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Assessment of Right of Way and Electric Field and Magnetic Field of High Voltage Overhead Transmission Lines in Nepal

by

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ABSTRACT

The current Right of Way (ROW) practices in Nepal for high-voltage transmission lines (HVTLs) are standardized based solely on voltage levels, without accounting for factors like span lengths, conductor types, or tower configurations. This limits the potential for ROW optimization and increases environmental impacts, especially in forested and urban areas. Moreover, Nepal's current ROW regulations do not allow for land use under transmission lines. Electric and magnetic field levels beneath and at the edge of the ROW also significantly influence ROW requirements, particularly for High Voltage lines.

This thesis evaluates ROW requirements and electric and magnetic field profiles for 132kV, 220kV, and 400kV double circuit transmission lines using both I-string and V-string insulators. The electric and magnetic field levels were analyzed at 1.8m and 3.5m heights and during conductor swing conditions. Findings show that while the standard ROW is generally sufficient for 220kV and 400kV lines with standard spans, it is inadequate for 132kV lines. Further the ROW for all voltage levels is found to be insufficient for long spans.

The study reveals that electric and magnetic field levels are within ICNIRP limits at 1.8m height but exceed safety limits at 3.5m height for 400kV lines. In 132kV lines, the electric field at the edge of an 18m ROW reaches 83kV/m during swing conditions, which drops to 4kV/m when a 23m ROW is used.

The ROW requirements for 400kV, 220kV and 132kV HVTLs on the gantry span are found to be within the standard ROW values. And the field values are found to be within the recommended limits by ICNIRP.

Further, trees up to 4.1m can be planted throughout the ROW, while the maximum allowable tree heights at ROW edges are 5.8m (132kV), 6m (220kV), and 7.1m (400kV), which can be increased using tower extensions. For 132kV lines with a 23m ROW, the maximum allowable tree height at the edge can reach 6.7m.

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LIST OF ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
ACSR	Aluminum Conductor Steel Reinforced
DOED	Department of Electricity Development
EHV	Extra High Voltage
ERC	Electricity Regulatory Commission
Hz	Hertz
HTLS	High Temperature Low Sag
HVTLs	High Voltage Transmission Lines
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IPPs	Independent Power Producers
IS	Indian Standard
KHz	Kilo Hertz
kV	Kilo Volt
kV/m	Kilo Volt per Meter
m	Meter
m/s	Meter per Second
μT	Microtesla
NEA	Nepal Electricity Authority
Pa	Pascals
ROW	Right of Way
RPGCL	Rastriya Prasaran Grid Company Limited
TL	Transmission Line
UTS	Ultimate Tensile Strength

CHAPTER-1: INTRODUCTION

1.1. Background

Overhead AC transmission lines are predominant in Nepal and, with the increasing generation capacity, integration of renewables and distributed energy resources, increasing local energy demand and the possibility of cross-border energy sale, the requirements for High Voltage AC Transmission Lines (HVTLs) will be more than ever. The Nepalese transmission network is composed of 400kV, 220kV, 132kV and 66kV single circuit and double circuit transmission lines. There are many transmission line projects under construction and many more under feasibility study and design phase.

As per the NEA annual report – 2024, Nepal currently has 3967 circuit-km of 132kV TL, 1105 circuit-km of 220kV TL and 384 circuit-km of 400kV TL. Further, there are multiple under construction transmission line projects amassing total of 1247.6 circuit-km of 132kV TL, 583 circuit-km of 220kV TL and 450 circuit-km of 400kV TL. Moreover, there are multiple planned and proposed HVTLs amassing total of 936 circuit-km of 132kV TL, 1780 circuit-km of 220kV TL and 3634 circuit-km of 400kV TL. Most of these lines are double circuit transmission lines and few are single circuit and multi-circuit transmission lines.

The Right of Way, also called Transmission Corridor, is a minimum safety corridor around power lines to meet the requisite safety clearances as well as the electromagnetic field exposure limits. This strip of land is also required by utilities for constructing, maintaining and protecting its transmission lines. In Nepal, the existing practice of ROW for 132kV, 220kV and 400kV transmission lines are 18m, 30m and 46m.

Transmission line projects affect forest areas and local communities, particularly villagers whose lands are used for the construction of transmission towers and the installation of conductors. These projects also impact natural resources, such as crops and trees, especially when the transmission lines pass through agricultural or forested areas.

The electric and magnetic fields below the line and at the edge of the ROW are also a governing factor while estimating the ROW requirement of HVTLs. They occur in nature and have become much more prevalent in our everyday lives through man-made sources such as electric power. When planning transmission lines, it is important that designers have a reasonable understanding of the nature of both so it can be considered during design; understand the effects of electric and magnetic fields from transmission line operation, including corona; and mitigate these effects by modifying the design, where possible.

Electric fields are generated by voltage, while magnetic fields are generated by current. These fields are coupled when the distance from the source is significantly greater than the wavelength. However, if the wavelength is much larger, the fields become independent and should be treated separately. For low-frequency fields, such as those in power systems, the wavelength is about 3,100 miles, which is much larger than the typical distance of interest from the source, so the fields are considered independent. When electric and magnetic fields are coupled, they are known as electromagnetic fields; when they are not coupled, they are referred to as electric fields and magnetic fields.

Currently, there is not any established practice and approach in Nepal for estimating these field limits and no provision has been made for safe limits. The transmission line traverses for a long distance and is within the vicinity of the public. Therefore, it is crucial that the electric and magnetic field values around these transmission lines are determined/estimated and kept within the acceptable limits and sufficient ROW is maintained.

Furthermore, most of the transmission lines in Nepal transverse through the forest areas, cultivable lands and valleys. There is no provision for the utilization of such lands below the transmission lines. Encouraging landowners to grow low-height trees, such as fruit-bearing plants and flowers and herbs on these lands, especially in forest areas and valley crossing areas, could provide landowners with additional income and act as a buffer for transmission corridors and mitigate the issue of ROW encroachment and help foster a positive relationship with the transmission licensee.

In this thesis, the Right of Way requirements and the electric and magnetic fields of HVTLs, viz. 132kV, 220kV and 400kV are assessed. The ROW requirements have been estimated for standard spans, reduced spans, long spans and gantry spans. The

ROW requirements and electric and magnetic field of HVTLs with V-string suspension insulators have also been estimated. Furthermore, the possibility of land utilization with tree plantations along the ROW has been assessed for 132kV, 220kV and 400kV transmission lines.

1.2. Problem Statement

The current ROW practices in Nepal are based on the voltage level and are considered the same values irrespective of design span lengths, type of conductor and tower configurations, which leaves no room for ROW optimization and the possibility of mitigating the impact on forest and urban areas. The ROW reduction and optimization could be achieved by adapting new innovative technologies and implementing site-specific design criteria, such as for rural areas, urban areas and forest areas. This could help in reducing ROW costs and impact on forest and social infrastructure. Further, the ROW consideration for HVTLs is much lesser than international practices, which are also guided by the electric and magnetic fields. For example: in India, the ROW for 66kV, 132kV, 220kV and 400kV overhead transmission lines are 18m, 27m, 36m and 46m respectively. Similarly, the utilities like LUMA and PG&E estimates the ROW based on conductor blowout at 8 to 9 psf wind with additional clearance buffer of 4.5ft to 6ft, which results in typical values of 100ft (30.48m) for 115kV TL and 200ft (60.96m) for 230kV TL. Whereas in Nepal, the ROW considered for 66kV, 132kV, 220kV and 400kV transmission lines are 12m, 18m, 30m and 46m.

Moreover, the transmission line utilities and the governing authorities do not have any established guidelines nor standards for the limits of electric and magnetic fields in/around transmission lines. The transmission line projects/utilities do not calculate the electric and magnetic fields in their transmission lines nor have any robust basis for ROW consideration. The electric and magnetic fields of the overhead transmission lines must be assessed, defined and maintained within the acceptable limits either by change in configuration of power conductors or by implementation of ways to reduce those values and by considering appropriate ROW. Besides physical electrical clearances, the ROW of overhead transmission lines is also guided by the electric and magnetic fields within the vicinity of the transmission lines.

Further, the majority of public concerns regarding HVTLs are related to:

- The project taking land or putting restrictions on how locals can use their land.
- Impacts on the livelihoods of local people and community resources.
- Environmental impacts, including cutting trees and electrocution of birds and animals.
- Negative aesthetic impacts.
- Fears about the impact of electromagnetic radiation on the health of people, livestock and crops.

Therefore, the primary strategy and focus should be on implementing measures that benefit the affected individuals and communities, aiming to mitigate or reverse any negative effects on the environment, ecology, and society.

This study aims to assess the ROW requirements and the electric and magnetic fields of HVTLs, viz. 132kV, 220kV and 400kV in the context of Nepal and explores the possibility of land utilization with tree plantations along the ROW. Further, this study will contribute to the knowledge and understanding of ROW requirements and electric and magnetic field of HVTLs in Nepal. The outcomes of this study will have practical implications for power utilities, engineers and policy - makers, enabling them to make informed decisions and implement effective measures.

1.3. Objective and Scope

The main objective of this thesis is to assess the ROW requirements and the electric and magnetic field of HVTLs in Nepal. The study on ROW requirements and the electric and magnetic fields has been carried out with the following scopes:

- Sag tension analysis of the HVTLs and development of sagging criteria.
- Model the high voltage overhead transmission lines in PLS-CADD considering flat terrain and a 4-span scenario.
- Analyze the conductor blowouts and ROW requirements for standard spans, reduced spans and long span.
- Analyze the conductor blowouts and ROW requirements for HVTLs with I-string and V-string suspension insulators.

- Estimate the electric and magnetic field below the line and at the edge of the ROW for HVTLs at 1.8m ht., 3,5m ht. and during design swing conditions.
- Analyze the gantry spans for conductor blowouts and ROW requirements as well as electric and magnetic fields.
- Evaluate the allowable tree heights and plantation corridor for the HVTLs.
- Recommend the potential solution and revisions required to existing practices to make the HVTLs more resilient and compliant with international practices.

1.4. Outline of Thesis

The thesis has been organized into five chapters:

Chapter I serves as an introductory chapter and provides the general background of the study. This chapter further focuses on highlighting the statement of problem, objective and scope of works.

Chapter II gives an overview of the existing provisions of ROW and electric and magnetic field for HVTLs in Nepal. This chapter also provides a comprehensive overview of international practices for ROW and electric and magnetic fields for HVTLs.

Chapter III elaborates the methodology employed in this study. This chapter provides the basis of data collection and sag tension calculations. It also includes an approach for the PLS-CADD modeling of HVTLs. Further, the chapter entails the approach and scenarios for conductor blowouts and ROW requirements as well as electric and magnetic field calculations.

Chapter IV provides the results obtained from the study. The chapter provides the detailed results of conductor blowouts and ROW requirements for HVTLs for standard spans, reduced spans, long span and gantry span. It also includes the results of the evaluation of allowable tree heights and plantation corridors for HVTLs.

Chapter V summarizes the results and findings of the thesis and proposes recommendations for transmission utilities and further research work.

CHAPTER-2: LITERATURE REVIEW

2.1. Overview of Existing Provisions in Nepal

The high voltage overhead transmission lines in Nepal are mainly owned and operated by NEA. Another transmission utility, Rastriya Prasaran Grid Company Limited (RPGCL), was established in 2015 by the Government of Nepal to develop the electricity transmission system. The RPGCL focuses on the development of transmission infrastructures to facilitate the electricity market for the management of the transmission grid to supply reliable electricity.

The Department of Electricity Development (DOED) functions as the regulatory and licensing body for the development of high voltage overhead transmission lines in Nepal. And the Electricity Regulatory Commission (ERC) functions as the regulatory body of Nepal's power sector. The current provisions, rules and regulations governing ROW for HVTLs in Nepal are as follows:

Provision under Nepal Electricity Grid Code, 2080

Section 4.5 Safety Standards: The grid owner shall operate and maintain the grid in a safety manner in accordance with the provisions in the Electricity Rules, 2050 (1993) and any amendments thereof. Other provisions not covered by this regulation shall be in accordance with the best industry practice.

Provision under Electricity Rules, 2050

Rule 48 – Minimum distance from ground to the electric wire

(1) Electric wires of various volts in the distribution and transmission system must be at least as far from the ground as specified in Schedule-12.

(2) If an electric line is to be constructed alongside or by the side of a road, the proper technological measures must be taken.

(3) The distance specified for 33,000 volts in Schedule-12 must be increased by 0.305 meters for every 33,000 volts if an electric line of higher voltage is to be installed.

Rule 50 – Distance to be maintained on either side of the electric line

(1) The distance between a dwelling and a tree specified in Schedule-13 must not be less than that when constructing an electric line for distribution and transmission.

(2) The distance specified for 33,000 volts in Schedule-13 must be increased by 0.305 meters for every 33,000 volts if an electric line of higher voltage is to be installed.

Rule 66 – Utilization of house and land around the construction site relating to production, transmission and distribution of electricity may be prohibited

(1) The Government of Nepal may, by periodically publishing a notice in the Nepal Gazette, forbid the use of the house and land at the construction site or at the location falling within a certain distance around the construction site for any specific purpose if any construction work has been done related to the production, transmission, and distribution of electricity for the purposes of Sub-section (3) of Section 33 of the Act.

(2) Nobody is allowed to build a house or plant a tree beneath an electric line that is constructed for the transmission or distribution of electricity, or to build a house on either side of such a line within the distance specified in Schedules 12 and 13.

Table 2.1: Schedule-12 of Electricity Rules (2050)

Distance which ought to be from wire to the ground				
S. N.	Standard of Voltage of Electricity	While Crossing the Road (meter)	On the side of Road (meter)	In Other Places (meter)
1	In between 230/400 and 11,000	5.8	5.5	4.6
2	In between 11,000 and 33,000	6.1	5.8	5.2

Table 2.2: Schedule-13 of Electricity Rules (2050)

Minimum Distance which ought to be from wire to the house or tree		
S.N.	Standard of Voltage of Electricity	Minimum Distance to be from house or tree (meter)
1	Standard 230/400 to 11,000	1.25
2	From 11,000 to 33,000	2.00
Note: While determining the minimum distance as above, maximum deflection of wire arising due to air pressure shall also have to be considered.		

Rule 50 and Schedule-13 of the Electricity Rules, 2050 defines the minimum distance to be maintained on either side of the electric wire, which in fact defines the ROW for transmission and distribution lines and associated safety clearance corridors governed by the wire swing during wind conditions.

The existing practices for ROW consideration in Nepal for HVTLs are as shown in Table 2.3.

Table 2.3: Existing Practice for ROW of EHV Transmission Lines

S.N.	Voltage Level	Right of Way	Number of Circuits
1	132 kV	18m	Single/ Double Circuit
2	220 kV	30m	Single/ Double Circuit
3	400 kV	46m	Single/ Double Circuit

The above ROW values based on voltage level are considered for all projects, irrespective of design span lengths, type of conductor, tower configurations, terrain and altitudes.

2.2. Literature Review

This work examines several research papers and articles related to the estimation of ROW and electric and magnetic fields of high voltage overhead transmission lines. The summary of the papers and articles relevant to the thesis work is as follows:

In the document titled 'Guidelines for Payment of Compensation in regard to Right of Way for Transmission Lines in Urban Areas' [4] authored by the Ministry of Power, India, the ROW for different high voltage transmission lines has been estimated along with the concept of reduced spans. The document recommends utilizing the reduced spans in urban areas and forest areas due to lower ROW requirements.

In their publication authored by N. Y. Jayalakshmi and S.N. Deepa, titled 'Modeling of Electric and Magnetic Fields Under High Voltage AC Transmission Line' [5], the method for modeling of electric and magnetic field under high voltage AC transmission lines is detailed. The electric and magnetic fields under high voltage AC transmission line at 1m and 5m above the ground level have been computed for a 132kV transmission line.

In their study [6] have presented the methods for mitigation of electric and magnetic field under high voltage AC transmission line. The electric and magnetic fields under high voltage AC transmission line at 1m above the ground level have been computed for a 500kV single circuit transmission line by varying center phase height and varying number of shield wires. Further, the authors relate the effect of electric and magnetic fields for ROW consideration.

The guidelines by ICNIRP [7], provide guidance on limiting exposure to time-varying electric and magnetic fields (1 Hz to 100kHz) to protect humans exposed to electric and magnetic fields in low-frequency range of electromagnetic spectrum. The occupational exposure limits for different time varying and frequency ranges have been recommended. The guidelines also provide recommendations for protective measures.

In the article by I. Nair, M. Granger Morgan and H. Keith, titled 'Biological Effects of Power Frequency Electric and Magnetic Fields' [8], the authors enlighten about the biological effects of power frequency electric and magnetic fields. Experiments at cellular level and whole animal level have been conducted. Further comparison between laboratory and human exposure has been made. Further, the relation between cancer and electromagnetic fields has been explored. The study concludes that the low-frequency magnetic fields can interact with, and produce changes in, biological systems. They concluded with the hypothesis that electromagnetic fields may play a role in cancer or tumor developments. However, none of the findings constitute proof or even necessarily a strong indication that it does.

CHAPTER-3: METHODOLOGY

3.1. Overall Flow Chart

The methodological approaches that have been adopted in this thesis are shown in Figure 3.1.

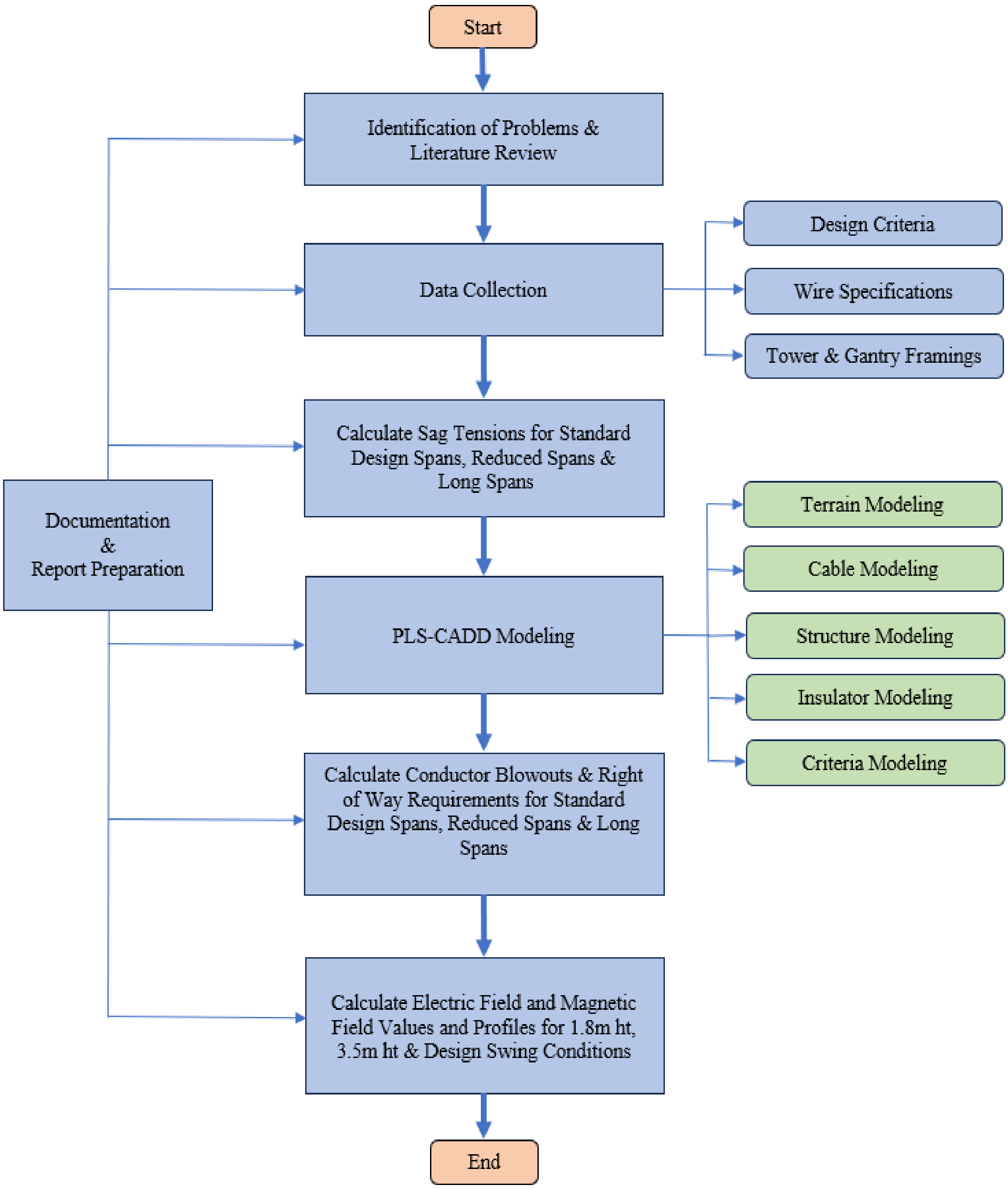

Figure 3.1: Process Flowchart

3.2. Data Collection

The data regarding transmission line design, tower framings and gantry framings for high voltage transmission lines in Nepal are collected from RPGCL and NEA. The referenced tower framings and gantry framings are presented in Appendix A – Tower Drawings. The wire specifications are presented in Appendix C – Wire Specifications.

The design criteria relating to the estimation of conductor blowouts and ROW requirements are collected through study of different technical specifications and design requirements of high voltage transmission lines as well as tender documents. Further, the clearance requirements and safety requirements are collected from Nepalese and Indian Standards.

3.2.1. Applicable Codes and Standards

The applicable codes and standards for the study are as follows:

i. Electricity Rules 2050, Nepal.
ii. ICNIRP guidelines for limiting exposure to time-varying electric and magnetic fields.
iii. IS 802 – code of practice for use of structural steel in overhead transmission line towers, India
iv. IS 5613 – code of practice for design, installation and maintenance of overhead power lines, India

3.3. Tools and Software

The study is conducted using PLS-CADD software. The PLS-CADD is industry-standard transmission line design software used by different utilities around the world, including RPGCL and NEA in Nepal. This software allows for terrain modeling, physical modeling and analysis of transmission structures, clearance analysis and electric and magnetic field studies of overhead transmission lines.

3.4. Sag Tension Calculations

The modeling of transmission lines requires sag-tension calculations. The sag-tension calculations for 132kV, 220kV and 400kV transmission lines are carried out for standard design spans, reduced spans and long spans. The standard design span for

400kV is considered as 400m and for 132kV and 220kV it is considered as 350m. The sag tension calculations require wind pressure calculations as well as initial stringing criteria.

Following scenario as per IS-802 is considered for wind speed and wind pressure calculations.

i. Wind zone: 4
ii. Reliability Level: 1
iii. Terrain Category: 2
iv. Basic Wind Speed: 47m/s

Further the initial stringing criteria is considered as follows,

i. For Conductors: 22% of UTS at 32°C, No Wind – Everyday Condition
ii. For Earthwire: Earthwire Sag ≤ 90% Cold Sag of Conductor – Min. Temp. Condition

The detailed sag tension calculations for conductors and earthwire of HVTLs are presented in Appendix D – Sag Tension Reports.

3.5. PLS-CADD Modeling

The 400kV, 220kV and 132kV TLs are modeled in PLS-CADD, considering a 4-span model. The standard tower framings and conductors are modeled, and design criteria are applied to estimate the conductor blowouts and field values.

The following design steps are considered for PLS-CADD Modeling.

- Terrain Modeling: The terrain is modeled as flat terrain.
- Cable Modeling: The conductors and earth wire are modeled as per specifications enlisted in Appendix C – Wire Specifications
- Structure Modeling: The towers are modeled as M1 structures. This method allows to model the tower framing based on conductor attachment levels.
- Insulator Modeling: The I-string, V-string and tension string insulators are modeled for M1 structures considering the standard dimensions and weights.

- Criteria Modeling: The design criteria for the wire sagging are modeled by following the tension values as presented in Appendix D – Sag Tension Reports. Different weather conditions are established as per standard design practice and guidelines to model and analyze the lines for conductor blowouts and electric field and magnetic field calculations.

The detailed inputs of PLS-CADD modeling are presented in Appendix E – PLS-CADD Modeling.

3.6. Conductor Blowouts and Right of Way Requirements

The Right of Way, also called Transmission Corridor, is a minimum safety corridor around power lines to meet the requisite safety clearances as well as the electromagnetic field exposure limits. This strip of land is also required by utilities for constructing, maintaining and protecting its transmission lines. The schematic representation of ROW is as shown in Figure 3.2.

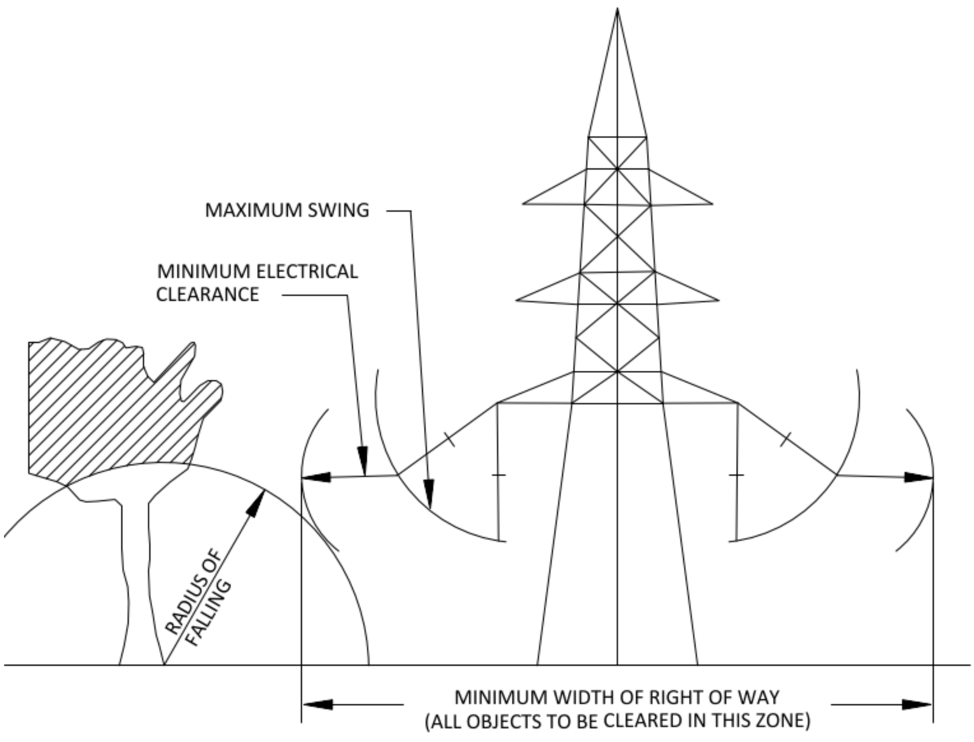

Figure 3.2: Right of Way Requirements [9]

The Right of Way requirements for HVTLs are estimated considering the conductor blowouts during wind conditions. The horizontal displacement of conductors and ROW of overhead transmission line depends upon the following factors:

- Voltage Level: ROW requirement increases with increase in voltage level.
- Span Length: ROW requirement increases with increase in span length
- Type and Size of Conductor: ROW requirement could vary depending upon the size and type/material of conductor being used.
- Wind Speed/Zone: Higher wind speed increases the wire swing, thus increasing the ROW requirements.
- Structure Configuration: Narrow body structures, monopoles and multi-circuit structures demand lower ROW.
- Altitude Factor: Higher altitude demands higher electrical clearance requirements, thus increasing the ROW requirements.
- Electric and Magnetic Field Limits: The electric and magnetic field values below the line and at the edge of the ROW shall be within specified limits.

The general formula for estimating the ROW for overhead TLs is as follows,

ROW = 2 x (Horizontal Displacement of Wires from Tower Center During Design Swing + Minimum Electrical Clearance)

Here, Rule 50 and Schedule-13 of the Electricity Rules, 2050 define the minimum clearance to be maintained on either side of the electric wires as, “if it is necessary to install an electric line of more than 33,000 volts, it shall have to be done by adding 0.305 meters for each 33,000 volts on the distance as prescribed for 33,000 volts in Schedule-13”. Such that the calculated minimum distance to be maintained from house or tree during swing conditions for HVTLs will be as shown in Table 3.1.

Table 3.1: Minimum Electrical Clearance as per Rule 50 of Electricity Rules, 2050

S.N.	Voltage Level (kV)	Minimum Electrical Clearance from Tree/House (m)
1	400kV	5.39m
2	220kV	3.73m
3	132kV	2.91m

For this study, above values are rounded up considering the standard practices in transmission line design as per Indian Standards. The final values considered for the ROW estimation are as shown in Table 3.2.

Table 3.2: Horizontal Electrical Clearances considered for HVTLs

S.N.	Voltage Level (kV)	Minimum Electrical Clearance from Tree/House (m)
1	400kV	5.6m
2	220kV	3.8m
3	132kV	2.9m

The minimum electrical clearance values are considered fixed values and would only vary depending on the elevation of a given transmission line. Therefore, the ROW requirement for any HVTLs will mainly depend on the horizontal displacement of conductors during the swing condition.

The transmission lines are modeled in PLS-CADD and corresponding design criteria are applied for wire sagging. Then the wind pressures are identified for a given span and conductors which will provide a 30° swing for I-string suspension insulators. The blowouts for conductors are estimated considering that wind pressure and 30° swing angle of I-string suspension insulators. And the same wind pressure is considered for estimating the conductor blowouts for HVTLs with V-string suspension insulators, tension insulators and the gantry spans.

For the ROW study of HVTLs with V-strings, tower framing similar to that of I-string is considered. However, the crossarm insulator arrangements are modified to reflect the crossarms requirements. The tower framings for HVTLs with V-strings are presented in Appendix A – Tower Drawings.

The conductor blowouts and ROW requirements are estimated for standard design spans, reduced spans, long span and gantry spans as enlisted in Table 3.3.

Table 3.3: Spans Considered for ROW estimation

S.N.	Voltage Level (kV)	Spans Under Consideration
1	400kV	Standard Span: 400m Reduced Span: 300m, 200m Long Span: 500m Gantry Span: 100m
2	220kV	Standard Span: 350m Reduced Span: 250m, 150m Long Span: 500m Gantry Span: 50m
3	132kV	Standard Span: 350m Reduced Span: 250m, 200m, 150m Long Span: 500m Gantry Span: 50m

3.7. Electric Field and Magnetic Field Calculations

The transmission lines are modeled in PLS-CADD using standard tower framing and conductor configurations. The R-Y-B phases of a double circuit line are assigned voltage and current values. The current and voltage assigned for each phase of HVTLs are shown in Table 3.4.

Table 3.4: Line-Line Voltage and Current for HVTLs

S.N.	Transmission Line	Line-Line Voltage (kV)	Phase Current (Ampere)
1	400kV	400kV	900A
2	220kV	220kV	700A
3	132kV	132kV	500A

The field profiles and maximum values at mid-span cross-section for HVTLs are estimated for the following scenarios:

i. 1.8m height above the ground

The electric and magnetic fields are estimated at mid-span, considering the flat terrain and the conductors at maximum sag and nil wind conditions. During this condition, the wires will be closest to the ground and will represent the normal human height. This scenario is used to estimate the field values for both I-string and V-string configurations.

ii. 3.5m height above the ground

The electric and magnetic fields are calculated at mid-span, considering the flat terrain and the conductors at maximum sag and nil wind condition. During this condition, the wires will be close to the ground and will represent the underbuilt temporary structures.

iii. Design swing condition

The electric and magnetic field are calculated at mid-span, considering the flat terrain and the conductors at maximum sag and design wind condition. During this condition the wires will be closest to the edge of the ROW and will allow to estimate the maximum field values at the edge of the ROW considering the building at the edge of the ROW. The height of 23m, 17m and 15m above the ground are considered for the 400kV, 220kV and 132kV transmission lines for estimating the field values.

iv. Gantry Span

The gantry span is modeled considering the standard framing for the terminal tower and the gantry. A double circuit arrangement is considered for the study. The slack span of 100m is considered for 400kV TL, and 50m is considered for 220kV and 132kV TL. The field values are estimated below the lowest conductor section at 1.8m height above the ground.

The schematic representation of the above cases is shown in Figure 3.3.

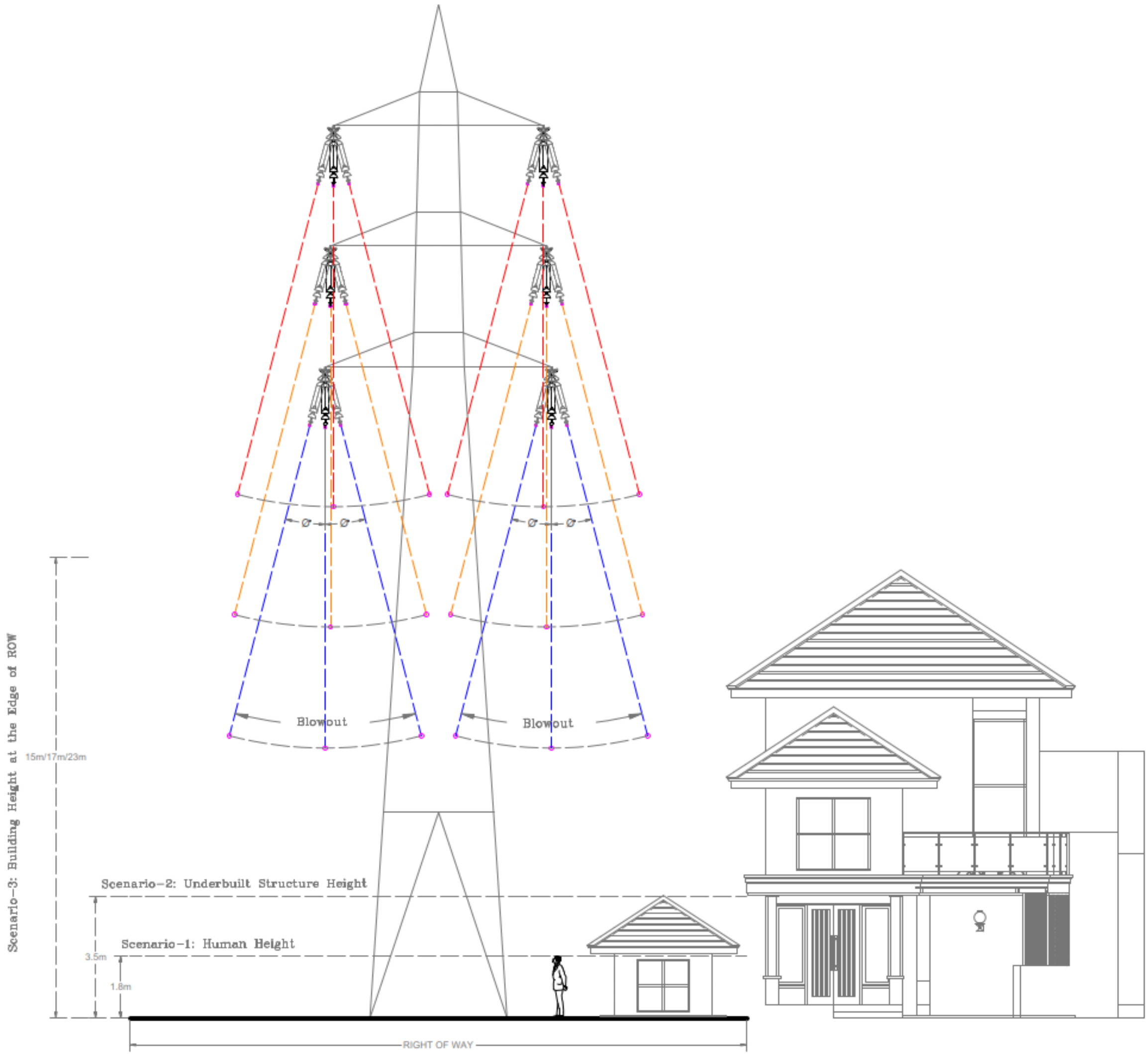

Figure 3.3: Electric Field and Magnetic Field Estimation Heights

3.7.1. Electric Field Calculation

An electric field is a vector field that represents the electric force experienced by a unit charge at a specific point. It radiates outward from a point charge in all directions. The electric field generated by transmission lines results from electric charges. The total electric field from multiple point charges can be determined by calculating the vector sum of the individual fields.

Point charges are used to model systems in translational equilibrium, making them suitable for simulating the electric field of HVTLs. For three-phase systems, the voltages applied to the three-phase high voltage transmission lines (HVTLs) are assumed to be sinusoidal and are presented in phasor form as follows:

$$V_1 = V_{rms} \angle 0° \quad (1)$$

$$V_2 = V_{rms} \angle 120° \quad (2)$$

$$V_3 = V_{rms} \angle 240° \quad (3)$$

It is presumed that the shielding wires have no potential. A system of linear equations in complex unknown charges is produced by applying this potential as a boundary condition at a number of surface locations of the HVTLs. The form of these equations is as follows:

$$\sum_{j=1}^{n} P_{ij} Q_i = V_i \quad i = 1, 2, \ldots, n \quad (4)$$

where Pij stands for potential coefficients, Qj stands for unknown simulating charges, and n is number of surface points. Moreover, Equation (4) can be arranged as follows:

$$[P]\,[Q] = [V] \quad (5)$$

Where;

[P] is square matrix of potential coefficients,

[Q] is vector of unknown charges,

[V] is vector of boundary conditions voltages

The line charge that replicates the system's transmission wires are provided by:

$$[Q] = [P]^{-1}\,[V] \quad (6)$$

To verify the accuracy, checkpoints are used at locations different from those used for the surface points in the calculation. Once the solution quality measures are satisfied, the electric field strength and potential at each point in space can be calculated using the following analytical expressions:

$$E_t = \sqrt{E_{vi}^2 + E_{hi}^2} \quad (7)$$

$$E_{hi} = \sum_{j=1}^{n} Q_j \,.\, L_{ij} \quad (8)$$

$$E_{vi} = \sum_{j=1}^{n} Q_j \,.\, K_{ij} \quad (9)$$

$$L_{ij} = (x_i - x_j)\left(\frac{1}{A_{ij}^2} - \frac{1}{I_{ij}^2}\right) \quad (10)$$

$$K_{ij} = \frac{(y_i - y_j)}{A_{ij}^2} - \frac{(y_i + y_j)}{I_{ij}^2} \quad (11)$$

$$V_i = \sum_{j=1}^{n} P_{ij} \,.\, Q_j \quad (12)$$

$$I_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \quad (13)$$

$$A_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \quad (14)$$

Where;

E_{hi}, E_{vi} are the component of an electric field at the specified i^{th} point in the horizontal plus vertical paths, respectively, (kV/m),

L_{ij}, K_{ij} are the horizontal plus vertical electric field coefficients at specified i^{th} point, respectively,

V_i is the potential at the specified i^{th} point, (V),

x_i , y_i are the coordinates of the i^{th} boundary contour point, and

x_j , y_j are the coordinates of the j^{th} line charge.

3.7.2. Magnetic Field Calculation

A magnetic field is the area surrounding a magnetic material or a moving electric charge where magnetic forces are exerted. Magnetic fields in transmission lines are generated by the flow of electrical current through the wires. As current flows through a power line, it creates a magnetic field, known as an electromagnetic field (EMF). The strength of the EMF is directly proportional to the amount of electrical current flowing through the power line and weakens with distance from the line.

Magnetic field calculations are performed using the Biot-Savart law. Equation (15) can be used to determine the H at a given point P (xi, yi) by applying the Biot Savart law as follows:

$$H = \frac{I}{2\pi d}\,\vec{a}_{\phi} \qquad (15)$$

where:

I is current in the conductor in root-mean-square value of Ampere,

d is distance from the conductor in meters,

aφ is unit vector, φ, direction

The sum of the current contributions from each conductor determines the overall magnetic field at a specific point P. The components of the field produced by the conductor system with currents are shown in Figure 3.4. The field extends in the z-direction, which is outward and perpendicular to the page.

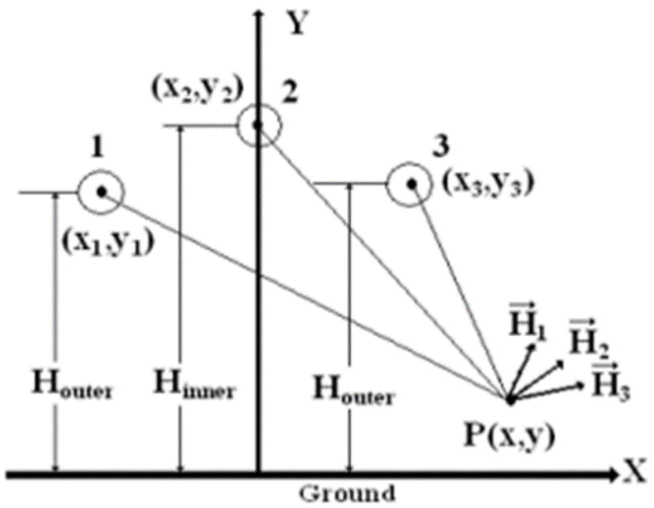

Figure 3.4: Magnetic Field Intensity Components for 3 Conductor System [5]

For HVTLs, the currents are sinusoidal and vary over time at given power frequency. Such that, the field in the vicinity of the power transmission lines fluctuates with the power frequency and phase. Algebraic methods can be applied to combine the various components, producing the amplitude of the required magnetic field (including both horizontal and vertical vectors). For a three-phase system, the current can be expressed as follows:

$$[I] = I_{rms}\angle 0°, I_{rms}\angle 120°, I_{rms}\angle 240° \tag{16}$$

The complex depth α of conductor's image current can be derived as:

$$\alpha = \sqrt{2}\delta e^{-\frac{j\pi}{4}} \tag{17}$$

Where; δ is the skin depth of the earth:

$$\delta = 503\sqrt{\frac{\rho}{f}} \tag{18}$$

Where, ρ is earth resistivity, and f is source current frequency in Hz.

The magnetic field intensity induced from current I_i and its image is computed as follows:

$$\vec{H}_{ij} = H_{xij}\,\vec{a}_x + H_{yij}\,\vec{a}_y \tag{19}$$

$$H_{xij} = \frac{-I_j}{2\pi}\left[\frac{y_i - y_j}{r_{ij}^2} - \frac{y_i + y_j + \alpha}{r_{ij}'^{\,2}}\right] \tag{20}$$

$$H_{yij} = \frac{I_j}{2\pi}\left[\frac{x_i - x_j}{r_{ij}^2} - \frac{x - x_j}{r_{ij}'^{\,2}}\right] \tag{21}$$

Where; ax is unit vector in the x-direction, ay is unit vector in the y-direction,

$$r_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \tag{22}$$

$$r_{in}' = \sqrt{(x_i - x_j)^2 + (y_i + y_j + \alpha)^2} \tag{23}$$

The total field intensity is:

$$H_{xt} = \sum_{j=1}^{3} H_{xij} \quad (24)$$

$$H_{yt} = \sum_{j=1}^{3} H_{yij} \quad (25)$$

The magnetic field intensity H_t is:

$$H_t = \sqrt{H_{xt}^2 + H_{yt}^2} \quad (26)$$

The multi-conductor transmission lines technique can be used to determine the current in the shielding wires, where:

$$\begin{bmatrix} \Delta V_p \\ \Delta V_G \end{bmatrix} = \begin{bmatrix} Z_{pp} & Z_{pG} \\ Z_{Gp} & Z_{GG} \end{bmatrix} \begin{bmatrix} I_p \\ I_G \end{bmatrix} \quad (27)$$

where Zij is the per unit series impedance (where i and j equal p or G), Ip and IG are three phases and shielding wire vector currents, and Vp and VG are two vectors that preset the drop along with the three phases and shielding wires, respectively (Ip = I in equation (16)). Zij can be computed in this way:

$$Z^{'} = j\omega L + Z_E + Z_{skin} \quad (28)$$

Additionally, a frequency-independent real symmetric matrix with specific entries is taken into consideration by the external-inductance matrix:

$$L_{ii} = \frac{\mu_0}{2\pi} \ln \frac{2y_i}{r_i} \quad (29a)$$

$$L_{ij} = \frac{\mu_0}{4\pi} \ln \frac{\left(y_i + y_j\right)^2 + \left(x_i + x_j\right)^2}{\left(y_i - y_j\right)^2 + \left(x_i + x_j\right)^2} \quad (29b)$$

where, r_i represents the radius of the conductor, while y_j and x_j denote the vertical and horizontal coordinates of the specified j^{th} conductor, respectively. Z_E represents the earth impedance correction matrix, which is considered a frequency-dependent complex matrix. Its entries can be determined using Carson's theory and/or the Dubanton complex ground plane method. The entries of Z_E are calculated as follows:

$$(Z_E)_{jj} = j\omega \frac{\mu_0}{2\pi} \ln\left(1 + \frac{\alpha}{y_j}\right) \tag{30a}$$

$$(Z_E)_{ij} = j\omega \frac{\mu_0}{4\pi} \ln\left(\frac{\left(y_i + y_j + 2\alpha\right)^2 + \left(x_i - x_j\right)^2}{\left(y_i - y_j\right)^2 + \left(x_i - x_j\right)^2}\right) \tag{30b}$$

Here, α is regarded as the complex depth, as equation (17) illustrates. The skin-effect theory for cylindrical conductors is used to calculate the entries of the matrix Zskin, which represents a frequency-dependent complex diagonal matrix. In situations with low frequencies, it reduces to:

$$(Z_{skin})_{jj} = (R_{dc})_j + j\omega \frac{\mu_0}{8\pi} \tag{31}$$

Here, (Rdc)j stands for the DC resistance of the designated jth conductor per unit length. VG = 0 is the result of the shielding wires being connected to the earth (ignoring tower resistances). Thus, using the three-phase currents Ip and the Zij matrix, the induced current in the shielding wires can be computed as follows from equation (27):

$$I_G = \frac{-1}{Z_{GG}} \left(Z_{Gp} I_p\right) \tag{32}$$

The degree to which the model accurately depicts the real world is the primary determinant of the prediction's accuracy regarding the electromagnetic fields beneath overhead transmission lines.

3.8. Allowable Tree Heights and Plantation Corridor

The estimation of allowable tree heights and plantation corridor is carried out considering the standard design spans and standard tower footing heights of 132kV, 220kV and 400kV TLs. The allowable conductor blowouts and swing during the maximum sag condition are estimated considering the standard ROW.

The conductor movement is traced to form a locus which is used to form a clearance buffer. These clearance buffers are the minimum clearance values required for trees from the high voltage transmission lines. The movement of the clearance buffer along with the conductor and the tree falling radius is used to estimate the maximum allowable tree heights. The minimum clearance value from tree is as shown in Table 3.5.

Table 3.5: Clearance of HVTLs from Tree

S.N.	Voltage Level (kV)	Horizontal and Vertical Clearance from Tree (m)
1	400kV	5.6m
2	220kV	3.8m
3	132kV	2.9m

Further, two construction corridors below the conductors are considered for the construction, operation and maintenance of the lines. This approach will provide three plantation corridors along the transmission line and both transmission lines and plantation corridors could be accessed via these construction corridors. The construction corridors considered for HVTLs are as shown in Table 3.6.

Table 3.6: Construction Corridors for HVTLs

S.N.	Voltage Level (kV)	Construction Corridors (m)
1	400kV	Two Corridors: 7m each
2	220kV	Two Corridors: 5m each
3	132kV	Two Corridors: 3.5m each

CHAPTER-4: RESULTS AND DISCUSSIONS

4.1. Overview

In this section, the detailed results of ROW requirements and electric and magnetic fields studies of 400kV, 220kV and 132kV high voltage transmission lines are presented.

The ROW requirements for high voltage transmission lines are estimated for standard design spans being followed in Nepal, reduced spans and long spans, considering both I-string and V-string suspension insulators.

The electric and magnetic field values for high voltage TL are determined at 1.8m height above ground level and 3.5m height above ground level, considering human height and height of underbuilt temporary structures. The field profiles at midspan were generated considering the standard tower configurations and wire attachment points. The field values and profiles are determined for both I-string and V-string wire arrangements.

The ROW requirements, electric and magnetic field values at terminal gantry locations of high voltage TL are also estimated. For this, a double-circuit gantry with horizontal configuration was considered. The gantry framing, terminal spans and slack tensions were considered based on standard practice in Nepal.

Furthermore, allowable tree heights and plantation corridors are estimated for high voltage TL considering the standard ROW boundary and conductor swing during maximum sag conditions. For this, two construction corridors were considered below the wires, and three plantation corridors were identified for each line.

4.2. Right of Way Requirement for Standard Design Spans

The standard practice for design spans of 400kV, 220kV and 132kV transmission lines in Nepal are 400m, 350m and 350m respectively. The midspan blowout of conductors is estimated considering the 30° allowable swing angles for suspension insulators during everyday conditions. The midspan blowout of conductors and hence ROW requirements are estimated considering both I-string and V-string suspension insulators for tangent structures.

4.2.1. 400kV Transmission Line

4.2.1.1. 400m Design Span with I-String Suspension Insulator

The midspan blowout of conductors from the tower center point is calculated to be 17.5m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The 30° swing of I-string insulators was observed at 386.5 Pa wind pressure.

The total ROW requirement for a 400kV double circuit transmission line with I-string is estimated to be 46m, which matches with the existing practice of 46m ROW for 400kV TL in Nepal. The result suggests that the existing practice of 46m ROW for 400kV TL is sufficient as long as a 400m design span is maintained. The summary of ROW estimation is presented in Table 4.1.

Table 4.1: ROW Requirement for 400kV TL, 400m Design Span with I-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
30°	19.2	25.1	386.5	17.5	46

4.2.1.2. 400m Design Span with V-String Suspension Insulator

The wind pressure of 386.5 Pa, which resulted in a 30º swing of I-string insulators, was considered for estimating the midspan conductor blowouts. The midspan blowout of conductors from the tower center point is calculated to be 13.4m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports.

The total ROW requirement for a 400kV double circuit transmission line with V-string is estimated to be 38m, which is 8m less than the existing practice of 46m ROW for 400kV TL in Nepal. The results suggest that the use of V-string could help reduce the ROW requirement by as much as 17%. The summary of ROW estimation is presented in Table 4.2.

Table 4.2: ROW Requirement for 400kV TL, 400m Design Span with V-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
NA	19.2	25.1	386.5	13.4	38

4.2.2. 220kV Transmission Line

4.2.2.1. 350m Design Span with I-String Suspension Insulator

The midspan blowout of conductors from the tower center point is calculated to be 11.45m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The 30° swing of I-string insulators was observed at 331.7 Pa wind pressure.

The total ROW requirement for a 220kV double circuit transmission line with I-string is estimated to be 30m, which matches with the existing practice of 30m ROW for 220kV TL in Nepal. The results suggest that the existing practice of 30m ROW for 220kV TL is sufficient as long as a 350m design span is maintained. The summary of ROW estimation is presented in Table 4.3.

Table 4.3: ROW Requirement for 220kV TL, 350m Design Span with I-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
30°	20.5	23.3	331.7	11.45	30

4.2.2.2. 350m Design Span with V-String Suspension Insulator

The wind pressure of 331.7 Pa, which resulted in a 30º swing of I-string insulators, was considered for estimating the midspan conductor blowouts. The midspan blowout of conductors from the tower center point is calculated to be 8.64m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports.

The total ROW requirement for a 220kV double circuit transmission line with V-string is estimated to be 25m, which is 5m less than the existing practice of 30m ROW for 220kV TL in Nepal. The results suggest that the use of V-string could help reduce the ROW requirement by as much as 17%. The summary of ROW estimation is presented in Table 4.4.

Table 4.4: ROW Requirement for 220kV TL, 350m Design Span with V-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
NA	20.5	23.3	331.7	8.64	25

4.2.3. 132kV Transmission Line

4.2.3.1. 350m Design Span with I-String Suspension Insulator

The midspan blowout of conductors from the tower center point is calculated to be 8.7m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The 30° swing of I-string insulators was observed at 357.2 Pa wind pressure.

The total ROW requirement for a 132kV double circuit transmission line with I-string is estimated to be 23m, which is 5m more than the existing practice of 18m ROW for 132kV TL in Nepal. The result suggests that the existing practice of 18m ROW for 132kV TL is not sufficient for a 350m design span. The summary of ROW estimation is presented in Table 4.5.

Table 4.5: ROW Requirement for 132kV TL, 350m Design Span with I-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
30°	23.5	24.14	357.2	8.7	23

4.2.3.2. 350m Design Span with V-String Suspension Insulator

The wind pressure of 357.2 Pa, which resulted in a 30º swing of I-string insulators, was considered for estimating the midspan conductor blowouts. The midspan blowout of conductors from the tower center point is calculated to be 7m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports.

The total ROW requirement for a 132kV double circuit transmission line with V-string is estimated to be 20m, which is 2m more than the existing practice of 18m ROW for 132kV TL in Nepal. The results suggest that the use of V-string could help reduce the ROW requirement by as much as 13% compared to I-string. However, the existing practice of 18m ROW for 132kV TL is not sufficient for a 350m design span even with V-string. The summary of ROW estimation is presented in Table 4.6.

Table 4.6: ROW Requirement for 132kV TL, 350m Design Span with V-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
NA	23.5	24.14	357.2	7.0	20

4.3. Right of Way Requirement for Reduced Design Spans

The ROW requirement for high voltage transmission lines at reduced spans is estimated. The reduced spans of 300m and 200m are considered for 400kV TL, 250m and 150m are considered for 220kV TL and 250m, 200m and 150m are considered for 132kV TL.

The midspan blowout of conductors and hence the ROW requirements are estimated considering both I-string and V-string suspension insulators for tangent structures

4.3.1. 400kV Transmission Line

4.3.1.1. 300m Design Span with I-String Suspension Insulator

The midspan blowout of conductors from the tower center point is calculated to be 15m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The 30° swing of I-string insulators was observed at 393.3 Pa wind pressure.

The total ROW requirement for a 400kV double circuit transmission line with I-string is estimated to be 41m, which is 5m less than the existing practice of 46m ROW for 400kV TL in Nepal. The result suggests that the use of a reduced 300m design span for 400kV TL could help reduce the ROW requirement by as much as 10%. The summary of ROW estimation is presented in Table 4.7.

Table 4.7: ROW Requirement for 400kV TL, 300m Design Span with I-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
30°	19	25.3	393.3	15.0	41

4.3.1.2. 300m Design Span with V-String Suspension Insulator

The wind pressure of 393.3 Pa, which resulted in a 30º swing of I-string insulators, was considered for estimating the midspan conductor blowouts. The midspan blowout of conductors from the tower center point is calculated to be 10.8m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports.

The total ROW requirement for a 400kV double circuit transmission line with V-string is estimated to be 33m, which is 13m less than the existing practice of 46m ROW for 400kV TL in Nepal. The result suggests that the use of V-string and a reduced 300m design span could help reduce the ROW requirement by as much as 28%. The summary of ROW estimation is presented in Table 4.8.

Table 4.8: ROW Requirement for 400kV TL, 300m Design Span with V-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
NA	19	25.3	393.3	10.8	33

4.3.1.3. 200m Design Span with I-String Suspension Insulator

The midspan blowout of conductors from the tower center point is calculated to be 13.4m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The 30° swing of I-string insulators was observed at 405.1 Pa wind pressure.

The total ROW requirement for a 400kV double circuit transmission line with I-string is estimated to be 38m, which is 8m less than the existing practice of 46m ROW for 400kV TL in Nepal. The result suggests that the use of a reduced 200m design span for 400kV TL could help reduce the ROW requirement by as much as 17%. The summary of ROW estimation is presented in Table 4.9.

Table 4.9: ROW Requirement for 400kV TL, 200m Design Span with I-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
30°	19.2	25.7	405.1	13.4	38

4.3.1.4. 200m Design Span with V-String Suspension Insulator

The wind pressure of 405.1 Pa, which resulted in a 30° swing of I-string insulators, was considered for estimating the midspan conductor blowouts. The midspan blowout of conductors from the tower center point is calculated to be 8.9m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports.

The total ROW requirement for a 400kV double circuit transmission line with V-string is estimated to be 29m, which is 17m less than the existing practice of 46m ROW for 400kV TL in Nepal. The result suggests that the use of V-string and a reduced 200m design span could help reduce the ROW requirement by as much as 37%. The summary of ROW estimation is presented in Table 4.10.

Table 4.10: ROW Requirement for 400kV TL, 200m Design Span with V-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
NA	19.2	25.7	405.1	8.92	29

4.3.2. 220kV Transmission Line

4.3.2.1. 250m Design Span with I-String Suspension Insulator

The midspan blowout of conductors from the tower center point is calculated to be 9.34m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The 30° swing of I-string insulators was observed at 339.8 Pa wind pressure.

The total ROW requirement for a 220kV double circuit transmission line with I-string is estimated to be 26m, which is 4m less than the existing practice of 30m ROW for 220kV TL in Nepal. The result suggests that the use of a reduced 250m design span for 220kV TL could help reduce the ROW requirement by as much as 13%. The summary of ROW estimation is presented in Table 4.11.

Table 4.11: ROW Requirement for 220kV TL, 250m Design Span with I-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
30°	21	23.54	339.8	9.34	26

4.3.2.2. 250m Design Span with V-String Suspension Insulator

The wind pressure of 339.8 Pa, which resulted in a 30º swing of I-string insulators, was considered for estimating the midspan conductor blowouts. The midspan blowout of conductors from the tower center point is calculated to be 6.54m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports.

The total ROW requirement for a 220kV double circuit transmission line with V-string is estimated to be 21m, which is 9m less than the existing practice of 30m ROW for 220kV TL in Nepal. The result suggests that the use of V-string and a reduced 250m design span could help reduce the ROW requirement by as much as 30%. The summary of ROW estimation is presented in Table 4.12.

Table 4.12: ROW Requirement for 220kV TL, 250m Design Span with V-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
NA	21	23.54	339.8	6.54	21

4.3.2.3. 150m Design Span with I-String Suspension Insulator

The midspan blowout of conductors from the tower center point is calculated to be 7.94m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The 30° swing of I-string insulators was observed at 369.14 Pa wind pressure.

The total ROW requirement for a 220kV double circuit transmission line with I-string is estimated to be 23m, which is 7m less than the existing practice of 30m ROW for 220kV TL in Nepal. The result suggests that the use of a reduced 150m design span for 220kV TL could help reduce the ROW requirement by as much as 23%. The summary of ROW estimation is presented in Table 4.13.

Table 4.13: ROW Requirement for 220kV TL, 150m Design Span with I-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
30°	22.5	24.54	369.14	7.94	23

4.3.2.4. 150m Design Span with V-String Suspension Insulator

The wind pressure of 369.14 Pa, which resulted in a 30º swing of I-string insulators, was considered for estimating the midspan conductor blowouts. The midspan blowout of conductors from the tower center point is calculated to be 5.11m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports.

The total ROW requirement for a 220kV double circuit transmission line with V-string is estimated to be 18m, which is 12m less than the existing practice of 30m ROW for 220kV TL in Nepal. The result suggests that the use of V-string and reduced 150m design span could help reduce the ROW requirement by as much as 40%. The summary of ROW estimation is presented in Table 4.14.

Table 4.14: ROW Requirement for 220kV TL, 150m Design Span with V-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
NA	22.5	24.54	369.14	5.11	18

4.3.3. 132kV Transmission Line

4.3.3.1. 250m Design Span with I-String Suspension Insulator

The midspan blowout of conductors from the tower center point is calculated to be 6.6m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The 30° swing of I-string insulators was observed at 380 Pa wind pressure.

The total ROW requirement for a 132kV double circuit transmission line with I-string is estimated to be 19m, which is 1m more than the existing practice of 18m ROW for 132kV TL in Nepal. The result suggests that the existing practice of 18m ROW for 132kV TL is not sufficient even for a reduced 250m design span. The summary of ROW estimation is presented in Table 4.15.

Table 4.15: ROW Requirement for 132kV TL, 250m Design Span with I-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
30°	25	24.89	380	6.6	19

4.3.3.2. 250m Design Span with V-String Suspension Insulator

The wind pressure of 380 Pa, which resulted in a 30º swing of I-string insulators, was considered for estimating the midspan conductor blowouts. The midspan blowout of conductors from the tower center point is calculated to be 5m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports.

The total ROW requirement for a 132kV double circuit transmission line with V-string is estimated to be 16m, which is 2m less than the existing practice of 18m ROW for 132kV TL in Nepal. The result suggests that the use of V-string and a reduced 250m design span could help reduce the ROW requirement by as much as 11%. The summary of ROW estimation is presented in Table 4.16.

Table 4.16: ROW Requirement for 132kV TL, 250m Design Span with V-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
NA	25	24.89	380	5.0	16

4.3.3.3. 200m Design Span with I-String Suspension Insulator

The midspan blowout of conductors from the tower center point is calculated to be 5.9m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The 30° swing of I-string insulators was observed at 402.8 Pa wind pressure.

The total ROW requirement for a 132kV double circuit transmission line with I-string is estimated to be 18m, which matches with the existing practice of 18m ROW for 132kV TL in Nepal. The result suggests that the existing practice of 18m ROW for 132kV TL is only sufficient for a reduced 200m design span. The summary of ROW estimation is presented in Table 4.17.

Table 4.17: ROW Requirement for 132kV TL, 200m Design Span with I-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
30°	26.5	25.63	402.8	5.9	18

4.3.3.4. 200m Design Span with V-String Suspension Insulator

The wind pressure of 402.8 Pa, which resulted in a 30º swing of I-string insulators, was considered for estimating the midspan conductor blowouts. The midspan blowout of conductors from the tower center point is calculated to be 4.23m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports.

The total ROW requirement for a 132kV double circuit transmission line with V-string is estimated to be 14m, which is 4m less than the existing practice of 18m ROW for 132kV TL in Nepal. The result suggests that the use of V-string and a reduced 200m design span could help reduce the ROW requirement by as much as 22%. The summary of ROW estimation is presented in Table 4.18.

Table 4.18: ROW Requirement for 132kV TL, 200m Design Span with V-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
NA	26.5	25.63	402.8	4.23	14

4.3.3.5. 150m Design Span with I-String Suspension Insulator

The midspan blowout of conductors from the tower center point is calculated to be 5.27m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The 30° swing of I-string insulators was observed at 440.8 Pa wind pressure.

The total ROW requirement for a 132kV double circuit transmission line with I-string is estimated to be 17m, which is 1m less than the existing practice of 18m ROW for 132kV TL in Nepal. The result suggests that the use of a reduced 150m design span for 132kV TL could help reduce the ROW requirement by as much as 5%. The summary of ROW estimation is presented in Table 4.19.

Table 4.19: ROW Requirement for 132kV TL, 150m Design Span with I-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
30°	29	26.81	440.8	5.27	17

4.3.3.6. 150m Design Span with V-String Suspension Insulator

The wind pressure of 440.8 Pa, which resulted in a 30º swing of I-string insulators, was considered for estimating the midspan conductor blowouts. The midspan blowout of conductors from the tower center point is calculated to be 3.6m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports.

The total ROW requirement for a 132kV double circuit transmission line with V-string is estimated to be 13m, which is 5m less than the existing practice of 18m ROW for 132kV TL in Nepal. The result suggest that the use of V-string and a reduced 150m design span could help reduce the ROW requirement by as much as 27%. The summary of ROW estimation is presented in Table 4.20.

Table 4.20: ROW Requirement for 132kV TL, 150m Design Span with V-String

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
NA	29	26.81	440.8	3.6	13

4.4. Right of Way Requirement for Long Spans

The ROW requirement for high voltage transmission lines at long spans was estimated. The long-span scenario is evaluated by considering the use of a suspension tower with I-string insulators and the use of a deadend tower with strain insulators. The midspan blowout of conductors and hence the ROW requirement for both scenarios are estimated considering the wind pressure equivalent to standard design spans – 357.2 Pa for 132kV, 331.7 Pa for 220kV and 386.5 Pa for 400kV TL.

For deadend tower with strain insulators, three different scenarios are evaluated. The first scenario is to maintain the tower maximum loading, the second scenario is to maintain the standard ROW in Nepal and the third scenario is to maintain the wire tension limits.

4.4.1. 400kV Transmission Line

4.4.1.1. 400kV TL Being Used For 500m Span with I-String

The midspan blowout of conductors from the tower center point is calculated to be 21.8m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The midspan blowout is estimated at a wind pressure of 386.5 Pa considering the 30º swing of I-string insulators for the 400m design span.

The total ROW requirement for a 400kV double circuit transmission line with I-string is estimated to be 55m, which is 9m more than the existing practice of 46m ROW for 400kV TL in Nepal. The result suggests that the existing practice of 46m ROW for 400kV TL is not sufficient for long spans with I-string and the ROW requirement increases by as much as 19%. The summary of ROW estimation is presented in Table 4.21.

Table 4.21: ROW Requirement for 400kV TL, 400m Design Span being used for 500m span with I-String Suspension Tower

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
30°	19.2	25.1	386.5	21.8	55

4.4.1.2. 400kV TL Being Used For 500m Span with Tension Tower

The following three scenarios are evaluated for analyzing the feasibility of long-span crossings with tension towers.

a) Maintaining the Maximum Loading of Tower

In the case of long span crossings, the maximum loading on tower is increased due to an increase in maximum wire tension. The wire tension is increased due to an increase in wind area of conductors. So, the primary approach is to reduce the initial wire stringing tension and maintain the maximum wire tension during the full wind condition. This is primarily done to mitigate the requirement for special towers.

For a 400kV line with a 400m design span, the design maximum wire tension is 9363 kg. This same value of 9363 kg was considered as the maximum allowable wire tension at full wind for a 500m span. The sag tension reports for the 400kV line are presented in Appendix D – Sag Tension Reports.

The midspan blowout of conductors from the tower center point is calculated to be 21m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The midspan blowout is estimated at a wind pressure of 386.5 Pa, considering the 30º swing of I-string insulators for the 400m design span.

The total ROW requirement for a 400kV double circuit transmission line with tension tower is estimated to be 53m, which is 7m more than the existing practice of 46m ROW for 400kV TL in Nepal. The result suggests that the existing practice of 46m ROW for 400kV TL is not sufficient for long spans with tension tower and the ROW requirement increases by as much as 15%. The summary of ROW estimation is presented in Table 4.22.

Table 4.22: ROW Requirement for 400kV TL, 400m Design Span being used for 500m span with Tension Tower – Maintaining Maximum Tower Loading

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
N/A	19.2	25.1	386.5	21	53

b) Maintaining the Standard 46m ROW

In the case of long-span crossings where the reduced wire tension violates the desired ROW, the ideal approach is to increase the initial wire stringing tension, so the blowout of conductors could be reduced, and the desired ROW is met.

For a 400kV line with a 400m design span, the standard/desired ROW is 46m. So, the initial wire tension was increased to be 4954 kg, 30% of UTS of ACSR Moose for a 500m long span which resulted in a maximum wire tension of 11,868 kg, 72% of UTS of ACSR Moose at full wind condition. This resulted in an increase in maximum tower tension by as much as 15% and violation of the maximum allowable wire tension limit of 70% at full wind and 25% at initial condition. This suggests that to maintain the standard ROW at 500m, the wire type with higher allowable tension limits shall be used, and the towers shall be special towers designed for heavy loading.

c) Maintaining the Wire Tension Limits

In the case of long-span crossings, another approach is to increase the initial wire stringing tension up to a point where the maximum allowable wire tension limit is met. This will allow to utilize the full allowable tensile limits of conductors and reduce the conductor blowouts.

For a 400kV line with a 400m design span, the initial wire stringing tension was increased to 4,140 kg, 25% of UTS of ACSR Moose for a 500m long span, which resulted in maximum wire tension of 10,850 kg, 66% of UTS of ACSR Moose. This resulted in an increase in maximum tower tension by as much as 9%.

The midspan blowout of conductors from the tower center point is calculated to be 19m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The midspan blowout is estimated at a wind pressure of 386.5 Pa, considering the 30º swing of I-String insulators for the 400m design span.

The total ROW requirement for a 500m long span is estimated to be 49m, which is 3m more than the existing practice of 46m ROW for 400kV TL in Nepal. The summary of ROW estimation is presented in Table 4.23.

Table 4.23: ROW Requirement for 400kV TL, 400m Design Span being used for 500m span with Tension Tower – Maintaining the Wire Tension Limits

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
N/A	19.2	25.1	386.5	19	49

The above result suggests that for 400kV TL long span crossings there will be violation of allowable wire tension limits for ACSR conductors, violation of ROW and violation of tower design tensions. These violations shall be addressed based upon the preferred priority and the reduction in violation of one will increase the violation of the other.

To resolve the violation of allowable wire tension limits, the use of Aluminum Alloy Conductors or any conductors with higher tensile strength could be an option. The violation in tower design tensions could be addressed using special towers designed for heavy loading. The violation of the ROW could be addressed either by using increased wire tension and special towers or by increasing the ROW itself.

4.4.2. 220kV Transmission Line

4.4.2.1. 220kV TL Being Used For 500m Span with I-String

The midspan blowout of conductors from the tower center point is calculated to be 17.5m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The midspan blowout is estimated at a wind pressure of 331.7 Pa, considering the 30º swing of I-string insulators for the 350m design span.

The total ROW requirement for a 220kV double circuit transmission line with I-string is estimated to be 43m, which is 13m more than the existing practice of 30m ROW for 220kV TL in Nepal. The result suggests that the existing practice of 30m ROW for 220kV TL is not sufficient for long spans with I-string and the ROW requirement increases by as much as 43%. The summary of ROW estimation is presented in Table 4.24.

Table 4.24: ROW Requirement for 220kV TL, 350m Design Span being used for 500m span with I-String Suspension Tower

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
30°	20.5	23.3	331.7	17.5	43

4.4.2.2. 220kV TL Being Used For 500m Span with Tension Tower

The following three scenarios are evaluated for analyzing the feasibility of long-span crossings with tension towers.

a) Maintaining the Maximum Loading of Tower

For a 220kV line with a 350m design span, the design maximum wire tension is 6460 kg. This same value of 6460 kg was considered as the maximum allowable wire tension at full wind for a 500m span. The sag tension reports for the 220kV line are presented in Appendix D – Sag Tension Reports.

The midspan blowout of conductors from the tower center point is calculated to be 16.3m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The midspan blowout is estimated at a wind pressure of 331.7 Pa, considering the 30º swing of I-string insulators for the 350m Design Span.

The total ROW requirement for a 220kV double circuit transmission line with tension tower is estimated to be 40m, which is 10m more than the existing practice of 30m ROW for 220kV TL in Nepal. The result suggests that the existing practice of 30m ROW for 220kV TL is not sufficient for long spans with tension tower and the ROW requirement increases by as much as 33%. The summary of ROW estimation is presented in Table 4.25.

Table 4.25: ROW Requirement for 220kV TL, 350m Design Span being used for 500m span with Tension Tower – Maintaining Maximum Tower Loading

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
N/A	20.5	23.3	331.7	16.3	40

a) Maintaining the Standard 30m ROW

For a 220kV line with a 350m design span, the standard/desired ROW is 30m. So, the initial wire tension was increased to be 4853 kg, 39% of UTS of ACSR Bison for a 500m long span, which resulted in maximum wire tension of 9,500 kg, 77% of UTS of ACSR Bison at full wind condition. This resulted in increase in maximum tower tension by as much as 47% and violation of maximum allowable wire tension limit of 70% at full wind and 25% at initial condition.

This suggests that to maintain the standard ROW at 500m, the wire type with higher allowable tension limits shall be used and the towers shall be special towers designed for heavy loading.

b) Maintaining the Wire Tension Limits

For a 220kV line with a 350m design span, the initial wire stringing tension was increased to 3082 kg, 25% of UTS of ACSR Bison for 500m long span which resulted in a maximum wire tension of 7,659 kg, 62% of UTS of ACSR Bison. This resulted in an increase in maximum tower tension by as much as 18.5%.

The midspan blowout of conductors from the tower center point is calculated to be 13.9m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The midspan blowout is estimated at a wind pressure of 331.7 Pa, considering the 30º swing of I-string insulators for the 350m design span.

The total ROW requirement for a 500m long span is estimated to be 35m, which is 5m more than the existing practice of 30m ROW for 220kV TL in Nepal. The summary of ROW estimation is presented in Table 4.26.

Table 4.26: ROW Requirement for 220kV TL, 350m Design Span being used for 500m span with Tension Tower – Maintaining the Wire Tension Limits

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
N/A	20.5	23.3	331.7	13.9	35

The above result suggests that for 220kV TL long span crossings there will be violation of allowable wire tension limits for ACSR conductors, violation of ROW and violation of tower design tensions. These violations shall be addressed based upon the preferred priority and the reduction in violation of one will increase the violation of the other.

To resolve the violation of allowable wire tension limits, the use of Aluminum Alloy Conductors or any conductors with higher tensile strength could be an option. The violation in tower design tensions could be addressed using special towers designed for heavy loading. The violation in the ROW could be addressed either by using increased wire tension and special towers or by increasing the ROW itself.

4.4.3. 132kV Transmission Line

4.4.3.1. 132kV TL Being Used For 500m Span with I-String

The midspan blowout of conductors from the tower center point is calculated to be 14.9m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The midspan blowout is estimated at a wind pressure of 357.2 Pa, considering the 30º swing of I-string insulators for the 350m design span.

The total ROW requirement for a 132kV double circuit transmission line with I-string is estimated to be 36m, which is 18m more than the existing practice of 18m ROW for 132kV TL in Nepal. The result suggests that the existing practice of 18m ROW for 132kV TL is not sufficient for long spans with I-string and the ROW requirement increases by as much as 100%. The summary of ROW estimation is presented in Table 4.27.

Table 4.27: ROW Requirement for 132kV TL, 350m Design Span being used for 500m span with I-String Suspension Tower

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
30°	23.5	24.14	357.2	14.9	36

4.4.3.2. 132kV TL Being Used For 500m Span with Tension Tower

The following three scenarios are evaluated for analyzing the feasibility of long-span crossings with tension towers.

a) Maintaining the Maximum Loading of Tower

For a 132kV line with a 350m design span, the design maximum wire tension is 5471 kg. This same value of 5471 kg was considered as the maximum allowable wire tension at full wind for a 500m span. The sag tension reports for the 132kV line are presented in Appendix D – Sag Tension Reports.

The midspan blowout of conductors from the tower center point is calculated to be 14.5m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The midspan blowout is estimated at a wind pressure of 357.2 Pa, considering the 30º swing of I-string insulators for the 350m design span.

The total ROW requirement for a 132kV double circuit transmission line with tension tower is estimated to be 35m, which is 17m more than the existing practice of 18m ROW for 132kV TL in Nepal. The result suggests that the existing practice of 18m ROW for 132kV TL is not sufficient for long spans with tension tower and the ROW requirement increases by as much as 94%. The summary of ROW estimation is presented in Table 4.28.

Table 4.28: ROW Requirement for 132kV TL, 350m Design Span being used for 500m span with Tension Tower – Maintaining Maximum Tower Loading

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
N/A	23.5	24.14	357.2	14.5	35

b) Maintaining the Standard 18m ROW

For a 132kV line with a 350m design span, the standard/desired ROW followed in Nepal is 18m. So, the initial wire tension was increased to be 12,000 kg, 106% of UTS of ACSR Bear for a 500m long span which resulted in a maximum wire tension of 13,553 kg, 120% of UTS of ACSR Bear at full wind condition. This resulted in an increase in maximum tower tension by as much as 147% and extreme violation of the maximum allowable wire tension limit of 70% at full wind and 25% at initial condition.

This suggests that to maintain the standard ROW at 500m, the wire type with higher allowable tension limits shall be used, and the towers shall be special towers designed for heavy loading.

c) Maintaining the Wire Tension Limits

For a 132kV line with a 350m design span, the initial wire stringing tension was increased to 2,835 kg, 25% of UTS of ACSR Bear for a 500m long span which resulted in a maximum wire tension of 6,465 kg, 58% of UTS of ACSR Bear. This resulted in an increase in maximum tower tension by as much as 18.2%.

The midspan blowout of conductors from the tower center point is calculated to be 11.9m on either side. The estimated midspan blowout reports of conductors are shown in Appendix F – Conductor Blowout Reports. The midspan blowout is estimated at a wind pressure of 357.2 Pa, considering the 30º swing of I-string insulators for the 350m design span.

The total ROW requirement for a 500m long span is estimated to be 30m, which is 12m more than the existing practice of 18m ROW for 132kV TL in Nepal. The summary of ROW estimation is presented in Table 4.29.

Table 4.29: ROW Requirement for 132kV TL, 350m Design Span being used for 500m span with Tension Tower – Maintaining the Wire Tension Limits.

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
N/A	23.5	24.14	357.2	11.9	30

The above result suggests that for 132kV TL long span crossings there will be extreme violation of allowable wire tension limits for ACSR conductors, violation of ROW and violation of tower design tensions. These violations shall be addressed based upon the preferred priority and the reduction in violation of one will increase the violation of the other.

To resolve the violation in allowable wire tension limits, the use of Aluminum Alloy Conductors or any conductors with higher tensile strength could be an option. The violation in tower design tensions could be addressed using special towers designed for heavy loading. The violation in the ROW could be addressed either by using increased wire tension and special towers or by increasing the ROW itself.

4.5. Electric Field and Magnetic Field Profiles

The electric and magnetic field profiles across the HVTLs are generated considering the typical tower framings for double circuit lines developed by utilities in Nepal. For 400kV TL, double circuit tower framing used by RPGCL was considered and for 220kV TL and 132kV TL, the double circuit tower framing used by NEA was considered. The reference tower framing drawings are shown in Appendix A – Tower Drawings. The field values are estimated considering standard voltage level and conductor current as presented in Table 4.30.

Table 4.30: Line-Line Voltage and Phase Current for HVTLs

S.N.	Transmission Voltage (kV)	Current (Amps)	Conductor
1	132kV	500	ACSR Bear
2	200kV	700	ACSR Bison
3	400kV	900	ACSR Moose

The field values below the line and at the edge of the ROW during the maximum sag condition are of primary concern. The ICNIRP recommendations on limiting exposure to electric and magnetic fields are as presented in Table 4.31.

Table 4.31: Electric Field and Magnetic Field Limits per ICNIRP

S.N.	Exposure	Frequency Range	Electric Field (kV/m)	Magnetic Field (μT)	Remarks
1	Occupational Exposure	25Hz - 300Hz	10	500	Inside ROW
2	General Public Exposure	25Hz - 50Hz	5	200	Edge of ROW

As per standard practice, field values at 1.8m height above the ground level are estimated for both I-string and V-string configurations. The field values at 3.5m height above ground level are also estimated for the I-string configuration, considering the underbuilt temporary structures.

Further, the field values at mid-span and at the edge of the ROW during design swing conditions are also estimated considering a building at the edge of the ROW.

4.5.1. 400kV Transmission Line

4.5.1.1. Electric Field and Magnetic Field at 1.8m Above Ground

The estimated field values and field profiles across the 400kV TL with I-string configuration and V-string configuration are as follows:

a) I-String Configuration

The estimated electric and magnetic field values are as shown in Table 4.32. These values are within the limits defined by ICNIRP.

Table 4.32: Electric Field and Magnetic Field for 400kV TL, I-String Configuration @1.8m

Configuration	Electric Field (kV/m)		Magnetic Flux Density (μT)	
	Below the Line	Edge of 46m ROW	Below the Line	Edge of 46m ROW
I-String	9.55	1.37	58.7	31.63

The electric and magnetic field profiles across the 400kV TL with I-string configuration are as shown in Figure 4.1. and Figure 4.2. It can be observed that the field values are peak exactly below the wire position and gradually reduce as we move further towards the edge of the ROW.

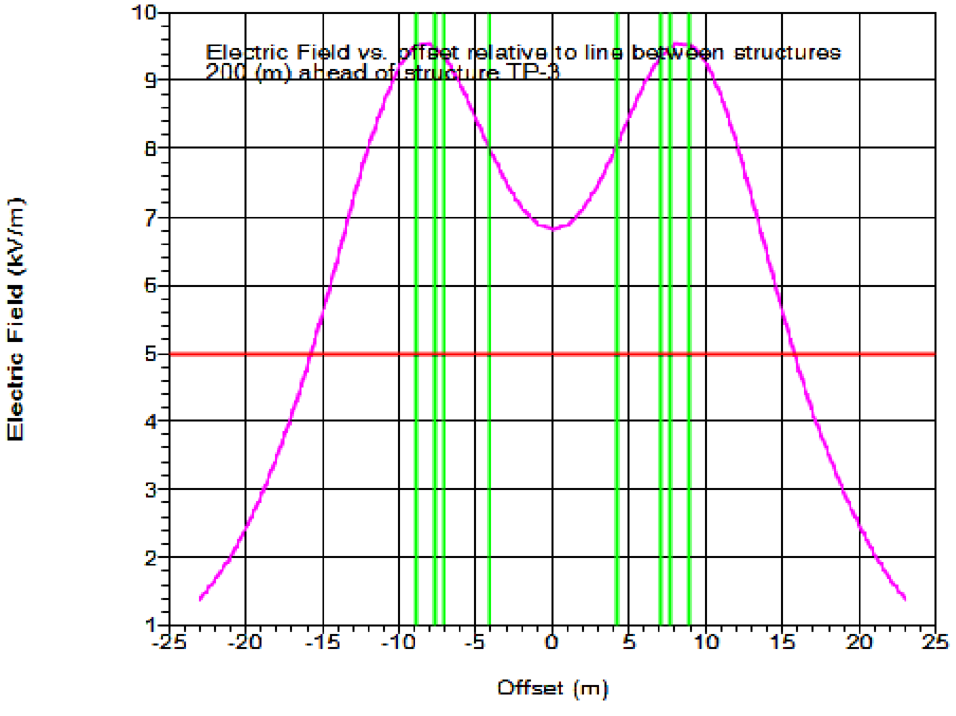

Figure 4.1: Electric Field Profile across the 400kV TL with I-String Configuration @1.8m

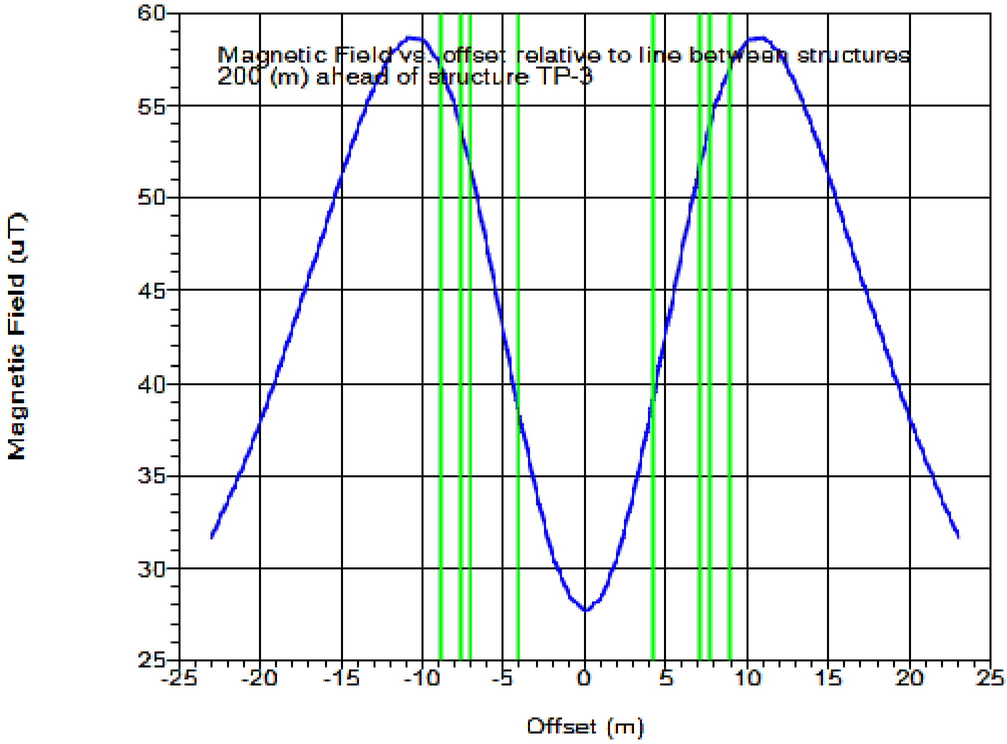

Figure 4.2: Magnetic Field Profile across the 400kV TL with I-String Configuration @1.8m

b) V-String Configuration

The estimated electric and magnetic field values are as shown in Table 4.33. These values are within the limits defined by ICNIRP.

Table 4.33: Electric Field and Magnetic Field for 400kV TL, V-String Configuration @1.8m

Configuration	Electric Field (kV/m)		Magnetic Flux Density (μT)	
	Below the Line	Edge of 38m ROW	Below the Line	Edge of 38m ROW
V-String	8.98	1.85	51.7	31.5

The electric and magnetic field profiles across the 400kV TL with V-string configuration are as shown in Figure 4.3. and Figure 4.4. It can be observed that the field values are peak exactly below the wire position and gradually reduce as we move further towards the edge of the ROW.

Further, it is found that the electric field values below the line have decreased by 6% and the magnetic field values below the line have decreased by 12% compared to the I-string configuration.

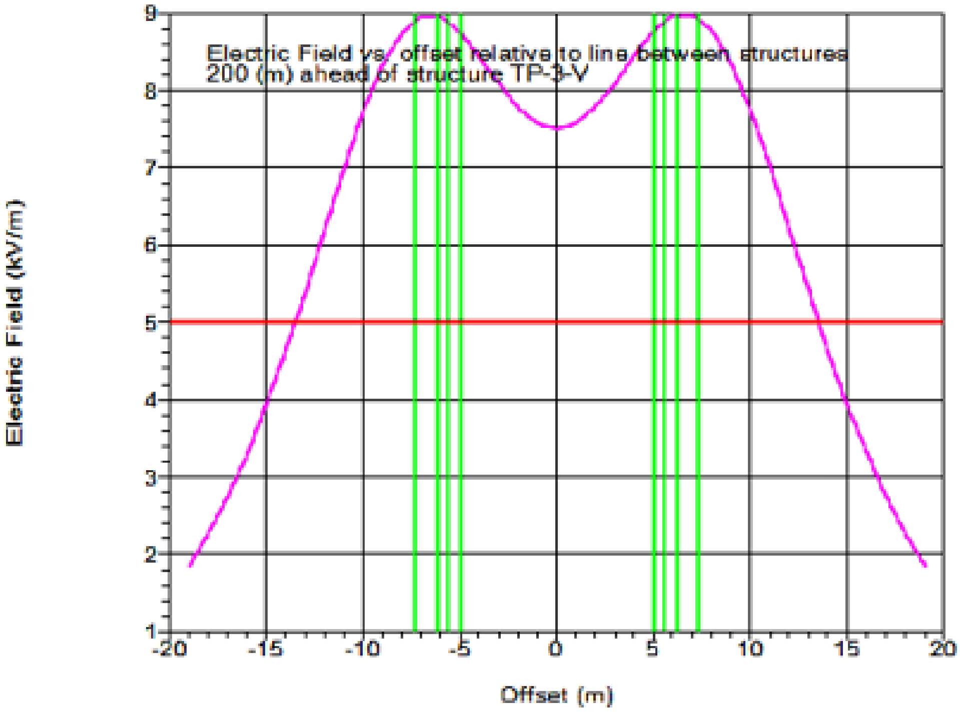

Figure 4.3: Electric Field Profile across the 400kV TL with V-String Configuration @1.8m

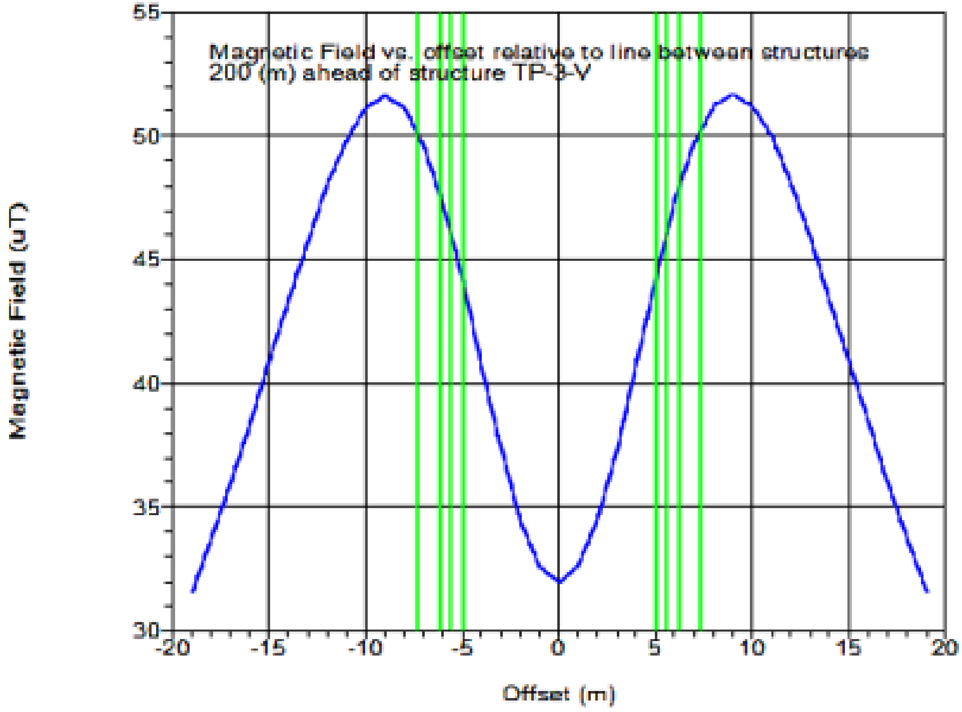

Figure 4.4: Magnetic Field Profile across the 400kV TL with V-String Configuration @1.8m

4.5.1.2. Electric Field and Magnetic Field at 3.5m Above Ground

The estimated electric and magnetic field values are shown in Table 4.34.

Table 4.34: Electric Field and Magnetic Field for 400kV TL, I-String Configuration @3.5m

Configuration	Electric Field (kV/m)		Magnetic Flux Density (μT)	
	Below the Line	Edge of 46m ROW	Below the Line	Edge of 46m ROW
I-String	11.17	1.45	77.5	34.6

It is found that the field values at the edge of the ROW are within the limits defined by ICNIRP. The magnetic field below the line increases but is still within the recommended limit of 500μT defined by ICNIRP. However, the electric field below the line is 11.17kV/m which is 11.7% more than the recommended limit of 10kV/m defined by ICNIRP.

The electric and magnetic field profiles across the 400kV TL with I-string configuration are as shown in Figure 4.5. and Figure 4.6.

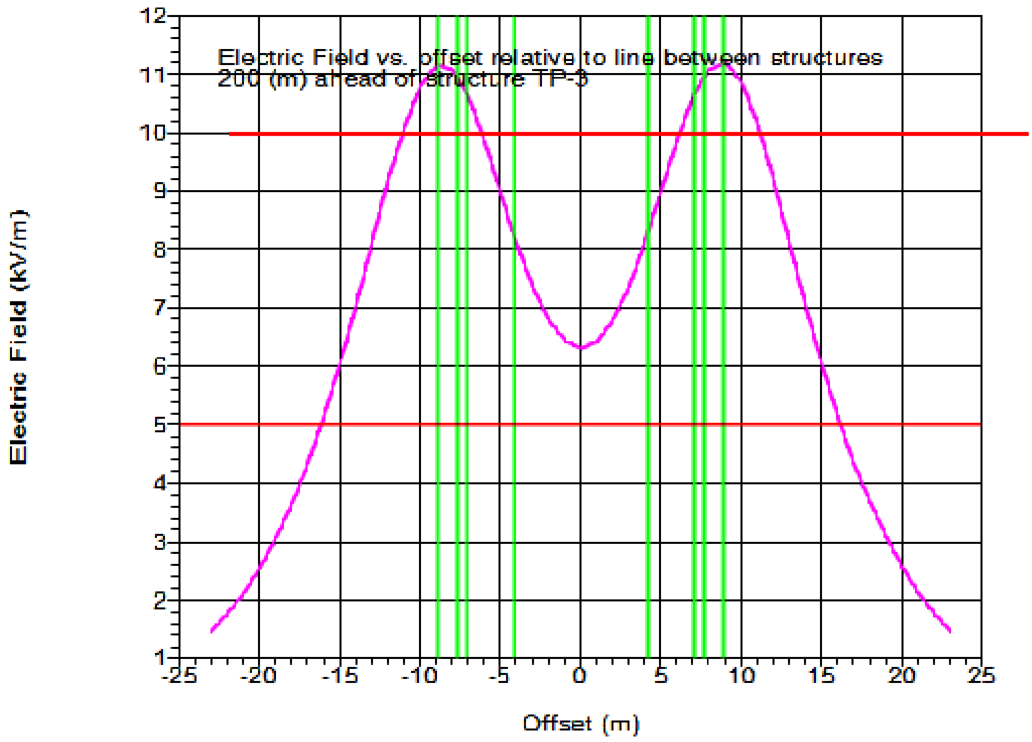

Figure 4.5: Electric Field Profile across the 400kV TL with I-String Configuration @3.5m

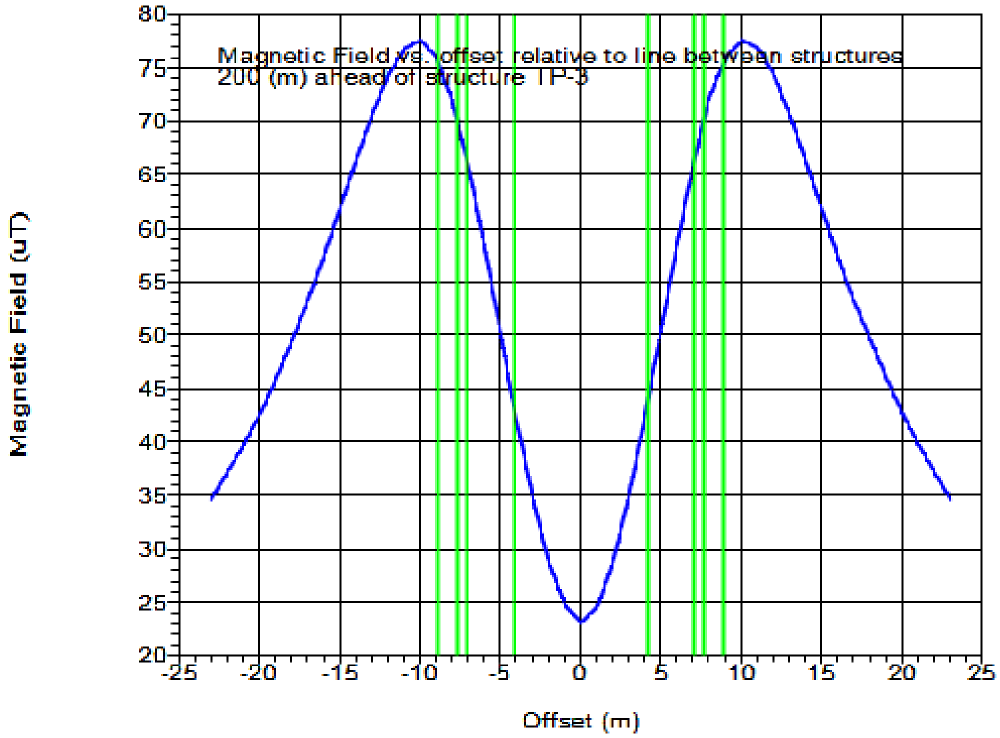

Figure 4.6: Magnetic Field Profile across the 400kV TL with I-String Configuration @3.5m

4.5.1.3. Electric Field and Magnetic Field during Swing Condition

The 30° design swing of the I-string occurs at 386.5 Pa wind pressure for 400kV, 400m design span. The electric and magnetic field values and profiles at the midspan and edge of ROW during design swing conditions are estimated considering a building height of 23m at the edge of ROW. The estimated electric and magnetic field values are shown in Table 4.35.

Table 4.35: Electric Field and Magnetic Field for 400kV TL @ Design Swing – 46m ROW

Configuration	Electric Field (kV/m)		Magnetic Flux Density (µT)	
	Below the Line	Edge of 46m ROW	Below the Line	Edge of 46m ROW
I-String	325.9	9.3	969.14	136.38

It is found that the electric and magnetic field values at the edge of 46m ROW at 23m height are 9.3kV/m and 136.38µT, which is within the recommended limits by ICNIRP for occupational exposure but violates the general public exposure limits. However, the swing conditions are for a short duration and the field values are within the occupational exposure limits, it can be considered safe. The electric and magnetic field profiles across the 400kV TL with I-string configuration at design swing condition and 46m ROW are as shown in Figure 4.7. and Figure 4.8.

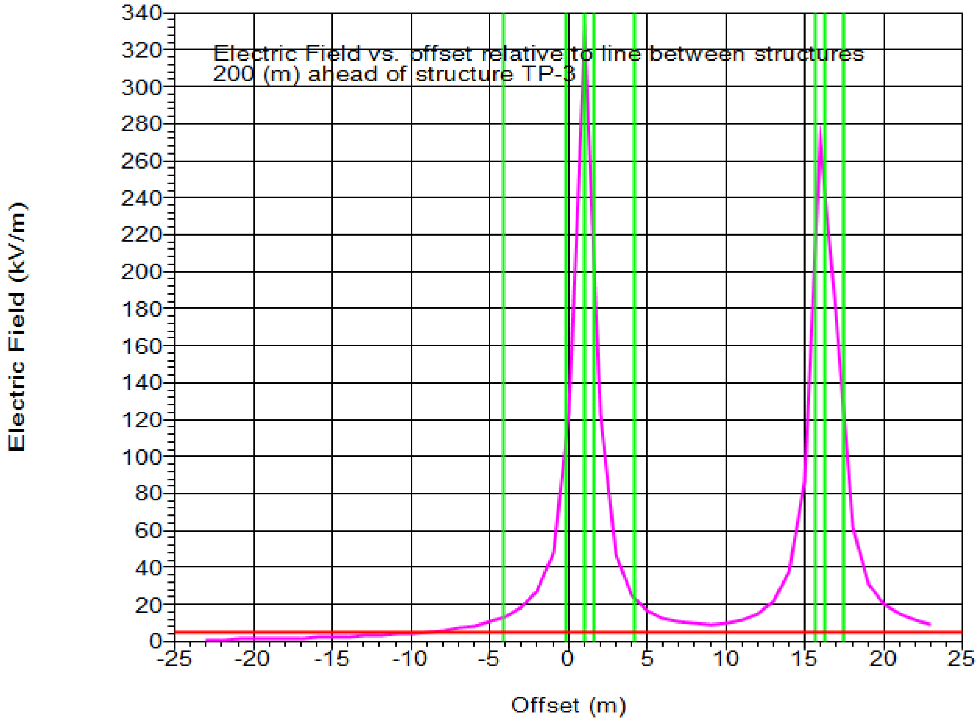

Figure 4.7: Electric Field Profile across the 400kV TL @ Design Swing – 46m ROW

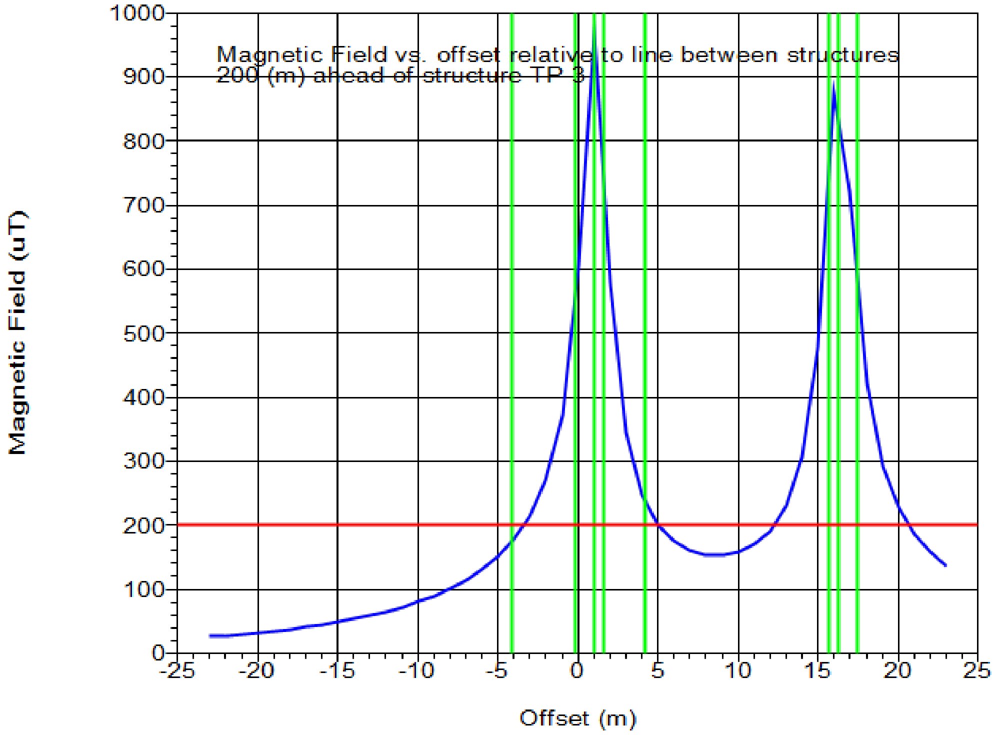

Figure 4.8: Magnetic Field Profile across the 400kV TL @ Design Swing – 46m ROW

4.5.2. 220kV Transmission Line

4.5.2.1. Electric Field and Magnetic Field at 1.8m Above Ground

The estimated field values and field profiles across the 220kV TL with I-string configuration and V-string configuration are as follows:

a) I-String Configuration

The estimated electric and magnetic field values are shown in Table 4.36. These values are within the limits defined by ICNIRP.

Table 4.36: Electric Field and Magnetic Field for 220kV TL, I-String Configuration @1.8m

Configuration	Electric Field (kV/m)		Magnetic Flux Density (µT)	
	Below the Line	Edge of 30m ROW	Below the Line	Edge of 30m ROW
I-String	5.61	0.99	29.53	17.1

The electric and magnetic field profiles across the 220kV TL with I-string configuration are as shown in Figure 4.9. and Figure 4.10. It can be observed that the field values are peak exactly below the wire position and gradually reduces as we move further towards the edge of the ROW.

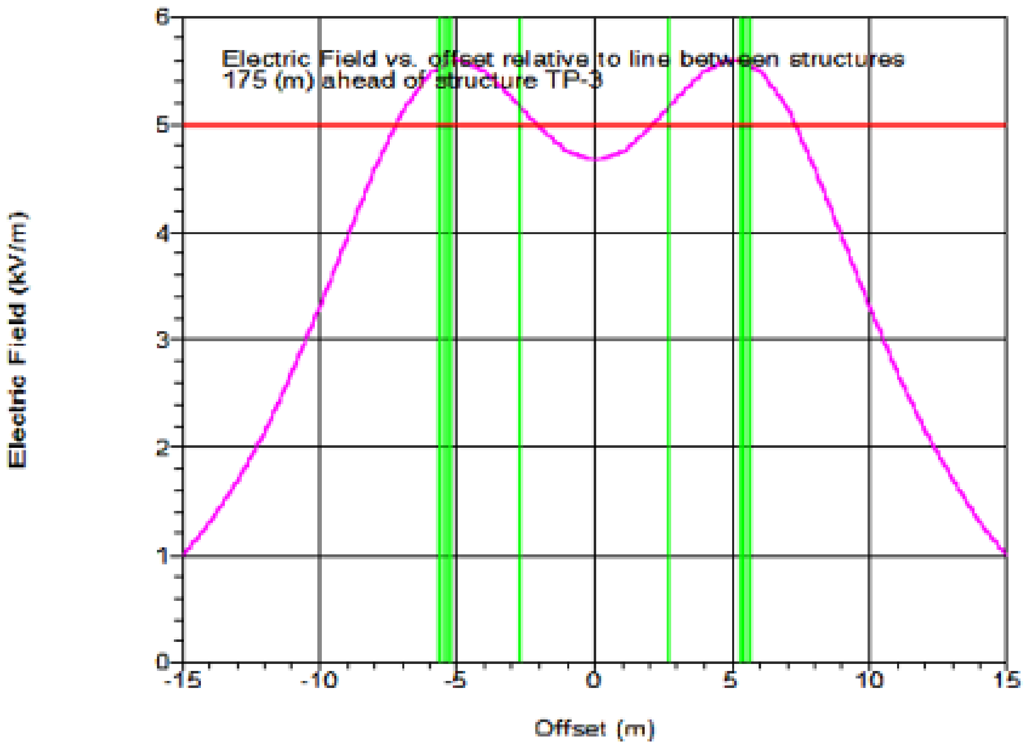

Figure 4.9: Electric Field Profile across the 220kV TL with I-String Configuration @1.8m

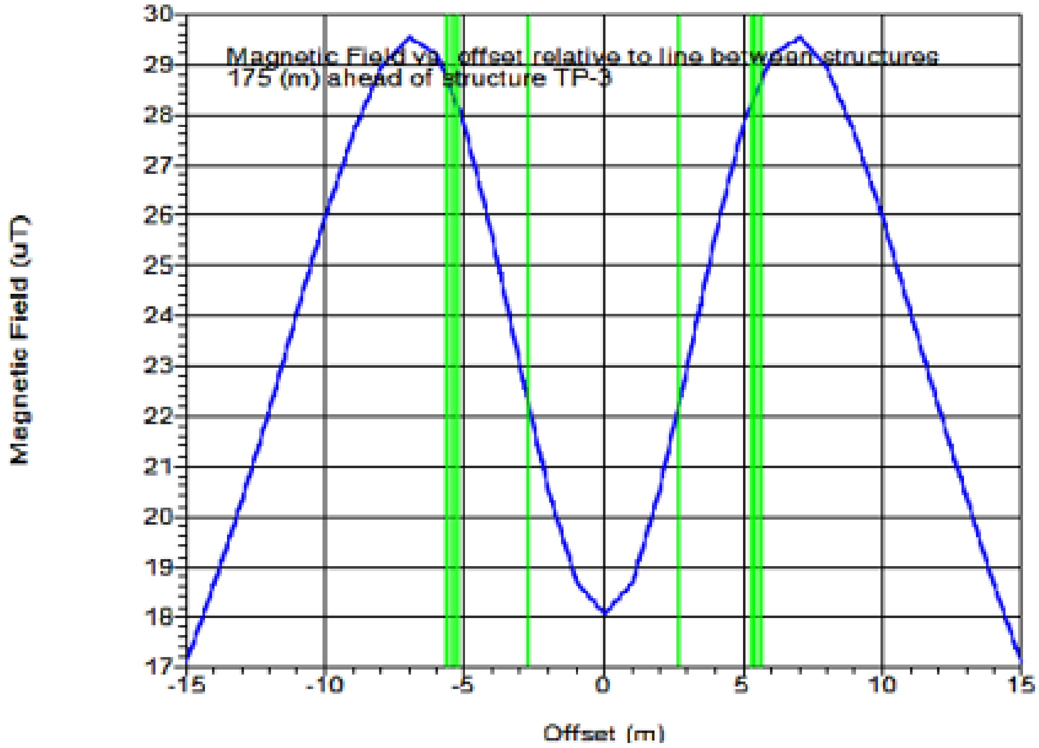

Figure 4.10: Magnetic Field Profile across the 220kV TL with I-String Configuration @1.8m

a) V-String Configuration

The estimated electric and magnetic field values are shown in Table 4.37. These values are within the limits defined by ICNIRP.

Table 4.37: Electric Field and Magnetic Field for 220kV TL, V-String Configuration @1.8m

Configuration	Electric Field (kV/m)		Magnetic Flux Density (µT)	
	Below the Line	Edge of 25m ROW	Below the Line	Edge of 25m ROW
V-String	5.61	1.17	29.2	17.2

The electric and magnetic field profiles across the 220kV TL with V-string configuration are as shown in Figure 4.11. and Figure 4.12. It can be observed that the field values are peak exactly below the wire position and gradually reduces as we move further towards the edge of the ROW.

Further, it is found that the electric and magnetic field values below the line and at the edge of the ROW for the V-string configuration remain similar to that of the I-string configuration.

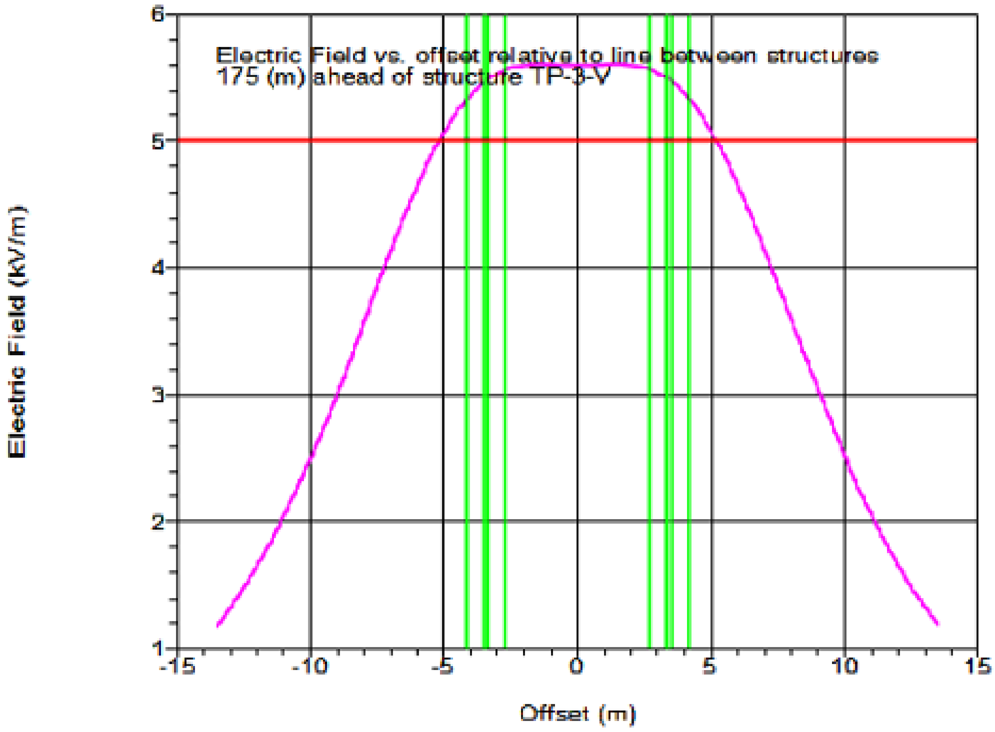

Figure 4.11: Electric Field Profile across the 220kV TL with V-String Configuration @1.8m

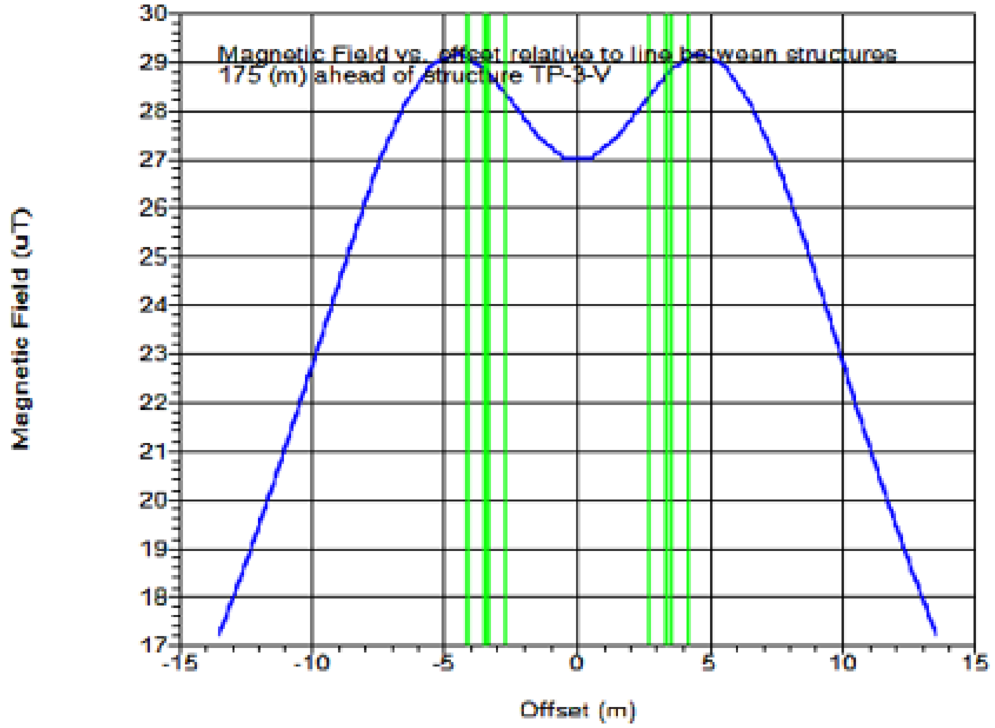

Figure 4.12: Magnetic Field Profile across the 220kV TL with V-String Configuration @1.8m

4.5.2.2. Electric Field and Magnetic Field at 3.5m Above Ground

The estimated electric and magnetic field values are shown in Table 4.38.

Table 4.38: Electric Field and Magnetic Field for 220kV TL, I-String Configuration @3.5m

Configuration	Electric Field (kV/m)		Magnetic Flux Density (µT)	
	Below the Line	Edge of 30m ROW	Below the Line	Edge of 30m ROW
I-String	6.4	1.66	43.23	23.0

It is found that the electric and magnetic field values below the line and at the edge of the ROW increases compared to 1.8m height but are within the limits defined by ICNIRP.

The electric and magnetic field profiles across the 220kV TL with I-string configuration are as shown in Figure 4.13. and Figure 4.14.

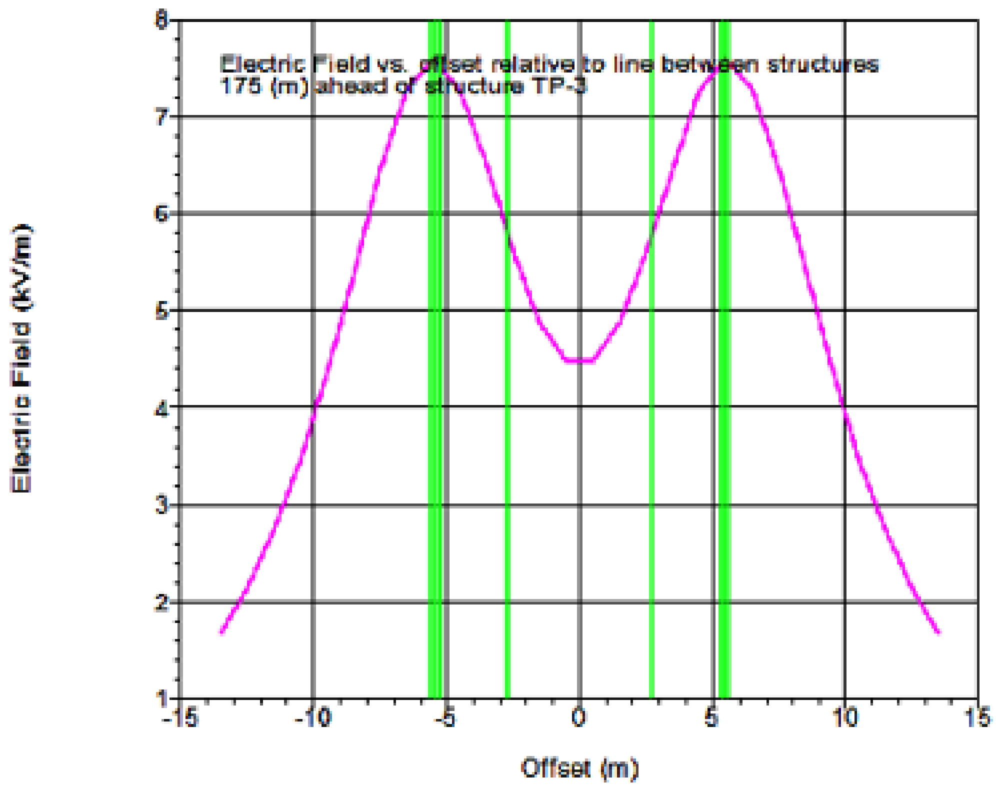

Figure 4.13: Electric Field Profile across the 220kV TL with I-String Configuration @3.5m

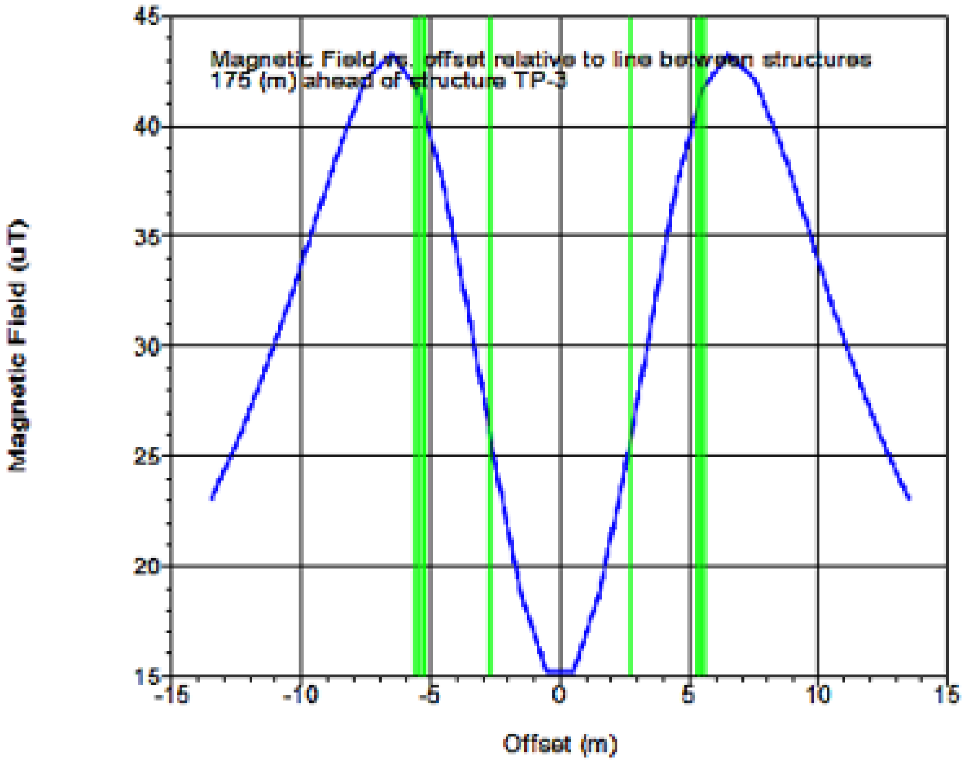

Figure 4.14: Magnetic Field Profile across the 220kV TL with I-String Configuration @3.5m

4.5.2.3. Electric Field and Magnetic Field during Swing Condition

The 30° design swing of the I-string occurs at 331.7 Pa wind pressure for 220kV, 350m design span. The electric and magnetic field values and profiles at the midspan and edge of the ROW during design swing conditions are estimated considering a building height of 17m at the edge of the ROW. The estimated electric and magnetic field values are shown in Table 4.39.

Table 4.39: Electric Field and Magnetic Field for 220kV TL @ Design Swing – 30m ROW

Configuration	Electric Field (kV/m)		Magnetic Flux Density (µT)	
	Below the Line	Edge of 30m ROW	Below the Line	Edge of 30m ROW
I-String	895.0	9.12	883.42	90.45

It is found that the electric and magnetic field values at the edge of 30m ROW at 17m height are 9.12kV/m and 90.45µT, which is within the recommended limits by ICNIRP for occupational exposure but violates the general public exposure limit. However, the swing conditions are for a short duration and the field values are within the occupational exposure limits, it can be considered safe. The electric and magnetic field profiles across the 220kV TL with I-string configuration at design swing condition and 46m ROW are as shown in Figure 4.15. and Figure 4.16.

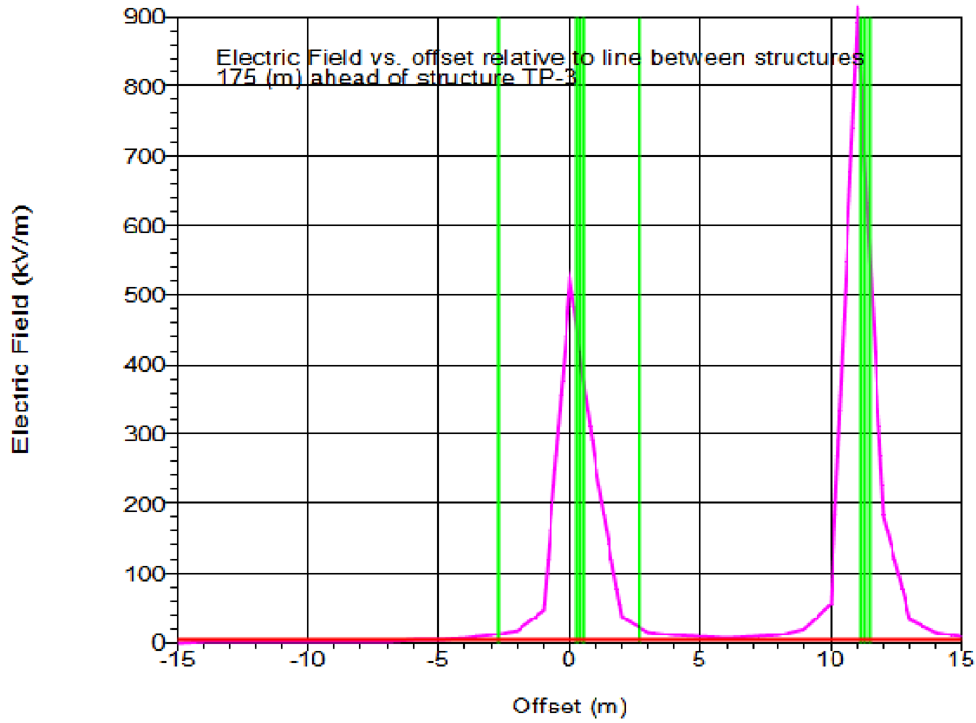

Figure 4.15: Electric Field Profile across the 220V TL @ Design Swing – 30m ROW

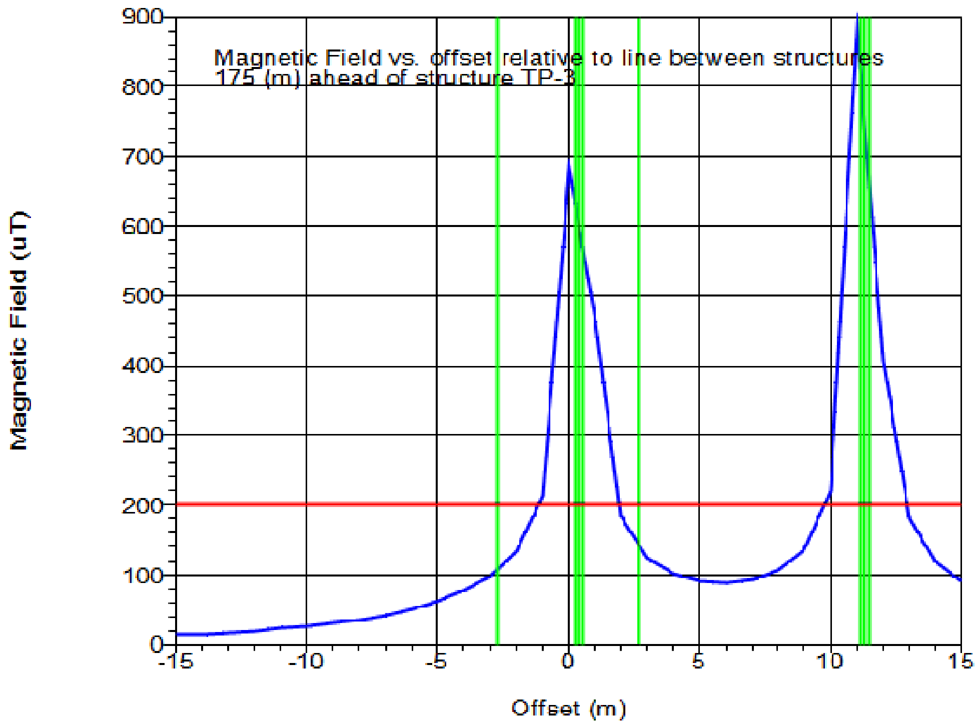

Figure 4.16: Magnetic Field Profile across the 220V TL @ Design Swing – 30m ROW

4.5.3. 132kV Transmission Line

4.5.3.1. Electric Field and Magnetic Field at 1.8m Above Ground

The estimated field values and field profiles across the 132kV TL with I-string configuration and V-string configuration are as follows:

a) I-String Configuration

The estimated electric and magnetic field values are shown in Table 4.40. These values are within the limits defined by ICNIRP for calculated 23m ROW as well as the existing 18m ROW.

Table 4.40: Electric Field and Magnetic Field for 132kV TL, I-String Configuration @1.8m

Configuration	Electric Field (kV/m)		Magnetic Flux Density (µT)	
	Below the Line	Edge of 23m ROW	Below the Line	Edge of 23m ROW
I-String	2.44	0.34	20.06	10.73

The electric and magnetic field profiles across the 132kV TL with I-string configuration are as shown in Figure 4.17. and Figure 4.18.

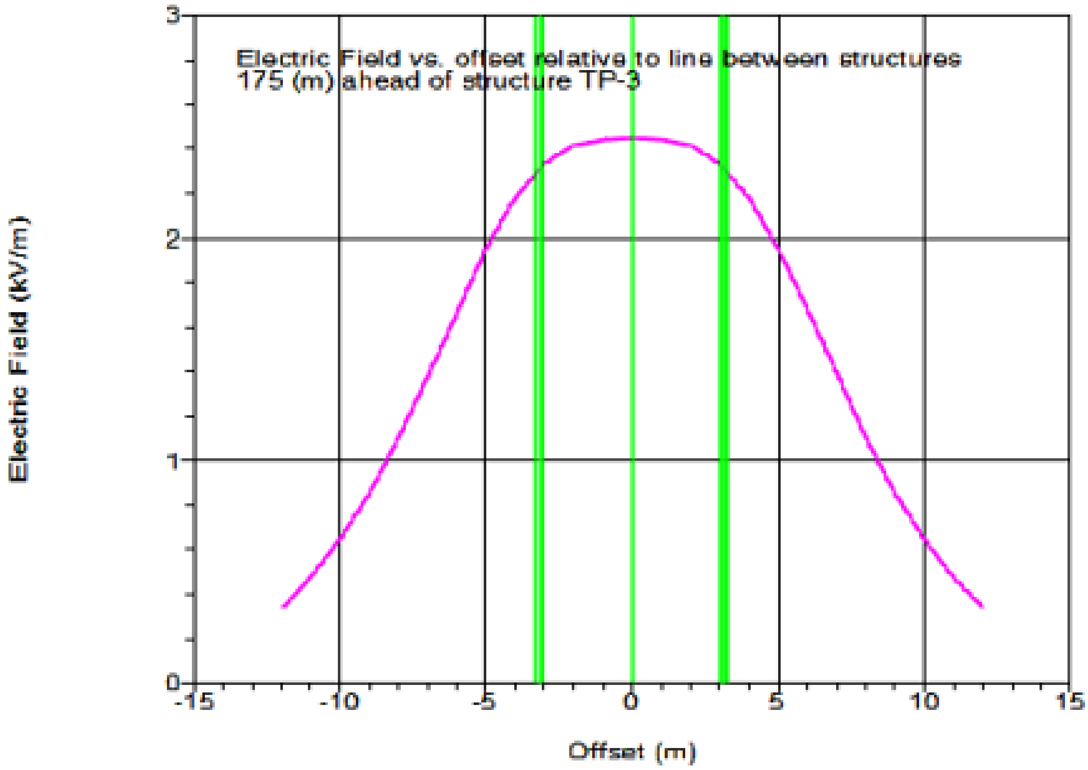

Figure 4.17: Electric Field Profile across the 132kV TL with I-String Configuration @1.8m

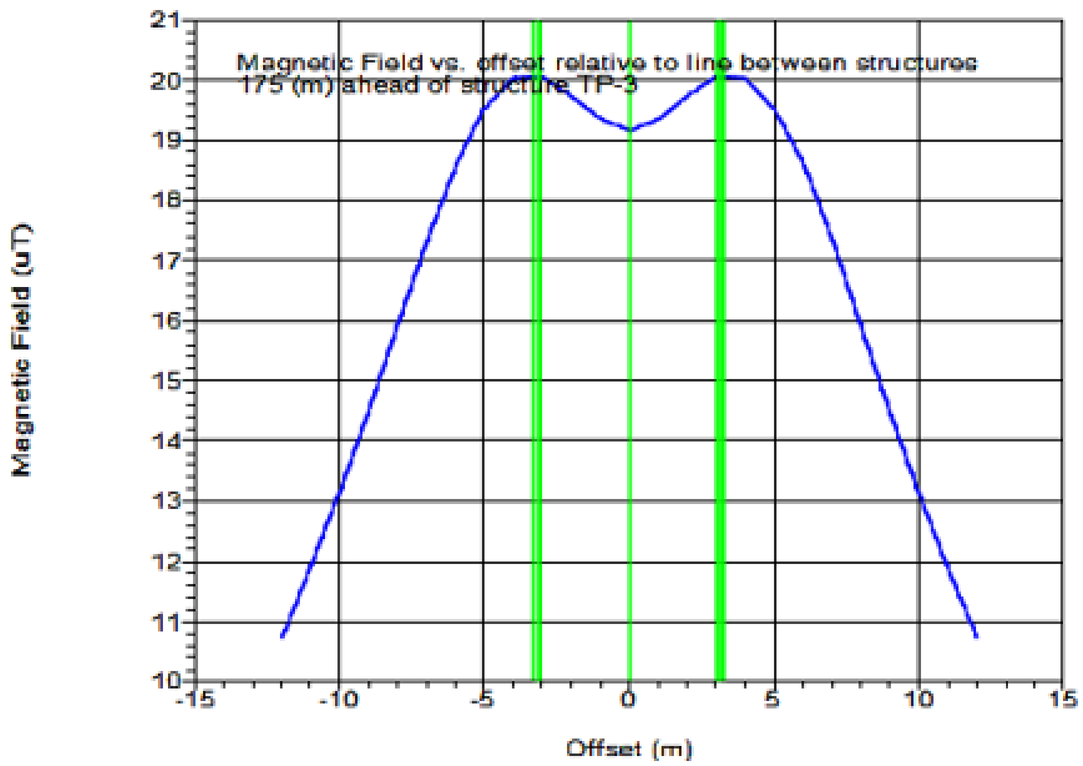

Figure 4.18: Magnetic Field Profile across the 132kV TL with I-String Configuration @1.8m

b) V-String Configuration

The estimated electric and magnetic field values are shown in Table 4.41. These values are within the limits defined by ICNIRP.

Table 4.41: Electric Field and Magnetic Field for 132kV TL, V-String Configuration @1.8m

Configuration	Electric Field (kV/m)		Magnetic Flux Density (µT)	
	Below the Line	Edge of 20m ROW	Below the Line	Edge of 25m ROW
V-String	2.49	0.56	21.3	12.2

The electric and magnetic field profiles across the 132kV TL with V-string configuration are as shown in Figure 4.19. and Figure 4.20. It can be observed that the field values are peak below the wire position and gradually reduces as we move further towards the edge of the ROW.

Further, it is found that the electric and magnetic field values below the line and at the edge of the ROW for the V-string configuration remain similar to that of the I-string configuration.

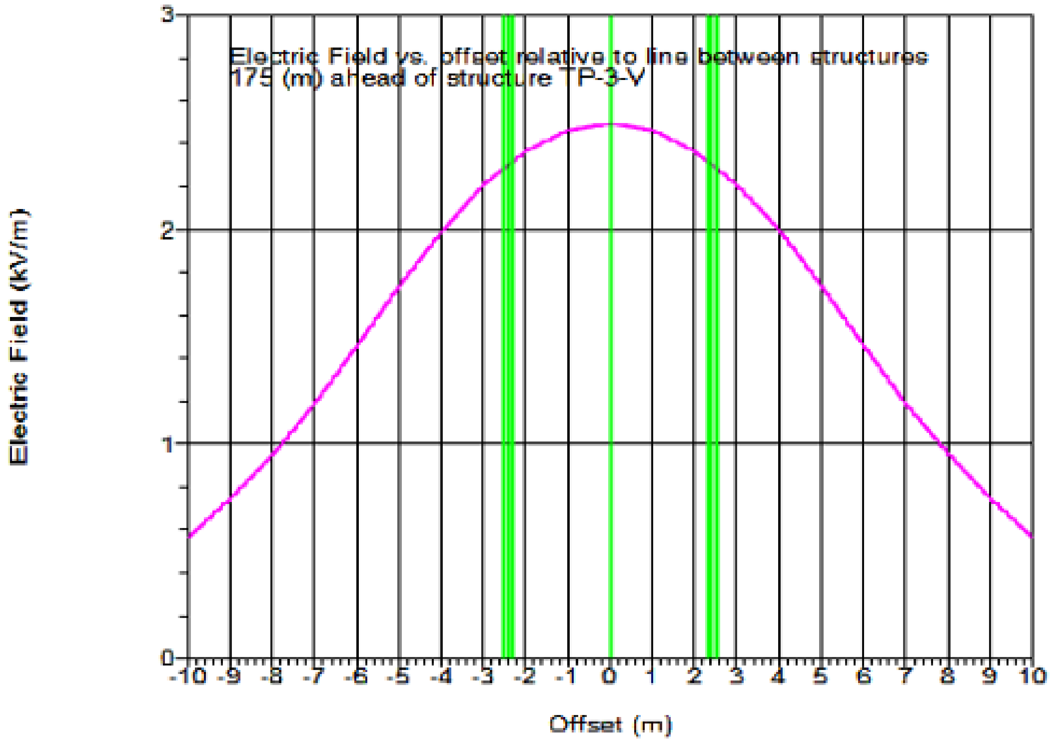

Figure 4.19: Electric Field Profile across the 132kV TL with V-String Configuration @1.8m

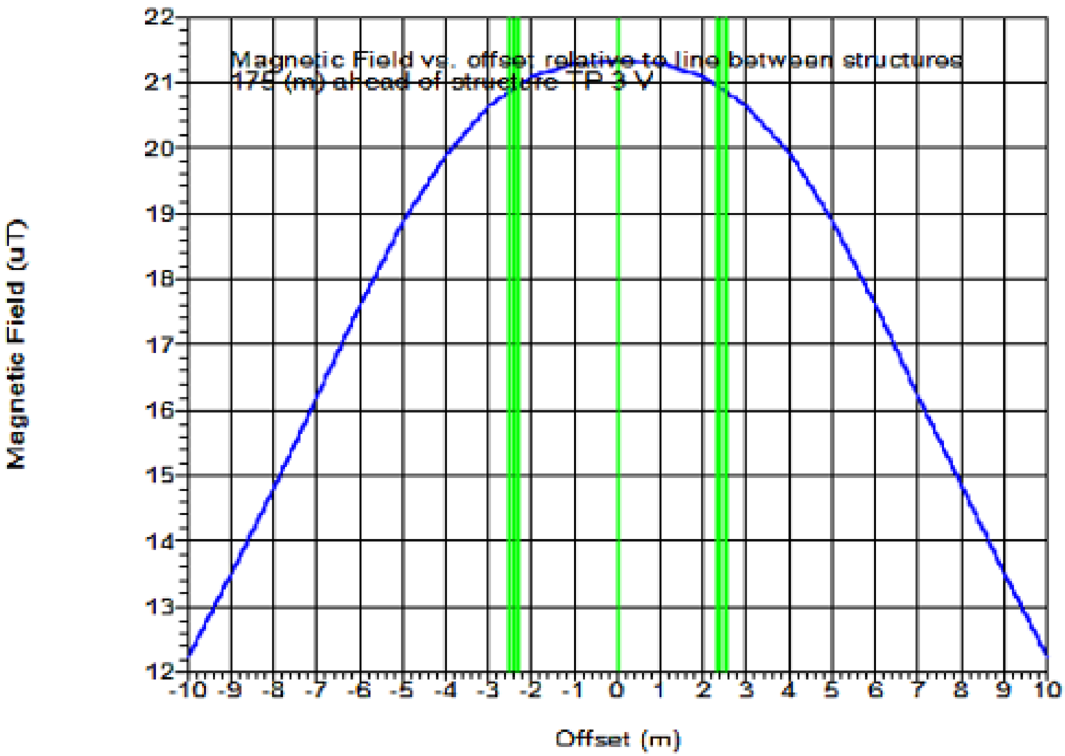

Figure 4.20: Magnetic Field Profile across the 132kV TL with V-String Configuration @1.8m

4.5.3.2. Electric Field and Magnetic Field at 3.5m Above Ground

The estimated electric and magnetic field values are shown in Table 4.42.

Table 4.42: Electric Field and Magnetic Field for 132kV TL, I-String Configuration @3.5m

Configuration	Electric Field (kV/m)		Magnetic Flux Density (μT)	
	Below the Line	Edge of 23m ROW	Below the Line	Edge of 23m ROW
I-String	3.11	0.42	28.59	12.53

It is found that the electric and magnetic field values below the line and at the edge of the ROW increases compared to 1.8m height but are within the limits defined by ICNIRP.

The electric and magnetic field profiles across the 132kV TL with I-string configuration are as shown in Figure 4.21. and Figure 4.22.

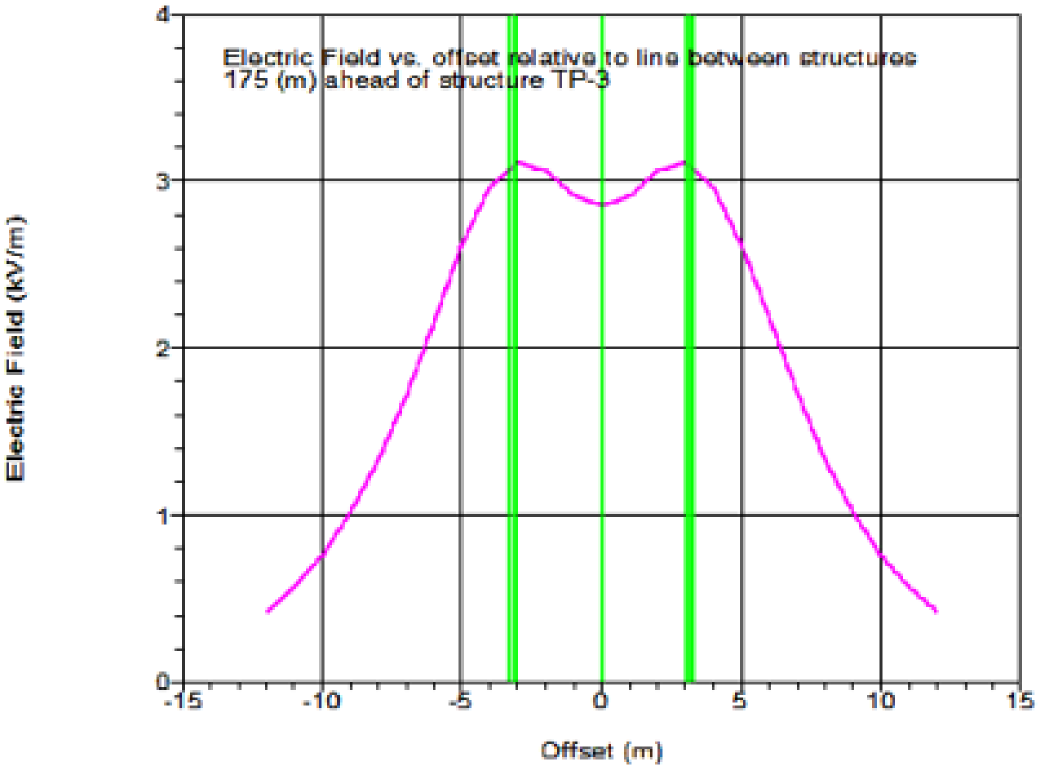

Figure 4.21: Electric Field Profile across the 132kV TL with I-String Configuration @3.5m

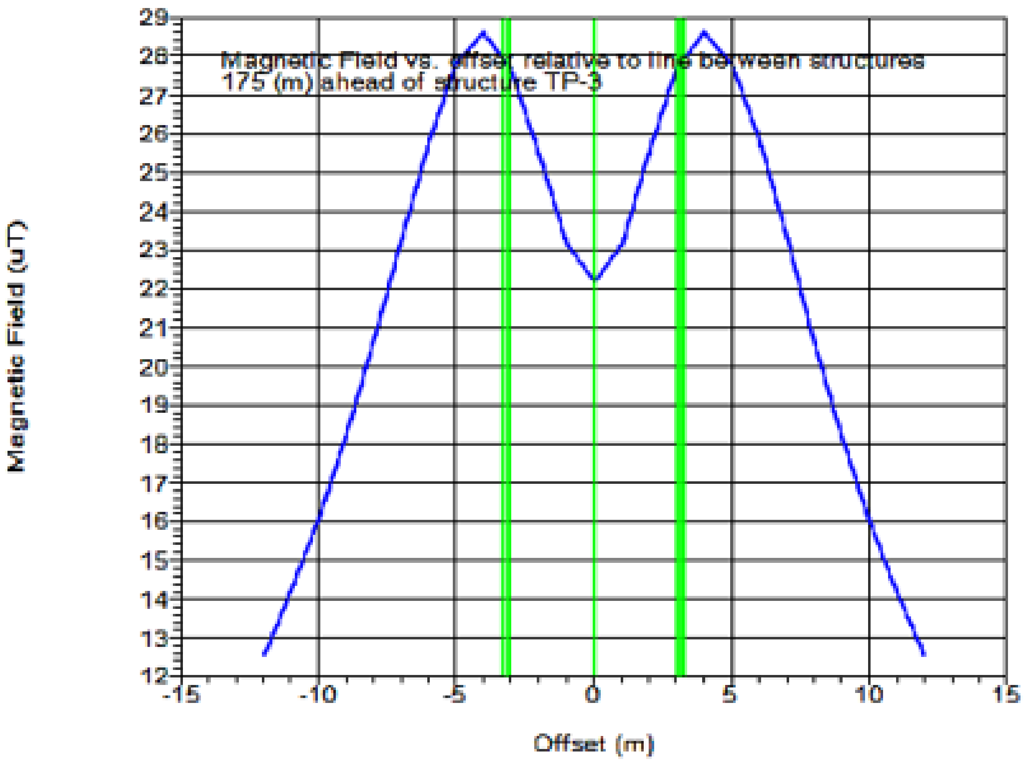

Figure 4.22: Magnetic Field Profile across the 132kV TL with I-String Configuration @3.5m

4.5.3.3. Electric Field and Magnetic Field during Swing Condition

The 30° design swing of I-string occurs at 357.2 Pa wind pressure for 132kV, 350m design span. The electric and magnetic field values and profiles at the midspan and edge of the estimated ROW and existing ROW during design swing conditions are estimated considering a building height of 15m at the edge of the ROW. The estimated electric and magnetic field values are shown in Table 4.43. and 4.44.

Table 4.43: Electric Field and Magnetic Field for 132kV TL @ Design Swing – 18m ROW

Configuration	Electric Field (kV/m)		Magnetic Flux Density (µT)	
	Below the Line	Edge of 18m ROW	Below the Line	Edge of 18m ROW
I-String	123.32	83.85	381.2	318.5

Table 4.44: Electric Field and Magnetic Field for 132kV TL @ Design Swing – 23m ROW

Configuration	Electric Field (kV/m)		Magnetic Flux Density (µT)	
	Below the Line	Edge of 23m ROW	Below the Line	Edge of 23m ROW
I-String	123.32	4.08	381.2	68.97

It is found that the electric and magnetic field values at the edge of 18m ROW at 15m height are 83.85kV/m and 318.5μT, which is very high compared to recommended limits by ICNIRP for both occupational exposure and general public exposure. This suggests that any buildings or structures that are at the edge of the existing 18m ROW are exposed to high level fields during wind conditions.

The field profiles across the 132kV TL with I-string configuration at design swing condition and 18m ROW are as shown in Figure 4.23. and Figure 4.24.

However, in case of the calculated ROW of 23m, the electric and magnetic field values at the edge of the ROW at 15m height are 4.08kV/m and 68.97μT, which is within the recommended limits by ICNIRP for both occupational exposure and general public exposure.

The electric and magnetic field profiles across the 132kV TL with I-string configuration at design swing condition and 23m ROW are as shown in Figure 4.25. and Figure 4.26.

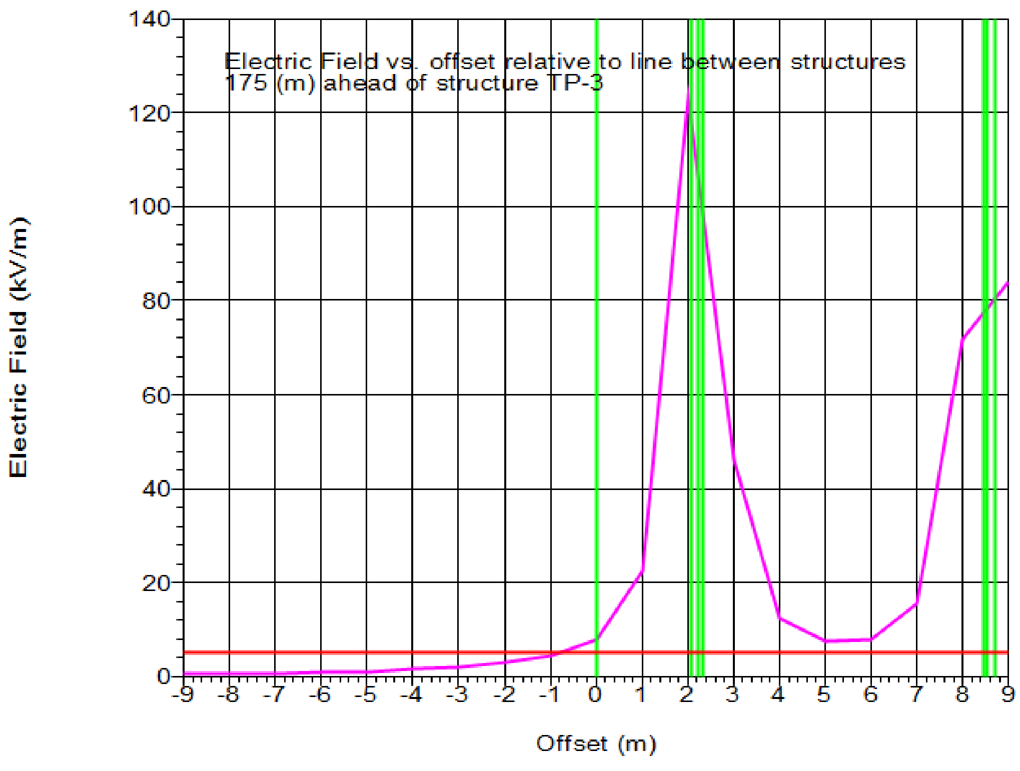

Figure 4.23: Electric Field Profile across the 132kV TL @ Design Swing – 18m ROW

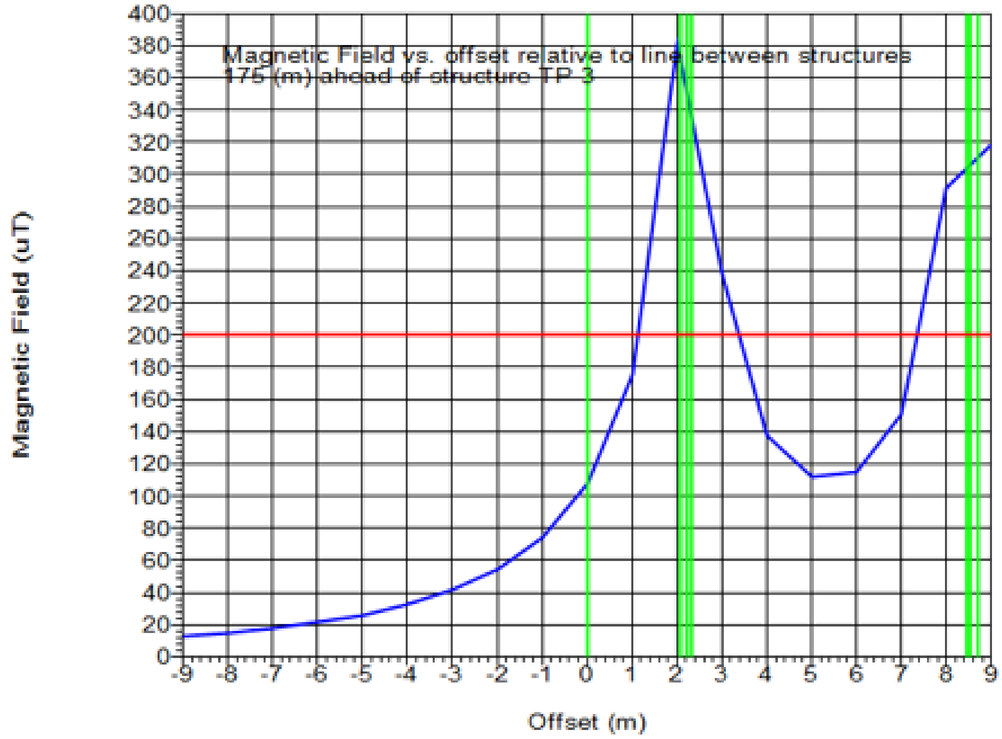

Figure 4.24: Magnetic Field Profile across the 132kV TL @ Design Swing – 18m ROW

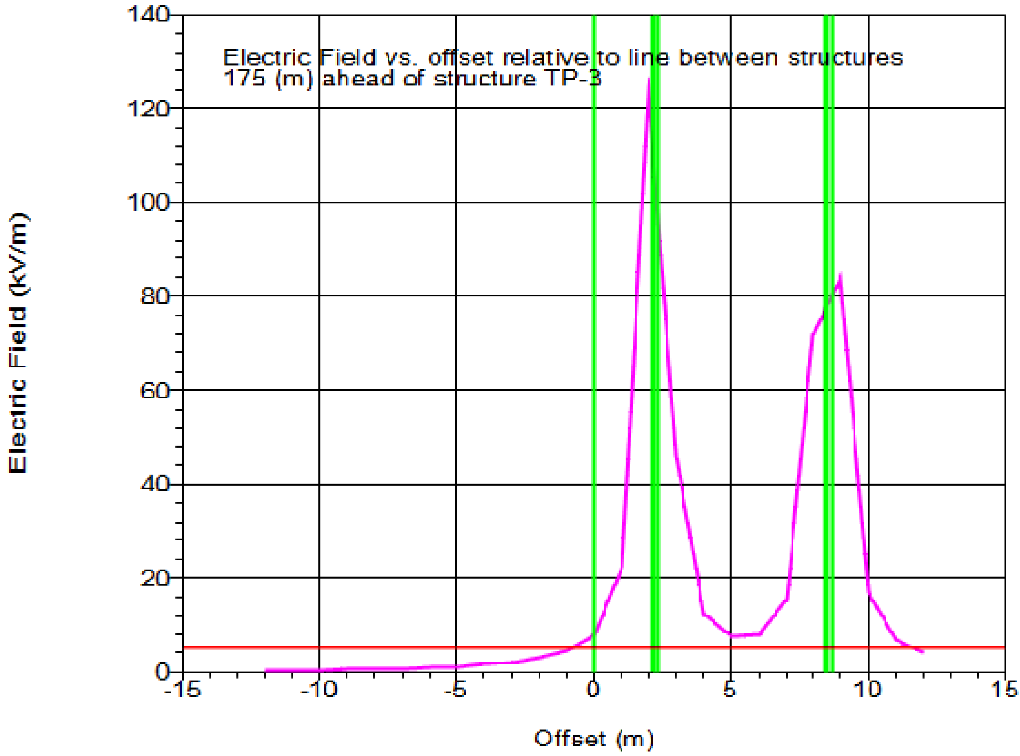

Figure 4.25: Electric Field Profile across the 132kV TL @ Design Swing – 23m ROW

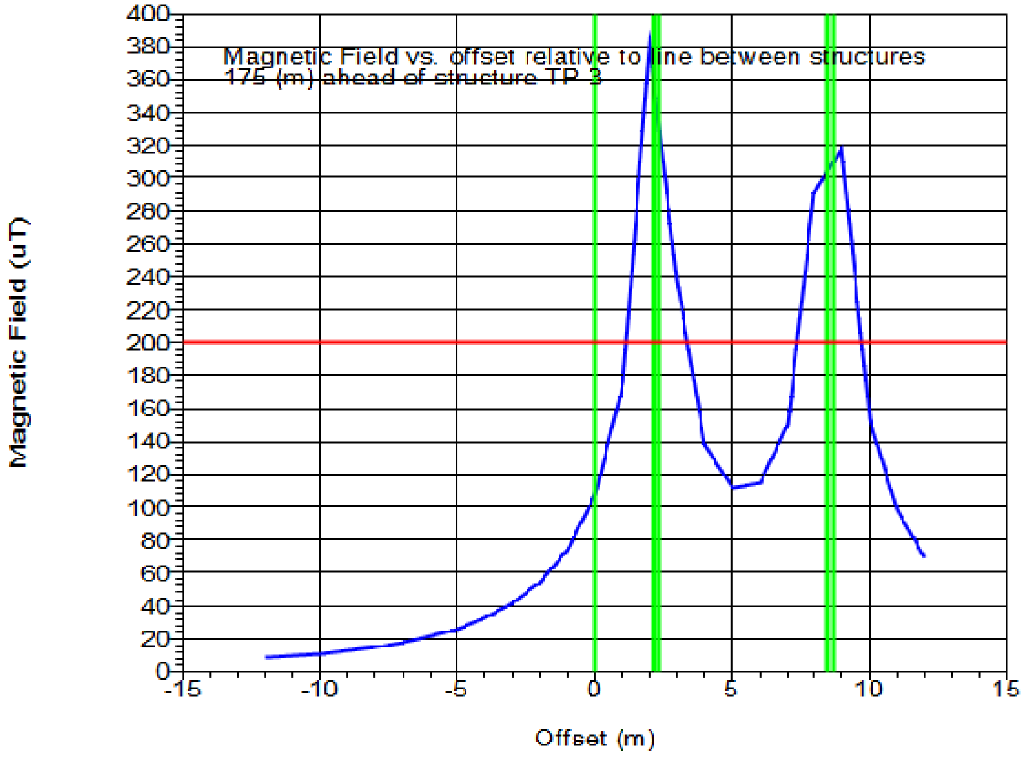

Figure 4.26: Magnetic Field Profile across the 132kV TL @ Design Swing – 23m ROW

4.6. Terminal Gantry Location

The ROW requirement, electric and magnetic field at terminal gantry locations for HVTLs are assessed considering the gantry framings and slack spans as per standard practice in Nepal.

4.6.1. 400kV Transmission Line

The terminal span from deadend tower to gantry is considered as 100m. The wind pressure of 386.5 Pa, considering the standard 400m design span, was used to estimate the blowouts. The referenced gantry framings are shown in Appendix B – Gantry Drawings.

The blowout of conductors from the tower center point is calculated to be 17.8m on either side. The result suggests that the existing practice of 46m ROW for 400kV TL is sufficient for the terminal gantry location. However, the horizontal clearance buffer of 5.6m is not satisfied in the area close to the gantry location. This has been neglected considering the gantry location will be on the substation switchyard area. The summary of ROW estimation is presented in Table 4.45.

Table 4.45: ROW Requirement for 400kV TL, 400m Design Span Gantry Location

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
N/A	19.2	25.1	386.5	17.8	46

The electric and magnetic field values are estimated at the lowest wire point, which depends on the heights of the deadend tower and gantry. The lowest wire point was observed at 55m towards the gantry, which is about midspan. The estimated electric and magnetic field values are shown in Table 4.46. These values are within the limits defined by ICNIRP.

Table 4.46: Electric Field and Magnetic Field for 400kV TL, Gantry Location @1.8m Ht.

Configuration	Electric Field (kV/m)		Magnetic Flux Density (μT)	
	Below the Line	Edge of 46m ROW	Below the Line	Edge of 46m ROW
Horizontal	2.26	1.93	11.56	10.828

The electric and magnetic field profiles across the span towards the gantry location are as shown in Figure 4.27. and Figure 4.28. It can be observed that the peak of field values is towards the edge of the ROW and the lowest value is at the central point, which is mainly due to the horizontal arrangement of conductors at the gantry.

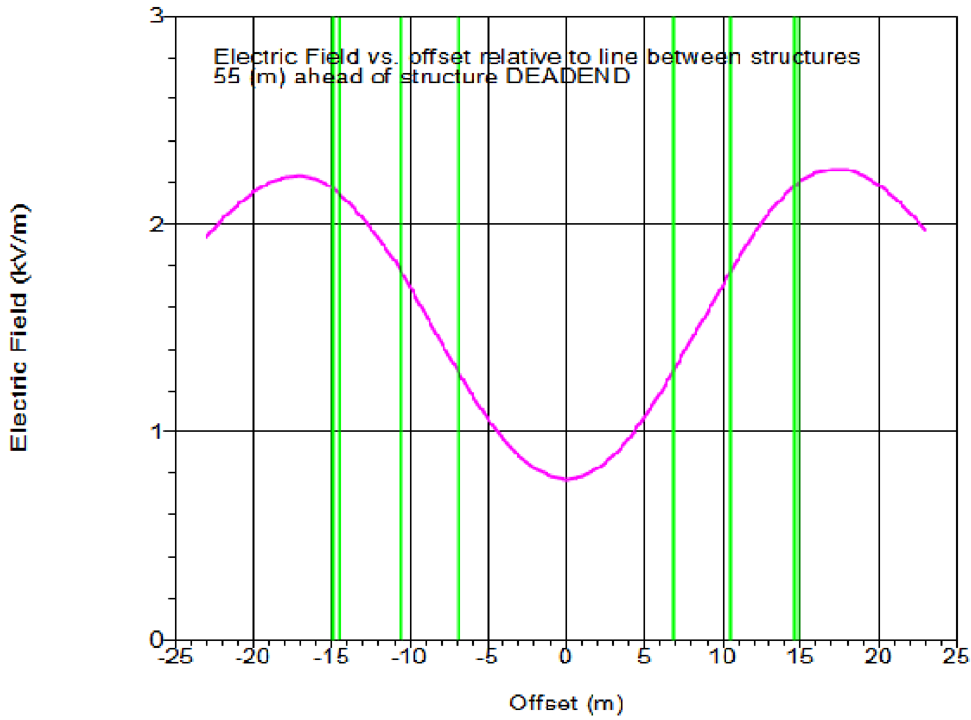

Figure 4.27: Electric Field Profile across the 400kV TL Gantry Location @1.8m

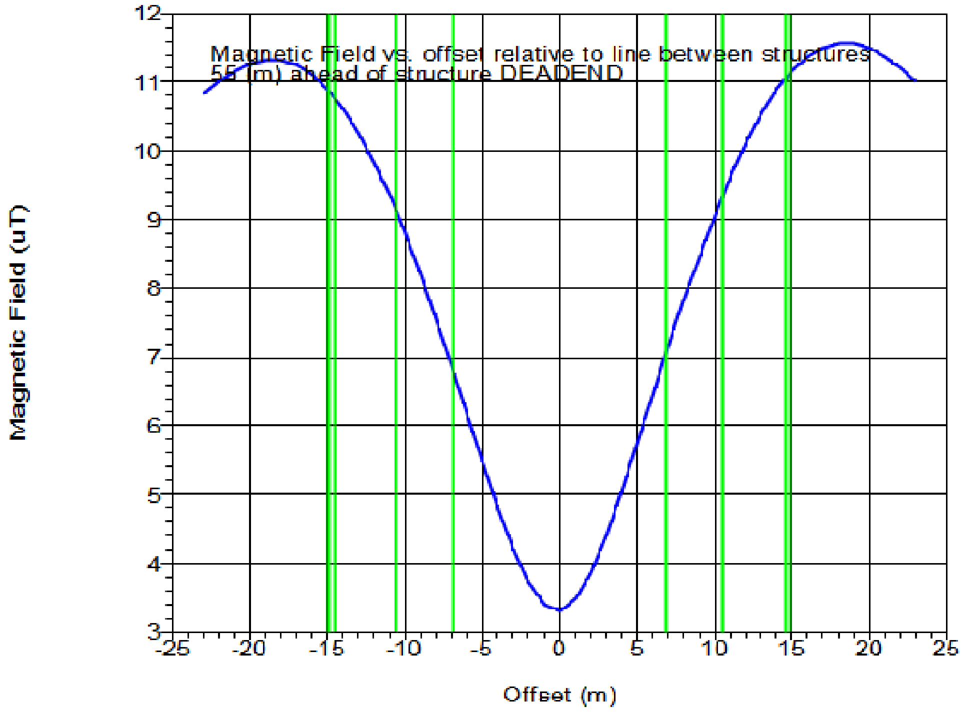

Figure 4.28: Magnetic Field Profile across the 400kV TL Gantry Location @1.8m

4.6.2. 220kV Transmission Line

The terminal span from deadend tower to gantry is considered as 50m. The wind pressure of 331.7 Pa, considering the standard 350m design span, was used to estimate the blowouts. The referenced gantry framings are shown in Appendix B – Gantry Drawings.

The blowout of conductors from the tower center point is calculated to be 12.17m on either side. The result suggests that the existing practice of 30m ROW for 220kV TL is sufficient for the terminal gantry location. However, the horizontal clearance buffer of 3.8m is not satisfied in the area close to the gantry location. This has been neglected considering the gantry location will be on the substation switchyard area. The summary of ROW estimation is presented in Table 4.47.

Table 4.47: ROW Requirement for 220kV TL, 350m Design Span Gantry Location

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
N/A	20.5	23.3	331.7	12.17	30

The electric and magnetic field values are estimated at the lowest wire point, which depends on the heights of the deadend tower and gantry. The lowest wire point was observed at 41m towards the gantry, which is almost about the gantry location. The estimated electric and magnetic field values are shown in Table 4.48. These values are within the limits defined by ICNIRP.

Table 4.48: Electric Field and Magnetic Field for 220kV TL, Gantry Location @1.8m Ht.

Configuration	Electric Field (kV/m)		Magnetic Flux Density (μT)	
	Below the Line	Edge of 30m ROW	Below the Line	Edge of 30m ROW
Horizontal	0.57	0.9	6.54	6.24

The electric and magnetic field profiles across the span towards the gantry location are as shown in Figure 4.29. and Figure 4.30. It can be observed that the electric field profile is inverted due to the horizontal arrangement of conductors at the gantry and the peak of both electric and magnetic field values is towards the edge of the ROW.

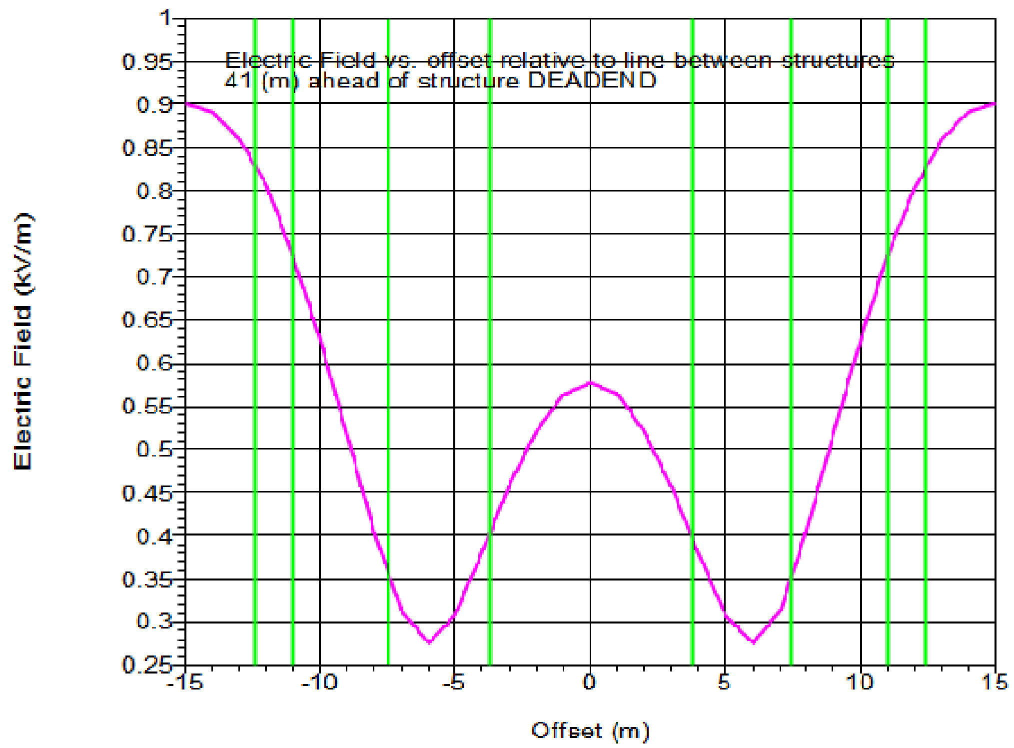

Figure 4.29: Electric Field Profile across the 220kV TL Gantry Location @1.8m

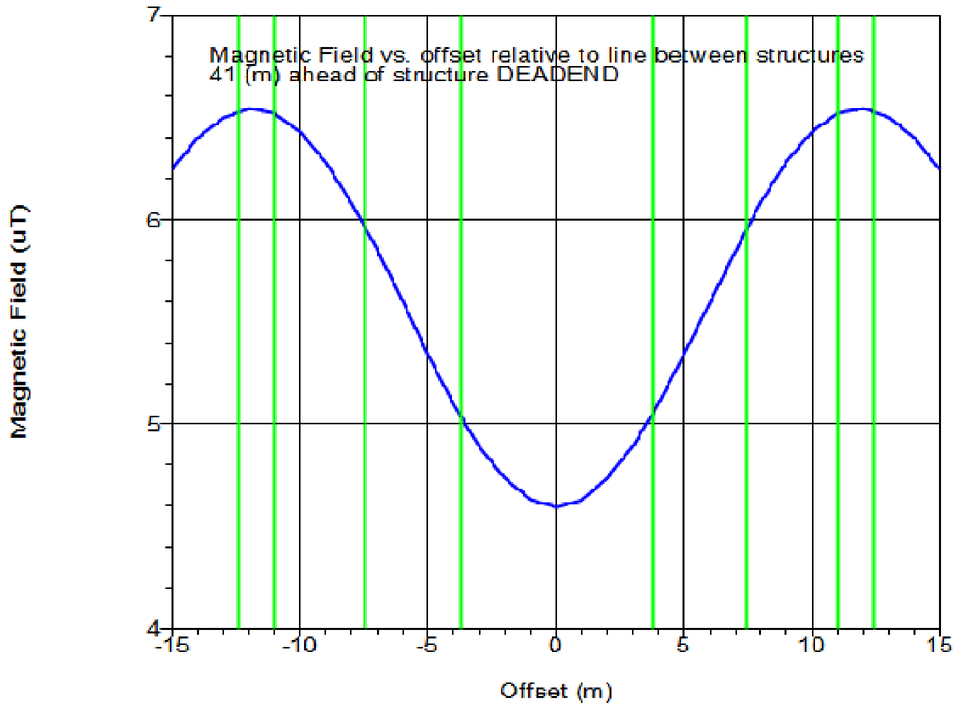

Figure 4.30: Magnetic Field Profile across the 220kV TL Gantry Location @1.8m

4.6.3. 132kV Transmission Line

The terminal span from deadend tower to gantry is considered as 50m. The wind pressure of 357.2 Pa, considering the standard 350m design span, was used to estimate the blowouts. The referenced gantry framings are shown in Appendix B – Gantry Drawings.

The blowout of conductors from the tower center point is calculated to be 7.83m on either side. The result suggests that the existing practice of 18m ROW for 132kV TL is sufficient for the terminal gantry location. However, the horizontal clearance buffer of 2.9m is not satisfied in the area close to the gantry location. This has been neglected considering the gantry location will be on the substation switchyard area. The summary of ROW estimation is presented in Table 4.49.

Table 4.49: ROW Requirement for 132kV TL, 350m Design Span Gantry Location

Suspension Insulator and Conductor Swing				Blowout from Tower Center Point (m)	Estimated ROW (m)
Insulator Swing	% of Full wind	Wind Speed (m/s)	Wind Pressure (Pa)		
N/A	23.5	24.14	357.2	7.83	18

The electric and magnetic field values are estimated at the lowest wire point, which depends on the heights of the deadend tower and gantry. The lowest wire point was observed at the gantry location. The estimated electric and magnetic field values are shown in Table 4.50. These values are within the limits defined by ICNIRP.

Table 4.50: Electric Field and Magnetic Field for 132kV TL, Gantry Location @1.8m Ht.

Configuration	Electric Field (kV/m)		Magnetic Flux Density (μT)	
	Below the Line	Edge of 18m ROW	Below the Line	Edge of 18m ROW
Horizontal	0.248	0.172	3.11	3.05

The electric and magnetic field profiles across the span towards the gantry location are as shown in Figure 4.31. and Figure 4.32. It can be observed that the electric field profile is inverted due to the horizontal arrangement of conductors at the gantry and the peak of both electric and magnetic field values is towards the edge of the ROW.

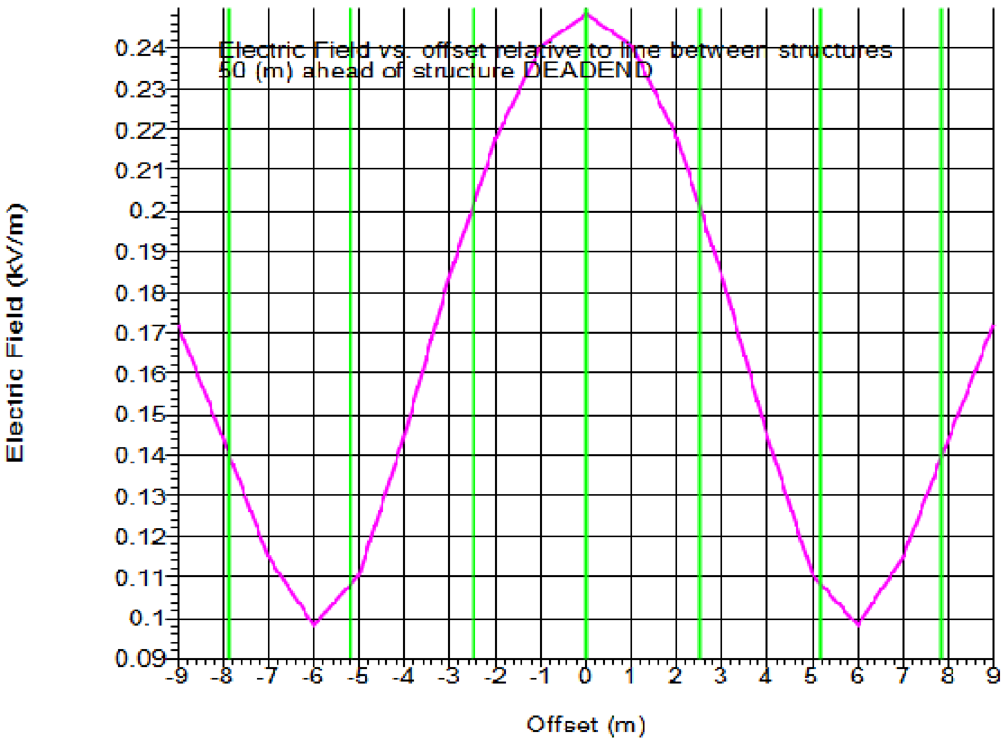

Figure 4.31: Electric Field Profile across the 132kV TL Gantry Location @1.8m

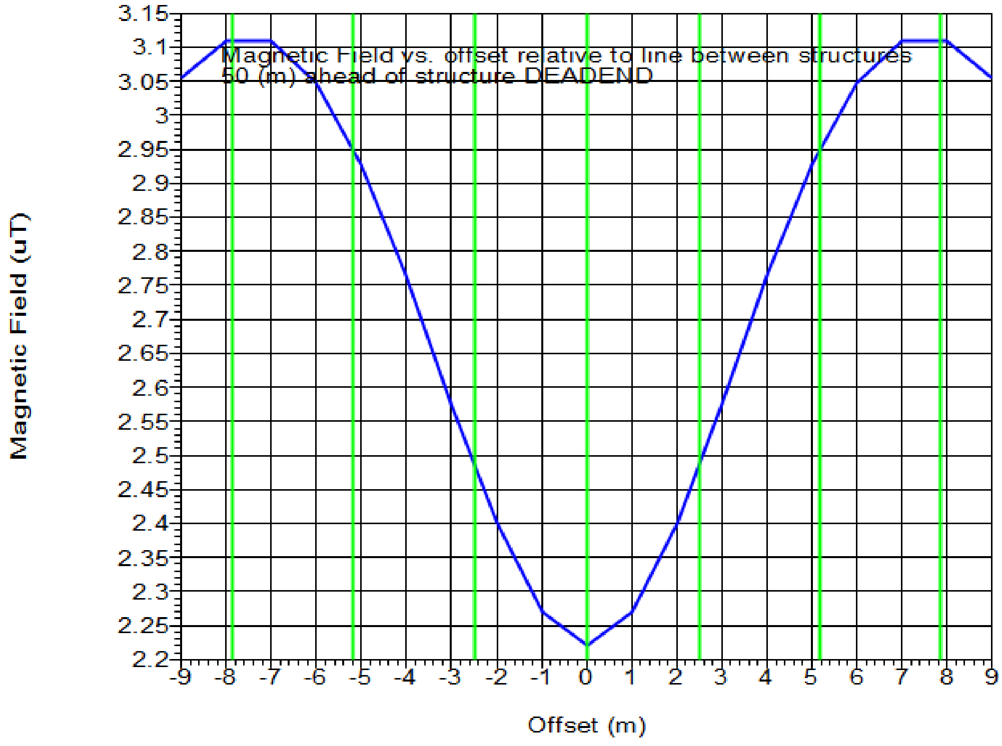

Figure 4.32: Magnetic Field Profile across the 132kV TL Gantry Location @1.8m

4.7. Allowable Tree Heights and Plantation Corridor

Allowable tree heights and plantation corridors are estimated for HVTLs considering the flat terrain, standard tower footing height, ROW boundary, conductor swing during maximum sag condition and tree falling radius. For this, two construction corridors were considered below the wires, and three plantation corridors were identified for each line. Mid-span blowouts with I-string were considered for establishing the horizontal and vertical clearance envelopes and estimating the allowable tree heights.

4.7.1. 400kV Transmission Line

In the case of 400kV TL, a minimum horizontal and vertical clearance of 5.6m is required from tree. So, a clearance envelope of 5.6m is considered along the conductor locus during swing conditions. The length of the suspension insulator string is considered to be 5.2m. The allowable insulator swing is estimated to be 26° during maximum sag conditions for maintaining the standard 46m ROW. Further, two construction corridors of 7m below the conductor position are considered for construction and operational maintenance purposes.

Three plantation corridors of 10.6m width were identified, one in the center and two towards the edge of ROW. The total available plantation corridor for a single 400m span is estimated to be 12,744m^2. This value will need reduction considering the tower's footprint and any permanent structures like roads, canals etc.

For the central corridor, the estimated allowable tree height is found to be 4.1m at the edges and gradually increases up to 5.3m at the center. In the case of outside corridors, the estimated allowable tree height is found to be 4.1m at the edge of the transmission centerline and gradually increases up to 7.1m at the edge of the ROW.

This concludes that a tree of 4.1m height could be planted throughout the ROW section for 400kV lines with a standard tower footing of 28.3m. The allowable tree heights could be increased with the use of tower body extensions.

The schematic representation of conductor blowouts, tree fall radius and plantation corridor for 400kV TL is shown in Figure 4.33.

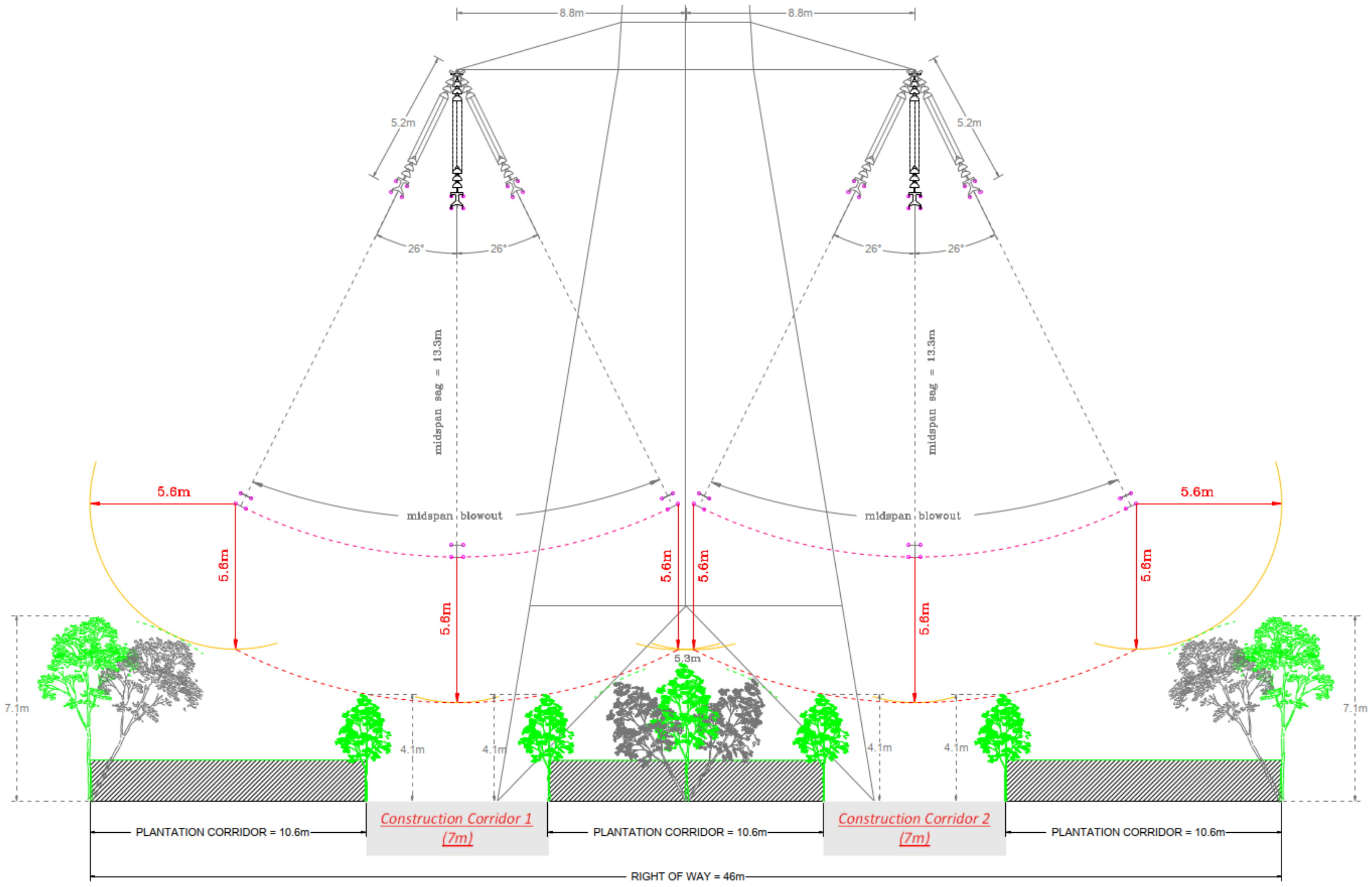

Figure 4.33: 400kV TL Plantation Corridor

4.7.2. 220kV Transmission Line

In the case of 220kV TL, a minimum horizontal and vertical clearance of 3.8m is required from tree. So, a clearance envelope of 3.8m is considered along the conductor locus during swing conditions. The length of the suspension insulator string is considered to be 2.75m. The allowable insulator swing is estimated to be 25° during maximum sag conditions for maintaining the standard 30m ROW. Further, two construction corridors of 5m below the conductor position are considered for construction and operational maintenance purposes.

Three plantation corridors were identified: a central corridor of 6.2m width and outside two corridors of 6.9m width towards the edge of ROW. The total available plantation corridor for a single 350m span is estimated to be 7,000m^2, this value will need reduction considering tower footprint and any permanent structures like roads, canals etc.

For the central corridor, the estimated allowable tree height is found to be 4.1m at the edges and gradually increases up to 4.8m at the center. In the case of outside corridors, the estimated allowable tree height is found to be 4.1m at the edge of the transmission centerline and gradually increases up to 6m at the edge of the ROW.

This concludes that a tree of 4.1m height could be planted throughout the ROW section for 220kV Lines with a standard tower footing of 20.6m. The allowable tree heights could be increased with the use of tower body extensions.

The schematic representation of conductor blowouts, tree fall radius and plantation corridor for 220kV TL is shown in Figure 4.34.

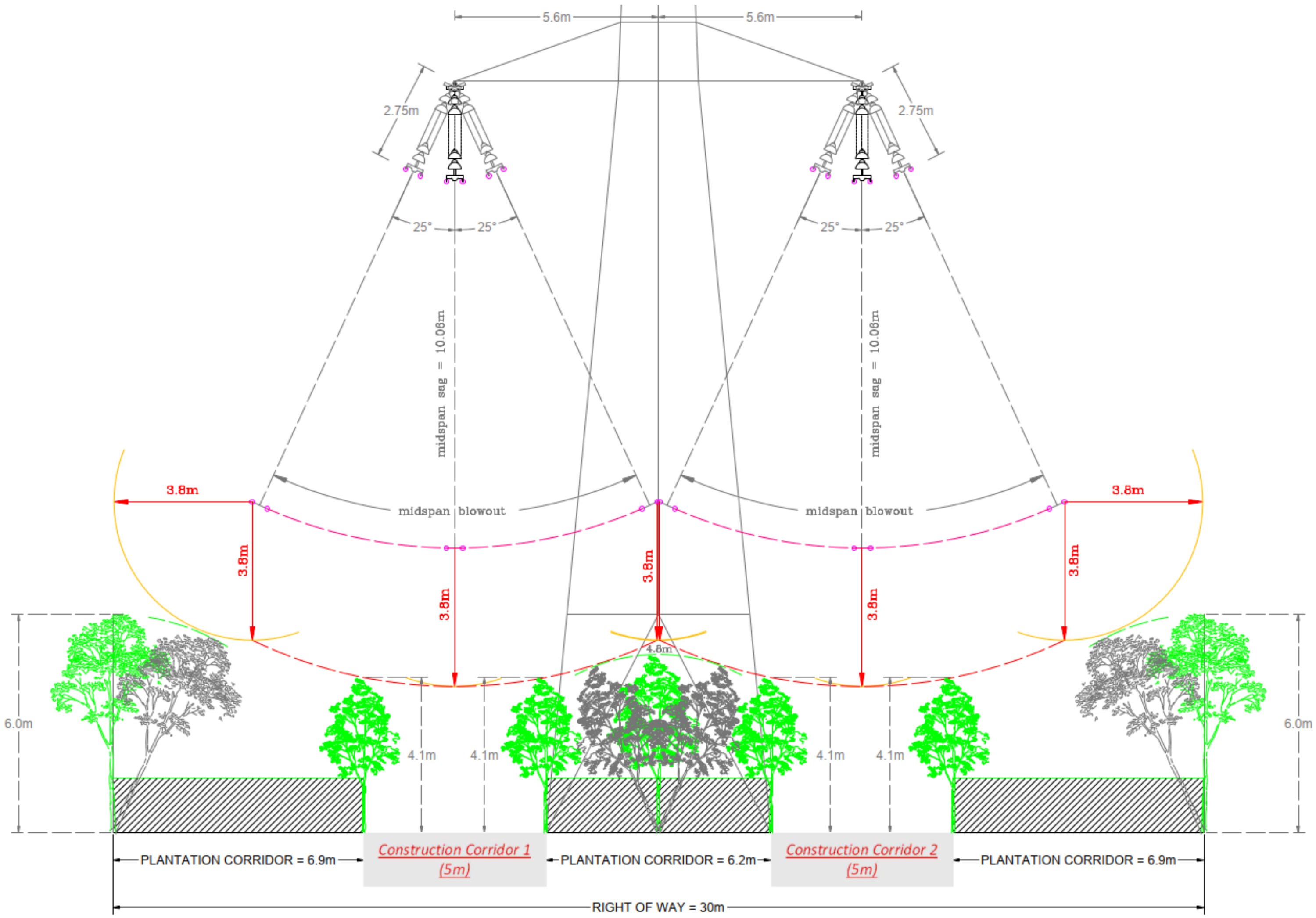

Figure 4.34: 220kV TL Plantation Corridor

4.7.3. 132kV Transmission Line

In the case of 132kV TL, a minimum horizontal and vertical clearance of 2.9m is required from tree. So, a clearance envelope of 2.9m is considered along the conductor locus during swing conditions. The length of the suspension insulator string is considered to be 1.75m. Further, two construction corridors of 3.5m below the conductor position are considered for construction and operational maintenance purposes.

i) Standard 18m ROW

The allowable insulator swing is estimated to be 15° during maximum sag conditions for maintaining the standard 18m ROW. Three plantation corridors were identified, a central corridor of 3.1m width and outside two corridors of 3.95m width. The total available plantation corridor for a single 350m span is estimated to be 1,790m^2, this value will need reduction considering tower footprint and any permanent structures like roads, canals etc. For the central corridor, the estimated allowable tree height is found to be 4.1m. and for outside corridors, the estimated allowable tree height is found to be 4.1m at the edge and gradually increases up to 5.8m at the edge of the ROW.

ii) Calculated 23m ROW

The allowable insulator swing is estimated to be 28° during maximum sag conditions for maintaining the calculated 23m ROW. Three plantation corridors were identified, a central corridor of 3.1m width and outside two corridors of 6.45m width. The total available plantation corridor for a single 350m span is estimated to be 5,600m^2, this value will need reduction considering tower footprint and any permanent structures like roads, canals etc. For the central corridor, the estimated allowable tree height is found to be 4.1m. In the case of outside corridors, the estimated allowable tree height is found to be 4.1m at the edge towards the transmission centerline and gradually increases up to 6.7m at the edge of the ROW.

This concludes that a tree of 4.1m height could be planted throughout the ROW section for 132kV Lines with a standard tower footing of 19m. The allowable tree heights could be increased with the use of tower body extensions. The schematic representation of conductor blowouts, tree fall radius and plantation corridor for 132kV TL with standard 18m ROW and calculated 23m ROW is shown in Figure 4.35 and Figure 4.36.

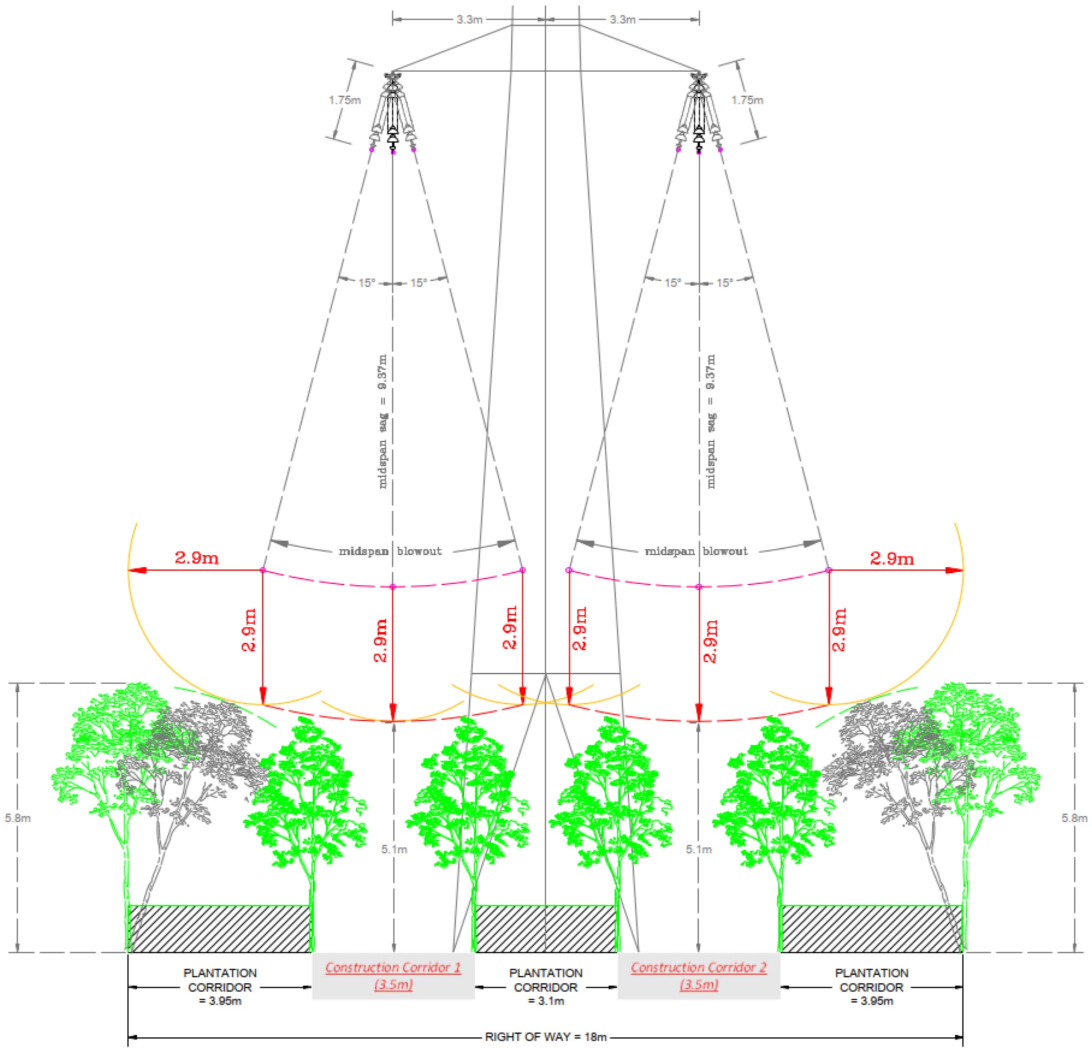

Figure 4.35: 132kV TL Plantation Corridor @18m ROW

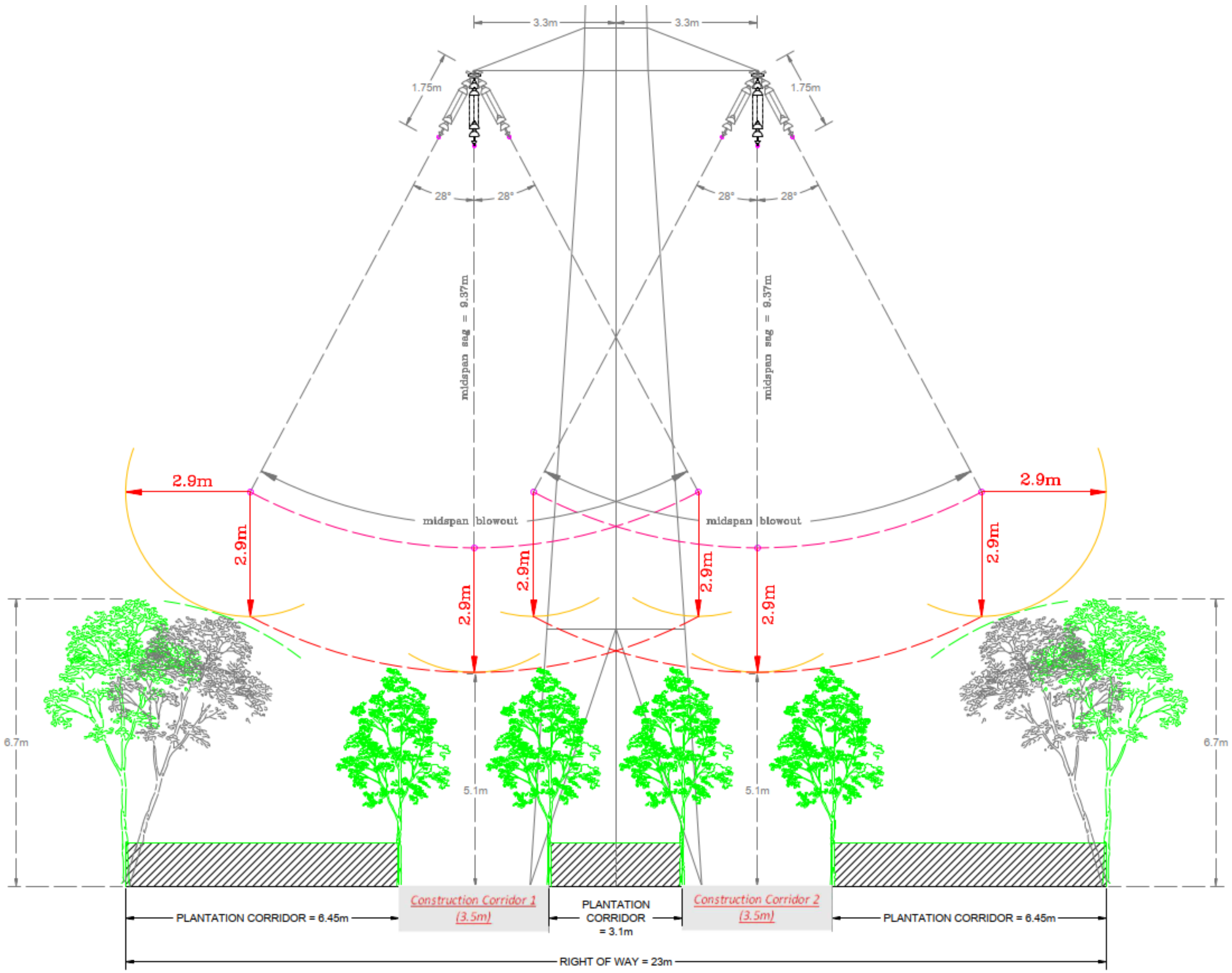

Figure 4.36: 132kV TL Plantation Corridor @23m ROW

CHAPTER-5: CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The thesis studied the ROW requirements and the electric and magnetic fields of 400kV, 220kV and 132kV high voltage transmission lines in Nepal. The ROW requirements were estimated for standard design spans being followed in Nepal, reduced spans and long spans, considering both I-string and V-string suspension insulators. The electric and magnetic field values and profiles across the ROW were determined at 1.8m height above ground level, 3.5m height above ground level and during design swing conditions.

Furthermore, the ROW requirements, electric and magnetic field values and profiles at terminal gantry locations were estimated. And the allowable tree heights and plantation corridor below the high voltage transmission line were also estimated considering the standard ROW boundary and conductor swing during maximum sag conditions.

The conclusions drawn from the study are as follows:

(a) ROW requirements of HVTLs for standard design spans

The existing practice of 46m and 30m ROW for 400kV and 220kV TL for standard design spans is sufficient and the use of V-string insulators could help reduce the ROW requirement by as much as 17%. However, it is revealed that the existing practice of 18m ROW for 132kV TL is not sufficient for both I-string and with V-string insulators. The estimated ROW requirement for HVTLs at standard design spans is as shown in Table 5.1.

Table 5.1: ROW Requirement @ Standard Design Spans

S. N.	Voltage Level	Design Span	Type of Suspension String	Estimated ROW	Comparison with Standard ROW
1	400kV	400m	I-String	46m	matched
2			V-String	38m	reduced by 8m
3	220kV	350m	I-String	30m	matched
4			V-String	25m	reduced by 5m
5	132kV	350m	I-String	23m	increased by 5m
6			V-String	20m	increased by 2m

(b) ROW requirements of HVTLs for reduced spans

It can be concluded that the use of reduced spans could help reduce the ROW requirement for HVTLs and, if used with V-string, the ROW requirements could be reduced significantly. Further, the standard 18m ROW of 132kV TL with I-string will be justified only at 200m span. The estimated ROW requirement for HVTLs at reduced design spans is as shown in Table 5.2.

Table 5.2: ROW Requirement @ Reduced Spans

S. N.	Voltage Level	Design Span	Type of Suspension String	Estimated ROW	Comparison with Standard ROW
1	400kV	300m	I-String	41m	reduced by 5m
2			V-String	33m	reduced by 13m
3		200m	I-String	38m	reduced by 8m
4			V-String	29m	reduced by 17m
5	220kV	250m	I-String	26m	reduced by 4m
6			V-String	21m	reduced by 9m
7		150m	I-String	23m	reduced by 7m
8			V-String	18m	reduced by 12m
9	132kV	250m	I-String	19m	increased by 1m
10			V-String	16m	reduced by 2m
11		200m	I-String	18m	matched
12			V-String	14m	reduced by 4m
13		150m	I-String	17m	reduced by 1m
14			V-String	13m	reduced by 5m

(c) ROW requirements of HVTLs for long spans

For a 500m long span, the standard ROW for 400kV, 220kV and 132kV TL is not sufficient with I-string and the ROW requirement increases. The estimated ROW requirement for HVTLs at 500m long spans with I-string is as shown in Table 5.3.

Table 5.3: ROW Requirement @ 500m Long Spans

S. N.	Voltage Level	Design Span	Type of Suspension String	Estimated ROW	Comparison with Standard ROW
1	400kV	500m	I-String	55m	increased by 9m
2	220kV	500m	I-String	43m	increased by 13m
3	132kV	500m	I-String	36m	increased by 18m

Further, with a tension string insulator there will still be violations of the ROW requirement, and it will depend on the preference of whether to maintain/violate the tower loading or wire tensions. The violation of the ROW could be addressed either by using increased wire tension and special towers or by increasing the ROW itself.

(d) Electric field and magnetic field of HV TLs

At 1.8m height above the ground, the electric and magnetic field values below the line and at the edge of the ROW of 400kV, 220kV and 132kV TLs are within the recommended limits defined by ICNIRP. The field values are maximum below the wire position and gradually reduces towards the edge of ROW. Further, the use of V-string configurations could help reduce the field values due to compact configuration.

At 3.5m height above the ground, the electric field value below the 400kV line exceeds the recommended limits defined by ICNIRP, whereas the magnetic field values are within the limit. Whereas, for 220kV and 132kV TLs the field values are within the recommended limits. Therefore, it can be concluded that if temporary underbuilds are to be considered, the tower footing heights of 400kV TL shall be increased by 3m.

During design swing conditions and building height consideration, the electric and magnetic field values at the edge of standard ROW for 400kV and 220kV TLs are within the recommended limits defined by ICNIRP. However, in the case of 132kV TL, the electric field value at the edge of standard 18m ROW at 15m height above ground level reaches alarming level of 83kV/m. This value gets reduced to 4kV/m at the edge of the calculated 23m ROW. Therefore, it can be concluded that the standard 18m ROW for 132kV TL is not sufficient and requires 23m ROW.

(e) Gantry locations

The ROW requirements for 400kV, 220kV and 132kV HVTLs on the gantry span are within the standard ROW values. The electric and magnetic field values are within the recommended limits by ICNIRP for general public exposure.

(f) Allowable tree heights and plantation corridor

Three different plantation corridors are identified for HVTLs, one in the center and two on the outside towards the edge of the ROW. The construction corridors of 3.5m, 5m and 7m were considered below the conductors for 132kV, 220kV and 400kV TL. The total plantation corridor available for 132kV, 220kV and 400kV TLs are estimated to be 1700m^2, 7000m^2 and 12744m^2. These values will need reduction considering the tower footprint and any permanent structures like roads, canals etc. It is found that the tree of 4.1m heights could be planted throughout the ROW section for 132kV, 220kV and 400kV TLs considering the standard tower footing heights. It is also observed that the tree heights could be increased towards the edge of the ROW, due to upward movement of conductor during swing conditions. The maximum allowable tree height at the edge of the ROW is estimated to be 5.8m, 6m and 7.1m for 132kV, 220kV and 400kV TLs. The plantation height could be increased with use of standard tower body/leg extensions. Further, for the 132kV transmission lines, if the calculated 23m ROW is considered, the maximum tree height at the edge of the ROW could be 6.7m and the total plantation corridor could be 5600m^2.

5.2. Recommendations

5.2.1. Recommendations for Utilities

The following recommendations have been brought forward for transmission line utilities in Nepal to make the HVTLs more resilient and compliant with international practices.

(a) Standardize minimum ROW width and make provisions for flexible ROW boundaries

The ROW requirement is governed by the physical electrical clearance requirements during wire swing conditions, and could vary, which mainly depends upon the design span, type of conductor and tower configurations. However, the current ROW practices in Nepal are based on voltage level and are considered the same values irrespective of design span lengths, type of conductor and tower configurations, which leaves no room for ROW optimization and the possibility of mitigating the impact on forest and urban areas.

The ROW reduction and optimization could be achieved by adapting new innovative technologies and approaches as below:

i) The use of monopoles, towers with insulated crossarms and narrow body towers could reduce the ROW requirements.
ii) The use of V-string insulators and braced post insulators could mitigate the possible insulator swings and reduce the ROW requirements.
iii) The use of HTLS conductors could reduce the sag and blowout of conductors and hence reduce the ROW requirements.
iv) The use of interphase spacers could help reduce the conductor blowout and hence the ROW requirements.
v) Implementing site-specific design criteria and flexible design spans, such as for rural areas, urban areas and forest areas could help optimize the line design and ROW requirements.

Hence, it is recommended that the minimum ROW width based on the voltage level of the transmission line shall be established along with provision for flexible ROW width based on geographic, environmental and social settings, such as for rural, urban and forest areas.

(b) Redefine land use and lessen community and environmental impact

In context of Nepal, most of the transmission lines transverse through the forest areas, cultivable lands and valleys. But there is no provision for the utilization of such lands below the transmission lines and, for this reason, all the ROW is completely cleaned up and bulk tree cutting is required. Encouraging landowners to grow low-height trees, such as fruit-bearing plants and flowers and herbs on these lands, especially in forest areas and valley crossing areas, could provide landowners with additional income and act as a buffer for transmission corridors and mitigate the issue of ROW encroachment and help foster a positive relationship with the transmission licensee. In the case of valley crossings, targeted tree cutting could save multiple trees.

Therefore, it is recommended that provisions shall be made to allow the utilization of land (e.g. small-height tree plantation or solar farms) below transmission lines based on feasibility of operation and without compromising the reliability and safety.

(c) Address public health and safety concerns regarding electric and magnetic fields

The electric and magnetic field below the line and at the edge of the ROW is also a governing factor while estimating the ROW requirement of HVTLs. Currently, there is not any established practice and approach for estimating these field values in Nepal. Therefore, provisions and approaches for estimating electric and magnetic fields below the line and at the edge of the ROW shall be introduced and made mandatory, to be in-line with international practice of public safety. This will help address/mitigate the public health and safety concerns relating to the effects of electric and magnetic fields from high voltage transmission lines.

The benefits of re-defining the ROW guidelines are highlighted as follows:

i) Reduction of right of way width in many places.
ii) Reduction in overall cost and time of right of way acquisition.
iii) Option for growing low-height trees and improved land utilization.
iv) Reduction in social and environmental impacts and disputes.
v) Compliance with international practices and address public health and safety concerns.

5.2.2. Recommendations for Future Study

The following recommendations have been made for future studies.

(a) This study has considered clearance values for elevation up to 1000m. Since Nepal has a wide range of elevation, the study could be conducted for higher elevation requirements.

(b) This study has considered ACSR Bear, ACSR Bison and ACSR Moose conductors for 132kV, 220kV and 400kV TLs. The choice of conductors could vary based on project requirement, so further study could be conducted for other conductors, like ACSR Cardinal for 132kV TL, ACSR Moose for 220kV TL and ACSR Bison for 400kV TL.

(c) The ROW requirement depends on the maximum sag of conductors. The study could be extended to consider HTLS conductors which have low sag compared to ACSR conductors.

(d) This study has been carried out only for 132kV, 220kV and 400kV HV TLs. Similar studies could be done for 66kV and 33kV transmission lines, as these are also widely being used by small IPPs for power evacuation and as sub-transmission lines.

(e) The study has considered I-string and V-string insulators for ROW analysis. Further studies could consider braced post insulators or insulated crossarms for the study.

(f) The study has considered a flat terrain model with ruling spans and is an effort to establish a design basis. This could be further implemented on any existing or new transmission line project to verify the ROW requirements, electric and magnetic field values as well as plantation corridors.

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[10] *Code of Practice for Design, Installation and Maintenance of Overhead Power Lines,* Indian Standard 5613-2-2, 1985.

APPENDICES

APPENDIX- A: TOWER DRAWINGS

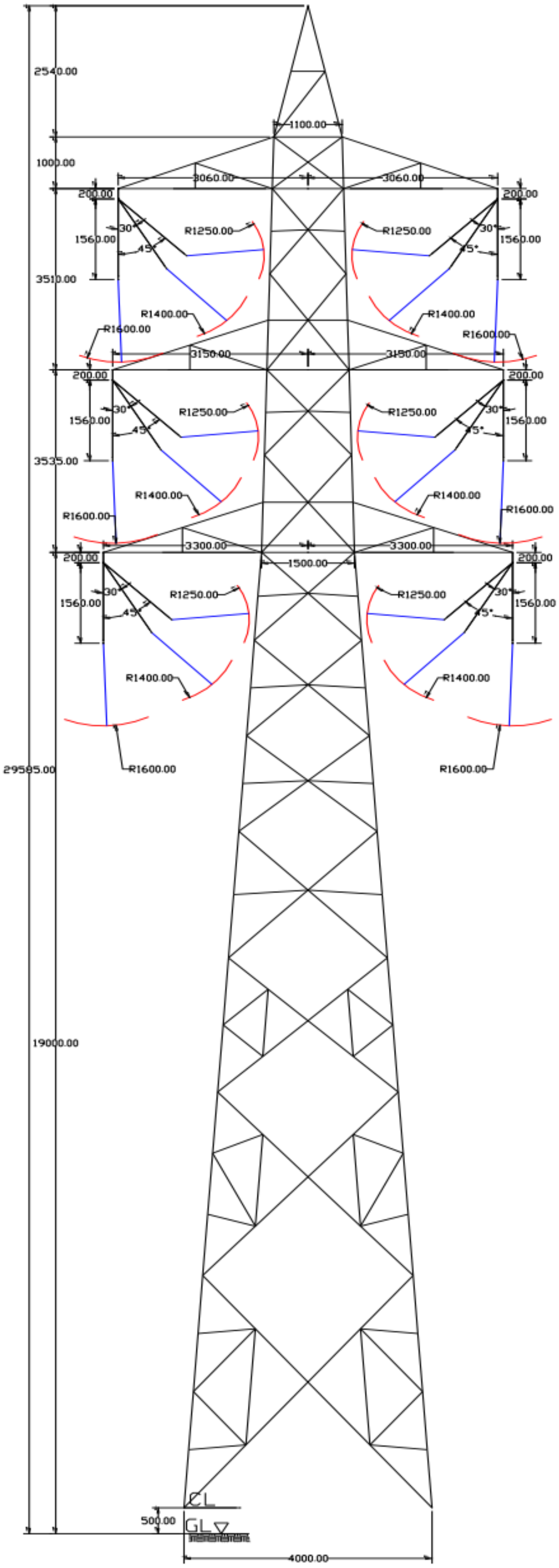


Figure-1: 132kV Double Circuit I-String Suspension Tower

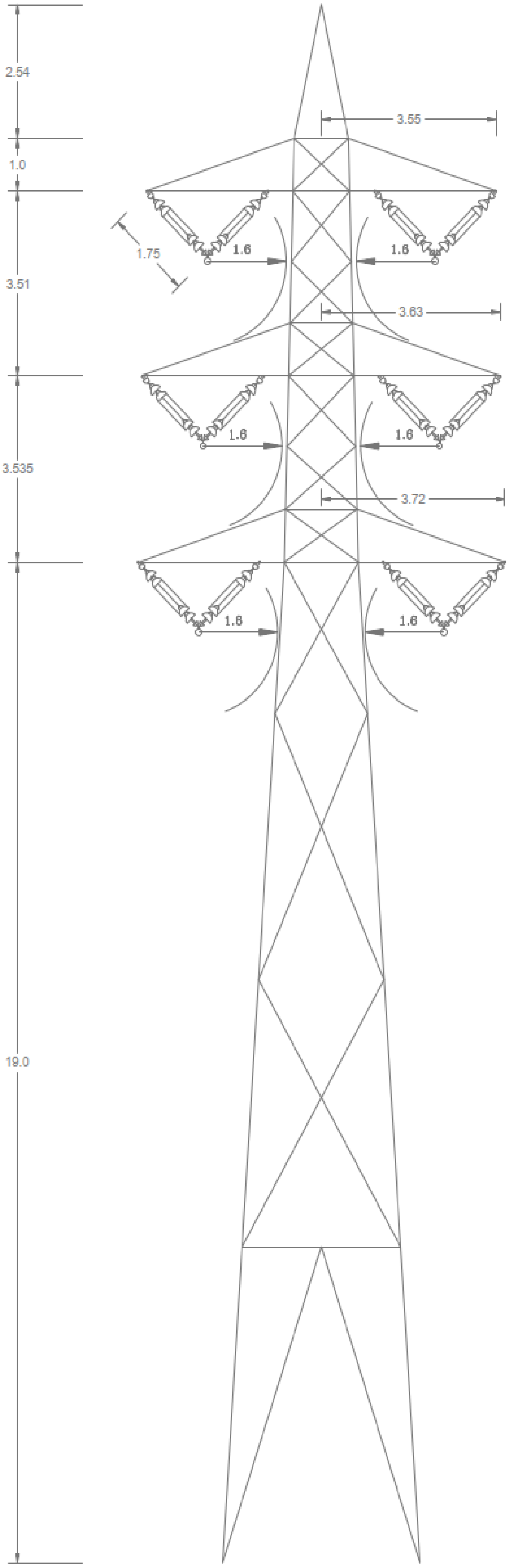


Figure-2: 132kV Double Circuit V-String Suspension Tower

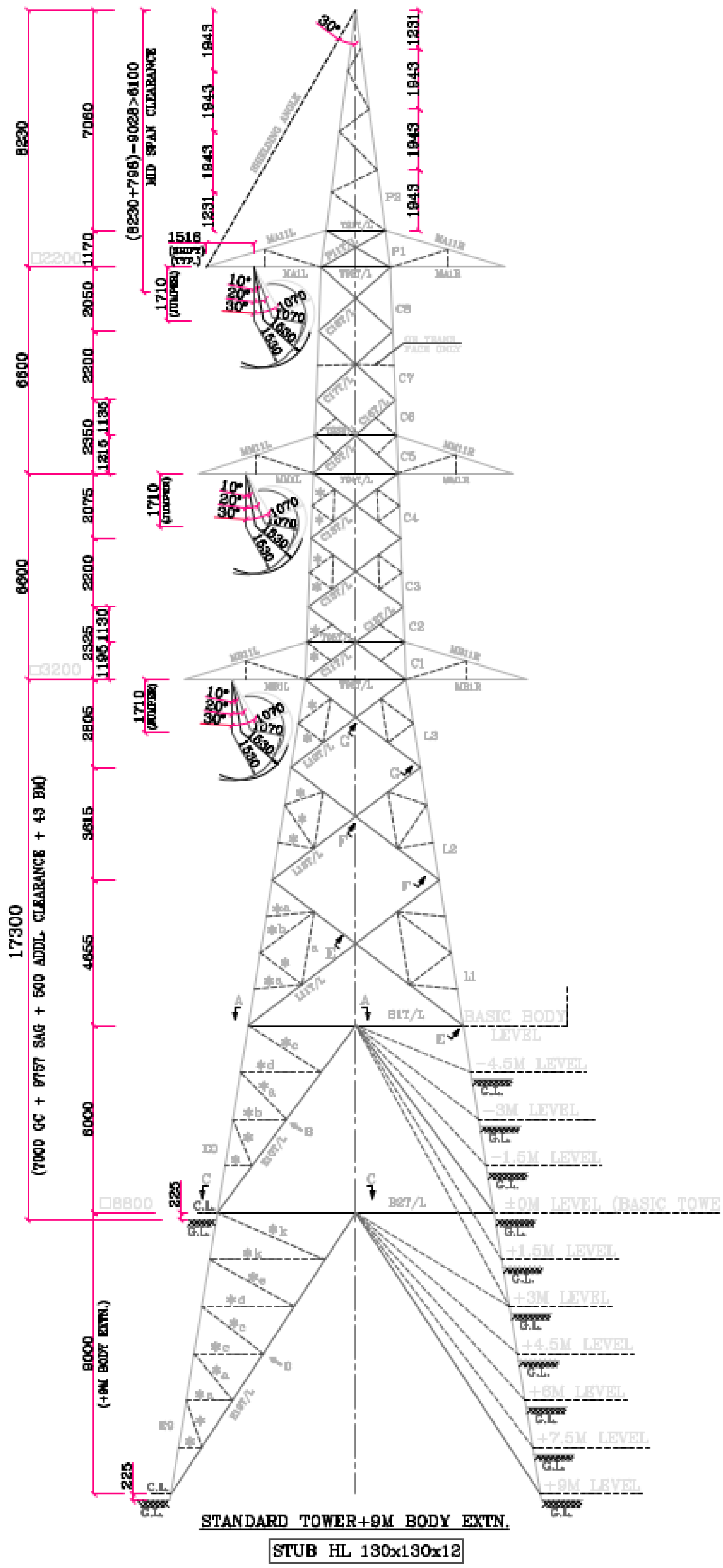


Figure-3: 132kV Double Circuit Tension Tower

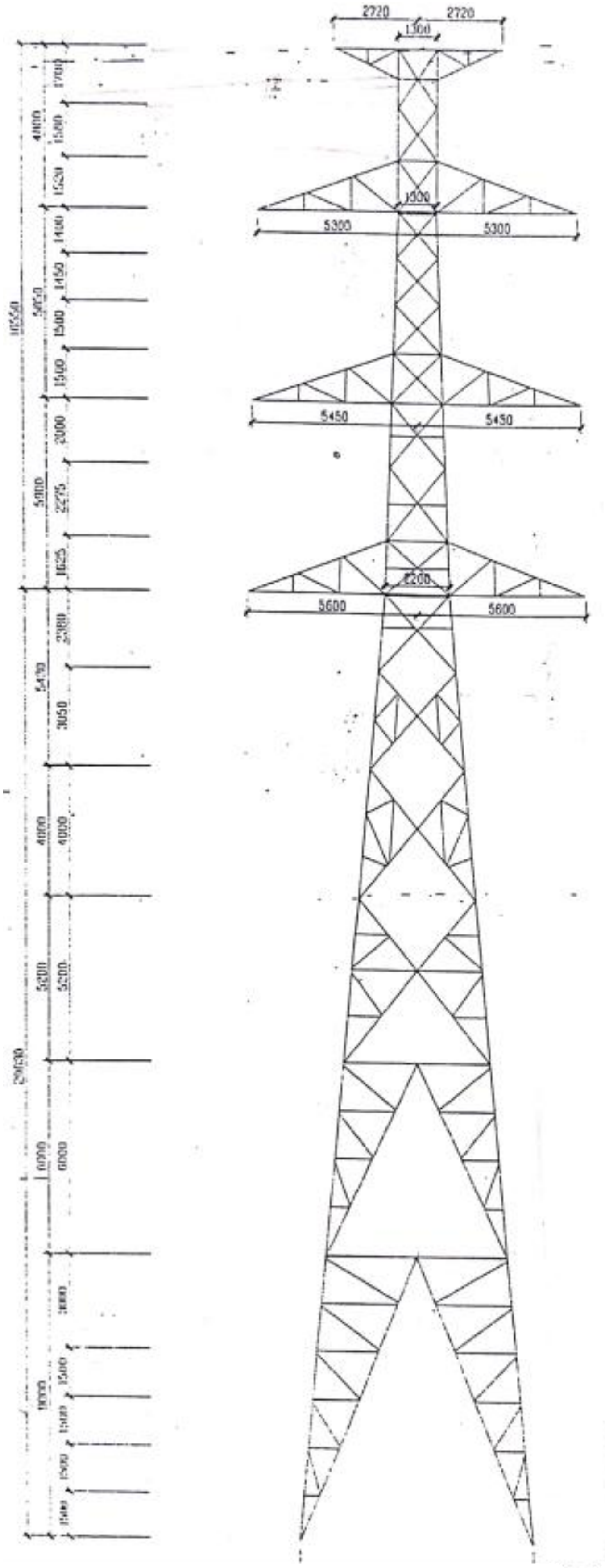


Figure-4: 220kV Double Circuit I-String Suspension Tower

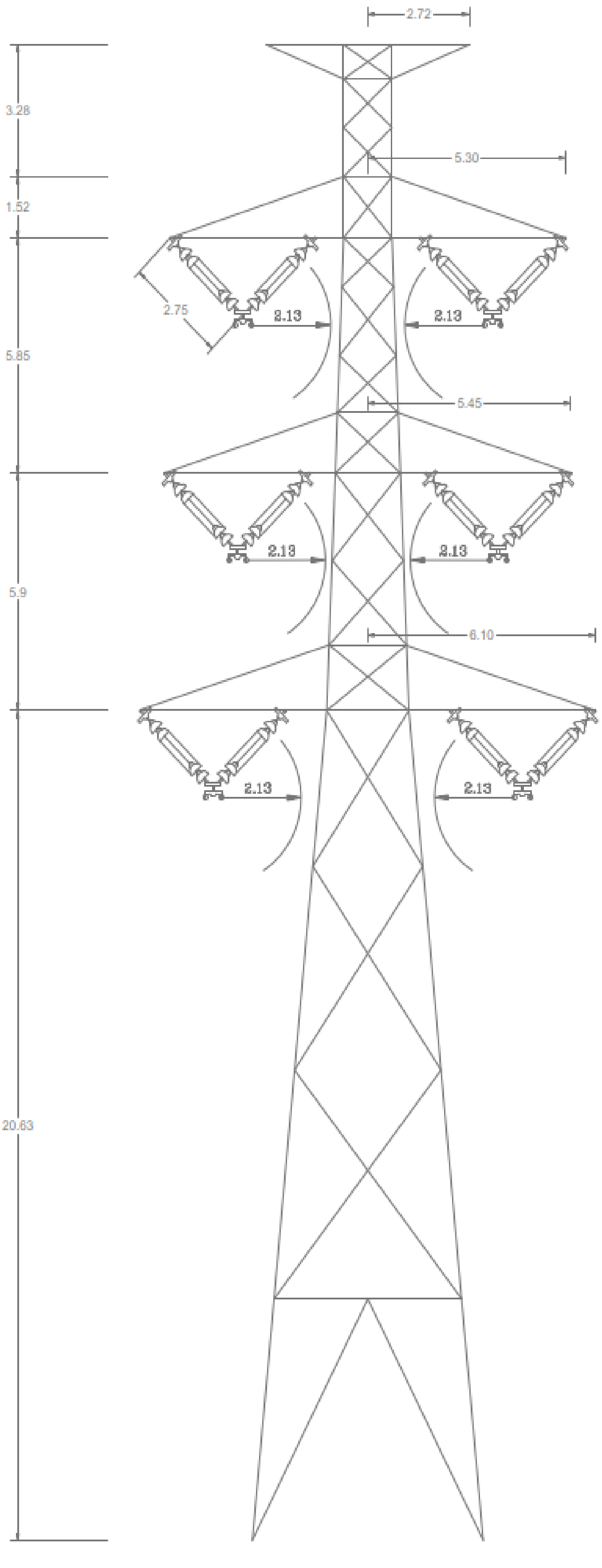


Figure-5: 220kV Double Circuit V-String Suspension Tower

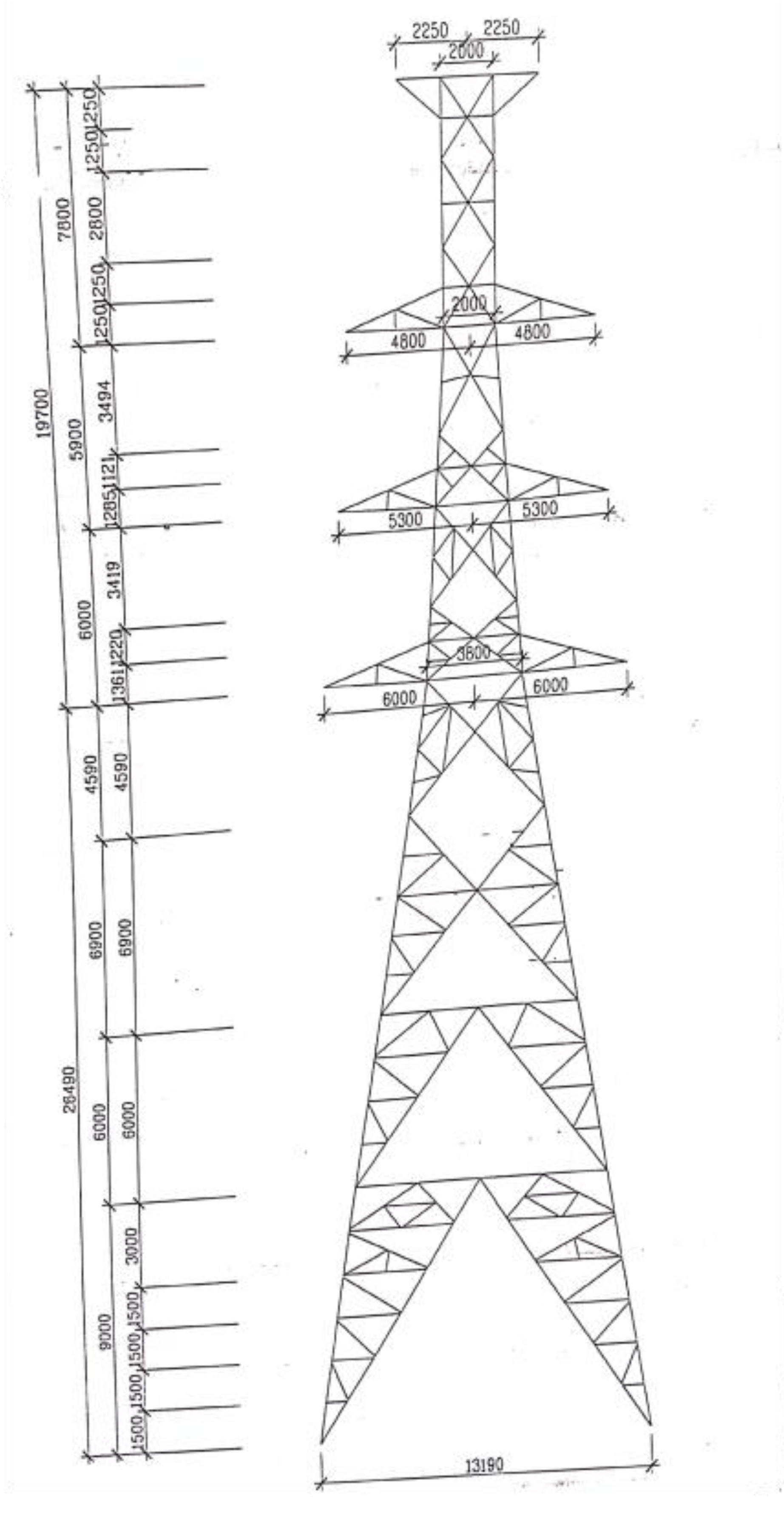


Figure-6: 220kV Double Circuit Tension Tower

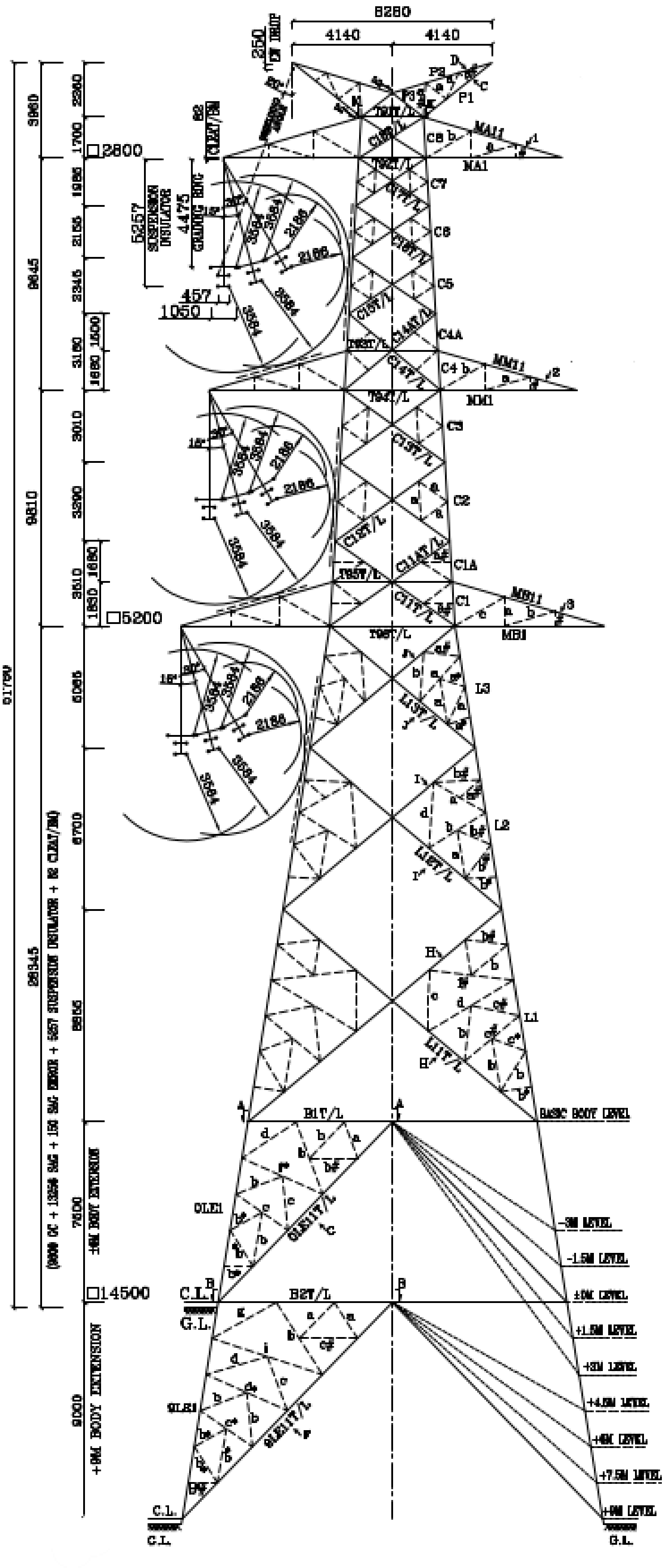


Figure-7: 400kV Double Circuit I-String Suspension Tower

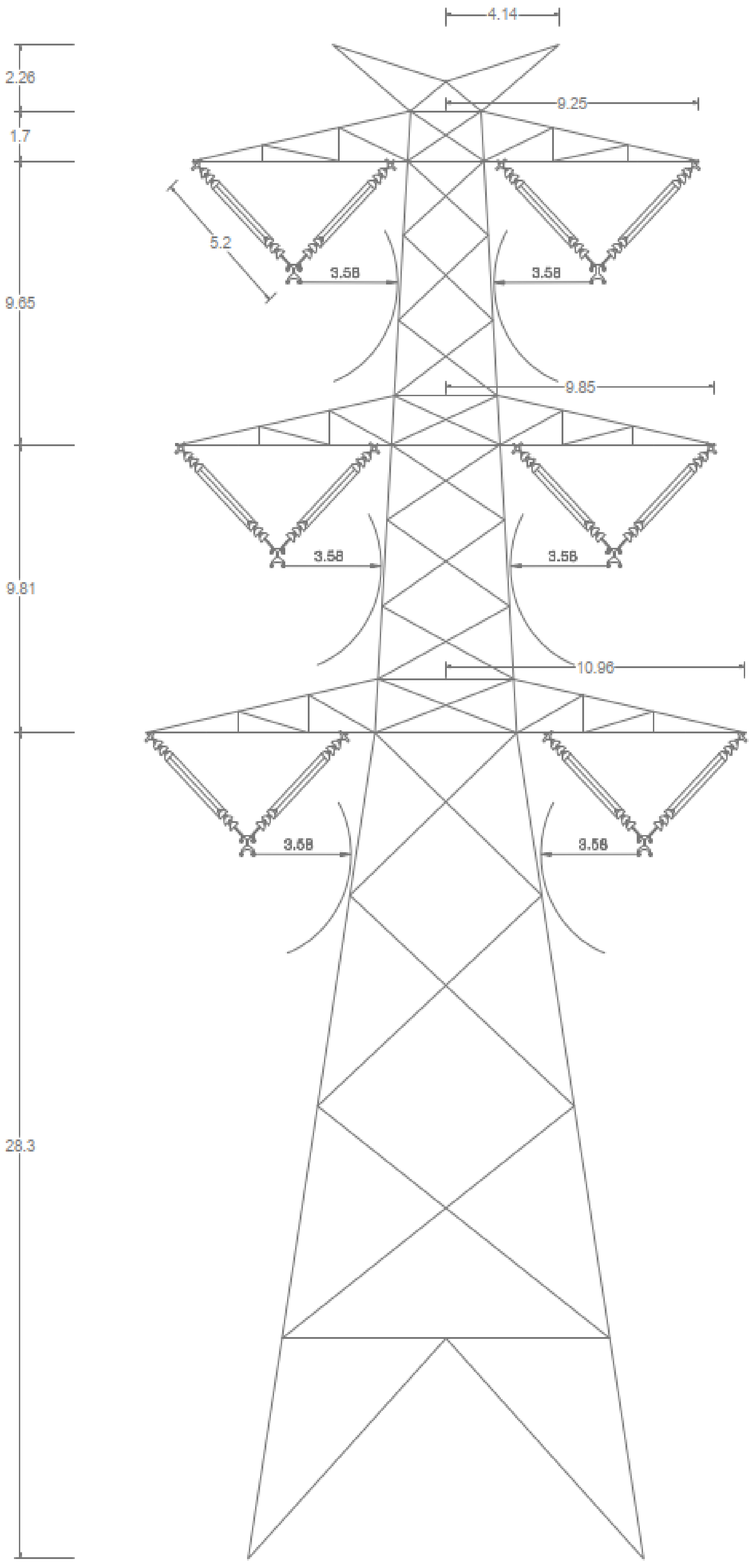


Figure-8: 400kV Double Circuit V-String Suspension Tower

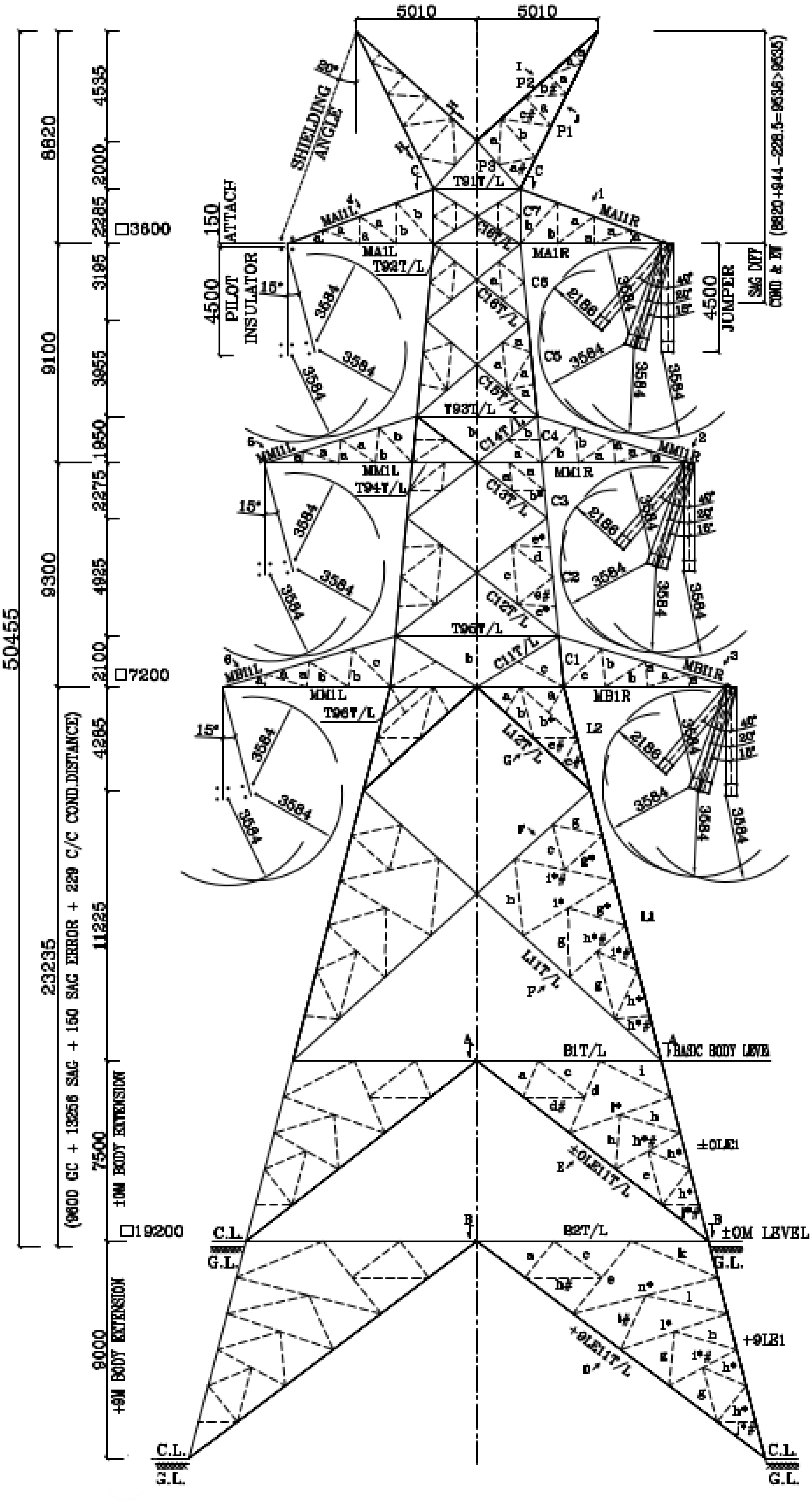


Figure-9: 400kV Double Circuit Tension Tower

APPENDIX- B: GANTRY DRAWINGS

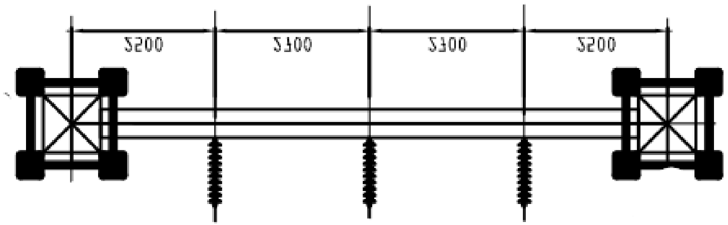


Figure-1: 132kV Gantry – Plan View

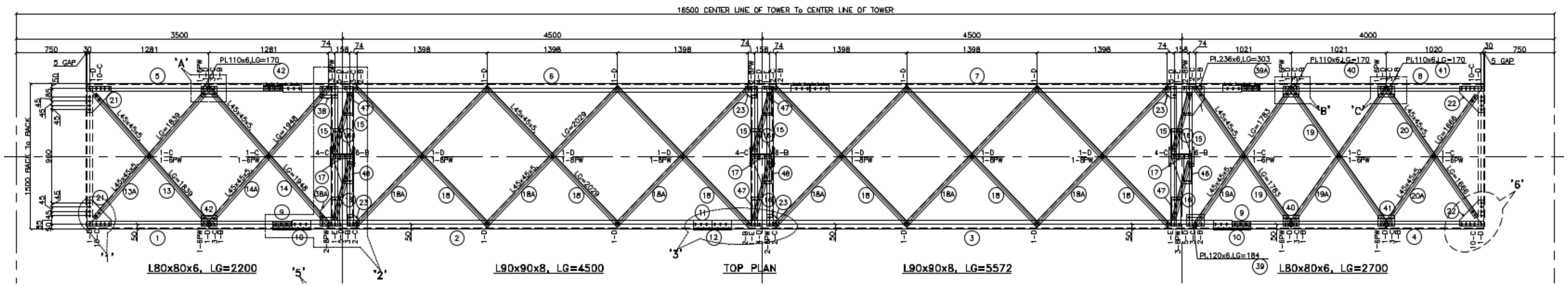


Figure-2: 220kV Gantry – Plan View

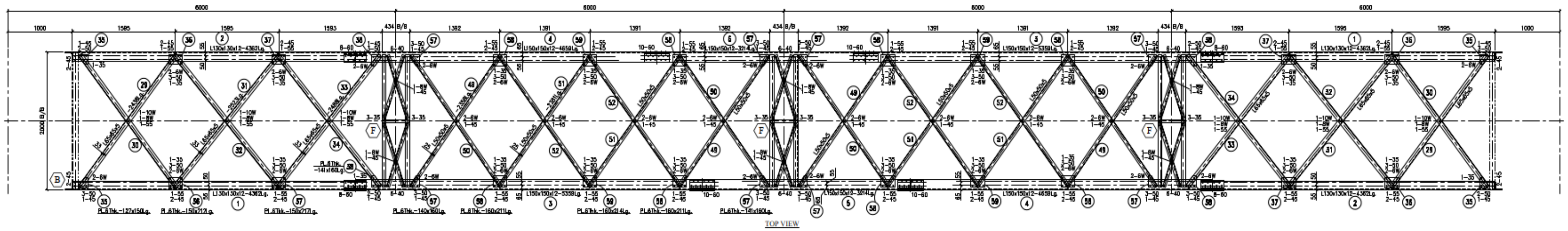


Figure-3: 400kV Gantry – Plan View

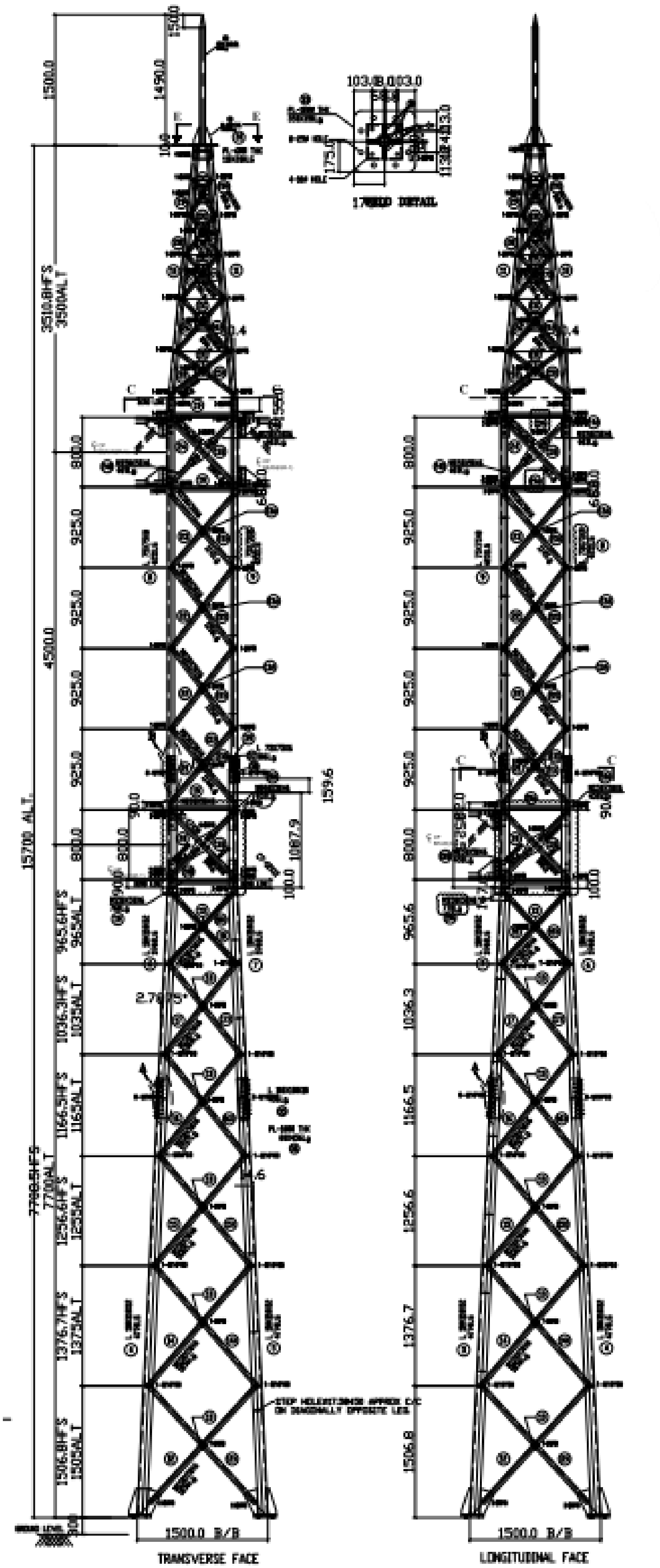


Figure-4: 132kV Gantry - Sectional View

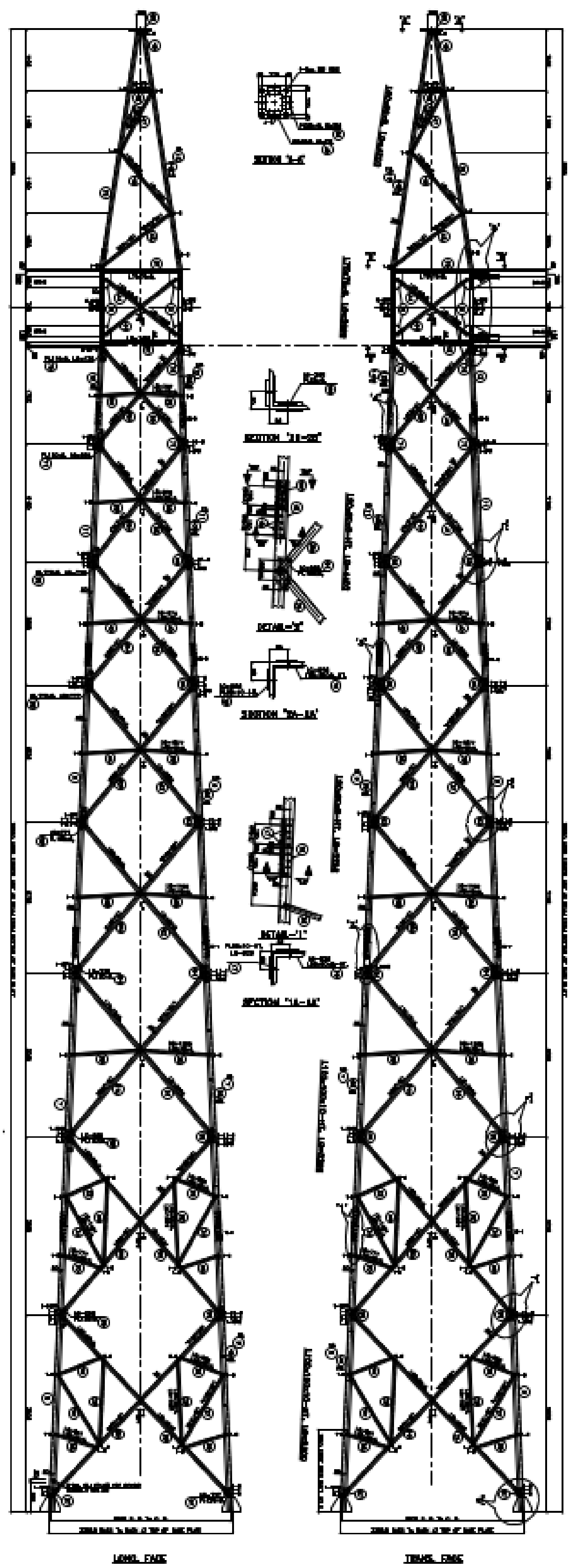


Figure-5: 220kV Gantry - Sectional View

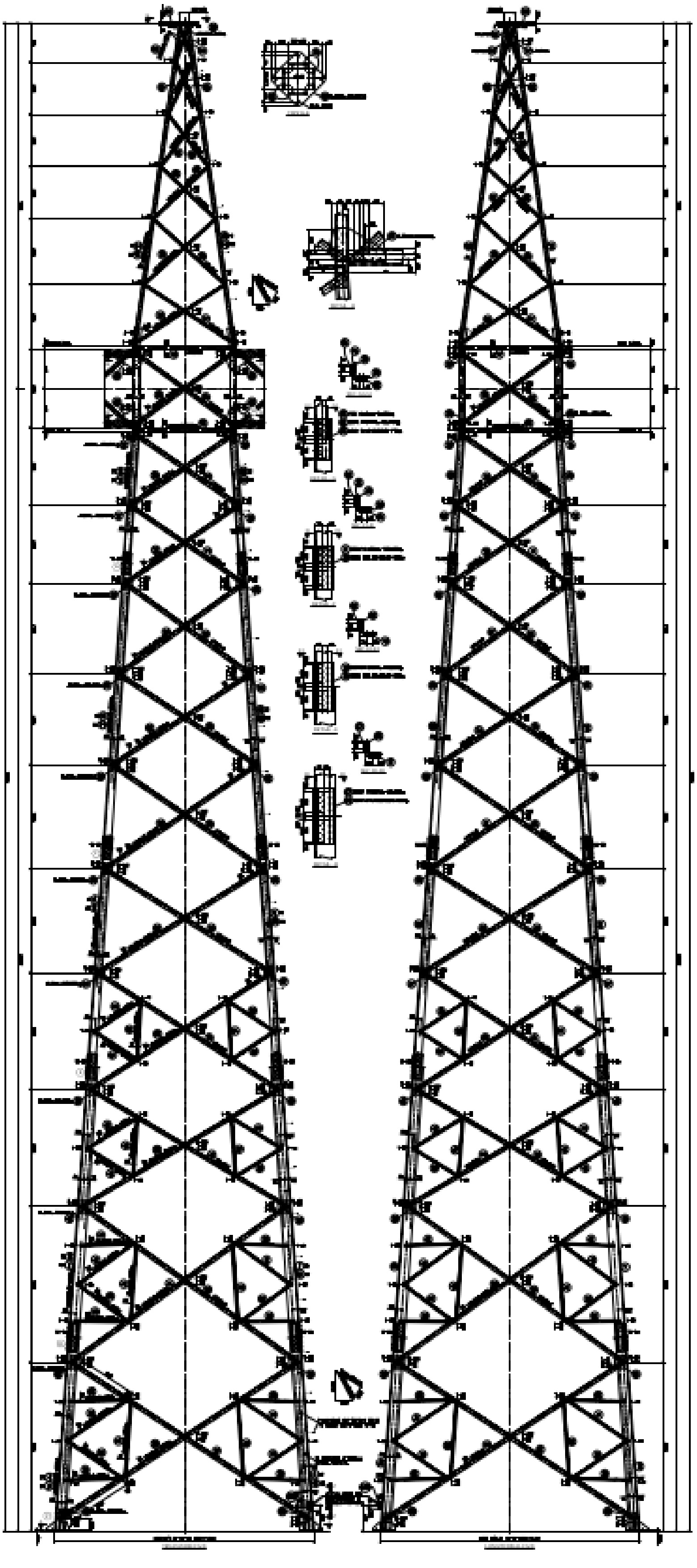


Figure-6: 400kV Gantry - Sectional View

APPENDIX- C: WIRE SPECIFICATIONS

Specifications for ACSR "Moose" Conductor

S.N.	Description	Data
1	Stranding and wire diameter	54/3.53 mm Al 7/3.53 mm Steel
2	Number of Strands Steel core 1st Steel Layer 1st Aluminum Layer 2nd Aluminum Layer 3rd Aluminum Layer	 1 6 12 18 24
3	Sectional area of Aluminum	528.5 mm^2
4	Total Sectional area	597 mm^2
5	Overall diameter	31.77 mm
6	Approximate mass	1,988 Kg/Km
7	Minimum UTS	16,420 Kg
8	Modulus of Elasticity	7,036 Kg/mm^2
9	Coefficient of Linear Expansion	$19.3 * 10^{-6}$ per ^oC

Specifications for ACSR "Bison" Conductor

S.N.	Description	Data
1	Stranding and wire diameter	54/3 mm Al 7/3 mm Steel
2	Number of Strands Steel core 1st Steel Layer 1st Aluminum Layer 2nd Aluminum Layer 3rd Aluminum Layer	 1 6 12 18 24
3	Sectional area of Aluminum	381.8 mm^2
4	Total Sectional area	431.2 mm^2
5	Overall diameter	27 mm
6	Approximate mass	1,444 Kg/Km
7	Minimum UTS	12,328.4 Kg
8	Modulus of Elasticity	7,034 Kg/mm^2
9	Coefficient of Linear Expansion	$19.3 * 10^{-6}$ per ^oC

Specifications for ACSR "Bear" Conductor

S.N.	Description	Data
1	Stranding and wire diameter	30/3.35 mm Al 7/3.35 mm Steel
2	Number of Strands Steel core 1st Steel Layer 1st Aluminum Layer 2nd Aluminum Layer	 1 6 12 18
3	Sectional area of Aluminum	264.4 mm^2
4	Total Sectional area	326.1 mm^2
5	Overall diameter	23.45 mm
6	Approximate mass	1,213 Kg/Km
7	Minimum UTS	11,340 Kg
8	Modulus of Elasticity	7,034 Kg/mm^2
9	Coefficient of Linear Expansion	$19.3 * 10^{-6}$ per ^oC

Specifications for OPGW

S.N.	Description	Data
1	Total Sectional Area	68 mm^2
2	Outer Diameter	11.4 mm
3	Breaking Load	8828 Kg
4	Cable Weight	487 Kg/Km
5	Modulus of Elasticity	16519 Kg/mm^2
6	Coefficient of Thermal Expansion	$3.0*10^{-6}$ per °C

Specifications for GSW – 10.98mm

S.N.	Description	Data
1	Total Sectional Area	73.65 mm^2
2	Outer Diameter	10.98 mm
3	Breaking Load	6934 Kg
4	Cable Weight	583 Kg/Km
5	Modulus of Elasticity	19361 Kg/mm^2
6	Coefficient of Thermal Expansion	$1.15*10^{-5}$ per °C

Specifications for GSW – 10.05mm

S.N.	Description	Data
1	Total Sectional Area	61.7 mm^2
2	Outer Diameter	10.05 mm
3	Breaking Load	6974.8 Kg
4	Cable Weight	483 Kg/Km
5	Modulus of Elasticity	19000 Kg/mm^2
6	Coefficient of Thermal Expansion	$1.15*10^{-5}$ per °C

APPENDIX- D: SAG TENSION REPORTS

Report Index

S.N.	Line Voltage Level (kV)	Span (m)	Wire
1	400kV Line	400m	ACSR Moose
2		400m	7/3.66 GSW
3		400m	11.4mm OPGW
4		300m	ACSR Moose
5		300m	7/3.66 GSW
6		300m	11.4mm OPGW
7		200m	ACSR Moose
8		200m	7/3.66 GSW
9		200m	11.4mm OPGW
10	220kV Line	350m	ACSR Bison
11		350m	7/3.35 GSW
12		350m	11.4mm OPGW
13		250m	ACSR Bison
14		250m	7/3.35 GSW
15		250m	11.4mm OPGW
16		150m	ACSR Bison
17		150m	7/3.35 GSW
18		150m	11.4mm OPGW
19	132kV Line	350m	ACSR Bear
20		350m	11.4mm OPGW
21		250m	ACSR Bear
22		250m	11.4mm OPGW
23		200m	ACSR Bear
24		200m	11.4mm OPGW
25		150m	ACSR Bear
26		150m	11.4mm OPGW

400 KV D/C T/L

DESIGN SPAN: 400M

WIRE : PHASE CONDUCTOR

SAG TENSION CALCULATION

Phase Conductor
"QUADRUPLE ACSR MOOSE "

NAME OF THE CONDUCTOR	:	54/7/3.53	
AREA	:	mm^2	597
DIA	:	mm	31.77
WT OF CONDUCTOR	:	Kg/m	2.004
ULTIMATE TENSILE STRENGTH	:	Kg	16438
MODULUS OF ELASTICITY	:	Kg/mm^2	7034
DESIGN SPAN	:	m	400
MIN TEMPERATURE	:	^0C	-5
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	85
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.93E-05
INITIAL F.O.S OR SAG (m)			
	:	FOS	4.545
	:	SAG	
INITIAL TEMP	:	^0C	32
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)	STRESS (Kg/cm^2)	TENSION (Kg)	% of UTS	SPAN (m)
	0	-5	0	9.435	711.58	4248	25.8	400
36%	72.5	-5	0	-	970.41	5793	35.2	400
INI	0	32	0	11.083	605.76	**3616**	**22.0**	400
75%	151.0	32	0	-	1292.99	7719	47.0	400
100%	201.3	32	0	-	1568.34	**9363**	**57.0**	400
	0	85	0	**13.256**	506.44	3023	18.4	400

Notes:

Basic wind speed V_b = **47** m/sec — **Wind zone - 4**

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **879** N/m^2 — Reliability level - 1; K_1 = **1.00**

[*As per Specification*] = 89.6 Kg/m^2 — Terrain Category -2; K_2 = **1.08**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{dc} * G_c$ — C_{dc} : **1.00**

= **201.3** Kg/m^2 — Gc : **2.246**

[G_c considered at a height of : 45.446 m]

100% wind pressure at everyday temperature :	201.3	Kg/m^2
75% wind pressure at everyday temperature :	151.0	Kg/m^2
36% wind pressure at minimum temperature :	72.5	Kg/m^2

400 KV D/C T/L

DESIGN SPAN: 400M

WIRE : EARTHWIRE (GSW)

SAG TENSION CALCULATION

NAME OF THE CONDUCTOR	:	7/3.66		***Earthwire***
AREA	:	mm^2	73.65	***7/3.66***
DIA	:	mm	10.98	
WT	:	Kg/m	0.583	
ULTIMATE TENSILE STRENGTH	:	Kg	6934	
MODULUS OF ELASTICITY	:	Kg/mm^2	19361	
DESIGN SPAN	:	m	400	
MIN TEMPERATURE	:	^0C	-5	
EVERY DAY TEMPERATURE	:	^0C	32	
MAX TEMPERATURE	:	^0C	53	
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.15E-05	
INITIAL F.O.S OR SAG (m)				
	:	FOS		
	:	SAG	8.491	
INITIAL TEMP	:	^0C	-5	
INITIAL WIND PRESSURE	:	Kg/m^2	0	
RADIAL ICE FORMATION	:	mm	0	

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)	STRESS (Kg/cm^2)	TENSION (Kg)	% of UTS	SPAN (m)
INI	0	-5	0	8.491	1864.47	1373	19.8	400
36%	90.1	-5	0	-	3007.29	2215	31.9	400
	0	32	0	9.551	1657.60	**1221**	**17.6**	400
75%	187.7	32	0	-	4386.69	3231	46.6	400
100%	250.2	32	0	-	5327.19	**3923**	**56.6**	400
	0	53	0	10.136	1561.88	1150	16.6	400

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **879** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 89.6 Kg/m^2 — Terrain Category -2; K_2 = **1.08**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **250.2** Kg/m^2 — G_e : 2.327

[G_e considered at a height of : 54.895 m]

100% wind pressure at everyday temperature :	250.2	Kg/m^2
75% wind pressure at everyday temperature :	187.7	Kg/m^2
36% wind pressure at minimum temperature :	90.1	Kg/m^2

400 KV D/C T/L

DESIGN SPAN: 400M

WIRE : EARTHWIRE (OPGW)

SAG TENSION CALCULATION

Earthwire

OPGW

NAME OF THE CONDUCTOR	:	OPGW	
AREA	:	mm^2	68
DIA	:	mm	11.4
WT	:	Kg/m	0.489
ULTIMATE TENSILE STRENGTH	:	Kg	8772
MODULUS OF ELASTICITY	:	Kg/mm^2	16519
DESIGN SPAN	:	m	400
MIN TEMPERATURE	:	^0C	-5
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	53
COEFF OF LINEAR EXPANSION	:	$/^0C$	3.00E-06
INITIAL F.O.S OR SAG (m)			
	:	FOS	
	:	SAG	8.491
INITIAL TEMP	:	^0C	-5
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)	STRESS (Kg/cm^2)	TENSION (Kg)	% of UTS	SPAN (m)
INI	0	-5	0	8.491	1693.79	1152	13.1	400
36%	90.1	-5	0	-	3041.20	2068	23.6	400
	0	32	0	8.766	1640.78	**1116**	**12.7**	400
75%	187.7	32	0	-	4706.13	3200	36.5	400
100%	250.2	32	0	-	5688.69	**3868**	**44.1**	400
	0	53	0	8.921	1612.25	1096	12.5	400

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **879** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 89.6 Kg/m^2 — Terrain Category -2; K_2 = **1.08**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **250.2** Kg/m^2 — G_e : 2.327

[G_e considered at a height of : 54.895 m]

100% wind pressure at everyday temperature :	250.2	Kg/m^2
75% wind pressure at everyday temperature :	187.7	Kg/m^2
36% wind pressure at minimum temperature :	90.1	Kg/m^2

400 KV D/C T/L

DESIGN SPAN: 300M

WIRE : PHASE CONDUCTOR

SAG TENSION CALCULATION

NAME OF THE CONDUCTOR :	54/7/3.53		***Phase Conductor***
AREA :	mm^2	597	***"QUADRUPLE ACSR MOOSE "***
DIA :	mm	31.77	
WT OF CONDUCTOR :	Kg/m	2.004	
ULTIMATE TENSILE STRENGTH :	Kg	16438	
MODULUS OF ELASTICITY :	Kg/mm^2	7034	
DESIGN SPAN :	m	300	
MIN TEMPERATURE :	^0C	-5	
EVERY DAY TEMPERATURE :	^0C	32	
MAX TEMPERATURE :	^0C	85	
COEFF OF LINEAR EXPANSION :	$/^0C$	1.93E-05	
INITIAL F.O.S OR SAG (m)			
:	FOS	4.545	
:	SAG		
INITIAL TEMP :	^0C	32	
INITIAL WIND PRESSURE :	Kg/m^2	0	
RADIAL ICE FORMATION :	mm	0	

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)	STRESS (Kg/cm^2)	TENSION (Kg)	% of UTS	SPAN (m)
	0	-5	0	4.820	782.93	4674	28.4	300
36%	74.5	-5	0	-	1004.18	5995	36.5	300
INI	0	32	0	6.230	605.76	**3616**	**22.0**	300
75%	155.3	32	0	-	1215.52	7257	44.1	300
100%	207.0	32	0	-	1452.89	**8674**	**52.8**	300
	0	85	0	**8.160**	462.96	2764	16.8	300

Notes:

Basic wind speed V_b = **47** m/sec — **Wind zone - 4**

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **879** N/m^2 — Reliability level - 1; K_1 = **1.00**

[*As per Specification*] = 89.6 Kg/m^2 — Terrain Category -2; K_2 = **1.08**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{dc} * G_c$ — C_{dc} : **1.00**

= **207.0** Kg/m^2 — Gc : **2.306**

[G_c considered at a height of : 43.420 m]

100% wind pressure at everyday temperature : 207.0 Kg/m^2

75% wind pressure at everyday temperature : 155.3 Kg/m^2

36% wind pressure at minimum temperature : 74.5 Kg/m^2

400 KV D/C T/L

DESIGN SPAN: 300M

WIRE : EARTHWIRE (GSW)

SAG TENSION CALCULATION

				Earthwire 7/3.66
NAME OF THE CONDUCTOR	:	7/3.66		
AREA	:	mm^2	73.65	
DIA	:	mm	10.98	
WT	:	Kg/m	0.583	
ULTIMATE TENSILE STRENGTH	:	Kg	6934	
MODULUS OF ELASTICITY	:	Kg/mm^2	19361	
DESIGN SPAN	:	m	300	
MIN TEMPERATURE	:	^0C	-5	
EVERY DAY TEMPERATURE	:	^0C	32	
MAX TEMPERATURE	:	^0C	53	
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.15E-05	
INITIAL F.O.S OR SAG (m)				
	:	FOS		
	:	SAG	4.340	
INITIAL TEMP	:	^0C	-5	
INITIAL WIND PRESSURE	:	Kg/m^2	0	
RADIAL ICE FORMATION	:	mm	0	

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)	STRESS (Kg/cm^2)	TENSION (Kg)	% of UTS	SPAN (m)
INI	0	-5	0	4.340	2051.41	1511	21.8	300
36%	92.5	-5	0	-	3004.51	2213	31.9	300
	0	32	0	5.210	1707.30	**1257**	**18.1**	300
75%	192.8	32	0	-	4059.88	2990	43.1	300
100%	257.0	32	0	-	4857.15	**3577**	**51.6**	300
	0	53	0	5.720	1556.59	1146	16.5	300

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **879** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 89.6 Kg/m^2 — Terrain Category -2; K_2 = **1.08**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **257.0** Kg/m^2 — G_e : 2.395

[G_e considered at a height of : 53.000 m]

100% wind pressure at everyday temperature : 257.0 Kg/m^2

75% wind pressure at everyday temperature : 192.8 Kg/m^2

36% wind pressure at minimum temperature : 92.5 Kg/m^2

400 KV D/C T/L

DESIGN SPAN: 300M

WIRE : EARTHWIRE (OPGW)

SAG TENSION CALCULATION

Earthwire

OPGW

NAME OF THE CONDUCTOR	:	OPGW	
AREA	:	mm^2	68
DIA	:	mm	11.4
WT	:	Kg/m	0.489
ULTIMATE TENSILE STRENGTH	:	Kg	8772
MODULUS OF ELASTICITY	:	Kg/mm^2	16519
DESIGN SPAN	:	m	300
MIN TEMPERATURE	:	^0C	-5
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	53
COEFF OF LINEAR EXPANSION	:	$/^0C$	3.00E-06
INITIAL F.O.S OR SAG (m)			
	:	FOS	
	:	SAG	4.340
INITIAL TEMP	:	^0C	-5
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)	STRESS (Kg/cm^2)	TENSION (Kg)	% of UTS	SPAN (m)
INI	0	-5	0	4.340	1863.62	1267	14.4	300
36%	92.5	-5	0	-	2980.08	2026	23.1	300
	0	32	0	4.558	1774.84	**1207**	**13.8**	300
75%	192.8	32	0	-	4348.32	2957	33.7	300
100%	257.0	32	0	-	5173.67	**3518**	**40.1**	300
	0	53	0	4.683	1727.39	1175	13.4	300

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **879** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 89.6 Kg/m^2 — Terrain Category -2; K_2 = **1.08**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = P_d * C_{de} * G_e — C_{de} : **1.20**

= **257.0** Kg/m^2 — G_e : 2.395

[G_e considered at a height of : 53.000 m]

100% wind pressure at everyday temperature :	257.0	Kg/m^2
75% wind pressure at everyday temperature :	192.8	Kg/m^2
36% wind pressure at minimum temperature :	92.5	Kg/m^2

400 KV D/C T/L

DESIGN SPAN: 200M

WIRE : PHASE CONDUCTOR

SAG TENSION CALCULATION

Phase Conductor
"QUADRUPLE ACSR MOOSE "

NAME OF THE CONDUCTOR	:	54/7/3.53	
AREA	:	mm^2	597
DIA	:	mm	31.77
WT OF CONDUCTOR	:	Kg/m	2.004
ULTIMATE TENSILE STRENGTH	:	Kg	16438
MODULUS OF ELASTICITY	:	Kg/mm^2	7034
DESIGN SPAN	:	m	200
MIN TEMPERATURE	:	^0C	-5
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	85
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.93E-05
INITIAL F.O.S OR SAG (m)			
	:	FOS	4.545
	:	SAG	
INITIAL TEMP	:	^0C	32
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)	STRESS (Kg/cm^2)	TENSION (Kg)	% of UTS	SPAN (m)
	0	-5	0	1.850	908.20	5422	33.0	200
36%	72.5	-5	0	-	1044.64	6237	37.9	200
INI	0	32	0	2.770	605.76	**3616**	**22.0**	200
75%	151.0	32	0	-	1076.78	6428	39.1	200
100%	201.3	32	0	-	1259.99	**7522**	**45.8**	200
	0	85	0	**4.290**	390.87	2334	14.2	200

Notes:

Basic wind speed V_b = **47** m/sec — **Wind zone - 4**

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **879** N/m^2 — Reliability level - 1; K_1 = **1.00**

[*As per Specification*] = 89.6 Kg/m^2 — Terrain Category -2; K_2 = **1.08**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{dc} * G_c$ — C_{dc} : **1.00**

= **211.0** Kg/m^2 — Gc : **2.353**

[G_c considered at a height of : 41.530 m]

100% wind pressure at everyday temperature :	211.0	Kg/m^2
75% wind pressure at everyday temperature :	158.3	Kg/m^2
36% wind pressure at minimum temperature :	76.0	Kg/m^2

400 KV D/C T/L

DESIGN SPAN: 200M

WIRE : EARTHWIRE (GSW)

SAG TENSION CALCULATION

NAME OF THE CONDUCTOR	:	7/3.66		**Earthwire**
AREA	:	mm^2	73.65	**7/3.66**
DIA	:	mm	10.98	
WT	:	Kg/m	0.583	
ULTIMATE TENSILE STRENGTH	:	Kg	6934	
MODULUS OF ELASTICITY	:	Kg/mm^2	19361	
DESIGN SPAN	:	m	200	
MIN TEMPERATURE	:	^0C	-5	
EVERY DAY TEMPERATURE	:	^0C	32	
MAX TEMPERATURE	:	^0C	53	
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.15E-05	
INITIAL F.O.S OR SAG (m)				
	:	FOS		
	:	SAG	1.660	
INITIAL TEMP	:	^0C	-5	
INITIAL WIND PRESSURE	:	Kg/m^2	0	
RADIAL ICE FORMATION	:	mm	0	

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)	STRESS (Kg/cm^2)	TENSION (Kg)	% of UTS	SPAN (m)
INI	0	-5	0	1.660	2379.65	1753	25.3	200
36%	90.1	-5	0	-	2979.86	2195	31.7	200
	0	32	0	2.182	1813.55	**1336**	**19.3**	200
75%	187.7	32	0	-	3567.23	2627	37.9	200
100%	250.2	32	0	-	4178.07	**3077**	**44.4**	200
	0	53	0	2.535	1561.00	1150	16.6	200

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **879** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 89.6 Kg/m^2 — Terrain Category -2; K_2 = **1.08**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **264.0** Kg/m^2 — G_e : 2.458

[G_e considered at a height of : 51.236 m]

100% wind pressure at everyday temperature : 264.0 Kg/m^2

75% wind pressure at everyday temperature : 198.0 Kg/m^2

36% wind pressure at minimum temperature : 95.0 Kg/m^2

400 KV D/C T/L

DESIGN SPAN: 200M

WIRE : EARTHWIRE (OPGW)

SAG TENSION CALCULATION

Earthwire
OPGW

NAME OF THE CONDUCTOR	:	OPGW	
AREA	:	mm^2	68
DIA	:	mm	11.4
WT	:	Kg/m	0.489
ULTIMATE TENSILE STRENGTH	:	Kg	8772
MODULUS OF ELASTICITY	:	Kg/mm^2	16519
DESIGN SPAN	:	m	200
MIN TEMPERATURE	:	^0C	-5
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	53
COEFF OF LINEAR EXPANSION	:	$/^0C$	3.00E-06
INITIAL F.O.S OR SAG (m)			
	:	FOS	
	:	SAG	1.660
INITIAL TEMP	:	^0C	-5
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)	STRESS (Kg/cm^2)	TENSION (Kg)	% of UTS	SPAN (m)
INI	0	-5	0	1.660	2161.81	1470	16.8	200
36%	90.1	-5	0	-	2875.00	1955	22.3	200
	0	32	0	1.778	2022.03	**1375**	**15.7**	200
75%	187.7	32	0	-	3834.18	2607	29.7	200
100%	250.2	32	0	-	4458.48	**3032**	**34.6**	200
	0	53	0	1.847	1945.78	1323	15.1	200

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **879** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 89.6 Kg/m^2 — Terrain Category -2; K_2 = **1.08**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **264.0** Kg/m^2 — G_e : 2.458

[G_e considered at a height of : 51.236 m]

100% wind pressure at everyday temperature : 264.0 Kg/m^2

75% wind pressure at everyday temperature : 198.0 Kg/m^2

36% wind pressure at minimum temperature : 95.0 Kg/m^2

220 KV D/C T/L

DESIGN SPAN: 350M

WIRE : PHASE CONDUCTOR

SAG TENSION CALCULATION

Phase Conductor
"Twin ACSR Bison"

NAME OF THE CONDUCTOR	:	54/7/3	
AREA	:	mm^2	431.2
DIA	:	mm	27
WT OF CONDUCTOR	:	Kg/m	1.444
ULTIMATE TENSILE STRENGTH	:	Kg	12328.4
MODULUS OF ELASTICITY	:	Kg/mm^2	7034
DESIGN SPAN	:	m	350
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	80
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.93E-05
INITIAL F.O.S OR SAG (m)			
	:	FOS	4.545
	:	SAG	
INITIAL TEMP	:	^0C	32
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
	0	0	0	6.800		3251	26.4	350
36%	59.4	0	0	-		4229	34.3	350
INI	0	32	0	8.152		**2712**	**22.0**	350
75%	123.8	32	0	-		5389	43.7	350
100%	165.0	32	0	-		**6460**	**52.4**	350
	0	80	0	**10.060**		2198	17.8	350

Notes:

Basic wind speed V_b = **47** m/sec — **Wind zone - 4**

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **716** N/m^2 — Reliability level - 1; K_1 = **1.00**

[*As per Specification*] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{dc} * G_c$ — C_{dc} : **1.00**

= **165.0** Kg/m^2 — Gc : **2.306**

100% wind pressure at everyday temperature : 165.0 Kg/m^2

75% wind pressure at everyday temperature : 123.8 Kg/m^2

36% wind pressure at minimum temperature : 59.4 Kg/m^2

220 KV D/C T/L

DESIGN SPAN: 350M

WIRE : EARTHWIRE (GSW)

SAG TENSION CALCULATION

Earthwire 7/3.35

NAME OF THE CONDUCTOR	:	7/3.35	
AREA	:	mm^2	61.7
DIA	:	mm	10.05
WT	:	Kg/m	0.483
ULTIMATE TENSILE STRENGTH	:	Kg	6974.8
MODULUS OF ELASTICITY	:	Kg/mm^2	19000
DESIGN SPAN	:	m	350
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	53
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.15E-05
INITIAL F.O.S OR SAG (m)			
	:	FOS	
	:	SAG	6.110
INITIAL TEMP	:	^0C	0
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
INI	0	0	0	6.110		1208	17.3	350
36%	72.4	0	0	-		1747	25.0	350
	0	32	0	6.970		**1061**	**15.2**	350
75%	150.8	32	0	-		2415	34.6	350
100%	201.0	32	0	-		**2897**	**41.5**	350
	0	53	0	7.520		983	14.1	350

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **716** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **201.0** Kg/m^2 — G_e : 2.341

100% wind pressure at everyday temperature : 201.0 Kg/m^2

75% wind pressure at everyday temperature : 150.8 Kg/m^2

36% wind pressure at minimum temperature : 72.4 Kg/m^2

220 KV D/C T/L

DESIGN SPAN: 350M

WIRE : EARTHWIRE (OPGW)

SAG TENSION CALCULATION

Earthwire
OPGW

NAME OF THE CONDUCTOR	:	OPGW	
AREA	:	mm^2	68
DIA	:	mm	11.4
WT	:	Kg/m	0.487
ULTIMATE TENSILE STRENGTH	:	Kg	8828
MODULUS OF ELASTICITY	:	Kg/mm^2	16519
DESIGN SPAN	:	m	350
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	53
COEFF OF LINEAR EXPANSION	:	$/^0C$	3.00E-06
INITIAL F.O.S OR SAG (m)			
	:	FOS	
	:	SAG	6.080
INITIAL TEMP	:	^0C	0
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
INI	0	0	0	6.082		1226	13.9	350
36%	72.4	0	0	-		1849	20.9	350
	0	32	0	7.026		**1061**	**12.0**	350
75%	150.8	32	0	-		2579	29.2	350
100%	201.0	32	0	-		**3099**	**35.1**	350
	0	53	0	7.642		976	11.1	350

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **716** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **201.0** Kg/m^2 — G_e : 2.341

100% wind pressure at everyday temperature : 201.0 Kg/m^2

75% wind pressure at everyday temperature : 150.8 Kg/m^2

36% wind pressure at minimum temperature : 72.4 Kg/m^2

220 KV D/C T/L

DESIGN SPAN: 250M

WIRE : PHASE CONDUCTOR

SAG TENSION CALCULATION

Phase Conductor
"Twin ACSR Bison"

NAME OF THE CONDUCTOR	:	54/7/3	
AREA	:	mm^2	431.2
DIA	:	mm	27
WT OF CONDUCTOR	:	Kg/m	1.444
ULTIMATE TENSILE STRENGTH	:	Kg	12328.4
MODULUS OF ELASTICITY	:	Kg/mm^2	7034
DESIGN SPAN	:	m	250
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	80
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.93E-05
INITIAL F.O.S OR SAG (m)			
	:	FOS	4.545
	:	SAG	
INITIAL TEMP	:	^0C	32
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
	0	0	0	3.120		3610	29.3	250
36%	59.4	0	0	-		4319	35.0	250
INI	0	32	0	4.160		**2712**	**22.0**	250
75%	123.8	32	0	-		4876	39.5	250
100%	165.0	32	0	-		**5737**	**46.5**	250
	0	80	0	**5.760**		1958	15.9	250

Notes:

Basic wind speed V_b = **47** m/sec — **Wind zone - 4**

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **716** N/m^2 — Reliability level - 1; K_1 = **1.00**

[*As per Specification*] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{dc} * G_c$ — C_{dc} : **1.00**

= **165.0** Kg/m^2 — Gc : **2.306**

100% wind pressure at everyday temperature : 165.0 Kg/m^2

75% wind pressure at everyday temperature : 123.8 Kg/m^2

36% wind pressure at minimum temperature : 59.4 Kg/m^2

220 KV D/C T/L

DESIGN SPAN: 250M

WIRE : EARTHWIRE (GSW)

SAG TENSION CALCULATION

Earthwire

7/3.35

NAME OF THE CONDUCTOR	:	7/3.35	
AREA	:	mm^2	61.7
DIA	:	mm	10.05
WT	:	Kg/m	0.483
ULTIMATE TENSILE STRENGTH	:	Kg	6974.8
MODULUS OF ELASTICITY	:	Kg/mm^2	19000
DESIGN SPAN	:	m	250
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	53
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.15E-05
INITIAL F.O.S OR SAG (m)			
	:	FOS	
	:	SAG	2.800
INITIAL TEMP	:	^0C	0
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
INI	0	0	0	2.800		1344	19.3	250
36%	72.4	0	0	-		1728	24.8	250
	0	32	0	3.420		**1103**	**15.8**	250
75%	150.8	32	0	-		2165	31.0	250
100%	201.0	32	0	-		**2547**	**36.5**	250
	0	53	0	3.850		979	14.0	250

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **716** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor $F_{wc} = P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **201.0** Kg/m^2 — G_e : 2.341

100% wind pressure at everyday temperature : 201.0 Kg/m^2

75% wind pressure at everyday temperature : 150.8 Kg/m^2

36% wind pressure at minimum temperature : 72.4 Kg/m^2

220 KV D/C T/L

DESIGN SPAN: 250M

WIRE : EARTHWIRE (OPGW)

SAG TENSION CALCULATION

Earthwire

OPGW

NAME OF THE CONDUCTOR	:	OPGW	
AREA	:	mm^2	68
DIA	:	mm	11.4
WT	:	Kg/m	0.487
ULTIMATE TENSILE STRENGTH	:	Kg	8828
MODULUS OF ELASTICITY	:	Kg/mm^2	16519
DESIGN SPAN	:	m	250
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	53
COEFF OF LINEAR EXPANSION	:	$/^0C$	3.00E-06
INITIAL F.O.S OR SAG (m)			
	:	FOS	
	:	SAG	2.800
INITIAL TEMP	:	^0C	0
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
INI	0	0	0	2.800		1355	15.3	250
36%	72.4	0	0	-		1803	20.4	250
	0	32	0	2.950		**1288**	**14.6**	250
75%	150.8	32	0	-		2439	27.6	250
100%	201.0	32	0	-		**2848**	**32.3**	250
	0	53	0	3.055		1246	14.1	250

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **716** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **201.0** Kg/m^2 — G_e : 2.341

100% wind pressure at everyday temperature :	201.0	Kg/m^2
75% wind pressure at everyday temperature :	150.8	Kg/m^2
36% wind pressure at minimum temperature :	72.4	Kg/m^2

220 KV D/C T/L

DESIGN SPAN: 150M

WIRE : PHASE CONDUCTOR

SAG TENSION CALCULATION

Phase Conductor "Twin ACSR Bison"

NAME OF THE CONDUCTOR	:	54/7/3	
AREA	:	mm^2	431.2
DIA	:	mm	27
WT OF CONDUCTOR	:	Kg/m	1.444
ULTIMATE TENSILE STRENGTH	:	Kg	12328.4
MODULUS OF ELASTICITY	:	Kg/mm^2	7034
DESIGN SPAN	:	m	150
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	80
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.93E-05
INITIAL F.O.S OR SAG (m)			
	:	FOS	4.545
	:	SAG	
INITIAL TEMP	:	^0C	32
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
	0	0	0	0.980		4128	33.5	150
36%	59.4	0	0	-		4457	36.1	150
INI	0	32	0	1.500		**2712**	**22.0**	150
75%	123.8	32	0	-		4148	33.6	150
100%	165.0	32	0	-		**4746**	**38.5**	150
	0	80	0	**2.610**		1553	12.6	150

Notes:

Basic wind speed V_b = **47** m/sec — **Wind zone - 4**

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **716** N/m^2 — Reliability level - 1; K_1 = **1.00**

[*As per Specification*] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{dc} * G_c$ — C_{dc} : **1.00**

= **167.3** Kg/m^2 — Gc : **2.340**

100% wind pressure at everyday temperature :	165.0	Kg/m^2
75% wind pressure at everyday temperature :	123.8	Kg/m^2
36% wind pressure at minimum temperature :	59.4	Kg/m^2

220 KV D/C T/L

DESIGN SPAN: 150M

WIRE : EARTHWIRE (GSW)

SAG TENSION CALCULATION

Earthwire
7/3.35

NAME OF THE CONDUCTOR	:	7/3.35	
AREA	:	mm^2	61.7
DIA	:	mm	10.05
WT	:	Kg/m	0.483
ULTIMATE TENSILE STRENGTH	:	Kg	6974.8
MODULUS OF ELASTICITY	:	Kg/mm^2	19000
DESIGN SPAN	:	m	150
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	53
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.15E-05
INITIAL F.O.S OR SAG (m)			
	:	FOS	
	:	SAG	0.880
INITIAL TEMP	:	^0C	0
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
INI	0	0	0	0.880		1540	22.1	150
36%	72.4	0	0	-		1716	24.6	150
	0	32	0	1.147		**1184**	**17.0**	150
75%	150.8	32	0	-		1830	26.2	150
100%	201.0	32	0	-		**2088**	**29.9**	150
	0	53	0	1.380		983	14.1	150

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **716** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor $F_{wc} = P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **201.0** Kg/m^2 — G_e : 2.341

100% wind pressure at everyday temperature : 201.0 Kg/m^2

75% wind pressure at everyday temperature : 150.8 Kg/m^2

36% wind pressure at minimum temperature : 72.4 Kg/m^2

220 KV D/C T/L

DESIGN SPAN: 150M

WIRE : EARTHWIRE (OPGW)

SAG TENSION CALCULATION

Earthwire OPGW

NAME OF THE CONDUCTOR	:	OPGW	
AREA	:	mm^2	68
DIA	:	mm	11.4
WT	:	Kg/m	0.487
ULTIMATE TENSILE STRENGTH	:	Kg	8828
MODULUS OF ELASTICITY	:	Kg/mm^2	16519
DESIGN SPAN	:	m	150
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	53
COEFF OF LINEAR EXPANSION	:	$/^0C$	3.00E-06
INITIAL F.O.S OR SAG (m)			
	:	FOS	
	:	SAG	0.880
INITIAL TEMP	:	^0C	0
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
INI	0	0	0	0.880		1553	17.6	150
36%	72.4	0	0	-		1761	19.9	150
	0	32	0	0.938		**1459**	**16.5**	150
75%	150.8	32	0	-		2102	23.8	150
100%	201.0	32	0	-		**2370**	**26.8**	150
	0	53	0	0.980		1398	15.8	150

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **716** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor $F_{wc} = P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **201.0** Kg/m^2 — G_e : 2.341

100% wind pressure at everyday temperature : 201.0 Kg/m^2

75% wind pressure at everyday temperature : 150.8 Kg/m^2

36% wind pressure at minimum temperature : 72.4 Kg/m^2

132KV D/C T/L

DESIGN SPAN: 350M

WIRE : PHASE CONDUCTOR

SAG TENSION CALCULATION

Phase Conductor
"ACSR Bear"

NAME OF THE CONDUCTOR	:	30/7/3.35	
AREA	:	mm^2	326.1
DIA	:	mm	23.45
WT OF CONDUCTOR	:	Kg/m	1.213
ULTIMATE TENSILE STRENGTH	:	Kg	11340
MODULUS OF ELASTICITY	:	Kg/mm^2	7034
DESIGN SPAN	:	m	350
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	80
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.93E-05
INITIAL F.O.S OR SAG (m)			
	:	FOS	4.550
	:	SAG	
INITIAL TEMP	:	^0C	32
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
	0	0	0	6.140		3026	26.7	350
36%	55.8	0	0	-		3768	33.2	350
INI	0	32	0	7.450		**2495**	**22.0**	350
75%	116.3	32	0	-		4617	40.7	350
100%	155.0	32	0	-		**5471**	**48.2**	350
	0	80	0	**9.370**		1983	17.5	350

Notes:

Basic wind speed V_b = **47** m/sec — **Wind zone - 4**

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **701** N/m^2 — Reliability level - 1; K_1 = **1.00**

[*As per Specification*] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor $F_{wc} = P_d * C_{dc} * G_c$ — C_{dc} : **1.00**

= **155.0** Kg/m^2 — Gc : **2.175**

100% wind pressure at everyday temperature :	155.0	Kg/m^2
75% wind pressure at everyday temperature :	116.3	Kg/m^2
36% wind pressure at minimum temperature :	55.8	Kg/m^2

132 KV D/C T/L

DESIGN SPAN: 350M

WIRE : EARTHWIRE (OPGW)

SAG TENSION CALCULATION

Earthwire
OPGW

NAME OF THE CONDUCTOR	:	OPGW	
AREA	:	mm^2	68
DIA	:	mm	11.4
WT	:	Kg/m	0.487
ULTIMATE TENSILE STRENGTH	:	Kg	8828
MODULUS OF ELASTICITY	:	Kg/mm^2	16519
DESIGN SPAN	:	m	350
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	53
COEFF OF LINEAR EXPANSION	:	$/^0C$	3.00E-06
INITIAL F.O.S OR SAG (m)			
	:	FOS	
	:	SAG	5.520
INITIAL TEMP	:	^0C	0
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
INI	0	0	0	5.520		1349	15.3	350
36%	68.4	0	0	-		1919	21.7	350
	0	32	0	5.730		**1300**	**14.7**	350
75%	142.5	32	0	-		2721	30.8	350
100%	190.0	32	0	-		**3220**	**36.5**	350
	0	53	0	5.870		1269	14.4	350

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **701** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor $F_{wc} = P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **190.0** Kg/m^2 — G_e : 2.210

100% wind pressure at everyday temperature : 190.0 Kg/m^2

75% wind pressure at everyday temperature : 142.5 Kg/m^2

36% wind pressure at minimum temperature : 68.4 Kg/m^2

132KV D/C T/L

DESIGN SPAN: 250M

WIRE : PHASE CONDUCTOR

SAG TENSION CALCULATION

Phase Conductor
"ACSR Bear"

NAME OF THE CONDUCTOR	:	30/7/3.35	
AREA	:	mm^2	326.1
DIA	:	mm	23.45
WT OF CONDUCTOR	:	Kg/m	1.213
ULTIMATE TENSILE STRENGTH	:	Kg	11340
MODULUS OF ELASTICITY	:	Kg/mm^2	7034
DESIGN SPAN	:	m	250
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	80
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.93E-05
INITIAL F.O.S OR SAG (m)			
	:	FOS	4.550
	:	SAG	
INITIAL TEMP	:	^0C	32
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
	0	0	0	2.870		3304	29.1	250
36%	55.8	0	0	-		3810	33.6	250
INI	0	32	0	3.800		**2495**	**22.0**	250
75%	116.3	32	0	-		4158	36.7	250
100%	155.0	32	0	-		**4835**	**42.6**	250
	0	80	0	**5.360**		1768	15.6	250

Notes:

Basic wind speed V_b = **47** m/sec — **Wind zone - 4**

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **701** N/m^2 — Reliability level - 1; K_1 = **1.00**

[*As per Specification*] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{dc} * G_c$ — C_{dc} : **1.00**

= **155.0** Kg/m^2 — Gc : **2.193**

100% wind pressure at everyday temperature : 155.0 Kg/m^2

75% wind pressure at everyday temperature : 116.3 Kg/m^2

36% wind pressure at minimum temperature : 55.8 Kg/m^2

132 KV D/C T/L

DESIGN SPAN: 250M

WIRE : EARTHWIRE (OPGW)

SAG TENSION CALCULATION

Earthwire

OPGW

NAME OF THE CONDUCTOR :	OPGW		
AREA :	mm^2	68	
DIA :	mm	11.4	
WT :	Kg/m	0.487	
ULTIMATE TENSILE STRENGTH :	Kg	8828	
MODULUS OF ELASTICITY :	Kg/mm^2	16519	
DESIGN SPAN :	m	250	
MIN TEMPERATURE :	^0C	0	
EVERY DAY TEMPERATURE :	^0C	32	
MAX TEMPERATURE :	^0C	53	
COEFF OF LINEAR EXPANSION :	$/^0C$	3.00E-06	
INITIAL F.O.S OR SAG (m)			
:	FOS		
:	SAG	2.580	
INITIAL TEMP :	^0C	0	
INITIAL WIND PRESSURE :	Kg/m^2	0	
RADIAL ICE FORMATION :	mm	0	

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
INI	0	0	0	2.580		1473	16.7	250
36%	68.4	0	0	-		1864	21.1	250
	0	32	0	2.710		**1400**	**15.9**	250
75%	142.5	32	0	-		2449	27.7	250
100%	190.0	32	0	-		**2837**	**32.1**	250
	0	53	0	2.811		1353	15.3	250

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **701** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **190.0** Kg/m^2 — G_e : 2.248

100% wind pressure at everyday temperature : 190.0 Kg/m^2

75% wind pressure at everyday temperature : 142.5 Kg/m^2

36% wind pressure at minimum temperature : 68.4 Kg/m^2

132KV D/C T/L

DESIGN SPAN: 200M

WIRE : PHASE CONDUCTOR

SAG TENSION CALCULATION

Phase Conductor "ACSR Bear"

NAME OF THE CONDUCTOR	:	30/7/3.35	
AREA	:	mm^2	326.1
DIA	:	mm	23.45
WT OF CONDUCTOR	:	Kg/m	1.213
ULTIMATE TENSILE STRENGTH	:	Kg	11340
MODULUS OF ELASTICITY	:	Kg/mm^2	7034
DESIGN SPAN	:	m	200
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	80
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.93E-05
INITIAL F.O.S OR SAG (m)			
	:	FOS	4.550
	:	SAG	
INITIAL TEMP	:	^0C	32
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
	0	0	0	1.750		3474	30.6	200
36%	55.8	0	0	-		3835	33.8	200
INI	0	32	0	2.430		**2495**	**22.0**	200
75%	116.3	32	0	-		3867	34.1	200
100%	155.0	32	0	-		**4439**	**39.1**	200
	0	80	0	**3.750**		1617	14.3	200

Notes:

Basic wind speed V_b = **47** m/sec — **Wind zone - 4**

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **701** N/m^2 — Reliability level - 1; K_1 = **1.00**

[*As per Specification*] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{dc} * G_c$ — C_{dc} : **1.00**

= **155.0** Kg/m^2 — Gc : **2.193**

100% wind pressure at everyday temperature :	155.0	Kg/m^2
75% wind pressure at everyday temperature :	116.3	Kg/m^2
36% wind pressure at minimum temperature :	55.8	Kg/m^2

132 KV D/C T/L

DESIGN SPAN: 200M

WIRE : EARTHWIRE (OPGW)

SAG TENSION CALCULATION

Earthwire
OPGW

NAME OF THE CONDUCTOR	:	OPGW	
AREA	:	mm^2	68
DIA	:	mm	11.4
WT	:	Kg/m	0.487
ULTIMATE TENSILE STRENGTH	:	Kg	8828
MODULUS OF ELASTICITY	:	Kg/mm^2	16519
DESIGN SPAN	:	m	200
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	53
COEFF OF LINEAR EXPANSION	:	$/^0C$	3.00E-06
INITIAL F.O.S OR SAG (m)			
	:	FOS	
	:	SAG	1.570
INITIAL TEMP	:	^0C	0
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
INI	0	0	0	1.570		1546	17.5	200
36%	68.4	0	0	-		1832	20.7	200
	0	32	0	1.660		**1461**	**16.5**	200
75%	142.5	32	0	-		2284	25.9	200
100%	190.0	32	0	-		**2609**	**29.5**	200
	0	53	0	1.730		1406	15.9	200

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **701** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = P_d * C_{de} * G_e — C_{de} : **1.20**

= **190.0** Kg/m^2 — G_e : 2.248

100% wind pressure at everyday temperature : 190.0 Kg/m^2

75% wind pressure at everyday temperature : 142.5 Kg/m^2

36% wind pressure at minimum temperature : 68.4 Kg/m^2

132KV D/C T/L

DESIGN SPAN: 150M

WIRE : PHASE CONDUCTOR

SAG TENSION CALCULATION

Phase Conductor "ACSR Bear"

NAME OF THE CONDUCTOR	:	30/7/3.35	
AREA	:	mm^2	326.1
DIA	:	mm	23.45
WT OF CONDUCTOR	:	Kg/m	1.213
ULTIMATE TENSILE STRENGTH	:	Kg	11340
MODULUS OF ELASTICITY	:	Kg/mm^2	7034
DESIGN SPAN	:	m	150
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	80
COEFF OF LINEAR EXPANSION	:	$/^0C$	1.93E-05
INITIAL F.O.S OR SAG (m)			
	:	FOS	4.550
	:	SAG	
INITIAL TEMP	:	^0C	32
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
	0	0	0	0.940		3642	32.1	150
36%	55.8	0	0	-		3862	34.1	150
INI	0	32	0	1.370		**2495**	**22.0**	150
75%	116.3	32	0	-		3526	31.1	150
100%	155.0	32	0	-		**3980**	**35.1**	150
	0	80	0	**2.400**		1423	12.6	150

Notes:

Basic wind speed V_b = **47** m/sec — **Wind zone - 4**

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **701** N/m^2 — Reliability level - 1; K_1 = **1.00**

[*As per Specification*] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{dc} * G_c$ — C_{dc} : **1.00**

= **155.0** Kg/m^2 — Gc : **2.175**

100% wind pressure at everyday temperature :	155.0	Kg/m^2
75% wind pressure at everyday temperature :	116.3	Kg/m^2
36% wind pressure at minimum temperature :	55.8	Kg/m^2

132 KV D/C T/L

DESIGN SPAN: 150M

WIRE : EARTHWIRE (OPGW)

SAG TENSION CALCULATION

Earthwire OPGW

NAME OF THE CONDUCTOR	:	OPGW	
AREA	:	mm^2	68
DIA	:	mm	11.4
WT	:	Kg/m	0.487
ULTIMATE TENSILE STRENGTH	:	Kg	8828
MODULUS OF ELASTICITY	:	Kg/mm^2	16519
DESIGN SPAN	:	m	150
MIN TEMPERATURE	:	^0C	0
EVERY DAY TEMPERATURE	:	^0C	32
MAX TEMPERATURE	:	^0C	53
COEFF OF LINEAR EXPANSION	:	$/^0C$	3.00E-06
INITIAL F.O.S OR SAG (m)			
	:	FOS	
	:	SAG	0.846
INITIAL TEMP	:	^0C	0
INITIAL WIND PRESSURE	:	Kg/m^2	0
RADIAL ICE FORMATION	:	mm	0

	WIND PRESS (Kg/m^2)	TEMP DEG (^0C)	ICE FORMATION (mm)	SAG (m)		TENSION (Kg)	% of UTS	SPAN (m)
INI	0	0	0	0.846		1619	18.3	150
36%	68.4	0	0	-		1799	20.4	150
	0	32	0	0.899		**1524**	**17.3**	150
75%	142.5	32	0	-		2102	23.8	150
100%	190.0	32	0	-		**2353**	**26.7**	150
	0	53	0	0.936		1462	16.6	150

Notes:

Basic wind speed V_b = **47** m/sec — Wind zone - 4

[Ref Table 4 - IS 802 (Part1/Sec1):1995

Design wind pressure P_d = **701** N/m^2 — Reliability level - 1; K_1 = **1.00**

[As per Specification] = 71.5 Kg/m^2 — Terrain Category -2; K_2 = **1.00**

(K_2 For Hilly Terrain)

Wind pressure on conductor F_{wc} = $P_d * C_{de} * G_e$ — C_{de} : **1.20**

= **190.0** Kg/m^2 — G_e : 2.230

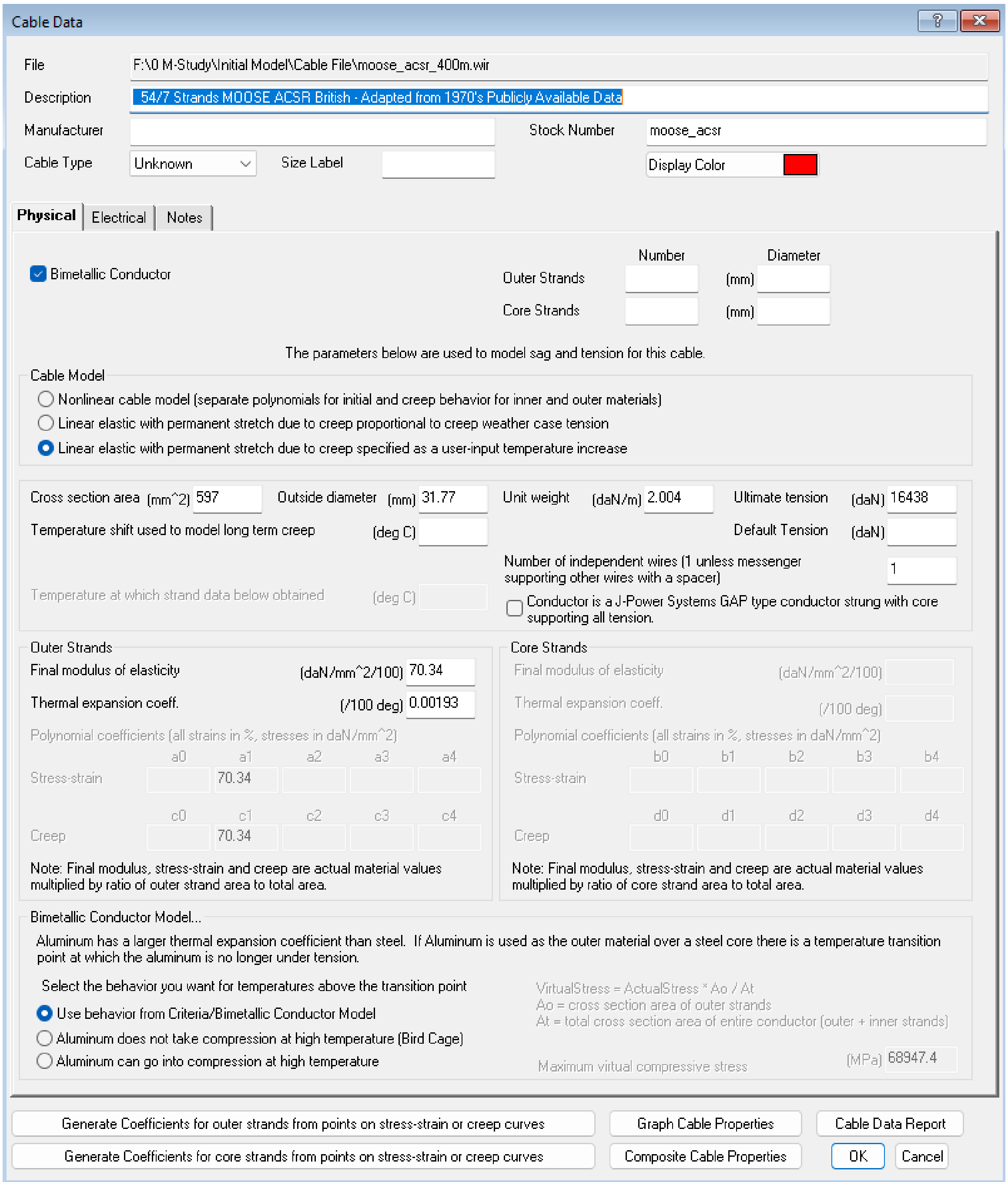
100% wind pressure at everyday temperature : 190.0 Kg/m^2

75% wind pressure at everyday temperature : 142.5 Kg/m^2

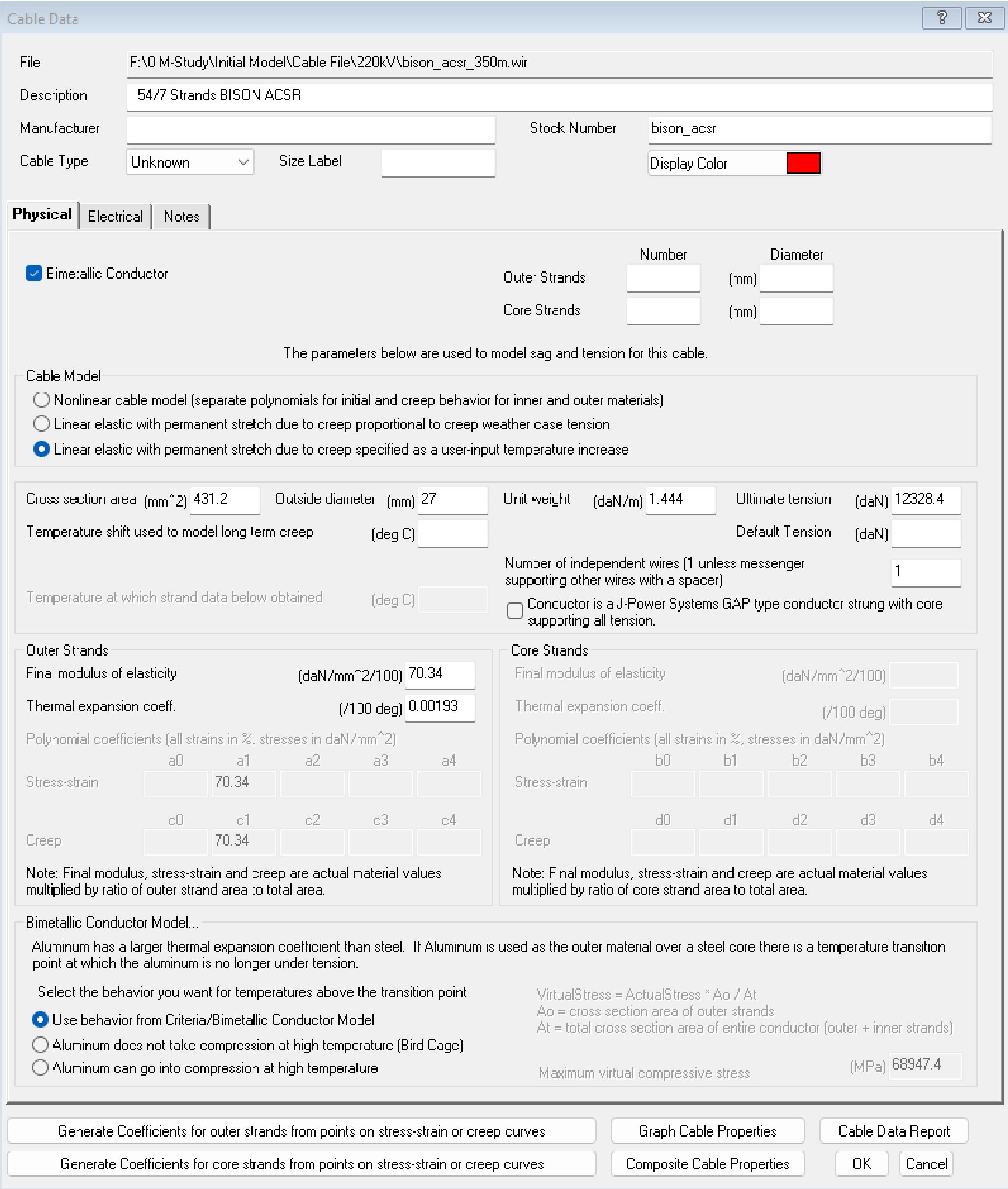
36% wind pressure at minimum temperature : 68.4 Kg/m^2

APPENDIX- E: PLS-CADD MODELING

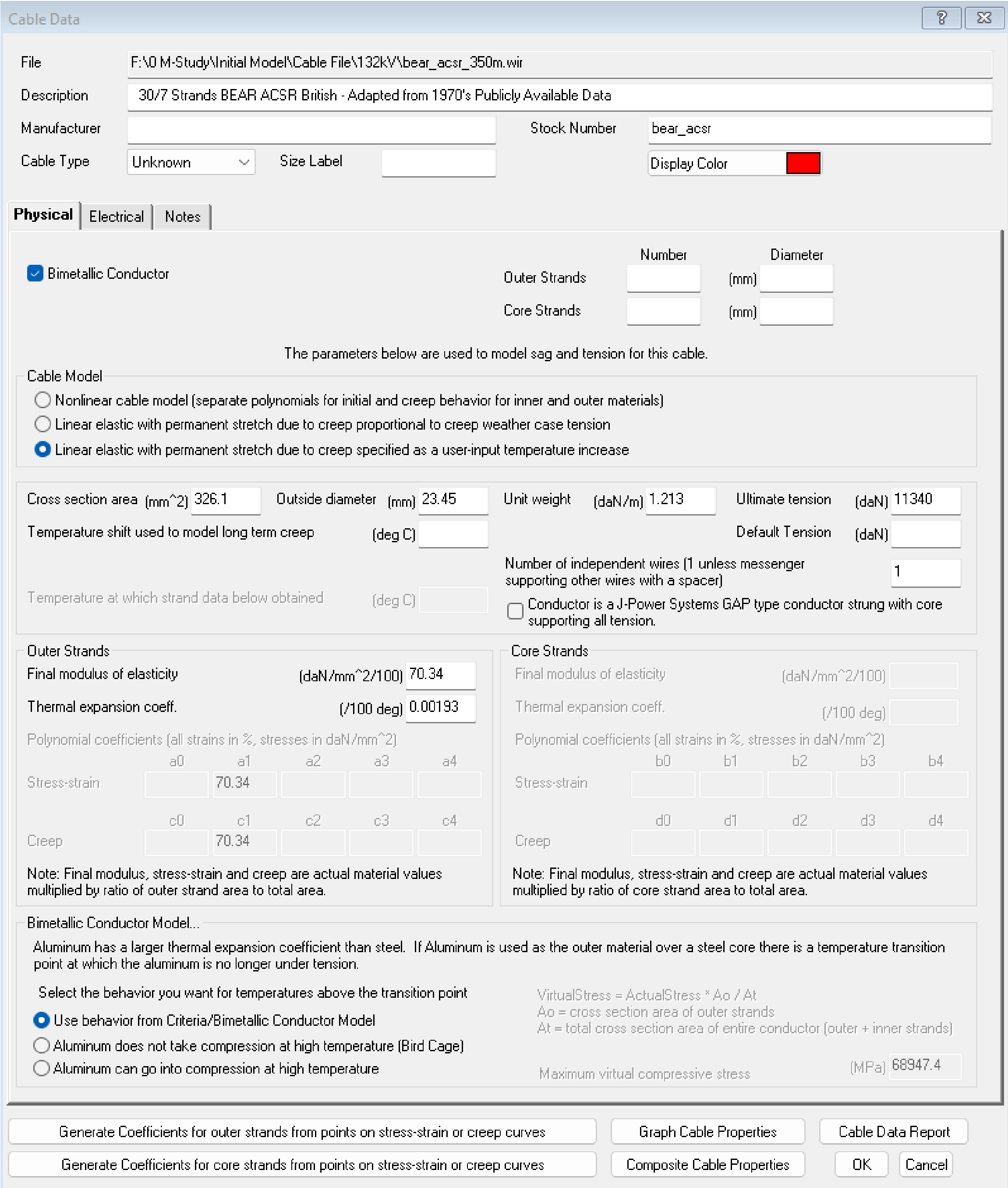
Modeling of ACSR "Moose" Conductor



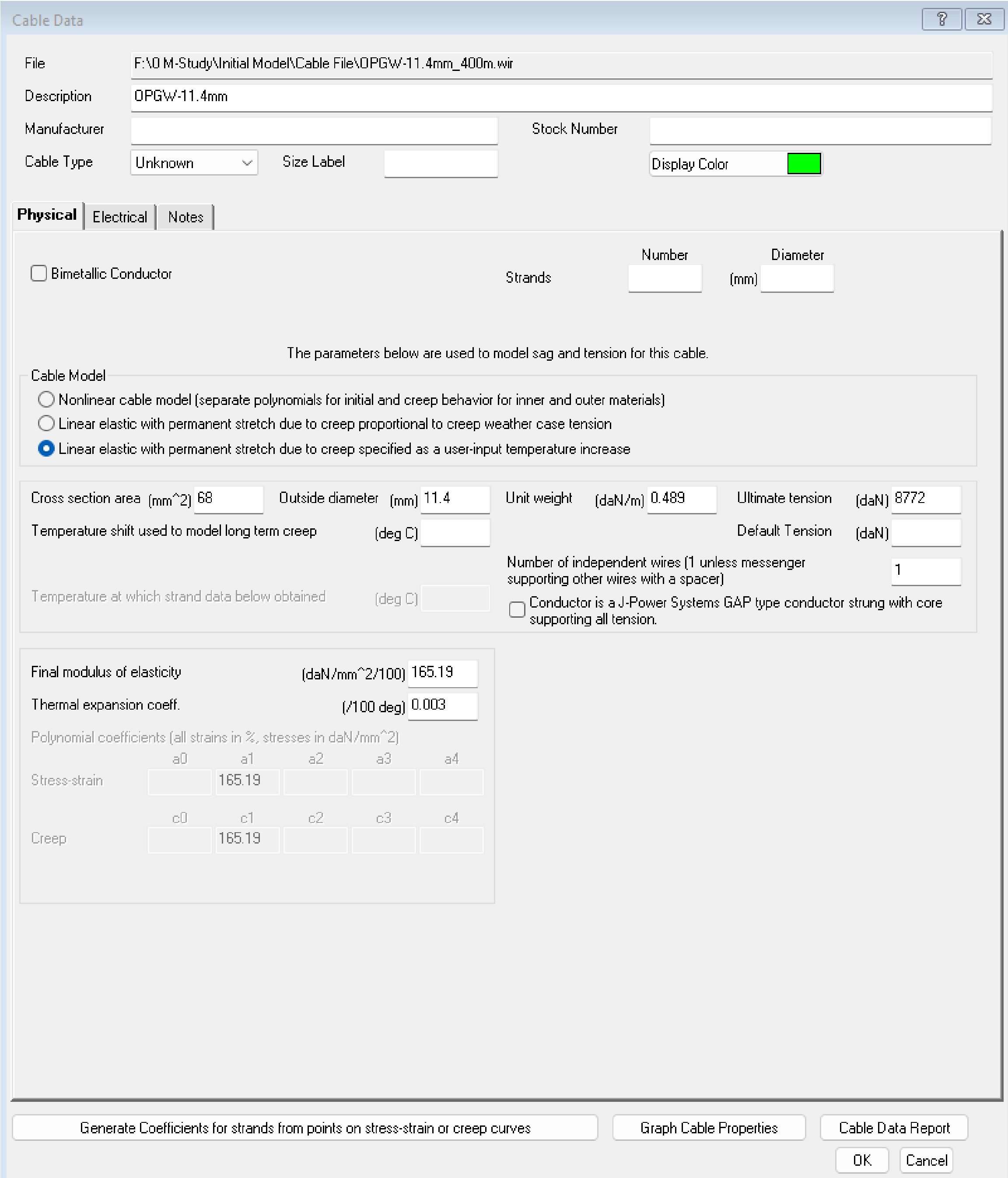
Modeling of ACSR "Bison" Conductor



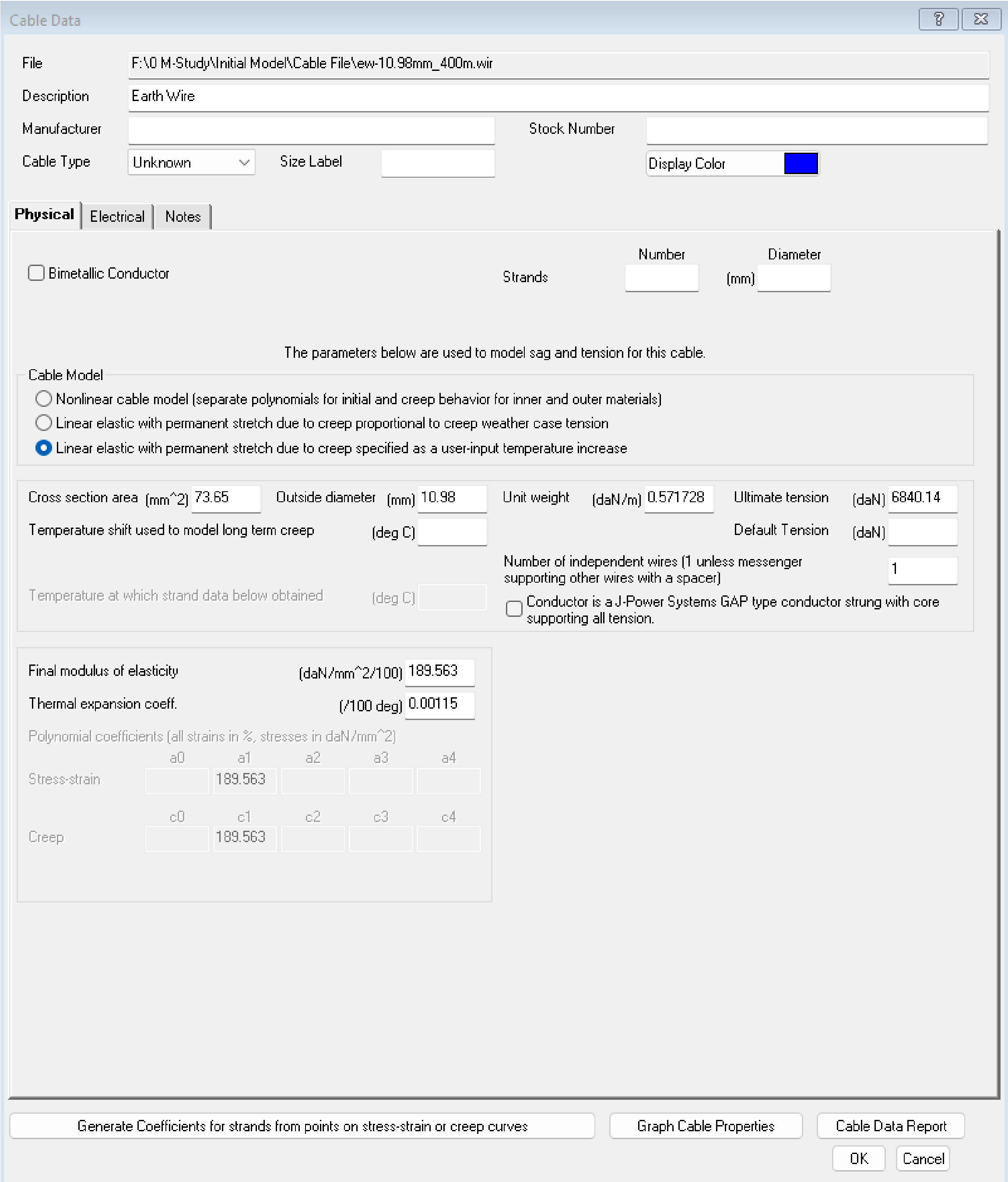
Modeling of ACSR "Bear" Conductor



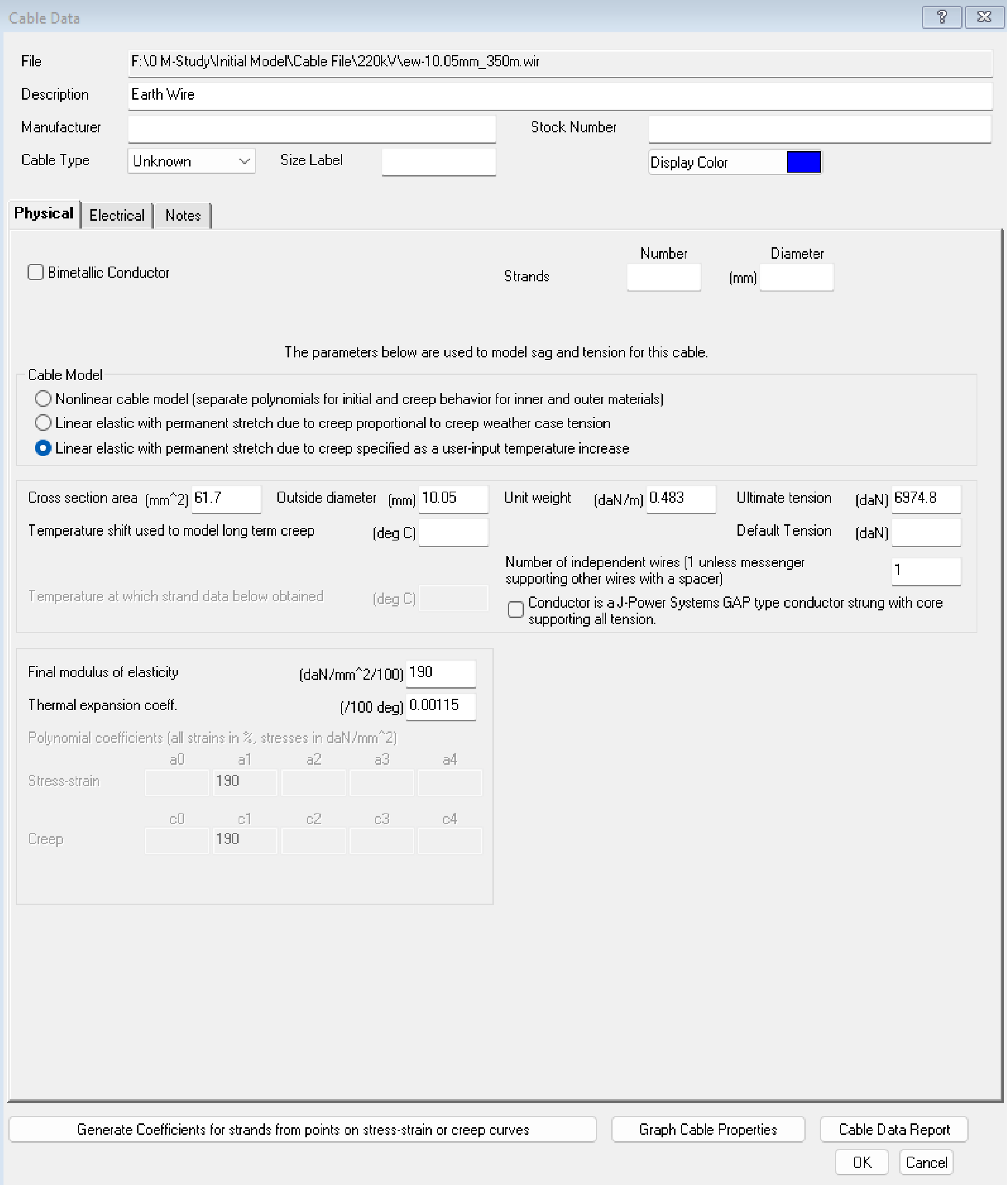
Modeling of 11.4mm OPGW Earthwire



Modeling of 10.98mm GSW Earthwire



Modeling of 10.05mm GSW Earthwire



Modeling of Weather Cases for 132kV TL

Weather Cases

See Criteria/Code Specific Wind and Terrain Parameters for more information on height adjustments and gust response factors.

	Description	Air Density Factor (Q) (kg/m^3) (Pa/(m/s)^2)	Wind Velocity (m/s)	Wind Pressure (Pa)	Wire Ice Thickness (cm)	Wire Ice Density (daN/dm^3)	Wire Ice Load (daN/m)	Wire Temp. (deg C)	Ambient Temp. (deg C)	Weather Load Factor	NESC Constant (daN/m)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	0° Nil Wind	0.613								1		None	1
2	32° Nil Wind	0.613						32.0	32.0	1		None	1
3	53° Nil Wind	0.613						53.0	53.0	1		None	1
4	80° Nil Wind	0.613						80.0	32.0	1		None	1
5	32° Full Wind-350m	0.613	49.7957	1520				32.0	32.0	1		None	1
6	32° 75% Wind-350m	0.613	43.1243	1140				32.0	32.0	1		None	1
7	32° 23.5% Wind-350m	0.613	24.1393	357.2				32.0	32.0	1		None	1
8	32° Full Wind-SW-350m	0.613	55.1323	1863.26				32.0	32.0	1		None	1
9	32° 75% Wind-SW-350m	0.613	47.7461	1397.45				32.0	32.0	1		None	1
10	32° 23.5% Wind-SW-350m	0.613	26.7264	437.866				32.0	32.0	1		None	1
11	32° Full Wind-250m	0.613	49.7957	1520				32.0	32.0	1		None	1
12	32° 75% Wind-250m	0.613	43.1243	1140				32.0	32.0	1		None	1
13	32° 25% Wind-250m	0.613	24.8978	380				32.0	32.0	1		None	1
14	32° Full Wind-SW-250m	0.613	55.1323	1863.26				32.0	32.0	1		None	1
15	32° 75% Wind-SW-250m	0.613	47.7461	1397.45				32.0	32.0	1		None	1
16	32° 25% Wind-SW-250m	0.613	27.5657	465.8				32.0	32.0	1		None	1
17	32° Full Wind-150m	0.613	49.7957	1520				32.0	32.0	1		None	1
18	32° 75% Wind-150m	0.613	43.1243	1140				32.0	32.0	1		None	1
19	32° 29% Wind-150m	0.613	26.8158	440.8				32.0	32.0	1		None	1
20	32° Full Wind-SW-150m	0.613	55.1323	1863.26				32.0	32.0	1		None	1
21	32° 75% Wind-SW-150m	0.613	47.7461	1397.45				32.0	32.0	1		None	1
22	32° 29% Wind-SW-150m	0.613	29.6895	540.34				32.0	32.0	1		None	1
23	32° Full Wind-200m	0.613	49.7957	1520				32.0	32.0	1		None	1
24	32° 75% Wind-200m	0.613	43.1243	1140				32.0	32.0	1		None	1
25	32° 26.5% Wind-200m	0.613	25.6339	402.8				32.0	32.0	1		None	1
26	32° Full Wind-SW-200m	0.613	55.1323	1863.26				32.0	32.0	1		None	1
27	32° 75% Wind-SW-200m	0.613	47.7461	1397.45				32.0	32.0	1		None	1
28	32° 26.5% Wind-SW-200m	0.613	28.381	493.76				32.0	32.0	1		None	1
29	EMF 80° 5% Wind-350m	0.613	15.7468	152				80.0	32.0	1		None	1
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Modeling of Weather Cases for 220kV TL

Weather Cases

See Criteria/Code Specific Wind and Terrain Parameters for more information on height adjustments and gust response factors.

	Description	Air Density Factor (Q) (kg/m^3) (Pa/(m/s)^2)	Wind Velocity (m/s)	Wind Pressure (Pa)	Wire Ice Thickness (cm)	Wire Ice Density (daN/dm^3)	Wire Ice Load (daN/m)	Wire Temp. (deg C)	Ambient Temp. (deg C)	Weather Load Factor	NESC Constant (daN/m)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	0° Nil Wind	0.613								1		None	1
2	32° Nil Wind	0.613						32.0	32.0	1		None	1
3	53° Nil Wind	0.613						53.0	53.0	1		None	1
4	80° Nil Wind	0.613						80.0	32.0	1		None	1
5	32° Full Wind-350m	0.613	51.3773	1618.09				32.0	32.0	1		None	1
6	32° 75% Wind-350m	0.613	44.5031	1214.06				32.0	32.0	1		None	1
7	32° 20.5% Wind-350m	0.613	23.2618	331.7				32.0	32.0	1		None	1
8	32° Full Wind-SW-350m	0.613	56.7059	1971.14				32.0	32.0	1		None	1
9	32° 75% Wind-SW-350m	0.613	49.1168	1478.84				32.0	32.0	1		None	1
10	32° 20.5% Wind-SW-350m	0.613	25.6746	404.08				32.0	32.0	1		None	1
11	32° Full Wind-250m	0.613	51.3773	1618.09				32.0	32.0	1		None	1
12	32° 75% Wind-250m	0.613	44.5031	1214.06				32.0	32.0	1		None	1
13	32° 21% Wind-250m	0.613	23.5441	339.8				32.0	32.0	1		None	1
14	32° Full Wind-SW-250m	0.613	56.7059	1971.14				32.0	32.0	1		None	1
15	32° 75% Wind-SW-250m	0.613	49.1168	1478.84				32.0	32.0	1		None	1
16	32° 21% Wind-SW-250m	0.613	25.9859	413.94				32.0	32.0	1		None	1
17	32° Full Wind-150m	0.613	51.7342	1640.65				32.0	32.0	1		None	1
18	32° 75% Wind-150m	0.613	44.803	1230.48				32.0	32.0	1		None	1
19	32° 22.5% Wind-150m	0.613	24.5395	369.14				32.0	32.0	1		None	1
20	32° Full Wind-SW-150m	0.613	56.7059	1971.14				32.0	32.0	1		None	1
21	32° 75% Wind-SW-150m	0.613	49.1168	1478.84				32.0	32.0	1		None	1
22	32° 22.5% Wind-SW-150m	0.613	26.8978	443.5				32.0	32.0	1		None	1
23													

Modeling of Weather Cases for 400kV TL

Weather Cases

See Criteria/Code Specific Wind and Terrain Parameters for more information on height adjustments and gust response factors.

	Description	Air Density Factor (Q) (kg/m^3) (Pa/(m/s)^2)	Wind Velocity (m/s)	Wind Pressure (Pa)	Wire Ice Thickness (cm)	Wire Ice Density (daN/dm^3)	Wire Ice Load (daN/m)	Wire Temp. (deg C)	Ambient Temp. (deg C)	Weather Load Factor	NESC Constant (daN/m)	Wire Wind Height Adjust Model	Wire Gust Response Factor
1	-5° Nil Wind	0.613						-5.0	-5.0	1		None	1
2	32° Nil Wind	0.613						32.0	32.0	1		None	1
3	53° Nil Wind	0.613						53.0	53.0	1		None	1
4	85° Nil Wind	0.613						85.0	32.0	1		None	1
5	32° Full Wind-400m	0.613	57.3049	2013				32.0	32.0	1		None	1
6	32° 75% Wind-400m	0.613	49.6275	1509.75				32.0	32.0	1		None	1
7	32° 19.2% Wind-400m	0.613	25.1099	386.5				32.0	32.0	1		None	1
8	32° Full Wind-SW-400m	0.613	63.8871	2502				32.0	32.0	1		None	1
9	32° 75% Wind-SW-400m	0.613	55.3279	1876.5				32.0	32.0	1		None	1
10	32° 19.2% Wind-SW-400m	0.613	27.9944	480.4				32.0	32.0	1		None	1
11	32° Full Wind-300m	0.613	58.1105	2070				32.0	32.0	1		None	1
12	32° 75% Wind-300m	0.613	50.3252	1552.5				32.0	32.0	1		None	1
13	32° 19% Wind-300m	0.613	25.3298	393.3				32.0	32.0	1		None	1
14	32° Full Wind-SW-300m	0.613	64.7495	2570				32.0	32.0	1		None	1
15	32° 75% Wind-SW-300m	0.613	56.0747	1927.5				32.0	32.0	1		None	1
16	32° 19% Wind-SW-300m	0.613	28.2236	488.3				32.0	32.0	1		None	1
17	32° Full Wind-200m	0.613	58.6693	2110				32.0	32.0	1		None	1
18	32° 75% Wind-200m	0.613	50.8091	1582.5				32.0	32.0	1		None	1
19	32° 19.2% Wind-200m	0.613	25.7076	405.12				32.0	32.0	1		None	1
20	32° Full Wind-SW-200m	0.613	65.6254	2640				32.0	32.0	1		None	1
21	32° 75% Wind-SW-200m	0.613	56.8332	1980				32.0	32.0	1		None	1
22	32° 19.2% Wind-SW-200m	0.613	28.7556	506.88				32.0	32.0	1		None	1
23	85° 16.5% Wind-400m	0.613	23.2774	332.145				85.0	32.0	1		None	1
24													

Modeling of Sagging Criteria for 132kV TL

Automatic Sagging Criteria

	Weather Case	Cable Condition	% of Ultimate	Maximum Tension (daN)	Maximum Catenary (m)	Applicable Cable (blank=all cables)
1	32° Nil Wind	Initial RS		2494.800		bear_acsr_350m.wir
2	32° Full Wind-350m	Initial RS		5470.800		bear_acsr_350m.wir
3	32° Nil Wind	Initial RS		1300.000		OPGW-11.4mm_350m.wir
4	32° Full Wind-SW-350m	Initial RS		3220.000		OPGW-11.4mm_350m.wir
5	0° Nil Wind	Initial RS		1349.000		OPGW-11.4mm_350m.wir
6	32° Nil Wind	Initial RS		2494.800		bear_acsr_250m.wir
7	32° Full Wind-250m	Initial RS		4835.000		bear_acsr_250m.wir
8	32° Nil Wind	Initial RS		1400.000		OPGW-11.4mm_250m.wir
9	32° Full Wind-SW-250m	Initial RS		2837.000		OPGW-11.4mm_250m.wir
10	0° Nil Wind	Initial RS		1473.000		OPGW-11.4mm_250m.wir
11	32° Nil Wind	Initial RS		2494.800		bear_acsr_200m.wir
12	32° Full Wind-200m	Initial RS		4439.000		bear_acsr_200m.wir
13	32° Nil Wind	Initial RS		1461.000		OPGW-11.4mm_200m.wir
14	32° Full Wind-SW-200m	Initial RS		2609.000		OPGW-11.4mm_200m.wir
15	0° Nil Wind	Initial RS		1546.000		OPGW-11.4mm_200m.wir
16	32° Nil Wind	Initial RS		2494.800		bear_acsr_150m.wir
17	32° Full Wind-150m	Initial RS		3980.000		bear_acsr_150m.wir
18	32° Nil Wind	Initial RS		1524.000		OPGW-11.4mm_150m.wir
19	32° Full Wind-SW-250m	Initial RS		2353.000		OPGW-11.4mm_150m.wir
20	0° Nil Wind	Initial RS		1619.000		OPGW-11.4mm_150m.wir
21	32° Full Wind-350m	Initial RS		5470.800		bear_acsr_500m.wir
22	32° Full Wind-SW-350m	Initial RS		3220.000		OPGW-11.4mm_500m.wir
23	32° Nil Wind	Initial RS		500.000		bear_acsr_slack.wir
24	32° Nil Wind	Initial RS		300.000		OPGW-11.4mm_slack.wir
25						

Modeling of Sagging Criteria for 220kV TL

Automatic Sagging Criteria

	Weather Case	Cable Condition	% of Ultimate	Maximum Tension (daN)	Maximum Catenary (m)	Applicable Cable (blank=all cables)
1	32° Nil Wind	Initial RS		2712.000		bison_acsr_350m.wir
2	32° Full Wind-350m	Initial RS		6460.000		bison_acsr_350m.wir
3	32° Nil Wind	Initial RS		1061.000		ew-10.05mm_350m.wir
4	32° Full Wind-SW-350m	Initial RS		2897.000		ew-10.05mm_350m.wir
5	0° Nil Wind	Initial RS		1208.000		ew-10.05mm_350m.wir
6	32° Nil Wind	Initial RS		1061.000		OPGW-11.4mm_350m.wir
7	32° Full Wind-SW-350m	Initial RS		3099.000		OPGW-11.4mm_350m.wir
8	0° Nil Wind	Initial RS		1226.000		OPGW-11.4mm_350m.wir
9	32° Nil Wind	Initial RS		2712.000		bison_acsr_250m.wir
10	32° Full Wind-250m	Initial RS		5737.000		bison_acsr_250m.wir
11	32° Nil Wind	Initial RS		1103.000		ew-10.05mm_250m.wir
12	32° Full Wind-SW-250m	Initial RS		2547.000		ew-10.05mm_250m.wir
13	0° Nil Wind	Initial RS		1344.000		ew-10.05mm_250m.wir
14	32° Nil Wind	Initial RS		1288.000		OPGW-11.4mm_250m.wir
15	32° Full Wind-SW-250m	Initial RS		2848.000		OPGW-11.4mm_250m.wir
16	0° Nil Wind	Initial RS		1355.000		OPGW-11.4mm_250m.wir
17	32° Nil Wind	Initial RS		2712.000		bison_acsr_150m.wir
18	32° Full Wind-150m	Initial RS		4746.000		bison_acsr_150m.wir
19	32° Nil Wind	Initial RS		1184.000		ew-10.05mm_150m.wir
20	32° Full Wind-SW-150m	Initial RS		2088.000		ew-10.05mm_150m.wir
21	0° Nil Wind	Initial RS		1540.000		ew-10.05mm_150m.wir
22	32° Nil Wind	Initial RS		1459.000		OPGW-11.4mm_150m.wir
23	32° Full Wind-SW-150m	Initial RS		2370.000		OPGW-11.4mm_150m.wir
24	0° Nil Wind	Initial RS		1553.000		OPGW-11.4mm_150m.wir
25	32° Nil Wind	Initial RS		300.000		ew-10.05mm_slack.wir
26	32° Nil Wind	Initial RS		300.000		OPGW-11.4mm_slack.wir
27	32° Nil Wind	Initial RS		800.000		bison_acsr_slack.wir
28	32° Full Wind-350m	Initial RS		6460.000		bison_acsr_500m.wir
29	32° Full Wind-SW-350m	Initial RS		2897.000		ew-10.05mm_500m.wir
30	32° Full Wind-SW-350m	Initial RS		3099.000		OPGW-11.4mm_500m.wir
31						

Modeling of Sagging Criteria for 400kV TL

Automatic Sagging Criteria

	Weather Case	Cable Condition	% of Ultimate	Maximum Tension (daN)	Maximum Catenary (m)	Applicable Cable (blank=all cables)
1	32° Nil Wind	Initial RS		3616.000		moose_acsr_400m.wir
2	32° Full Wind-400m	Initial RS		9363.000		moose_acsr_400m.wir
3	32° Nil Wind	Initial RS		1221.000		ew-10.98mm_400m.wir
4	32° Full Wind-SW-400m	Initial RS		3923.000		ew-10.98mm_400m.wir
5	-5° Nil Wind	Initial RS		1373.000		ew-10.98mm_400m.wir
6	32° Nil Wind	Initial RS		1116.000		OPGW-11.4mm_400m.wir
7	32° Full Wind-SW-400m	Initial RS		3868.000		OPGW-11.4mm_400m.wir
8	-5° Nil Wind	Initial RS		1152.000		OPGW-11.4mm_400m.wir
9	32° Nil Wind	Initial RS		3616.000		moose_acsr_300m.wir
10	32° Full Wind-300m	Initial RS		8674.000		moose_acsr_300m.wir
11	32° Nil Wind	Initial RS		1257.000		ew-10.98mm_300m.wir
12	32° Full Wind-SW-300m	Initial RS		3577.000		ew-10.98mm_300m.wir
13	-5° Nil Wind	Initial RS		1511.000		ew-10.98mm_300m.wir
14	32° Nil Wind	Initial RS		1207.000		OPGW-11.4mm_300m.wir
15	32° Full Wind-SW-300m	Initial RS		3518.000		OPGW-11.4mm_300m.wir
16	-5° Nil Wind	Initial RS		1267.000		OPGW-11.4mm_300m.wir
17	32° Nil Wind	Initial RS		3616.000		moose_acsr_200m.wir
18	32° Full Wind-200m	Initial RS		7522.000		moose_acsr_200m.wir
19	32° Nil Wind	Initial RS		1336.000		ew-10.98mm_200m.wir
20	32° Full Wind-SW-200m	Initial RS		3077.000		ew-10.98mm_200m.wir
21	-5° Nil Wind	Initial RS		1753.000		ew-10.98mm_200m.wir
22	32° Nil Wind	Initial RS		1375.000		OPGW-11.4mm_200m.wir
23	32° Full Wind-SW-200m	Initial RS		3032.000		OPGW-11.4mm_200m.wir
24	-5° Nil Wind	Initial RS		1470.000		OPGW-11.4mm_200m.wir
25	32° Nil Wind	Initial RS		1000.000		moose_acsr_slack.wir
26	32° Nil Wind	Initial RS		310.000		ew-10.98mm_slack.wir
27	32° Nil Wind	Initial RS		280.000		OPGW-11.4mm_slack.wir
28	32° Full Wind-400m	Initial RS		9363.000		moose_acsr_500m.wir
29	32° Full Wind-SW-400m	Initial RS		3923.000		ew-10.98mm_500m.wir
30	32° Full Wind-SW-400m	Initial RS		3868.000		OPGW-11.4mm_500m.wir
31						

Modeling of I-String Suspension Tower for 132kV TL

Structure Data Editor

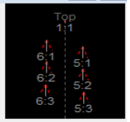
Structure file name F:\0 M-Study\Initial Model...\350m_132KV-DA-I STRING.stk

Description DA SUSPENSION TOWER - I STRING

Height (ground to top of structure) (m) 29.59

Embedded length (for report purposes only) (m)

Lowest wire attachment point height above ground (m) 17.25



	Set #	Phase #	Dead End Set	Set Description	Insulator Type	Insul. Weight (N)	Insul. Wind Area (cm^2)	Insul. Length (m)	Attach. Trans. Offset (m)	Attach. Dist. Below Top (m)	Attach. Longit. Offset (m)	Min. Req. Vertical Load (uplift) (N)	Allowable Suspension, Lambda, Double Sus Swing Angles and 2-Part Load Angles min,max for 4 conditions (deg)	Draw Sheds	Side Sep. or Roll Angle (deg)	Insul. Weight Side 2 (N)	Insul. Wind Area Side 2 (cm^2)	Insul. Length Side 2 (m)	Attach. Trans. Offset Side 2 (m)	Attach. Dist. Below Top Side 2 (m)	Attach. Longit. Offset Side 2 (m)	Suspension or 2-Part Side 1 Tension Only	2-Part Tension Only Side 2	2-Part Bottom Right
1	1	1	No	OPGW	Suspension	100.00	10.00	0.25				No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
2	5	1	No	132KV-CKT-A	Suspension	2000.00	3500.00	1.75	3.06	3.54		No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
3	5	2	NA	NA	Suspension	2000.00	3500.00	1.75	3.15	7.05		No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
4	5	3	NA	NA	Suspension	2000.00	3500.00	1.75	3.30	10.59		No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
5	6	1	No	132KV-CKT-B	Suspension	2000.00	3500.00	1.75	-3.06	3.54		No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
6	6	2	NA	NA	Suspension	2000.00	3500.00	1.75	-3.15	7.05		No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
7	6	3	NA	NA	Suspension	2000.00	3500.00	1.75	-3.30	10.59		No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
8			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Modeling of V-String Suspension Tower for 220kV TL

Structure Data Editor

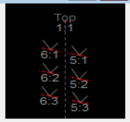
Structure file name F:\0 M-Study\Initial Mode...\350m_132KV-DA-V STRING.stk

Description DA SUSPENSION TOWER - V STRING

Height (ground to top of structure) (m) 29.59

Embedded length (for report purposes only) (m)

Lowest wire attachment point height above ground (m) 17.80

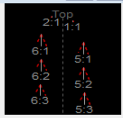


	Set #	Phase #	Dead End Set	Set Description	Insulator Type	Insul. Weight (N)	Insul. Wind Area (cm^2)	Insul. Length (m)	Attach. Trans. Offset (m)	Attach. Dist. Below Top (m)	Attach. Longit. Offset (m)	Min. Req. Vertical Load (uplift) (N)	Allowable Suspension, Lambda, Double Sus Swing Angles and 2-Part Load Angles min,max for 4 conditions (deg)	Draw Sheds	Side Sep. or Roll Angle (deg)	Insul. Weight Side 2 (N)	Insul. Wind Area Side 2 (cm^2)	Insul. Length Side 2 (m)	Attach. Trans. Offset Side 2 (m)	Attach. Dist. Below Top Side 2 (m)	Attach. Longit. Offset Side 2 (m)	Suspension or 2-Part Side 1 Tension Only	2-Part Tension Only Side 2	2-Part Bottom Right
1	1	1	No	OPGW	Suspension	100.00	10.00	0.25				No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
2	5	1	No	132KV-CKT-A	2-Part	2000.00	2500.00	1.75	3.56	3.54		No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	2000.00	2500.00	1.75	1.07	3.54		No	No	Yes
3	5	2	NA	NA	2-Part	2000.00	2500.00	1.75	3.65	7.05		No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	2000.00	2500.00	1.75	1.16	7.05		No	No	Yes
4	5	3	NA	NA	2-Part	2000.00	2500.00	1.75	3.80	10.59		No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	2000.00	2500.00	1.75	1.25	10.59		No	No	Yes
5	6	1	No	132KV-CKT-B	2-Part	2000.00	2500.00	1.75	-3.56	3.54		No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	2000.00	2500.00	1.75	-1.07	3.54		No	No	Yes
6	6	2	NA	NA	2-Part	2000.00	2500.00	1.75	-3.65	7.05		No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	2000.00	2500.00	1.75	-1.16	7.05		No	No	Yes
7	6	3	NA	NA	2-Part	2000.00	2500.00	1.75	-3.80	10.59		No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	2000.00	2500.00	1.75	-1.25	10.59		No	No	Yes
8			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Modeling of I-String Suspension Tower for 220kV TL

Structure Data Editor

Structure file name F:\0 M-Study\Initial Model...\350m_220KV-DA-I STRING.stk
Description DA SUSPENSION TOWER - I STRING
Height (ground to top of structure) (m) 37.18
Embedded length (for report purposes only) (m)
Lowest wire attachment point height above ground (m) 17.88

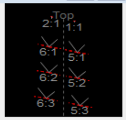


	Set #	Phase #	Dead End Set	Set Description	Insulator Type	Insul. Weight (N)	Insul. Wind Area (cm^2)	Insul. Length (m)	Attach. Trans. Offset (m)	Attach. Dist. Below Top (m)	Attach. Longit. Offset (m)	Min. Req. Vertical Load (uplift) (N)	Allowable Suspension, Lambda, Double Sus Swing Angles and 2-Part Load Angles min,max for 4 conditions (deg)	Draw Sheds	Side Sep. or Roll Angle (deg)	Insul. Weight Side 2 (N)	Insul. Wind Area Side 2 (cm^2)	Insul. Length Side 2 (m)	Attach. Trans. Offset Side 2 (m)	Attach. Dist. Below Top Side 2 (m)	Attach. Longit. Offset Side 2 (m)	Suspension or 2-Part Side 1 Tension Only	2-Part Tension Only Side 2	2-Part Bottom Right
1	1	1	No	OPGW	Suspension	100.00	10.00	0.25	2.72			No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
2	2	1	No	OHGW	Suspension	100.00	10.00	0.25	-2.72			No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
3	5	1	No	220KV-CKT-A	Suspension	2000.00	3500.00	2.75	5.30	4.80		No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
4	5	2	NA	NA	Suspension	2000.00	3500.00	2.75	5.45	10.65		No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
5	5	3	NA	NA	Suspension	2000.00	3500.00	2.75	5.60	16.55		No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
6	6	1	No	220KV-CKT-B	Suspension	2000.00	3500.00	2.75	-5.30	4.80		No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
7	6	2	NA	NA	Suspension	2000.00	3500.00	2.75	-5.45	10.65		No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
8	6	3	NA	NA	Suspension	2000.00	3500.00	2.75	-5.60	16.55		No Uplift	-30,30 -30,30 -30,30 -30,30	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
9			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Modeling of V-String Suspension Tower for 220kV TL

Structure Data Editor

Structure file name F:\0 M-Study\Initial Mode...\350m_220KV-DA-V STRING.stk
Description DA SUSPENSION TOWER - V STRING
Height (ground to top of structure) (m) 37.18
Embedded length (for report purposes only) (m)
Lowest wire attachment point height above ground (m) 18.69

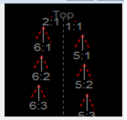


	Set #	Phase #	Dead End Set	Set Description	Insulator Type	Insul. Weight (N)	Insul. Wind Area (cm^2)	Insul. Length (m)	Attach. Trans. Offset (m)	Attach. Dist. Below Top (m)	Attach. Longit. Offset (m)	Min. Req. Vertical Load (uplift) (N)	Allowable Suspension, Lambda, Double Sus Swing Angles and 2-Part Load Angles min,max for 4 conditions (deg)	Draw Sheds	Side Sep. or Roll Angle (deg)	Insul. Weight Side 2 (N)	Insul. Wind Area Side 2 (cm^2)	Insul. Length Side 2 (m)	Attach. Trans. Offset Side 2 (m)	Attach. Dist. Below Top Side 2 (m)	Attach. Longit. Offset Side 2 (m)	Suspension or 2-Part Side 1 Tension Only	2-Part Tension Only Side 2	2-Part Bottom Right
1	1	1	No	OPGW	Suspension	100.00	10.00	0.25	2.72			No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
2	2	1	No	OHGW	Suspension	100.00	10.00	0.25	-2.72			No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
3	5	1	No	220KV-CKT-A	2-Part	2000.00	2500.00	2.75	5.30	4.80		No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	2000.00	2500.00	2.75	1.40	4.80		No	No	Yes
4	5	2	NA	NA	2-Part	2000.00	2500.00	2.75	5.45	10.65		No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	2000.00	2500.00	2.75	1.55	10.65		No	No	Yes
5	5	3	NA	NA	2-Part	2000.00	2500.00	2.75	6.10	16.55		No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	2000.00	2500.00	2.75	2.20	16.55		No	No	Yes
6	6	1	No	220KV-CKT-B	2-Part	2000.00	2500.00	2.75	-5.30	4.80		No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	2000.00	2500.00	2.75	-1.40	4.80		No	No	Yes
7	6	2	NA	NA	2-Part	2000.00	2500.00	2.75	-5.45	10.65		No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	2000.00	2500.00	2.75	-1.55	10.65		No	No	Yes
8	6	3	NA	NA	2-Part	2000.00	2500.00	2.75	-6.10	16.55		No Uplift	-90,90 -90,90 -90,90 -90,90	Yes	NA	2000.00	2500.00	2.75	-2.20	16.55		No	No	Yes
9			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Modeling of I-String Suspension Tower for 400kV TL

Structure Data Editor

Structure file name F:\0 M-Study\Initial Model...\400m_400KV-DA-I STRING.stk
Description DA SUSPENSION TOWER - I STRING
Height (ground to top of structure) (m) 51.76
Embedded length (for report purposes only) (m)
Lowest wire attachment point height above ground (m) 23.15



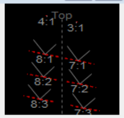
	Set #	Phase #	Dead End Set	Set Description	Insulator Type	Insul. Weight (N)	Insul. Wind Area (cm^2)	Insul. Length (m)	Attach. Trans. Offset (m)	Attach. Dist. Below Top (m)	Attach. Longit. Offset (m)	Min. Req. Vertical Load (uplift) (N)	Allowable Suspension, Lambda, Double Sus Swing Angles and 2-Part Load Angles min,max for 4 conditions (deg)
1	1	1	No	OPGW	Suspension	100.00	9.29	0.25	4.14			No Uplift	-30,30 -30,30 -30,30 -30,30
2	2	1	No	OHGW	Suspension	100.00	9.29	0.25	-4.14			No Uplift	-30,30 -30,30 -30,30 -30,30
3	5	1	No	400KV-CKT-A	Suspension	4300.01	6995.60	5.20	7.04	3.96		No Uplift	-30,30 -30,30 -30,30 -30,30
4	5	2	NA	NA	Suspension	4300.01	6995.60	5.20	7.63	13.61		No Uplift	-30,30 -30,30 -30,30 -30,30
5	5	3	NA	NA	Suspension	4300.01	6995.60	5.20	8.80	23.41		No Uplift	-30,30 -30,30 -30,30 -30,30
6	6	1	No	400KV-CKT-B	Suspension	4300.01	6995.60	5.20	-7.04	3.96		No Uplift	-30,30 -30,30 -30,30 -30,30
7	6	2	NA	NA	Suspension	4300.01	6995.60	5.20	-7.63	13.61		No Uplift	-30,30 -30,30 -30,30 -30,30
8	6	3	NA	NA	Suspension	4300.01	6995.60	5.20	-8.80	23.41		No Uplift	-30,30 -30,30 -30,30 -30,30
9			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

	Draw Sheds	Side Sep. or Roll Angle (deg)	Insul. Weight Side 2 (N)	Insul. Wind Area Side 2 (cm^2)	Insul. Length Side 2 (m)	Attach. Trans. Offset Side 2 (m)	Attach. Dist. Below Top Side 2 (m)	Attach. Longit. Offset Side 2 (m)	Suspension or 2-Part Side 1 Tension Only	2-Part Tension Only Side 2	2-Part Bottom Right
1	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
2	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
3	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
4	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
5	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
6	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
7	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
8	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Modeling of V-String Suspension Tower for 400kV TL

Structure Data Editor

Structure file name F:\0 M-Study\Initial Mode...\400m_400KV-DA-V STRING.stk
Description DA SUSPENSION TOWER - V STRING
Height (ground to top of structure) (m) 49.00
Embedded length (for report purposes only) (m)
Lowest wire attachment point height above ground (m) 23.35



	Set #	Phase #	Dead End Set	Set Description	Insulator Type	Insul. Weight (N)	Insul. Wind Area (cm^2)	Insul. Length (m)	Attach. Trans. Offset (m)	Attach. Dist. Below Top (m)	Attach. Longit. Offset (m)	Min. Req. Vertical Load (uplift) (N)	Allowable Suspension, Lambda, Double Sus Swing Angles and 2-Part Load Angles min,max for 4 conditions (deg)
1	3	1	No	OPGW	Suspension	100.00	10.00	0.25	5.00			No Uplift	-90,90 -90,90 -90,90 -90,90
2	4	1	No	OHGW	Suspension	100.00	10.00	0.25	-5.00			No Uplift	-90,90 -90,90 -90,90 -90,90
3	7	1	No	400KV-CKT-A	2-Part	4300.00	5000.00	5.20	9.23	8.00		No Uplift	-90,90 -90,90 -90,90 -90,90
4	7	2	NA	NA	2-Part	4300.00	5000.00	5.20	9.83	15.00		No Uplift	-90,90 -90,90 -90,90 -90,90
5	7	3	NA	NA	2-Part	4300.00	5000.00	5.20	11.00	22.00		No Uplift	-90,90 -90,90 -90,90 -90,90
6	8	1	No	400KV-CKT-B	2-Part	4300.00	5000.00	5.20	-9.23	8.00		No Uplift	-90,90 -90,90 -90,90 -90,90
7	8	2	NA	NA	2-Part	4300.00	5000.00	5.20	-9.83	15.00		No Uplift	-90,90 -90,90 -90,90 -90,90
8	8	3	NA	NA	2-Part	4300.00	5000.00	5.20	-11.00	22.00		No Uplift	-90,90 -90,90 -90,90 -90,90
9			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

	Draw Sheds	Side Sep. or Roll Angle (deg)	Insul. Weight Side 2 (N)	Insul. Wind Area Side 2 (cm^2)	Insul. Length Side 2 (m)	Attach. Trans. Offset Side 2 (m)	Attach. Dist. Below Top Side 2 (m)	Attach. Longit. Offset Side 2 (m)	Suspension or 2-Part Side 1 Tension Only	2-Part Tension Only Side 2	2-Part Bottom Right
1	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
2	Yes	NA	NA	NA	NA	NA	NA	NA	No	NA	NA
3	Yes	NA	4300.00	5000.00	5.20	1.90	8.00		No	No	Yes
4	Yes	NA	4300.00	5000.00	5.20	2.50	15.00		No	No	Yes
5	Yes	NA	4300.00	5000.00	5.20	3.60	22.00		No	No	Yes
6	Yes	NA	4300.00	5000.00	5.20	-1.90	8.00		No	No	Yes
7	Yes	NA	4300.00	5000.00	5.20	-2.50	15.00		No	No	Yes
8	Yes	NA	4300.00	5000.00	5.20	-3.60	22.00		No	No	Yes
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

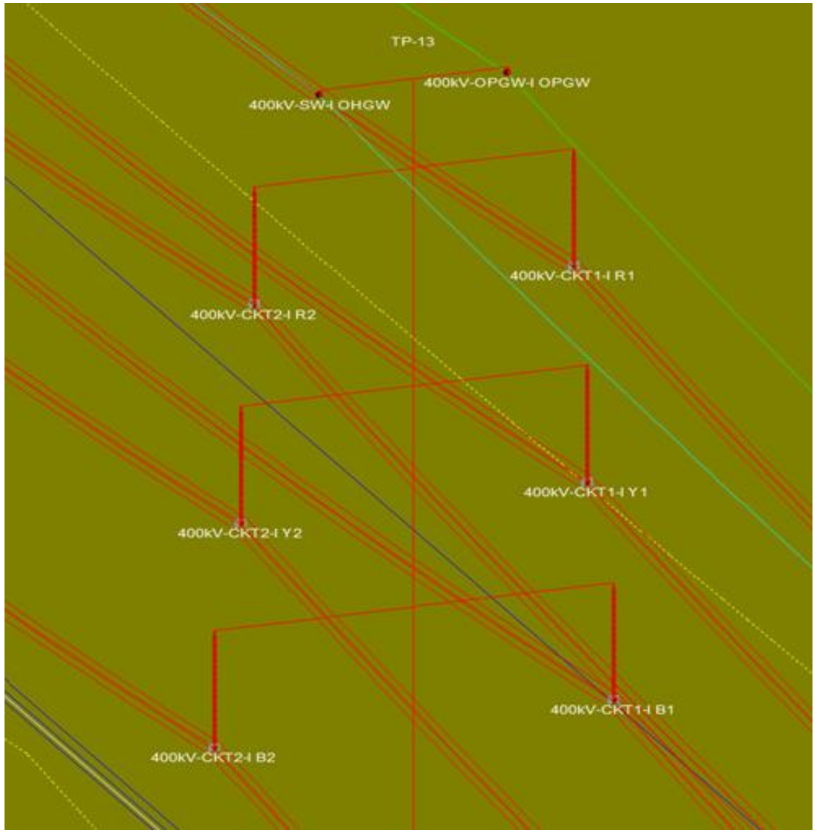


Figure-1: I-String in PLS-CADD Model

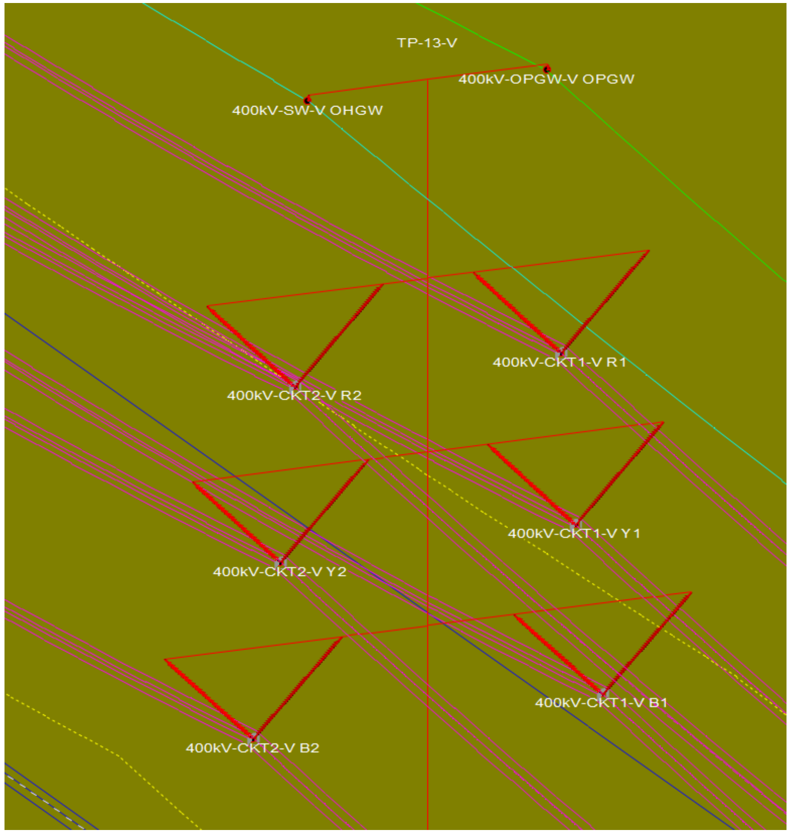


Figure-2: V-String in PLS-CADD Model

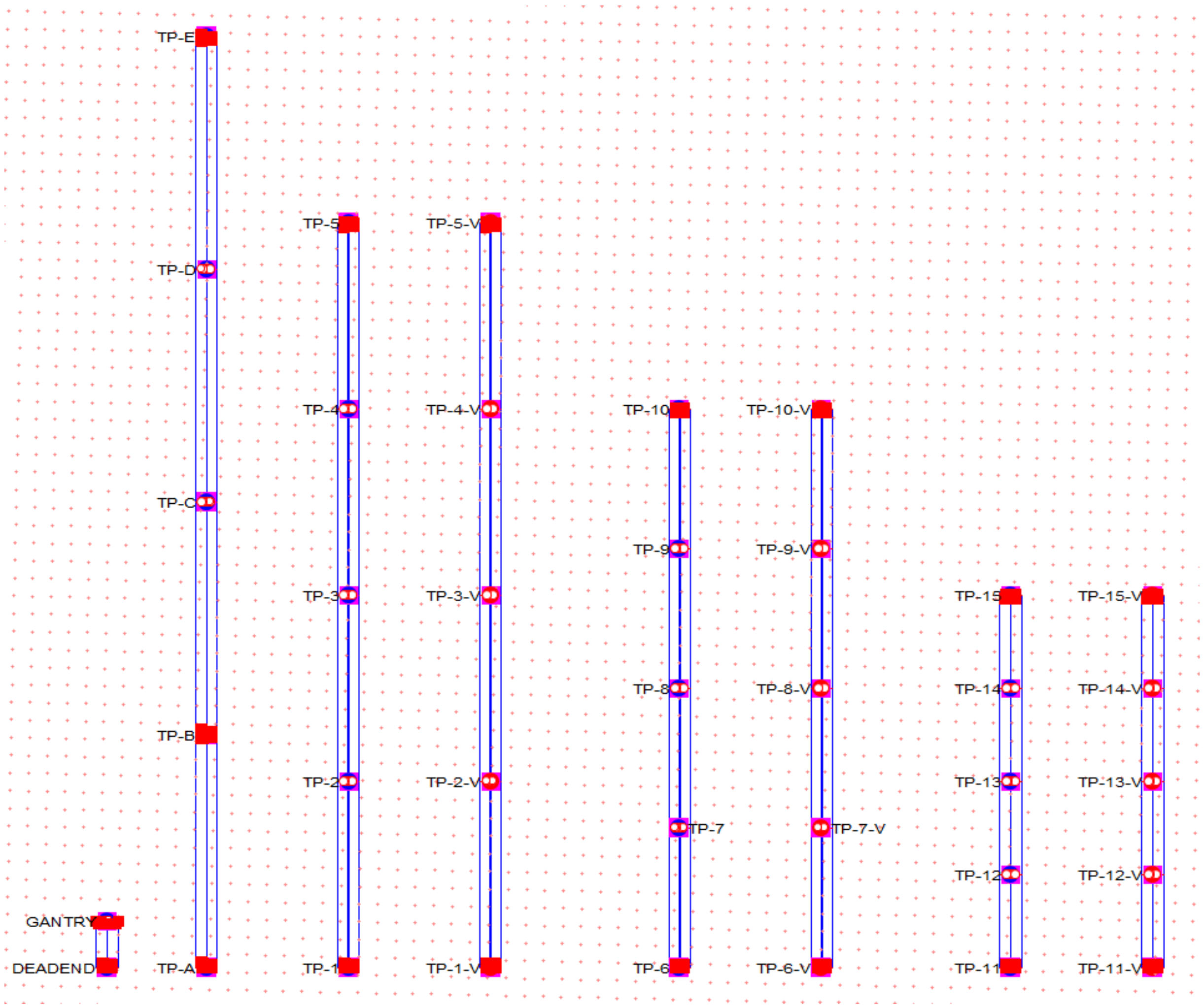


Figure-3: Plan View in PLS-CADD Model

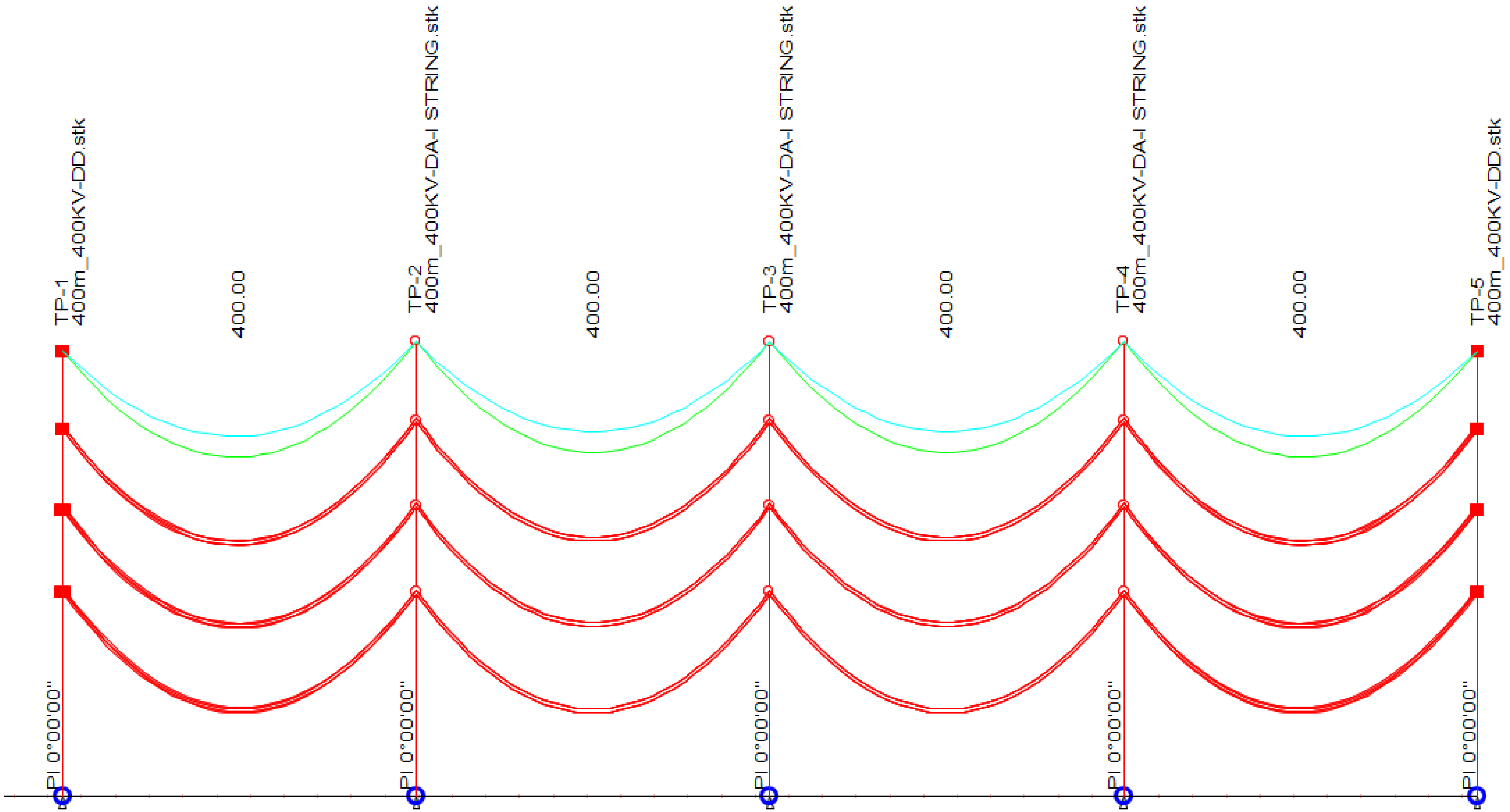


Figure-4: Profile View in PLS-CADD Model

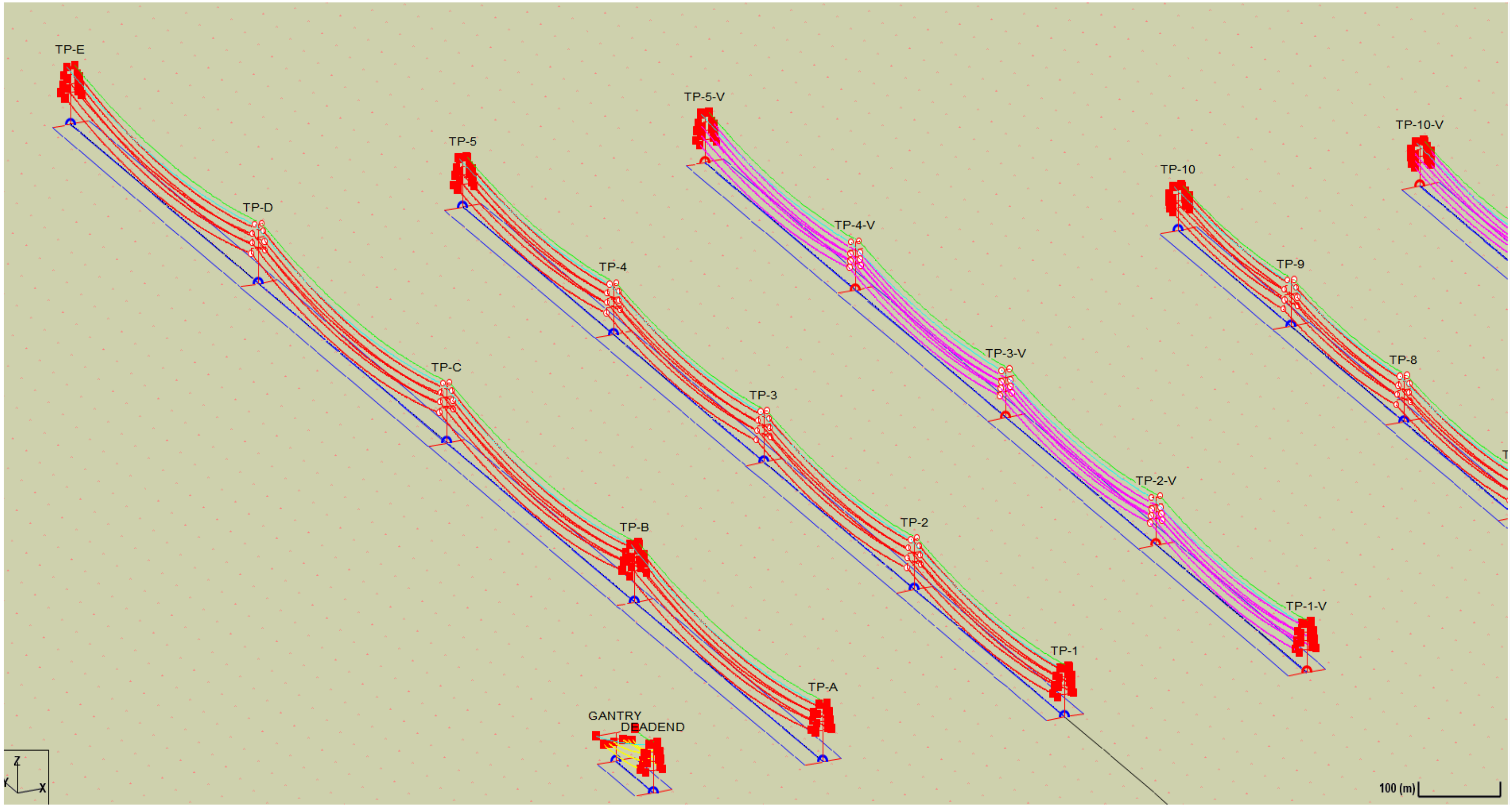


Figure-5: 3D View in PLS-CADD Model

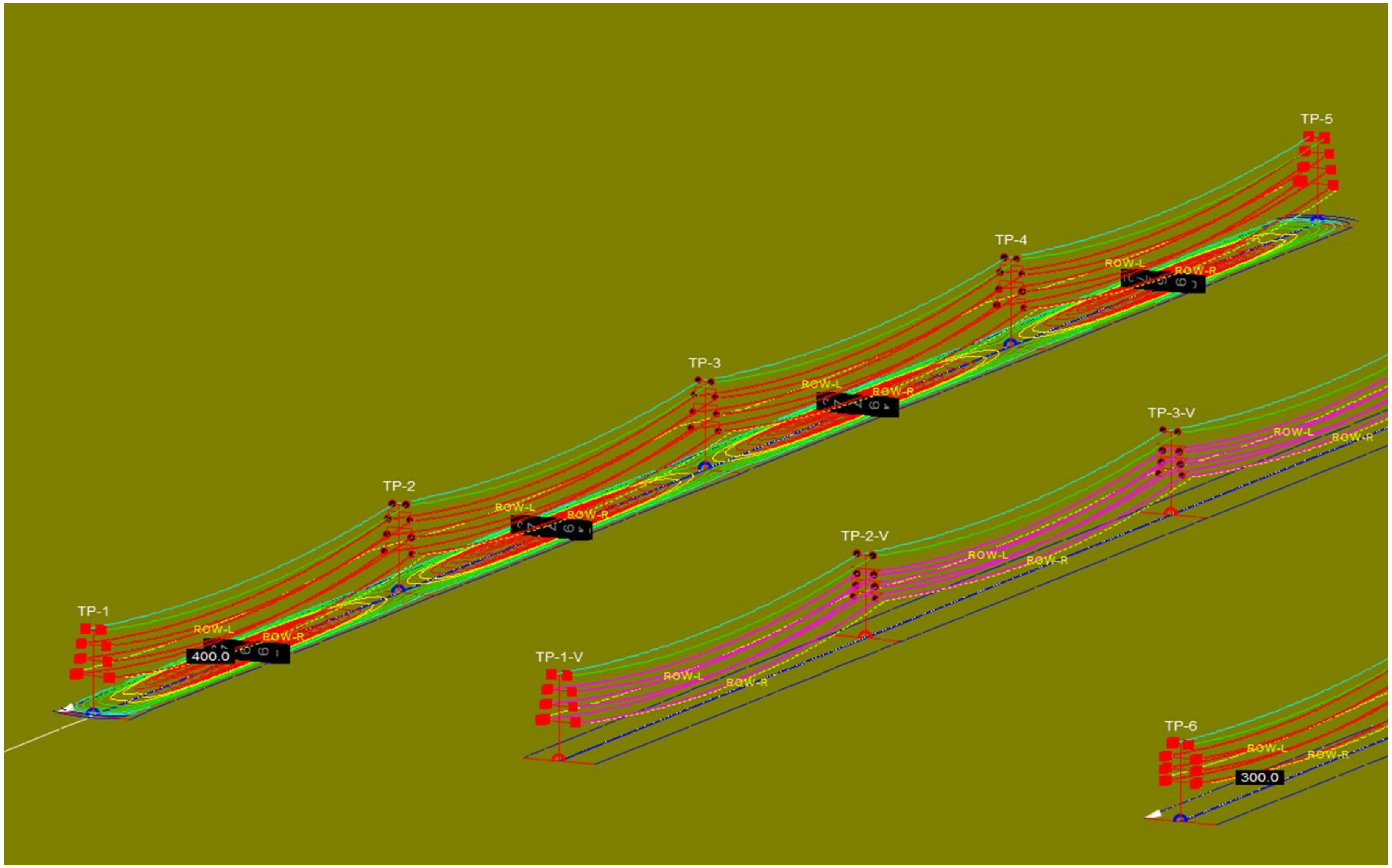


Figure-6: Electric Field and Magnetic Field Contours below TL in PLS-CADD Model

APPENDIX- F: CONDUCTOR BLOWOUT REPORTS

Report Index – 400kV TL Conductor Blowout Reports

S.N.	Voltage Level (kV)	Conductor	Span (m)	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
1	400kV	ACSR Moose	400m	I-String	30°	386.5 Pa	17.5m
2				V-String	N/A	386.5 Pa	13.4m
3			300m	I-String	30°	393.3 Pa	15.0m
4				V-String	N/A	393.3 Pa	10.8m
5			200m	I-String	30°	405.1 Pa	13.4m
6				V-String	N/A	405.1 Pa	8.93m
7			500m	I-String	30°	386.5 Pa	21.8m
8				Strain	Max. Tower Tension	386.5 Pa	21.0m
9				Strain	Max. Wire Tension	386.5 Pa	19.0m

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
1	400kV	400m	ACSR Moose	I-String	30°	386.5 Pa	17.5m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-3	1	1	TP-4	1	1	OPGW-11.4mm_400m.wir	0	32° 19.2% Wind-400m	Creep RS	Left	1000.00	12.18	1200.00	4.30	1000.00	12.18	
TP-3	1	1	TP-4	1	1	OPGW-11.4mm_400m.wir	0	32° 19.2% Wind-400m	Creep RS	Right	1200.00	3.98	1000.00	-3.90	1200.00	3.98	
TP-3	2	1	TP-4	2	1	ew-10.98mm_400m.wir	0	32° 19.2% Wind-400m	Creep RS	Left	1200.00	-4.00	1200.00	-4.00	1000.00	2.02	
TP-3	2	1	TP-4	2	1	ew-10.98mm_400m.wir	0	32° 19.2% Wind-400m	Creep RS	Right	1000.00	-10.30	1000.00	-10.30	800.00	-4.29	
TP-3	5	1	TP-4	5	1	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	1000.15	15.71	800.00	9.64	1000.15	15.71	
TP-3	5	2	TP-4	5	2	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	1000.30	16.31	800.00	10.23	1000.30	16.31	
TP-3	5	3	TP-4	5	3	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	1000.61	17.50	800.00	11.40	1000.61	17.50	
TP-3	5	1	TP-4	5	1	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	1200.00	4.49	999.54	-1.59	1200.00	4.49	
TP-3	5	2	TP-4	5	2	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	1200.00	5.08	999.55	-1.00	1200.00	5.08	
TP-3	5	3	TP-4	5	3	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	1200.01	6.27	999.39	0.17	1200.01	6.27	
TP-3	6	1	TP-4	6	1	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	1200.00	-4.49	1200.00	-4.49	999.54	1.59	
TP-3	6	2	TP-4	6	2	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	1200.00	-5.08	1200.00	-5.08	999.55	1.00	
TP-3	6	3	TP-4	6	3	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	1200.01	-6.27	1200.01	-6.27	999.39	-0.18	
TP-3	6	1	TP-4	6	1	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	1000.15	-15.70	1000.15	-15.70	800.00	-9.64	
TP-3	6	2	TP-4	6	2	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	1000.30	-16.30	1000.30	-16.30	800.00	-10.23	
TP-3	6	3	TP-4	6	3	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	1000.61	-17.49	1000.61	-17.49	800.00	-11.40	

For 0kV wires between structures TP-3, maximum offset is 12.18 (m), the leftmost offset is -10.30 (m), rightmost offset is 12.18 (m)
For 400kV wires between structures TP-3, maximum offset is 17.50 (m), the leftmost offset is -17.49 (m), rightmost offset is 17.50 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
2	400kV	400m	ACSR Moose	V-String	N/A	386.5 Pa	13.4m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-3-V	3	1	TP-4-V	3	1	OPGW-11.4mm_400m.wir	0	32° 19.2% Wind-400m	Creep RS	Left	3100.00	13.04	2900.00	5.17	3100.00	13.04	
TP-3-V	3	1	TP-4-V	3	1	OPGW-11.4mm_400m.wir	0	32° 19.2% Wind-400m	Creep RS	Right	2900.00	4.83	3100.00	-3.04	2900.00	4.83	
TP-3-V	4	1	TP-4-V	4	1	ew-10.98mm_400m.wir	0	32° 19.2% Wind-400m	Creep RS	Left	2900.00	-4.85	2900.00	-4.85	3100.00	1.16	
TP-3-V	4	1	TP-4-V	4	1	ew-10.98mm_400m.wir	0	32° 19.2% Wind-400m	Creep RS	Right	3100.00	-11.16	3100.00	-11.16	2900.00	-5.15	
TP-3-V	7	1	TP-4-V	7	1	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	3100.00	11.62	3300.00	5.57	3100.00	11.62	
TP-3-V	7	2	TP-4-V	7	2	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	3100.00	12.22	3300.00	6.17	3100.00	12.22	
TP-3-V	7	3	TP-4-V	7	3	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	3100.00	13.36	3300.00	7.30	3100.00	13.36	
TP-3-V	7	1	TP-4-V	7	1	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	3300.00	5.57	3100.00	-0.49	3300.00	5.57	
TP-3-V	7	2	TP-4-V	7	2	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	3300.00	6.17	3100.00	0.11	3300.00	6.17	
TP-3-V	7	3	TP-4-V	7	3	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	2900.00	7.30	3100.00	1.24	2900.00	7.30	
TP-3-V	8	1	TP-4-V	8	1	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	3300.00	-5.57	3300.00	-5.57	3100.00	0.49	
TP-3-V	8	2	TP-4-V	8	2	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	3300.00	-6.17	3300.00	-6.17	3100.00	-0.11	
TP-3-V	8	3	TP-4-V	8	3	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	2900.00	-7.30	2900.00	-7.30	3100.00	-1.25	
TP-3-V	8	1	TP-4-V	8	1	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	3100.00	-11.62	3100.00	-11.62	3300.00	-5.57	
TP-3-V	8	2	TP-4-V	8	2	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	3100.00	-12.22	3100.00	-12.22	3300.00	-6.17	
TP-3-V	8	3	TP-4-V	8	3	moose_acsr_400m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	3100.00	-13.35	3100.00	-13.35	3300.00	-7.30	

For 0kV wires between structures TP-3-V, maximum offset is 13.04 (m), the leftmost offset is -11.16 (m), rightmost offset is 13.04 (m)
For 400kV wires between structures TP-3-V, maximum offset is 13.36 (m), the leftmost offset is -13.35 (m), rightmost offset is 13.36 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
3	400kV	300m	ACSR Moose	I-String	30°	393.3 Pa	15.0m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt-age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-8	1	1	TP-9	1	1	OPGW-11.4mm_300m.wir	0	32° 19% Wind-300m	Creep RS	Left	4950.00	9.10	5100.00	4.31	4950.00	9.10	
TP-8	1	1	TP-9	1	1	OPGW-11.4mm_300m.wir	0	32° 19% Wind-300m	Creep RS	Right	5100.00	3.98	4950.00	-0.82	5100.00	3.98	
TP-8	2	1	TP-9	2	1	ew-10.98mm_300m.wir	0	32° 19% Wind-300m	Creep RS	Left	5100.00	-4.00	5100.00	-4.00	4950.00	-0.61	
TP-8	2	1	TP-9	2	1	ew-10.98mm_300m.wir	0	32° 19% Wind-300m	Creep RS	Right	4950.00	-7.67	4950.00	-7.67	4800.00	-4.29	
TP-8	5	1	TP-9	5	1	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Left	4952.13	13.22	4800.00	9.64	4952.13	13.22	
TP-8	5	2	TP-9	5	2	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Left	4952.89	13.85	4800.00	10.23	4952.89	13.85	
TP-8	5	3	TP-9	5	3	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Left	4953.35	15.05	4800.00	11.40	4953.35	15.05	
TP-8	5	1	TP-9	5	1	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Right	5100.01	4.66	4947.57	1.06	5100.01	4.66	
TP-8	5	2	TP-9	5	2	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Right	5100.01	5.10	4949.24	1.58	5100.01	5.10	
TP-8	5	3	TP-9	5	3	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Right	4800.00	6.20	4951.52	2.64	4800.00	6.20	
TP-8	6	1	TP-9	6	1	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Left	5100.01	-4.66	5100.01	-4.66	4947.57	-1.06	
TP-8	6	2	TP-9	6	2	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Left	5100.01	-5.10	5100.01	-5.10	4949.24	-1.58	
TP-8	6	3	TP-9	6	3	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Left	4800.00	-6.20	4800.00	-6.20	4951.52	-2.64	
TP-8	6	1	TP-9	6	1	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Right	4952.13	-13.22	4952.13	-13.22	4800.00	-9.64	
TP-8	6	2	TP-9	6	2	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Right	4952.89	-13.85	4952.89	-13.85	4800.00	-10.23	
TP-8	6	3	TP-9	6	3	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Right	4953.35	-15.05	4953.35	-15.05	4800.00	-11.40	

For 0kV wires between structures TP-8, maximum offset is 9.10 (m), the leftmost offset is -7.67 (m), rightmost offset is 9.10 (m)
For 400kV wires between structures TP-8, maximum offset is 15.05 (m), the leftmost offset is -15.05 (m), rightmost offset is 15.05 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
4	400kV	300m	ACSR Moose	V-String	N/A	393.3 Pa	10.8m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt -age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-8-V	3	1	TP-9-V	3	1	OPGW-11.4mm_300m.wir	0	32° 19% Wind-300m	Creep RS	Left	6650.00	9.96	6500.00	5.17	6650.00	9.96	
TP-8-V	3	1	TP-9-V	3	1	OPGW-11.4mm_300m.wir	0	32° 19% Wind-300m	Creep RS	Right	6500.00	4.83	6650.00	0.04	6500.00	4.83	
TP-8-V	4	1	TP-9-V	4	1	ew-10.98mm_300m.wir	0	32° 19% Wind-300m	Creep RS	Left	6500.00	-4.85	6500.00	-4.85	6650.00	-1.46	
TP-8-V	4	1	TP-9-V	4	1	ew-10.98mm_300m.wir	0	32° 19% Wind-300m	Creep RS	Right	6650.00	-8.54	6650.00	-8.54	6500.00	-5.15	
TP-8-V	7	1	TP-9-V	7	1	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Left	6650.00	9.05	6800.00	5.57	6650.00	9.05	
TP-8-V	7	2	TP-9-V	7	2	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Left	6650.00	9.65	6800.00	6.17	6650.00	9.65	
TP-8-V	7	3	TP-9-V	7	3	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Left	6650.00	10.79	6800.00	7.30	6650.00	10.79	
TP-8-V	7	1	TP-9-V	7	1	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Right	6800.00	5.57	6650.00	2.08	6800.00	5.57	
TP-8-V	7	2	TP-9-V	7	2	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Right	6800.00	6.17	6650.00	2.68	6800.00	6.17	
TP-8-V	7	3	TP-9-V	7	3	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Right	6800.00	7.30	6650.00	3.81	6800.00	7.30	
TP-8-V	8	1	TP-9-V	8	1	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Left	6800.00	-5.57	6800.00	-5.57	6650.00	-2.08	
TP-8-V	8	2	TP-9-V	8	2	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Left	6800.00	-6.17	6800.00	-6.17	6650.00	-2.68	
TP-8-V	8	3	TP-9-V	8	3	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Left	6800.00	-7.30	6800.00	-7.30	6650.00	-3.81	
TP-8-V	8	1	TP-9-V	8	1	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Right	6650.00	-9.05	6650.00	-9.05	6800.00	-5.57	
TP-8-V	8	2	TP-9-V	8	2	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Right	6650.00	-9.65	6650.00	-9.65	6800.00	-6.17	
TP-8-V	8	3	TP-9-V	8	3	moose_acsr_300m.wir	400	32° 19% Wind-300m	Creep RS	Right	6650.00	-10.79	6650.00	-10.79	6800.00	-7.30	

For 0kV wires between structures TP-8-V, maximum offset is 9.96 (m), the leftmost offset is -8.54 (m), rightmost offset is 9.96 (m)
For 400kV wires between structures TP-8-V, maximum offset is 10.79 (m), the leftmost offset is -10.79 (m), rightmost offset is 10.79 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
5	400kV	200m	ACSR Moose	I-String	30°	405.1 Pa	13.4m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-13	1	1	TP-14	1	1	OPGW-11.4mm_200m.wir	0	32° 19.2% Wind-200m	Creep RS	Left	8100.00	6.74	8200.00	4.31	8100.00	6.74	
TP-13	1	1	TP-14	1	1	OPGW-11.4mm_200m.wir	0	32° 19.2% Wind-200m	Creep RS	Right	8200.00	3.98	8099.85	1.54	8200.00	3.98	
TP-13	2	1	TP-14	2	1	ew-10.98mm_200m.wir	0	32° 19.2% Wind-200m	Creep RS	Left	8200.00	-4.00	8200.00	-4.00	8099.85	-2.48	
TP-13	2	1	TP-14	2	1	ew-10.98mm_200m.wir	0	32° 19.2% Wind-200m	Creep RS	Right	8100.00	-5.80	8100.00	-5.80	8000.00	-4.29	
TP-13	5	1	TP-14	5	1	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Left	8106.08	11.46	8000.00	9.63	8106.08	11.46	
TP-13	5	2	TP-14	5	2	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Left	8108.67	12.14	8000.00	10.22	8108.67	12.14	
TP-13	5	3	TP-14	5	3	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Left	8110.81	13.38	8000.00	11.39	8110.81	13.38	
TP-13	5	1	TP-14	5	1	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Right	8200.02	4.95	8092.39	3.06	8200.02	4.95	
TP-13	5	2	TP-14	5	2	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Right	8200.01	5.20	8097.42	3.50	8200.01	5.20	
TP-13	5	3	TP-14	5	3	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Right	8000.00	6.21	8105.18	4.41	8000.00	6.21	
TP-13	6	1	TP-14	6	1	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Left	8200.02	-4.95	8200.02	-4.95	8092.39	-3.06	
TP-13	6	2	TP-14	6	2	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Left	8200.01	-5.20	8200.01	-5.20	8097.42	-3.50	
TP-13	6	3	TP-14	6	3	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Left	8000.00	-6.21	8000.00	-6.21	8105.18	-4.41	
TP-13	6	1	TP-14	6	1	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Right	8106.08	-11.46	8106.08	-11.46	8000.00	-9.63	
TP-13	6	2	TP-14	6	2	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Right	8108.67	-12.14	8108.67	-12.14	8000.00	-10.22	
TP-13	6	3	TP-14	6	3	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Right	8110.81	-13.38	8110.81	-13.38	8000.00	-11.39	

For 0kV wires between structures TP-13, maximum offset is 6.74 (m), the leftmost offset is -5.80 (m), rightmost offset is 6.74 (m)
For 400kV wires between structures TP-13, maximum offset is 13.38 (m), the leftmost offset is -13.38 (m), rightmost offset is 13.38 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
6	400kV	200m	ACSR Moose	V-String	N/A	405.1 Pa	8.93m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt-age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-13-V	3	1	TP-14-V	3	1	OPGW-11.4mm_200m.wir	0	32° 19.2% Wind-200m	Creep RS	Left	9400.15	7.61	9300.00	5.17	9400.15	7.61	
TP-13-V	3	1	TP-14-V	3	1	OPGW-11.4mm_200m.wir	0	32° 19.2% Wind-200m	Creep RS	Right	9300.00	4.83	9400.15	2.39	9300.00	4.83	
TP-13-V	4	1	TP-14-V	4	1	ew-10.98mm_200m.wir	0	32° 19.2% Wind-200m	Creep RS	Left	9300.00	-4.85	9300.00	-4.85	9400.15	-3.33	
TP-13-V	4	1	TP-14-V	4	1	ew-10.98mm_200m.wir	0	32° 19.2% Wind-200m	Creep RS	Right	9400.15	-6.67	9400.15	-6.67	9300.00	-5.15	
TP-13-V	7	1	TP-14-V	7	1	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Left	9400.00	7.19	9500.00	5.57	9400.00	7.19	
TP-13-V	7	2	TP-14-V	7	2	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Left	9400.00	7.79	9500.00	6.17	9400.00	7.79	
TP-13-V	7	3	TP-14-V	7	3	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Left	9400.00	8.93	9500.00	7.30	9400.00	8.93	
TP-13-V	7	1	TP-14-V	7	1	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Right	9500.00	5.57	9400.00	3.94	9500.00	5.57	
TP-13-V	7	2	TP-14-V	7	2	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Right	9500.00	6.17	9400.00	4.54	9500.00	6.17	
TP-13-V	7	3	TP-14-V	7	3	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Right	9500.00	7.30	9400.00	5.67	9500.00	7.30	
TP-13-V	8	1	TP-14-V	8	1	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Left	9500.00	-5.57	9500.00	-5.57	9400.00	-3.94	
TP-13-V	8	2	TP-14-V	8	2	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Left	9500.00	-6.17	9500.00	-6.17	9400.00	-4.54	
TP-13-V	8	3	TP-14-V	8	3	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Left	9500.00	-7.30	9500.00	-7.30	9400.00	-5.67	
TP-13-V	8	1	TP-14-V	8	1	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Right	9400.00	-7.19	9400.00	-7.19	9500.00	-5.57	
TP-13-V	8	2	TP-14-V	8	2	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Right	9400.00	-7.79	9400.00	-7.79	9500.00	-6.17	
TP-13-V	8	3	TP-14-V	8	3	moose_acsr_200m.wir	400	32° 19.2% Wind-200m	Creep RS	Right	9400.00	-8.93	9400.00	-8.93	9500.00	-7.30	

For 0kV wires between structures TP-13-V, maximum offset is 7.61 (m), the leftmost offset is -6.67 (m), rightmost offset is 7.61 (m)
For 400kV wires between structures TP-13-V, maximum offset is 8.93 (m), the leftmost offset is -8.93 (m), rightmost offset is 8.93 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
7	400kV	500m	ACSR Moose	I-String	30°	386.5 Pa	21.8m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-C	1	1	TP-D	1	1	OPGW-11.4mm_500m.wir	0	32° 19.2% Wind-400m	Creep RS	Left	12050.00	16.66	12300.00	4.31	12050.00	16.66	
TP-C	1	1	TP-D	1	1	OPGW-11.4mm_500m.wir	0	32° 19.2% Wind-400m	Creep RS	Right	12050.00	-8.38	12050.00	-8.38	12300.00	3.98	
TP-C	2	1	TP-D	2	1	ew-10.98mm_500m.wir	0	32° 19.2% Wind-400m	Creep RS	Left	12050.00	6.95	12300.00	-3.99	12050.00	6.95	
TP-C	2	1	TP-D	2	1	ew-10.98mm_500m.wir	0	32° 19.2% Wind-400m	Creep RS	Right	12050.00	-15.24	12050.00	-15.24	12300.00	-4.29	
TP-C	5	1	TP-D	5	1	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	12050.00	20.04	12300.00	9.67	12050.00	20.04	
TP-C	5	2	TP-D	5	2	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	12050.00	20.65	12300.00	10.28	12050.00	20.65	
TP-C	5	3	TP-D	5	3	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	12050.00	21.84	12300.00	11.47	12050.00	21.84	
TP-C	5	1	TP-D	5	1	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	12050.00	-5.93	12050.00	-5.93	12300.00	4.45	
TP-C	5	2	TP-D	5	2	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	12050.00	-5.34	12050.00	-5.34	12300.00	5.04	
TP-C	5	3	TP-D	5	3	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	12300.00	6.22	12050.00	-4.16	12300.00	6.22	
TP-C	6	1	TP-D	6	1	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	12050.00	5.92	12300.00	-4.45	12050.00	5.92	
TP-C	6	2	TP-D	6	2	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	12050.00	5.33	12300.00	-5.04	12050.00	5.33	
TP-C	6	3	TP-D	6	3	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	12300.00	-6.22	12300.00	-6.22	12050.00	4.15	
TP-C	6	1	TP-D	6	1	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	12050.00	-20.04	12050.00	-20.04	12300.00	-9.67	
TP-C	6	2	TP-D	6	2	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	12050.00	-20.64	12050.00	-20.64	12300.00	-10.28	
TP-C	6	3	TP-D	6	3	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	12050.00	-21.83	12050.00	-21.83	12300.00	-11.47	

For 0kV wires between structures TP-C, maximum offset is 16.66 (m), the leftmost offset is -15.24 (m), rightmost offset is 16.66 (m)
For 400kV wires between structures TP-C, maximum offset is 21.84 (m), the leftmost offset is -21.83 (m), rightmost offset is 21.84 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Case	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
8	400kV	500m	ACSR Moose	Strain	Max. Tower Tension	386.5 Pa	21.0m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-A	1	1	TP-B	11	1	OPGW-11.4mm_500m.wir	0	32° 19.2% Wind-400m	Creep RS	Left	11050.00	17.33	11299.50	5.03	11050.00	17.33	
TP-A	1	1	TP-B	11	1	OPGW-11.4mm_500m.wir	0	32° 19.2% Wind-400m	Creep RS	Right	11050.00	-7.31	11050.00	-7.31	11299.50	4.99	
TP-A	2	1	TP-B	12	1	ew-10.98mm_500m.wir	0	32° 19.2% Wind-400m	Creep RS	Left	11050.00	5.91	11299.50	-4.99	11050.00	5.91	
TP-A	2	1	TP-B	12	1	ew-10.98mm_500m.wir	0	32° 19.2% Wind-400m	Creep RS	Right	11050.00	-15.93	11050.00	-15.93	11299.50	-5.03	
TP-A	5	1	TP-B	15	1	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	11050.00	18.25	10807.07	8.46	11050.00	18.25	
TP-A	5	2	TP-B	15	2	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	11050.00	19.15	10807.07	9.36	11050.00	19.15	
TP-A	5	3	TP-B	15	3	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	11050.00	20.90	10807.07	11.11	11050.00	20.90	
TP-A	5	1	TP-B	15	1	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	10807.07	7.34	11050.00	-2.45	10807.07	7.34	
TP-A	5	2	TP-B	15	2	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	10807.07	8.24	11050.00	-1.55	10807.07	8.24	
TP-A	5	3	TP-B	15	3	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	10807.07	9.99	11050.00	0.20	10807.07	9.99	
TP-A	6	1	TP-B	16	1	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	10808.08	-7.35	10808.08	-7.35	11050.00	2.34	
TP-A	6	2	TP-B	16	2	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	11291.29	-8.25	11291.29	-8.25	11050.00	1.39	
TP-A	6	3	TP-B	16	3	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	11290.66	-10.00	11290.66	-10.00	11050.00	-0.41	
TP-A	6	1	TP-B	16	1	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	11050.00	-18.14	11050.00	-18.14	10808.08	-8.45	
TP-A	6	2	TP-B	16	2	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	11050.00	-18.99	11050.00	-18.99	11291.29	-9.35	
TP-A	6	3	TP-B	16	3	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	11050.00	-20.69	11050.00	-20.69	11290.66	-11.10	

For 0kV wires between structures TP-A, maximum offset is 17.33 (m), the leftmost offset is -15.93 (m), rightmost offset is 17.33 (m)
For 400kV wires between structures TP-A, maximum offset is 20.90 (m), the leftmost offset is -20.69 (m), rightmost offset is 20.90 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Case	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
9	400kV	500m	ACSR Moose	Strain	Max. Wire Tension	386.5 Pa	19.0m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt -age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-A	1	1	TP-B	11	1	OPGW-11.4mm_500m.wir	0	32° 19.2% Wind-400m	Creep RS	Left	11050.00	13.48	11299.50	5.03	11050.00	13.48	
TP-A	1	1	TP-B	11	1	OPGW-11.4mm_500m.wir	0	32° 19.2% Wind-400m	Creep RS	Right	11299.50	4.99	11050.00	-3.46	11299.50	4.99	
TP-A	2	1	TP-B	12	1	ew-10.98mm_500m.wir	0	32° 19.2% Wind-400m	Creep RS	Left	11299.50	-4.99	11299.50	-4.99	11050.00	2.82	
TP-A	2	1	TP-B	12	1	ew-10.98mm_500m.wir	0	32° 19.2% Wind-400m	Creep RS	Right	11050.00	-12.84	11050.00	-12.84	11299.50	-5.03	
TP-A	5	1	TP-B	15	1	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	11050.08	16.02	11292.90	8.34	11050.08	16.02	
TP-A	5	2	TP-B	15	2	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	11050.08	16.92	11292.90	9.24	11050.08	16.92	
TP-A	5	3	TP-B	15	3	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	11050.08	18.67	11292.90	10.99	11050.08	18.67	
TP-A	5	1	TP-B	15	1	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	11292.90	7.46	11050.08	-0.22	11292.90	7.46	
TP-A	5	2	TP-B	15	2	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	11292.90	8.36	11050.08	0.68	11292.90	8.36	
TP-A	5	3	TP-B	15	3	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	11292.90	10.11	11050.08	2.43	11292.90	10.11	
TP-A	6	1	TP-B	16	1	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	10808.10	-7.44	10808.10	-7.44	11050.00	0.56	
TP-A	6	2	TP-B	16	2	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	11291.27	-8.34	11291.27	-8.34	11050.00	-0.38	
TP-A	6	3	TP-B	16	3	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Left	11290.64	-10.09	11290.64	-10.09	11050.08	-2.17	
TP-A	6	1	TP-B	16	1	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	11050.00	-16.36	11050.00	-16.36	10808.10	-8.36	
TP-A	6	2	TP-B	16	2	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	11050.00	-17.22	11050.00	-17.22	11291.27	-9.26	
TP-A	6	3	TP-B	16	3	moose_acsr_500m.wir	400	32° 19.2% Wind-400m	Creep RS	Right	11050.08	-18.93	11050.08	-18.93	11290.64	-11.01	

For 0kV wires between structures TP-A, maximum offset is 13.48 (m), the leftmost offset is -12.84 (m), rightmost offset is 13.48 (m)
For 400kV wires between structures TP-A, maximum offset is -18.93 (m), the leftmost offset is -18.93 (m), rightmost offset is 18.67 (m)

Report Index – 220kV TL Conductor Blowout Reports

S.N.	Voltage Level (kV)	Conductor	Span (m)	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
1	220kV	ACSR Bison	350m	I-String	30°	331.7 Pa	11.45m
2				V-String	N/A	331.7 Pa	8.64m
3			250m	I-String	30°	339.8 Pa	9.34m
4				V-String	N/A	339.8 Pa	6.54m
5			150m	I-String	30°	369.14 Pa	7.94m
6				V-String	N/A	369.14 Pa	5.11m
7			500m	I-String	30°	331.7 Pa	17.5m
8				Strain	Max. Tower Tension	331.7 Pa	16.3m
9				Strain	Max. Wire Tension	331.7 Pa	13.9m

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
1	220kV	350m	ACSR Bison	I-String	30°	331.7 Pa	11.45m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt -age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-3	1	1	TP-4	1	1	OPGW-11.4mm_350m.wir	0	32° 20.5% Wind-350m	Creep RS	Left	875.00	8.22	1050.00	2.87	875.00	8.22	
TP-3	1	1	TP-4	1	1	OPGW-11.4mm_350m.wir	0	32° 20.5% Wind-350m	Creep RS	Right	875.00	-2.78	875.00	-2.78	700.00	2.57	
TP-3	2	1	TP-4	2	1	ew-10.05mm_350m.wir	0	32° 20.5% Wind-350m	Creep RS	Left	700.00	-2.58	700.00	-2.58	875.00	1.64	
TP-3	2	1	TP-4	2	1	ew-10.05mm_350m.wir	0	32° 20.5% Wind-350m	Creep RS	Right	875.00	-7.08	875.00	-7.08	1050.00	-2.86	
TP-3	5	1	TP-4	5	1	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	874.85	11.14	1050.00	6.64	874.85	11.14	
TP-3	5	2	TP-4	5	2	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	874.85	11.30	1050.00	6.80	874.85	11.30	
TP-3	5	3	TP-4	5	3	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	875.00	11.46	700.00	6.96	875.00	11.46	
TP-3	5	1	TP-4	5	1	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	700.00	3.94	875.15	-0.56	700.00	3.94	
TP-3	5	2	TP-4	5	2	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	1050.00	4.09	875.00	-0.40	1050.00	4.09	
TP-3	5	3	TP-4	5	3	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	1050.00	4.26	874.85	-0.24	1050.00	4.26	
TP-3	6	1	TP-4	6	1	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	700.00	-3.94	700.00	-3.94	875.15	0.56	
TP-3	6	2	TP-4	6	2	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	1050.00	-4.09	1050.00	-4.09	875.00	0.40	
TP-3	6	3	TP-4	6	3	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	1050.00	-4.26	1050.00	-4.26	874.85	0.24	
TP-3	6	1	TP-4	6	1	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	874.85	-11.14	874.85	-11.14	1050.00	-6.64	
TP-3	6	2	TP-4	6	2	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	874.85	-11.30	874.85	-11.30	1050.00	-6.80	
TP-3	6	3	TP-4	6	3	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	875.00	-11.46	875.00	-11.46	700.00	-6.96	

For 0kV wires between structures TP-3, maximum offset is 8.22 (m), the leftmost offset is -7.08 (m), rightmost offset is 8.22 (m)
For 220kV wires between structures TP-3, maximum offset is 11.46 (m), the leftmost offset is -11.46 (m), rightmost offset is 11.46 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
2	220kV	350m	ACSR Bison	V-String	N/A	331.7 Pa	8.64m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-3-V	1	1	TP-4-V	1	1	OPGW-11.4mm_350m.wir	0	32° 20.5% Wind-350m	Creep RS	Left	2775.00	8.22	2950.00	2.87	2775.00	8.22	
TP-3-V	1	1	TP-4-V	1	1	OPGW-11.4mm_350m.wir	0	32° 20.5% Wind-350m	Creep RS	Right	2775.00	-2.78	2775.00	-2.78	2600.00	2.57	
TP-3-V	2	1	TP-4-V	2	1	ew-10.05mm_350m.wir	0	32° 20.5% Wind-350m	Creep RS	Left	2600.00	-2.58	2600.00	-2.58	2775.00	1.64	
TP-3-V	2	1	TP-4-V	2	1	ew-10.05mm_350m.wir	0	32° 20.5% Wind-350m	Creep RS	Right	2775.00	-7.08	2775.00	-7.08	2950.00	-2.86	
TP-3-V	5	1	TP-4-V	5	1	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	2775.00	7.84	2950.00	3.35	2775.00	7.84	
TP-3-V	5	2	TP-4-V	5	2	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	2775.00	7.99	2950.00	3.50	2775.00	7.99	
TP-3-V	5	3	TP-4-V	5	3	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	2775.00	8.64	2950.00	4.15	2775.00	8.64	
TP-3-V	5	1	TP-4-V	5	1	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	2950.00	3.35	2775.00	-1.14	2950.00	3.35	
TP-3-V	5	2	TP-4-V	5	2	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	2950.00	3.50	2775.00	-0.99	2950.00	3.50	
TP-3-V	5	3	TP-4-V	5	3	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	2950.00	4.15	2775.00	-0.34	2950.00	4.15	
TP-3-V	6	1	TP-4-V	6	1	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	2950.00	-3.35	2950.00	-3.35	2775.00	1.14	
TP-3-V	6	2	TP-4-V	6	2	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	2950.00	-3.50	2950.00	-3.50	2775.00	0.99	
TP-3-V	6	3	TP-4-V	6	3	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	2950.00	-4.15	2950.00	-4.15	2775.00	0.34	
TP-3-V	6	1	TP-4-V	6	1	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	2775.00	-7.84	2775.00	-7.84	2950.00	-3.35	
TP-3-V	6	2	TP-4-V	6	2	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	2775.00	-7.99	2775.00	-7.99	2950.00	-3.50	
TP-3-V	6	3	TP-4-V	6	3	bison_acsr_350m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	2775.00	-8.64	2775.00	-8.64	2950.00	-4.15	

For 0kV wires between structures TP-3-V, maximum offset is 8.22 (m), the leftmost offset is -7.08 (m), rightmost offset is 8.22 (m)
For 220kV wires between structures TP-3-V, maximum offset is 8.64 (m), the leftmost offset is -8.64 (m), rightmost offset is 8.64 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
3	220kV	250m	ACSR Bison	I-String	30°	339.8 Pa	9.34m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-8	1	1	TP-9	1	1	OPGW-11.4mm_250m.wir	0	32° 21% Wind-250m	Creep RS	Left	4425.00	5.88	4550.00	2.87	4425.00	5.88	
TP-8	1	1	TP-9	1	1	OPGW-11.4mm_250m.wir	0	32° 21% Wind-250m	Creep RS	Right	4300.00	2.57	4425.00	-0.44	4300.00	2.57	
TP-8	2	1	TP-9	2	1	ew-10.05mm_250m.wir	0	32° 21% Wind-250m	Creep RS	Left	4300.00	-2.58	4300.00	-2.58	4425.00	-0.40	
TP-8	2	1	TP-9	2	1	ew-10.05mm_250m.wir	0	32° 21% Wind-250m	Creep RS	Right	4425.00	-5.04	4425.00	-5.04	4550.00	-2.86	
TP-8	5	1	TP-9	5	1	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Left	4424.54	9.02	4550.00	6.62	4424.54	9.02	
TP-8	5	2	TP-9	5	2	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Left	4424.70	9.18	4550.00	6.79	4424.70	9.18	
TP-8	5	3	TP-9	5	3	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Left	4425.15	9.34	4300.00	6.95	4425.15	9.34	
TP-8	5	1	TP-9	5	1	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Right	4300.00	3.95	4425.30	1.55	4300.00	3.95	
TP-8	5	2	TP-9	5	2	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Right	4550.00	4.10	4425.00	1.71	4550.00	4.10	
TP-8	5	3	TP-9	5	3	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Right	4550.00	4.28	4424.54	1.88	4550.00	4.28	
TP-8	6	1	TP-9	6	1	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Left	4300.00	-3.95	4300.00	-3.95	4425.30	-1.55	
TP-8	6	2	TP-9	6	2	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Left	4550.00	-4.10	4550.00	-4.10	4425.00	-1.71	
TP-8	6	3	TP-9	6	3	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Left	4550.00	-4.28	4550.00	-4.28	4424.54	-1.88	
TP-8	6	1	TP-9	6	1	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Right	4424.54	-9.02	4424.54	-9.02	4550.00	-6.62	
TP-8	6	2	TP-9	6	2	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Right	4424.70	-9.18	4424.70	-9.18	4550.00	-6.79	
TP-8	6	3	TP-9	6	3	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Right	4425.15	-9.34	4425.15	-9.34	4300.00	-6.95	

For 0kV wires between structures TP-8, maximum offset is 5.88 (m), the leftmost offset is -5.04 (m), rightmost offset is 5.88 (m)
For 220kV wires between structures TP-8, maximum offset is 9.34 (m), the leftmost offset is -9.34 (m), rightmost offset is 9.34 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
4	220kV	250m	ACSR Bison	V-String	N/A	339.8 Pa	6.54m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-8-V	1	1	TP-9-V	1	1	OPGW-11.4mm_250m.wir	0	32° 21% Wind-250m	Creep RS	Left	5925.00	5.88	6050.00	2.87	5925.00	5.88	
TP-8-V	1	1	TP-9-V	1	1	OPGW-11.4mm_250m.wir	0	32° 21% Wind-250m	Creep RS	Right	5800.00	2.57	5925.00	-0.44	5800.00	2.57	
TP-8-V	2	1	TP-9-V	2	1	ew-10.05mm_250m.wir	0	32° 21% Wind-250m	Creep RS	Left	5800.00	-2.58	5800.00	-2.58	5925.00	-0.40	
TP-8-V	2	1	TP-9-V	2	1	ew-10.05mm_250m.wir	0	32° 21% Wind-250m	Creep RS	Right	5925.00	-5.04	5925.00	-5.04	6050.00	-2.86	
TP-8-V	5	1	TP-9-V	5	1	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Left	5925.00	5.74	6050.00	3.35	5925.00	5.74	
TP-8-V	5	2	TP-9-V	5	2	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Left	5925.00	5.89	6050.00	3.50	5925.00	5.89	
TP-8-V	5	3	TP-9-V	5	3	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Left	5925.00	6.54	6050.00	4.15	5925.00	6.54	
TP-8-V	5	1	TP-9-V	5	1	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Right	6050.00	3.35	5925.00	0.96	6050.00	3.35	
TP-8-V	5	2	TP-9-V	5	2	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Right	6050.00	3.50	5925.00	1.11	6050.00	3.50	
TP-8-V	5	3	TP-9-V	5	3	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Right	6050.00	4.15	5925.00	1.76	6050.00	4.15	
TP-8-V	6	1	TP-9-V	6	1	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Left	6050.00	-3.35	6050.00	-3.35	5925.00	-0.96	
TP-8-V	6	2	TP-9-V	6	2	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Left	6050.00	-3.50	6050.00	-3.50	5925.00	-1.11	
TP-8-V	6	3	TP-9-V	6	3	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Left	6050.00	-4.15	6050.00	-4.15	5925.00	-1.76	
TP-8-V	6	1	TP-9-V	6	1	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Right	5925.00	-5.74	5925.00	-5.74	6050.00	-3.35	
TP-8-V	6	2	TP-9-V	6	2	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Right	5925.00	-5.89	5925.00	-5.89	6050.00	-3.50	
TP-8-V	6	3	TP-9-V	6	3	bison_acsr_250m.wir	220	32° 21% Wind-250m	Creep RS	Right	5925.00	-6.54	5925.00	-6.54	6050.00	-4.15	

For 0kV wires between structures TP-8-V, maximum offset is 5.88 (m), the leftmost offset is -5.04 (m), rightmost offset is 5.88 (m)
For 220kV wires between structures TP-8-V, maximum offset is 6.54 (m), the leftmost offset is -6.54 (m), rightmost offset is 6.54 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
5	220kV	150m	ACSR Bison	I-String	30°	369.14 Pa	7.94m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-13	1	1	TP-14	1	1	OPGW-11.4mm_150m.wir	0	32° 22.5% Wind-150m	Creep RS	Left	7175.00	4.19	7250.00	2.87	7175.00	4.19	
TP-13	1	1	TP-14	1	1	OPGW-11.4mm_150m.wir	0	32° 22.5% Wind-150m	Creep RS	Right	7100.00	2.56	7175.15	1.25	7100.00	2.56	
TP-13	2	1	TP-14	2	1	ew-10.05mm_150m.wir	0	32° 22.5% Wind-150m	Creep RS	Left	7100.00	-2.57	7100.00	-2.57	7175.15	-1.74	
TP-13	2	1	TP-14	2	1	ew-10.05mm_150m.wir	0	32° 22.5% Wind-150m	Creep RS	Right	7174.85	-3.69	7174.85	-3.69	7250.00	-2.86	
TP-13	5	1	TP-14	5	1	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Left	7173.32	7.58	7250.00	6.58	7173.32	7.58	
TP-13	5	2	TP-14	5	2	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Left	7174.09	7.75	7250.00	6.77	7174.09	7.75	
TP-13	5	3	TP-14	5	3	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Left	7175.46	7.94	7100.00	6.97	7175.46	7.94	
TP-13	5	1	TP-14	5	1	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Right	7100.00	3.93	7175.91	2.95	7100.00	3.93	
TP-13	5	2	TP-14	5	2	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Right	7250.00	4.09	7174.85	3.13	7250.00	4.09	
TP-13	5	3	TP-14	5	3	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Right	7250.00	4.32	7173.32	3.32	7250.00	4.32	
TP-13	6	1	TP-14	6	1	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Left	7100.00	-3.93	7100.00	-3.93	7175.91	-2.95	
TP-13	6	2	TP-14	6	2	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Left	7250.00	-4.09	7250.00	-4.09	7174.85	-3.13	
TP-13	6	3	TP-14	6	3	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Left	7250.00	-4.32	7250.00	-4.32	7173.32	-3.32	
TP-13	6	1	TP-14	6	1	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Right	7173.32	-7.58	7173.32	-7.58	7250.00	-6.58	
TP-13	6	2	TP-14	6	2	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Right	7174.09	-7.75	7174.09	-7.75	7250.00	-6.77	
TP-13	6	3	TP-14	6	3	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Right	7175.46	-7.94	7175.46	-7.94	7100.00	-6.97	

For 0kV wires between structures TP-13, maximum offset is 4.19 (m), the leftmost offset is -3.69 (m), rightmost offset is 4.19 (m)
For 220kV wires between structures TP-13, maximum offset is 7.94 (m), the leftmost offset is -7.94 (m), rightmost offset is 7.94 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
6	220kV	150m	ACSR Bison	V-String	N/A	369.14 Pa	5.11m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt -age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-13-V	1	1	TP-14-V	1	1	OPGW-11.4mm_150m.wir	0	32° 22.5% Wind-150m	Creep RS	Left	8275.00	4.19	8350.00	2.87	8275.00	4.19	
TP-13-V	1	1	TP-14-V	1	1	OPGW-11.4mm_150m.wir	0	32° 22.5% Wind-150m	Creep RS	Right	8200.00	2.56	8275.15	1.25	8200.00	2.56	
TP-13-V	2	1	TP-14-V	2	1	ew-10.05mm_150m.wir	0	32° 22.5% Wind-150m	Creep RS	Left	8200.00	-2.57	8200.00	-2.57	8275.15	-1.74	
TP-13-V	2	1	TP-14-V	2	1	ew-10.05mm_150m.wir	0	32° 22.5% Wind-150m	Creep RS	Right	8274.85	-3.69	8274.85	-3.69	8350.00	-2.86	
TP-13-V	5	1	TP-14-V	5	1	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Left	8275.00	4.31	8350.00	3.35	8275.00	4.31	
TP-13-V	5	2	TP-14-V	5	2	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Left	8275.00	4.46	8350.00	3.50	8275.00	4.46	
TP-13-V	5	3	TP-14-V	5	3	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Left	8275.00	5.11	8350.00	4.15	8275.00	5.11	
TP-13-V	5	1	TP-14-V	5	1	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Right	8350.00	3.35	8275.00	2.39	8350.00	3.35	
TP-13-V	5	2	TP-14-V	5	2	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Right	8350.00	3.50	8275.00	2.54	8350.00	3.50	
TP-13-V	5	3	TP-14-V	5	3	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Right	8350.00	4.15	8275.00	3.19	8350.00	4.15	
TP-13-V	6	1	TP-14-V	6	1	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Left	8350.00	-3.35	8350.00	-3.35	8275.00	-2.39	
TP-13-V	6	2	TP-14-V	6	2	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Left	8350.00	-3.50	8350.00	-3.50	8275.00	-2.54	
TP-13-V	6	3	TP-14-V	6	3	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Left	8350.00	-4.15	8350.00	-4.15	8275.00	-3.19	
TP-13-V	6	1	TP-14-V	6	1	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Right	8275.00	-4.31	8275.00	-4.31	8350.00	-3.35	
TP-13-V	6	2	TP-14-V	6	2	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Right	8275.00	-4.46	8275.00	-4.46	8350.00	-3.50	
TP-13-V	6	3	TP-14-V	6	3	bison_acsr_150m.wir	220	32° 22.5% Wind-150m	Creep RS	Right	8275.00	-5.11	8275.00	-5.11	8350.00	-4.15	

For 0kV wires between structures TP-13-V, maximum offset is 4.19 (m), the leftmost offset is -3.69 (m), rightmost offset is 4.19 (m)
For 220kV wires between structures TP-13-V, maximum offset is 5.11 (m), the leftmost offset is -5.11 (m), rightmost offset is 5.11 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
7	220kV	500m	ACSR Bison	I-String	30°	331.7 Pa	17.5m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt -age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-C	1	1	TP-D	1	1	OPGW-11.4mm_500m.wir	0	32° 20.5% Wind-350m	Creep RS	Left	10800.00	14.88	11050.00	2.87	10800.00	14.88	
TP-C	1	1	TP-D	1	1	OPGW-11.4mm_500m.wir	0	32° 20.5% Wind-350m	Creep RS	Right	10800.00	-9.44	10800.00	-9.44	11050.00	2.57	
TP-C	2	1	TP-D	2	1	ew-10.05mm_500m.wir	0	32° 20.5% Wind-350m	Creep RS	Left	10800.00	8.03	11050.00	-2.58	10800.00	8.03	
TP-C	2	1	TP-D	2	1	ew-10.05mm_500m.wir	0	32° 20.5% Wind-350m	Creep RS	Right	10800.00	-13.47	10800.00	-13.47	11050.00	-2.86	
TP-C	5	1	TP-D	5	1	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	10800.00	17.19	11050.00	6.68	10800.00	17.19	
TP-C	5	2	TP-D	5	2	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	10800.00	17.34	11050.00	6.83	10800.00	17.34	
TP-C	5	3	TP-D	5	3	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	10800.00	17.50	11050.00	6.99	10800.00	17.50	
TP-C	5	1	TP-D	5	1	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	10800.00	-6.60	10800.00	-6.60	11050.00	3.91	
TP-C	5	2	TP-D	5	2	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	10800.00	-6.44	10800.00	-6.44	11050.00	4.06	
TP-C	5	3	TP-D	5	3	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	10800.00	-6.29	10800.00	-6.29	11050.00	4.22	
TP-C	6	1	TP-D	6	1	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	10800.00	6.60	11050.00	-3.91	10800.00	6.60	
TP-C	6	2	TP-D	6	2	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	10800.00	6.44	11050.00	-4.06	10800.00	6.44	
TP-C	6	3	TP-D	6	3	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	10800.00	6.29	11050.00	-4.22	10800.00	6.29	
TP-C	6	1	TP-D	6	1	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	10800.00	-17.19	10800.00	-17.19	11050.00	-6.68	
TP-C	6	2	TP-D	6	2	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	10800.00	-17.34	10800.00	-17.34	11050.00	-6.83	
TP-C	6	3	TP-D	6	3	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	10800.00	-17.50	10800.00	-17.50	11050.00	-6.99	

For 0kV wires between structures TP-C, maximum offset is 14.88 (m), the leftmost offset is -13.47 (m), rightmost offset is 14.88 (m)
For 220kV wires between structures TP-C, maximum offset is 17.50 (m), the leftmost offset is -17.50 (m), rightmost offset is 17.50 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Case	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
8	220kV	500m	ACSR Bison	Strain	Max. Tower Tension	331.7 Pa	16.3m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-A	1	1	TP-B	11	1	OPGW-11.4mm_500m.wir	0	32° 20.5% Wind-350m	Creep RS	Left	9800.00	10.43	9551.25	2.27	9800.00	10.43	
TP-A	1	1	TP-B	11	1	OPGW-11.4mm_500m.wir	0	32° 20.5% Wind-350m	Creep RS	Right	9800.00	-5.93	9800.00	-5.93	9551.25	2.23	
TP-A	2	1	TP-B	12	1	ew-10.05mm_500m.wir	0	32° 20.5% Wind-350m	Creep RS	Left	9800.00	5.18	9551.25	-2.24	9800.00	5.18	
TP-A	2	1	TP-B	12	1	ew-10.05mm_500m.wir	0	32° 20.5% Wind-350m	Creep RS	Right	9800.00	-9.68	9800.00	-9.68	9551.25	-2.26	
TP-A	5	1	TP-B	15	1	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	9800.08	15.12	10045.04	5.05	9800.08	15.12	
TP-A	5	2	TP-B	15	2	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	9800.08	15.62	10045.04	5.55	9800.08	15.62	
TP-A	5	3	TP-B	15	3	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	9800.08	16.32	10045.04	6.25	9800.08	16.32	
TP-A	5	1	TP-B	15	1	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	9800.08	-5.52	9800.08	-5.52	10045.04	4.55	
TP-A	5	2	TP-B	15	2	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	10045.04	5.05	9800.08	-5.02	10045.04	5.05	
TP-A	5	3	TP-B	15	3	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	10045.04	5.75	9800.08	-4.32	10045.04	5.75	
TP-A	6	1	TP-B	16	1	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	9800.08	5.52	10045.04	-4.55	9800.08	5.52	
TP-A	6	2	TP-B	16	2	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	10045.04	-5.05	10045.04	-5.05	9800.08	5.02	
TP-A	6	3	TP-B	16	3	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	10045.04	-5.75	10045.04	-5.75	9800.08	4.32	
TP-A	6	1	TP-B	16	1	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	9800.08	-15.12	9800.08	-15.12	10045.04	-5.05	
TP-A	6	2	TP-B	16	2	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	9800.08	-15.62	9800.08	-15.62	10045.04	-5.55	
TP-A	6	3	TP-B	16	3	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	9800.08	-16.32	9800.08	-16.32	10045.04	-6.25	

For 0kV wires between structures TP-A, maximum offset is 10.43 (m), the leftmost offset is -9.68 (m), rightmost offset is 10.43 (m)
For 220kV wires between structures TP-A, maximum offset is 16.32 (m), the leftmost offset is -16.32 (m), rightmost offset is 16.32 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Case	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
9	220kV	500m	ACSR Bison	Strain	Max. Wire Tension	331.7 Pa	13.9m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt-age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-A	1	1	TP-B	11	1	OPGW-11.4mm_500m.wir	0	32° 20.5% Wind-350m	Creep RS	Left	9800.00	10.43	9551.25	2.27	9800.00	10.43	
TP-A	1	1	TP-B	11	1	OPGW-11.4mm_500m.wir	0	32° 20.5% Wind-350m	Creep RS	Right	9800.00	-5.93	9800.00	-5.93	9551.25	2.23	
TP-A	2	1	TP-B	12	1	ew-10.05mm_500m.wir	0	32° 20.5% Wind-350m	Creep RS	Left	9800.00	5.18	9551.25	-2.24	9800.00	5.18	
TP-A	2	1	TP-B	12	1	ew-10.05mm_500m.wir	0	32° 20.5% Wind-350m	Creep RS	Right	9800.00	-9.68	9800.00	-9.68	9551.25	-2.26	
TP-A	5	1	TP-B	15	1	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	9800.08	12.64	10045.02	4.99	9800.08	12.64	
TP-A	5	2	TP-B	15	2	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	9800.08	13.14	10045.02	5.49	9800.08	13.14	
TP-A	5	3	TP-B	15	3	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	9800.08	13.84	10045.02	6.19	9800.08	13.84	
TP-A	5	1	TP-B	15	1	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	10045.02	4.61	9800.08	-3.04	10045.02	4.61	
TP-A	5	2	TP-B	15	2	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	10045.02	5.11	9800.08	-2.54	10045.02	5.11	
TP-A	5	3	TP-B	15	3	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	10045.02	5.81	9800.08	-1.84	10045.02	5.81	
TP-A	6	1	TP-B	16	1	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	10045.02	-4.61	10045.02	-4.61	9800.08	3.04	
TP-A	6	2	TP-B	16	2	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	10045.02	-5.11	10045.02	-5.11	9800.08	2.54	
TP-A	6	3	TP-B	16	3	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Left	10045.02	-5.81	10045.02	-5.81	9800.08	1.84	
TP-A	6	1	TP-B	16	1	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	9800.08	-12.64	9800.08	-12.64	10045.02	-4.99	
TP-A	6	2	TP-B	16	2	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	9800.08	-13.14	9800.08	-13.14	10045.02	-5.49	
TP-A	6	3	TP-B	16	3	bison_acsr_500m.wir	220	32° 20.5% Wind-350m	Creep RS	Right	9800.08	-13.84	9800.08	-13.84	10045.02	-6.19	

For 0kV wires between structures TP-A, maximum offset is 10.43 (m), the leftmost offset is -9.68 (m), rightmost offset is 10.43 (m)
For 220kV wires between structures TP-A, maximum offset is 13.84 (m), the leftmost offset is -13.84 (m), rightmost offset is 13.84 (m)

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S.N.	Voltage Level (kV)	Conductor	Span (m)	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
1	132kV	ACSR Bear	350m	I-String	30°	357.2 Pa	8.7m
2				V-String	N/A	357.2 Pa	7.0m
3			250m	I-String	30°	380 Pa	6.6m
4				V-String	N/A	380 Pa	5.0m
5			200m	I-String	30°	402.8 Pa	5.9m
6				V-String	N/A	402.8 Pa	4.23m
7			150m	I-String	30°	440.8 Pa	5.27m
8				V-String	N/A	440.8 Pa	3.6m
9			500m	I-String	30°	357.2 Pa	14.9m
10				Strain	Max. Tower Tension	357.2 Pa	14.5m
11				Strain	Max. Wire Tension	357.2 Pa	11.9m

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
1	132kV	350m	ACSR Bear	I-String	30°	357.2 Pa	8.7m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-3	1	1	TP-4	1	1	OPGW-11.4mm_350m.wir	0	32° 23.5% Wind-350m	Creep RS	Left	875.00	4.31	700.00	0.16	875.00	4.31	
TP-3	1	1	TP-4	1	1	OPGW-11.4mm_350m.wir	0	32° 23.5% Wind-350m	Creep RS	Right	875.00	-4.31	875.00	-4.31	700.00	-0.16	
TP-3	5	1	TP-4	5	1	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	875.15	8.45	700.00	3.93	875.15	8.45	
TP-3	5	2	TP-4	5	2	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	875.15	8.54	700.00	4.02	875.15	8.54	
TP-3	5	3	TP-4	5	3	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	875.15	8.69	700.00	4.17	875.15	8.69	
TP-3	5	1	TP-4	5	1	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	875.00	-2.32	875.00	-2.32	1050.00	2.20	
TP-3	5	2	TP-4	5	2	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	1050.00	2.29	874.85	-2.23	1050.00	2.29	
TP-3	5	3	TP-4	5	3	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	1050.00	2.44	874.85	-2.08	1050.00	2.44	
TP-3	6	1	TP-4	6	1	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	875.00	2.32	1050.00	-2.20	875.00	2.32	
TP-3	6	2	TP-4	6	2	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	1050.00	-2.29	1050.00	-2.29	874.85	2.23	
TP-3	6	3	TP-4	6	3	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	1050.00	-2.44	1050.00	-2.44	874.85	2.08	
TP-3	6	1	TP-4	6	1	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	875.15	-8.45	875.15	-8.45	700.00	-3.93	
TP-3	6	2	TP-4	6	2	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	875.15	-8.54	875.15	-8.54	700.00	-4.02	
TP-3	6	3	TP-4	6	3	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	875.15	-8.69	875.15	-8.69	700.00	-4.17	

For 0kV wires between structures TP-3, maximum offset is 4.31 (m), the leftmost offset is -4.31 (m), rightmost offset is 4.31 (m)
For 132kV wires between structures TP-3, maximum offset is 8.69 (m), the leftmost offset is -8.69 (m), rightmost offset is 8.69 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
2	132kV	350m	ACSR Bear	V-String	N/A	357.2 Pa	7.0m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt -age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-3-V	1	1	TP-4-V	1	1	OPGW-11.4mm_350m.wir	0	32° 23.5% Wind-350m	Creep RS	Left	2775.00	4.31	2600.00	0.16	2775.00	4.31	
TP-3-V	1	1	TP-4-V	1	1	OPGW-11.4mm_350m.wir	0	32° 23.5% Wind-350m	Creep RS	Right	2775.00	-4.31	2775.00	-4.31	2600.00	-0.16	
TP-3-V	5	1	TP-4-V	5	1	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	2775.00	6.83	2950.00	2.32	2775.00	6.83	
TP-3-V	5	2	TP-4-V	5	2	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	2775.00	6.92	2950.00	2.40	2775.00	6.92	
TP-3-V	5	3	TP-4-V	5	3	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	2775.00	7.04	2950.00	2.52	2775.00	7.04	
TP-3-V	5	1	TP-4-V	5	1	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	2950.00	2.32	2775.00	-2.20	2950.00	2.32	
TP-3-V	5	2	TP-4-V	5	2	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	2950.00	2.40	2775.00	-2.11	2950.00	2.40	
TP-3-V	5	3	TP-4-V	5	3	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	2950.00	2.52	2775.00	-1.99	2950.00	2.52	
TP-3-V	6	1	TP-4-V	6	1	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	2950.00	-2.32	2950.00	-2.32	2775.00	2.20	
TP-3-V	6	2	TP-4-V	6	2	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	2950.00	-2.40	2950.00	-2.40	2775.00	2.11	
TP-3-V	6	3	TP-4-V	6	3	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	2950.00	-2.52	2950.00	-2.52	2775.00	1.99	
TP-3-V	6	1	TP-4-V	6	1	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	2775.00	-6.83	2775.00	-6.83	2950.00	-2.32	
TP-3-V	6	2	TP-4-V	6	2	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	2775.00	-6.92	2775.00	-6.92	2950.00	-2.40	
TP-3-V	6	3	TP-4-V	6	3	bear_acsr_350m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	2775.00	-7.04	2775.00	-7.04	2950.00	-2.52	

For 0kV wires between structures TP-3-V, maximum offset is 4.31 (m), the leftmost offset is -4.31 (m), rightmost offset is 4.31 (m)
For 132kV wires between structures TP-3-V, maximum offset is 7.04 (m), the leftmost offset is -7.04 (m), rightmost offset is 7.04 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
3	132kV	250m	ACSR Bear	I-String	30°	380 Pa	6.6m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt -age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-8	1	1	TP-9	1	1	OPGW-11.4mm_250m.wir	0	32° 25% Wind-250m	Creep RS	Left	4425.15	2.34	4300.00	0.16	4425.15	2.34	
TP-8	1	1	TP-9	1	1	OPGW-11.4mm_250m.wir	0	32° 25% Wind-250m	Creep RS	Right	4425.15	-2.34	4425.15	-2.34	4300.00	-0.16	
TP-8	5	1	TP-9	5	1	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Left	4425.30	6.43	4300.00	3.93	4425.30	6.43	
TP-8	5	2	TP-9	5	2	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Left	4425.30	6.52	4300.00	4.02	4425.30	6.52	
TP-8	5	3	TP-9	5	3	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Left	4425.30	6.67	4300.00	4.17	4425.30	6.67	
TP-8	5	1	TP-9	5	1	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Right	4550.00	2.21	4424.85	-0.29	4550.00	2.21	
TP-8	5	2	TP-9	5	2	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Right	4550.00	2.30	4424.85	-0.20	4550.00	2.30	
TP-8	5	3	TP-9	5	3	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Right	4550.00	2.46	4424.70	-0.04	4550.00	2.46	
TP-8	6	1	TP-9	6	1	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Left	4550.00	-2.21	4550.00	-2.21	4424.85	0.29	
TP-8	6	2	TP-9	6	2	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Left	4550.00	-2.30	4550.00	-2.30	4424.85	0.20	
TP-8	6	3	TP-9	6	3	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Left	4550.00	-2.46	4550.00	-2.46	4424.70	0.04	
TP-8	6	1	TP-9	6	1	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Right	4425.30	-6.43	4425.30	-6.43	4300.00	-3.93	
TP-8	6	2	TP-9	6	2	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Right	4425.30	-6.52	4425.30	-6.52	4300.00	-4.02	
TP-8	6	3	TP-9	6	3	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Right	4425.30	-6.67	4425.30	-6.67	4300.00	-4.17	

For 0kV wires between structures TP-8, maximum offset is 2.34 (m), the leftmost offset is -2.34 (m), rightmost offset is 2.34 (m)
For 132kV wires between structures TP-8, maximum offset is 6.67 (m), the leftmost offset is -6.67 (m), rightmost offset is 6.67 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
4	132kV	250m	ACSR Bear	V-String	N/A	380 Pa	5.0m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt -age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-8-V	1	1	TP-9-V	1	1	OPGW-11.4mm_250m.wir	0	32° 25% Wind-250m	Creep RS	Left	5925.15	2.34	5800.00	0.16	5925.15	2.34	
TP-8-V	1	1	TP-9-V	1	1	OPGW-11.4mm_250m.wir	0	32° 25% Wind-250m	Creep RS	Right	5925.15	-2.34	5925.15	-2.34	5800.00	-0.16	
TP-8-V	5	1	TP-9-V	5	1	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Left	5925.00	4.80	6050.00	2.32	5925.00	4.80	
TP-8-V	5	2	TP-9-V	5	2	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Left	5925.00	4.89	6050.00	2.40	5925.00	4.89	
TP-8-V	5	3	TP-9-V	5	3	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Left	5925.00	5.01	6050.00	2.52	5925.00	5.01	
TP-8-V	5	1	TP-9-V	5	1	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Right	6050.00	2.32	5925.00	-0.17	6050.00	2.32	
TP-8-V	5	2	TP-9-V	5	2	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Right	6050.00	2.40	5925.00	-0.08	6050.00	2.40	
TP-8-V	5	3	TP-9-V	5	3	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Right	6050.00	2.52	5925.00	0.04	6050.00	2.52	
TP-8-V	6	1	TP-9-V	6	1	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Left	6050.00	-2.32	6050.00	-2.32	5925.00	0.17	
TP-8-V	6	2	TP-9-V	6	2	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Left	6050.00	-2.40	6050.00	-2.40	5925.00	0.08	
TP-8-V	6	3	TP-9-V	6	3	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Left	6050.00	-2.52	6050.00	-2.52	5925.00	-0.04	
TP-8-V	6	1	TP-9-V	6	1	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Right	5925.00	-4.80	5925.00	-4.80	6050.00	-2.32	
TP-8-V	6	2	TP-9-V	6	2	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Right	5925.00	-4.89	5925.00	-4.89	6050.00	-2.40	
TP-8-V	6	3	TP-9-V	6	3	bear_acsr_250m.wir	132	32° 25% Wind-250m	Creep RS	Right	5925.00	-5.01	5925.00	-5.01	6050.00	-2.52	

For 0kV wires between structures TP-8-V, maximum offset is 2.34 (m), the leftmost offset is -2.34 (m), rightmost offset is 2.34 (m)
For 132kV wires between structures TP-8-V, maximum offset is 5.01 (m), the leftmost offset is -5.01 (m), rightmost offset is 5.01 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
5	132kV	200m	ACSR Bear	I-String	30°	402.8 Pa	5.9m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-18	1	1	TP-19	1	1	OPGW-11.4mm_200m.wir	0	32° 26.5% Wind-200m	Creep RS	Left	12550.15	1.62	12450.00	0.17	12550.15	1.62	
TP-18	1	1	TP-19	1	1	OPGW-11.4mm_200m.wir	0	32° 26.5% Wind-200m	Creep RS	Right	12550.15	-1.62	12550.15	-1.62	12450.00	-0.17	
TP-18	5	1	TP-19	5	1	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Left	12550.46	5.65	12450.00	3.93	12550.46	5.65	
TP-18	5	2	TP-19	5	2	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Left	12550.46	5.74	12450.00	4.02	12550.46	5.74	
TP-18	5	3	TP-19	5	3	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Left	12550.46	5.89	12450.00	4.17	12550.46	5.89	
TP-18	5	1	TP-19	5	1	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Right	12650.00	2.21	12549.70	0.49	12650.00	2.21	
TP-18	5	2	TP-19	5	2	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Right	12650.00	2.31	12549.54	0.59	12650.00	2.31	
TP-18	5	3	TP-19	5	3	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Right	12650.00	2.47	12549.54	0.74	12650.00	2.47	
TP-18	6	1	TP-19	6	1	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Left	12650.00	-2.21	12650.00	-2.21	12549.70	-0.49	
TP-18	6	2	TP-19	6	2	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Left	12650.00	-2.31	12650.00	-2.31	12549.54	-0.59	
TP-18	6	3	TP-19	6	3	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Left	12650.00	-2.47	12650.00	-2.47	12549.54	-0.74	
TP-18	6	1	TP-19	6	1	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Right	12550.46	-5.65	12550.46	-5.65	12450.00	-3.93	
TP-18	6	2	TP-19	6	2	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Right	12550.46	-5.74	12550.46	-5.74	12450.00	-4.02	
TP-18	6	3	TP-19	6	3	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Right	12550.46	-5.89	12550.46	-5.89	12450.00	-4.17	

For 0kV wires between structures TP-18, maximum offset is 1.62 (m), the leftmost offset is -1.62 (m), rightmost offset is 1.62 (m)
For 132kV wires between structures TP-18, maximum offset is 5.89 (m), the leftmost offset is -5.89 (m), rightmost offset is 5.89 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
6	132kV	200m	ACSR Bear	V-String	N/A	402.8 Pa	4.2m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt -age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-18-V	1	1	TP-19-V	1	1	OPGW-11.4mm_200m.wir	0	32° 26.5% Wind-200m	Creep RS	Left	13850.15	1.62	13750.00	0.17	13850.15	1.62	
TP-18-V	1	1	TP-19-V	1	1	OPGW-11.4mm_200m.wir	0	32° 26.5% Wind-200m	Creep RS	Right	13850.15	-1.62	13850.15	-1.62	13750.00	-0.17	
TP-18-V	5	1	TP-19-V	5	1	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Left	13850.00	4.03	13950.00	2.32	13850.00	4.03	
TP-18-V	5	2	TP-19-V	5	2	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Left	13850.00	4.12	13950.00	2.40	13850.00	4.12	
TP-18-V	5	3	TP-19-V	5	3	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Left	13850.00	4.24	13950.00	2.52	13850.00	4.24	
TP-18-V	5	1	TP-19-V	5	1	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Right	13950.00	2.32	13850.00	0.60	13950.00	2.32	
TP-18-V	5	2	TP-19-V	5	2	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Right	13950.00	2.40	13850.00	0.69	13950.00	2.40	
TP-18-V	5	3	TP-19-V	5	3	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Right	13950.00	2.52	13850.00	0.81	13950.00	2.52	
TP-18-V	6	1	TP-19-V	6	1	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Left	13950.00	-2.32	13950.00	-2.32	13850.00	-0.60	
TP-18-V	6	2	TP-19-V	6	2	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Left	13950.00	-2.40	13950.00	-2.40	13850.00	-0.69	
TP-18-V	6	3	TP-19-V	6	3	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Left	13950.00	-2.52	13950.00	-2.52	13850.00	-0.81	
TP-18-V	6	1	TP-19-V	6	1	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Right	13850.00	-4.03	13850.00	-4.03	13950.00	-2.32	
TP-18-V	6	2	TP-19-V	6	2	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Right	13850.00	-4.12	13850.00	-4.12	13950.00	-2.40	
TP-18-V	6	3	TP-19-V	6	3	bear_acsr_200m.wir	132	32° 26.5% Wind-200m	Creep RS	Right	13850.00	-4.24	13850.00	-4.24	13950.00	-2.52	

For 0kV wires between structures TP-18-V, maximum offset is 1.62 (m), the leftmost offset is -1.62 (m), rightmost offset is 1.62 (m)
For 132kV wires between structures TP-18-V, maximum offset is 4.24 (m), the leftmost offset is -4.24 (m), rightmost offset is 4.24 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
7	132kV	150m	ACSR Bear	I-String	30°	440.8 Pa	5.27m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt-age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-13	1	1	TP-14	1	1	OPGW-11.4mm_150m.wir	0	32° 29% Wind-150m	Creep RS	Left	7175.46	1.06	7100.00	0.17	7175.46	1.06	
TP-13	1	1	TP-14	1	1	OPGW-11.4mm_150m.wir	0	32° 29% Wind-150m	Creep RS	Right	7175.46	-1.06	7175.46	-1.06	7100.00	-0.17	
TP-13	5	1	TP-14	5	1	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Left	7176.07	5.03	7100.00	3.93	7176.07	5.03	
TP-13	5	2	TP-14	5	2	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Left	7175.91	5.12	7100.00	4.02	7175.91	5.12	
TP-13	5	3	TP-14	5	3	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Left	7175.91	5.27	7100.00	4.17	7175.91	5.27	
TP-13	5	1	TP-14	5	1	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Right	7250.00	2.21	7174.54	1.13	7250.00	2.21	
TP-13	5	2	TP-14	5	2	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Right	7250.00	2.31	7174.39	1.23	7250.00	2.31	
TP-13	5	3	TP-14	5	3	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Right	7250.00	2.48	7174.09	1.38	7250.00	2.48	
TP-13	6	1	TP-14	6	1	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Left	7250.00	-2.21	7250.00	-2.21	7174.54	-1.13	
TP-13	6	2	TP-14	6	2	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Left	7250.00	-2.31	7250.00	-2.31	7174.39	-1.23	
TP-13	6	3	TP-14	6	3	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Left	7250.00	-2.48	7250.00	-2.48	7174.09	-1.38	
TP-13	6	1	TP-14	6	1	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Right	7176.07	-5.03	7176.07	-5.03	7100.00	-3.93	
TP-13	6	2	TP-14	6	2	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Right	7175.91	-5.12	7175.91	-5.12	7100.00	-4.02	
TP-13	6	3	TP-14	6	3	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Right	7175.91	-5.27	7175.91	-5.27	7100.00	-4.17	

For 0kV wires between structures TP-13, maximum offset is 1.06 (m), the leftmost offset is -1.06 (m), rightmost offset is 1.06 (m)
For 132kV wires between structures TP-13, maximum offset is 5.27 (m), the leftmost offset is -5.27 (m), rightmost offset is 5.27 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
8	132kV	150m	ACSR Bear	V-String	N/A	440.8 Pa	3.6m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-13-V	1	1	TP-14-V	1	1	OPGW-11.4mm_150m.wir	0	32° 29% Wind-150m	Creep RS	Left	8275.46	1.06	8200.00	0.17	8275.46	1.06	
TP-13-V	1	1	TP-14-V	1	1	OPGW-11.4mm_150m.wir	0	32° 29% Wind-150m	Creep RS	Right	8275.46	-1.06	8275.46	-1.06	8200.00	-0.17	
TP-13-V	5	1	TP-14-V	5	1	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Left	8275.00	3.38	8350.00	2.32	8275.00	3.38	
TP-13-V	5	2	TP-14-V	5	2	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Left	8275.00	3.47	8350.00	2.40	8275.00	3.47	
TP-13-V	5	3	TP-14-V	5	3	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Left	8275.00	3.59	8350.00	2.52	8275.00	3.59	
TP-13-V	5	1	TP-14-V	5	1	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Right	8350.00	2.32	8275.00	1.25	8350.00	2.32	
TP-13-V	5	2	TP-14-V	5	2	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Right	8350.00	2.40	8275.00	1.34	8350.00	2.40	
TP-13-V	5	3	TP-14-V	5	3	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Right	8350.00	2.52	8275.00	1.46	8350.00	2.52	
TP-13-V	6	1	TP-14-V	6	1	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Left	8350.00	-2.32	8350.00	-2.32	8275.00	-1.25	
TP-13-V	6	2	TP-14-V	6	2	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Left	8350.00	-2.40	8350.00	-2.40	8275.00	-1.34	
TP-13-V	6	3	TP-14-V	6	3	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Left	8350.00	-2.52	8350.00	-2.52	8275.00	-1.46	
TP-13-V	6	1	TP-14-V	6	1	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Right	8275.00	-3.38	8275.00	-3.38	8350.00	-2.32	
TP-13-V	6	2	TP-14-V	6	2	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Right	8275.00	-3.47	8275.00	-3.47	8350.00	-2.40	
TP-13-V	6	3	TP-14-V	6	3	bear_acsr_150m.wir	132	32° 29% Wind-150m	Creep RS	Right	8275.00	-3.59	8275.00	-3.59	8350.00	-2.52	

For 0kV wires between structures TP-13-V, maximum offset is 1.06 (m), the leftmost offset is -1.06 (m), rightmost offset is 1.06 (m)
For 132kV wires between structures TP-13-V, maximum offset is 3.59 (m), the leftmost offset is -3.59 (m), rightmost offset is 3.59 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Insulator Swing (Degrees)	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
9	132kV	500m	ACSR Bear	I-String	30°	357.2 Pa	14.9m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-C	1	1	TP-D	1	1	OPGW-11.4mm_500m.wir	0	32° 23.5% Wind-350m	Creep RS	Left	10800.00	11.11	11050.00	0.16	10800.00	11.11	
TP-C	1	1	TP-D	1	1	OPGW-11.4mm_500m.wir	0	32° 23.5% Wind-350m	Creep RS	Right	10800.00	-11.11	10800.00	-11.11	11050.00	-0.16	
TP-C	5	1	TP-D	5	1	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	10800.00	14.69	11050.00	3.97	10800.00	14.69	
TP-C	5	2	TP-D	5	2	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	10800.00	14.77	11050.00	4.06	10800.00	14.77	
TP-C	5	3	TP-D	5	3	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	10800.00	14.92	11050.00	4.21	10800.00	14.92	
TP-C	5	1	TP-D	5	1	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	10800.00	-8.56	10800.00	-8.56	11050.00	2.16	
TP-C	5	2	TP-D	5	2	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	10800.00	-8.47	10800.00	-8.47	11050.00	2.25	
TP-C	5	3	TP-D	5	3	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	10800.00	-8.31	10800.00	-8.31	11050.00	2.40	
TP-C	6	1	TP-D	6	1	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	10800.00	8.56	11050.00	-2.16	10800.00	8.56	
TP-C	6	2	TP-D	6	2	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	10800.00	8.47	11050.00	-2.25	10800.00	8.47	
TP-C	6	3	TP-D	6	3	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	10800.00	8.31	11050.00	-2.40	10800.00	8.31	
TP-C	6	1	TP-D	6	1	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	10800.00	-14.69	10800.00	-14.69	11050.00	-3.97	
TP-C	6	2	TP-D	6	2	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	10800.00	-14.77	10800.00	-14.77	11050.00	-4.06	
TP-C	6	3	TP-D	6	3	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	10800.00	-14.92	10800.00	-14.92	11050.00	-4.21	

For 0kV wires between structures TP-C, maximum offset is 11.11 (m), the leftmost offset is -11.11 (m), rightmost offset is 11.11 (m)
For 132kV wires between structures TP-C, maximum offset is 14.92 (m), the leftmost offset is -14.92 (m), rightmost offset is 14.92 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Case	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
10	132kV	500m	ACSR Bear	Strain	Max. Tower Tension	357.2 Pa	14.5m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt-age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-A	1	1	TP-B	11	1	OPGW-11.4mm_500m.wir	0	32° 23.5% Wind-350m	Creep RS	Left	9800.00	10.84	10048.75	0.02	9800.00	10.84	
TP-A	1	1	TP-B	11	1	OPGW-11.4mm_500m.wir	0	32° 23.5% Wind-350m	Creep RS	Right	9800.00	-10.84	9800.00	-10.84	10048.75	-0.02	
TP-A	5	1	TP-B	5	1	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	9802.00	14.37	10050.02	3.82	9802.00	14.37	
TP-A	5	2	TP-B	5	2	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	9802.00	14.47	10050.02	3.92	9802.00	14.47	
TP-A	5	3	TP-B	5	3	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	9802.00	14.52	10050.02	4.17	9802.00	14.52	
TP-A	5	1	TP-B	5	1	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	9802.00	-7.07	9802.00	-7.07	10050.02	3.48	
TP-A	5	2	TP-B	5	2	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	9802.00	-6.97	9802.00	-6.97	10050.02	3.58	
TP-A	5	3	TP-B	5	3	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	9802.00	-6.72	9802.00	-6.72	10050.02	3.83	
TP-A	6	1	TP-B	16	1	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	9800.00	6.87	10046.02	-3.48	9800.00	6.87	
TP-A	6	2	TP-B	16	2	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	9800.00	6.77	10046.02	-3.58	9800.00	6.77	
TP-A	6	3	TP-B	16	3	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	9800.00	6.52	10046.02	-3.83	9800.00	6.52	
TP-A	6	1	TP-B	16	1	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	9800.00	-14.17	9800.00	-14.17	10046.02	-3.82	
TP-A	6	2	TP-B	16	2	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	9800.00	-14.27	9800.00	-14.27	10046.02	-3.92	
TP-A	6	3	TP-B	16	3	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	9800.00	-14.52	9800.00	-14.52	10046.02	-4.17	

For 0kV wires between structures TP-A, maximum offset is 10.84 (m), the leftmost offset is -10.84 (m), rightmost offset is 10.84 (m)
For 132kV wires between structures TP-A, maximum offset is 14.52 (m), the leftmost offset is -14.52 (m), rightmost offset is 14.52 (m)

S.N.	Voltage Level (kV)	Span (m)	Conductor	Type of Attachment	Case	Wind Pressure (Pa)	Maximum Blowout from Tower Center Point (m)
11	132kV	500m	ACSR Bear	Strain	Max. Wire Tension	357.2 Pa	11.9m

Blowout Report

Start Struct Number	Start Struct Set	Start Struct Phase	End Struct Number	End Struct Set	End Struct Phase	Ahead Span Cable File Name	Volt -age (kV)	Weather Case Description	Cable Condition	Wind From	Max Blowout Station (m)	Max Blowout Offset (m)	Leftmost Blowout Station (m)	Leftmost Blowout Offset (m)	Rightmost Blowout Station (m)	Rightmost Blowout Offset (m)	Notes
TP-A	1	1	TP-B	11	1	OPGW-11.4mm_500m.wir	0	32° 23.5% Wind-350m	Creep RS	Left	9800.00	7.56	10048.75	0.02	9800.00	7.56	
TP-A	1	1	TP-B	11	1	OPGW-11.4mm_500m.wir	0	32° 23.5% Wind-350m	Creep RS	Right	9800.00	-7.56	9800.00	-7.56	10048.75	-0.02	
TP-A	5	1	TP-B	5	1	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	9802.00	11.64	10050.01	3.78	9802.00	11.64	
TP-A	5	2	TP-B	5	2	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	9802.00	11.74	10050.01	3.88	9802.00	11.74	
TP-A	5	3	TP-B	5	3	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	9802.00	11.90	10050.01	4.13	9802.00	11.90	
TP-A	5	1	TP-B	5	1	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	9802.00	-4.34	9802.00	-4.34	10050.01	3.52	
TP-A	5	2	TP-B	5	2	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	9802.00	-4.24	9802.00	-4.24	10050.01	3.62	
TP-A	5	3	TP-B	5	3	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	9802.00	-3.99	9802.00	-3.99	10050.01	3.87	
TP-A	6	1	TP-B	16	1	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	9800.00	4.21	9553.99	-3.52	9800.00	4.21	
TP-A	6	2	TP-B	16	2	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	9800.00	4.11	9553.99	-3.62	9800.00	4.11	
TP-A	6	3	TP-B	16	3	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Left	9553.99	-3.87	9553.99	-3.87	9800.00	3.86	
TP-A	6	1	TP-B	16	1	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	9800.00	-11.51	9800.00	-11.51	9553.99	-3.78	
TP-A	6	2	TP-B	16	2	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	9800.00	-11.61	9800.00	-11.61	9553.99	-3.88	
TP-A	6	3	TP-B	16	3	bear_acsr_500m.wir	132	32° 23.5% Wind-350m	Creep RS	Right	9800.00	-11.86	9800.00	-11.86	9553.99	-4.13	

For 0kV wires between structures TP-A, maximum offset is 7.56 (m), the leftmost offset is -7.56 (m), rightmost offset is 7.56 (m)
For 132kV wires between structures TP-A, maximum offset is 11.9 (m), the leftmost offset is -11.86 (m), rightmost offset is 11.9 (m)

APPENDIX- G: PLANTATION CORRIDOR

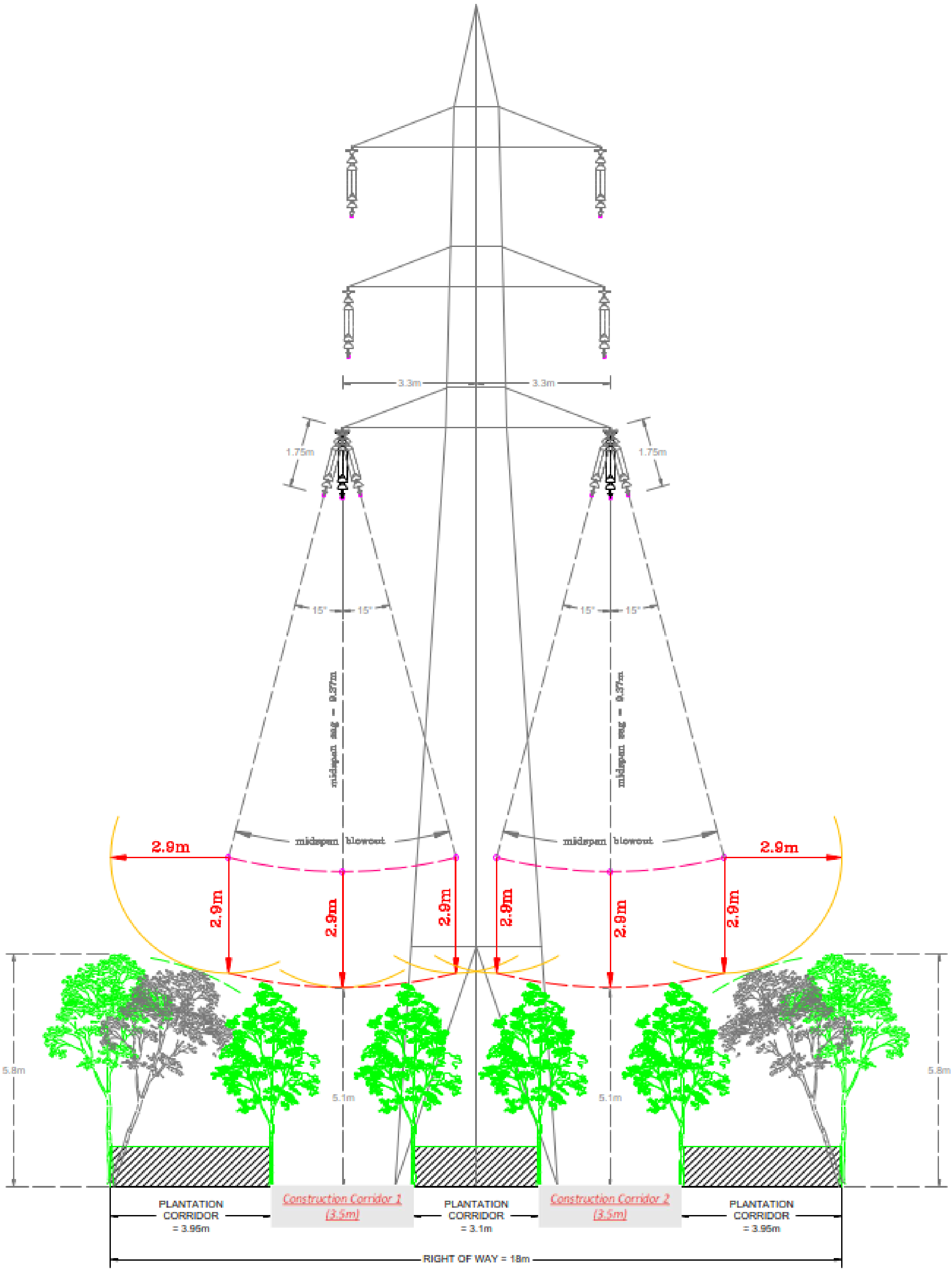

Figure-1: Allowable Tree Heights and Plantation Corridor for 132kV TL @18m ROW

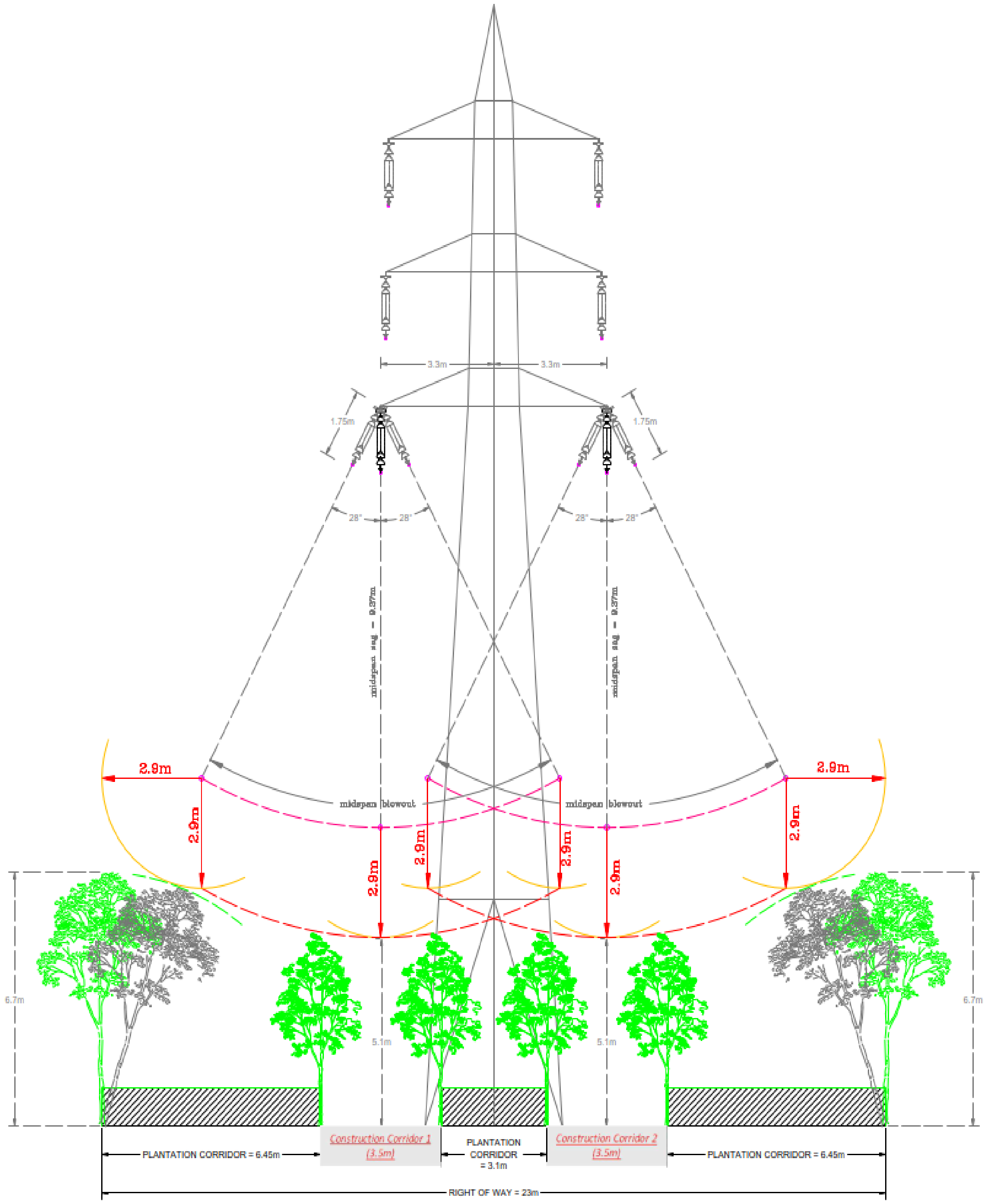

Figure-2: Allowable Tree Heights and Plantation Corridor for 132kV TL @23m ROW

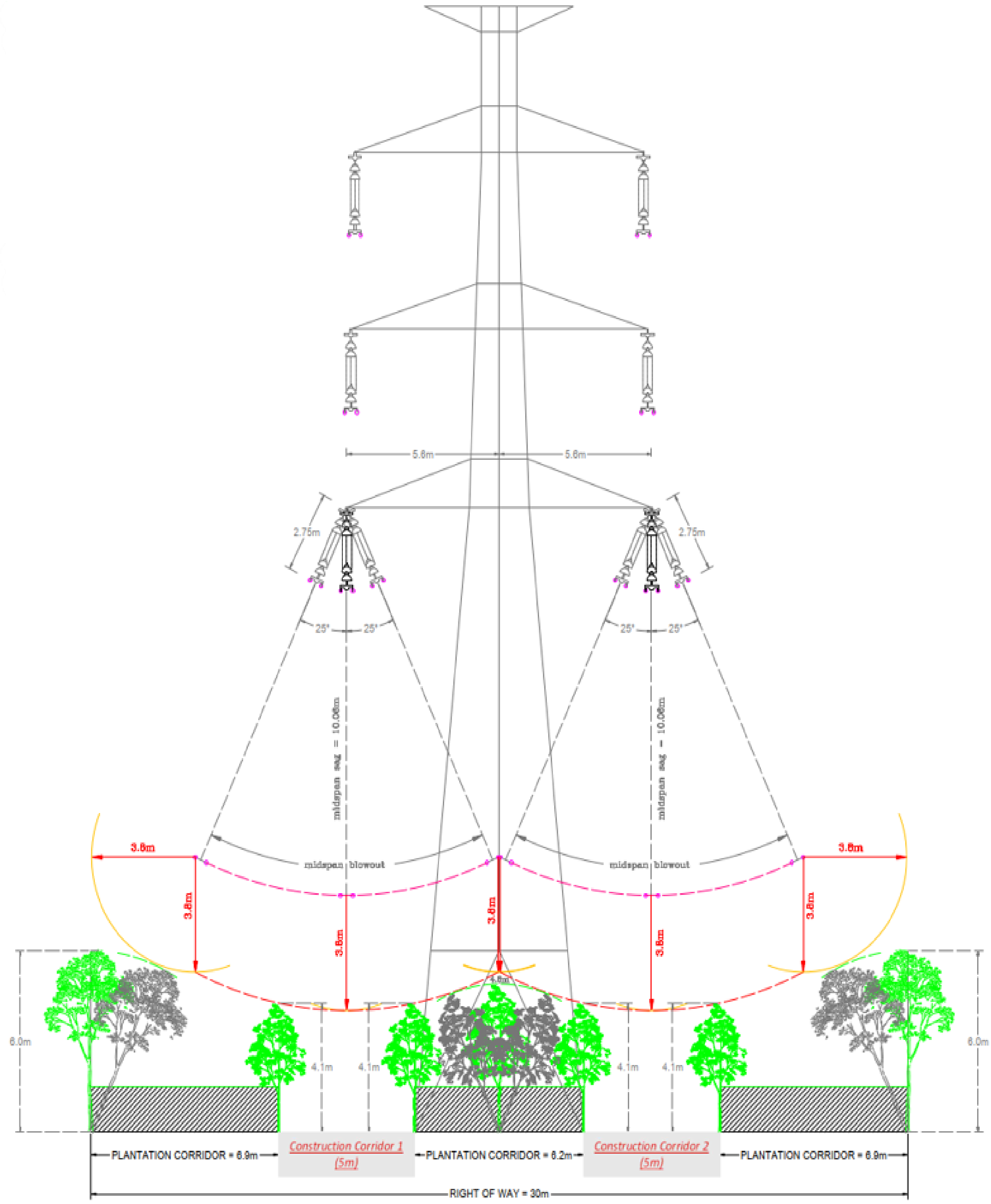

Figure-3: Allowable Tree Heights and Plantation Corridor for 220kV TL @30m ROW

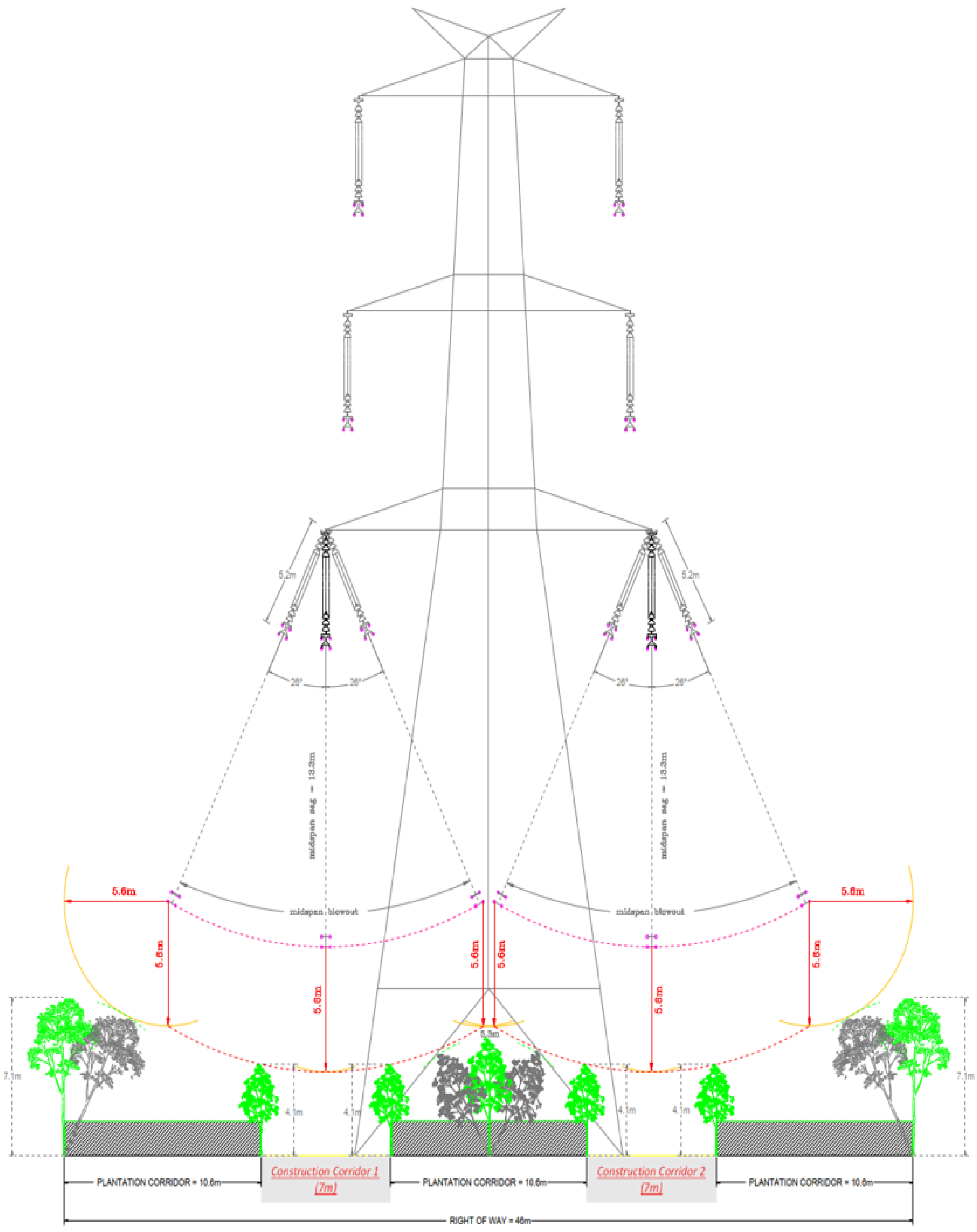

Figure-4: Allowable Tree Heights and Plantation Corridor for 400kV TL @46m ROW

APPENDIX- H: PUBLICATION

Gmail **Bibek Rai <007bibek.rai@gmail.com>**

Submission of Manuscript for RESSD 2025

IEEE Power & Energy Society Nepal Chapter <ieeepesnp@gmail.com> Tue, Apr 22, 2025 at 2:09 PM
To: Bibek Rai <007bibek.rai@gmail.com>
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Dear Authors

RESSD-2025 technical committee is pleased to inform you that your paper **has been Accepted** to be presented in the conference, congratulations!
Additional details will be sent in the upcoming days.

Regards,
RESSD2025 Technical Committee
[Quoted text hidden]

Assessment of Right of Way and Electric Field and Magnetic Field of High Voltage Overhead Transmission Lines in Nepal

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***Abstract* - The existing Right of Way (ROW) practices for high voltage overhead transmission lines (HVTLs) in Nepal are based on the voltage level and are considered the same values irrespective of design span lengths, type of conductor and tower configurations. There is not any established practice and approach for estimating the electric and magnetic fields of HVTLs. The study focuses on modeling the HVTLs in PLS-CADD and assessing the ROW requirements for standard design spans, considering both I-string and V-string suspension insulators. Further, the electric and magnetic field profiles below the HVTLs are generated at 1.8m height above ground to estimate the maximum values below the line and at the edge of ROW. The result suggests that the existing practice of 46m and 30m ROW for 400kV and 220kV TL for standard design spans are sufficient and the use of V-string insulators could help reduce the ROW requirement by as much as 17%. However, it is revealed that the existing practice of 18m ROW for 132kV TL is not sufficient for both I-string and with V-string insulators. The electric and magnetic fields during maximum sag no wind conditions are found to be within the recommended limits by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) at 1.8m above the ground. The research results can provide a basis for determining ROW and estimating the electric and magnetic field of HVTLs in Nepal.**

Keywords - Right of Way, Electric Field, Magnetic Field, High Voltage Overhead Transmission Lines

I. INTRODUCTION

Overhead AC transmission lines are predominant in Nepal and with the increasing generation capacity, integration of renewables and distributed energy resources, increasing local energy demand and the possibility of cross-border energy sale, the requirements for high voltage AC transmission lines (HVTLs) will be more than ever. The Nepalese transmission network is composed of 400kV, 220kV, 132kV and 66kV single circuit and double circuit transmission lines. There are many transmission line projects under construction and many more under feasibility study and design phase [1].

Transmission line projects affect forest areas and local communities, particularly villagers whose lands are used for the construction of transmission towers and the installation of conductors. These projects also impact natural resources, such as crops and trees, especially when the transmission lines pass through agricultural or forested areas.

The Right of Way (ROW), also called Transmission Corridor, is a minimum safety corridor around power lines to meet the requisite safety clearances as well as the electric and magnetic field exposure limits. This strip of land is also required by utilities for constructing, maintaining and protecting its transmission lines. The ROW of transmission lines mainly depends upon voltage, span length, type and size of conductor, wind speed, structure configuration, altitude, electric and magnetic fields [2].

The electric and magnetic field below the line and at the edge of the ROW is also a governing factor while estimating the ROW requirement of HVTLs because of their expected biological effects on the human body [3] [4].

The electric field is produced by voltage, and the magnetic field is produced by current. The electric and magnetic fields are coupled – therefore related to each other – when the distance to the source is much larger than the wavelength. However, when the wavelength is much larger, they are un-coupled and the effects of each should be considered separately. For low frequency fields, as is the case with power systems, the wavelength is about 3,100 miles and much larger than the typical distance of concern from the source, and therefore, the two are un-coupled. When electric and magnetic fields are coupled, they are referred to as electromagnetic fields; when they are not coupled, they are referred to as electric fields and magnetic fields [5].

Currently, there is not any established practice and approach in Nepal for estimating the ROW and electric and magnetic field limits. Also, there is not any provision for safety limits. The ROW requirement is governed by the physical electrical clearance requirements during swing conditions as well as electric and magnetic fields generated from the HVTLs, and these could vary depending upon the design span, type of conductor, tower configuration and terrain. The transmission line traverses for a long distance and is within the vicinity of the public. Therefore, it is crucial that the conductor blowouts, electric and magnetic field values around these transmission lines are determined/estimated and kept within the acceptable limits and sufficient ROW is maintained.

In this study, the ROW requirements of HVTLs, viz. 400kV, 220kV and 132kV for standard spans considering I-string and V-string suspension insulators are assessed considering the standard tower framings and design criteria for HVTLs in Nepal. Further, the electric and magnetic fields below the line and at the edge of the ROW are assessed.

II. BACKGROUND

A. *Existing Provisions in Nepal*

The current provisions, rules and regulations governing ROW for HVTLs in Nepal as per Electricity Rules 2050 are as follows [6]:

1) Rule 48 – Minimum distance from ground to the electric wire

a) The distance between the electric wire of different volts of the distribution and transmission system and the ground shall not be less than values as shown in Table I.

b) In cases where an electric line is to be installed by the side of the road or along it, it shall be done by adopting appropriate technological measures.

c) If it is necessary to install an electric line of more than 33,000 volts, it shall be done by adding 0.305 meter for each 33,000 volts on the distance as prescribed for 33,000 volts in Table I.

2) Rule 50 – Distance to be maintained on either side of the electric line

a) While installing an electric line of distribution and transmission system, it shall not be installed in a distance lower than the distance as prescribed in Table II from the house or tree.

b) If it is necessary to install an electric line of more than 33,000 volt, it shall be done by adding 0.305 meter for each 33,000 volts on the distance as prescribed for 33,000 volts in Table II. While determining the minimum distance as above, maximum deflection of wire arising due to air pressure shall be considered.

While the Act and Regulations stipulate general safety requirements, they do not provide detailed specifications for ROW dimensions or electric and magnetic field limits.

The existing practice of ROW for HVTLs in Nepal is as shown in Table III. These values are based on voltage level and considered as fixed, irrespective of design span lengths, type of conductors and tower configurations.

TABLE I. SCHEDULE 12 OF ELECTRICITY RULES (2050)

Standard Voltage of Electricity (Volts)	While Crossing the Road (m)	On the side of Road (m)	In Other Places (m)
In between 230/400 and 11,000	5.8	5.5	4.6
In between 11,000 and 33,000	6.1	5.8	5.2

TABLE II. SCHEDULE 13 OF ELECTRICITY RULES (2050)

Standard Voltage of Electricity (Volts)	Minimum Distance to be from House or Tree (m)
Standard 230/400 to 11,000	1.25
From 11,000 to 33,000	2.00

TABLE III. EXISTING PRACTICE OF ROW FOR HVTLS

Voltage Level	Right of Way	Number of Circuits
400 kV	46m	Single/ Double Circuit
220 kV	30m	Single/ Double Circuit
132 kV	18m	Single/ Double Circuit

B. *Recommended Limits for Electric and Magnetic Field*

The guidelines by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) for limiting exposure to time-varying electric and magnetic fields (1Hz to 100 kHz) [7] provide guidance on limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz) to protect the humans exposed to electric and magnetic fields in low-frequency range of electromagnetic spectrum.

The recommended exposure limits for different time-varying and frequency ranges are as shown in Table IV.

III. METHODOLOGY

A. *Data Collection*

The data regarding tower framings, design spans and wires for HVTLs in Nepal are collected from transmission line projects of Rastriya Prasaran Grid Company Limited (RPGCL) and Nepal Electricity Authority (NEA).

The design criteria relating to wind speed, wind pressure, wire specifications and conductor sagging criteria are collected through technical specifications and design requirements of HVTLs in Nepal. The conductor type and ampacity for HVTLs are considered as shown in Table V.

B. *Tools and Software*

The study was carried out using PLS-CADD software. The PLS-CADD is an industry-standard transmission line design software used by different utilities around the world, including RPGCL and NEA in Nepal. This software allows for terrain modeling, physical modeling and analysis of transmission structures, clearance analysis and electric and magnetic field studies of overhead transmission lines.

C. *Sag Tension Calculations*

The sag-tension calculations for 400kV, 220kV and 132kV transmission lines were carried out for standard design spans. The standard design span for 400kV was considered as 400m and for 220kV and 132kV it was considered as 350m. The following scenarios as per IS-802 were considered for wind speed and wind pressure calculations [8].

- Wind zone: 4
- Reliability Level: 1
- Terrain Category: 2
- Basic Wind Speed: 47m/s

TABLE IV. RECOMMENDED LIMITING EXPOSURE

Exposure	Frequency Range	Electric Field Strength (kV/m)	Magnetic Field Strength (μT)
Occupational	25Hz - 300Hz	10	500
General Public	25Hz – 50Hz	5	200

TABLE V. CONDUCTOR AND AMPACITY FOR HVTLS

Transmission Line	Conductor	Phase Current (A)
400kV	ACSR Moose	900
220kV	ACSR Bison	700
132kV	ACSR Bear	500

The initial stringing criteria was considered as follows.

- For Conductors:

22% of Ultimate Tensile Strength at 32°C, No Wind

- For Earthwire:

Earthwire Sag $\leqslant$ 90% Cold Sag of Conductor

D. PLS-CADD Modeling

The 400kV, 220kV and 132kV TLs were modeled in PLS-CADD using standard tower framing and conductor configurations, considering the four-span model as shown in Fig. 1. The following design steps were considered for PLS-CADD Modeling.

- Terrain Modeling: The terrain was modeled as flat terrain.
- Cable Modeling: The conductors and earth wire were modeled as per the technical specifications.
- Structure Modeling: The towers were modeled as M1 structures. This method allows to model the tower framing based on conductor attachment levels.
- Insulator Modeling: The I-string, V-string and tension string insulators were modeled for M1 Structures considering the standard dimensions and weights.
- Criteria Modeling: The design criteria for the wire sagging were modeled by following the tension values for individual wires and lines for wire stringing.

E. Conductor Blowouts and ROW Requirements

The general representation of the ROW for overhead transmission lines is as shown in Fig. 2 and can be formulated as [9]:

$$ROW = 2 \text{ x } (X + Y) \quad (1)$$

Where,

X = Horizontal displacement of wires from tower center during design swing

Y = Minimum horizontal electrical clearance

The minimum horizontal electrical clearance values are considered fixed values and would only vary depending on the elevation of a given transmission line. Therefore, the ROW requirement for any HVTLs will mainly depend on the horizontal displacement of conductors during the swing condition.

The minimum horizontal clearance to be maintained on either side of the electric wires is considered as per Rule 50 and Schedule-13 of the Electricity Rules, 2050 as shown in Table VI.

The wind pressure is identified for a given span which will provide a 30° swing for I-string suspension insulators. The obtained wind pressure is used to estimate the blowout of conductors for HVTLs with I-string and V-string suspension insulators.

For the ROW study of HVTLs with V-strings, the tower framing similar to that of I-string is considered. However, the crossarm and insulator arrangements are modified to reflect the crossarm requirements.

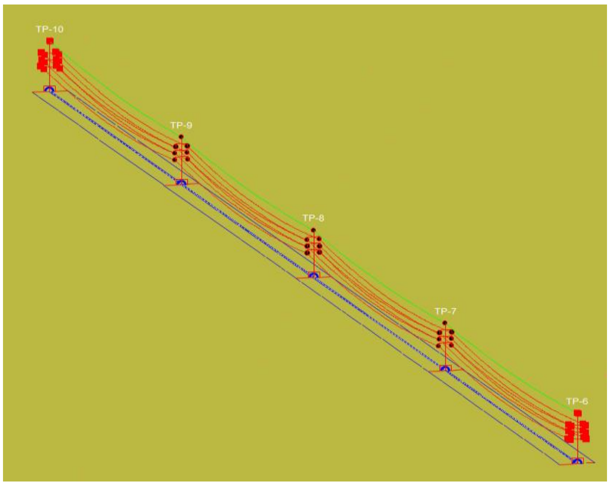

Fig. 1. Four-span model in PLS-CADD

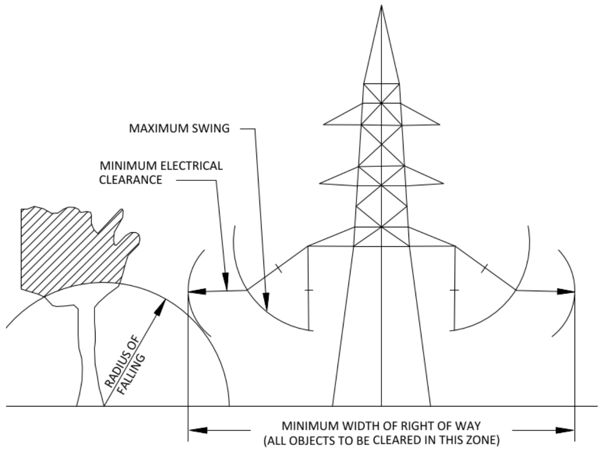

Fig. 2. Transmission line Right of Way [9]

F. Electric Field and Magnetic Field Calculations

The R-Y-B phases of double circuit lines are assigned voltage and current values as shown in Table V. The 220kV and 400kV TLs are modeled with two shield wires and 132kV TL is modeled with one shield wire.

The values recommended by ICNIRP, as shown in Table IV, are considered as boundary values to verify if the field values are within the recommended limits. The values corresponding to general public exposure are considered as limiting values at the edge of the ROW and values corresponding to occupational exposure are considered as limiting values below the line. The electric and magnetic fields are estimated at mid-span and the conductors at maximum sag and nil wind conditions. The field profiles and maximum values at mid-span cross-section for HVTLs are estimated at 1.8m height above the ground to represent the normal human height.

TABLE VI. HORIZONTAL ELECTRICAL CLEARANCES

Transmission Line	**Minimum Horizontal Clearance (m)**
400kV	5.6m
220kV	3.8m
132kV	2.9m

IV. RESULTS AND DISCUSSIONS

A. *Conductor Blowouts and Right of Way Requirements*

1) *400kV Transmission Line*

a) *With I-String*

The 30° swing of I-string insulators was observed at 386.5 Pa wind pressure. The midspan blowout of conductors from the tower center point is found to be 17.5m on either side. The total ROW requirement with I-string is estimated to be 46m. The result suggests that the existing practice of 46m ROW for 400kV TL is sufficient for a 400m design span. The summary of ROW estimation is presented in Table VII.

b) *With V-String*

The wind pressure of 386.5 Pa, which resulted in a 30º swing of I-string insulators, was considered for estimating the midspan conductor blowouts. The midspan blowout of conductors from the tower center point is found to be 13.4m on either side. The total ROW requirement with V-string is estimated to be 38m, which is 8m less than the existing practice of 46m ROW. The results suggest that the use of V-string could help reduce the ROW requirement by as much as 17%. The summary of ROW estimation is presented in Table VIII.

2) *220kV Transmission Line*

a) *With I-String*

The 30° swing of I-string insulators was observed at 331.7 Pa wind pressure. The midspan blowout of conductors from the tower center point is found to be 11.45m on either side. The total ROW requirement with I-string is estimated to be 30m. The result suggests that the existing practice of 30m ROW for 220kV TL is sufficient for a 350m design span. The summary of ROW estimation is presented in Table IX.

b) *With V-String*

The wind pressure of 331.7 Pa, which resulted in a 30º swing of I-string insulators, was considered for estimating the midspan conductor blowouts. The midspan blowout of conductors from the tower center point is found to be 8.64m on either side. The total ROW requirement with V-string is estimated to be 25m, which is 5m less than the existing practice of 30m ROW. The results suggest that the use of V-string could help reduce the ROW requirement by as much as 17%. The summary of ROW estimation is presented in Table X.

3) *132kV Transmission Line*

a) *With I-String*

The 30° swing of I-string insulators was observed at 357.2 Pa wind pressure. The midspan blowout of conductors from the tower center point is found to be 8.7m on either side. The total ROW requirement with I-string is estimated to be 23m, which is 5m more than the existing practice of 18m ROW. The result suggests that the existing practice of 18m ROW for 132kV TL is not sufficient for 350m design span. The summary of ROW estimation is presented in Table XI.

b) *With V-String*

The wind pressure of 357.2 Pa, which resulted in a 30º swing of I-string insulators, was considered for estimating the midspan conductor blowouts. The midspan blowout of conductors from the tower center point is found to be 7m on either side. The total ROW requirement with V-string is estimated to be 20m, which is 2m more than the existing practice of 18m ROW. The results suggest that the use of V-string could help reduce the ROW requirement by as much as 13% compared to I-string. However, the existing practice of 18m ROW for 132kV TL is not sufficient for a 350m design span even with V-string. The summary of ROW estimation is presented in Table XII.

TABLE VII. ROW FOR 400KV TL, I-STRING

Conductor Swing			**Blowout from Tower Center Point (m)**	**Estimated ROW (m)**
Insulator Swing	**Wind Speed (m/s)**	**Wind Pressure (Pa)**		
30°	25.1	386.5	17.5	46

TABLE VIII. ROW FOR 400KV TL, V-STRING

Conductor Swing			**Blowout from Tower Center Point (m)**	**Estimated ROW (m)**
Insulator Swing	**Wind Speed (m/s)**	**Wind Pressure (Pa)**		
NA	25.1	386.5	13.4	38

TABLE IX. ROW FOR 220KV TL, I-STRING

Conductor Swing			**Blowout from Tower Center Point (m)**	**Estimated ROW (m)**
Insulator Swing	**Wind Speed (m/s)**	**Wind Pressure (Pa)**		
30°	20.5	331.7	11.45	30

TABLE X. ROW FOR 220KV TL, V-STRING

Conductor Swing			**Blowout from Tower Center Point (m)**	**Estimated ROW (m)**
Insulator Swing	**Wind Speed (m/s)**	**Wind Pressure (Pa)**		
NA	20.5	331.7	8.64	25

TABLE XI. ROW FOR 132KV TL, I-STRING

Conductor Swing			**Blowout from Tower Center Point (m)**	**Estimated ROW (m)**
Insulator Swing	**Wind Speed (m/s)**	**Wind Pressure (Pa)**		
30°	23.5	357.2	8.7	23

TABLE XII. ROW FOR 132KV TL, V-STRING

Conductor Swing			**Blowout from Tower Center Point (m)**	**Estimated ROW (m)**
Insulator Swing	**Wind Speed (m/s)**	**Wind Pressure (Pa)**		
NA	23.5	357.2	7.0	20

B. Electric Field Profiles

1) 400kV Transmission Line

The electric field is found to be 9.55 kV/m below the line and 1.37 kV/m at the edge of 46m ROW. The result suggests that the electric field below the 400kV TL and at the edge of ROW is within the recommended safe limits as shown in Table IV. The electric field profile at mid-span is as shown in Fig. 3.

2) 220kV Transmission Line

The electric field is found to be 5.6 kV/m below the line and 0.99 kV/m at the edge of 30m ROW. The result suggests that the electric field below the 220kV TL and at the edge of ROW is within the recommended safe limits as shown in Table IV. The electric field profile at mid-span is as shown in Fig. 4.

3) 132kV Transmission Line

The electric field is found to be 2.44 kV/m below the line and 0.68 kV/m at the edge of 18m ROW. The result suggests that the electric field below the 132kV TL and at the edge of ROW is within the recommended safe limits as shown in Table IV. The electric field profile at mid-span is as shown in Fig. 5.

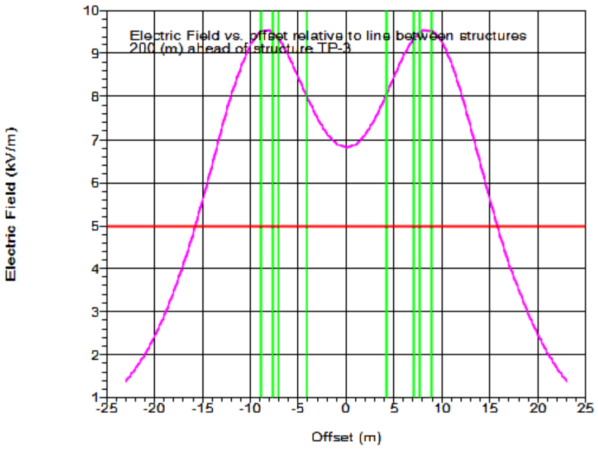

Fig. 3. Mid-span electric field profile across the 400kV TL

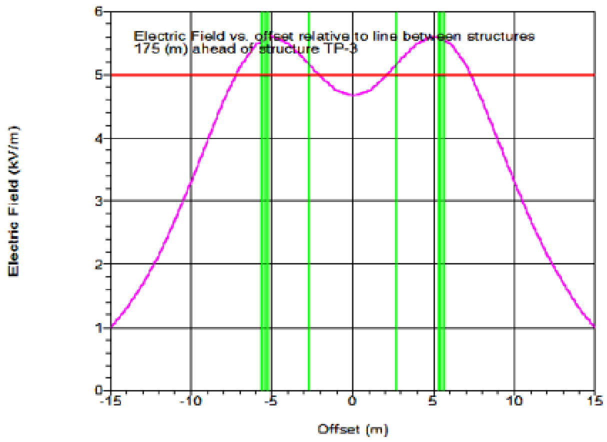

Fig. 4. Mid-span electric field profile across the 220kV TL

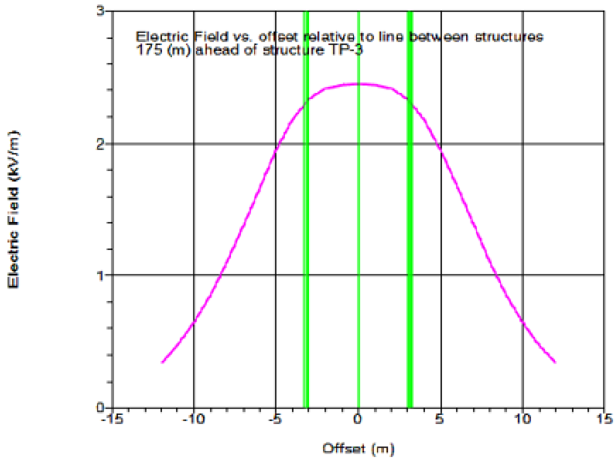

Fig. 5. Mid-span electric field profile across the 132kV TL

C. Magnetic Field Profiles

1) 400kV Transmission Line

The magnetic field is found to be 58.7 µT below the line and 31.63 µT at the edge of 46m ROW. The result suggests that the magnetic field below the 400kV TL is within the recommended safe limits as shown in Table IV. The magnetic field profile at mid-span is as shown in Fig. 6.

2) 220kV Transmission Line

The magnetic field is found to be 29.53 µT below the line and 17.1 µT at the edge of 30m ROW. The result suggests that the magnetic field below the 220kV TL is within the recommended safe limits as shown in Table IV. The magnetic field profile at mid-span is as shown in Fig. 7.

3) 132kV Transmission Line

The magnetic field is found to be 20 µT below the line and 13.5 µT at the edge of 18m ROW. The result suggests that the magnetic field below the 132kV TL is within the recommended safe limits as shown in Table IV. The magnetic field profile at mid-span is as shown in Fig. 8

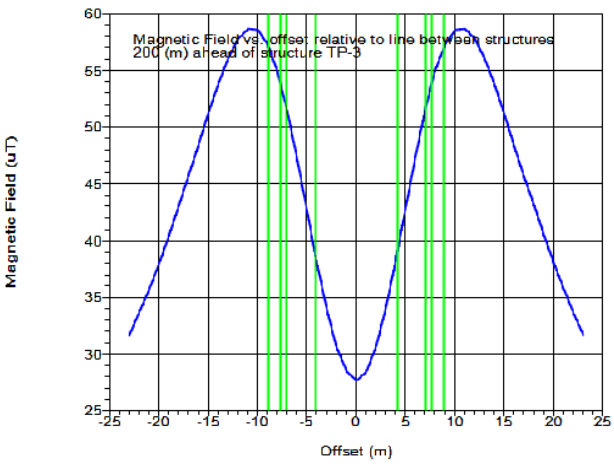

Fig. 6. Mid-span magnetic field profile across the 400kV TL

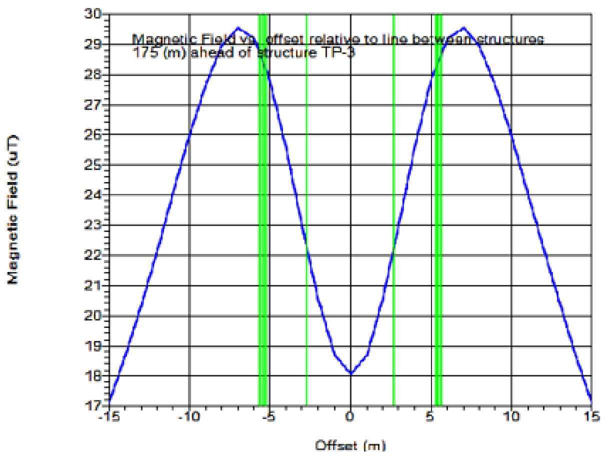

Fig. 7. Mid-span magnetic field profile across the 220kV TL

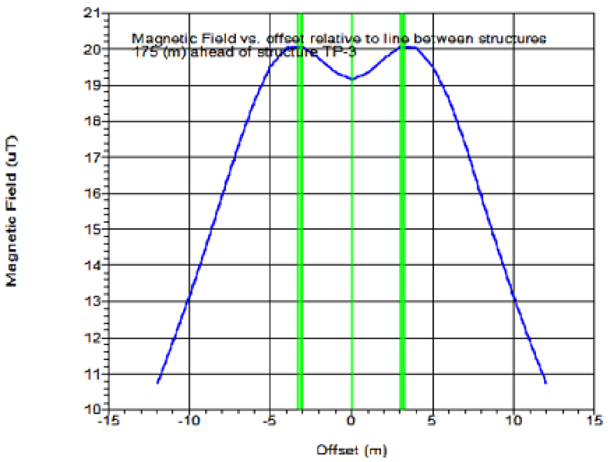

Fig. 8. Mid-span magnetic field profile across the 132kV TL

V. CONCLUSIONS AND RECOMMENDATIONS

The study assessed the ROW requirements and electric and magnetic fields of HVTLs in Nepal. The results indicate that the existing practice of ROW for 400kV and 220kV TLs is sufficient, whereas the ROW for 132kV TL should be increased to 23m. And the use of V-string insulators could help reduce the ROW requirements for HVTLs. Further, it has been found that the electric and magnetic fields below the line and at the edge of the ROW of HVTLs are within the recommended safe limits by ICNIRP.

The following recommendations have been brought forward for transmission line utilities in Nepal to make the HVTLs more resilient and compliant with international practices.

1) It is recommended that the minimum ROW width based on the voltage level of the transmission lines shall be established along with provision for flexible ROW width based on geographic, environmental and social settings, such as for rural, urban and forest areas.

2) It is recommended that provisions and approaches for estimating electric and magnetic fields below the line and at the edge of the ROW shall be introduced and made mandatory, to be in-line with international practice of public safety. This will help address the public health and safety concerns relating to the effects of electric and magnetic fields from HVTLs.

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APPENDIX- I: PLAGIARISM TEST REPORT

Bibek Rai

Assessment of Right of Way and Electric Field and Magnetic Field of High Voltage Overhead Transmission Lines in Nepal

Tribhuvan University

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