INTRODUCTION TO TRANSMISSION LINE & 3D MODELLING OF TRANSMISSIO LINE IN PLS CADD

Presenter-

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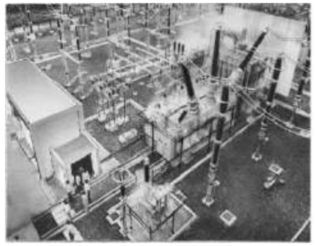
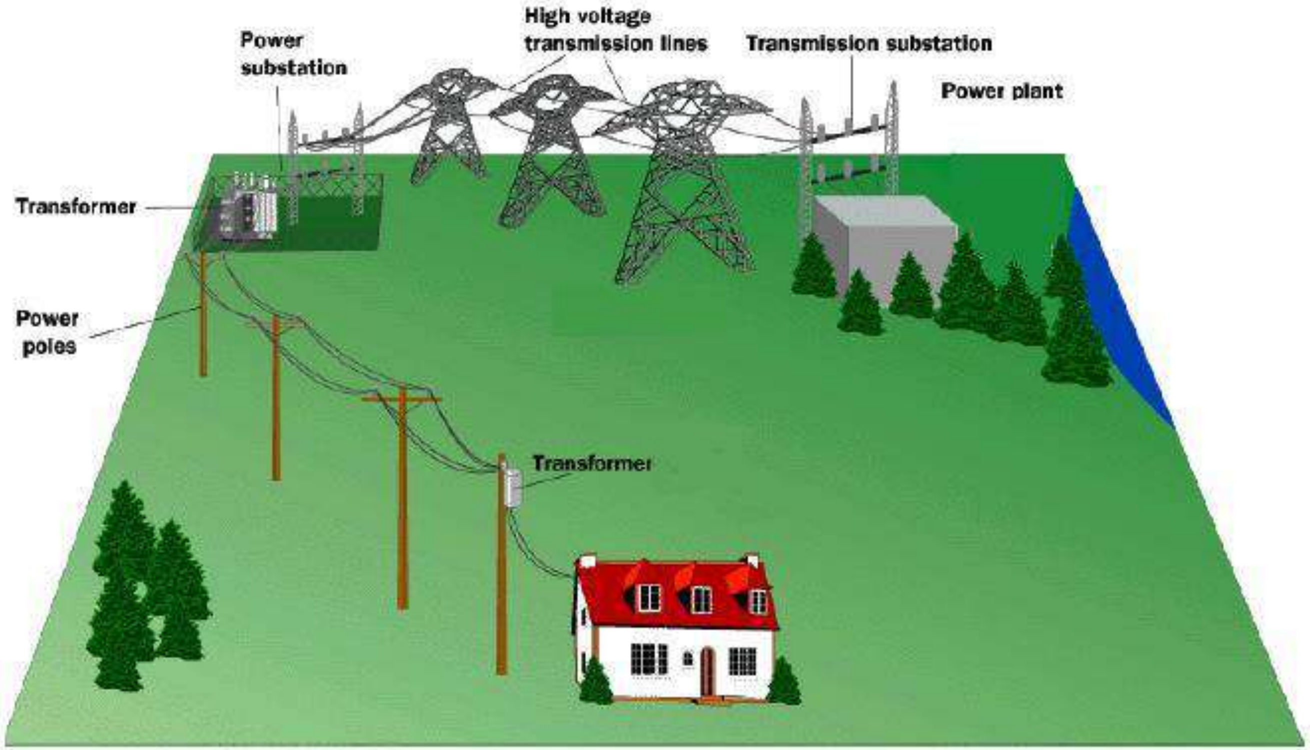
TYPICAL MODEL OF TRANSMISSION LINE

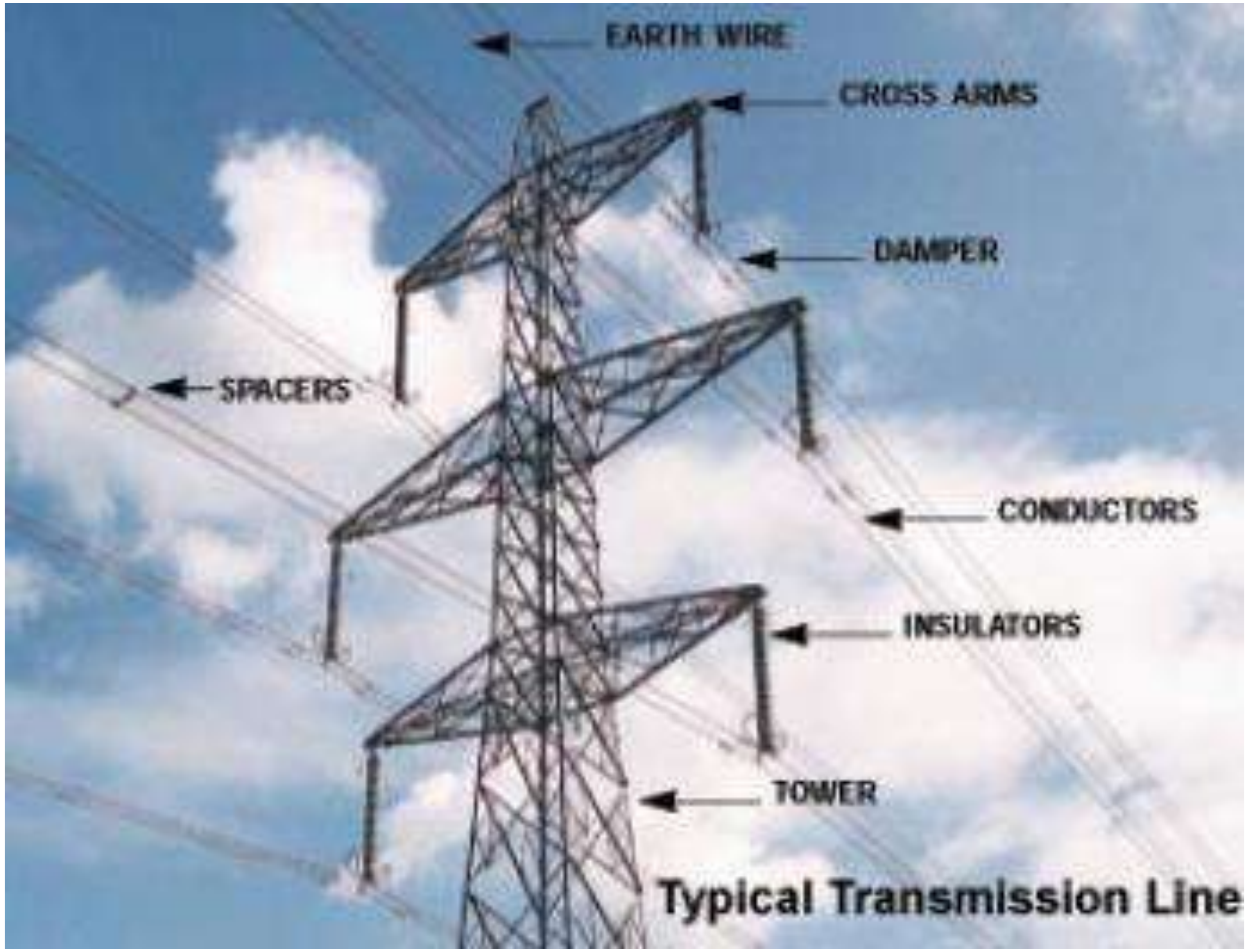


Generation → **Transmission Line** → Sub Station → Loads

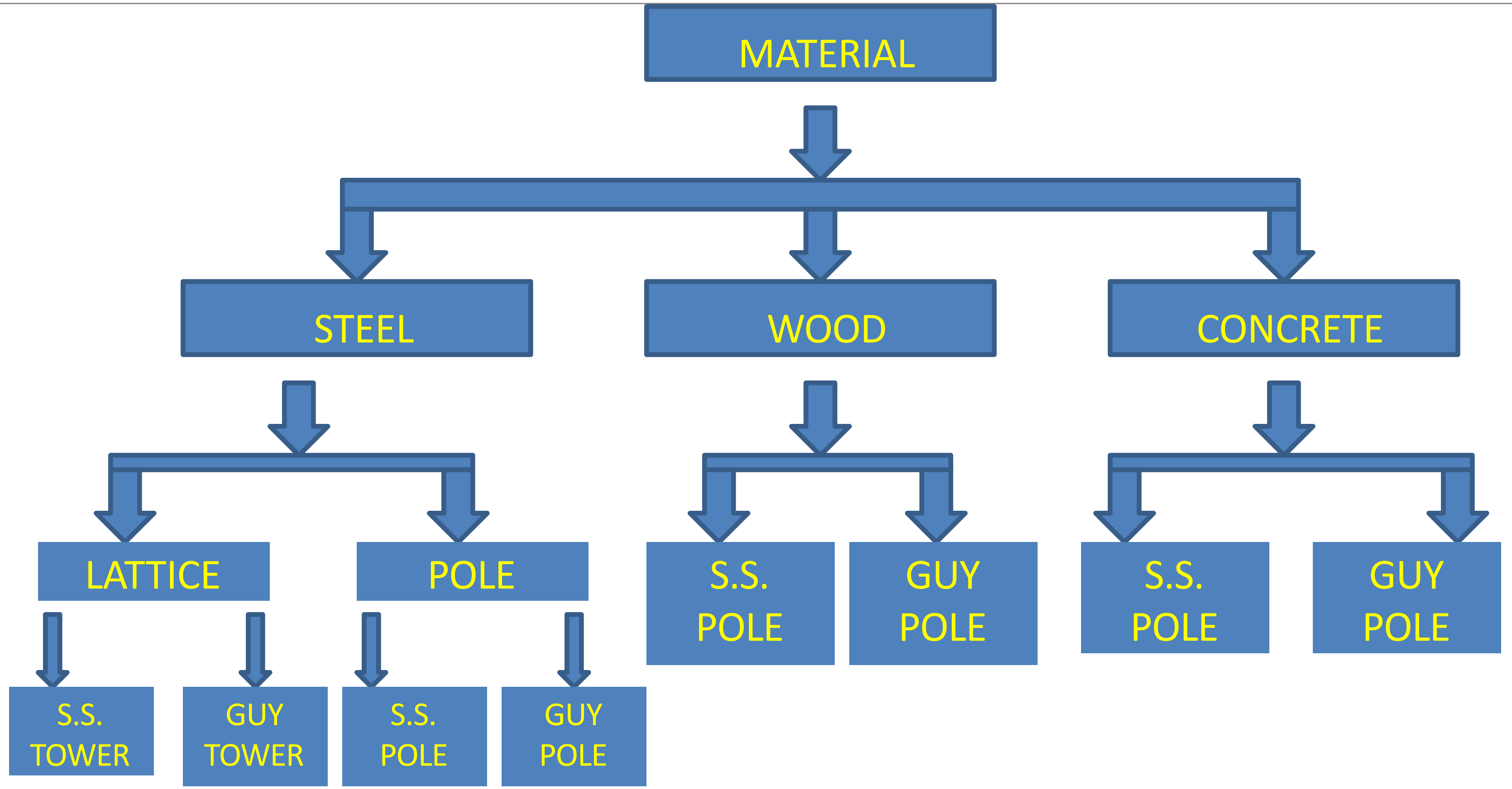


TYPICAL MODEL OF TRANSMISSION LINE

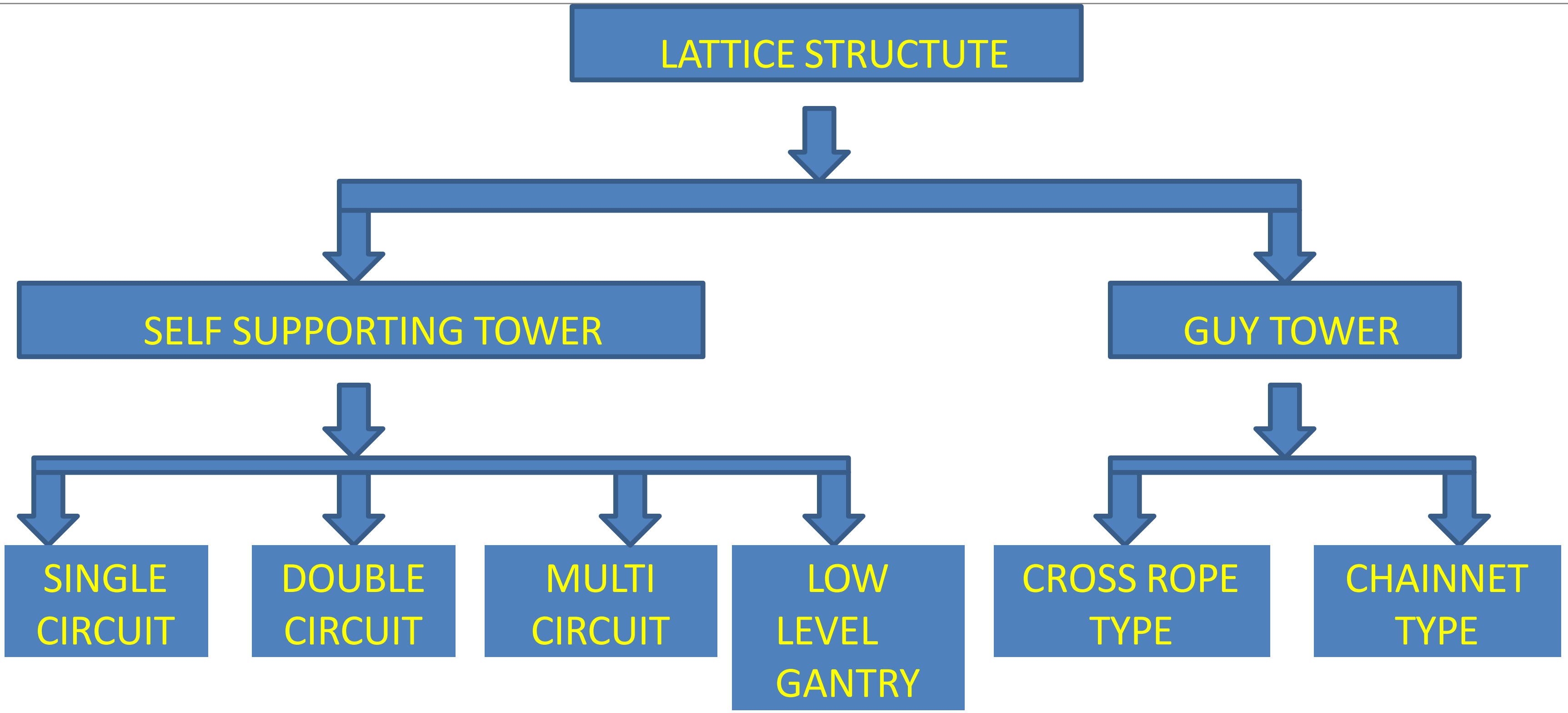
COMPONENTS OF TRANSMISSION LINE



TYPES OF SUPPORT STRUCTURE BASED ON MATERIAL



TYPES OF SUPPORT STRUCTURE



TYPES OF SUPPORT STRUCTURE

- SINGLE CIRCUIT
  - VERTICAL
  - HORIZONTAL
  - DELTA

SINGLE CIRCUIT STRUCTURE

VERTICAL CONFIGURATION

SINGLE CIRCUIT STRUCTURE

HORIZONTAL CONFIGURATION

SINGLE CIRCUIT STRUCTURE

DELTA(CHAT) CONFIGURATION

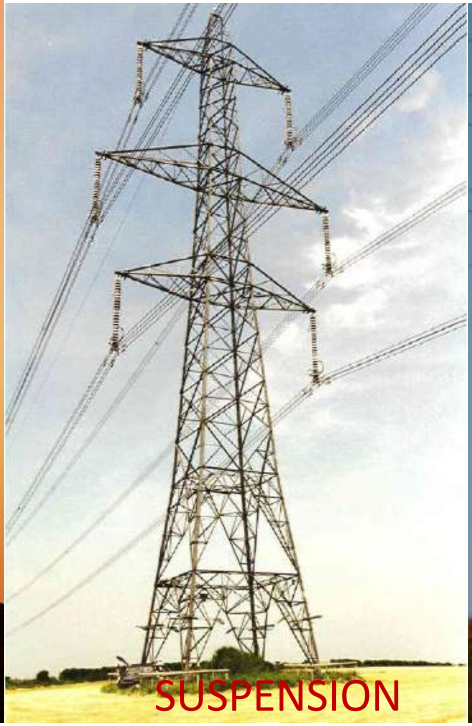
TYPES OF SUPPORT STRUCTURE

DOUBLE CIRCUIT

- VERTICAL
- DELTA

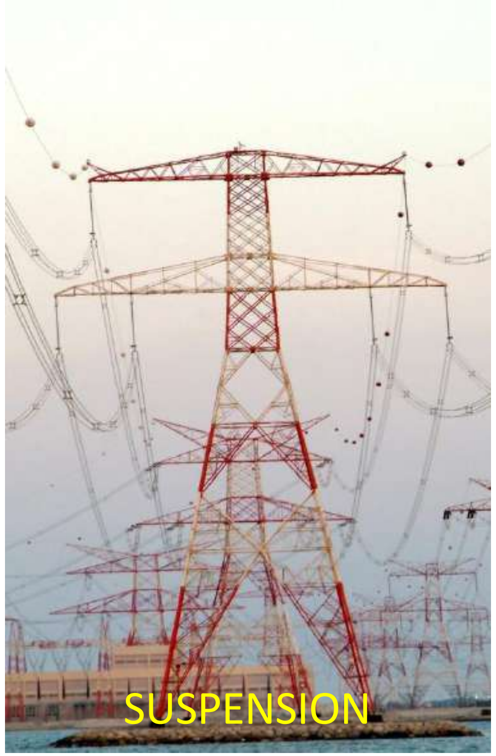
DOUBLE CIRCUIT STRUCTURE

VERTICAL CONFIGURATION

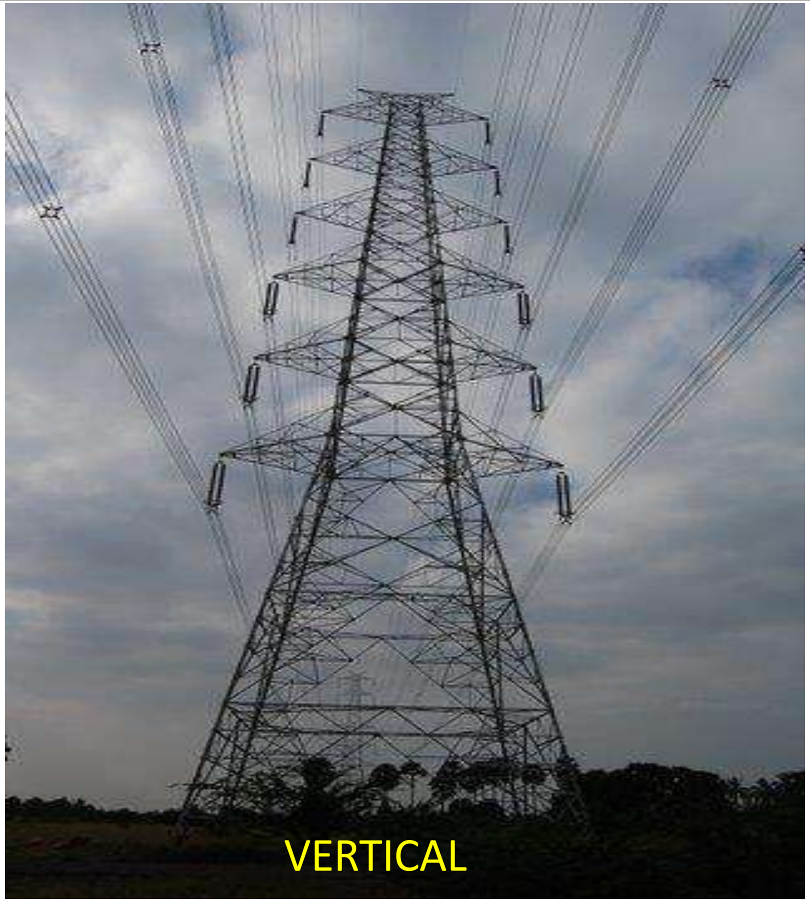


DOUBLE CIRCUIT STRUCTURE

DELTA CONFIGURATION



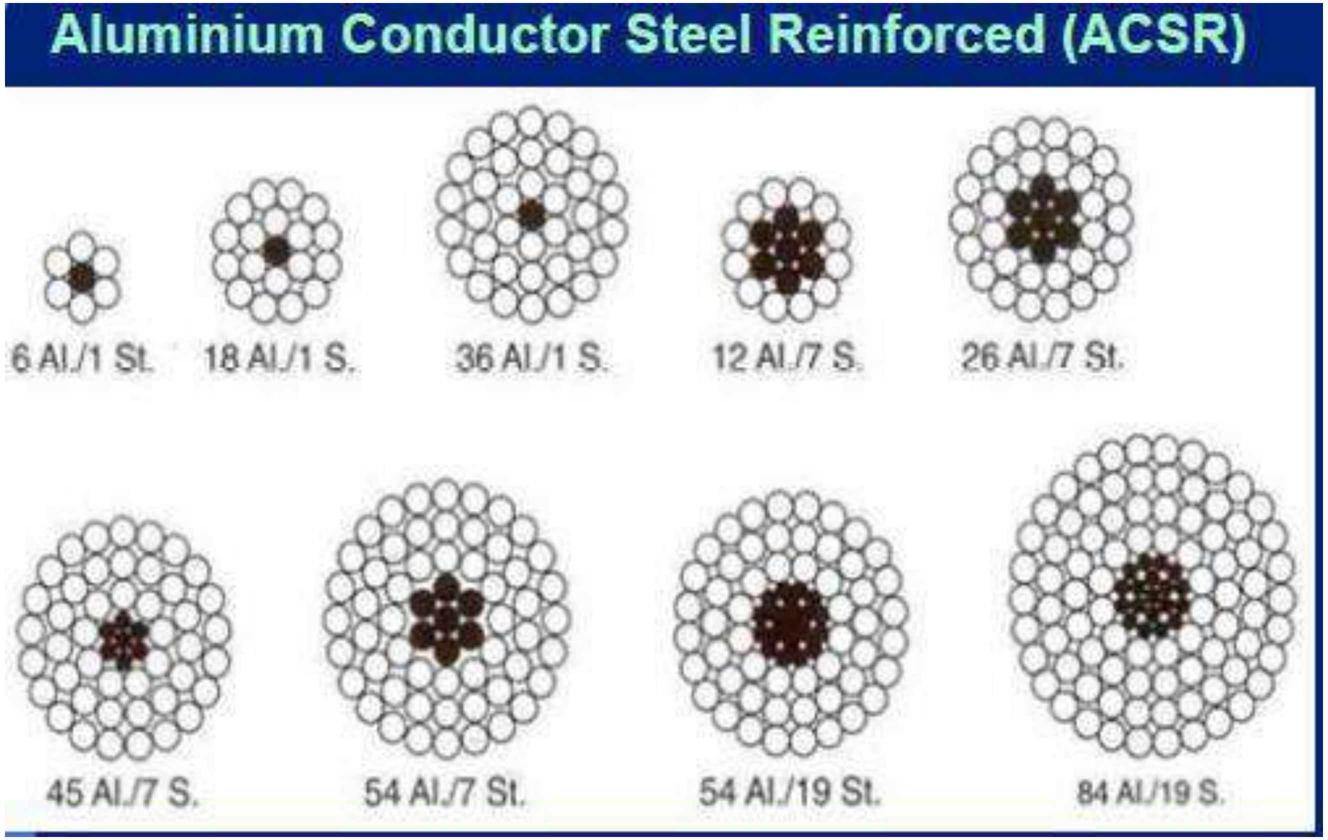
MULTI CIRCUIT STRUCTURE



COMPONENTS OF TRANSMISSION LINE

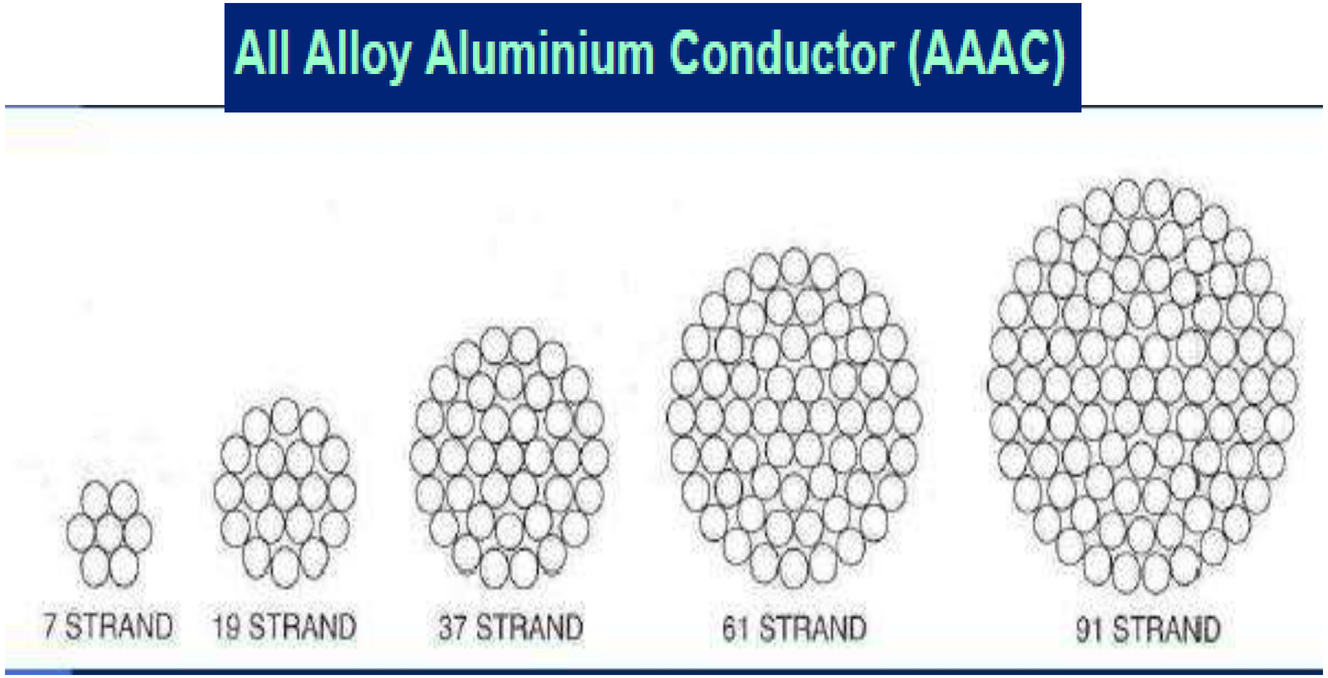
CONDUCTORS

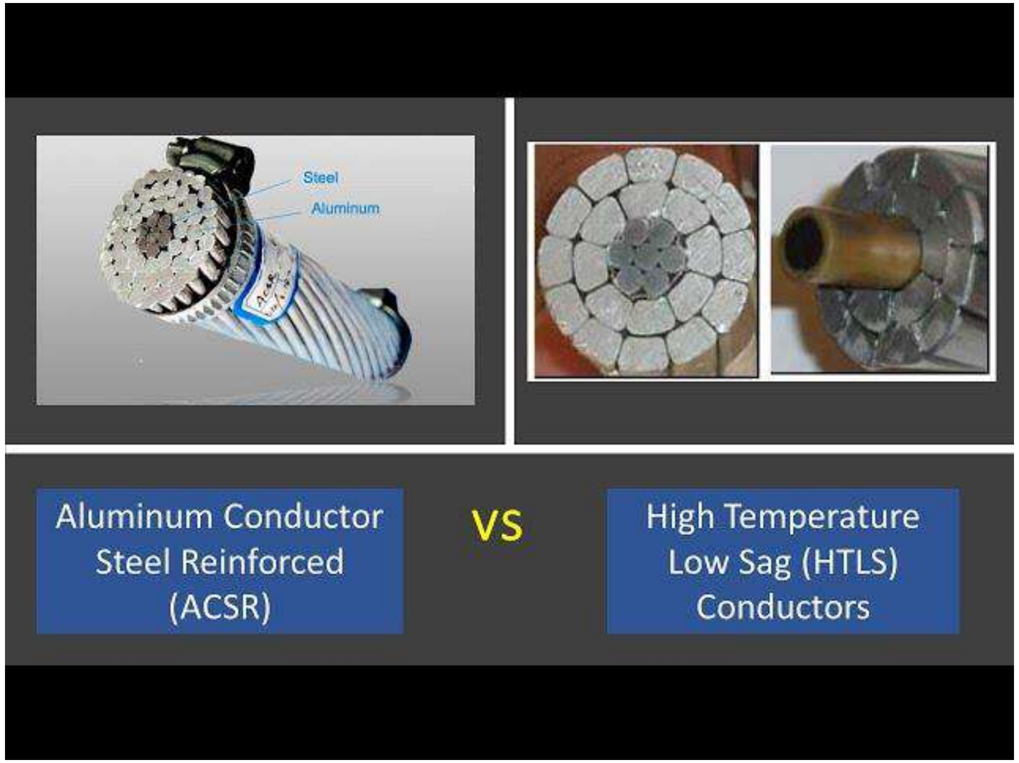
- Power conducting wire carry high Voltage current.
- Material : Stranded wires of Aluminum, Steel, Aluminum alloy or Copper
- Type:-Aluminum Conductors Steel Reinforced (ACSR)
  - All Aluminum Conductors (AAC or ASC)
  - All Aluminum Alloy Conductors (AAAC)
  -Aluminum Alloy conductors Steel reinforced (AACSR)
- Purchase from Manufacturers
- Type & property of conductor is generally specified in the Tower specification by purchaser/client.
- Property like Diameter, Area, Unit weight, Ultimate Tension, Modulus of Elasticity & Coefficient of Linear Expansion should be obtained for Sag Tension, Load Calculations etc. for Tower designs .



COMPONENTS OF TRANSMISSION LINE CONDUCTORS-ACSR TYPE

COMPONENTS OF TRANSMISSION LINE CONDUCTORS- AAAC TYPE





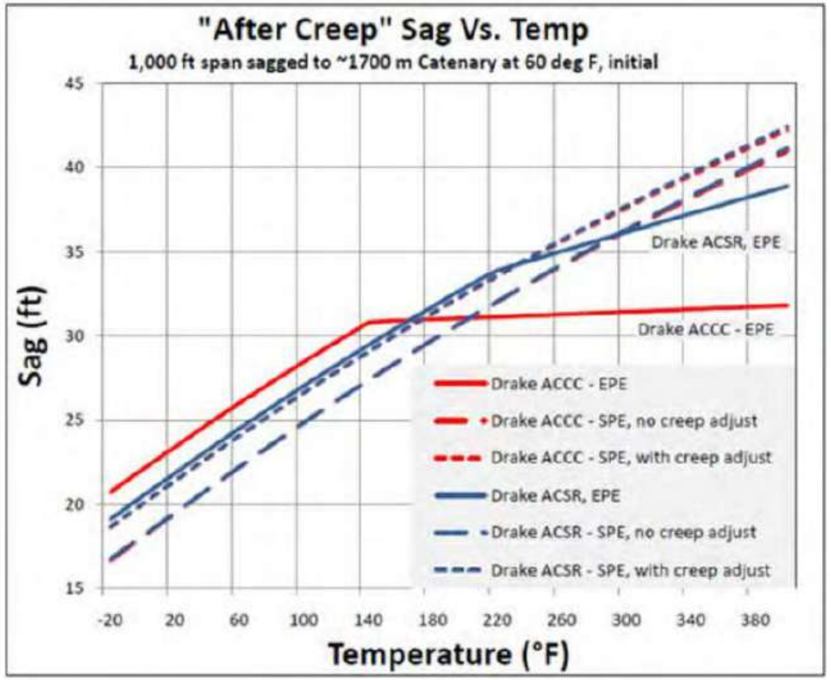
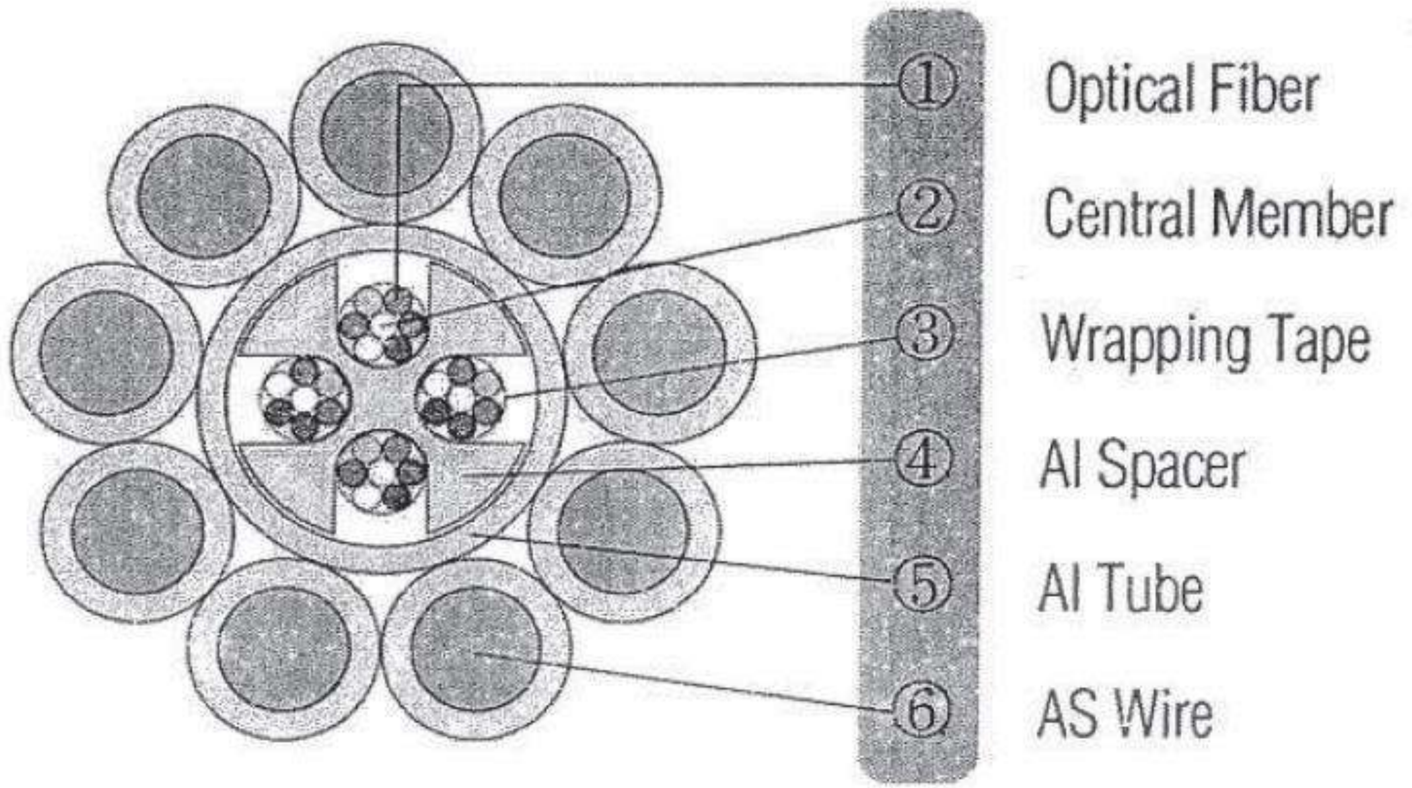


Figure 58 - Differences in calculated sag and tension of ACSR & ACCC conductor using different modeling methods. The EPE method is the most accurate method.

COMPONENTS OF TRANSMISSION LINE CONDUCTORS- HTLS



OPGW

COMPONENTS OF TRANSMISSION LINE OPGW

- Neutral wire to protect tower & line from Lighting.
- Material : Stranded wires Galvanized Steel, Aluminum

Conductors Steel Reinforced (ACSR) or Alumino weld Steel wire.

- When above wires are provided with Optical Fiber it is called as OPGW which is used for Telecommunication purpose also.

- Purchase from other parties/Manufacturers
- Type & property of Earthwire/OPGW is generally specified in

the Tower specification by purchaser.

- Property like Diameter, Area, Unit weight, Ultimate Tension, Modulus of Elasticity & Coefficient of Linear Expansion should be obtained for Sag Tension, Load Calculations etc. for Tower designs .

COMPONENTS OF TRANSMISSION LINE INSULATOR

Substance that blocks or retards the flow of electric current.

An insulator is a poor conductor because it has a high resistance to such flow.

Electrical insulators are commonly used to hold conductors in place, separating them from one another and from surrounding structures to form a barrier between energized parts of an electric circuit and confine the flow of current to wires or other conducting paths.

Material: Porcelain, Toughened Glass, Silicon rubber with Fiberglass Rod & Silicon rubber weathering shed.

COMPONENTS OF TRANSMISSION LINE INSULATOR

Type : Ball & socket type, Long Rod type & Composite /Polymeric type .

Insulator Assembly of two types. Suspension types to be used with Suspension towers and Tension types used with Tension/Terminal towers.

Design of Insulators is depend on Electrical requirements such as kV, current capacity and leakage distance which done by manufacture with specification requirement.

Drawings showing details like Diameter, Length, Unit weight, leakage distance, Hardware details for tower attachment, Arcing Horn should be obtained for Load Calculations & clearance requirement for Tower designs .

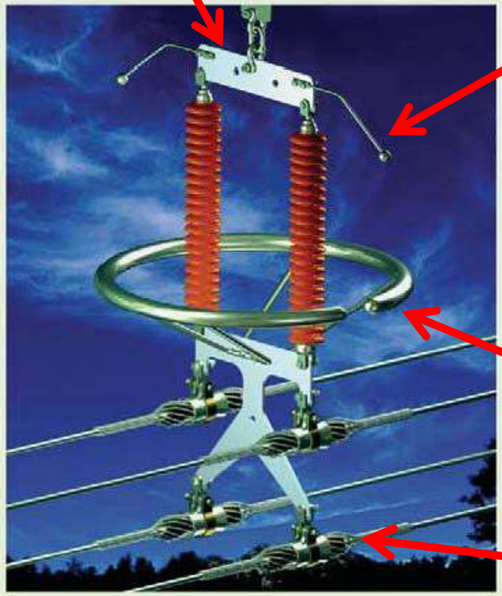
Hardware fitting are provided to connect Insulator at both end , to attach one for conductor and other for tower cross arms.

COMPONENTS OF TRANSMISSION LINE INSULATOR

- PORCEALIN
- GLASS
- COMPOSITE

COMPONENTS OF TRANSMISSION LINE

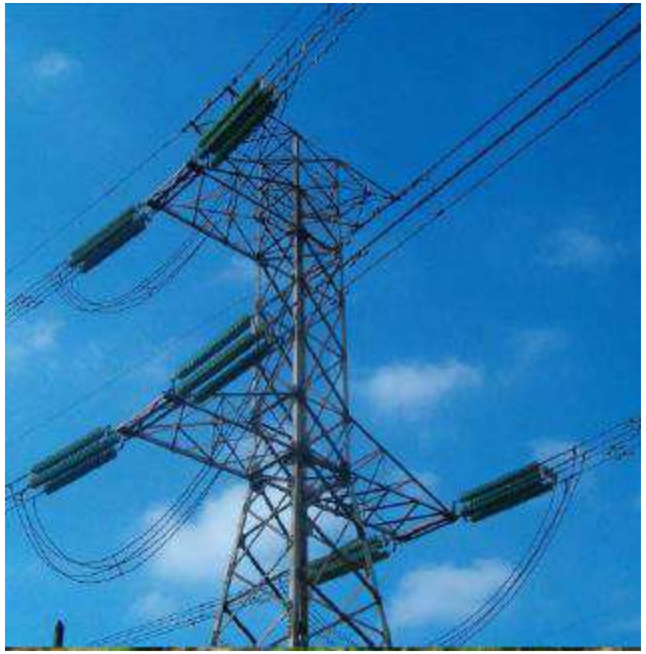
COMPONENTS OF INSULATOR STRING



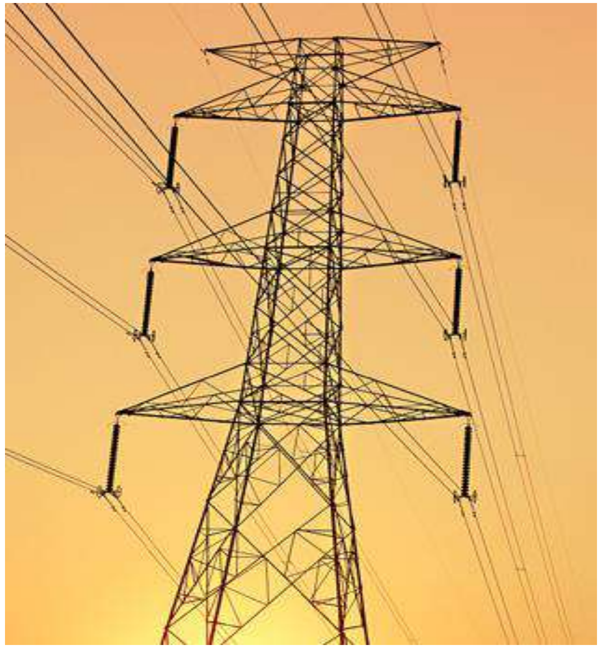
400 KV Quadruple Suspension Fittings

COMPONENTS OF TRANSMISSION LINE

TYPE OF INSULATOR STRING



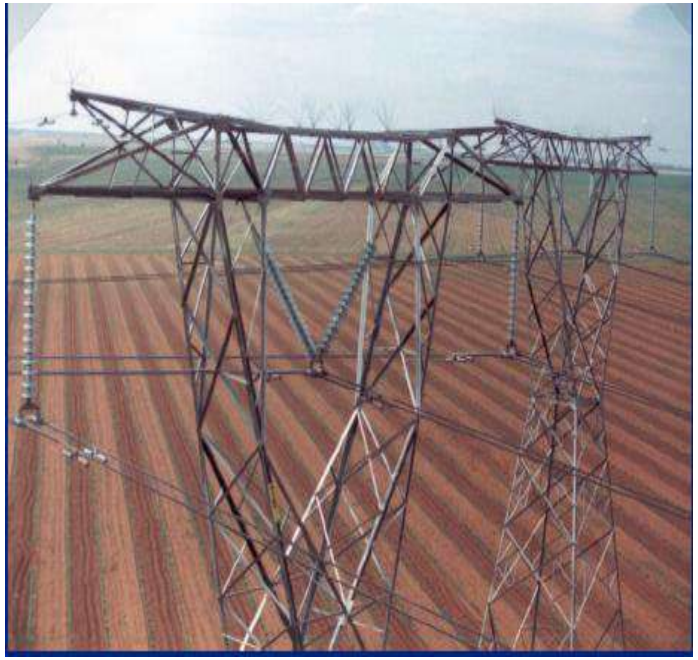
STRAIN/TENSION



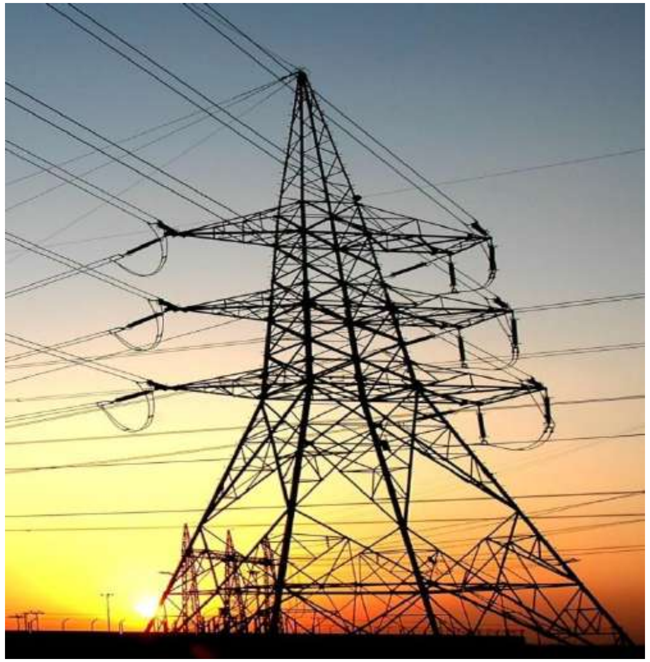
SUSPENSION- I STRING

COMPONENTS OF TRANSMISSION LINE

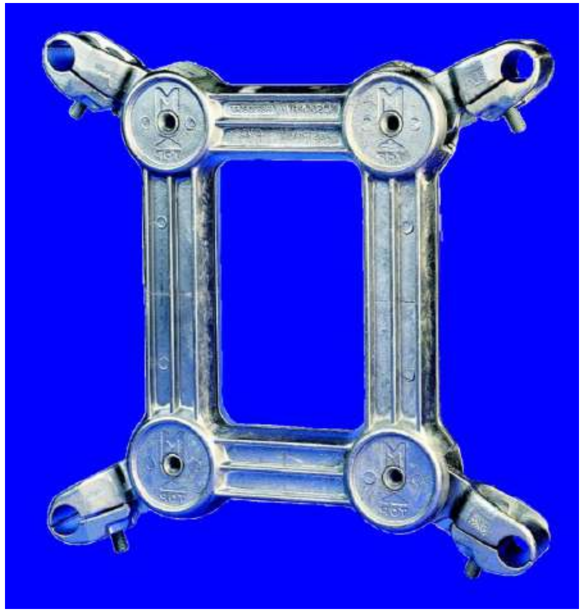
TYPE OF INSULATOR STRING



SUSPENSION –V STRING



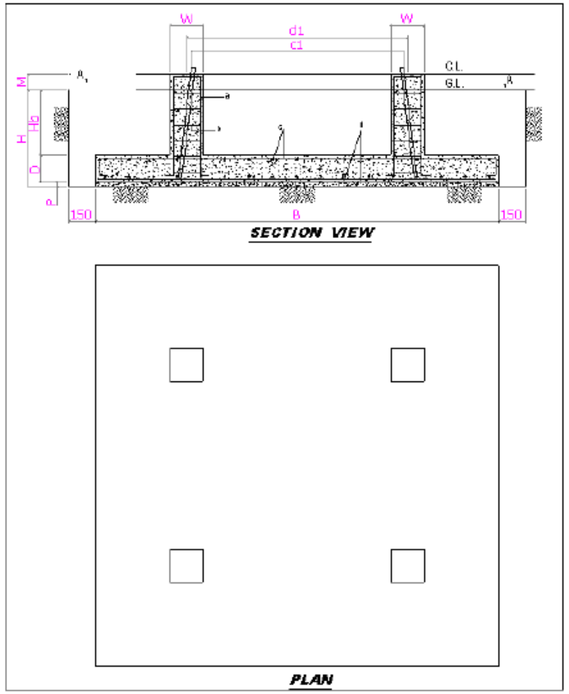
JUMPER SUSPENSION STRING



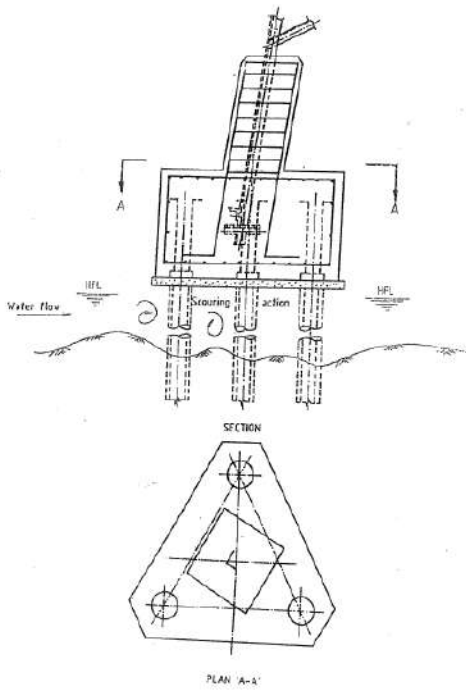
COMPONENTS OF TRANSMISSION LINE CONDUCTOR SPACER & VIBRATION DAMPER

COMPONENTS OF TRANSMISSION LINE

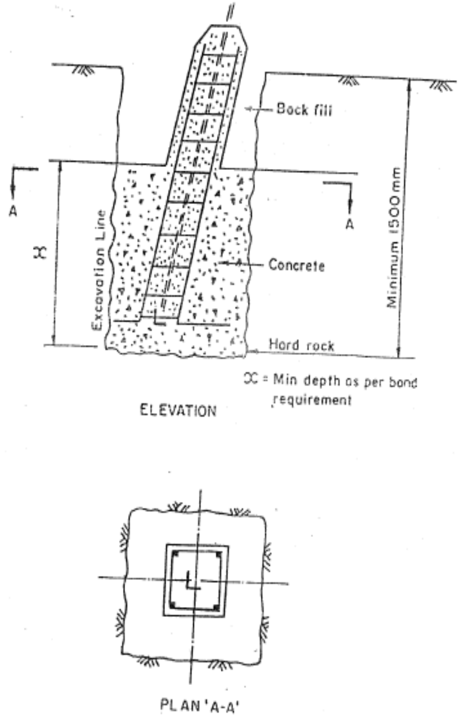
TOWER FOUNDATION



STRAIN/TENSION



PILE FOUNDATION



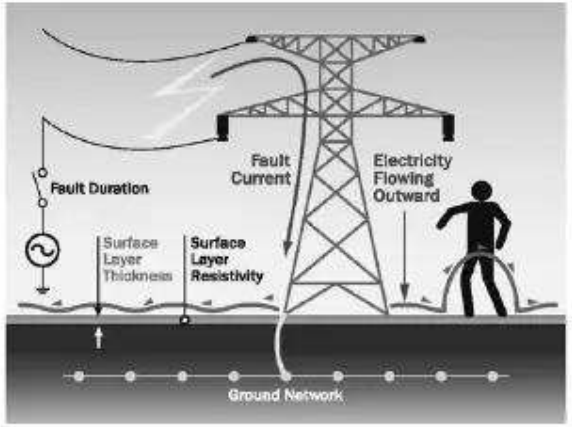
HARD ROCK

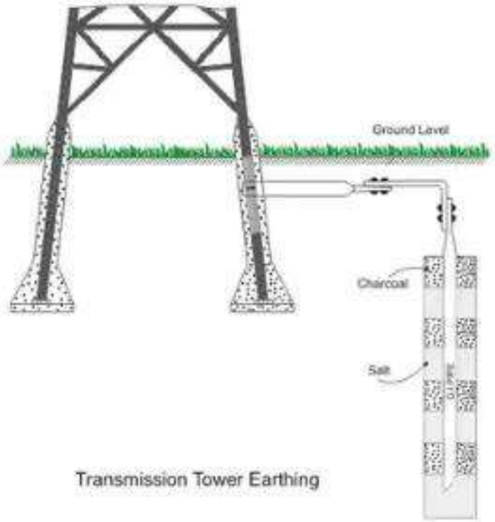
etcbl global

COMPONENTS OF TRANSMISSION LINE

<u>EARTHING OF TOWERS</u>

What is Earthing of Electrical Transmission Tower?



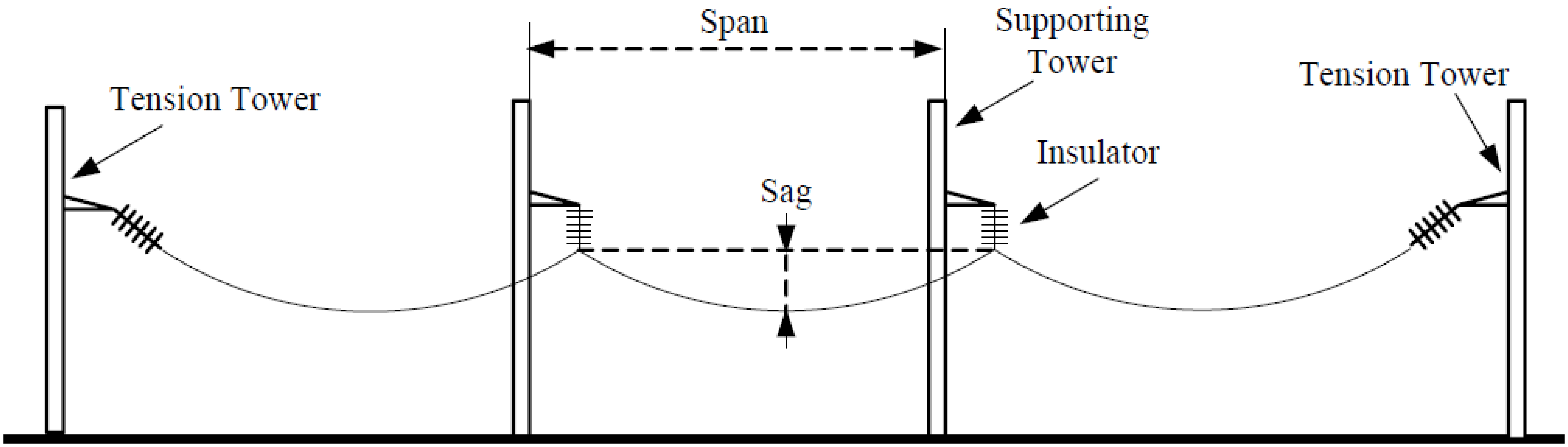


APPROACH TO DESIGN

- Spans : Normal, Wind, Weight Spans
- General Climatic Conditions like temperature range, wind speed, Terrain category, Reliability Level
- Conductors, Earth wires / OPGW and their characteristics
- Reference Standards which has direct impact on Design
- Materials, their sizes Standards and Grades that can be followed. (This will give different limitations to be followed which should be noted for easy access.
- Length & Diameter of Insulators (Suspension / Tension /Single / Double)
- Swing Angles & Clearances for Insulator/Jumper
- Ground Clearance

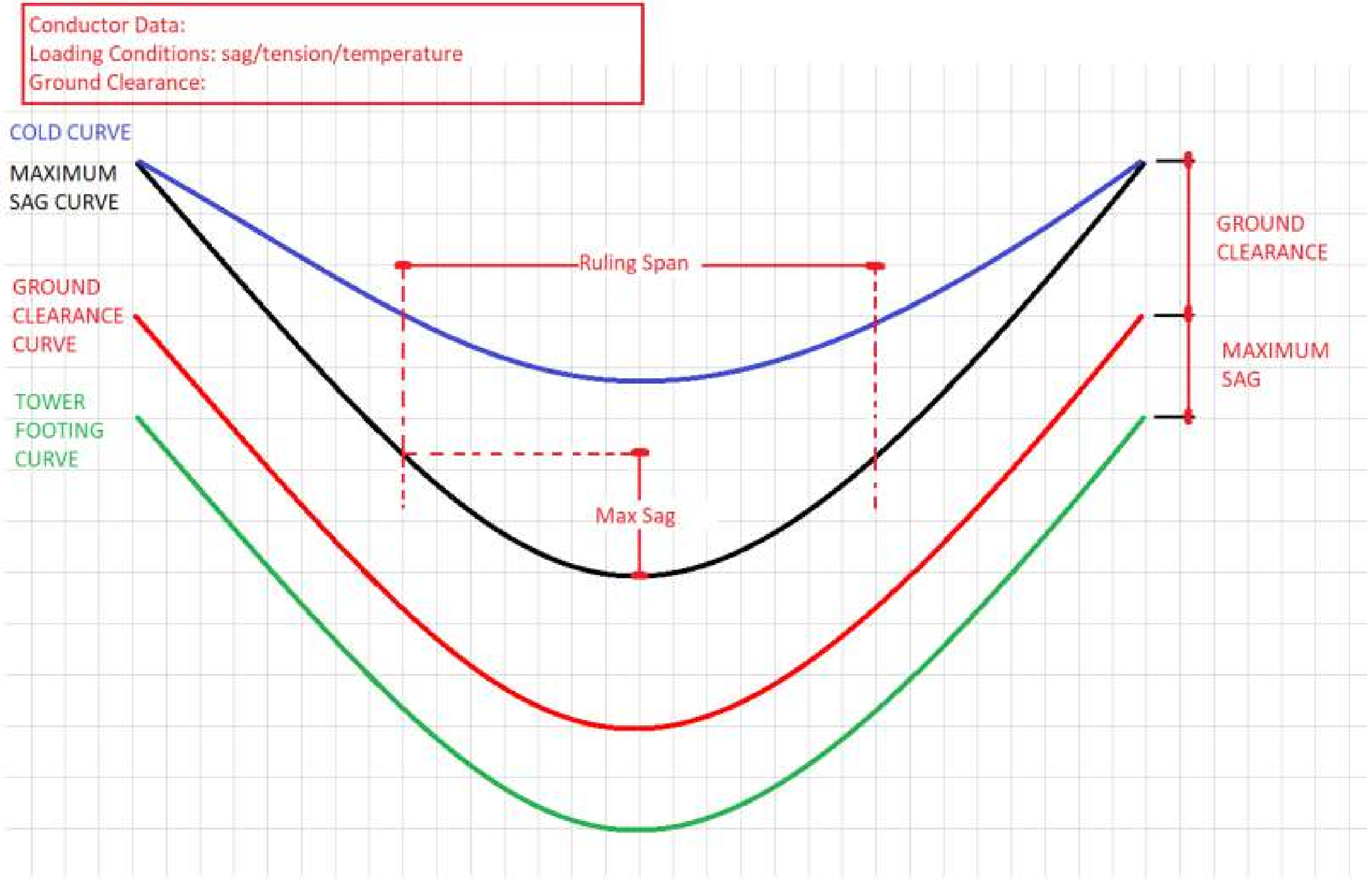
COMMON TERMINOLOGIES

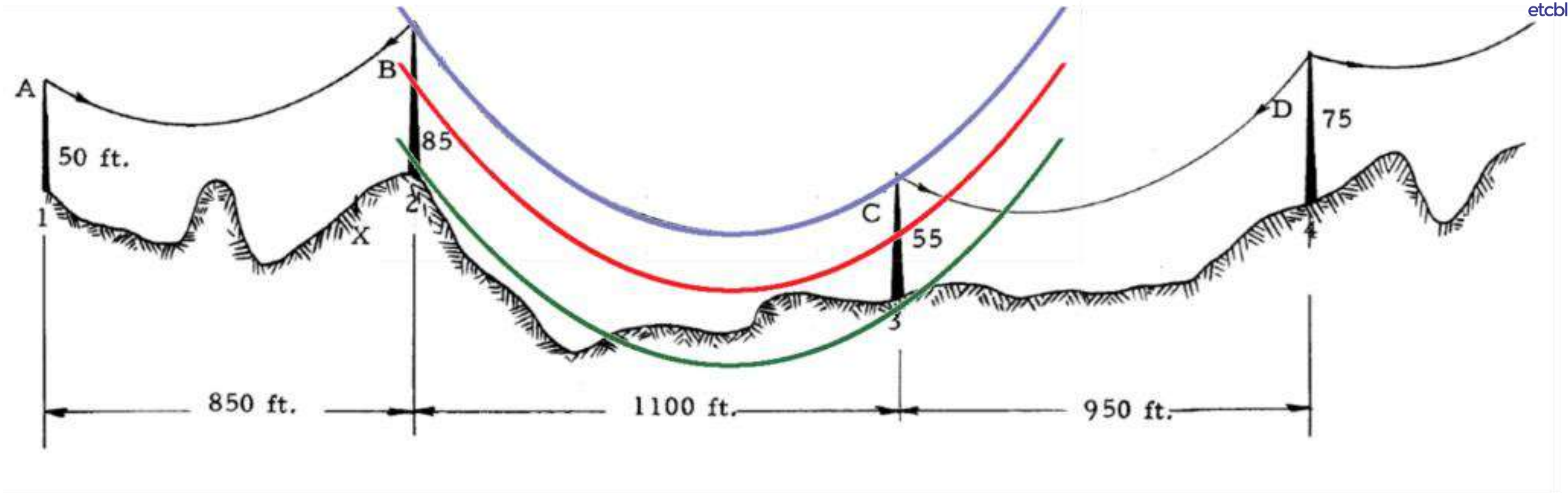
- Normal Span, Equivalent Spans
- Wind Span
- Weight Span (Downward / Upward)
- Angle of Deviation
- Sag Tension
- Sag Template
- Right of Way
- Stringing Chart (Initial/ Final)
- Materials used (Steel, Bolts/nuts)
- Cables (Conductors / Earth wires / OPGW)
- Insulators, Hardwires
- Wind Zones 6 as per IS875
- Electrical Clearance



TRANSMISSION LINES

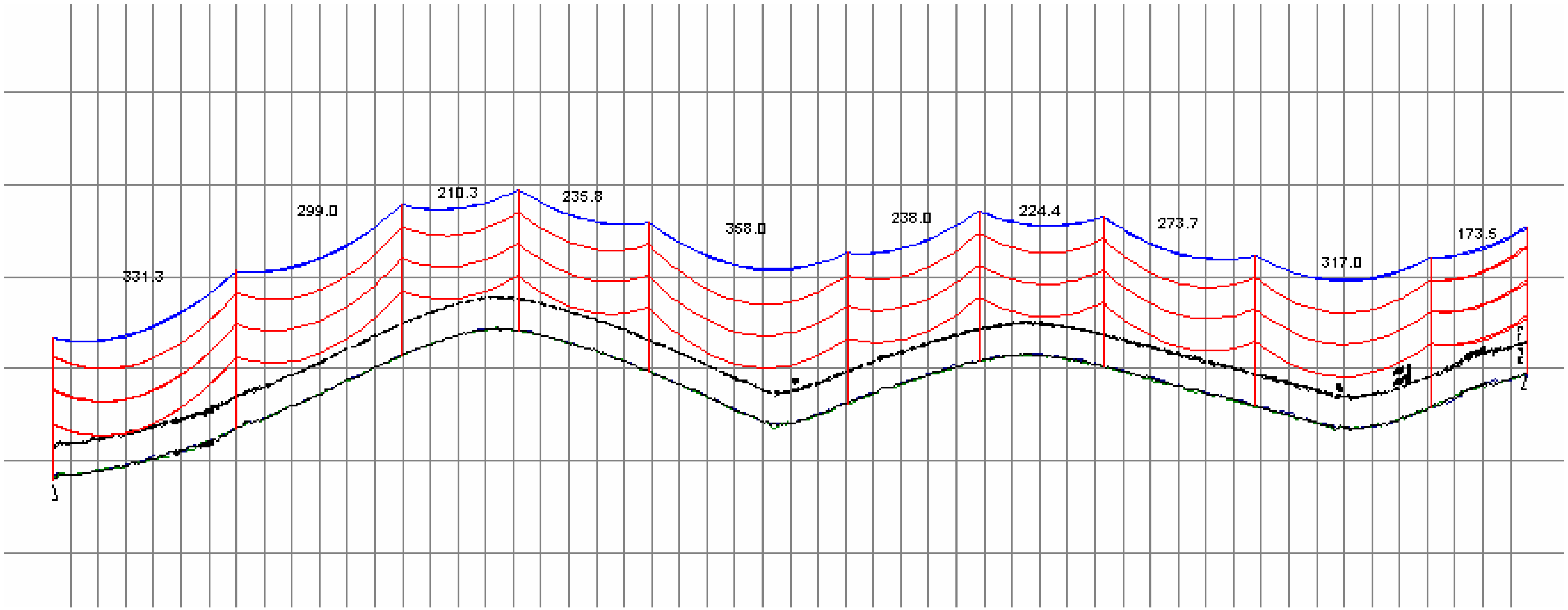
SAG TEMPLATE ILLUSTRATED



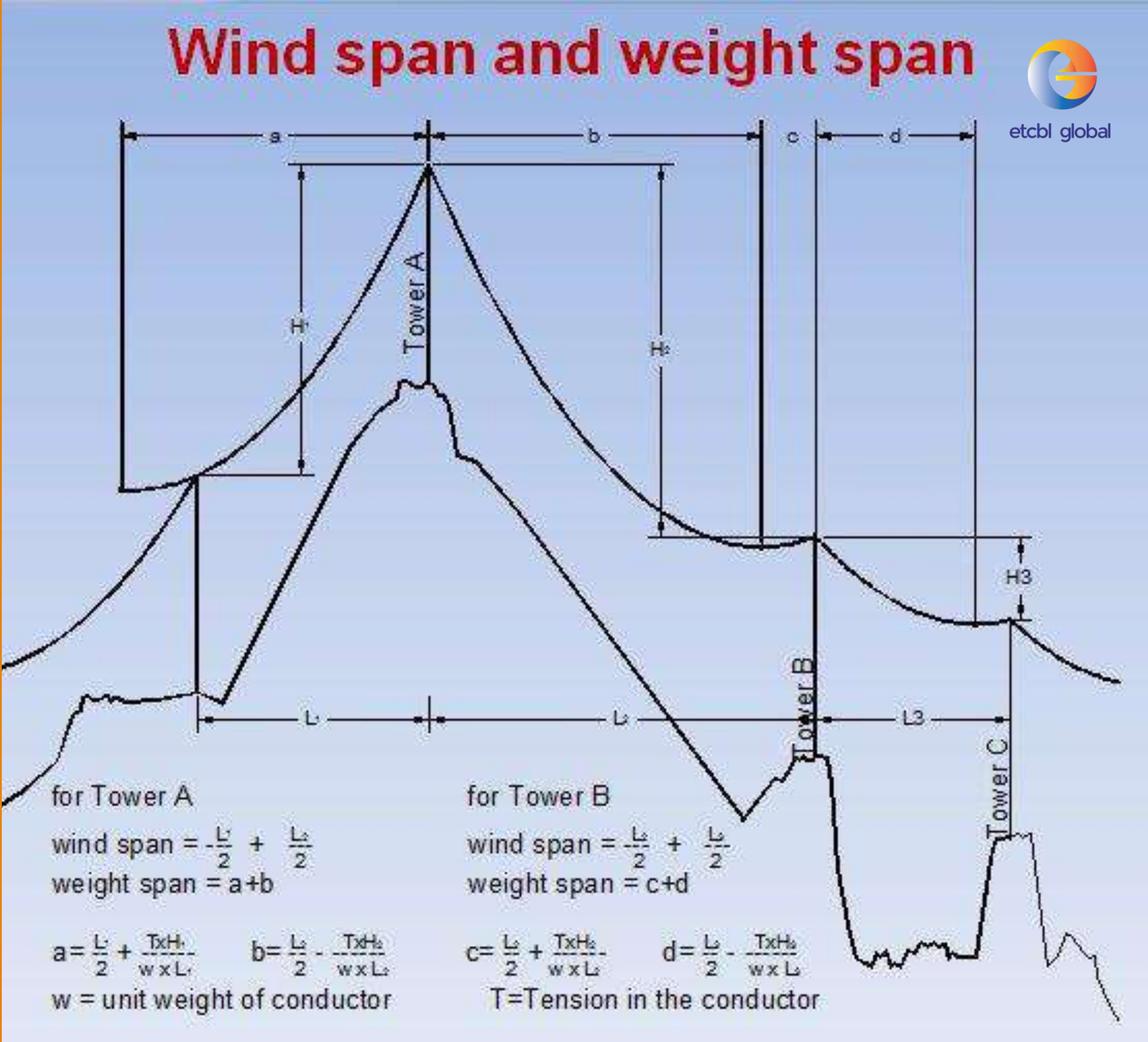


USE TEMPLATE FOR PLOTTING TOWERS

Profiling Concepts: Ground Clearance



WIND SPAN AND WEIGHT SPAN



Normal (Basic span)

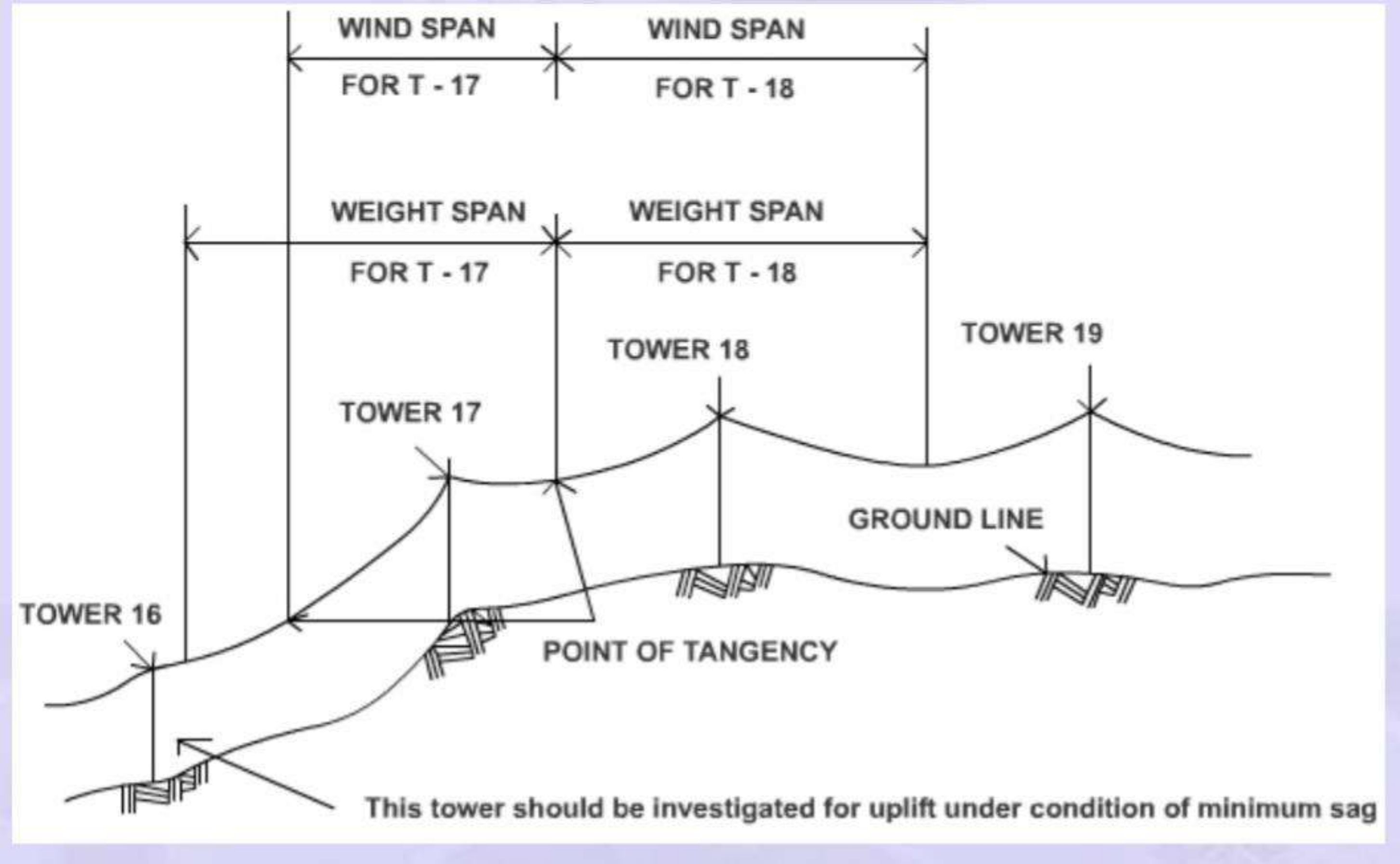
- The normal span(or basic span) is the most economical span for which the line is to be designed over level ground, so that the requisite ground clearance is obtained at the maximum specified conductor temperature.
- Standard or normal tower height is decided by normal span.
- Approximate quantity of towers can be calculated from normal span.
- Approximate quantity of towers equal to length of line divided by normal span.

WIND SPAN

- The wind span is that on which the wind is assumed to act transversely on the conductor and is taken as half the sum of the two spans, adjacent to the support.
- Generally wind span is considered 1.1 to 1.2 times basic span of the line.
- For particular tower type, wind span can be increased by reducing angle of deviation so that total transverse load equal to less than for which it is designed.
- The wind span is used to calculate wind load on tower.

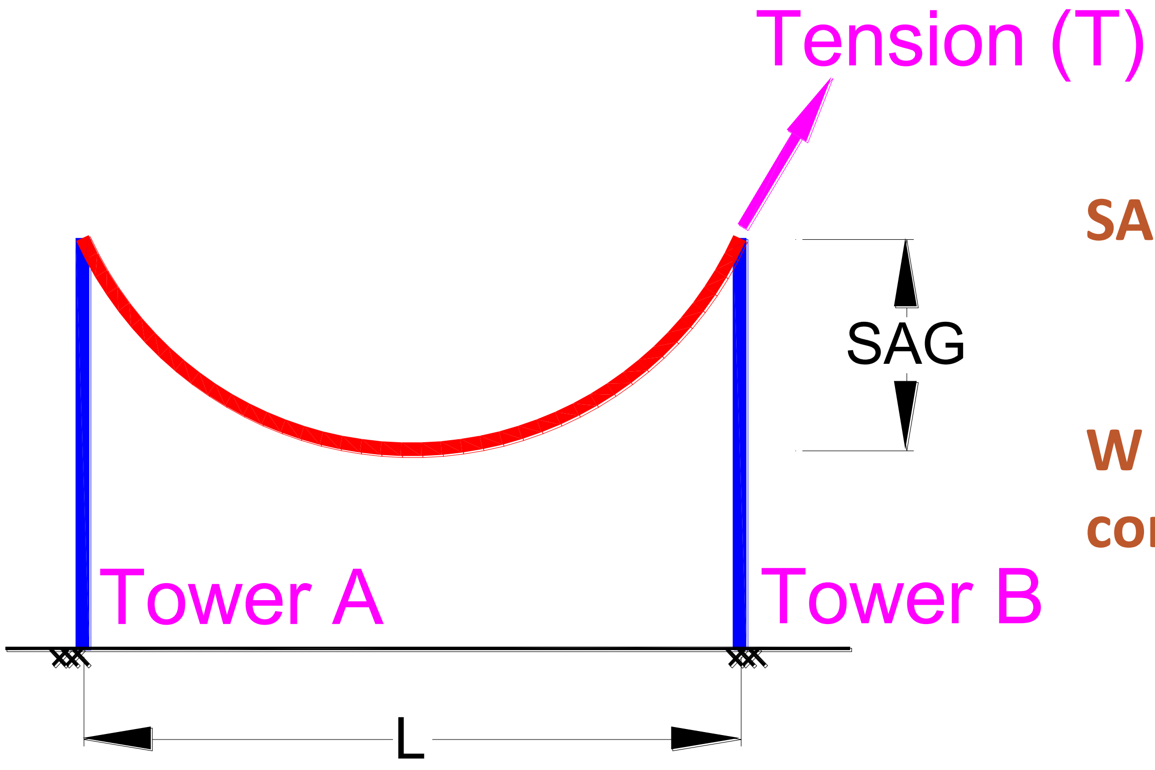
WEIGHT SPAN

- The weight span is the horizontal distance between the lowest point of the conductors, on the two spans adjacent to the tower.
- Weight span may be positive (acting down ward) or negative (acting upward) depend on tower position in the line.
- The weight span is used to calculate vertical load on towers.



SPANS AND PROFILES

SAG TENSION

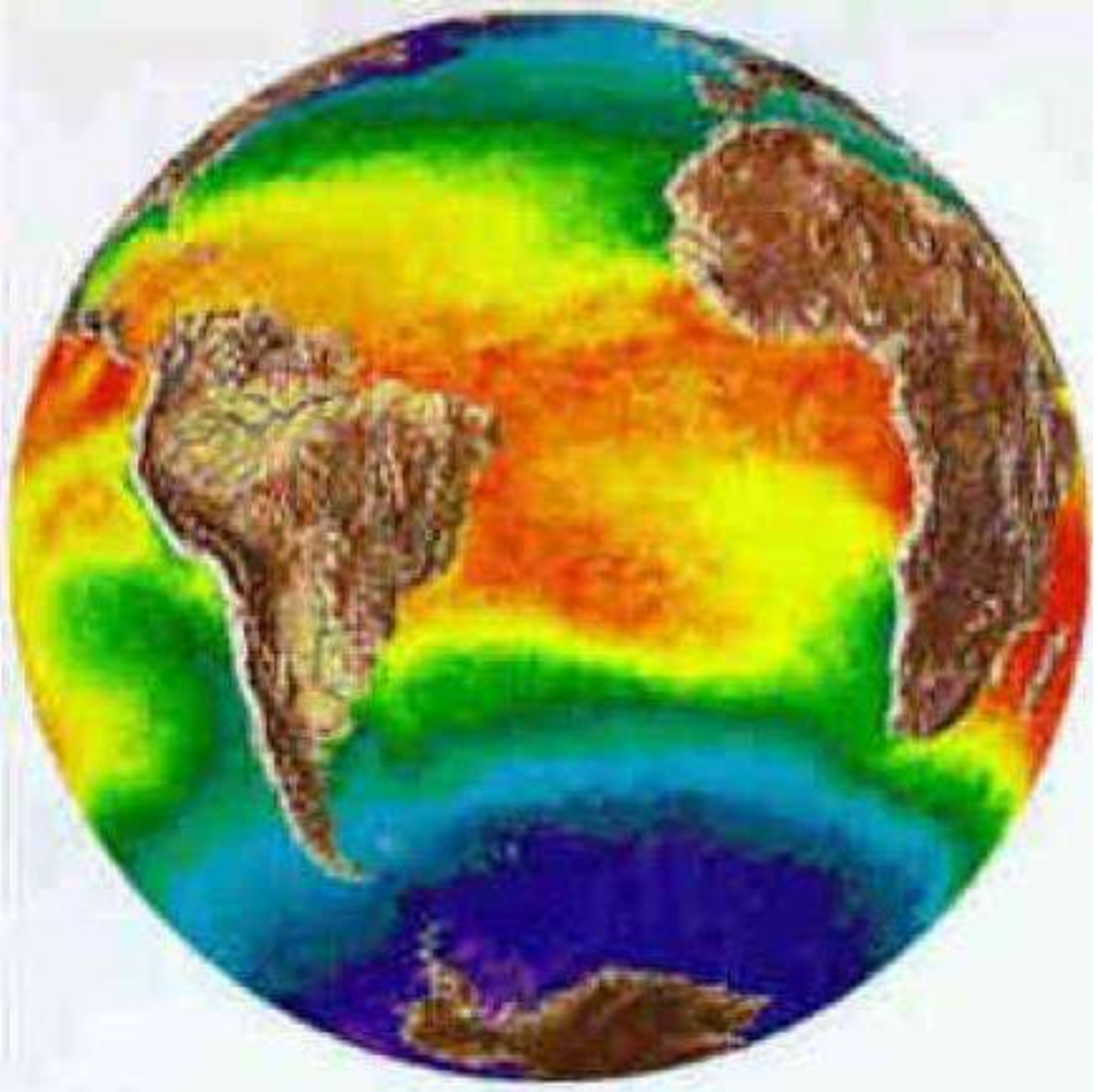


$$SAG = \frac{W \times L^2}{8 \times Tension}$$

W = unit weight of conductor

Design Criteria & Loads

- Climatic loads
- Seismic loads
- Construction & Maintenance
- Tension in wires



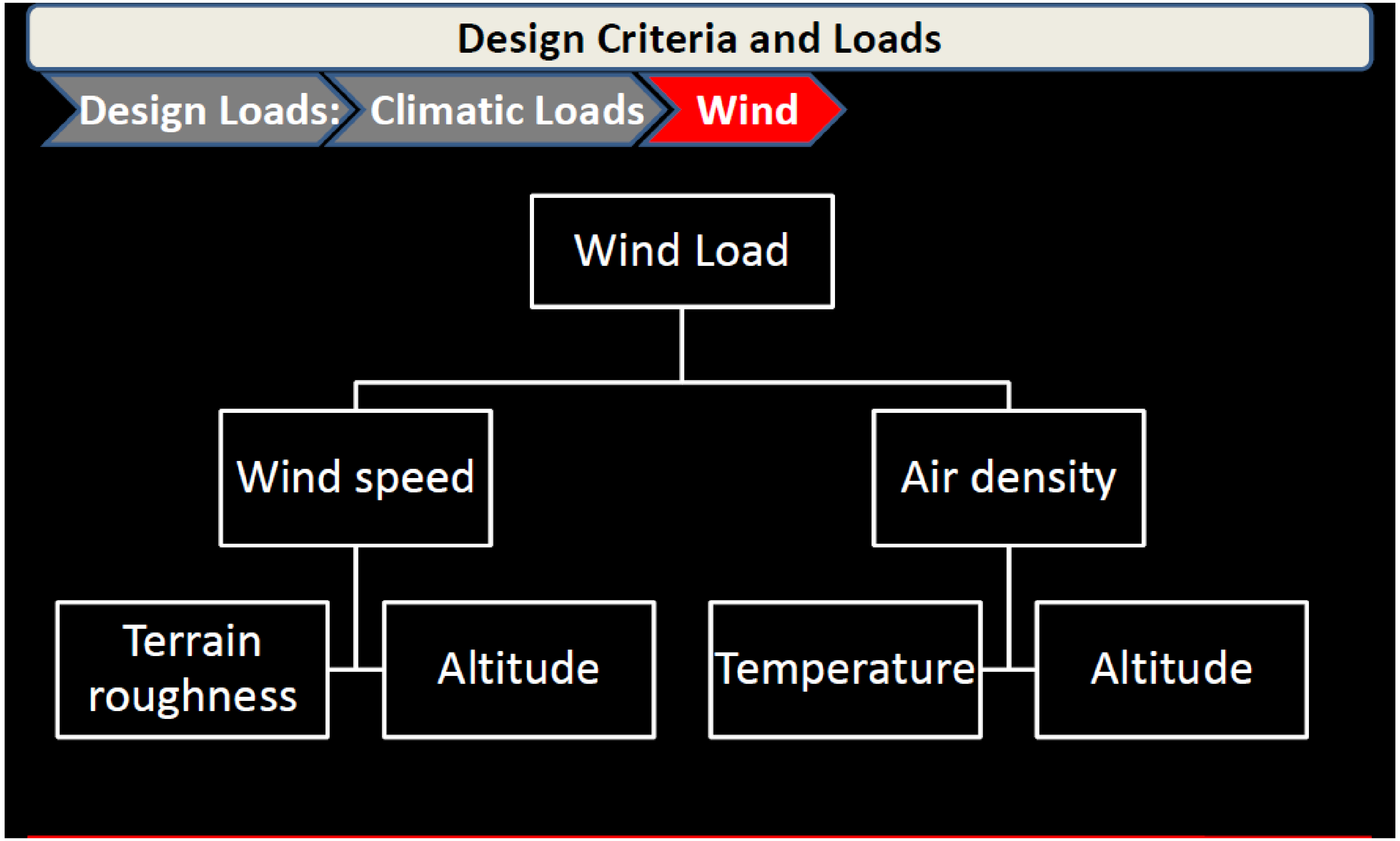
Design Criteria & Loads

- Climatic loads
  - Wind
  - Ice
  - Wind + ice

Design Criteria & Loads

- Climatic loads
  - **Wind**
  - Ice
  - Wind + ice

Design Criteria & Loads



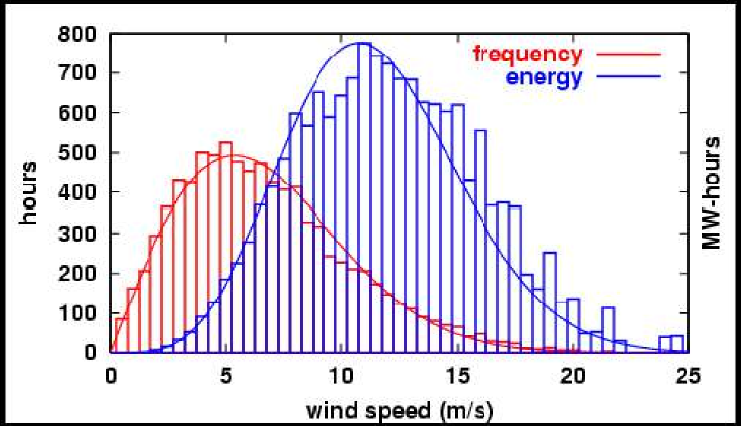
Design Criteria & Loads

Design Criteria and Loads

Design Loads: Climatic Loads › Wind › Speed

Reference wind speed V_r (m/s)

V_r is defined as the reference wind speed (m/s) It is a wind speed data at 10 m above ground and with an averaging period of 10 min. Usually *V_r is measured in weather stations*



Design Criteria & Loads

Design Criteria and Loads

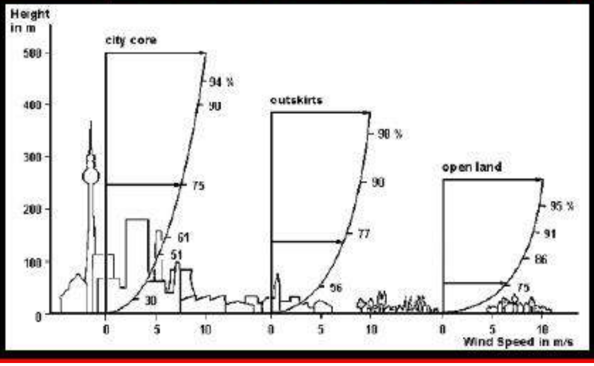
Design Loads: › Climatic Loads › Wind › Speed › Terrain roughness

Terrain roughness factor K_r

Classification of terrain categories

Category	Roughness characteristics	Kr
A	Large stretch of water upwind, flat coastal areas	1.80
B	Open country with very few obstacles.	1.00
C	Terrain with numerous small obstacles of low height.	0.85
D	Suburban areas or terrain with many tall trees	0.67

As per IEC 60826



Design Criteria & Loads

Design Criteria and Loads

Design Loads: Climatic Loads Wind **Density**

Reference Air Density μ (Kg/m^3)

μ is the air mass per unit volume equal to 1.225 kg/m^3 at a temperature of 15 °C and an atmospheric pressure of 101.3 kPa at sea level.

AIR DENSITY CORRECTION FACTOR 'τ'				
Temperature in degree	Altitude (m)			
	0	1	2	3
30	0.95	0.84	0.75	0.66
15	1.00	0.89	0.79	0.69
0	1.04	0.94	0.83	0.73
−15	1.12	0.99	0.88	0.77
−30	1.19	1.05	0.93	0.82
Note:-The reference value corresponds to 0 m altitude and a temperature of 15°C				

As per IEC 60826

Design Criteria & Loads

Design Criteria and Loads

Design Loads: Climatic Loads > Wind > Density

Reference Air Density μ (Kg/m^3)

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30	0.95	0.84	0.75	0.66
15	1.00	0.89	0.79	0.69
0	1.04	0.94	0.83	0.73
–15	1.12	0.99	0.88	0.77
–30	1.19	1.05	0.93	0.82

Note:-The reference value corresponds to 0 m altitude and a temperature of 15°C

As per IEC 60826

Design Criteria & Loads

Design Criteria and Loads

Design Loads: › Climatic Loads › Wind › **Wind load On wires**

Wind loads on wires Ac (N)

$$\boxed{Ac = q_0 \times G_c \times G_L \times D \times L \times \sin^2 \Omega}$$

Where

q_0 is basic wind pressure.

G_c is wind factor.

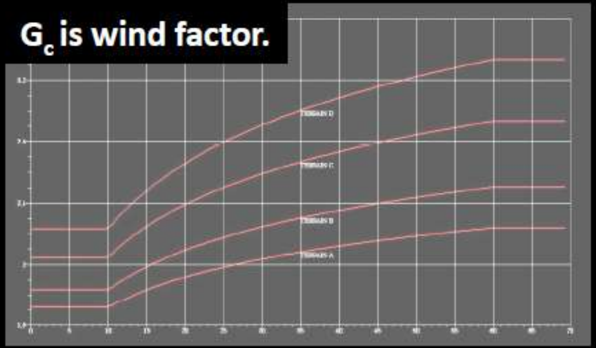
G_L is Span factor.

D is Diameter of wire.

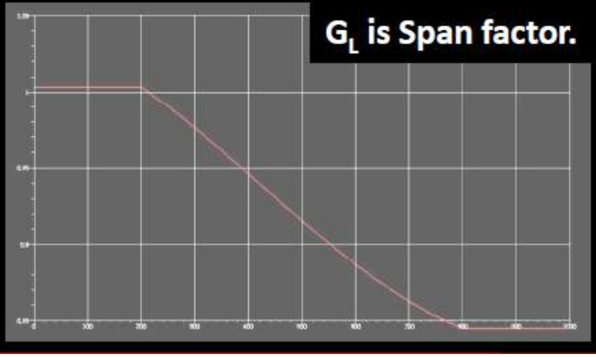
L is Length of span.

Ω is wind direction.

G_c is wind factor.



G_L is Span factor.



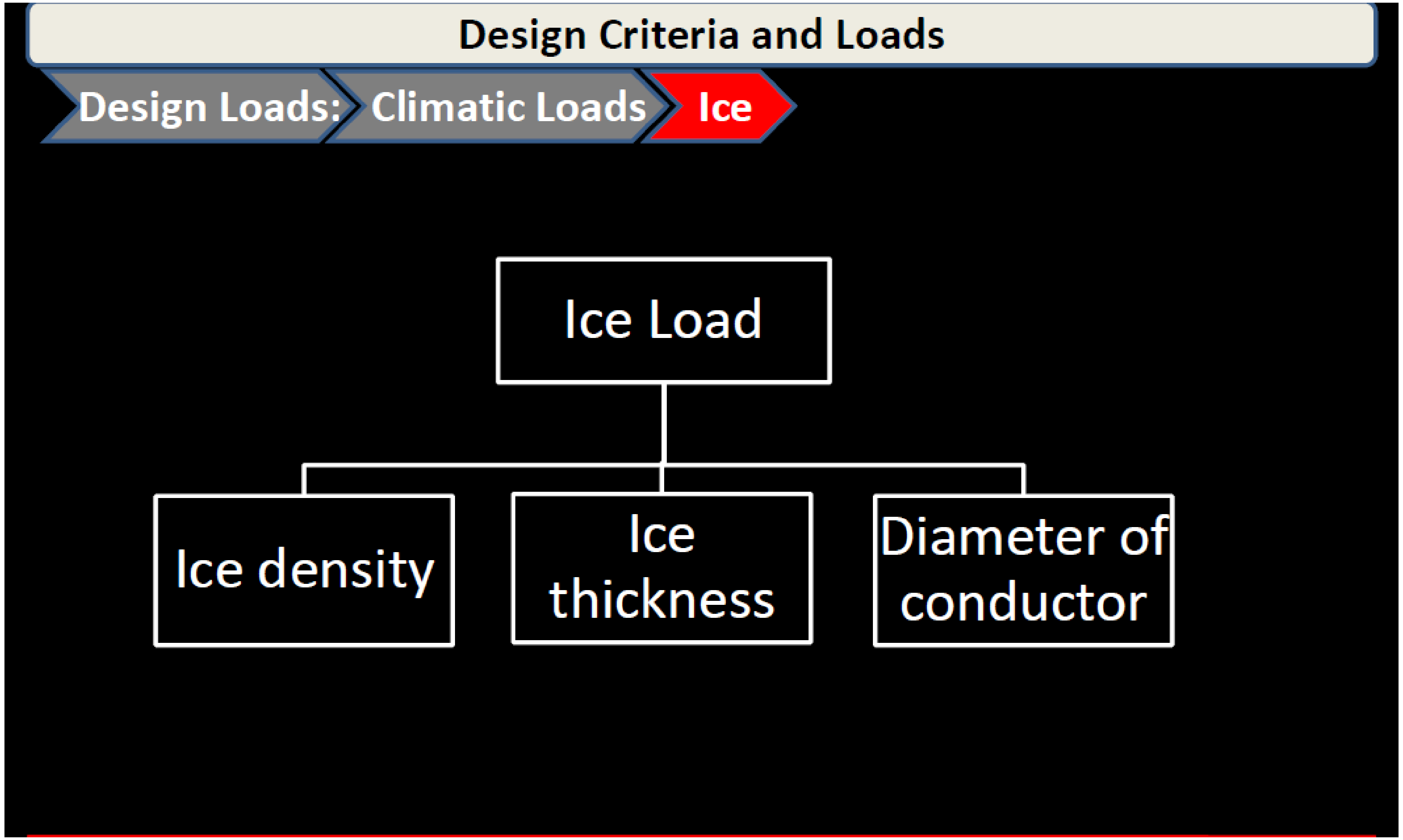
Design Criteria & Loads

Design Criteria and Loads

Design Loads: Climatic Loads

1. Wind.
2. **Ice.**
3. Wind + Ice.

Design Criteria & Loads



Design Criteria & Loads

Design Criteria and Loads

Design Loads: Climatic Loads › Ice › **Load On Wires**

Ice weight on wire g (N/m)

$$\boxed{g = 9.82 \times 10^{-3}\, \delta\, \pi\, t\, (d + t/1\,000)}$$

Where

δ is the ice density (kg/m3)

t is radial ice thickness (mm)

d is diameter of wire (m)

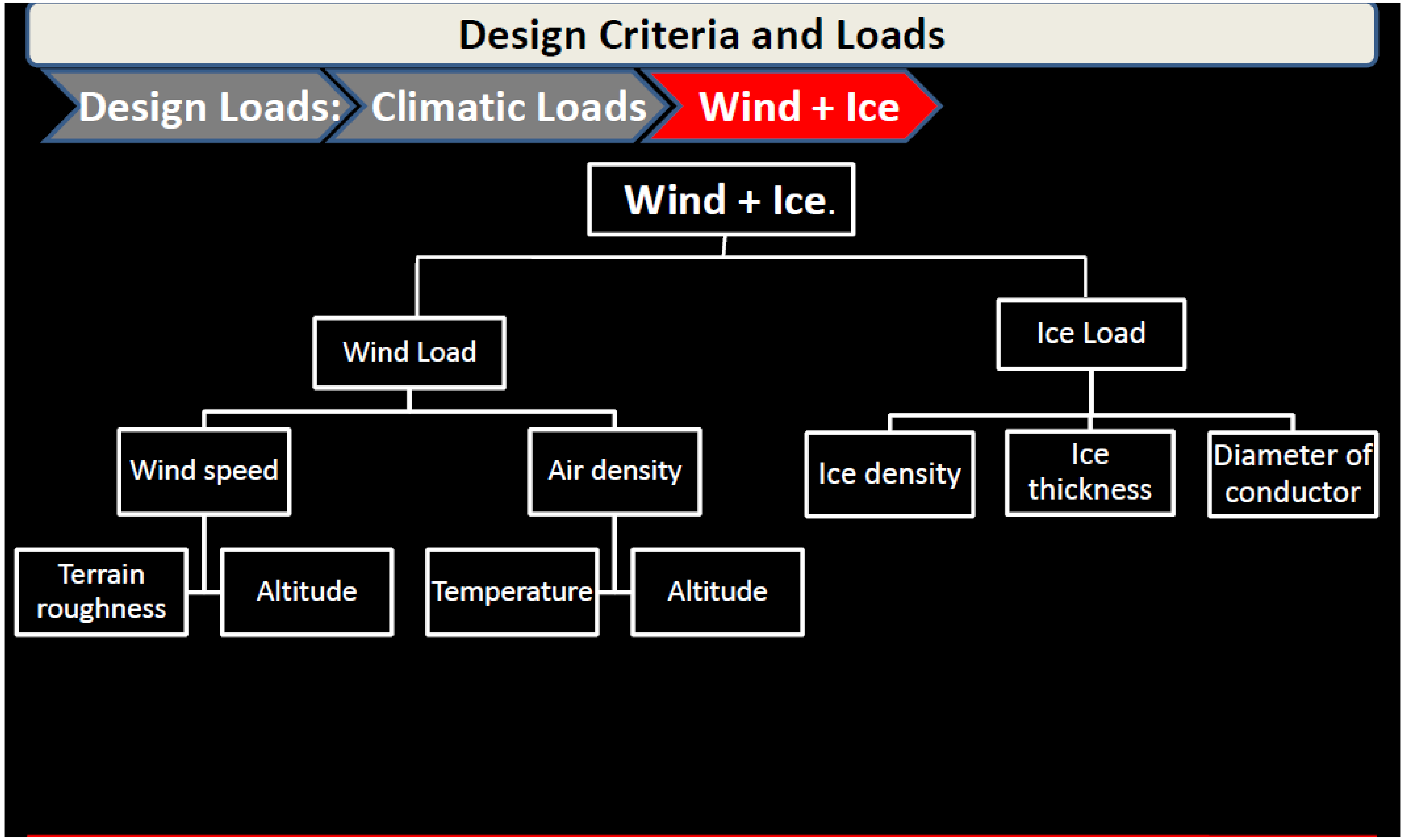
Design Criteria & Loads

Design Criteria and Loads

Design Loads: Climatic Loads

1. Wind.
2. Ice.
3. **Wind + Ice.**

Design Criteria & Loads



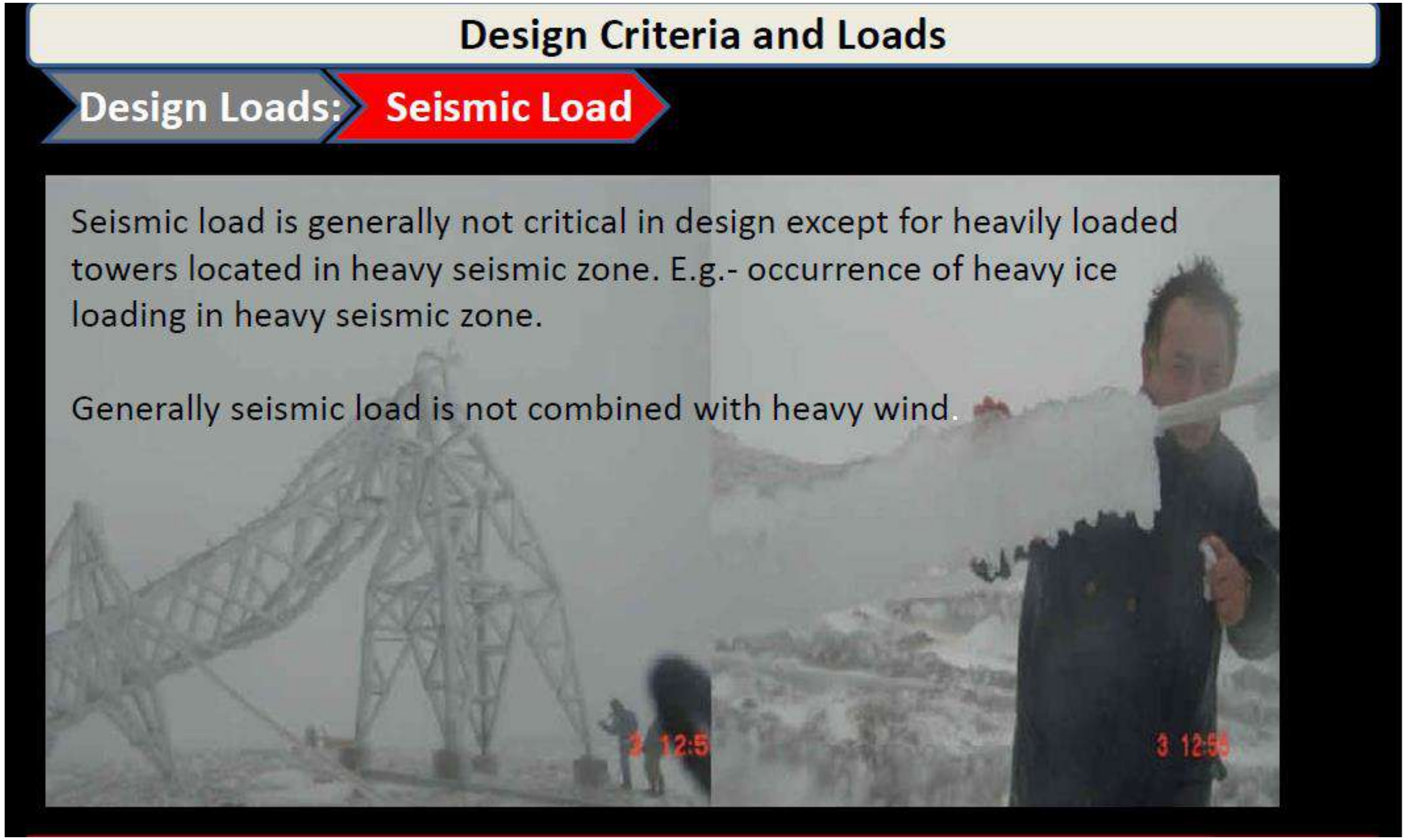
Design Criteria & Loads

Design Criteria and Loads

Design Loads

1. Climatic Loads.
2. Seismic Loads
3. Construction & maintenance.
4. Tension in wires.

Design Criteria & Loads



Design Criteria & Loads

Design Criteria and Loads

Design Loads

1. Climatic Loads.
2. Seismic Loads
3. **Construction & maintenance.**
4. Tension in wires

Design Criteria & Loads

Design Criteria and Loads

Design Loads: Construction & maintenance

Construction and maintenance loads depends on the construction and maintenance methods.

Towers are designed for such loads to prevent injury or loss of human life during construction or maintenance.

Design Criteria & Loads

Design Criteria and Loads

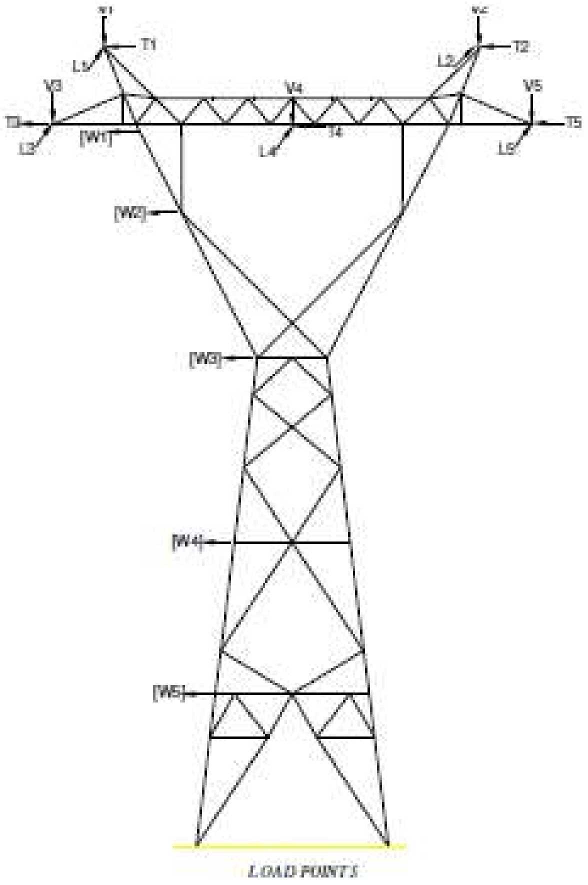
Design Loads

1. Climatic Loads.
2. Seismic Loads
3. Construction & maintenance.
4. **Tension in wires**

Design Criteria & Loads

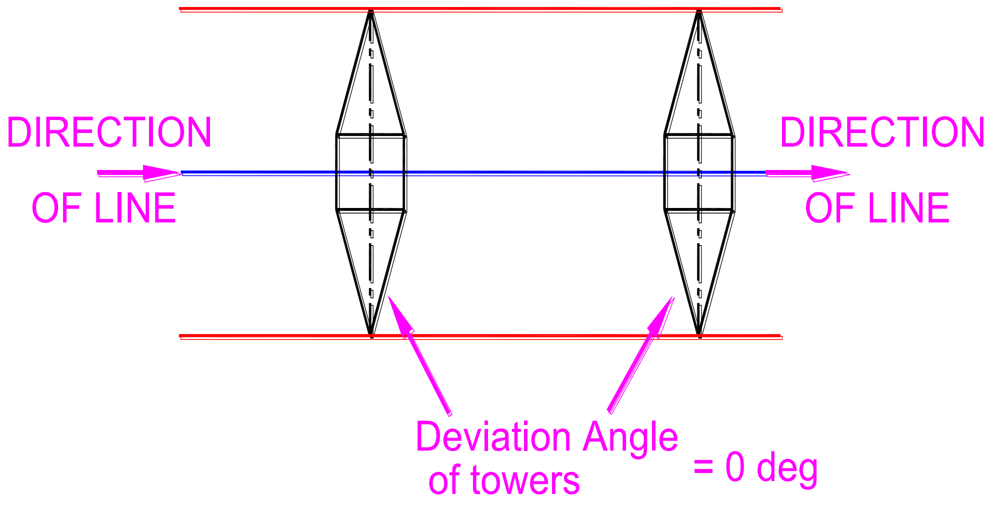
TOWER LOADING

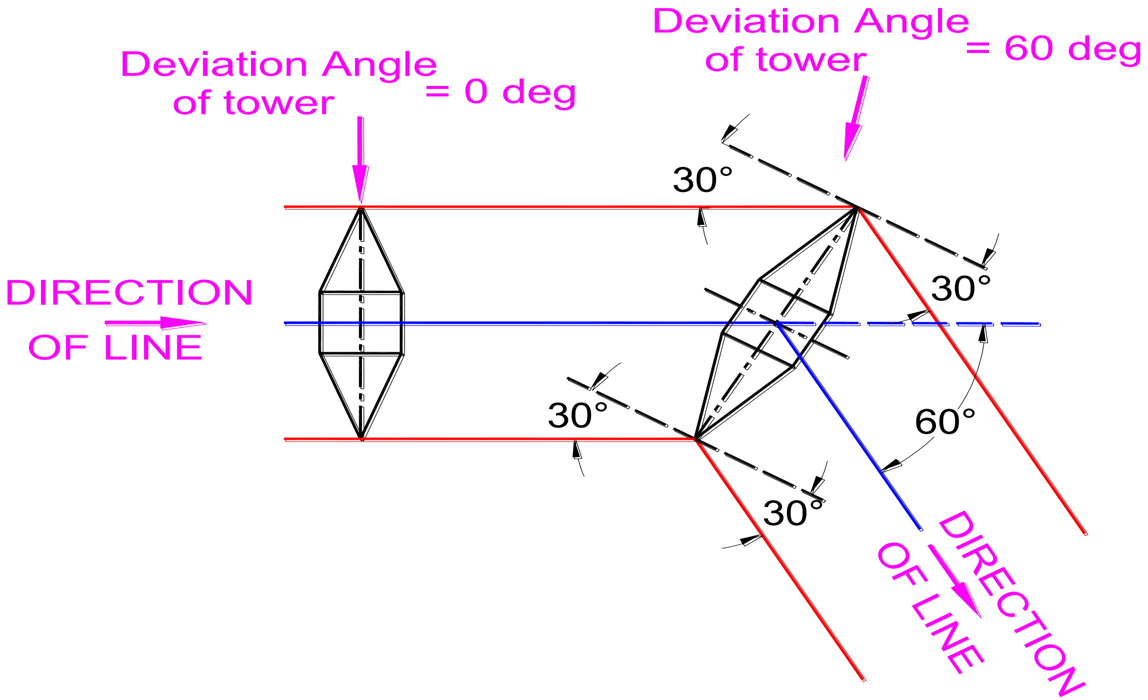
- TRANSVERSE LOADS
- VERTICAL LOAD
- LONG LOAD



Design Criteria & Loads

LINE DEVIATION





TOWER CLEARANCES

- From safety considerations, power conductors along the route of transmission line should maintain requisite clearances to ground in open country, national highways, rivers, railway tracks, telecommunication lines, other power lines etc.
- Ground clearance is the distance between ground and the lowest point of the boom conductor.
- Minimum ground clearance is depend on kV of Line. For higher kV more ground clearance required.

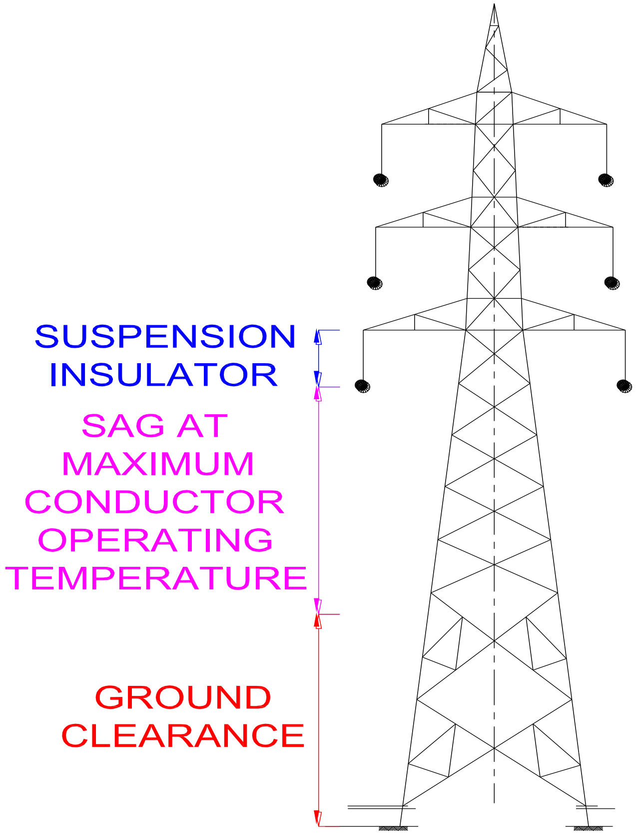
TOWER CLEARANCES

- Following is minimum ground clearance generally required for pedestrians.

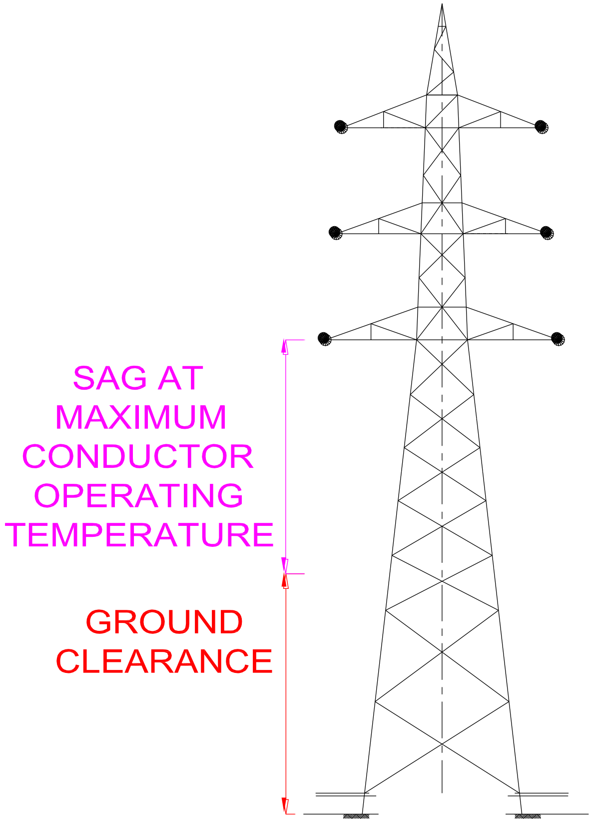
Voltage	Normal Ground Clearance in m.
66 kV	7.0
132 kV	7.5
220 kV	8.0
400 kV	9.0

- For road, railway & power line crossing higher clearance is required.

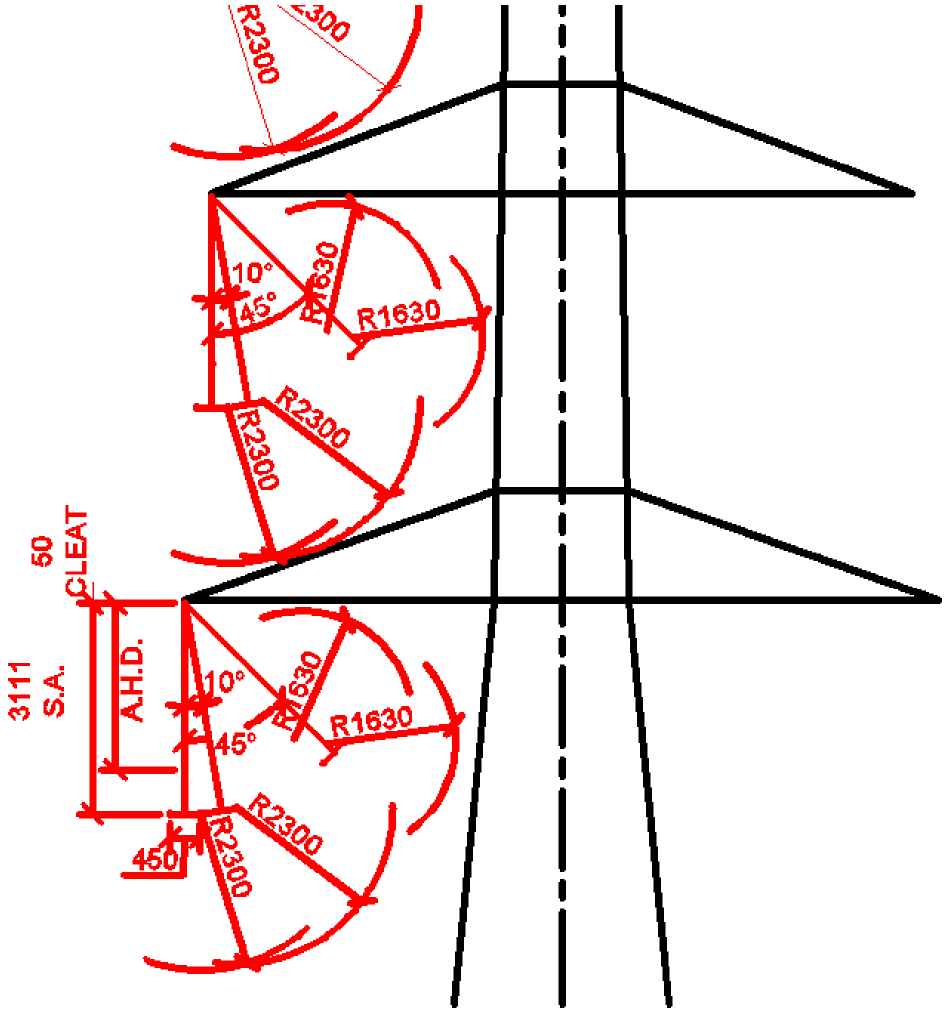
TOWER CLEARANCES



Suspension Tower

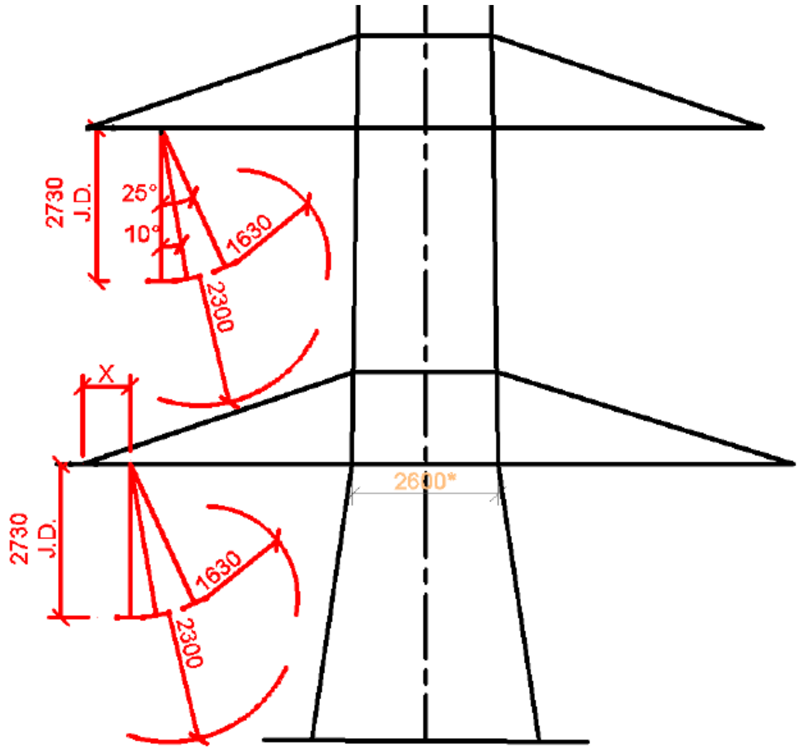


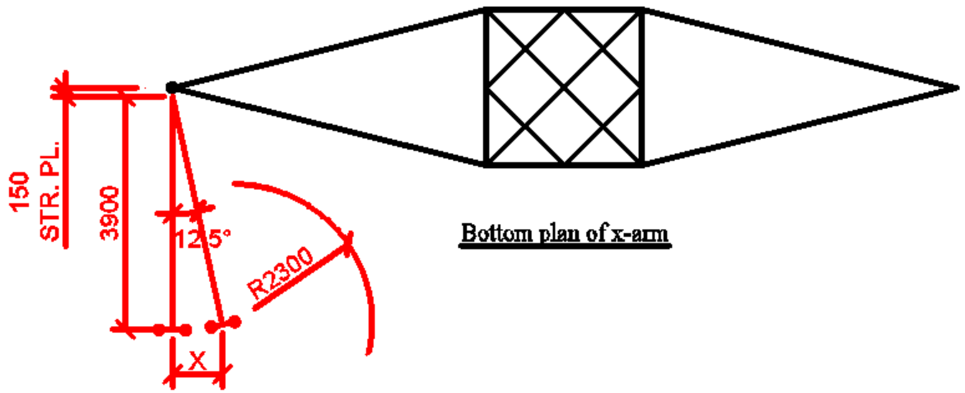
Tension Tower



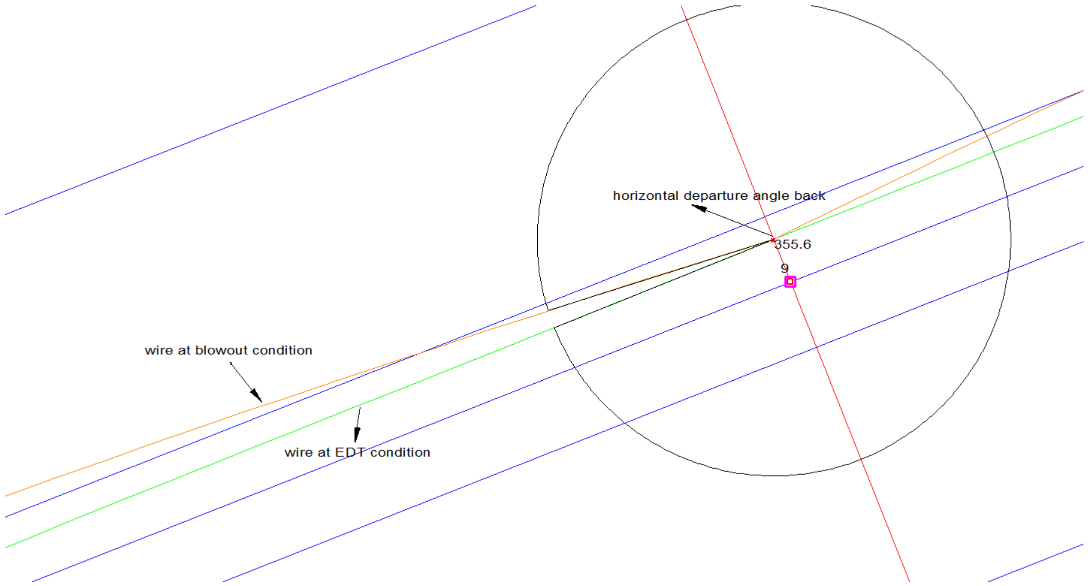
TOWER CLEARANCES

CLEARANCE FOR 230KV SUSPENSION TOWER – BANGLADESH





TOWER CLEARANCES



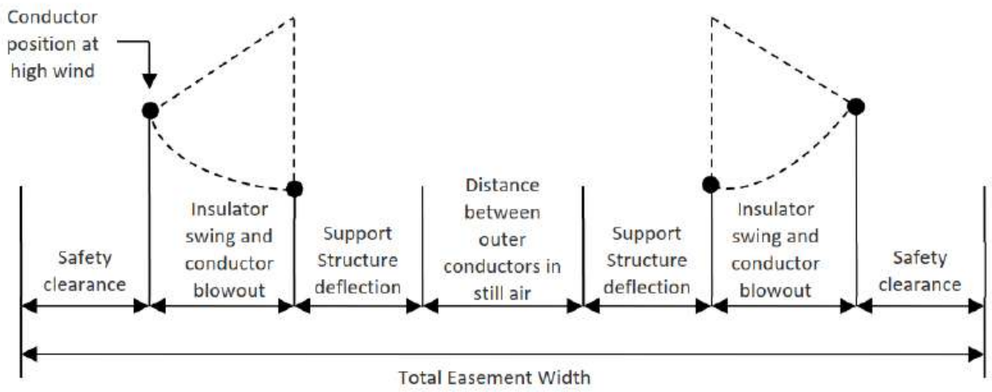
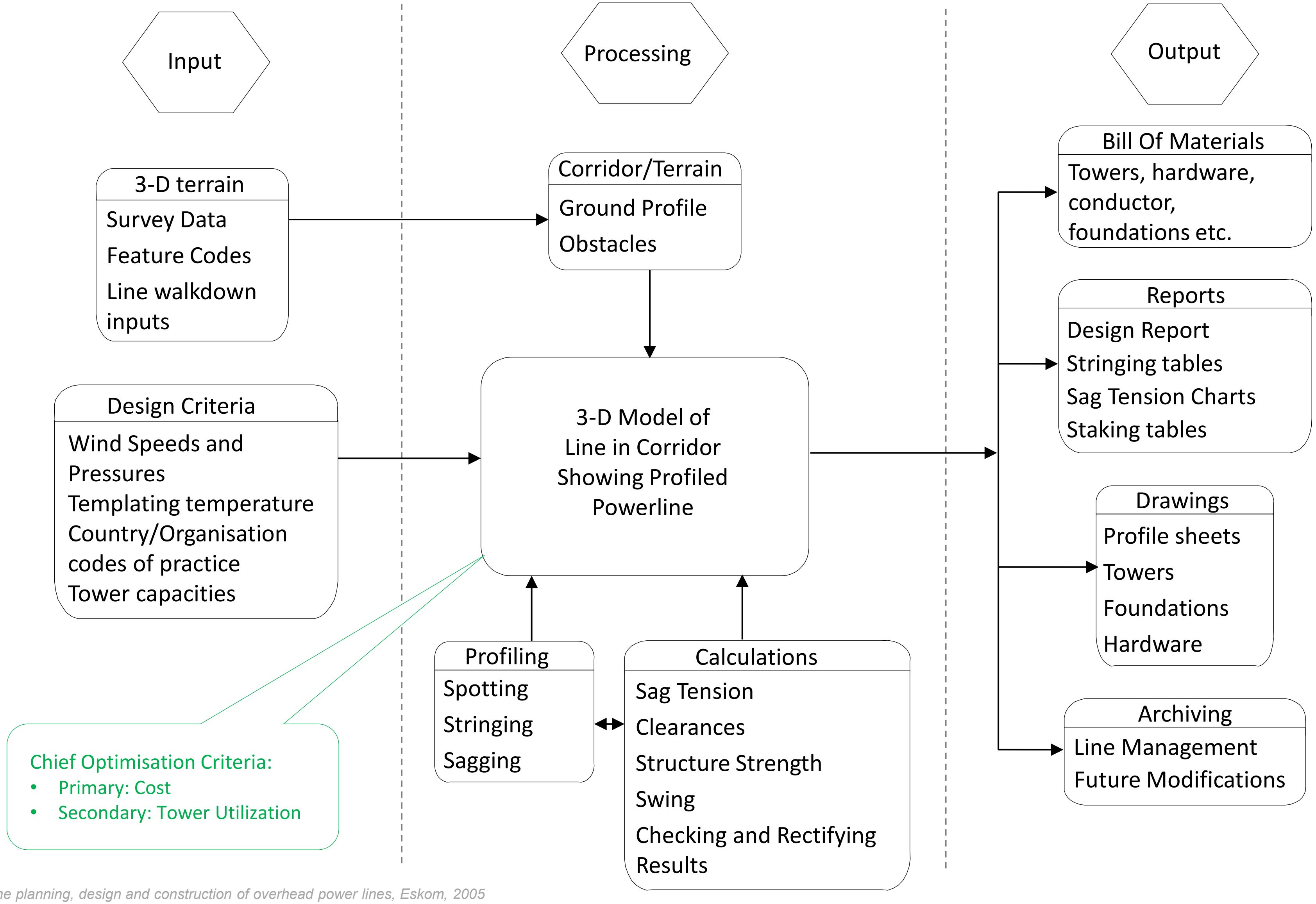


Figure 3.1: Components of Easement Width

RIGHT OF WAY

Overhead Powerline Design Process Overview



The planning, design and construction of overhead power lines, Eskom, 2005

Overview of BASIC PLS Modelling Process

The following steps will be followed to generate the example profile. The same basic sequence is

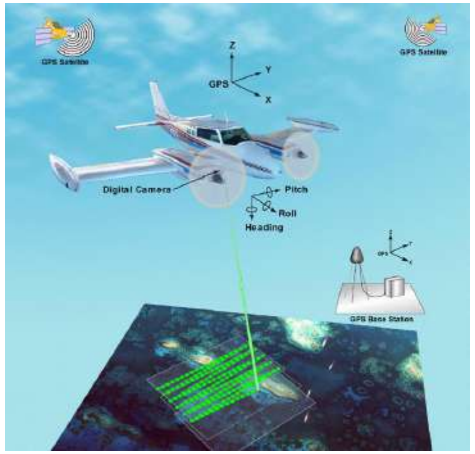
relevant for the generation of all profiles in PLS-CADD, irrespective of the model type.

Figure 5: PLS-CADD Modelling Process

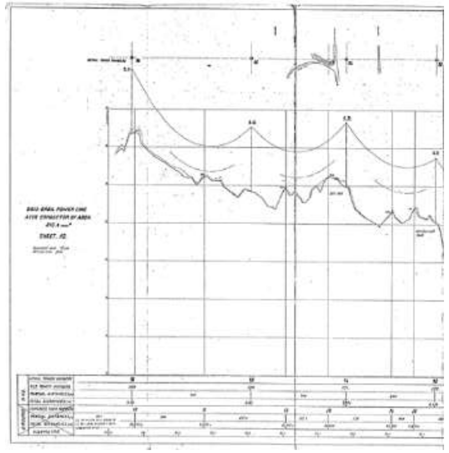
Survey Data Sources

Traditional Survey

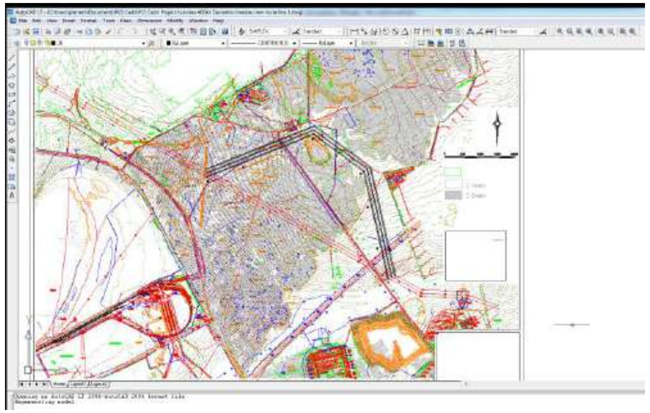
LiDAR Survey



Older Scanned Profiles



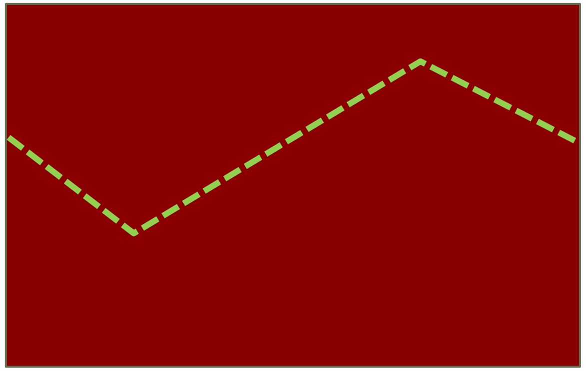
2D & 3D DXF drawings



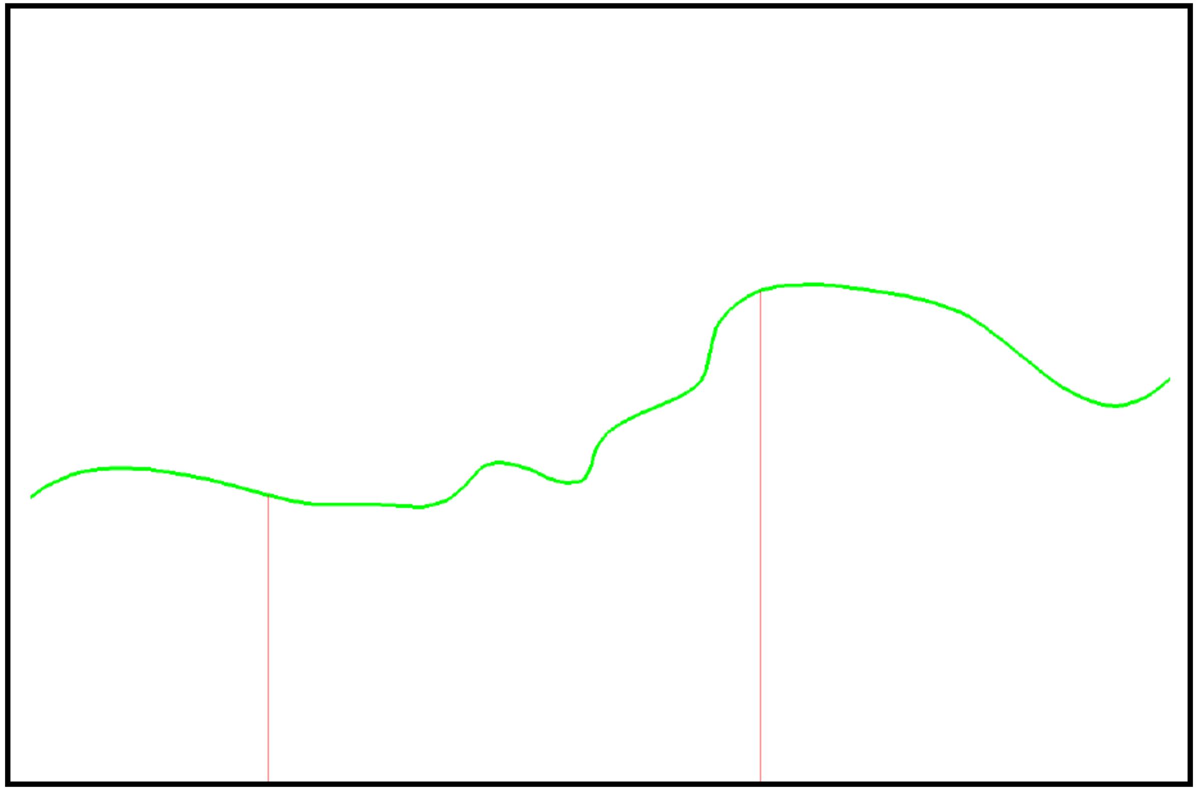
Other DTM info

Line Profile Inputs

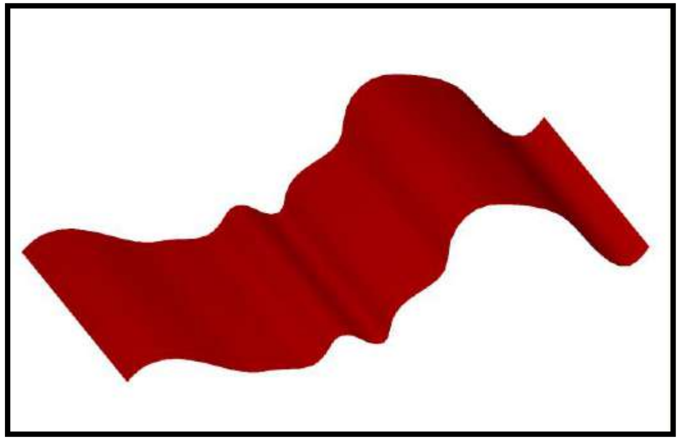
ROUTE



= Profile



+ Terrain Model



Line Profile Inputs

Survey / Cadastral / Environmental Inputs

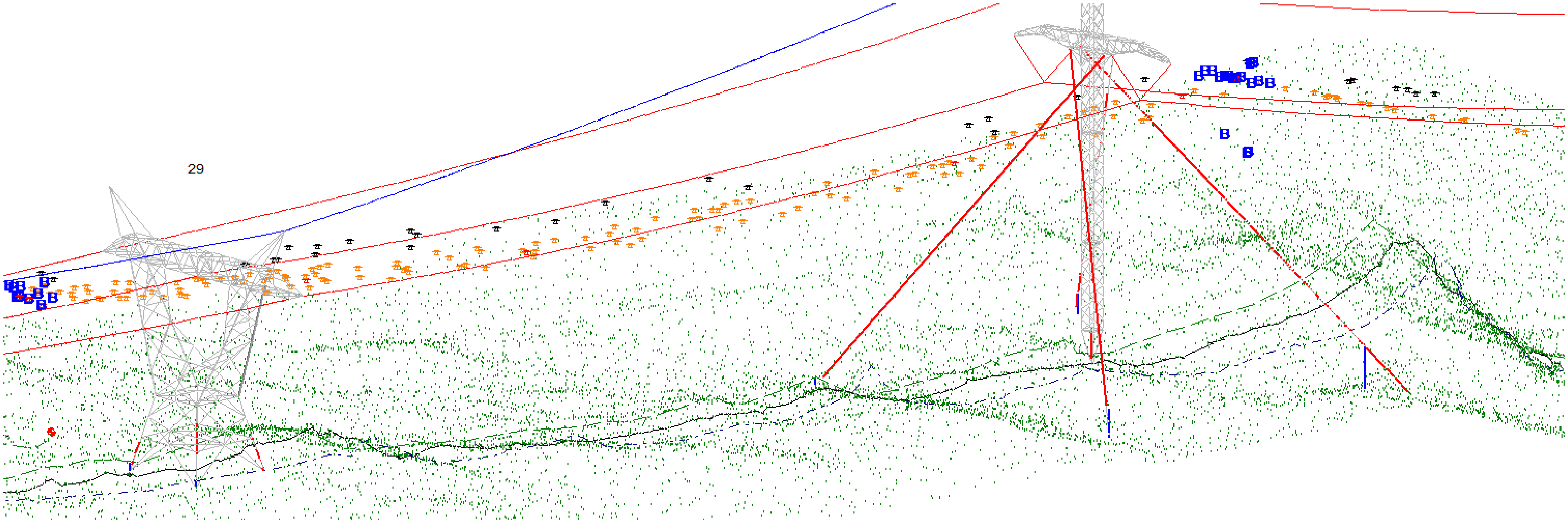
- Bend points (old scanned profiles)
- ALS Data/ground points
- Landowner requirements/limitations
- Restricted/prohibited zones
- High resolution survey images

Obtained from surveyor and/ or client/ publicly available data.

PLS CADD input:

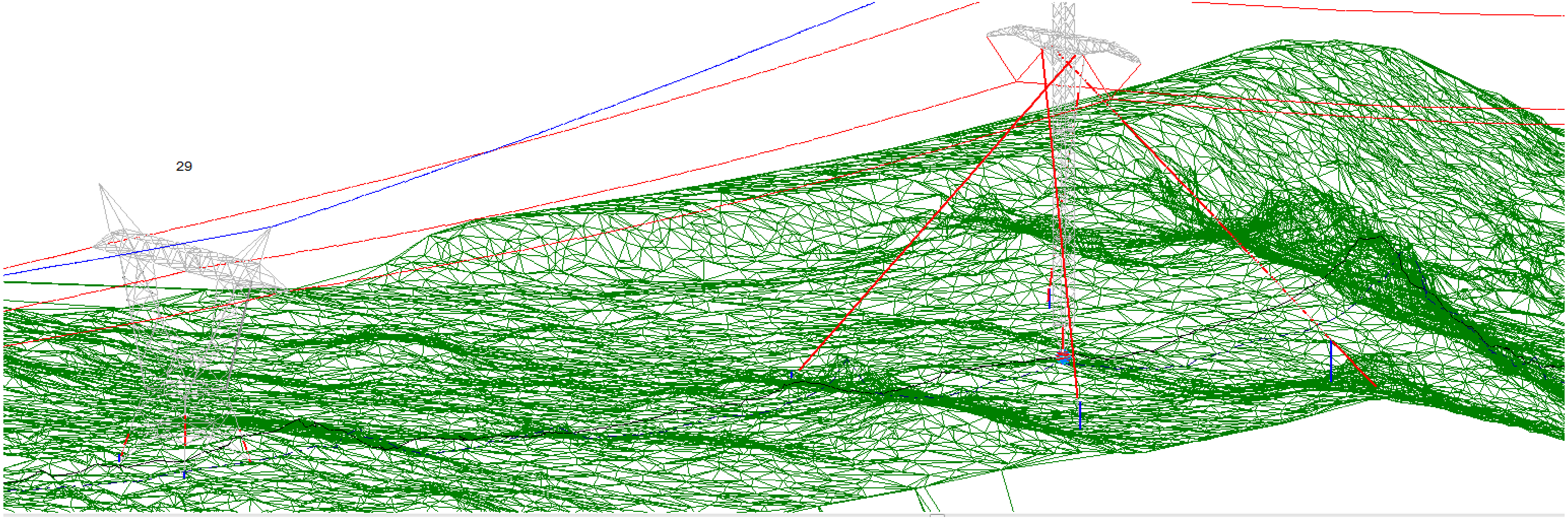
- Import bend points
- Insert PI's (points of interest)
- Import ground points
- Import/set criteria, feature code files
- Create method 1 structure models and .wir files
- Insert towers at special locations
- Insert prohibited zones

Input into PLS CADD



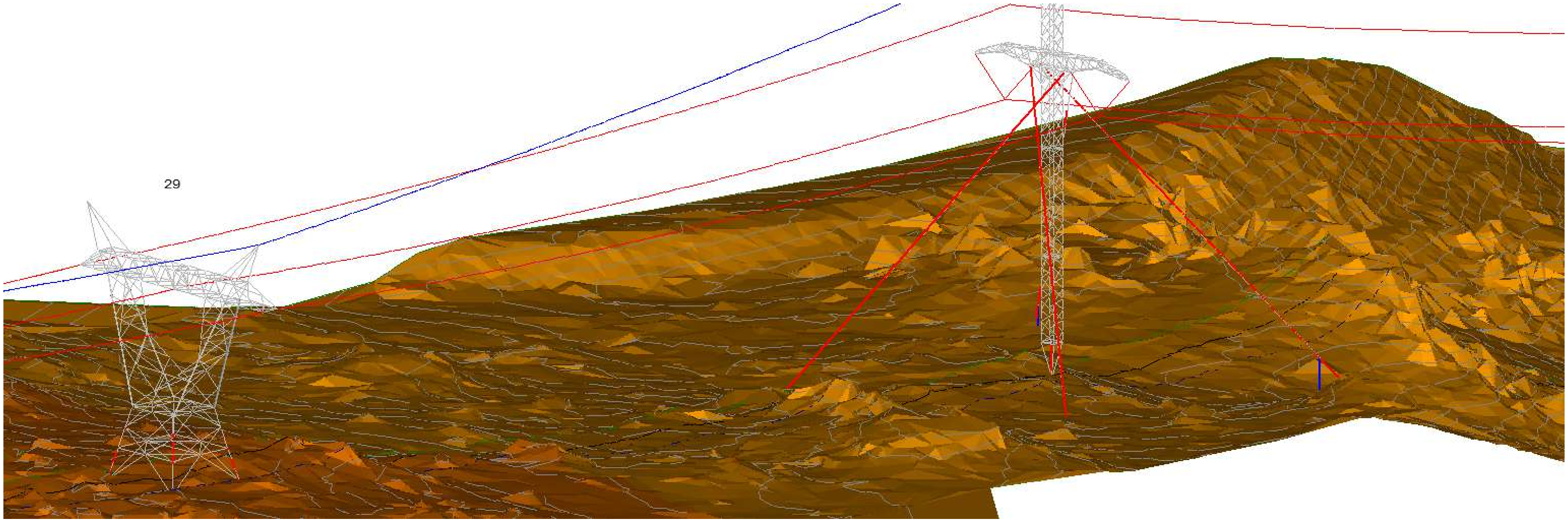
3D Templating

LASER SURVEY POINTS



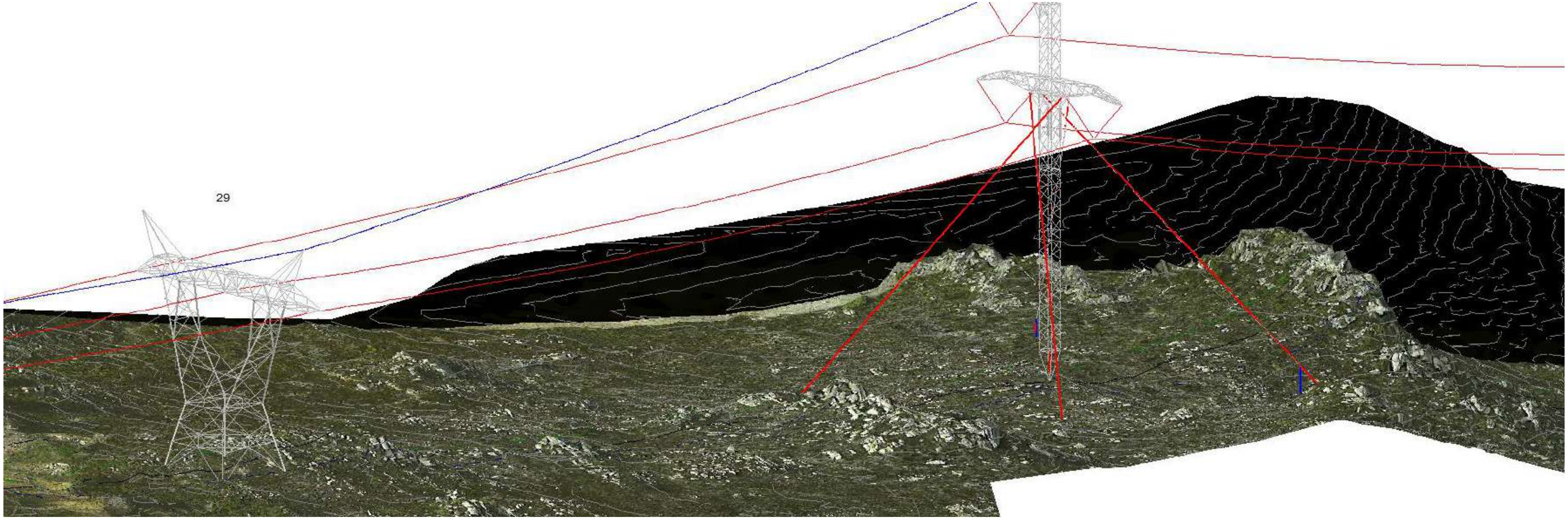
3D Templating

POINTS CONNECTED TO FORM TIN (TRIANGULATED IRREGULAR NETWORK)



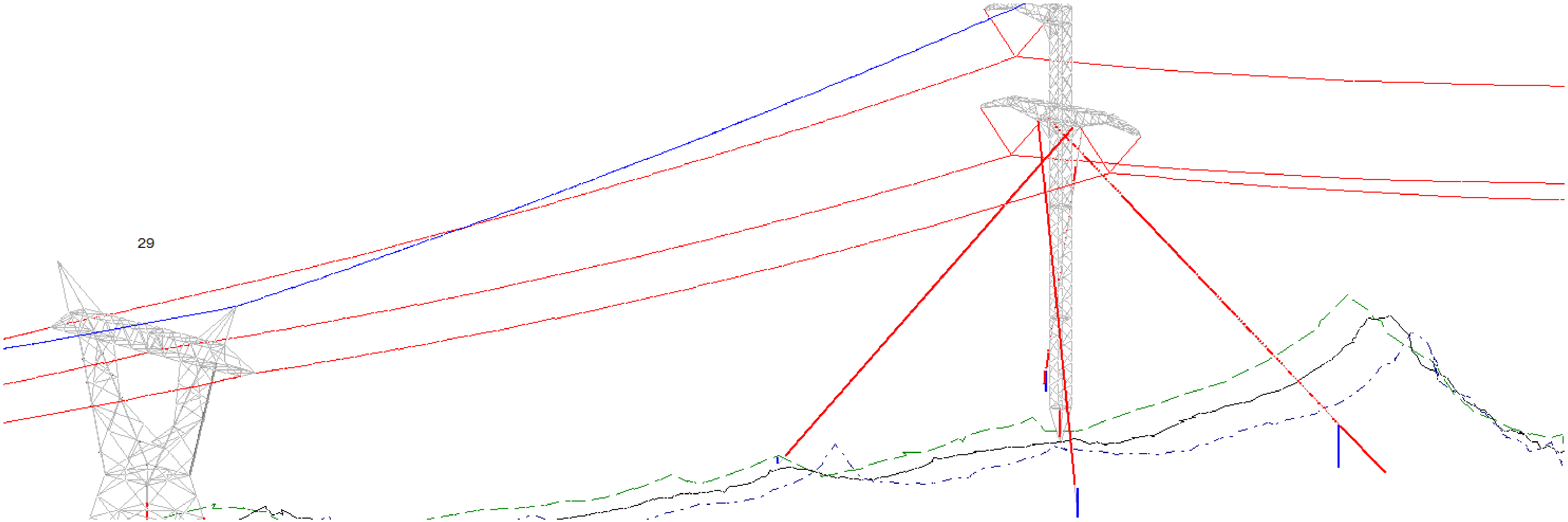
3D Templating

TIN RENDERED WITH CONTOUR LINES



3D Templating

TIN WITH BITMAP DRAPED ON TERRAIN & CONTOUR LINES



3D Templating

SIDE PROFILES ONLY

Profiling Concepts: Feature Codes

- A symbol which defines obstacle types, terrain types, and power line types
- Includes the required clearance for a range of different voltages

Feature Code Data Edit

Assumptions for interpreting clearances in Survey Point Clearance and Terrain/Clearance commands

Treatment of points that have insufficient vertical clearance but adequate horizontal clearance?

○ Not a violation (must infringe on both vertical and horizontal clearance requirements to be a violation)
Recommended when have horizontal clearance requirements entered in table below and have reasonably dense ground point coverage below all wires.

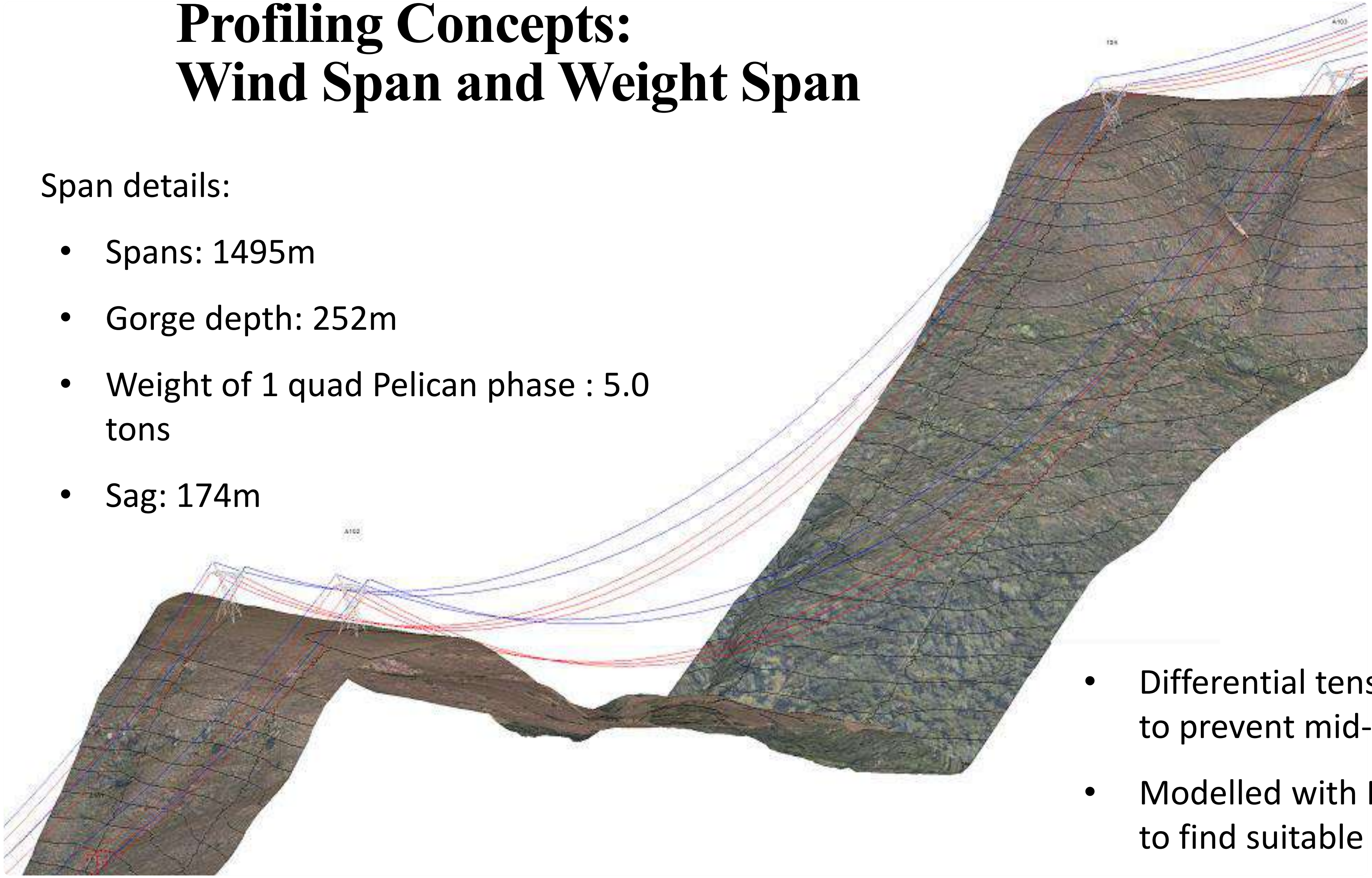
◉ Questionable violations to be indicated by ?? in reports and blue markers in graphics
Recommended when table below doesn't specify horizontal clearance requirements. Also recommended for sparse terrain models like centerline surveys where want to check vertical clearance to centerline ground for all wires regardless of offset.

	Feat. Code	Feature Description	Prof Symbol	Plan Symbol	Line From Feature Top To Bottom	Aerial Obst-acle	Point is on Ground	Req Vert Clear 0kV (m)	Req Horiz Clear 0kV (m)	Req Vert Clear 66kV (m)	Req Horiz Clear 66kV (m)	Req Vert Clear 132kV (m)	Req Horiz Clear 132kV (m)	Req Vert Clear 275kV (m)	Req Horiz Clear 275kV (m)	Req Vert Clear 400kV (m)	Req Horiz Clear 400kV (m)	Prof Label Feature code, Feature des., S,O,H,Z,Z+H, Point des. Comment
1	10	Ground outside townships			No	No	Yes	5.3	0.4	6.1	6.1	6.7	1.85	7.8	2.9	8.5	3.6	000000001
2	11	11kV conductor			No	Yes	No	1.2	0.7	1.8	2	2.4	2.08	3.5	4	4.2	5.2	000000001
3	20	Ground inside townships			No	No	Yes	5.9	0.4	6.1	6.1	6.7	1.85	7.8	2.9	8.5	3.6	000000001
4	22	22kV conductor			No	Yes	No	1.3	0.8	1.8	2	2.4	2.08	3.5	4	4.2	5.2	000000001
5	30	Public Roads, non electrifi			No	No	Yes	6.5	0.4	7.3	7.3	7.9	1.85	9	2.9	9.7	3.6	000000001
6	33	33kV conductor			No	Yes	No	1.4	0.9	1.8	2	2.4	2.08	3.5	4	4.2	5.2	000000001
7	40	Communication lines _power			No	Yes	No	1	0.4	1.8	2	2.4	2.08	3.5	4	4.2	5.2	000000001
8	50	Buildings, structures not p	B	B	Yes	No	No	3.4	0.4	3.6	3.6	4.2	1.85	5.3	2.9	6	3.6	000000001
9	60	Vegetation canopy			Yes	No	No	3.4	0.4	3.6	3.6	4.2	1.85	5.3	2.9	6	3.6	000000001
10	66	66kV conductor			No	Yes	No	1.8	1.29	1.8	2	2.4	2.08	3.5	4	4.2	5.2	000000001
11	70	NO GO AREA			No	No	Yes	5.3	0.4	6.1	0.4	6.7	1.85	7.8	2.9	8.5	3.6	000000001
12	88	88kV conductor			No	Yes	No	2	1.54	1.9	2.1	2.4	2.08	3.5	4	4.2	5.2	000000001
13	97	Bend point of deviated Dx L			No	No	No	5.3	0.4	6.1	0.4	6.7	1.85	7.8	2.9	8.5	3.6	000000001
14	98	Tower position from N2 engi			No	No	No	5.3	0.4	6.1	0.4	6.7	1.85	7.8	2.9	8.5	3.6	000000001
15	99	Imported tower position			No	No	No	5.3	0.4	6.1	0.4	6.7	1.85	7.8	2.9	8.5	3.6	000000001
16	100	POWER LINE BEND			No	No	No	5.3	0.4	6.1	0.4	6.7	1.85	7.8	2.9	8.5	3.6	000000001
17	101	Required tower position			No	No	No	5.3	0.4	6.1	0.4	6.7	1.85	7.8	2.9	8.5	3.6	000000001
18	102	WATER COURSE/RIVER - EDGE			No	No	Yes	5.3	0.4	6.1	0.4	6.7	1.85	7.8	2.9	8.5	3.6	000000001
19	103	Navigable WATER			No	No	Yes	18.4	0.4	6.1	0.4	19.85	1.85	20.75	2.9	21.6	3.6	000000001
20	104	Invisible Tower cable			No	No	No	5.3	0.4	6.1	0.4	6.7	1.85	7.8	2.9	8.5	3.6	000000001
21	111	Spoornet Conductor			No	Yes	No	2.8	2.8	3	3	3.3	3.3	4.2	4.2	5	5	000000001
22	132	132kV conductor			No	Yes	No	2.4	2.08	2.3	2.5	2.4	2.08	3.5	4	4.2	5.2	000000001
23	200	Ground outside townships			No	No	Yes	5.3	0.4	6.1	6.1	6.7	1.85	7.8	2.9	8.5	3.6	000000001
24	220	220kV conductor			No	Yes	No	3.1	3.1	3.2	3.5	3.1	3.1	3.5	4	4.2	5.2	000000001
25	222	Inv twr view point			No	No	Yes	5.9	0.4	6.1	6.1	6.7	1.85	7.8	2.9	8.5	3.6	000000001
26	275	275kV conductor			No	Yes	No	3.5	4	3.8	4	3.5	4	3.5	4	4.2	5.2	000000001

OK Cancel

Profiling Concepts:
Wind Span and Weight Span

- Span details:
  - Spans: 1495m
  - Gorge depth: 252m
  - Weight of 1 quad Pelican phase : 5.0 tons
  - Sag: 174m



- Differential tension used in middle phase to prevent mid-span clashing
- Modelled with Method 4 tower models to find suitable tower

Profiling Concepts: Ground Clearance

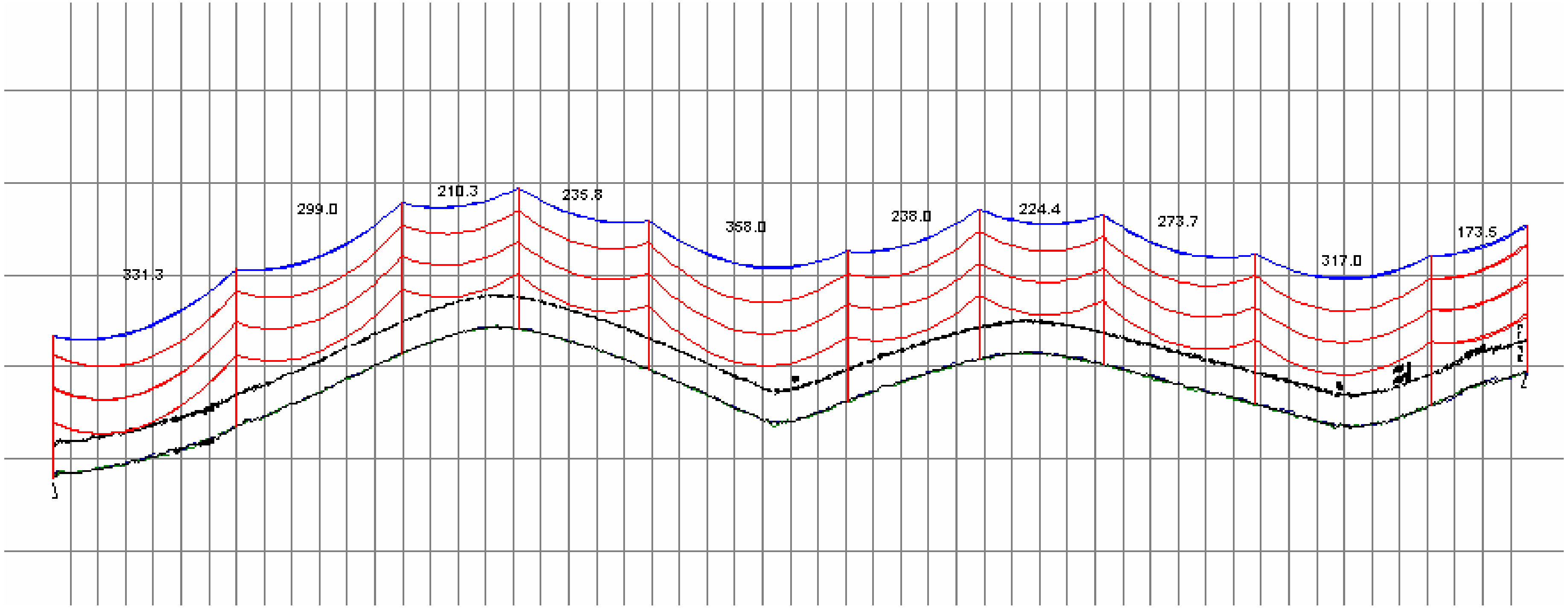
Table C.1 — Minimum clearances for power lines that cross services other than those owned by Transnet and by the South African Rail Commuter Corporation

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Highest system r.m.s. voltage kV	System nominal r.m.s. voltage kV	Safety clearance phase-to-earth m	Safety clearance phase-to-phase m	Minimum vertical clearances m					Minimum live-line working clearances m		Tower-top clearances m		
				Outside town-ships	In town-ships	Roads in townships, and proclaimed roads, railways, tramways	To communica-tion lines or between power lines and cradles	To buildings, poles and structures, not part of power lines	Phase-to-earth	Phase-to-phase	Still air con-ditions	Normal swing	Maximum swing
≤1	–	–	–	4,9	5,5	6,1	0,6	3,0	–	–	–	–	–
7,2	6,6	0,15	0,2	5,0	5,5	6,2	0,7	3,0	–	–	–	–	–
12	11	0,20	0,3	5,1	5,5	6,3	0,8	3,0	–	–	–	–	–
24	22	0,32	0,4	5,2	5,5	6,4	0,9	3,0	–	–	–	–	–
36	33	0,43	0,5	5,3	5,5	6,5	1,0	3,0	–	–	–	–	–
48	44	0,54	0,61	5,4	5,5	6,6	1,1	3,0	0,8	1,1	0,54	0,5	0,15
72	66	0,77	0,89	5,7	5,7	6,9	1,4	3,2	0,9	1,3	0,77	0,71	0,20
100	88	1,00	1,14	5,9	5,9	7,1	1,6	3,4	1,0	1,5	1,00	0,92	0,24
145	132	1,45	1,68	6,3	6,3	7,5	2,0	3,8	1,2	1,9	1,45	1,30	0,35
245	220	2,1	2,7	7,0	7,0	8,2	2,7	4,5	1,7	2,8	2,1	1,88	0,6
300	275	2,5	3,6	7,4	7,4	8,6	3,1	4,9	2,0	3,4	2,5	2,2	0,7
362	330	2,9	4,3	7,8	7,8	9,0	3,5	5,3	2,3	4,1	2,9	2,6	0,86
420	400	3,2	4,8	8,1	8,1	9,3	3,8	5,6	2,8	4,8	3,2	2,9	1,0
800	765	5,5	8,9	10,4	10,4	11,6	6,1	8,5	5,5	9,7	5,5	5,2	1,9
d.c. 533 kV[1)]	–	3,7	–	8,6	8,6	9,8	4,3	6,1					

1) Maximum voltage to earth, for which insulation is designed.

NOTE The assumption on which the values are based is given in clause C.2.

Profiling Concepts: Ground Clearance



- This leads into Catenary, Sag and Tension and temperature considerations

Profiling Concepts: Line walkdown

- Proximity of other lines and objects
- Other infrastructure (eg pipelines)
- Environmental impacts (eg protected trees, birds)
- Poor soil conditions (eg marshes)
- Access to tower sites
- Side slope

etcbl global

Modelling a line in PLS CADD

Oct 2025

Topics Covered

- ✓ Structure Spotting
- ✓ Stringing a Tension Section
- ✓ Clipped/Unclipped Sections
- ✓ Design Method
- ✓ Conductor Swing/Blowout
- ✓ Wire Departure Angle
- ✓ Modelling Aerial Warning Markers

etcbl global

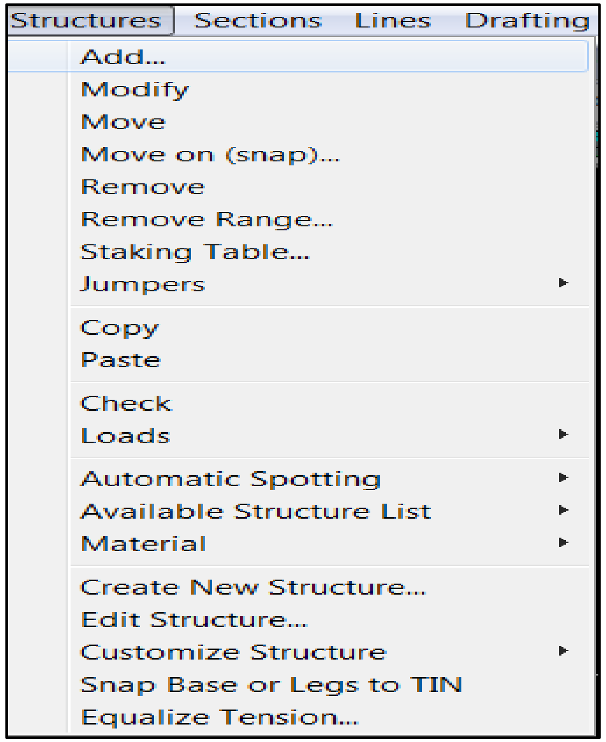
Structure Spotting

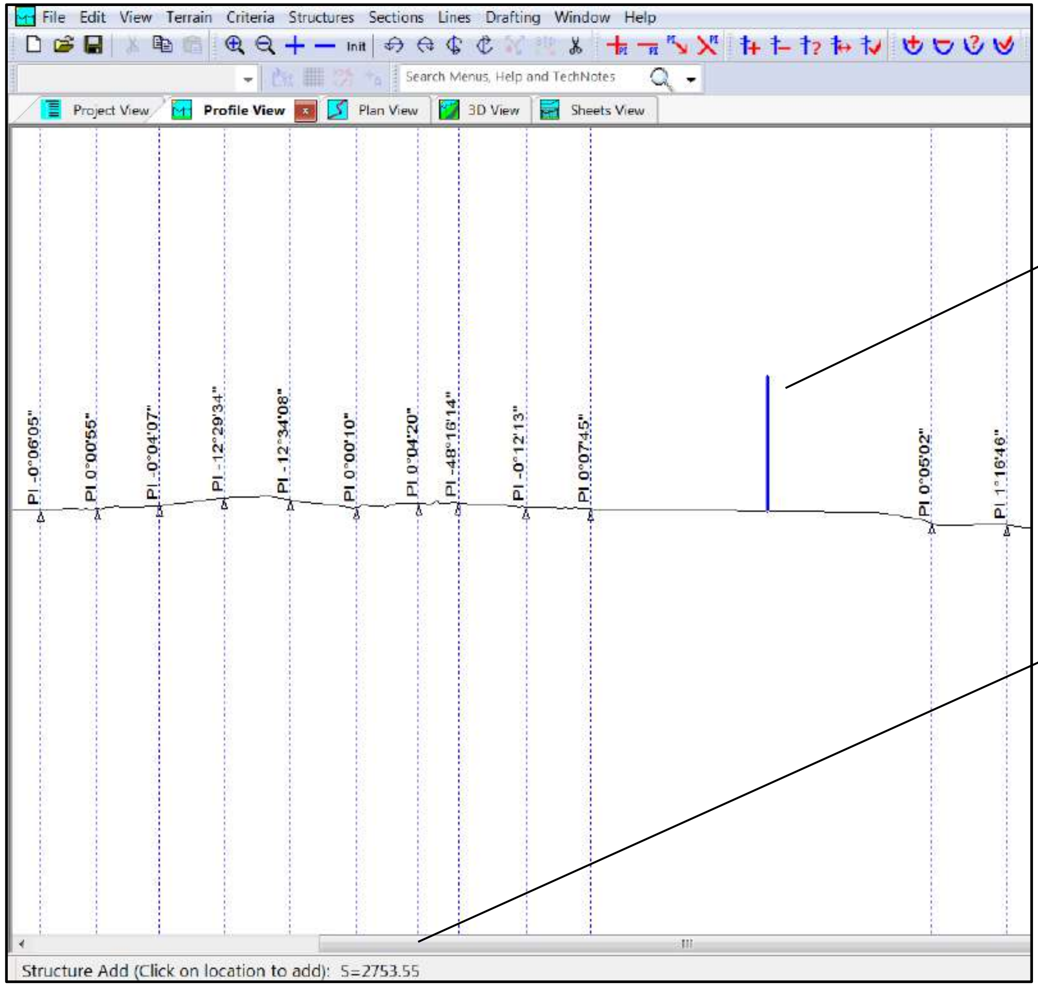
- Once alignment is defined, you can add structures using two ways:
- Manual (Interactive) or
- Automatic

- The user should first spot the structures at the ends of the line and at all angle points
- Structures are to be added at all alignment PI points

Structure Spotting - Interactive

- Go to Structures -> Add command as shown below





A blue line appears indicating a structure to be added

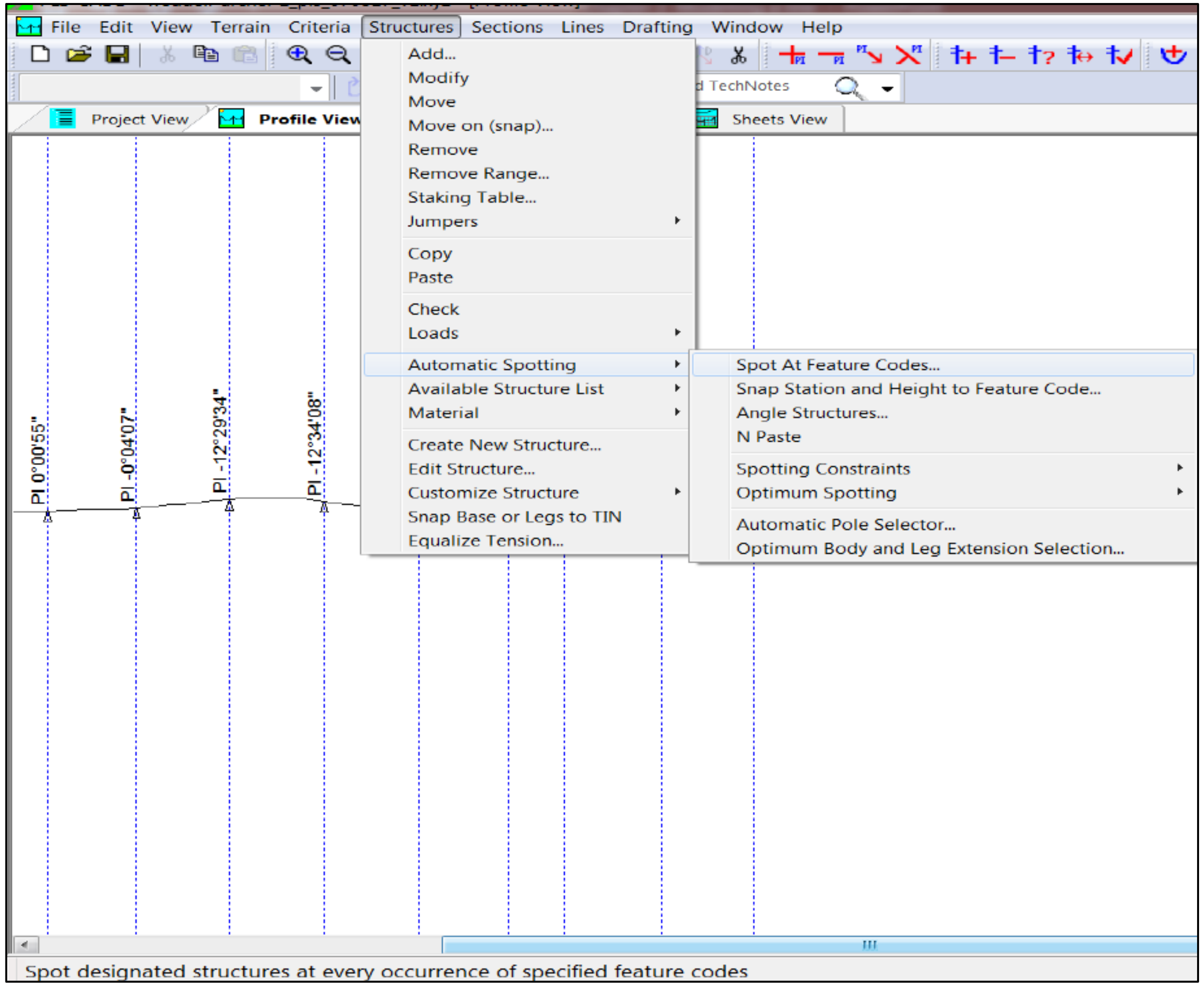
The Status Bar indicates the location and Station number at which the structure is added

etcbl global

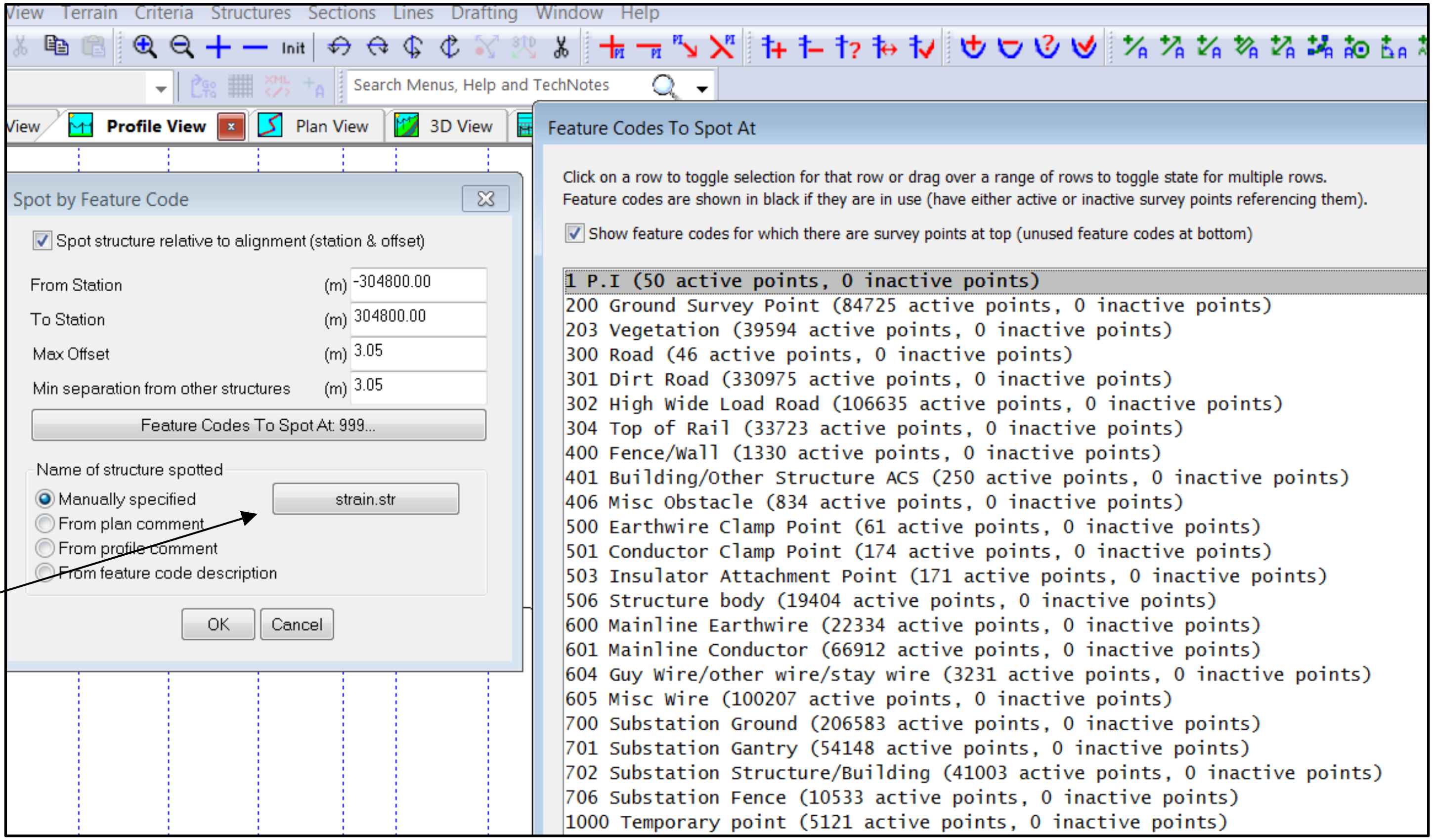
Structure Spotting – Automatic Spotting

- Spotting structures at unique feature codes (example at PI points/ line angles)
- It is recommended to assign a unique feature code for a PI point in the Feature Code table
- Use Structures -> Automatic Spotting -> Spot at Feature Codes command as shown on next slide
- This command will automatically locate specific structures at the assigned feature codes

Structure Spotting – Automatic Spotting



Structure Spotting – Automatic Spotting



Select type of Structure to automatically spot at selected Feature Code

etcbl global

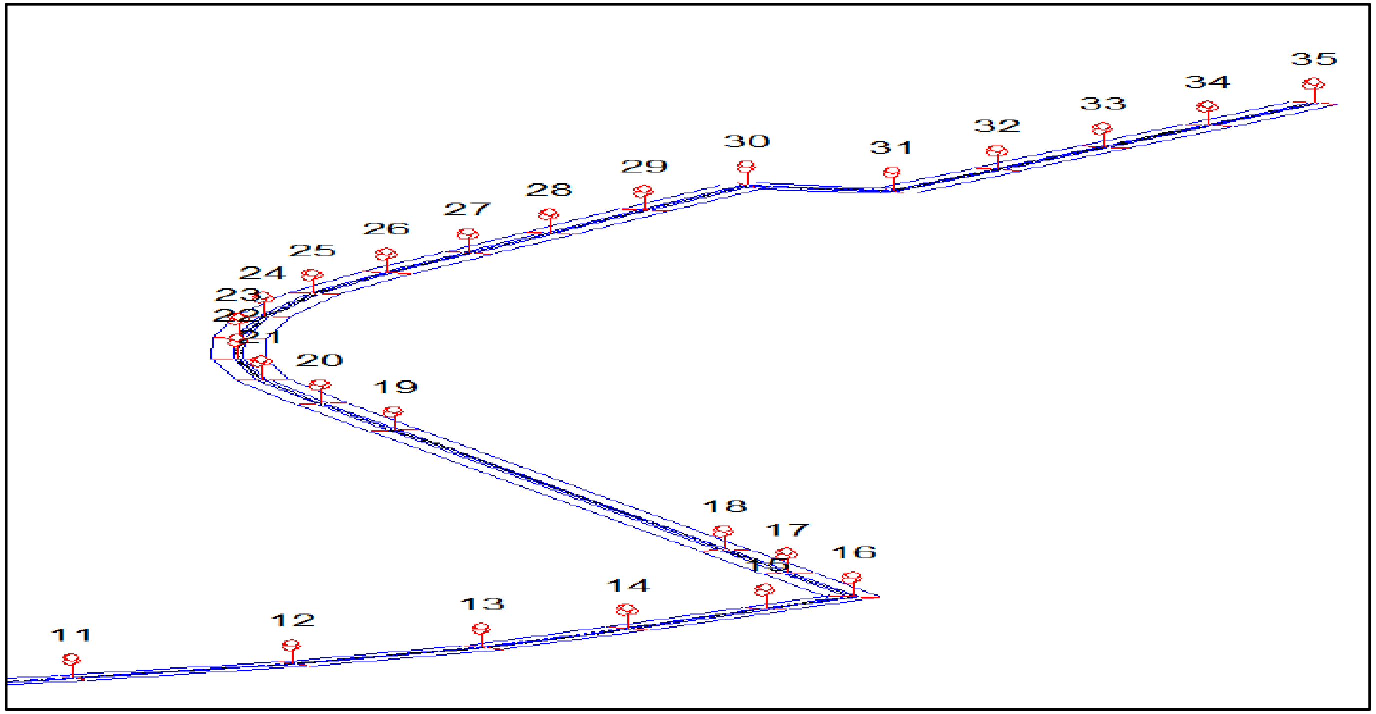
Structure Spotting – Spotting Structures at Line Angles

- A structure is to be added at each line angle position on the alignment

- To make sure a structure is added at line angles, add one arbitrary structure at all angle locations and then later use Structure -> Modify to adjust the Structure Type. See example next slide.

Structure Spotting – Spotting Structures at Line Angles

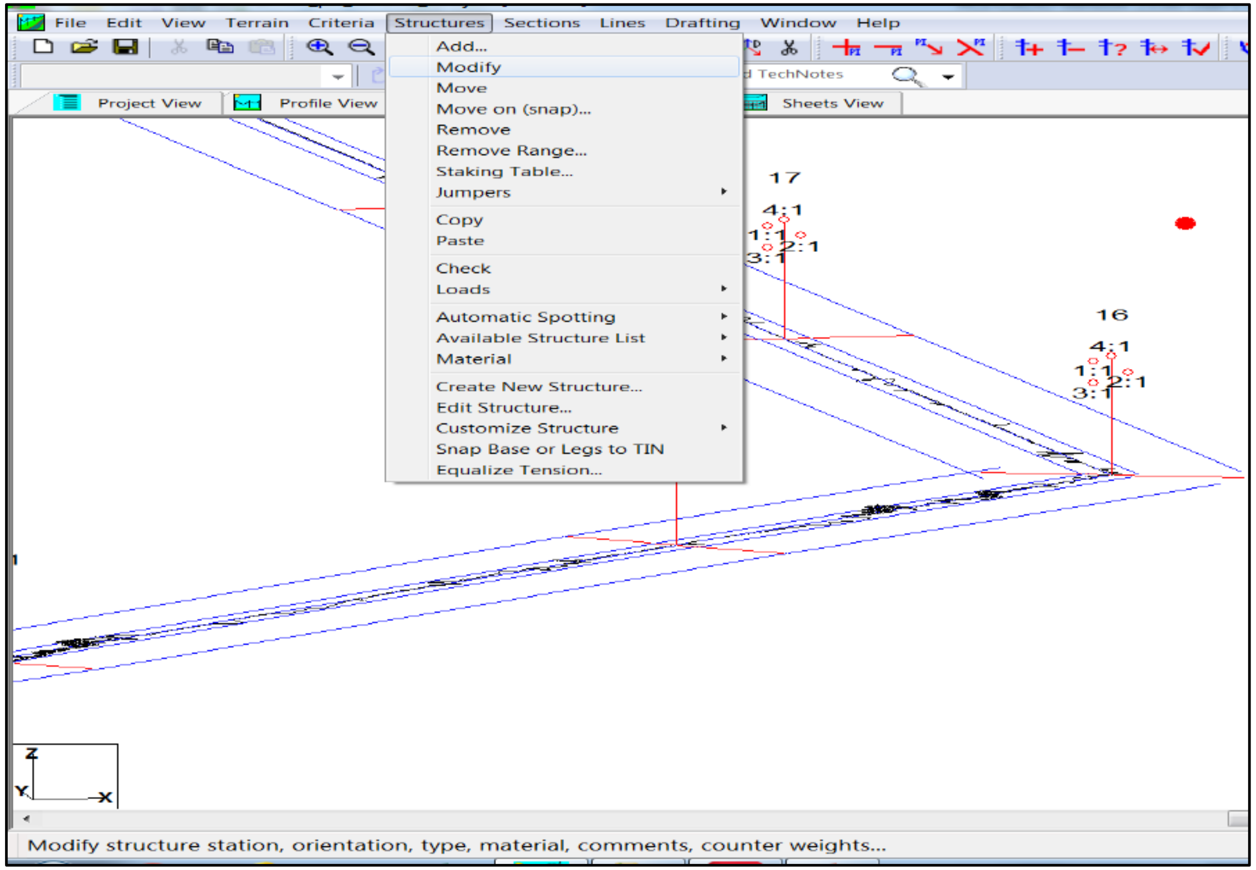
- One arbitrary structure is automatically spotted in the entire line at each PI location
- In the example below, it is a suspension type structure
- Now to change structure 16 to a strain type structure, you can use Structure -> Modify command



etcbl global

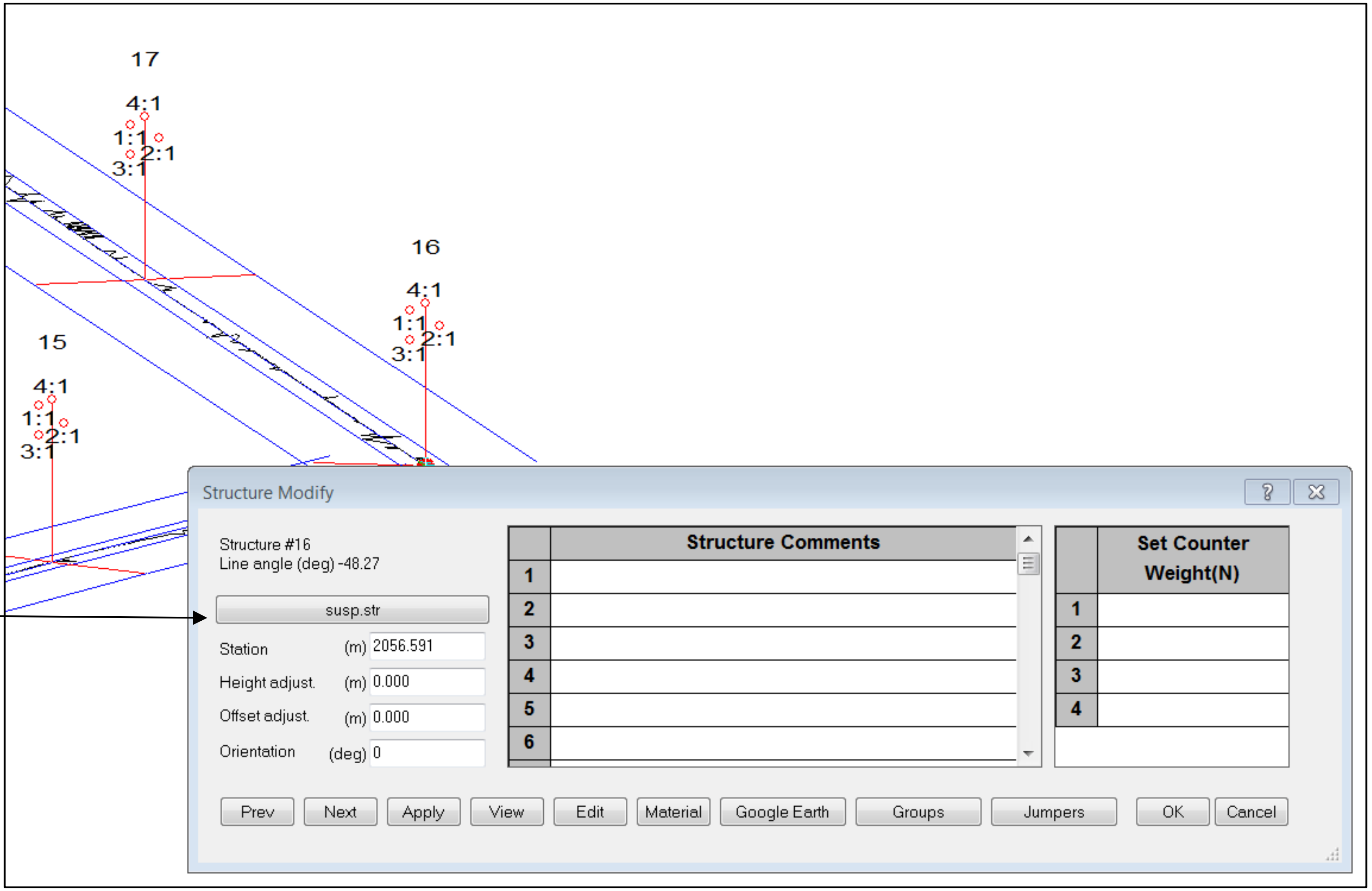
Structure Spotting – Spotting Structures at Line Angles

- Now to change structure 16 to a strain type structure, you can use Structures -> Modify command. A Structure Modify box will appear as on next slide.



Structure Spotting – Spotting Structures at Line Angles

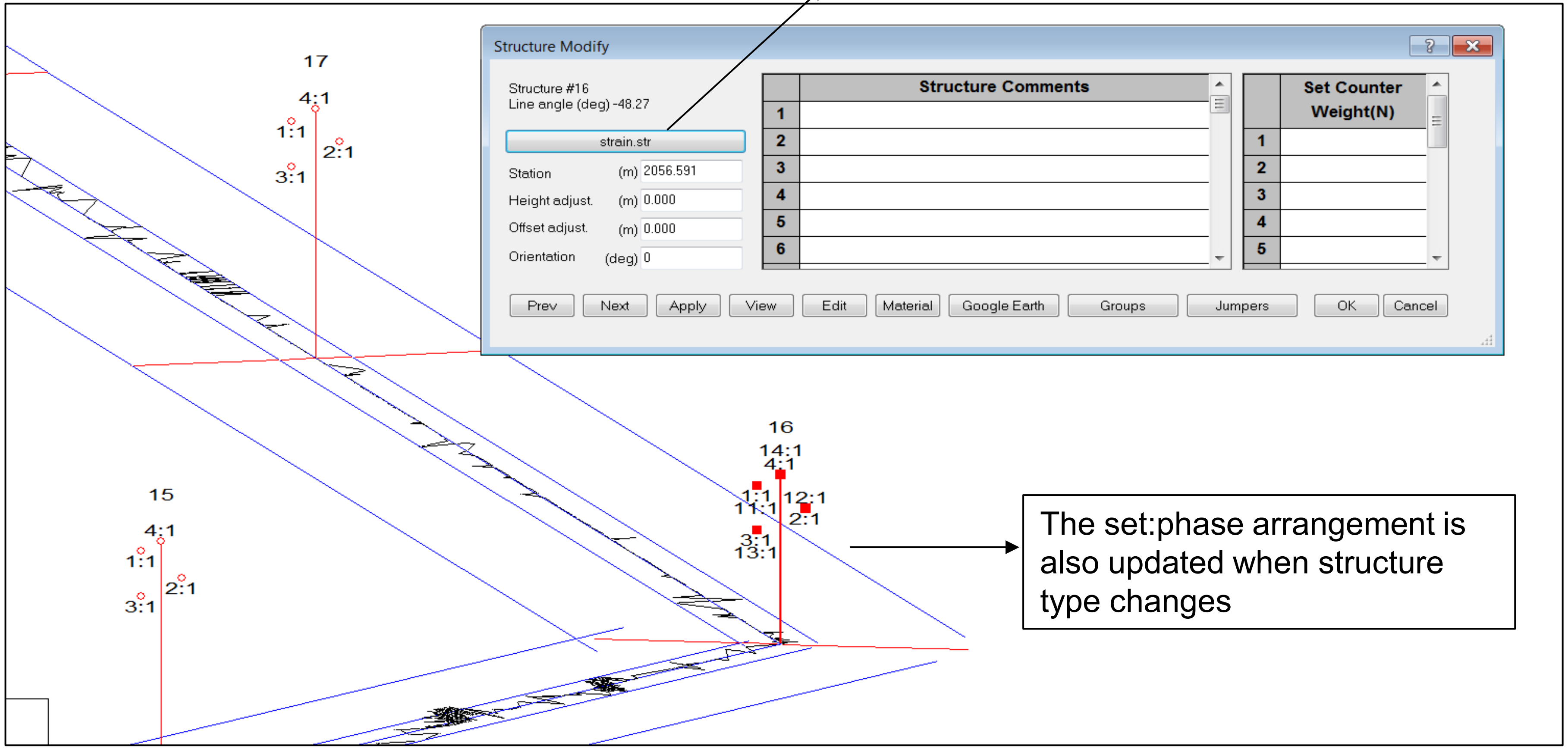
Select strain structure file



etcbl global

Structure Spotting – Spotting Structures at Line Angles

Strain structure selected at location 16

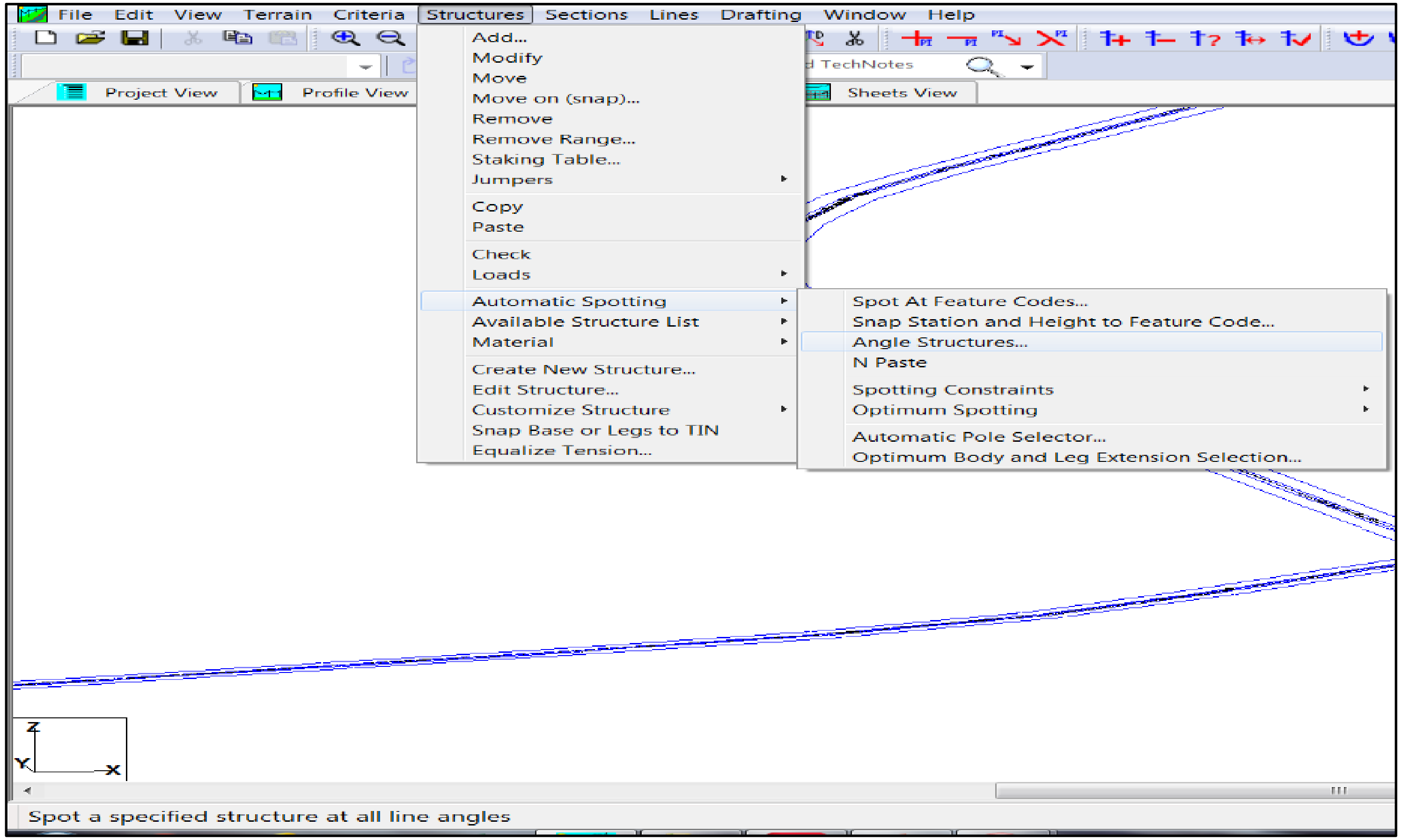


The set:phase arrangement is also updated when structure type changes

etcbl global

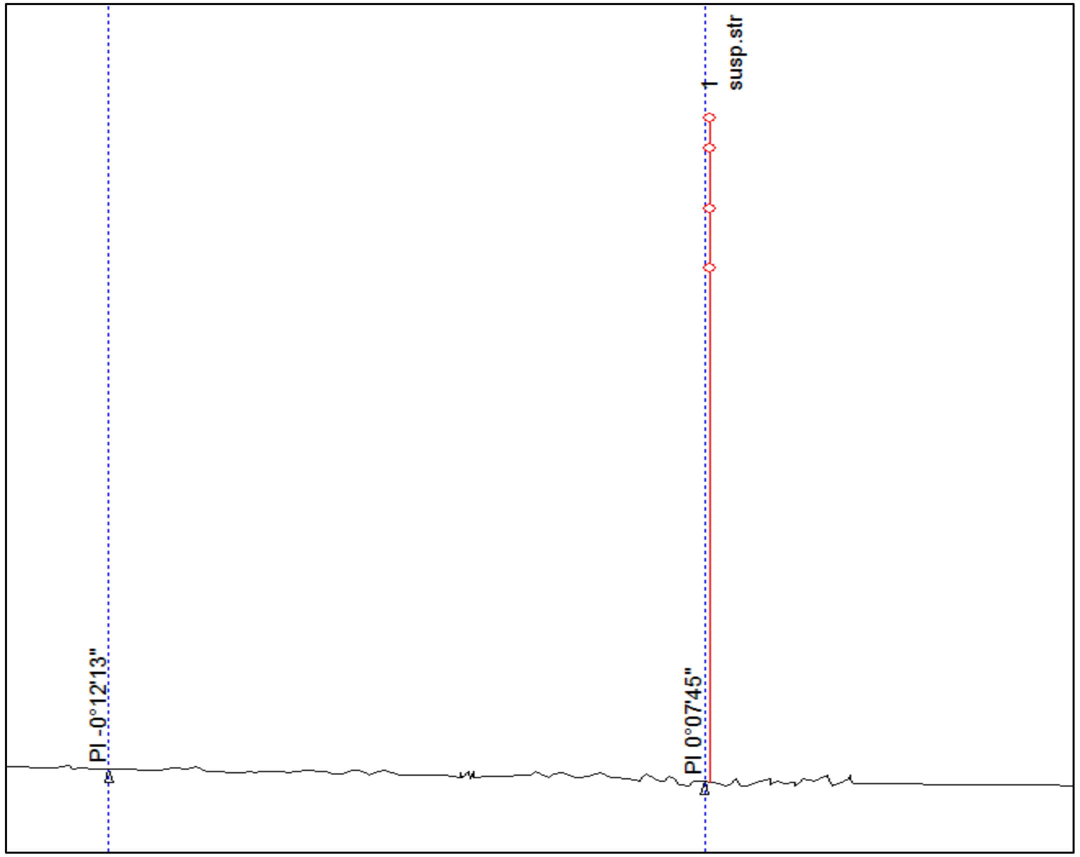
Structure Spotting – Spotting Structures at Line Angles

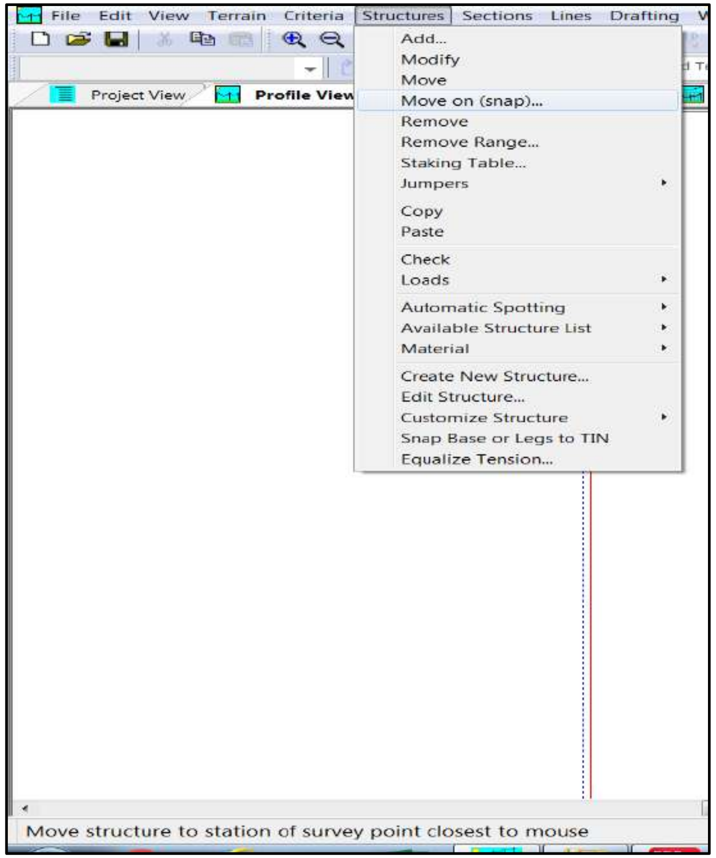
- Another method to add a arbitrary structure at each line angle location is to use Structures -> Automatic Spotting -> Angle Structures command



Structure Spotting – Adjusting Structure location

- If you have manually added a structure as below and would like to snap to the desired PI location, use Structures -> Move on (snap) command

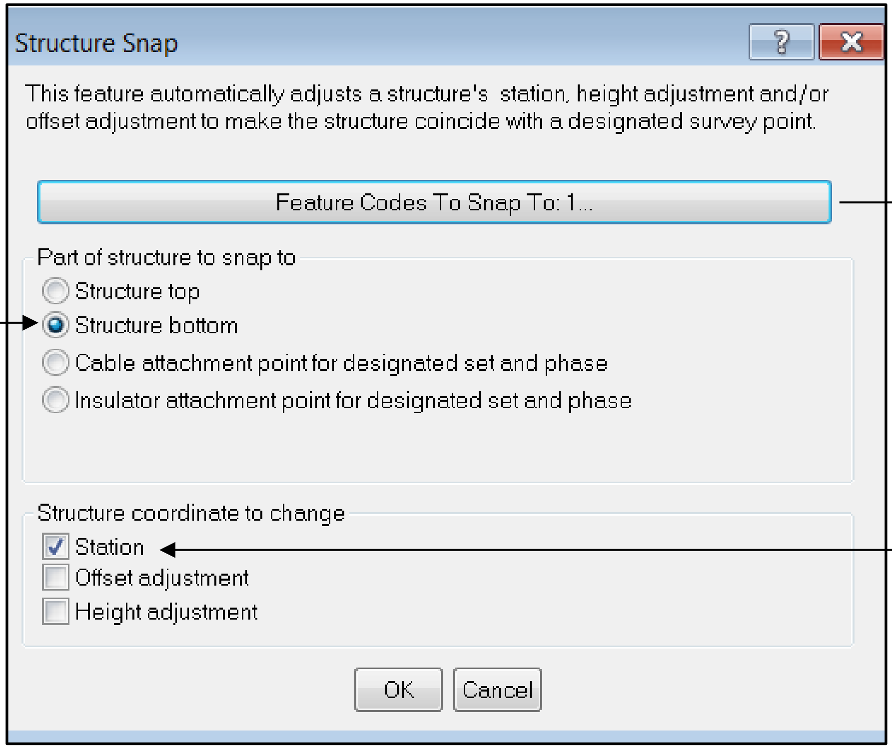




Structure Spotting – Adjusting Structure location

- If you have manually added a structure as below and would like to snap to the desired PI location, use Structures -> Move on (snap) command

Select Bottom of the structure to snap to the desired PI location



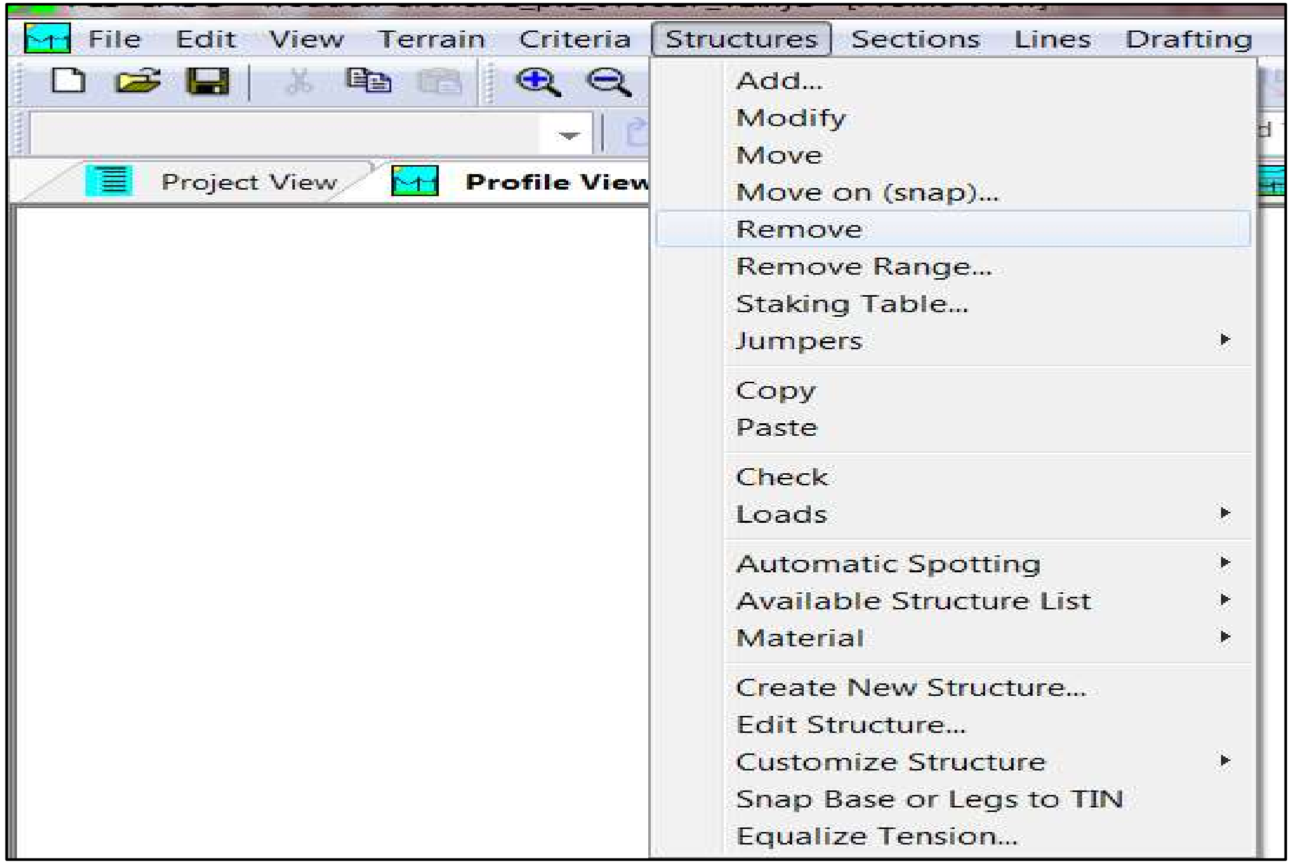
Select PI Feature Code

Structure Station number to be adjusted after adjusting structure location

etcbl global

Structure Spotting – Removing Structures

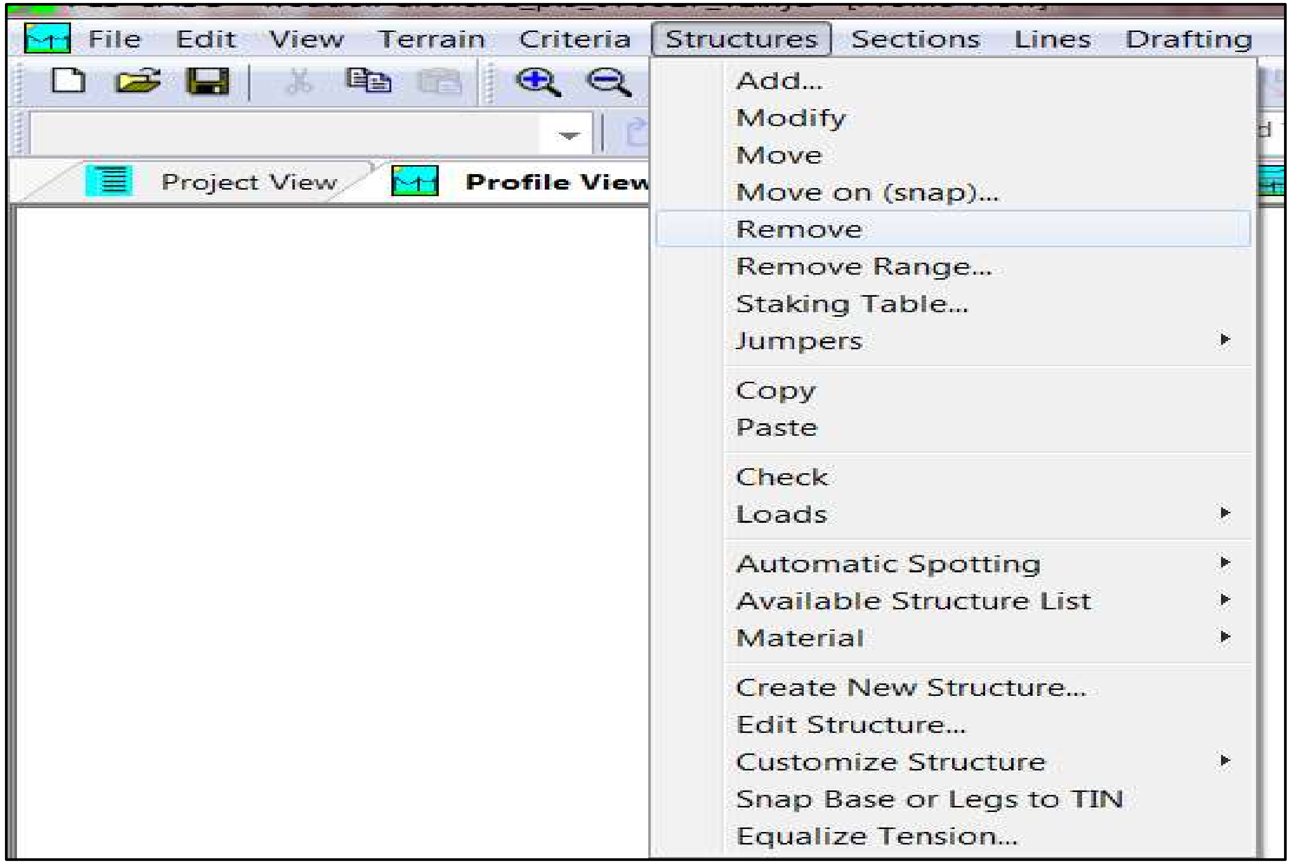
- To remove an individual structure from the alignment, use Structures -> Remove command as below

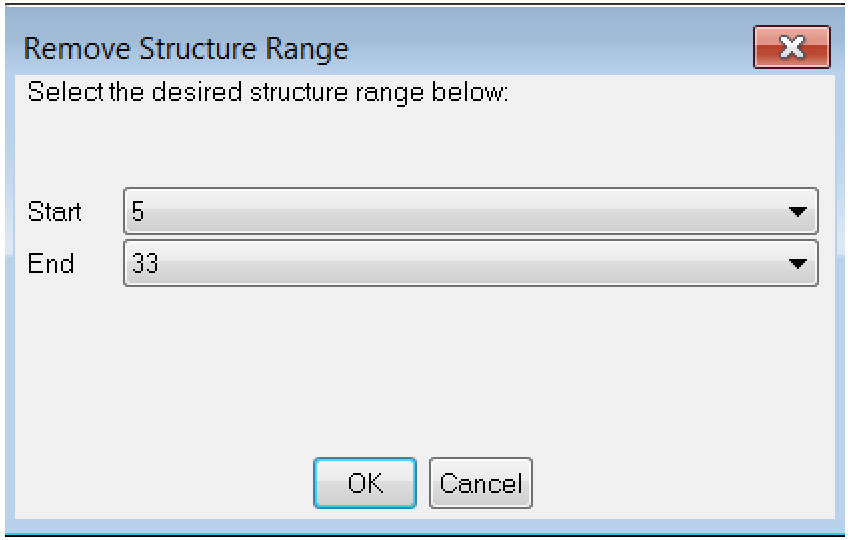


etcbl global

Structure Spotting – Removing Structures

- To remove a group of structures from the alignment, use Structures -> Remove Range command





etcbl global

Stringing a Tension Section

- Recommended to string the wire in Profile View
- Wire will be strung left to right
- Go to left most structure in Profile View
- Click Sections -> Add to string a tension section

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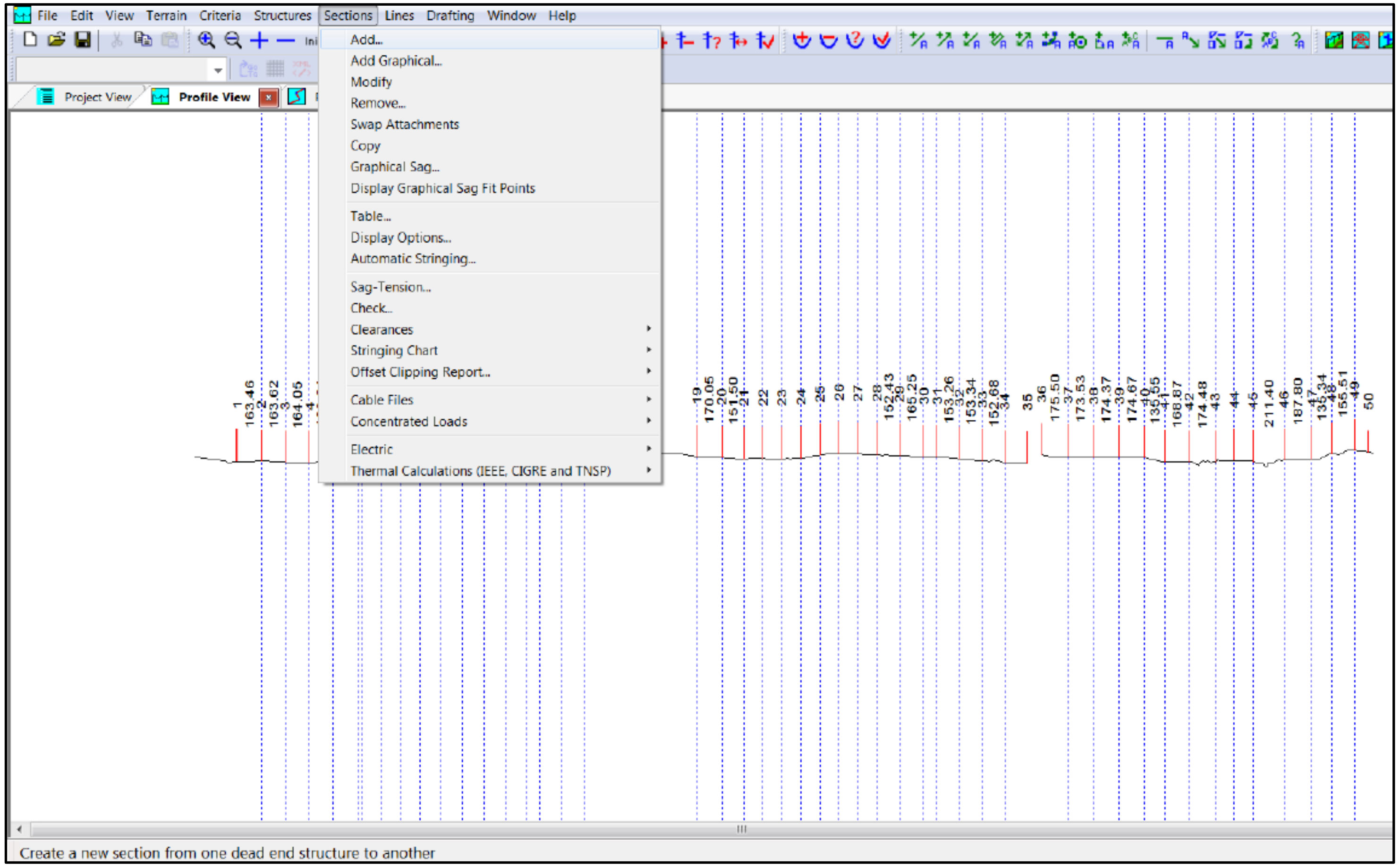
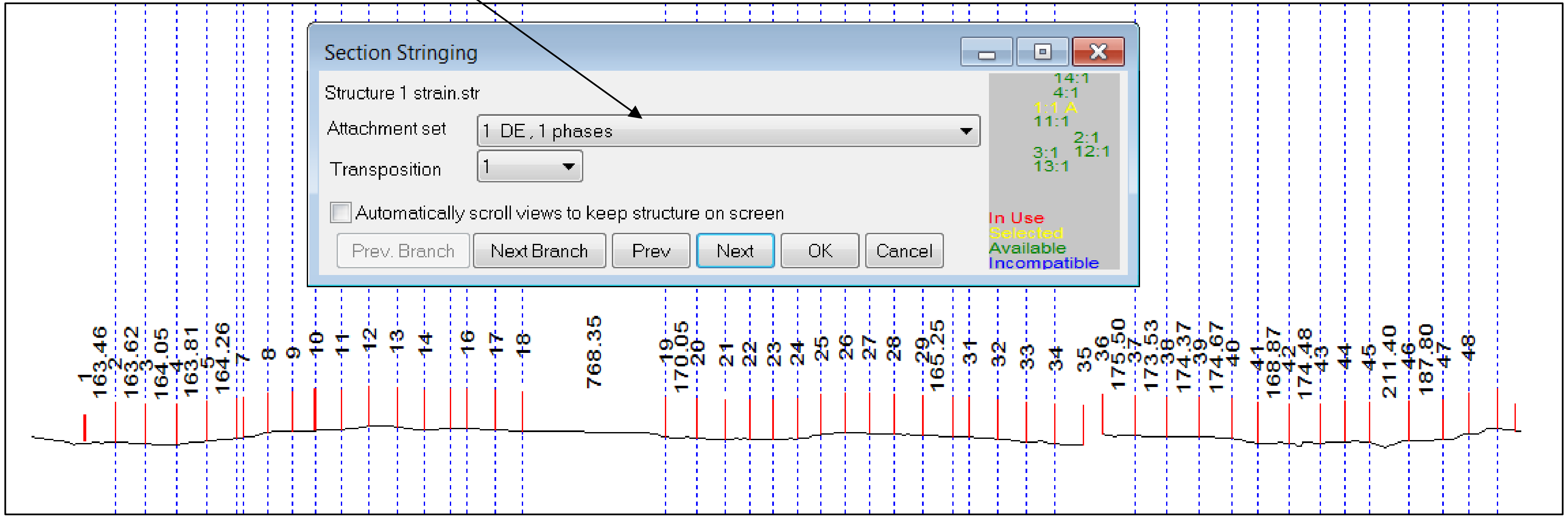
Stringing a Tension Section



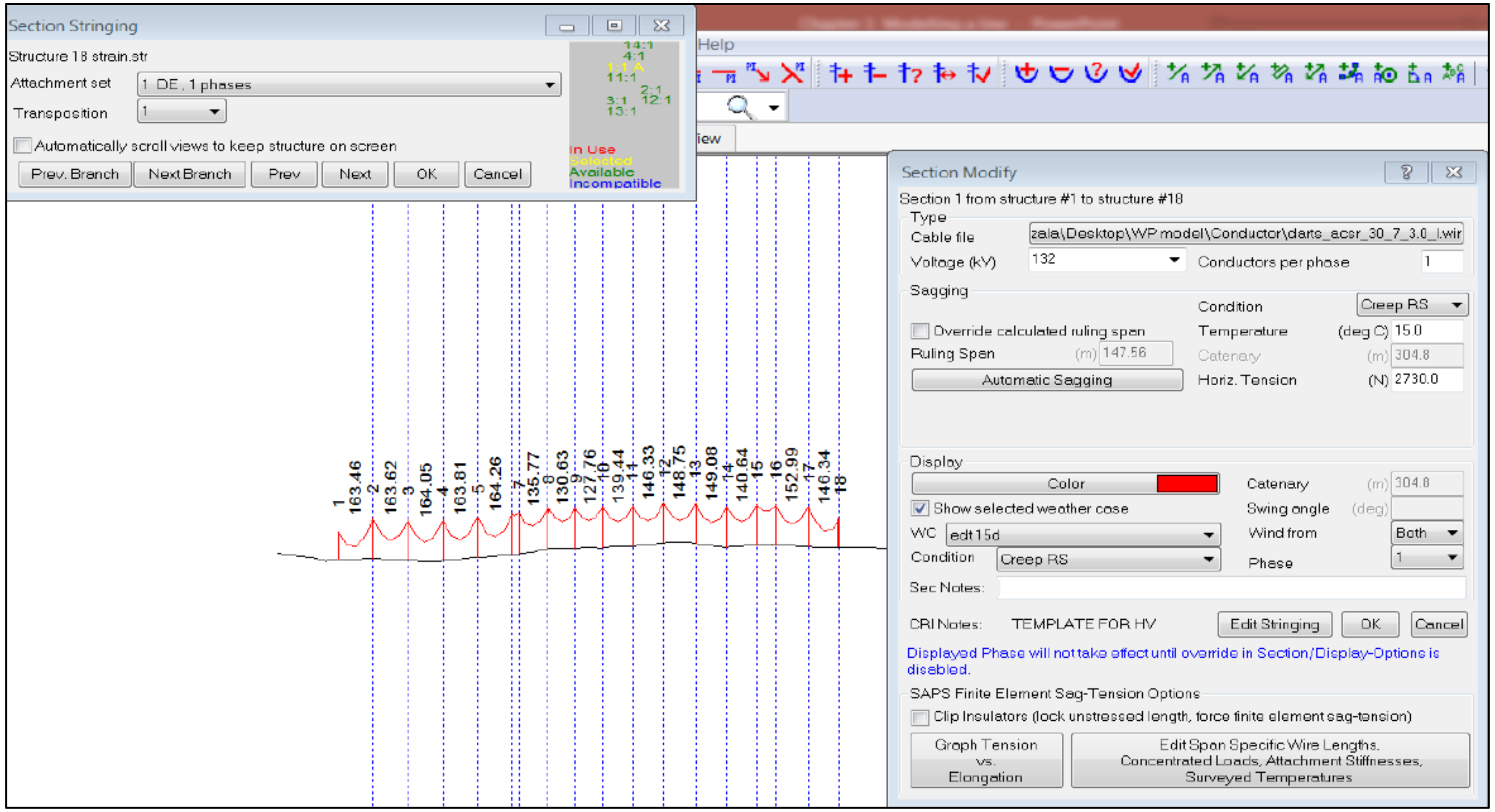
Stringing a Tension Section

Choose from available attachment sets to string the wire and click Next to connect next structure in the stringing section



Stringing a Tension Section

- Once tension section is added, go to Section Modify where you can change section parameters (e.g. Cable file, voltage level, Display weather case, Conductors per phase, Sagging Tension, Finite Element Sag-Tension options)



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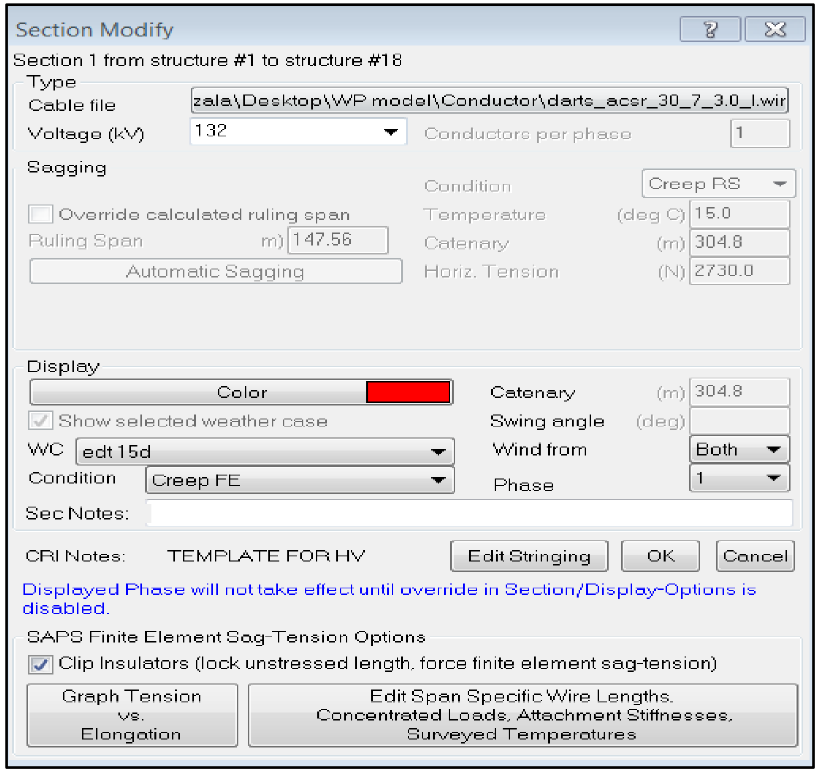
Clipped / Unclipped Sections

- If Clip Insulators is checked in Section Modify, all sags, tensions and load calculations will be based on Finite Element method
- In Finite Element method, all calculations are based on fixed unstressed lengths for each cable in each span.
- Unstressed length is the physical length of cable between clip points.
- In Finite Element, tensions are different in every wire of every span.



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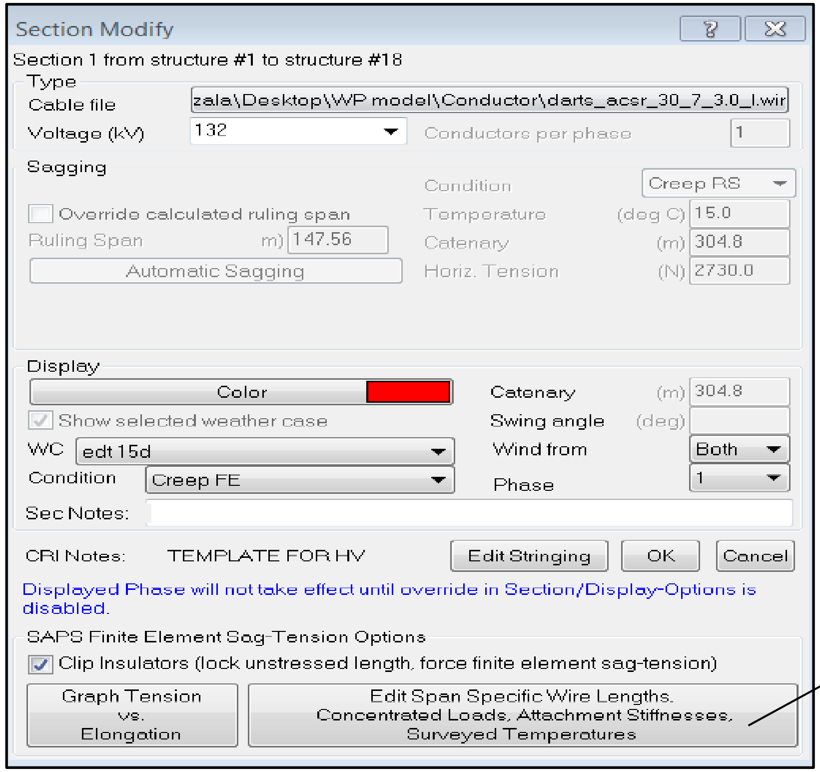
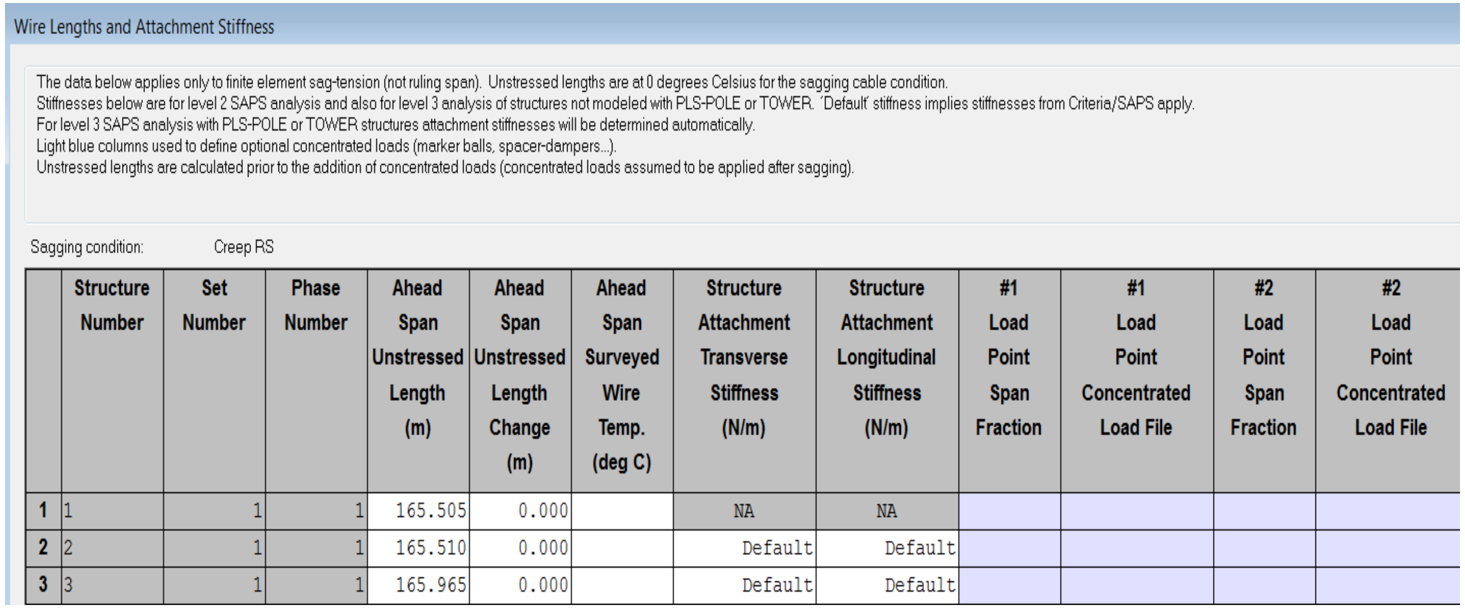
Clipped / Unclipped Sections

- Click Edit Span Specific Wire Lengths in Section Modify to calculate unstressed lengths in each span.
- Unstressed lengths are of 3 types at a reference temp of 0deg and under no tension : Initial unstressed length, “After creep” unstressed length and “After load” unstressed length





Wire Lengths and Attachment Stiffness

The data below applies only to finite element sag-tension (not ruling span). Unstressed lengths are at 0 degrees Celsius for the sagging cable condition.
Stiffnesses below are for level 2 SAPS analysis and also for level 3 analysis of structures not modeled with PLS-POLE or TOWER. 'Default' stiffness implies stiffnesses from Criteria/SAPS apply.
For level 3 SAPS analysis with PLS-POLE or TOWER structures attachment stiffnesses will be determined automatically.
Light blue columns used to define optional concentrated loads (marker balls, spacer-dampers...).
Unstressed lengths are calculated prior to the addition of concentrated loads (concentrated loads assumed to be applied after sagging).

Sagging condition: Creep RS

	Structure Number	Set Number	Phase Number	Ahead Span Unstressed Length (m)	Ahead Span Unstressed Length Change (m)	Ahead Span Surveyed Wire Temp. (deg C)	Structure Attachment Transverse Stiffness (N/m)	Structure Attachment Longitudinal Stiffness (N/m)	#1 Load Point Span Fraction	#1 Load Point Concentrated Load File	#2 Load Point Span Fraction	#2 Load Point Concentrated Load File
1	1	1	1	165.505	0.000		NA	NA				
2	2	1	1	165.510	0.000		Default	Default				
3	3	1	1	165.965	0.000		Default	Default				

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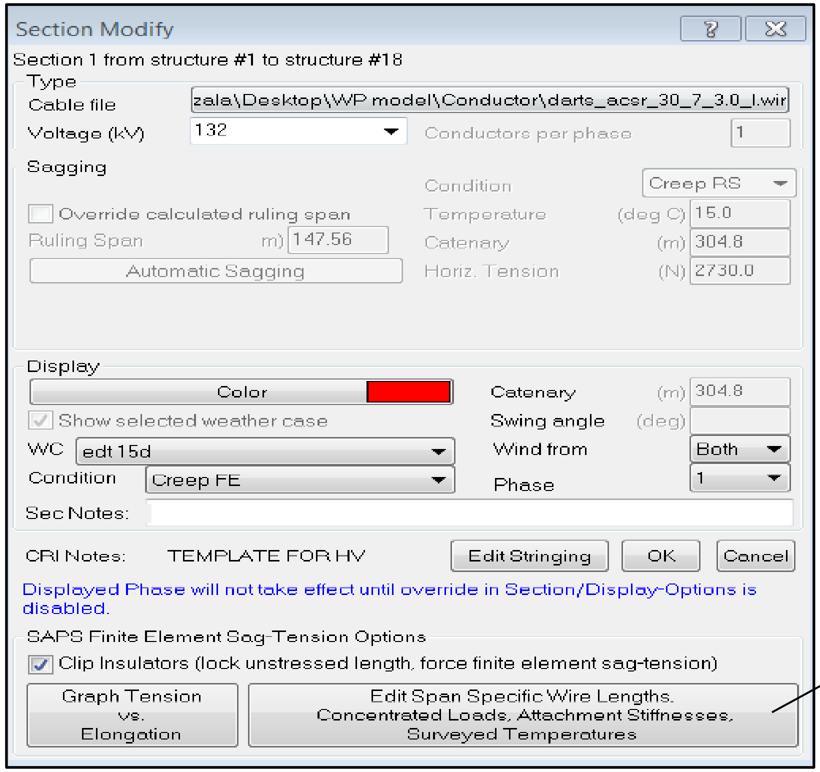
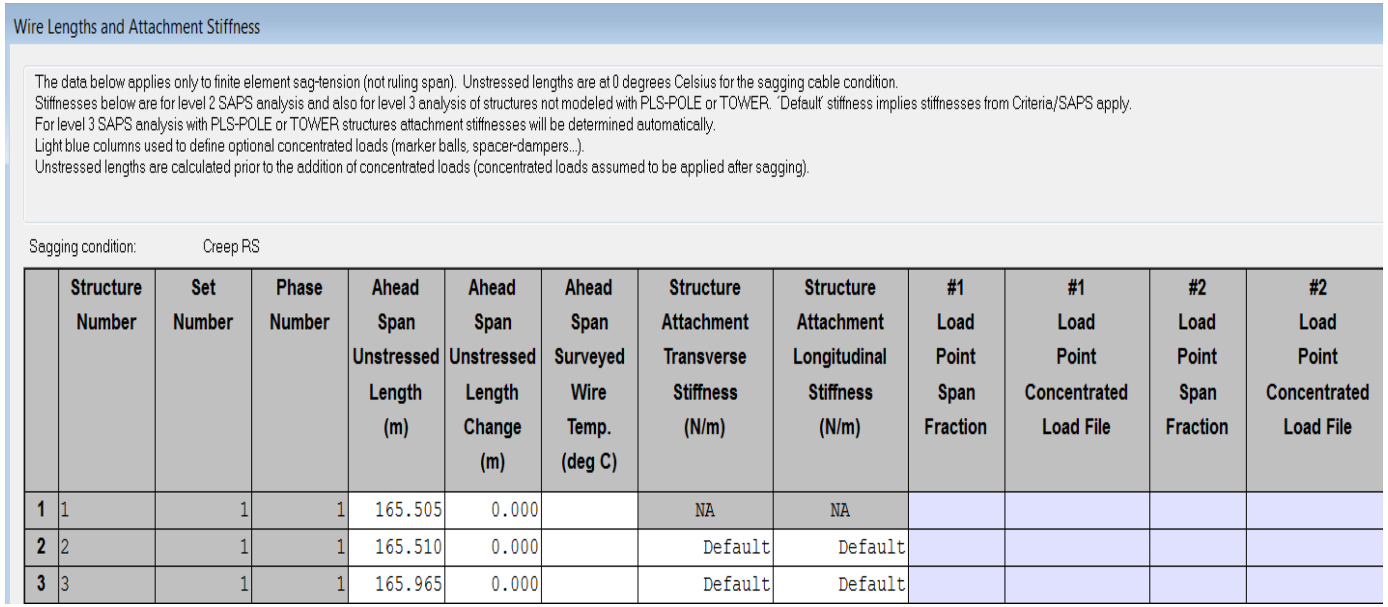
Clipped / Unclipped Sections

- Changing unstressed lengths can be used to simulate adding or subtracting a wire length from the span.





Wire Lengths and Attachment Stiffness

The data below applies only to finite element sag-tension (not ruling span). Unstressed lengths are at 0 degrees Celsius for the sagging cable condition.
Stiffnesses below are for level 2 SAPS analysis and also for level 3 analysis of structures not modeled with PLS-POLE or TOWER. 'Default' stiffness implies stiffnesses from Criteria/SAPS apply.
For level 3 SAPS analysis with PLS-POLE or TOWER structures attachment stiffnesses will be determined automatically.
Light blue columns used to define optional concentrated loads (marker balls, spacer-dampers...).
Unstressed lengths are calculated prior to the addition of concentrated loads (concentrated loads assumed to be applied after sagging).

Sagging condition: Creep RS

	Structure Number	Set Number	Phase Number	Ahead Span Unstressed Length (m)	Ahead Span Unstressed Length Change (m)	Ahead Span Surveyed Wire Temp. (deg C)	Structure Attachment Transverse Stiffness (N/m)	Structure Attachment Longitudinal Stiffness (N/m)	#1 Load Point Span Fraction	#1 Load Point Concentrated Load File	#2 Load Point Span Fraction	#2 Load Point Concentrated Load File
1	1	1	1	165.505	0.000		NA	NA				
2	2	1	1	165.510	0.000		Default	Default				
3	3	1	1	165.965	0.000		Default	Default				

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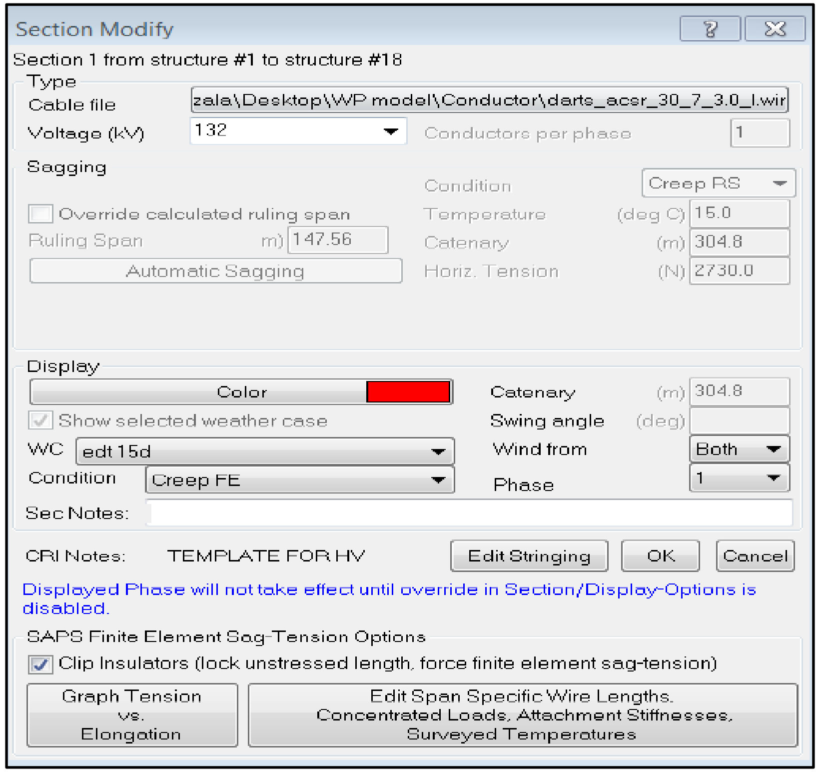
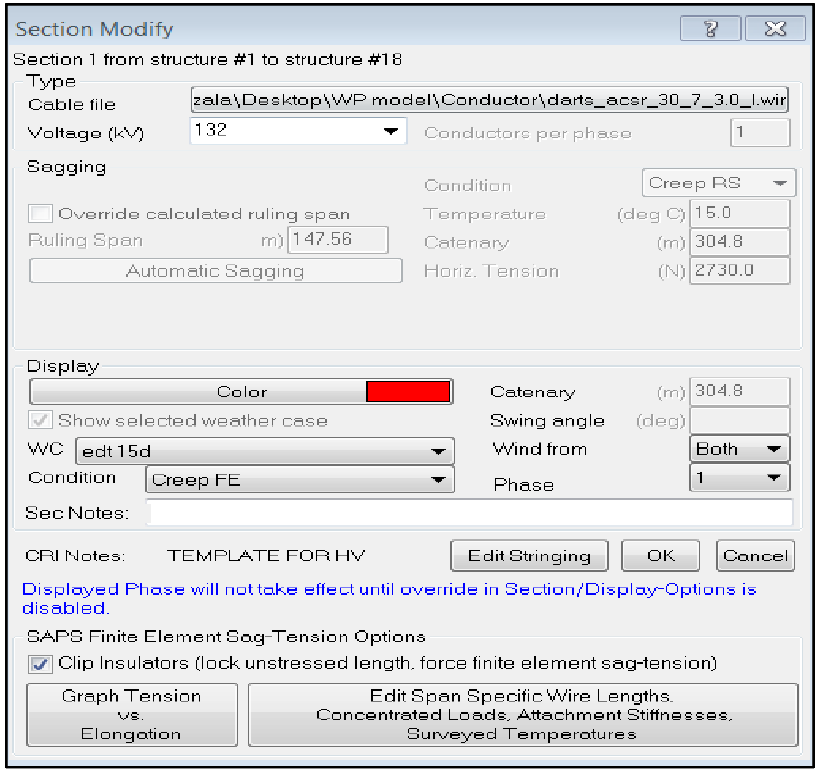
Clipped / Unclipped Sections

- Note: When unstressed lengths of a tension section are locked, you cannot move structures within that tension section. Remember to unlock the unstressed lengths before moving structures.
- Unlocking the unstressed lengths means to put the wire back on to sheave.



Clipped / Unclipped Sections

- If unstressed length is locked and user adds a new structure within the tension section, PLS-CADD will divide the original unstressed length into two unstressed lengths (one for the new back span and one for the new forward span) to match the sagging condition.



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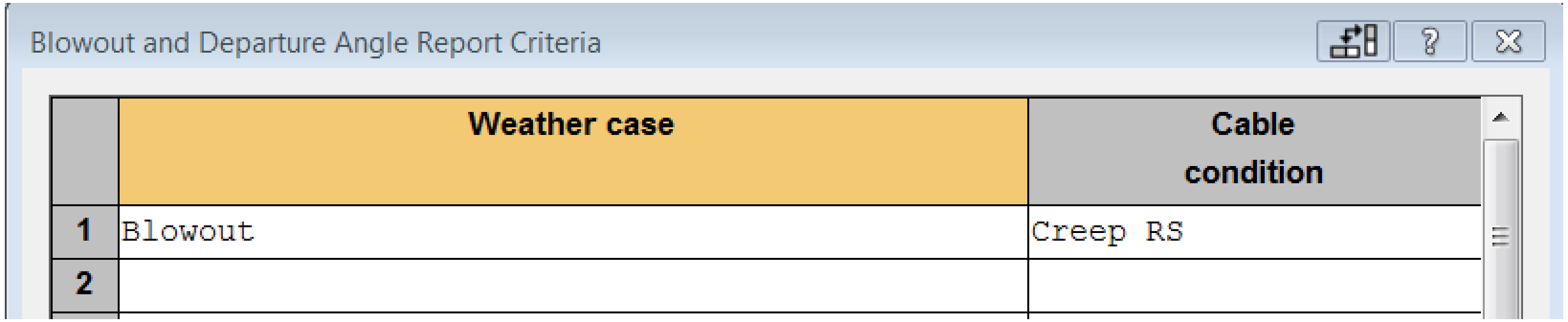
Blowout and Departure Angle

- Create blowout weather case criteria in Criteria -> Weather
- Define Blowout and Departure Angle Report Criteria in Criteria Menu



Chapter 3 – Modelling a line

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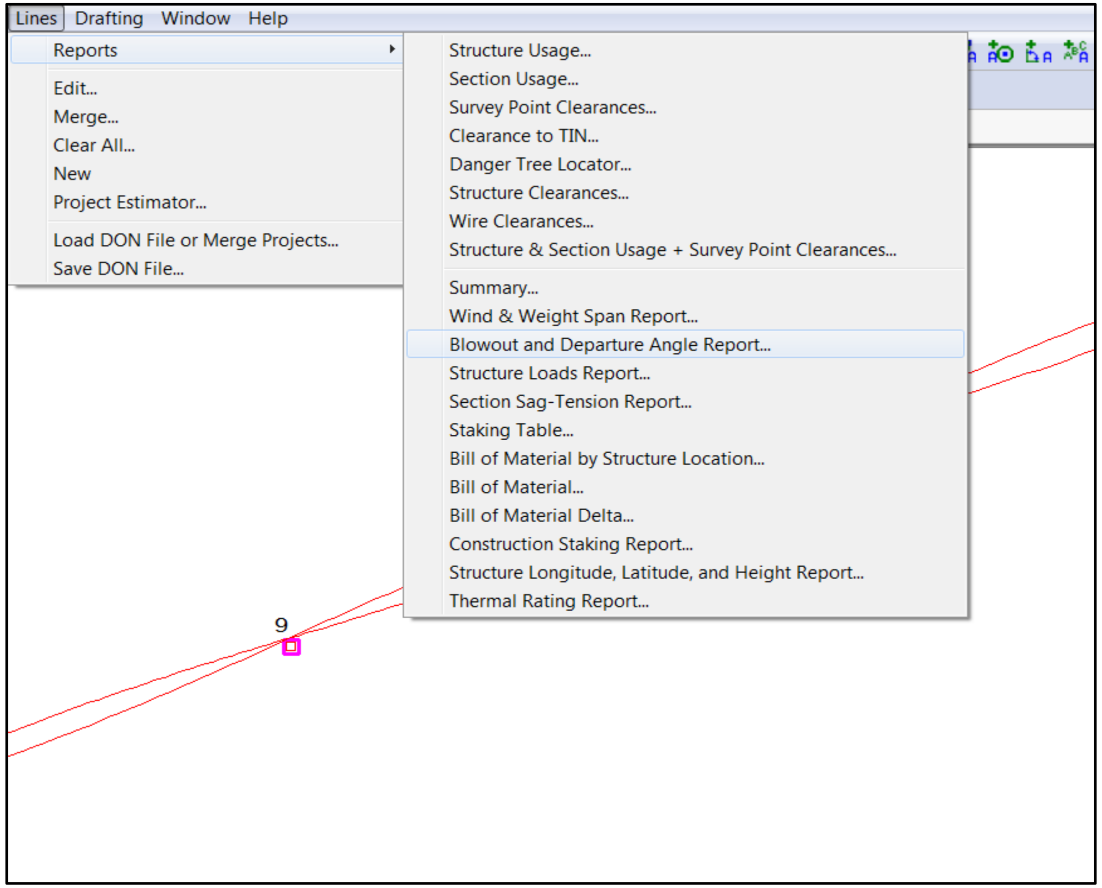
Blowout and Departure Angle

- Go to Lines -> Reports -> Blowout and Departure Angle Report



Blowout and Departure Angle

- Format of the blowout report will be as below:

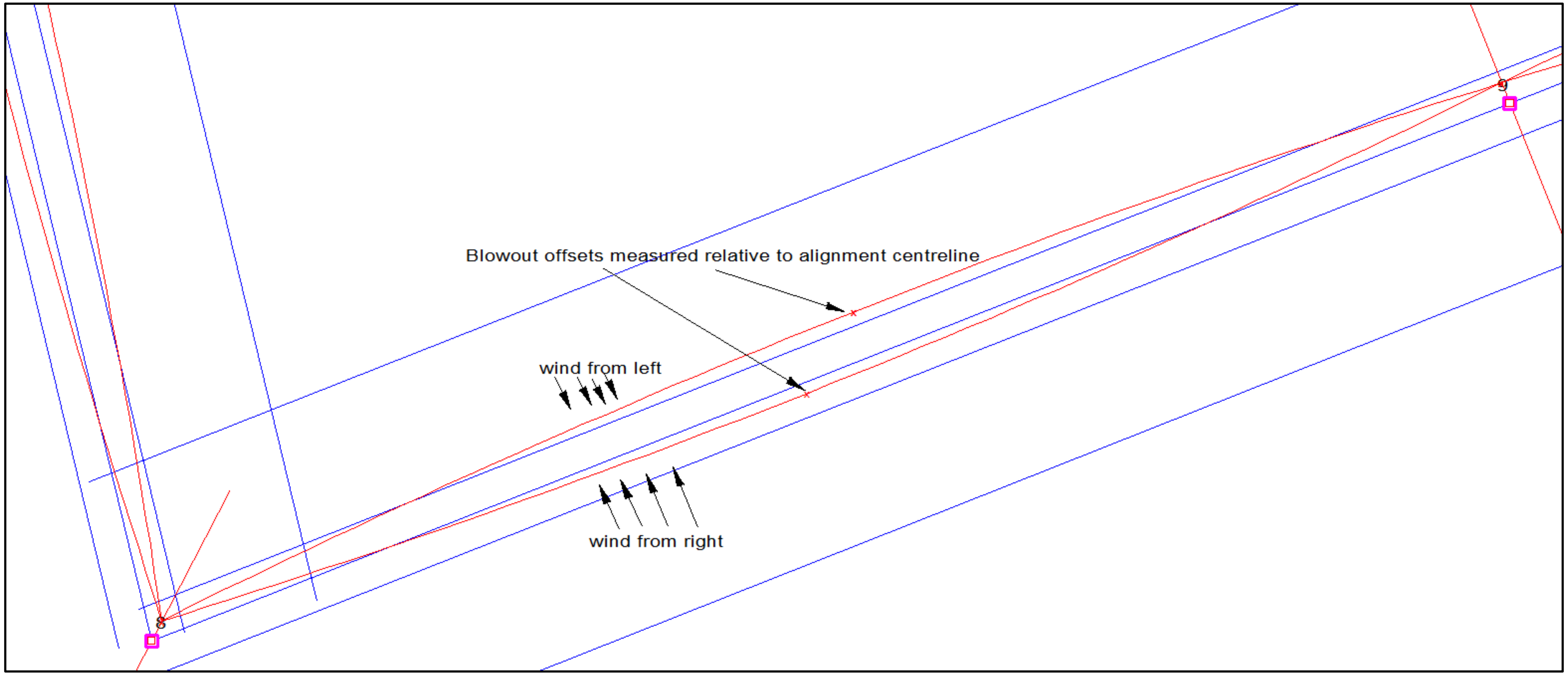
Blowout Report

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
8	1	1	9	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Left	1115.98	-2.00	1115.98	-2.00	1048.10	0.96	
8	1	1	9	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Right	1054.66	-4.27	1054.66	-4.27	986.86	-1.31	
9	1	1	10	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Left	1243.74	-2.00	1243.74	-2.00	1180.91	0.56	
9	1	1	10	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Right	1180.91	-4.56	1180.91	-4.56	1115.98	-2.00	
10	1	1	11	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Left	1243.74	-2.00	1243.74	-2.00	1314.61	1.00	
10	1	1	11	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Right	1314.61	-5.00	1314.61	-5.00	1383.19	-2.00	
11	1	1	12	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Left	1383.19	-2.00	1383.19	-2.00	1457.48	1.28	
11	1	1	12	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Right	1454.99	-5.27	1454.99	-5.27	1529.30	-1.99	

For 132kV wires between structures 8 and 11, maximum offset is -5.27 (m), the leftmost offset is -5.27 (m), rightmost offset is 1.28 (m)

Blowout and Departure Angle

- Blowouts are measured as offset from alignment centreline.
- PLS-CADD will create these offsets by applying wind perpendicular to the span in opposite directions as shown below.



Blowout and Departure Angle

- The departure angle calculation can be used to compare with the limits required for line hardware (e.g. AGSU design)
- Departure Angle report format is shown below:

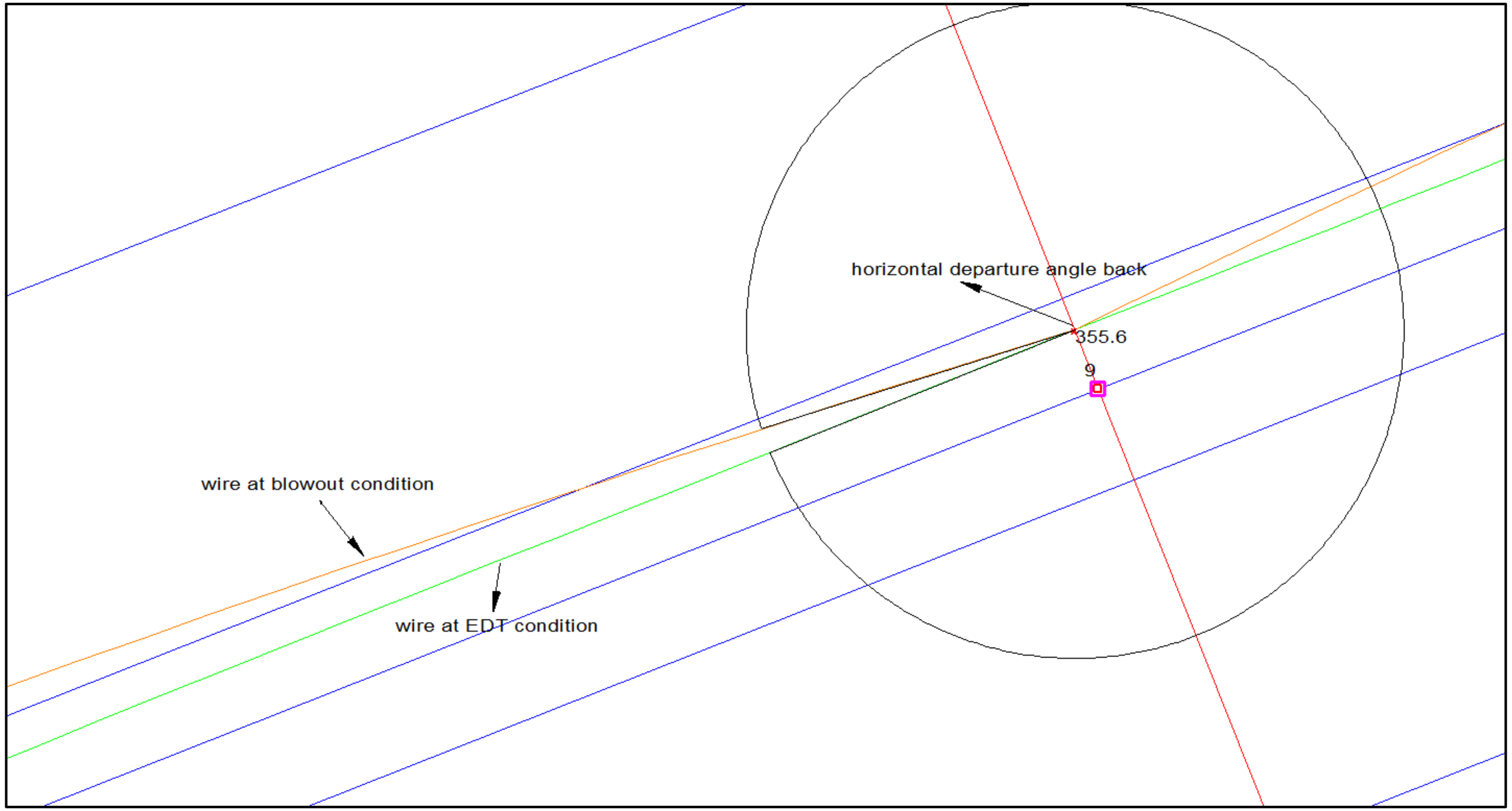
Departure Angle Report

Wire angle turned is measured in the plane of the wire and is the total angle turned at this structure.

Structure Number	Structure File Name	Station (m)	Line Angle (deg)	Set	Phase	Ahead Span Cable File Name	Voltage (kV)	Weather Case Description	Cable Condition	Wind From	Horiz. Departure Angle Back (deg)	Horiz. Departure Angle Ahead (deg)	Vertical Departure Angle Back (deg)	Vertical Departure Angle Ahead (deg)	Wire Angle Turned (deg)
8	susp.str	985.35	-98.12	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Left	-44.5	-44.8	7.0	5.5	89.9
8	susp.str	985.35	-98.12	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Right	-53.9	-53.9	7.0	5.5	108.3
9	susp.str	1115.98	-0.10	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Left	4.8	4.5	5.7	5.3	14.4
9	susp.str	1115.98	-0.10	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Right	-4.3	-4.6	5.7	5.3	14.2
10	susp.str	1243.74	0.02	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Left	4.5	4.9	5.8	5.8	14.9
10	susp.str	1243.74	0.02	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Right	-4.5	-4.8	5.8	5.8	14.9
11	susp.str	1383.18	-0.07	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Left	4.8	5.0	6.2	5.5	15.3
11	susp.str	1383.18	-0.07	1	1	darts_acsr_30_7_3.0_1.wir	132	Blowout	Creep RS	Right	-4.9	-5.1	6.2	5.5	15.4

Blowout and Departure Angle

- Structure 9 Horizontal departure angle back shown in plan view below



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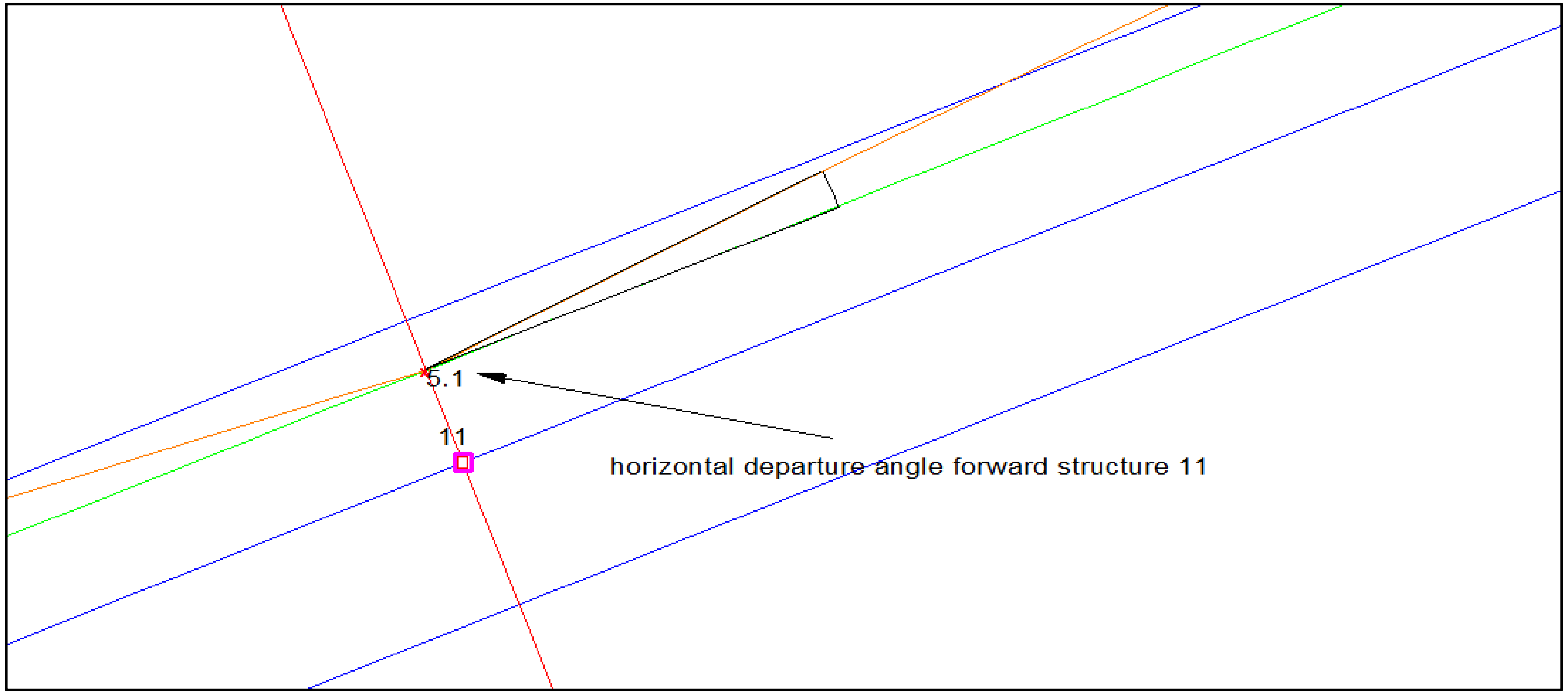
Blowout and Departure Angle

- Structure 11 horizontal departure angle forward = 5.1deg shown in plan view below



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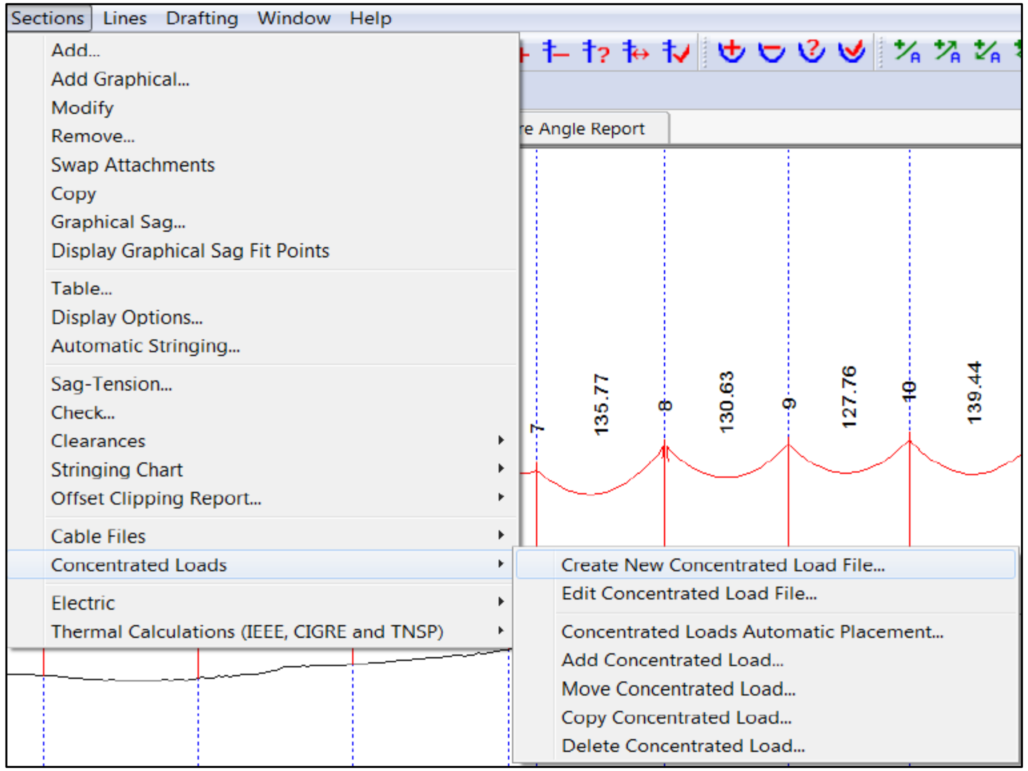
Modelling Aerial Warning Markers

- With finite element method, a user can apply concentrated loads to a span (e.g. aerial warning markers)
- To create a concentrated load, use Sections –> Concentrated Loads -> Create New Concentrated Load File command as below



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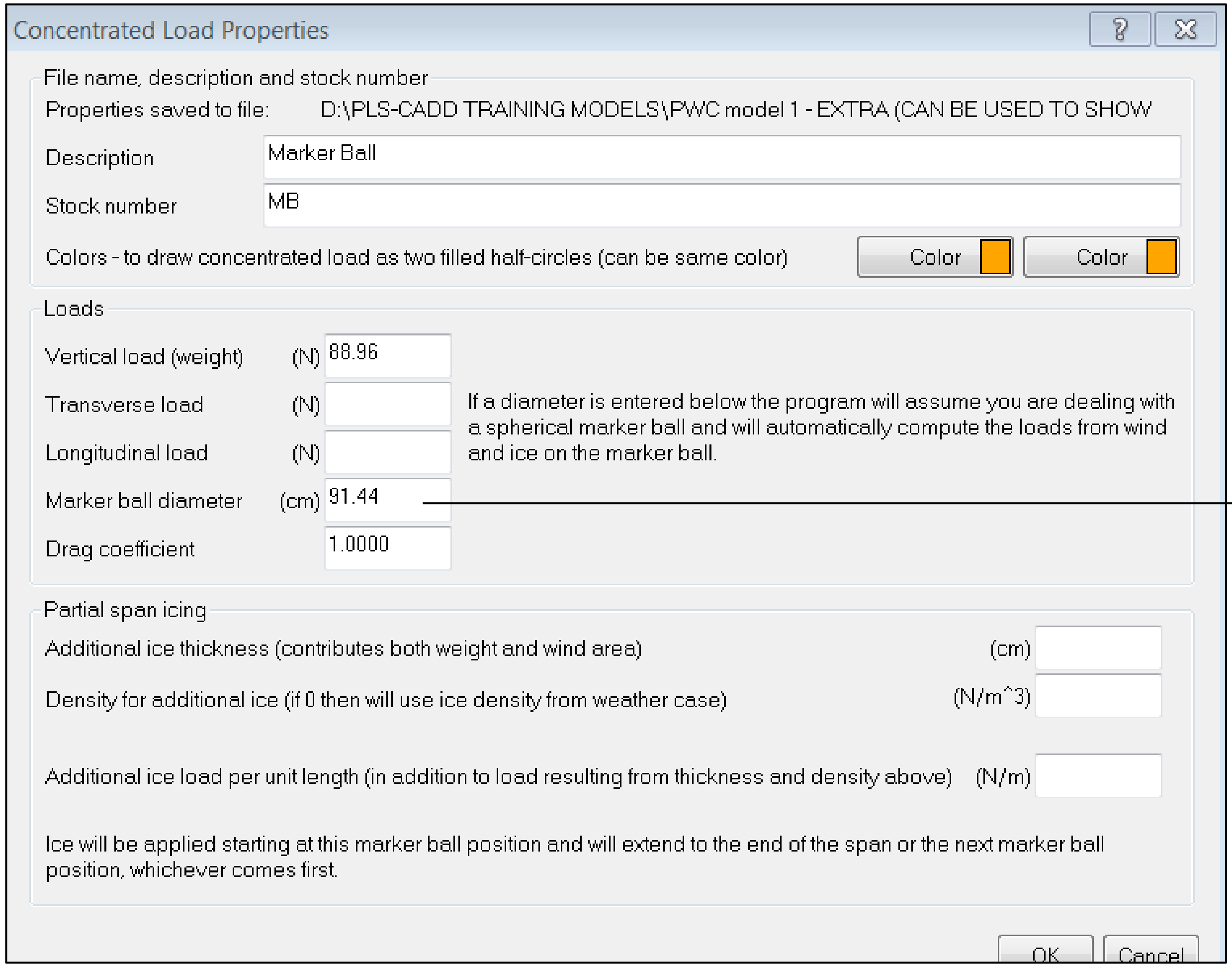
Modelling Aerial Warning Markers



The marker ball diameter will be used to calculate the wind load on the marker ball

Modelling Aerial Warning Markers

- Go to Section -> Modify -> Edit Span Specific Wire Lengths
- Specify location of marker ball as a fraction of the span

Wire Lengths and Attachment Stiffness

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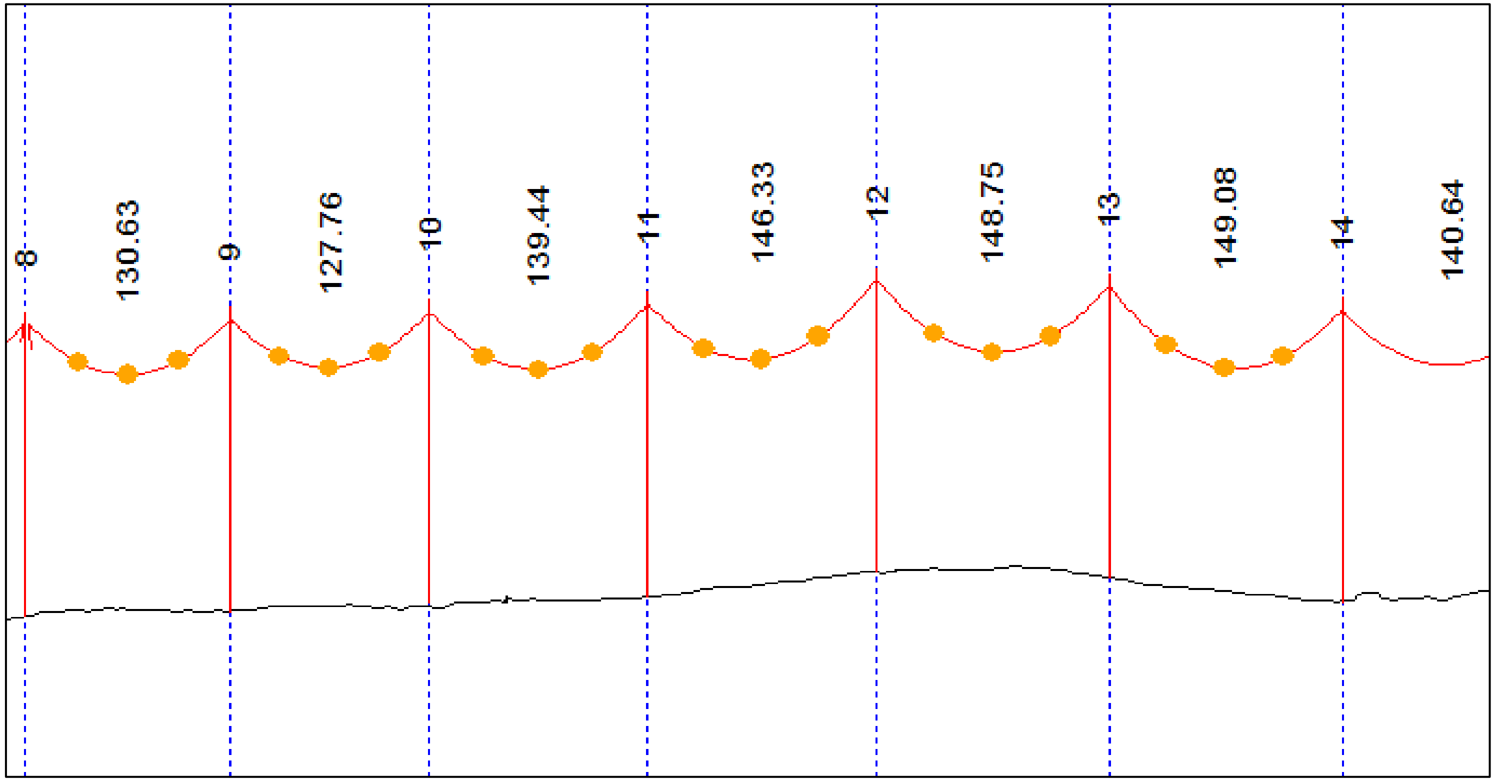
Stiffnesses below are for level 2 SAPS analysis and also for level 3 analysis of structures not modeled with PLS-POLE or TOWER. ´Default´ stiffness implies stiffnesses from Criteria/SAPS apply.
For level 3 SAPS analysis with PLS-POLE or TOWER structures attachment stiffnesses will be determined automatically.
Light blue columns used to define optional concentrated loads (marker balls, spacer-dampers...).
Unstressed lengths are calculated prior to the addition of concentrated loads (concentrated loads assumed to be applied after sagging).

Sagging condition: Creep RS

	Ahead Span Unstressed Length (m)	Ahead Span Unstressed Length Change (m)	Ahead Span Surveyed Wire Temp. (deg C)	Structure Attachment Transverse Stiffness (N/m)	Structure Attachment Longitudinal Stiffness (N/m)	#1 Load Point Span Fraction	#1 Load Point Concentrated Load File	#2 Load Point Span Fraction	#2 Load Point Concentrated Load File	#3 Load Point Span Fraction	#3 Load Point Concentrated Load File
1	164.105	0.000	0.0	NA	NA						
2	164.105	0.000	0.0	Default	Default						
3	164.549	0.000	0.0	Default	Default	0.250	\cables\mb.mar	0.500	\cables\mb.mar	0.750	\cables\mb.mar
4	164.310	0.000		Default	Default	0.250	\cables\mb.mar	0.500	\cables\mb.mar	0.750	\cables\mb.mar
5	164.778	0.000		Default	Default	0.250	\cables\mb.mar	0.500	\cables\mb.mar	0.750	\cables\mb.mar
6	31.563	0.000		Default	Default	0.250	\cables\mb.mar	0.500	\cables\mb.mar	0.750	\cables\mb.mar
7	135.718	0.000		Default	Default	0.250	\cables\mb.mar	0.500	\cables\mb.mar	0.750	\cables\mb.mar
8	129.337	0.000		Default	Default	0.250	\cables\mb.mar	0.500	\cables\mb.mar	0.750	\cables\mb.mar
9	127.963	0.000		Default	Default	0.250	\cables\mb.mar	0.500	\cables\mb.mar	0.750	\cables\mb.mar
10	139.728	0.000		Default	Default	0.250	\cables\mb.mar	0.500	\cables\mb.mar	0.750	\cables\mb.mar
11	146.458	0.000		Default	Default	0.250	\cables\mb.mar	0.500	\cables\mb.mar	0.750	\cables\mb.mar
12	148.662	0.000		Default	Default	0.250	\cables\mb.mar	0.500	\cables\mb.mar	0.750	\cables\mb.mar
13	149.229	0.000		Default	Default	0.250	\cables\mb.mar	0.500	\cables\mb.mar	0.750	\cables\mb.mar

Modelling Aerial Warning Markers

- Go to Section -> Modify -> Edit Span Specific Wire Lengths
- Specify location of marker ball as a fraction of the span
- It is not recommended to have very small fractions in a span between marker balls



Questions/Queries/Comments

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January 16, 2024