	136.77	-150.00
873	18.40	-7.68	122.59	-16.68	136.77	-150.00
874	105.57	-147.75	108.53	164.23	118.54	-150.00
875	101.40	-130.64	104.35	164.23	118.54	-150.00
876	60.02	-82.85	133.52	-25.95	138.08	-150.00
877	75.16	-61.69	29.26	-8.89	97.37	-150.00
878	64.94	-77.88	42.13	-5.19	97.37	-150.00
879	124.10	-3.22	123.89	164.23	138.08	-150.00
880	85.08	-130.64	86.45	164.23	121.22	-150.00
881	104.08	-128.80	107.03	-114.82	121.22	-150.00
882	34.92	-65.67	34.19	-62.50	68.82	-150.00
883	51.68	-32.92	54.63	-31.96	68.82	-150.00
884	86.09	-133.39	89.05	-139.90	99.06	-150.00
885	81.92	-147.08	84.87	-149.19	99.06	-150.00
886	128.42	-135.47	114.86	-139.25	138.82	-150.00
887	121.68	-135.60	124.63	-123.56	138.82	-150.00
888	84.96	-84.14	80.89	-81.51	103.04	-150.00
889	85.06	-87.15	81.46	-84.59	103.04	-150.00
890	88.72	-130.64	91.67	164.23	105.86	-150.00
891	17.64	-15.79	17.77	-17.39	141.46	-150.00
892	34.22	-23.27	32.72	-24.71	141.46	-150.00
893	84.52	-104.01	83.30	-93.43	97.49	-150.00
894	80.35	-122.25	93.54	-109.81	97.49	-150.00
895	107.49	-147.75	110.45	164.23	120.46	-150.00
896	103.32	-130.64	106.27	-144.92	120.46	-150.00
897	51.38	-56.98	51.11	-55.91	107.44	-150.00
898	57.10	-55.70	56.39	-55.40	107.44	-150.00
899	101.40	-58.87	104.35	-60.74	118.54	-150.00
900	67.45	-127.90	55.24	-128.74	118.54	-150.00
901	25.59	-49.93	24.99	-37.84	107.84	-150.00
902	53.58	-23.41	49.54	-12.65	107.84	-150.00
903	27.71	-28.93	32.24	-32.69	97.49	-150.00
904	28.24	-26.73	32.70	-30.52	97.49	-150.00
905	80.35	-134.78	89.92	-90.42	97.49	-150.00
906	37.02	-67.80	34.50	-61.13	108.24	-150.00
907	81.26	-21.30	80.35	-34.59	108.24	-150.00
908	63.61	-138.54	66.56	-149.97	80.75	-150.00
909	75.15	-20.57	48.82	-20.21	95.15	-150.00
910	17.76	-83.59	80.96	-74.98	95.15	-150.00
911	83.02	-113.03	83.70	-110.58	120.84	-150.00
912	102.72	-91.84	98.88	-94.65	120.84	-150.00
913	63.61	-130.64	66.56	164.23	80.75	-150.00
914	47.27	-138.78	49.07	-126.32	120.46	-150.00

915	103.32	-54.48	106.27	-33.77	120.46	-150.00
916	38.89	-30.44	39.74	-29.71	71.55	-150.00
917	30.33	-40.45	29.56	-42.06	71.55	-150.00
918	110.30	-25.08	96.08	-32.36	118.54	-150.00
919	50.13	-93.99	35.67	-95.45	118.54	-150.00
920	16.10	-139.95	16.08	-133.03	126.74	-150.00
921	125.86	-46.32	119.42	-25.62	126.74	-150.00
922	65.28	-45.14	53.46	-6.47	102.64	-150.00
923	24.16	-42.23	13.25	-52.68	102.64	-150.00
924	9.05	-10.98	15.49	-17.14	120.08	-150.00
925	7.84	-10.59	14.78	-16.25	120.08	-150.00
926	31.67	-32.93	32.87	-33.53	102.64	-150.00
927	30.65	-31.13	31.73	-31.94	102.64	-150.00
928	80.07	-82.43	36.56	-37.89	120.08	-150.00
929	82.82	-81.40	38.04	-38.34	120.08	-150.00
930	61.67	-138.91	64.61	-121.37	120.46	-150.00
931	103.32	-68.82	106.27	-58.77	120.46	-150.00
932	61.91	-62.05	60.17	-60.81	89.05	-150.00
933	39.09	-84.07	40.65	-67.65	123.10	-150.00
934	65.72	-119.99	68.68	-120.20	78.69	-150.00
935	61.55	-139.30	64.50	-140.28	78.69	-150.00
936	85.95	-45.90	85.05	-31.66	123.10	-150.00
937	80.35	-130.64	83.30	164.23	97.49	-150.00
938	66.44	-3.12	63.52	-10.40	118.54	-150.00
939	24.09	-43.81	20.97	-60.53	118.54	-150.00
940	69.70	-71.58	90.10	-83.49	97.49	-150.00
941	60.76	-62.61	84.92	-85.61	97.49	-150.00
942	66.37	-54.04	87.84	-79.98	97.49	-150.00
943	52.79	-50.67	68.62	-66.26	97.49	-150.00
944	48.23	-50.68	63.53	-66.86	97.49	-150.00
945	82.51	-81.40	75.07	-71.45	97.49	-150.00
946	113.77	-133.75	116.73	-148.93	126.74	-150.00
947	109.60	-149.98	112.55	164.23	126.74	-150.00
948	75.77	-106.02	84.10	-107.74	119.31	-150.00
949	110.06	-79.36	110.66	-85.55	119.31	-150.00
950	106.34	-147.75	109.30	164.23	119.31	-150.00
951	102.17	-130.64	105.12	164.23	119.31	-150.00
952	42.67	-42.68	49.08	-51.20	138.30	-150.00
953	41.24	-58.16	47.82	-62.89	138.30	-150.00
954	27.61	-23.40	26.41	-19.85	145.28	-150.00
955	57.14	-94.17	60.00	-91.59	92.07	-150.00
956	92.05	-57.50	89.76	-61.35	92.07	-150.00
957	30.74	-31.15	27.29	-28.16	145.28	-150.00
958	80.35	-135.06	83.30	-130.39	97.49	-150.00

959	13.38	-12.98	17.53	-17.20	148.70	-150.00
960	55.18	-6.78	54.00	-15.33	112.24	-150.00
961	11.10	-50.43	20.13	-47.94	112.64	-150.00
962	88.70	-119.76	7.83	-112.00	105.84	-150.00
963	105.28	-14.53	96.66	-22.68	105.84	-150.00
964	23.60	-24.61	26.05	-27.14	141.46	-150.00