BANGLASESH RURAL ELECTRIFICATION BOARD

PBS INSTRUCTION 100-70

Line Construction Design
For
636 MCM & 795 MCM Conductors
In 33 kV Sub-Transmission Line

Table of Contents

(Md. Mozibur Rahman)
Consultant TAPP BREB

(Md. Duhidul Islam)
Consultant TAPP BREB

(Md. Mozammel Huq)
Consultant TAPP BREB

(Md. Abdul Khaleque)
Consultant TAPP BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakrabortty)
PD, TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

BANGLADESH RURAL ELECTRIFICATION BOARD
PBS INSTRUCTION 100-70

Approval Date: 19/02/2020
Revision Date : -

SUBJECT: LINE CONSTRUCTION DESIGN FOR GROSSBEAK (636 MCM) AND MALLARD (795 MCM) CONDUCTORS

1. INTRODUCTION:

BREB is licensee for electricity business in the rural segment of the country by the government of Bangladesh since 29th October 1977 through an Ordinance. BREB started RE (Rural Electric) program from January 1978. At the initial stage of RE program, electric connection rate was very few but at present BREB has covered about 92%. Within this year 2019, BREB is determined to complete hundred percent electric connection in it's commending area.

KWH demand of BREB is increasing dramatically for the following reasons-

(a) Within city area value of land is high, which will incur higher cost for industrial development. So industrial development in rural area is higher than city area;

(b) Space is not available in city area for industrial development. So industrial development in rural area is higher than city area;

(c) Industrial development in city area is not environment friendly. So industrial development in rural area is higher than city area;

(d) People migration rate from rural segment to city area is not higher than past because of available citizen facility in rural area;

BREB has been using 4/0 ACSR, 1/0 ACSR and # 3 ACSR conductor for 11/6.35 KV HT line and 477 mcm conductor for 33 KV source line. Due to rapid load growth these

(Md. Mozibur Rahman)
Consultant TAPP, BREB

(Md. Duhidul Islam)
Consultant, TAPP, BREB

(Md. Mozammel Huq)
Consultant, TAPP, BREB

(Md. Abdul Khaleque)
Consultant, TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakrabortty)
PD, TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

conductors are not capable to carry higher amount of current. To ensure adequate level of voltage at the consumer end and to reduce system loss, higher size conductor, such Grosbeak, Mallard etc. can be used for PBS system construction. But BREB has no construction standard for such type of higher size conductors. Considering the above discussed issue a separate PBS Instruction 100-70: LINE CONSTRUCTION DESIGN FOR 795 MCM AND 636 MCM CONDUCTORS is developed.

2. RULING SPAN LENGTH AND ITS ESTABLISHMENT:

At the beginning of this design the ruling span must be estimated, Ruling span length may be considered as an assumed design span that assures the best average tension through a line between dead ends non-uniform span length. The actual tension, under loaded and unloaded conditions may be greater or less than the ruling span tension due to various span lengths, ground slope, loading conditions etc.. The ruling span length depends on various factor. It must be within the limit of conductor's tension, pole strength, cross-arm strength, bolt strength and so on. It is a quantitative procedure. However, as the pole height has got narrower limit, so this can be estimated by assuming a height of base structure. Base structure is the structure that is expected to be used mostly throughout the line. The structure or the pole height must be such that the clearance between the lowest conductor and the ground level in still air meets the requirement of the Overhead Line Regulations. So the base structure's height minus the minimum ground clearance minus the height of the lowest phase conductor from the top of the structure/pole. The result is the allowable sag as limited by ground clearance. The ruling span may be chosen whose value is approximately equal to the allowable sag of the base structure. The sag value is to be taken at 120° F. The ruling span value is to be checked whether it is conformed with the following customary approximate equation-

$RS = L_{avg} + 2/3(L_{max} - L_{avg})$,   Where RS = Ruling Span

(Md. Mozibur Rahman) Consultant, TAPP, BREB
(Md. Duhidul Islam) Consultant, TAPP, BREB
(Md. Mozammel Huq) Consultant, TAPP, BREB
(Md. Abdul Khaleque) Consultant, TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque) Consultant TAPP BREB
(Debasish Chakraborty) PD, TAPP BREB
(Kamrul Ahsan Mollik) Asst. Secy. (Board), BREB

L_{avg} = Average Span
L_{max} = Average Span

If the above estimate does not hold good, the value should be changed and the procedure is to be repeated again. If the differences between estimated ruling span and the actual ruling span is more than 15% approximately, the procedure is to be repeated. So, to find allowable sag limited by ground clearance, structure/ pole height, minimum vertical clearances of conductors are required. Followings are the vertical clearances of conductors to ground.

3. MINIMUM VERTICAL CLEARANCE IN METER OR FEET:

The minimum vertical clearance under different situations for different conditions are tabulated below-

Table 3.1
Minimum Vertical Clearance Required Between Conductors and Ground When Conductors Cross Over

Sl No.	Location	Clearance (m/ft)
01	Rail road & Tracks	9.4 (31′)
02	Roads, Streets, Alleys	7.0 (23′)
03	Land that may be traversed by	7.0 (23′)
04	Spaces and ways accessible to pedestrians only or Water areas not suitable for sail boating	5.5 (18′)
05	Water ways suitable for sail boating including lakes, rivers less than 20 acre	7.0 (23′)

Table 3.2
Vertical Clearance Required Between Conductors

and Ground When Run the Travelled Way or Adjacent Land

Sl No.	Location	Clearance (m/ft)
01	Road in rural district	6.4 (21′)
02	Streets or alleys in urban district	7.0 (23′)

For safety measures when the conductors cross over buildings and other following clearance are to be maintained-

Table 3.3
Clearance when Conductors Cross Over

Sl No.	Location	Clearance (m/ft)
01	Building roofs or projections not accessible to	4.0 (13′)
02	Building roofs or projections accessible to	5.5 (18′)
03	Sign, Chimneys, radio & television antennas, tanks, bridges & other installations like	3.4 (11′)
04	Lighting support, traffic signals, or a supporting structure of another line	2.5 (8′)
05	Swimming pools	8.6 (28′)

To avoid ground fault where the conductors of one line cross over the conductors of another line, the following clearances are to be maintained-For safety measures when the conductors cross over buildings and other following clearance are to be maintained-

Table 3.4
Clearance Required Between upper and lower level Conductors when Crosses Over (when upper conductor has ground fault relaying)

Sl No.	Location	Clearance (m/ft)
01	Communication lines	2.2 (7′)
02	Overhead ground wire	1.5 (5′)
03	Distribution conductors	1.5 (5′)
04	Transmission conductors (132 KV)	2.2 (7′)
05	Transmission conductors (230 KV)	3.4 (11′)

Table 3.5
Clearance Required Between upper and lower level Conductors when crosses Over (when upper conductors do not have ground fault relaying)

Sl No.	Location	Clearance (m/ft)
01	Communication lines	2.2 (7′)
02	Overhead ground wire	1.5 (5′)
03	Distribution conductors	1.5 (5′)
04	Transmission conductors (132 KV)	2.9 (9.5′)
05	Transmission conductors (230 KV)	4.4 (14.4′)

It is considered that vehicles with an overall operating height equal to or less than 4.3 meters (14 ft.) will pass under the line. If the vehicles height is normally greater than 4.3 meters (14 ft.). It is recommended to add the clearances by the amount by which the vehicles operating height exceeds 4.3 meters (14 ft.).

(Md. Mozibur Rahman) Consultant, TAPP, BREB
(Md. Duhidul Islam) Consultant, TAPP, BREB
(Md. Mozammel Huq) Consultant, TAPP, BREB
(Md. Abdul Khaleque) Consultant, TAPP, BREB
(Md. Ahsanul Haque) Consultant TAPP BREB
(Debasish Chakrabortty) PD, TAPP BREB
(Kamrul Ahsan Mollik) Asst. Secy. (Board), BREB.

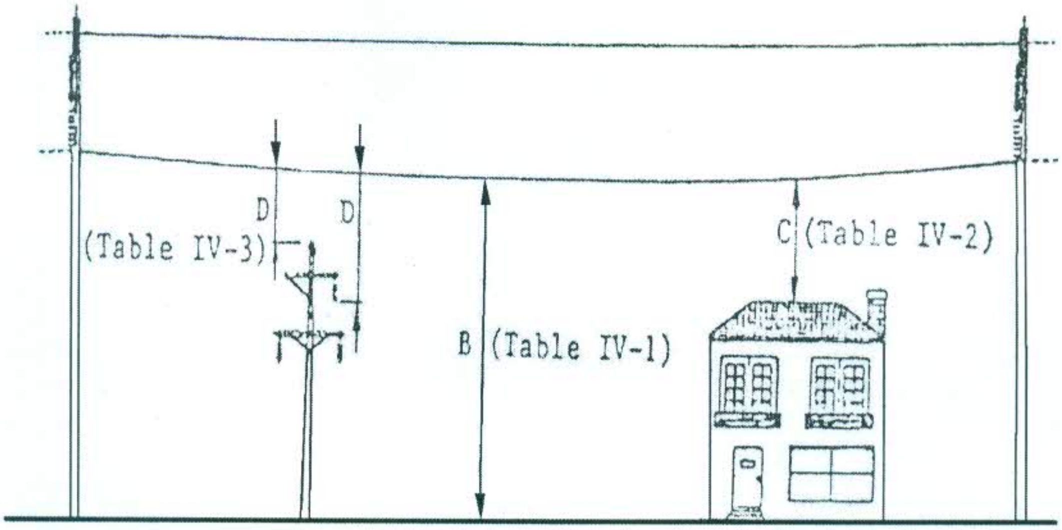


Figure- 3.1: Clearances situations covered in Table 3.1 to 3.5

Table 3.6
Vertical Separation Between Conductors of Same KV_{L-L} when conductors cross over

Sl No.	Location	Clearance (m/ft)
01	Phases of the same circuit	1.22 (4′)
02	Phases of different circuit of same voltage	1.22 (4′)

Vertical Separation Between Conductors of different KV_{L-L} when conductors cross over

If the circuit is have different voltage, the vertical separation can be determined by the following equation:

$V = 1.2 + 0.0102\ (K_VLG1 + K_VLG2 - 50)$ MKS Form Equation 3.1

$V = 4 + 0.40\ (K_VLG1 + K_VLG2 - 50)$ English Form Equation 3.2

(Md. Mozibur Rahman)
Consultant, TAPP, BREB

(Md. Dunidul Islam)
Consultant, TAPP, BREB

(Md. Mozammel Huq)
Consultant, TAPP BREB

(Md. Abdul Khaleque)
Consultant TAPP. BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

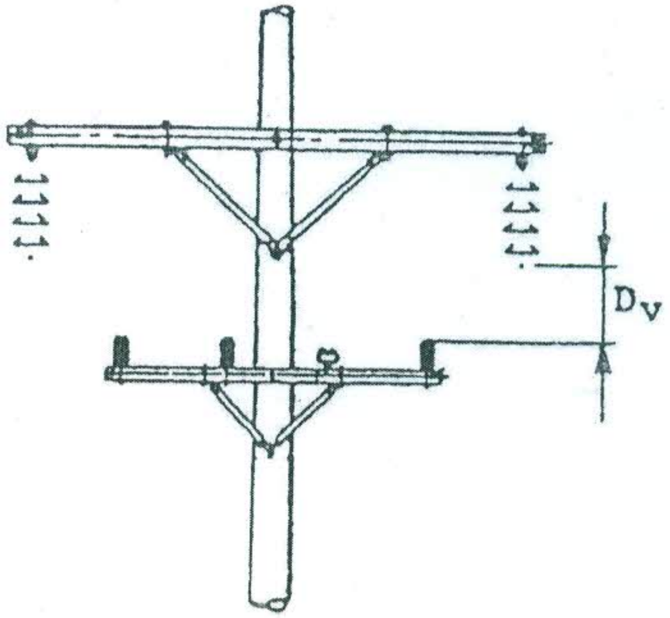
(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakraborty)
PD, TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

Where V = Vertical Separation between different circuit with different voltage
Other symbols as previously defined.

Vertical Separation Between Conductors of Different K_VL-L from Point of Suspension of Transmission Conductor to Point of Suspension of Underbuilt Distribution or Communication when Conductors Run as Underbuild.



TGURW XVI-2: VERTICAL CLEARANCE REQUIREMENTS AT STRUCTURE FOR UNDERBUILT

Figure-3.2: Vertical Clearances for Underbuild Line at Point of Suspension

Table-3.7

Vertical Clearances for Underbuild Line at Point of Suspension

Sl No.	Location	Clearance (m/ft)
01	Communication lines	1.6 (5′)
02	Distribution Conductors (25 KV and below)	1.6 (5′)
03	33 KV Line	1.6 (5′)

Vertical Separation at any point in span from 33 KV conductors to Underbuild Conductor

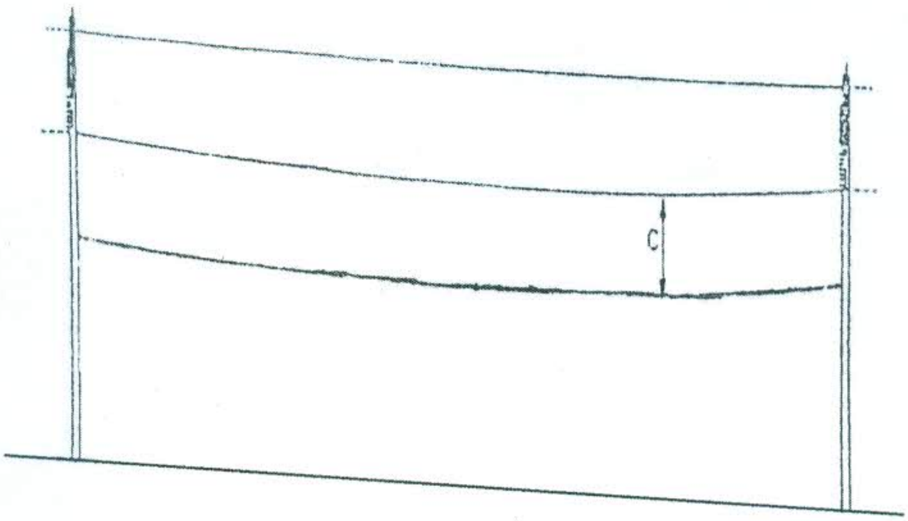


Figure-3.3: Vertical Clearances for Underbuild Line at any Point in the span

Table-3.8

Vertical Clearances for Underbuild Line at any Point in the span- "C"

Sl No.	Location	Clearance (m/ft)
01	Communication lines	1.2 (3.8′)
02	Distribution Conductors (25 KV and below)	1.2 (3.8′)
03	33 KV Line	1.2 (3.8′)

Overhead Ground Wire Sags and Clearances:

Usally the sag at mid-span of overhead ground wire (OHGW) is kept 80% of the phase conductors at 16^0 C (60^0 F) for initial sag at no load condition so that there will be little or very low chance of a mid-span flashover during a system disturbance.

4. HORIZONTAL CLEARANCES:

Minimum horizontal clearances of conductors to objects

Minimum horizontal clearances of conductors to various objects are given in Table- 4.1. It may be noted that these clearances will be applicable only for those lines where that are capable to clear automatically the line to ground fault(s).

Table-4.1

Horizontal Clearances Requirement for Conductor to Objects

Sl No.	Location	Clearance (m/ft)
01	Buildings, bridges, signs, television antennas, tanks containing non-flammables and like others.	3.4 (11′)
02	Lighting support, traffic signals, or a supporting structure of another line	1.9 (6′)
03	Rail of rail road trucks	4.9 (16′)

Now the total Horizontal clearances requirement $\mathbf{Y = (l_i + S_f) Sin Ø + x + δ}$. The factor "δ" is the deflection of the structure must be taken into account.

(Md. Mozibur Rahman)
Consultant, TAPP, BREB

(Md. Duhidul Islam)
Consultant, TAPP, BREB

(Md. Mozammel Huq)
Consultant, TAPP, BREB

(Md. Abdul Khaleque)
Consultant, TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakrabortty)
PD, TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

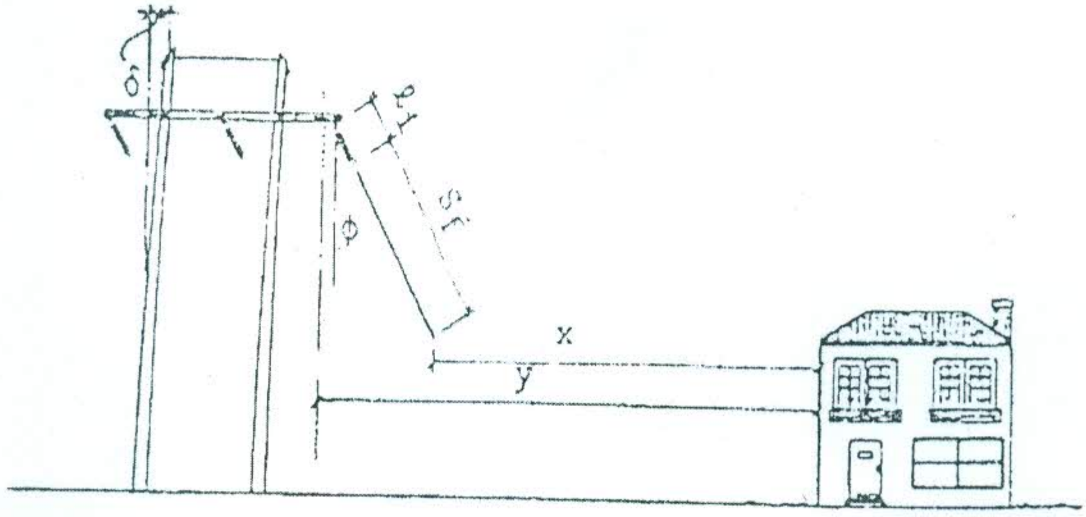


Figure-4.1: Horizontal Clearances Requirement for Conductor to Objects

The formula for horizontal clearances is:

$Y = (l_i + S_f)\ Sin\O + x + \delta$. **Figure-4.1**

Where: l_i = Insulator String length (l = 0 for post insulator: 1.94 ft.

S_f = Conductor final sag at 16^0 C(60^0 F) with 9 psi of wind pressure

$\O$ = Conductor swing out angle in degrees under 9 psi of wind pressure; Sin$\O$ for grosbeak and mallard are 0.647 & 0.5692 respectively

X = Clearance required as mentioned earlier, 3.40 m of 11′ for 33 KV lines (Table- 4.1)

δ = Structure deflection under 9 psi of wind pressure, Here it is neglected.

(Md. Mozibur Rahman)
Consultant TAPP, BREB

(Md. Duhidul Islam)
Consultant, TAPP BREB

(Md. Mozammel Huq)
Consultant, TAPP, BREB

(Md. Abdul Khaleque)
Consultant, TAPP BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

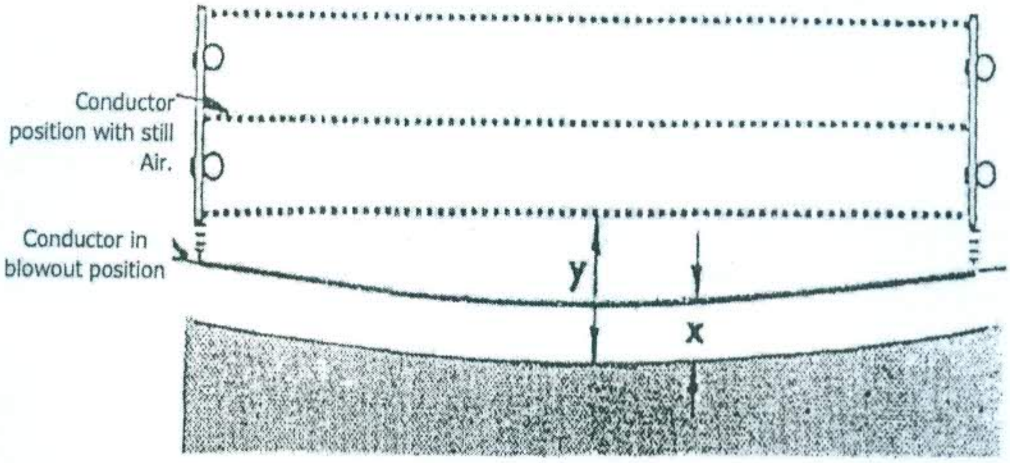
(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakrabortty)
PD, TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

Y = Total horizontal distance from the conductor attachment point (i.e. either the insulator suspension or the top of the pin or post type insulator to the object(s).

The total horizontal distance (Y) at a particular point in the span depends upon the conductor sag at that point. The swing of the conductor at a particular point depends upon the sag that particular point. So the value of 'Y' varies according to the value of sag. As the sag is minimum at the point of support and maximum generally at the mid span for level ground and is different where the level of the supports are not same. So the 'Y' will be minimum at the point of support and maximum at the mid-span for same ground level. Figure 4.2 can be



seen.

X = Clearance required when the conductor is in blowout position. This is as per Table 4.1

Y = Total horizontal clearance which is (x + sag at that point)

Figure-4.2: Top View of Line Showing Horizontal Clearances Requirement for Conductor to Objects

Separation between Conductors Carried on Different Lines

If insulators are free to swing, one line should be assumed to be displaced by a 0.431 pascals (9.0 psi) while other line should be assumed to be unaffected by the wind, the equations for clearances should be as follows:

(Md. Mozibur Rahman)
Consultant, TAPP, BREB

(Md. Duhidul Islam)
Consultant, TAPP BREB

(Md. Mozammel Huq)
Consultant, TAPP, BREB

(Md. Abdul Khaleque)
Consultant TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakrabortty)
PD, TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

$$C_2 = 0.61 + 0.0102\ \{(KV_{LG1} + KV_{LG2}) - 8.7\} + (\delta_1 + \delta_2)$$ **in MKS Form Equation 4.2**

$$C_2 = 2.0 + (0.40 \div 12)\{(KV_{LG1} + KV_{LG2}) - 8.7\} + (\delta_1 + \delta_2)$$ **in English Form Equation 4.2**

Where:

C_2 = Clearance requirement between conductors of one line to conductor of another line in meters (of in feet)

KV_{LG1} = Maximum line to ground voltage in KV of line-1

KV_{LG2} = Maximum line to ground voltage in KV of line-2

δ_1 = Structure deflection of line-1 in meters (or in feet)

δ_2 = Structure deflection of line-2 in meters (or in feet)

Separation between Conductors from One Line to the Structure of Another

The horizontal clearance of a phase conductor of one line to the supporting structure of another line when the conductor and insulator are displaced by a 0.431 kilopascals(9 psi) wind pressure at 16_0 C (60_0 F) final sag must meet:

$$C_4 = 1.9 + 0.0102\ \{(KV_{LG1} - 50) - 8.7\} + (\delta_1 - \delta_2)$$ **in MKS Form Equation 4.4**

$$C_4 = 6.0 + (0.40 \div 12)\{(KV_{LG} - 50\} + (\delta_1 - \delta_2)$$ **in English Form Equation 4.5**

Where:

C_4 = Clearance requirement of one line to structure of another line in meters (of in feet)

KV_{LG} = Maximum line to ground voltage in KV of line

Other symbols are as previously defined.

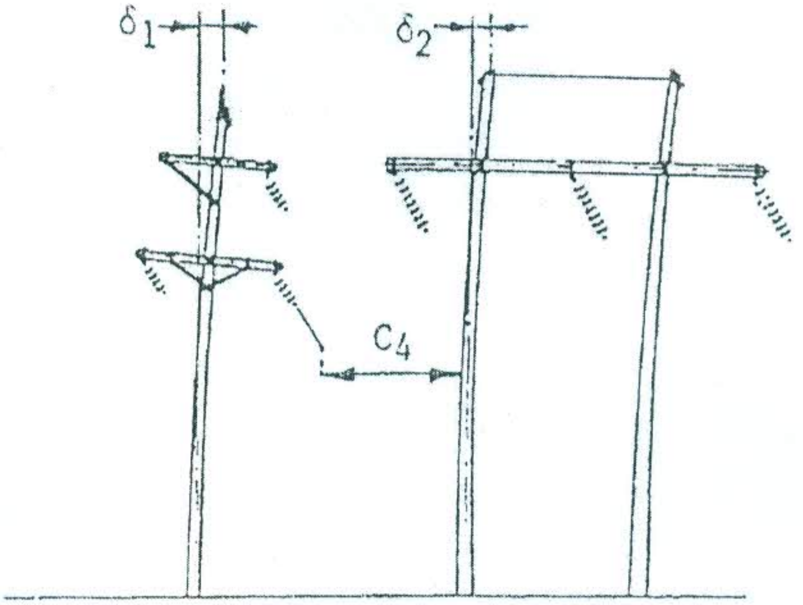


Figure-4.3: Clearance Between Conductor of one Line and Structure of another Line

Separation Between Conductors

Sufficient horizontal separation between phases is necessary to prevent swinging contracts and flashover between phases of the same or different circuits where there is insufficient vertical separation. The equations given below is the sufficient horizontal phase spacing related to conductor sag and the span length:

$\mathbf{H = (0.00762)\times KV + F_c(S_f\times 0.3048)\times 0.5 + l_i(Sin\O_{max})}$ **for MKS System**

$\mathbf{H = (0.025)\times KV + F_c(S_f^{1/2}) + l_i(Sin\O_{max})}$ **for FPS System**

Where:

H = Horizontal separation between the phase conductors at the structure in meters (feet)

KV = The nominal line to line voltage in kV

F_c = Experience Factor which is 1.15 for light loading zone

(Md. Mozibur Rahman)
Consultant TAPP BREB

(Md. Duhidul Islam)
Consultant TAPP BREB

(Md. Mozammel Huq)
Consultant TAPP BREB

(Md. Abdul Khaleque)
Consultant TAPP BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakraborty)
PD, TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

S_f = Conductor final sag at 16^O C or 60^O F with 9 psf of wind pressure.

l_i = Insulator string length (l = 0 for post insulator): 1.94

$\O_{max}$ = Conductor swing out angle in degrees under 9 psf of wind; Sin$\O_{max}$ forgrosbeak and for mallard are 0.647 and 0.5692 respectively.

Applying Equation 4.7, the spacing between the conductor for ruling span- 150 ft and for ruling span- 200 ft with Grosbeak and mallard conductors are calculated and tabulated in the Table- 4.2.

According to NESC, Horizontal Separation in ft. is

$H = (0.025)\times KV + F_c(S_f)^{½} + 0.707\times l_i$ **for FPS System**

All the symbols are defined earlier

Table

Tal

Factor, Fc: 1.5 Insulator, Ft = 1.94 KV_{L-L} = 33 Wind Pressure = 9

Conductor Code	Conductor Dia Inch d_c	Conductor Wt. Wc lbs/Ft	$d_c\times$ F/12Wc	$\O = Tan^{-1} (d_c\times F/Wc)$	Final Sag, Ft at 60^0 F for RS_{150} at 28% U.S.	Final Sag, Ft at 60^0 F for RS_{200} at 28% U.S.	Sin Ø	Sin (Ø/2)	Hirizontal Spacing H_{150} at 28% U.S. in ft	Hirizontal Spacing H_{150} at 28% U.S. in meter	Hirizontal Spacing H_{200} at 28% U.S. in ft	Hirizontal Spacing H_{200} at 28% U.S. in meter	Hirizontal Spacing H_{150} at 28% U.S. in ft. NESC formula	Hirizontal Spacing H_{200} at 28% U.S. in ft NESC formula
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

(Md. Mozibur Rahman)
Consultant. TAPP, BREB

(Md. Dubidul Islam)
Consultant, TAPP, BREB

(Md. Mozammel Huq)
Consultant, TAPP, BREB

(Md. Abdul Khaleque)
Consultant TAPP. BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakrabortty)
PD, TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB

Mallard	Grosbeak
1.140	0.990
1.24	0.88
0.692	0.849
34.695	40.317
1.8735	1.9231
2.528	2.598
0.569	0.647
0.2982	0.3446
3.9824	4.1603
1.21	1.27
4.31	4.50
1.32	1.37
4.25	4.28
4.58	4.61

If the horizontal separation is increased than the calculated value, span limit can be increased.

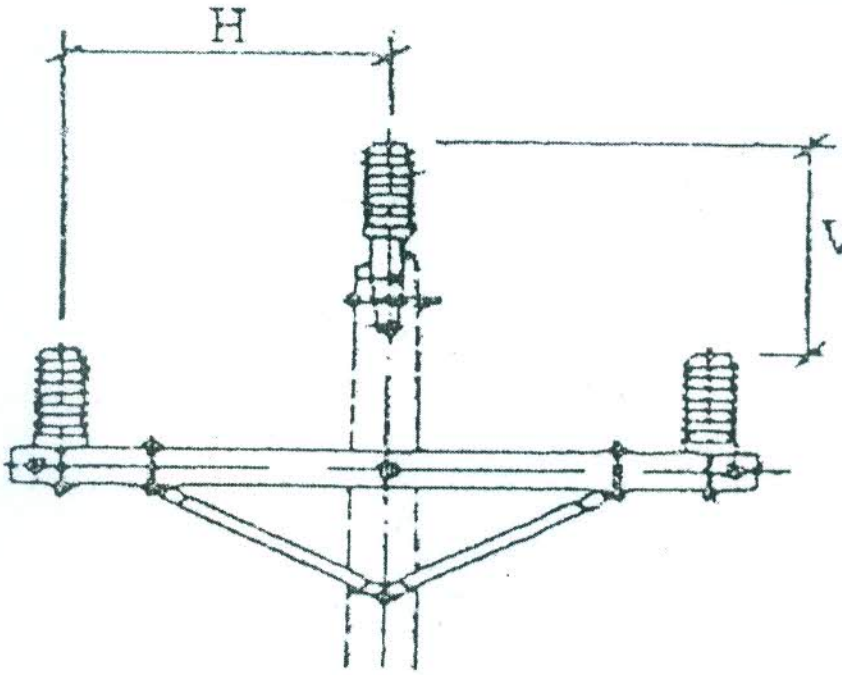


Figure-4.4: Horizontal Separation between Phase Conductor

(Md. Mozibur Rahman)
Consultant, TAPP, BREB

(Md. Duhidul Islam)
Consultant, TAPP, BREB

(Md. Mozammel Huq)
Consultant, TAPP, BREB

(Md. Abdul Khaleque)
Consultant, TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakrabortty)
PD, TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

Horizontal Separation between Transmission Lines & Underbuild Lines

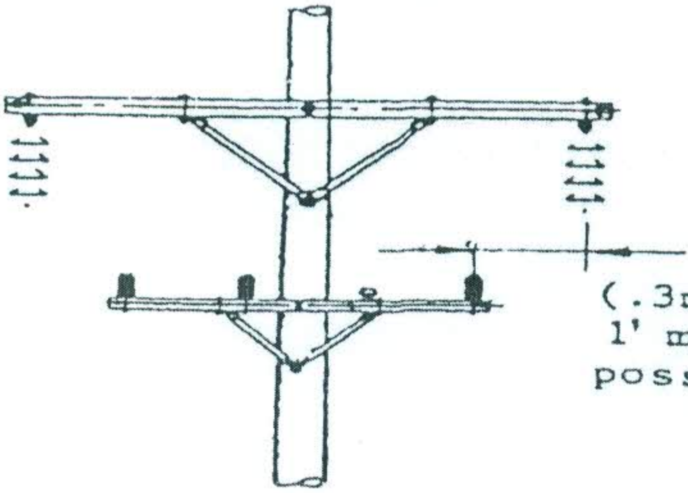


Figure-4.5: Horizontal Separation between Transmission Lines and Under build Lines

Maximum Span

Maximum Span is limited by various factors, such as horizontal separation, vertical separation, pole height, weight of conductor tension and so on. Maximum span as limited by horizontal separation can be calculated by following equation-

$L_{max} = \{(RS/0.552) \times ((H-(0.0762\times KV) - (li\times Sin\emptyset))/(Fc(S_{RS}\wedge 0.5))\}$ MKS Form Equation 4.8

$L_{max} = \{(RS) \times ((H - (0.025\times KV) - (li\times Sin\emptyset))/(Fc(S_{RS}\wedge 0.5))\}$ FPS Form Equation 4.9

Where:

L_{max} = Maximum Span as limited by horizontal conductor separation in meters (feet)

RS = Length of Ruling Span in meters (feet)

S_{RS} = Sag of Ruling Span in meters (feet)

Other symbols are as previously defined.

It may be noted that by increasing the horizontal separation, span limit can be increased.

Clearance between phase conductors when it runs from crossarm construction assembly unit to vertical construction assembly unit

Spacing between conductors in horizontal crossarm reduces when they cross from horizontal crossarm type construction to vertical type construction. It can be increased by proper phase arrangement and by limiting the span lengths.

Insulator Swing and Minimum Clearances Between Conductor and Steelwork

Suspension insulators at the tangent or angle structures swings about their points support due to to wind, so reasonable clearance are to be maintained to structures and guy wires. The swing of the suspension insulator depends on the ratio of the horizontal span or wind span to allow for a swing of 45^0 for both conductors and jumpers. There are no defined formula which gives the actual clearance to be required. Following is an empirical rule which gives excellent result in practice.

Clearances Between Conductor and Steelwork = 0.31 $(KV)^{1/2}$ ft. Equation 4.10

Symbol is as previously defined.

The angle of insulator swing can be determined from the following equation-

$\tan Ø = \{2TSin(\Theta/2)\} + \{(HS)\times (P_c)\}/ \{(VS) \times (W_c) + (1/2)W_i\}$ Equation 4.11

$P_c = \{(d_c) \times (F)\}/1000$ MKS System Equation 4.12

$P_c = \{(d_c) \times (F)\}/12$ MKS System Equation 4.12

Where:

Ø = Angle between the vertical and the insulator strings swings in degrees.

Blowing of insulator is to be considered as "+"

Θ = Line angle in degrees

T = Conductor tension in Newton (Pounds)

Pulling insulator towards structures is to be considered as "+"

HS = Horizontal span in meters (feets)

VS = Vertical span in meters (feets)

P_c = Wind load per unit length of bare conductor, Newton/meter (Pound/feet)

W_c = Weight per unit length of bare conductor, Newton/meter (Pound/feet)

W_i = Weight of insulator strings neglecting wind pressure, Newton (Pounds)

F = Wind force in Pa (Lbs/sft)

$\mathbf{d_c}$ = Diameter of conductor, in millimeter(inches)

5. Right of Way (ROW) Width

It is necessary to safe the distribution or transmission lines from unwanted interruption. ROW width should be such that it allows the line to be operated and maintained safely and reliably. For this trees, bamboos and rapidly growing trees which threat to the line are to be removed within the ROW width. Trees adjacent to the ROW are to be trimmed in such a way that the ROW is clear from the width required. Fruit trees is dead tree or leaning trees which can strike the line in falling are also to be removed. Fruit trees and ornamental trees are to be trimmed to a particular height. The widths have proven to be satisfactory so that if a line structure falls, it will remains within the right of way. This is normal method.

Table- 5.1
Normal ROW width

Meter	22 - 30
Feet	75 - 100

a) **First Method**: This method provides sufficient clearance. If a building is built at anywhere at the edge of the right of way, the clearance required given in Table- 5.1 will met. This is generally higher than the value in Equation 5.2.

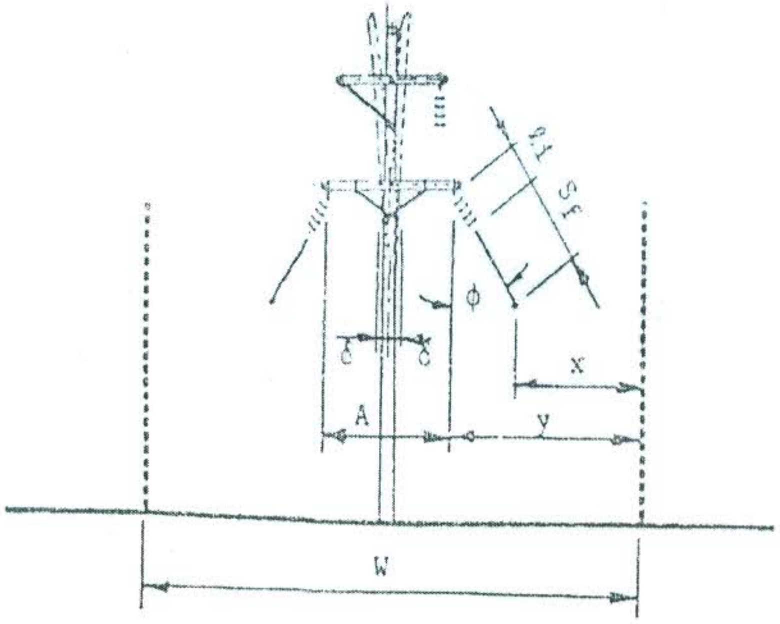


Figure-5.1: ROW width for Single Line of Structure (First Method)

The formula for above calculation is as follows-

ROW width: $W = A + 2(l_i + S_f)Sin\emptyset + 2X + 2\delta$ **Equation 5.1**

Where:

W = Total ROW width required;

A = Separation between points of suspension of insulator strings for outer two phases;

l_i = Insulator string length;

S_f = Conductor final sag at 16^0 C (60^0 F) with 9 psi of wind pressure;

Ø = Conductor swing out angle in degrees under 9 psi of wind pressure;

X = Clearance required as mentioned earlier, 3.4 m or 11 ft. for 33 KV lines (Table- 4.1);

δ = Structure deflection under 9 psi of wind;

Y = Total horizontal distance from the conductor attachment point (i.e. either the insulator suspension point or the top of the pin or post type insulator to the object(s).

b) **First Method**: If there is extremely low probability of building structures near the line, the row width can be based on the blowing of phase conductor at the edge of the row under extreme wind conditions considering 50 to 100 years wind mean. The clearance required for building, bridges, lighting support as depicted in Table-4.1 is not needed here.

The formula for above calculation is as follows-

ROW width: $\mathbf{W = A + 2(l_i + S_f)Sin\text{Ø} + 2\delta}$ **Equation 5.2**

All symbols are as defined above.

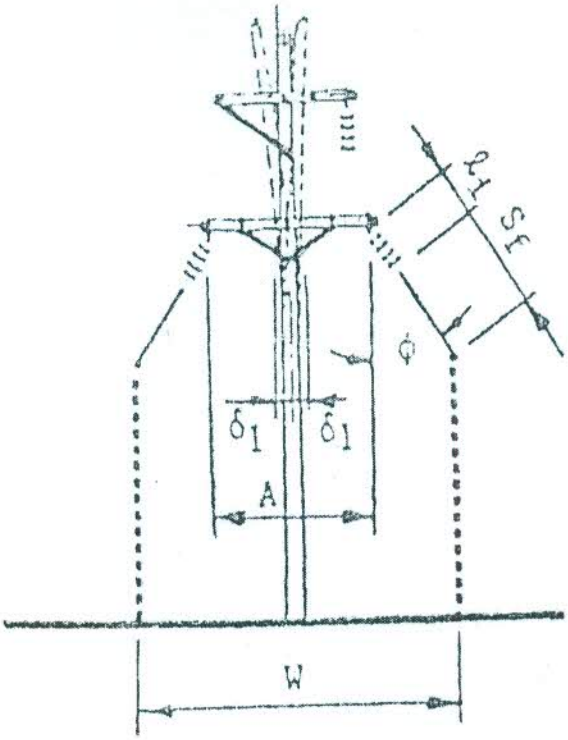


Figure-5.2: ROW width for Single Line of Structure (Second Method)

6. Structure/ Pole Height:

It is depicted above that for finding ruling span, minimum ground clearance, the sag of the lowest conductor and the height of the lowest pyase conductor attachment from top of the pole is to be considered. The sag under no circumstances should be less than 49^{O} C (120^{O} F). These are given below-

Total length of pole in meters(feet): Top of the pole to OHGW +OHGW to top crossarm + Top crossarm to bottom crossarm + length of Insulator String + Sag + Minimum Clearance from Ground + Plantation Depth of pole i.e. as per Table- 3.1.

$L_a = 0.15(0.5)^{*1} + 0.93(3.06)^{*2} + 1.5(5)^{*3} + 0.6(1.94)^{*4} + 1.5(5)^{*5} + 9.4(31) = 16.38\ (54'\text{-}0'')$

$L_b = 0.15(0.5) + 0.93(3.06) + 1.5(5) + 0.6(1.94) + 1.5(5) + 7(23) + 2.0(6.5) = 13.68$ (45′-0″)

$L_c = 0.15(0.5) + 0.93(3.06) + 1.5(5) + 0.6(1.94) + 1.5(5) + 7(23) + 2.0(6.5) = 13.68$ (45′-0″)

$L_d = 0.15(0.5) + 0.93(3.06) + 1.5(5) + 0.6(1.94) + 1.5(5) + 5.5(18) + 1.8(6) = 12.5$ (40′-0″)

Even for 18′ Ground clearance, the minimum pole height should be (40′-0″) 40′. So less than 40′ can't be used. Moreover deflection of pole is to be added.

Note:-

*1 = Length from pole to top crossarm

*2 = Length from top X-arm to bottom crossarm

*3 = Length frombottom crossarm to lowest of suspension insulator

*4 = Length from lowest level of insulator to lowest level of conductor i.e. Sag

*5 = Sag level to clearance for 33 KV lines; for mallard it is 5′ and for Grosbeak 4′

*6 = Setting depth of pole

In our country it is practiced that the ground wire is used for a distance of 0.8 Km. (0.5 mile) from the sub-station. So the area where the ground wire will not be used with 5′ lower size pole i.e. the base pole without OHGW will be 10.6 meters(35′-0″).

7. Conductors

Aluminum conductor steel reinforced (ACSR) is commonly used for transmission and distribution lines. The selection of conductor should meet the system voltage drop requirement, loss reduction requirement, thermal capability of the conductor, tension or strength requirement. Economics is also an important factor in determining the conductor size. Future considerations and load growth are also to be counted. It is found that minimum sizes are not economical in the long run. Rather it costs more for replacement. Sometimes the firet

(Md. Mozibur Rahman)
Consultant. TAPP. BREP

(Md. Duhidul Islam)
Consultant. TAPP. BREP

(Md. Mozammel Huq)
Consultant. TAPP. BREP

(Md. Abdul Khaleque)
Consultant TAPP. BREP

(Md. Ahsanul Haque)
Consultant TAPP BREP

(Debasish Chakrabortty)
PD, TAPP BREP

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

cost is more for higher size conductor, but the higher cost may be offset due to lower losses of the conductor during its life. Moreover it will be more justified and economical considering future growth. Considering all this , it is decided to build lines in 33 KV with Grosbeak and Mallard Conductor. Followings are some base data for the selected conductors.

Table- 7.1
Basic Conductor Data
W. Pressure, F, LBS/Sft. 9

Conductor Code	Size mcm	KV_{L-L}	Conductor Dia d_c (inch)	Initial 50% U. Strength	Final 28% U. Strength	1200 F Final 23% U. Strength	Weight of Conductor W_c (Lbs/Ft)
1	2	3	4	5	6	7	8
Grosbeak	636.0	33.00	0.9900	12600	7056	5796	0.8750
Mallard	795.0	33.00	1.1400	19200	10752	8832	1.2350

There are heavy conductor. So special care have to be taken during storage, stringing, running out in blocks, sagging, jointing and terminating of the conductor. During installation emphasis are to be given to use minimum number of mid-span joints. There shall not be more than one joint per conductor in any one span. Within 3 m from the suspension clamp or tension joint there should not be any joint. Over highways, main road, railways, building of any other such objects and the adjacent span of such span) if it is not dead end point) there should not be any joint. During stringing the conductor or the OHGW should not made any contact with ground or any obstacles such as walls, fences or buildings etc.. It should not also be overstrained during stringing. During installation of conductor or any subsequent work on the conductor, the conductors are to be grounded according to the grounding practice. Temporary scaffolding may be required during stringing for crossing over road, railways, buildings or such obstacles.

Conductor tension may vary approximately from 10% to 60% of its ultimate strength due to change in loading and temperature. However mostly the tension varies within relatively narrow limits. It is recommended that design tension of transmission line conductors should not exceed 50% of the ultimate strength of the conductor.

Table- 7.2
Maximum Working Stress and Sag

Temperature- 20^{O} F **Ruling Span: 200 ft.**

Conductor Code	X-sectional area of conductor inch^2	Weight of conductor per ft(Area, inch^2 a, Lbs	Wind Pressure on conductor; Lbs per ft run	Loading Factor, q_1	Maxm Working Stress, Initial conductor at 20^0 F with 50% Ultimate Strength f_1 Lbs/inch^2	Maxm Working Stress, final conductor at 20^0 F with 28% Ultimate Strength f_1 Lbs/inch^2
1	2	3	4	5	6	7
Grosbeak	0.7694	1.1373	0.74	1.31	16377	9171.0
Mallard	1.0202	1.2106	0.86	1.22	18820	10539

Overhead Ground Wire

To avoid unnecessary tension on guys, supporting structure, the OHGW sgould be tensioned to a level such that the sag of OHGW is 80% less than that of conductor. Followings are the base data of OHGW.

Table- 7.3
Base Overhead Ground Wire Data

OHGW Size	OHGW Diameter in inch d_{OHGW}	Cross Sectional Area of OHGW	Weight of OHGW in Lbs/ft	Initial 50% Ultimate Strength of OHGW 3/8 HS	Final 35% Ultimate Strength of OHGW 3/8 HS
1	2	3	4	5	6
3/8 HS Steel	0.360	0.079	0.273	5400	3780
7/16 HS Steel	0.435	0.116	0.399	7250	5075

Selection of Ruling Span

The true ruling span can be determined when the different span length of the line are known. Using tables of sag for various ruling span, a ruling span length can be chosen whose sag is

(Md. Mozibur Rahman) Consultant TAPP BREB
(Md. Duhidul Islam) Consultant TAPP BREB
(Md. Mozammel Huq) Consultant TAPP BREB
(Md. Abdul Khaleque) Consultant TAPP BREB
৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০
(Md. Ahsanul Haque) Consultant TAPP BREB
(Debasish Chakrabortty) PD,TAPP BREB
(Kamrul Ahsan Mollik) Asst. Secy. (Board), BREB.

approximately equal to the allowable sag of the base structure height. So to find out the allowable sag from the base structure height, following equation is to be used.

Allowable sag = Length of base Pole – (Setting depth + Length from top to lowest Crossarm + Length of Insulator + Ground clearance)

Now as the base pole height is 40 ft, so the allowable sag = 40 - (0.5 + 3.06 + 5 + 1.94 + 18 + 6)
= 5.5′

So the allowable maximum span on base pole height for RS-200′ with Mallard and Grosbeak conductor are as follows:

Table- 7.4
Base Overhead Ground Wire Data

Conductor Code	Ruling Span	Final Sag at 120^{0} F	Allowable Sag	Allowable Span
1	2	3	4	5
Grosbeak	150	3.022	5.5	202.35
Mallard	150	2.949	5.5	204.853
Grosbeak	200	4.051	5.5	233.037
Mallard	200	3.951	5.5	235.980

The final sag of conductor at 120^{0} F are taken from the sag chart. So in no case the span for base pole should be higher. If the higher span is required, pole height is to be increased

Table- 7.5
Resultant Modulus of Elasticity and Coefficient of Expansion for Different Conductor

Eal 10000000 **Es 29000000**

$\beta_{a/}$ °F al. 0.00001 $\beta_{s/}$ °F S 0.0000064

(Md. Mozibur Rahman) Consultant TAPP BREB
(Md. Duhidul Islam) Consultant TAPP BREB
(Md. Mozammel Huq) Consultant TAPP BREB
(Md. Abdul Khaleque) Consultant TAPP, BREB

(Md. Ahsanul Haque) Consultant TAPP BREB
(Debasish Chakraborty) PD, TAPP, BREB
(Kamrul Ahsan Mollik) Asst. Secy. (Board), BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

Conductor Code	Area of Aluminum % H_a	Area of Steel % H_s	Resultant Modulus of Elasticity, E_{as}	Coefficient of Expansion ^{0}F of Conductor, β_{as}
1	2	3	4	5
Grosbeak	85.987	14.01	1266242038	0.00001075
Mallard	81.429	18.57	1352842984	0.00001025

8. Stringing and Sag Chart

For Stringing, traveler sometimes called stringing blocks are to be installed on each structure or pole. For protection of conductor travelers should not be scratched or notched. These are often lined with non-conductive materials. A light weight line normally synthetic fiber rope, manila rope called finger line is placed over the traveler when it is hung. It is generally from the ground of one side of pole to the other side of pole through the traveler. It is used to thread another synthetic fiber rope called pilot line that is used to pull the pulling line to pull the conductor. This will eliminate the need of workmen on the structure during stringing. Prior to pilling the conductor, two portable grounding device that connect the moving conductor with electrical ground called running ground are to be installed: one between the reel stand and first structure, another one between the puller and the last structure. These ground must be bonded with the system ground temporarily. Pulling line or the pilot line should be kept in tension so that it can't touch the ground. The outer surface of the rope can be damaged by the earth surface. The pulling line is than connected to the conductor through rope connector. Conductor is than dragged along the route and deposited on the ground up to that span where that is not hung on the pole. The conductor reel is positioned on jacks that is either mounted on vehicle or ground so that it can turn when the conductor is pulled out. There should also be braking system so that it can prevent over running or backlash. When conductor is reached to the supporting structure, the pulling is stopped and the conductor is placed on the traveler that is attached to the structure. Pulling speed in achieving a smooth operation should not be more than 3 - 5 mph (5 - 8 KmH). The maximum tension imposed on the conductor should not exceed that necessary to clear obstructions on the ground. Light and steady back tension, sufficient to prevent over run in case sudden stop, should be maintained on the conductor reel at all times. Completion of conductor stringing, sagging and clipping should be done as early as possible to prevent conductor damage from weather, particularly wind. Conductor should not be strung if it can't be completed all sequences before gusty, or advise weather prediction. The ground wire is normally installed prior to pulling the conductors due to their higher location on the pole or structure. If the conductor is installed prior to ground wire. It may damage the conductor during pulling up through them.

Sagging is to be done after stringing. But in a series of suspension spans, the conductor in spans located in upper level will have tendency to run the lower level. Gravity acting on the conductor will make more sag in the lower level of the sagging section and too little sag in the upper level. This results unbalanced horizontal tension in the spans. To equalize this this unbalanced tension, it is necessary to allow some time to redistribute the conductor between the spans. This process of pulling the conductor to upper level is known as "clipping offset".

Sag of the conductors depends on tension of the conductor. The approximate sag- tension relationship is as follows-

$$S = (W_c L^2)/ 8T_h)$$

$$T = Th + W_c \times S$$

$$T_{avg} = (T_h + T)/2 = T_h + (W_c \times S/2)$$

Where:

S = Sag at center of span in meters (feet)

W_c = Weight of conductor in Newton per meter (Pounds per feet)

L = Span length in meter (feet)

T_h = Horizontal tension of conductor in Newton (Pounds)

T = Tension of conductor at the point of support in Newton(Pounds)

T_{avg} = The average of the tension at the support and the tension at the mid span.

(Md. Mozibur Rahman)
Consultant TAPP, BREB

(Md. Duhidul Islam)
Consultant TAPP BREB

(Md. Mozammel Huq)
Consultant, TAPP, BREB

(Md. Abdul Khaleque)
Consultant TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakrabortty)
PD, TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

This is helpful for sag & tension calculation for span length below 300 meters (1000 feet) or where the sag is less than 5% of the span length.

The conductors are installed initially according to "Initial Sag Chart" which is given in Table-8.1 and 8.2. After initial stringing if thay are kept for sometimes, it will elongate, the sag will increase and tension will decrease & come to final sag position.

(Md. Mozibur Rahman)
Consultant TAPP BREB

(Md. Duhidul Islam)
Consultant TAPP BREB

(Md. Mozammel Huq)
Consultant, TAPP, BREB

(Md. Abdul Khaleque)
Consultant TAPP BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakraborty)
PD,TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

Table- 8.1
Initial Sag Chart

Conductor : Grosbeak (636 mcm)
Ruling Span: 150 Feet **Rated Strength: 12600 Lbs.**

Temp ^{O}F	Tension in Lbs	Sag in Feet							
		130	140	150	160	170	180	190	200
120	1073.9	2.26	2.62	3.01	3.64	3.86	4.33	4.82	5.34
110	1132.2	2.14	2.48	2.85	3.24	3.66	4.11	4.57	5.07
100	1201.1	2.02	2.34	2.69	3.06	3.45	3.87	4.31	4.78
90	1284.4	1.89	2.19	2.51	2.86	3.23	3.62	4.03	4.47
80	1387.8	1.75	2.03	2.33	2.65	2.99	3.35	3.73	4.13
70	1521.0	1.59	1.85	2.12	2.41	2.73	3.06	3.40	3.77
60	1701.5	1.42	1.65	1.90	2.16	2.44	2.73	3.04	3.37
50	1966.6	1.23	1.43	1.64	1.87	2.11	2.36	2.63	2.92

Table- 8.2
Initial Sag Chart

Conductor : Grosbeak (636 mcm)
Ruling Span: 200 Feet **Rated Strength: 12600 Lbs.**

Temp ^{O}F	Tension in Lbs	Sag in Feet										
		150	160	170	180	190	200	210	220	230	240	250
120	1428	2.26	2.57	2.90	3.26	3.63	4.02	4.43	4.86	5.32	5.79	6.28
110	1505	2.15	2.44	2.76	3.09	3.44	3.81	4.20	4.61	5.04	5.49	5.96
100	1596	2.02	2.30	2.60	2.91	3.25	3.60	3.96	4.35	4.76	5.18	5.62
90	1705	1.89	2.15	2.43	2.73	3.04	3.36	3.71	4.07	4.45	4.85	5.26
80	1841	1.75	1.99	2.25	2.52	2.81	3.12	3.44	3.77	4.12	4.49	4.87
70	2016	1.60	1.82	2.06	2.31	2.57	2.85	3.14	3.44	3.76	4.10	4.45
60	2251	1.43	1.63	1.84	2.06	2.30	2.55	2.81	3.08	3.37	3.67	3.98
50	2595	1.24	1.42	1.60	1.79	2.00	2.21	2.44	2.68	2.92	3.18	3.45

Table- 8.3
Final Sag Chart

(Md. Mozibur Rahman)
Consultant TAPP BREB

(Md. Duhidul Islam)
Consultant TAPP BREB

(Md. Mozammel Huq)
Consultant, TAPP, BREB

(Md. Abdul Khaleque)
Consultant TAPP BREB

(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakraborty)
PD, TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

Conductor : Grosbeak (636 mcm)

Ruling Span: 150 Feet **Rated Strength: 7056 Lbs.**

Temp °F	Tension in Lbs	Sag in Feet							
		130	140	150	160	170	180	190	200
120	814.25	2.27	2.63	3.02	3.44	3.88	4.35	4.85	5.37
110	857.92	2.15	2.50	2.87	3.26	3.68	4.13	4.60	5.10
100	909.46	2.03	2.36	2.71	3.08	3.48	3.90	4.34	4.81
90	971.57	1.90	2.21	2.53	2.88	3.25	3.65	4.06	4.50
80	1048.40	1.76	2.04	2.35	2.67	3.01	3.38	3.77	4.17
70	1146.90	1.61	1.87	2.15	2.44	2.76	3.09	3.44	3.81
60	1279.70	1.44	1.68	1.92	2.19	2.47	2.77	3.09	3.42
50	1472.40	1.26	1.46	1.67	1.90	2.15	2.41	2.68	2.97

Table- 8.4

Final Sag Chart

Conductor : Grosbeak (636 mcm)

Ruling Span: 200 Feet **Rated Strength: 7056 Lbs.**

Temp °F	Tension in Lbs	Sag in Feet										
		150	160	170	180	190	200	210	220	230	240	250
120	1080	2.28	2.59	2.93	3.28	3.66	4.05	4.47	4.90	5.36	5.83	6.33
110	1137	2.16	2.46	2.78	3.12	3.47	3.85	4.24	4.66	5.09	5.54	6.01
100	1205	2.04	2.32	2.62	2.94	3.28	3.63	4.00	4.39	4.80	5.23	5.67
90	1286	1.91	2.18	2.46	2.76	3.07	3.40	3.75	4.12	4.50	4.90	5.32
80	1386	1.78	2.02	2.28	2.56	2.85	3.16	3.48	3.82	4.18	4.55	4.93
70	1513	1.63	1.85	2.09	2.34	2.61	2.89	3.19	3.50	3.82	4.16	4.52
60	1684	1.46	1.66	1.88	2.10	2.34	2.60	2.86	3.14	3.44	3.74	4.06
50	1929	1.28	1.45	1.64	1.84	2.05	2.27	2.50	2.74	3.00	3.27	3.54

Table- 8.5

Initial Sag Chart

(Md. Mozibur Rahman)
Consultant TAPP BREB

(Md. Duhidul Islam)
Consultant, TAPP, BREB

(Md. Mozammel Huq)
Consultant TAPP BREB

(Md. Abdul Khaleque)
Consultant TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakraborty)
PD, TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB

Conductor : Mallard (795 mcm)

Ruling Span: 150 Feet **Rated Strength: 19200 Lbs.**

Temp °F	Tension in Lbs	Sag in Feet							
		130	140	150	160	170	180	190	200
120	1441.40	2.20	2.55	2.93	3.33	3.76	4.22	4.70	5.21
110	1519.90	2.09	2.42	2.78	3.16	3.57	4.00	4.46	4.94
100	1612.80	1.97	2.28	2.62	2.98	3.36	3.77	4.20	4.66
90	1725.10	1.84	2.13	2.45	2.79	3.15	3.53	3.93	4.35
80	1864.70	1.70	1.97	2.27	2.58	2.91	3.26	3.63	4.03
70	2044.70	1.55	1.80	2.07	2.35	2.65	2.98	3.31	3.67
60	2289.40	1.39	1.61	1.85	2.10	2.37	2.66	2.96	3.28
50	2649.50	1.20	1.39	1.59	1.81	2.05	2.30	2.56	2.83

Table- 8.6

Initial Sag Chart

Conductor : Mallard (795 mcm)

Ruling Span: 200 Feet **Rated Strength: 19200 Lbs.**

Temp °F	Tension in Lbs	Sag in Feet										
		150	160	170	180	190	200	210	220	230	240	250
120	1917	2.20	2.51	2.83	3.17	3.54	3.92	4.32	4.74	5.18	5.64	6.12
110	2021	2.09	2.38	2.68	3.01	3.35	3.72	4.10	4.50	4.91	5.35	5.81
100	2144	1.97	2.24	2.53	2.84	3.16	3.50	3.86	4.24	4.63	5.04	5.47
90	2292	1.84	2.10	2.37	2.65	2.96	3.28	3.61	3.96	4.33	4.72	5.12
80	2476	1.71	1.94	2.19	2.46	2.74	3.03	3.34	3.67	4.01	4.37	4.74
70	2713	1.56	1.77	2.00	2.24	2.50	2.77	3.05	3.35	3.66	3.99	4.33
60	3034	1.39	1.58	1.79	2.01	2.23	2.48	2.73	3.00	3.27	3.56	3.87
50	3503	1.21	1.37	1.55	1.74	1.93	2.14	2.36	2.59	2.84	3.09	3.35

Table- 8.7

Final Sag Chart

Conductor : Mallard (795 mcm)

(Md. Mozibur Rahman) Consultant TAPP BREB
(Md. Duhidul Islam) Consultant TAPP BREB
(Md. Mozammel Huq) Consultant TAPP BREB
(Md. Abdul Khaleque) Consultant, TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque) Consultant TAPP BREB
(Debasish Chakrabortty) PD, TAPP BREB
(Kamrul Ahsan Mollik) Asst. Secy. (Board), BREB.

Ruling Span: 150 Feet **Rated Strength: 10752 Lbs.**

Temp ^{O}F	Tension in Lbs	Sag in Feet							
		130	140	150	160	170	180	190	200
120	1177.90	2.21	2.57	2.95	3.36	3.97	4.25	4.73	5.24
110	1241.20	2.10	2.44	2.80	3.18	3.69	4.03	4.49	4.98
100	1315.90	1.98	2.30	2.64	3.00	3.39	3.80	4.23	4.69
90	1406.10	1.86	2.15	2.47	2.81	3.17	3.56	3.96	4.39
80	1517.70	1.72	1.99	2.29	2.60	2.94	3.30	3.67	4.07
70	1660.80	1.57	1.82	2.09	2.38	2.69	3.01	3.36	3.72
60	1854.00	1.41	1.63	1.87	2.13	2.41	2.70	3.01	3.33
50	2135.00	1.22	1.42	1.63	1.85	2.09	2.34	2.61	2.89

Table- 8.8

Final Sag Chart

Conductor : Mallard (795 mcm)

Ruling Span: 200 Feet **Rated Strength: 10752 Lbs.**

Temp ^{O}F	Tension in Lbs	Sag in Feet										
		150	160	170	180	190	200	210	220	230	240	250
120	1563	2.22	2.53	2.85	3.20	3.57		4.36	4.78	5.22	5.69	6.17
110	1646	2.11	2.40	2.71	3.04	3.39	3.75	4.14	4.54	4.96	5.40	5.86
100	1744	1.99	2.27	2.56	2.87	3.20	3.54	3.90	4.28	4.68	5.10	5.53
90	1862	1.87	2.12	2.40	2.69	2.99	3.32	3.66	4.01	4.39	4.78	5.18
80	2007	1.73	1.97	2.22	2.49	2.78	3.08	3.39	3.72	4.07	4.43	4.81
70	2193	1.58	1.80	2.03	2.28	2.54	2.82	3.10	3.41	3.72	4.05	4.40
60	2443	1.42	1.62	1.83	2.05	2.28	2.53	2.79	3.06	3.34	3.64	3.95
50	2802	1.24	1.41	1.59	1.79	1.99	2.20	2.43	2.67	2.91	3.17	3.44

It should be stressed during that staking that the actual ruling span should be very closer to the designed ruling span. The difference between designed and actual ruling span should not be greater than 15% approximately. The exact method for determination the ruling span is as follows-

$(L_1^3 L_2^3 + L_3^3$ ---------------------- $+ L_n^3)/ (L_1 + L_2 + L_3 +$ ------------------------ $+ L_n)^{1/2}$

(Md. Mozibur Rahman) Consultant TAPP BREB

(Md. Duhidul Islam) Consultant TAPP BREB

(Md. Mozammel Huq) Consultant, TAPP, BREB

(Md. Abdul Khaleque) Consultant TAPP BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque) Consultant TAPP BREB

(Debasish Chakrabortty) PD, TAPP BREB

(Kamrul Ahsan Mollik) Asst. Secy. (Board), BREB.

Where:

L_1, L_2, L_3 etc. = different span length in the line in meters (feet) ruling span in meters (feet)

Other symbols are as previously stated.

If the actual RS (Ruling Span) is less than the designed RS and conductor temperature is less than the temperature at which the conductor was strung, the actual sag will be lesser than the designed sag and thus there will be more tension than the designed tension. If the temperature is greater than the temperature at which the conductor was strung and the actual RS is lesser than the designed the RS, the actual sag will be greater than the designed sag and thus there may be clearance problem and vice versa. However, without deadending i.e. within the ruling span one go for double average span for long span and similarly can go one half of the ruling span if the conductor tension limits are satisfactory.

9. Stability of Structure/ Pole:

The function of structure if necessary in conjunction with guys or struts is to withstand the longitudinal, transverse and vertical forces due to wind and wire tension loads for line angles. Longitudinal loads are due to deadending or unequal spans. The embedded portion of the pole distribute these lateral forces over a sufficient area of soil, so that the earth will resist the lateral forces. So it depends largely on earth quality. The load bearing capacity of soil, depends on soil characteristics such as internal function, cohesion, unit weight, fineness of grain, moisture content, consolidation and plasticity. The embedment depth of pole in soil should be greater so that earth can resist the lateral forces. Poles in sandy soil with high water table may "kick" out the pole. With time , single pole may not remain plumb. Some movement (leaning) of pole structures in the ground may occur due to above reasons which is permitted, if it does not affect the continuity of service and if the adequate clearance maintained. It can be prevented by increasing the embedment depth, by increasing diameter of the embedment, by backfilling or by using bog shoes. Before backfilling all water should be removed. It is desirable to backfill with broken rock or gravel. The backfill should be banked and around the poles as this helps to keep the hole drier.

Table- 9.1A

Base Pole Data: Spun Pre-stressed Concrete (SPC) Pole

MKS System

Item No. & Pole Size	Pole Height In meter	Top Dia of Pole in mm	Bottom Dia of Pole in mm	Working Load in KN	Setting Depth in Meter	Dia at Ground Level in mm	Load area due to Wind in m^2	Center location of Wind load from GL, M	Wall thickness in mm
1	2	3	4	5	6	7	8	9	10
R-43; 35′-N6	10.6	160	302.00	2.00	1.829	277.5	1.92	3.993	45
R-44; 35′-N5	10.6	180	321.30	2.60	1.829	296.9	2.09	4.027	45
R-45; 40′-N5	12.0	200	380.00	2.60	1.829	352.6	2.81	4.617	45
R-46; 40′-N4	12.0	220	380.00	3.30	1.829	355.6	2.93	4.686	50
R-47; 45′-N4	13.7	220	380.00	3.30	1.982	356.9	3.39	5.405	50
R-48; 50′-N4	15.2	220	422.60	3.30	2.134	394.2	4.03	5.935	50
R- ; 55′-N3	16.8	238	461.60	4.10	2.287	431.1	4.84	6.544	55
R-49; 60′-N2	18.3	256	500.00	5.20	2.439	467.5	5.73	7.155	65
35′-N4	10.6	220	361.33	3.30	1.829	336.9	2.44	4.078	50
35′-N3	10.6	238	379.33	4.10	1.829	354.9	2.60	4.097	55
40′-N3	12.0	238	398.00	4.10	1.829	373.6	3.11	4.710	55
40′-N2	12.0	256	416.00	5.20	1.829	391.6	3.29	4.730	65
45′-N3	13.7	238	400.60	4.10	1.829	376.2	3.18	4.794	55
45′-N2	13.7	256	438.92	5.20	1.982	412.5	3.92	5.411	65
50′-N3	15.2	238	481.90	4.10	1.982	455.5	5.66	7.303	55
50′-N2	15.2	256	438.92	5.20	1.982	412.5	3.92	5.411	65
55′-N2	16.8	256	438.92	5.20	1.982	412.5	3.92	5.411	65
60′-N2	18.3	274	517.9	5.20	2.439	485.4	6.02	7.191	70

(Md. Mozibur Rahman) Consultant, TAPP, BREB

(Md. Duhidul Islam) Consultant, TAPP, BREB

(Md. Mozammel Huq) Consultant, TAPP, BREB

(Md. Abdul Khaleque) Consultant, TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque) Consultant TAPP BREB

(Debasish Chakrabortty) PD, TAPP, BREB

(Kamrul Ahsan Mollik) Asst. Secy. (Board), BREB.

Table- 9.1B

Base Pole Data: Spun Pre-stressed Concrete (SPC) Pole
FPS System

Item No. & Pole Size	Pole Height In feet	Top Dia of Pole in inch	Bottom Dia of Pole in inch	Working Load at 2 ft. from top in Lbs	Setting Depth in feet	Dia at Ground Level in inch	Load area due to Wind in sft	Center location of Wind load from GL, Ft	Wall thick -ness in inch
1	2	3	4	5	6	7	8	9	10
R-43; 35′-N6	35	6.30	11.89	449.60	6.0	10.93	20.82	13.201	1.77
R-44; 35′-N5	35	7.09	12.65	584.48	6.0	11.70	22.70	13.314	1.77
R-45; 40′-N5	40	7.87	14.96	584.48	6.0	13.90	30.84	15432	1.77
R-46; 40′-N4	40	8.66	14.96	741.84	6.0	14.02	32.13	15662	1.97
R-47; 45′-N4	45	8.66	14.96	741.84	6.5	14.05	36.44	17.727	1.97
R-48; 50′-N4	50	8.66	16.64	741.84	7.0	15.52	43.33	19.467	1.97
R- ; 55′-N3	55	9.37	18.17	921.68	7.5	16.97	52.14	21.465	2.17
R-49; 60′-N2	60	10.08	19.69	1169.0	8.0	18.41	61.72	23.467	2.56
35′-N4	35	8.66	14.23	741.80	6.0	13.27	26.50	13.484	1.97
35′-N3	35	9.37	14.93	921.70	6.0	13.98	28.22	13.546	2.17
40′-N3	40	9.37	15.67	921.68	6.0	14.73	34.14	15.741	2.17
40′-N2	40	10.1	16.38	1169.0	6.0	15.43	36.14	15.811	2.56
45′-N3	45	9.37	15.77	921.68	6.5	14.85	38.85	17.799	2.17
45′-N2	45	10.1	17.28	1169.0	6.5	16.24	42.22	17.748	2.56
50′-N3	50	9.37	18.97	921.68	7.0	17.63	48.37	19.308	2.17
50′-N2	50	10.1	17.28	1169.0	7.0	16.27	47.21	19.816	2.56
55′-N2	55	10.1	17.28	1169.0	7.5	16.30	52.21	21.883	2.56
60′-N2	60	10.8	20.39	1169.0	8.0	19.11	64.78	23.588	2.76

Some poles have no material identification number and have no data with BREB. The required data are assumed for work.

Transverse Load:

(Md. Mozibur Rahman)
Consultant TAPP BREB

(Md. Duhidul Islam)
Consultant TAPP BREB

(Md. Mozammel Huq)
Consultant, TAPP BREB

(Md. Abdul Khaleque)
Consultant,TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakrabortty)
PD,TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB,

Horizontal loads applied perpendicular to the line or at an angle pole or structure applied in the direction of the bisector of the angle.

Assume Insulator Area: 0.2917 Sft.

Table- 9.2
Transverse Load Due to Wind on Conductor, OHGW, X-arms and Insulator for RS 150′ & 200′

Conductor Code	Wind Load Conductor/ Conductor for RS 150′ P_{TW}, lb	Wind Load Conductor/ Conductor for RS 200′ P_{TW}, lb	Wind Load Insulator/ Conductor, P_{tin}, lb	Wind Load X-arm/ Conductor, $P_{x\text{-}arm}$, lb	Wind Load OHGW 3/8 HS steel for RS- 150′, P_{TWOHW}, lb	Wind Load OHGW 3/8 HS steel for RS- 200′, P_{TWOHW}, lb	Total Transverse Load for 3-Conductor & OHGW for RS-150′, lbs	Total Transverse Load for 3-Conductor & OHGW for RS-200′, lbs
1	2	3	4	5	6	7	8	9
Grosbeak	122.5	163.35	7.88	3.82	44.55	59.40	447.18	585
Mallard	141.1	188.10	7.88	3.82	44.55	59.40	502.87	659

Column 6 & 7: X-Arm 4″×4″×1/2″- 2 Nos. Brace 3″×3″×3/8″- 4′ Nos. at 450 angle- 1 No. & 3″×3″×3/8″- 5′

Wind force for flat surface = 14.1 lbs: X-Arms & Brace's Weight is divided by 3 for calculation of 1 Conductor; 3/8″ thickness = 0

Center Position of Total Transverse Load for RS-150′

Grosbeak $L_{TCGROSBEAK}$ 2.696 downward from top crossarm

Mallard, $L_{TCGROSBEAK}$ 2.767 downward from top crossarm

Moment at ground level for 40 pole with Grosbeak

$= (40^{*1} - 6.0^{*2} - 3.56^{*3} - 2.6924^{*4}) \times 447.1810^{*5} = 12406$

Center Position of Total Transverse Load for RS-200′

Grosbeak $L_{TCGROSBEAK}$ 2.6837 downward from top crossarm

Mallard, $L_{TCGROSBEAK}$ 2.7569 downward from top crossarm

^{*1} - Pole Height

^{*2} - Setting Depth of Pole

^{*3} - Upward of Poles from Top Cross Arm i.e. 3.06′ + 6″ = 3.56′

^{*4} - Center Position of Transverse Load

^{*5} - Total Transverse Load

Table- 9.3

Total Wind Load on Grosbeak or Mallard Conductor and SPC Pole for RS 150′

Center Position of Total Transverse Load for Conductor, OHGW, Cross Arm and Insulator.

Grosbeak, $L_{TCGROSBEAK}$ 2.6964 downward from top crossarm for RS 150′

Mallard, $L_{TCGROSBEAK}$ 2.7669 downward from top crossarm for RS 150′

Grosbeak, $L_{TCGROSBEAK}$ 2.6837 downward from top crossarm for RS 200′

Mallard, $L_{TCGROSBEAK}$ 2.7569 downward from top crossarm for RS 200′

Total Transverse Load for 3-Grosbeak OHGW for RS-150′ Lb = 447.2

(Md. Mozibur Rahman) Consultant TAPP BREB

(Md. Duhidul Islam) Consultant TAPP BREB

(Md. Mozammel Huq) Consultant, TAPP BREB

(Md. Abdul Khaleque) Consultant, TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque) Consultant TAPP BREB

(Debasish Chakrabortty) PD, TAPP BREB

(Kamrul Ahsan Mollik) Asst. Secy. (Board), BREB.

Total Transverse Load for 3-Mallard OHGW for RS-150′ Lb = 502.9

Total Transverse Load for 3-Grosbeak OHGW for RS-200′ Lb = 584.5

Total Transverse Load for 3-Mallard OHGW for RS-200′ Lb = 658.8

Item No. & Pole Size	Pole Height In feet	Setting Depth in feet	Allowable Working Load at 2 ft. from top in Lbs	Wind Load on Pole Lbs	Total Wind Load for 3-Grossbeak OHGW & on Pole for RS 150′ Lbs	Total Wind Load for 3-Mallard OHGW & on Pole for RS 150′ Lbs	Total Wind Load for 3-Grossbeak OHGW & on Pole for RS 200′ Lbs	Total Wind Load for 3-Mallard OHGW & on Pole for RS 200′ Lbs
1	2	3	4	5	6	7	8	9
R-43; 35′-N6	35	6.0	449.60	187.4	634.60	690.30	772	846.2
R-44; 35′-N5	35	6.0	584.48	204.3	651.50	707.20	789	863.1
R-45; 40′-N5	40	6.0	584.48	277.6	724.80	780.50	862	936.4
R-46; 40′-N4	40	6.0	741.84	289.1	736.30	792.00	874	947.9
R-47; 45′-N4	45	6.5	741.84	327.9	775.10	830.80	912	986.7
R-48; 50′-N4	50	7.0	741.84	390.0	837.10	892.80	975	1049
R- ; 55′-N3	55	7.5	921.68	469.2	916.40	972.10	1054	1128
R-49; 60′-N2	60	8.0	1169.0	555.4	1002.6	1058.3	1140	1214
35′-N4	35	6.0	741.80	238.5	685.70	741.40	823	897
35′-N3	35	6.0	921.70	253.9	701.10	756.80	838	913
40′-N3	40	6.0	921.68	307.2	754.40	810.10	892	966
40′-N2	40	6.0	1169.0	325.3	772.50	828.20	910	984.1
45′-N3	45	6.5	921.68	349.6	796.80	852.50	934	1008
45′-N2	45	6.5	1169.0	380.0	827.20	882.90	965	1039
50′-N3	50	7.0	921.68	435.4	882.50	938.20	1020	1094
50′-N2	50	7.0	1169.0	424.9	872.10	927.80	1009	1084
55′-N2	55	7.5	1169.0	469.9	917.00	972.7	1054	1129
60′-N2	60	8.0	1169.0	583.0	1030.2	1085.9	1168	1242

The above table gives data due to wind load on conductor and SPC pole.

Longitudinal Load:

Horizontal Loads applied in line with pole line, i.e. unbalanced conductor tension applied to structure and at dead ends consist of the entire horizontal component of conductor tension

$P_L = 0$

Vertical Load:

$P_V = P_C + P_I + P_{X\text{-}Arm} + P_{Brace}$ **Equation- 9.1**

Where:

P_C = Load due to Weight of Conductor = $W_C \times 1.1 \times$ Basic Span

P_I = Load due to Weight of Insulator

$P_{X\text{-}Arm}$ = Load due to Weight of Cross Arm

P_{Brace} = Load due to Weight of Brace

Table- 9.4

Vertical Load Due to Weight of Conductor, OHGW, X-arm and Insulator for RS 150′ & 200′

Conductor Code	Weight of Conductor, W_C Lbs/ft	Load due to Weight of Conductor for RS 150' P_c	Load due to Weight of Conductor for RS 200' P_c	Load due to Weight of Insulator, P_I	Load due to Weight of Cross Arm $P_{cross\text{-}arm}$	Load due to Weight of Brace, P_{Brace}	Load due to Wt. of OHGW 3/8 HS Steerl for RS- 150', P_{OHGW}	Load due to Wt. of OHGW 3/8 HS Steerl for RS- 200', P_{OHGW}	Vertical Load, $P_V = P_C + P_I + P_{X\text{-}Arm} + P_{Brace}$ for RS- 150'	Vertical Load, $P_V = P_C + P_I + P_{X\text{-}Arm} + P_{Brace}$ for RS- 200'
1	2	3	4	5	6	7	8	9	10	11
Grosbeak	0.88	144.4	192.5	45.00	179.2	100.8	45.05	60.06	893	1053
Mallard	1.24	203.8	271.7	45.00	179.2	100.8	45.05	60.06	1071	1290

Column 5: Weight of insulator is taken from Appendix C-5

Column 6: Weight of Crossarm for 4″×4″×1/2″ per ft = 12.8 lbs

: Crossarm required 1 no. 8′ and 1 no. 6′

Column 7: Weight of brace for 3″×3″×3/8″ per ft = 7.2 lbs

: Brace required 2 no. 5′ and 1 no. 4′

Column 10 & 11: Conductor 3 nos + OHGW 1 no. & Insulator 3 sets

(Md. Mozibur Rahman)
Consultant TAPP BREP

(Md. Duhidul Islam)
Consultant TAPP BREP

(Md. Mozammel Huq)
Consultant, TAPP, BREP

(Md. Abdul Khaleque)
Consultant TAPP BREP

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭৩০

(Md. Ahsanul Haque)
Consultant TAPP BREP

(Debasish Chakrabortty)
PD, TAPP BREP

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

Table- 9.5

BM at GL for Wind Load on Grosbeak or Mallard & Pole in ft-lb & Min^{m} Plantation Depth Required for SPC Pole with Grosbeak & Mallard Conductor for Span 150′

Item No. & Pole Size	Pole Height In feet	Setting Depth in feet	BM at GL for Wind Load on Grosbeak ft-lb	BM at GL for Wind Load on Mallard ft-lb	BM at GL for Wind Load on Pole ft-lb	BM at GL for Wind Load on Grosbeak & Pole ft-lb	BM at GL for Wind Load on Mallard & Pole ft-lb	Design BM at GL on Working Load ft-lb	Main Dia of embedded portion, D in inch	Min^{m} Plantation Depth required for Grosbeak, t ft	Min^{m} Plantation Depth required for Mallard, t ft
1	2	3	4	5	6	7	8	9	10	11	12
R-43; 35′-N6	35	6.0	10171	11402	2474	12644	13875	12139	11.4	4.14	4.24
R-44; 35′-N5	35	6.0	10171	11402	2720	12890	14121	15781	12.2	4.10	4.19
R-45; 40′-N5	40	6.0	12406	13916	4284	16690	18200	18703	14.4	4.19	4.28
R-46; 40′-N4	40	6.0	12406	13916	4529	16935	18445	23739	14.5	4.20	4.29
R-47; 45′-N4	45	6.5	14419	16179	5813	20232	21992	27077	14.5	4.39	4.48
R-48; 50′-N4	50	7.0	16431	18442	7591	24022	26033	30415	16.1	4.46	4.55
R- ; 55′-N3	55	7.5	18443	20705	10072	28516	30777	41936	17.6	4.56	4.65
R-49; 60′-N2	60	8.0	20456	22968	13034	33490	36002	58448	19.0	4.65	4.73
35′-N4	35	6.0	10171	11402	3216	13387	14618	20030	13.7	4.01	4.10
35′-N3	35	6.0	10171	11402	3440	13610	14841	24885	14.5	3.98	4.06
40′-N3	40	6.0	12406	13916	4836	17242	18752	29494	15.2	4.17	4.26
40′-N2	40	6.0	12406	13916	5143	17549	19059	37407	15.9	4.14	4.22
45′-N3	45	6.5	14419	16179	6223	20642	22402	33641	15.3	4.35	4.44
45′-N2	45	6.5	14419	16179	6744	21163	22923	42667	16.8	4.28	4.37
50′-N3	50	7.0	16431	18442	8406	·24837	26848	37789	18.3	4.36	4.44
50′-N2	50	7.0	16431	18442	8420	24851	26862	47927	16.8	4.45	4.54
55′-N2	55	7.5	18443	20705	10282	28726	30987	53188	16.8	4.62	4.71
60′-N2	60	8.0	20456	22968	13752	34208	36719	58448	19.8	4.63	4.71

Each cell of column-9 is greater than column-7 or column-8 except R-43, So pole of each class from R-44 to R-49 and other suggested pole are safe as regards the bending moment due to

(Md. Mozibur Rahman)
Consultant TAPP BREB

(Md. Duhidul Islam)
Consultant TAPP BREB

(Md. Mozammel Huq)
Consultant, TAPP, BREB

(Md. Abdul Khaleque)
Consultant,TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant,TAPP BREB

(Debasish Chakraborty)
PD,TAPP. BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

transverse load for span 150 ft. Again setting depth of pole is higher than the required plantation depth for Grosbeak as well as Mallard conductor for span 150 ft. So each pole is also safe from overturning.

Table- 9.6

BM at GL for Wind Load on Grosbeak or Mallard & Pole in ft-lb & Min^{m} Plantation Depth Required for SPC Pole with Grosbeak & Mallard Conductor for Span 200′

Item No. & Pole Size	Pole Height In feet	Setting Depth in feet	BM at GL for Wind Load on Grosbeak ft-lb	BM at GL for Wind Load on Mallard ft-lb	BM at GL for Wind Load on Pole ft-lb	BM at GL for Wind Load on Grosbeak & Pole ft-lb	BM at GL for Wind Load on Mallard & Pole ft-lb	Design BM at GL on Working Load ft-lb	Main Dia of embedded portion, D in inch	Min^{m} Plantation Depth required for Grosbeak, t ft	Min^{m} Plantation Depth required for Mallard, t ft
1	2	3	4	5	6	7	8	9	10	11	12
R-43; 35′-N6	35	6.0	13302	14943	2474	15776	17417	12139	11.4	4.38	4.49
R-44; 35′-N5	35	6.0	13302	14943	2720	16022	17663	15781	12.2	4.32	4.43
R-45; 40′-N5	40	6.0	16225	18237	4284	20509	22521	18703	14.4	4.41	4.51
R-46; 40′-N4	40	6.0	16225	18237	4529	20753	22766	23739	14.5	4.42	4.52
R-47; 45′-N4	45	6.5	18855	21202	5813	24668	27015	27077	14.5	4.61	4.72
R-48; 50′-N4	50	7.0	21486	24167	7591	29077	31758	30415	16.1	4.68	4.79
R- ; 55′-N3	55	7.5	24408	27461	10072	34481	37533	42397	17.6	4.78	4.88
R-49; 60′-N2	60	8.0	26747	30096	13034	39781	43130	58448	19.0	4.85	4.95
35′-N4	35	6.0	13302	14943	3217	16518	18160	20030	13.7	4.23	4.33
35′-N3	35	6.0	13302	14943	3440	16742	18383	24885	14.5	4.19	4.29
40′-N3	40	6.0	16225	18237	4836	21061	23073	29494	15.2	4.38	4.48
40′-N2	40	6.0	16225	18237	5143	21368	23381	37407	15.9	4.35	4.45
45′-N3	45	6.5	18855	21202	6223	25079	27425	33641	15.3	4.57	4.67
45′-N2	45	6.5	18855	21202	6744	25599	27946	42667	16.8	4.49	4.59
50′-N3	50	7.0	21486	24167	8406	29892	32573	37789	18.3	4.56	4.66
50′-N2	50	7.0	21486	24167	8420	29906	32587	47927	16.8	4.67	4.77
55′-N2	55	7.5	24116	27131	10282	.34398	37413	53188	16.8	4.83	4.93
60′-N2	60	8.0	26747	30096	13752	40499	43848	58448	19.8	4.83	4.93

As regards pole size from R-43 to R-45 & R-48 are not suitable for 200 ft span. From pole sizes R-46 to R-47 & R-49 and other poles are safe as regards the bending moment due to transverse load for span 200 ft. for both Grosbeak and Mallard conductor as the column-9 is greater than column-7 & column-8. Again setting depth of pole is higher than the required plantation depth for Grosbeak as well as Mallard conductor for span 200 ft. So each pole is also safe from overturning.

(Md. Mozibur Rahman) Consultant, TAPP, BREB

(Md. Duhidul Islam) Consultant, TAPP, BREB

(Md. Mozammel Huq) Consultant, TAPP, BREB

(Md. Abdul Khaleque) Consultant, TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque) Consultant, TAPP, BREB

(Debasish Chakrabortty) PD, TAPP, BREB.

(Kamrul Ahsan Mollik) Asst. Secy. (Board), BREB.

Table- 9.7

Base Pole Data: Southern Yellow Pine (SYP) Pole

Fiber Stress in psi = 8,000

Modulus of Elasticity in psi = 1,800,000

Design Ultimate Bending Stress in psi = 7,400

Item No. & Pole Size	Pole Height In feet	Top Dia of Pole in inch	Bottom Dia of Pole in inch	Working Load at 2 ft. from top in Lbs	Setting Depth in feet	Dia at Ground Level in inch	Load area due to Wind in sft	Center location of Wind load from GL in Ft	Dia at Load in inch D_t	Resisting Moment Ft-lb	Allowable transverse moment, Ft-lb	Dia at 6 ft from the butt in inch
1	2	3	4	5	6	7	8	9	10	11	12	13
R-43; 35′-N6	35	6.05	9.8896	449.60	6.0	9.23	18.46	13.493	6.2674	47610	23805	9.23
R-44; 35′-N5	35	6.68	10.718	584.48	6.0	10.03	20.19	13.533	6.9150	61015	30508	10.0
R-45; 40′-N5	40	6.68	12.302	584.48	6.0	11.46	25.70	15.509	6.9654	91078	45539	11.5
R-46; 40′-N4	40	7.32	12.189	741.84	6.0	11.46	26.61	15.751	7.5645	91078	45539	11.5
R-47; 45′-N4	45	7.32	12.647	741.84	6.5	11.88	30.80	17.727	7.5578	102944	51472	11.9
R-48; 50′-N4	50	7.32	13.109	741.84	7.0	12.30	35.15	19.682	7.5526	115798	57899	12.4
R- ; 55′-N3	55	7.96	14.568	921.68	7.5	13.67	42.80	21.660	8.1981	160685	80343	13.8
R-49; 60′-N2	60	8.59	16.022	1169.0	8.0	15.03	51.19	23.639	8.8419	215889	107945	15.3
35′-N4	35	7.32	11.547	741.80	6.0	10.82	21.92	13.567	7.5626	76726	38363	10.8
35′-N3	35	7.96	12.394	921.70	6.0	11.63	23.67	13.593	8.2113	95301	47651	11.6
40′-N3	40	7.96	13.013	921.68	6.0	12.25	28.63	15.795	8.2105	111401	55701	12.3
40′-N2	40	8.59	13.837	1169.0	6.0	13.05	30.66	15.833	8.8565	134542	67271	13.1
45′-N3	45	7.96	13.663	921.68	6.5	12.84	33.36	17.744	8.2113	130016	65008	12.9
45′-N2	45	8.59	14.471	1169.0	6.5	13.62	35.64	17.798	8.8556	155208	77604	13.7
50′-N3	50	7.96	14.107	921.68	7.0	13.25	37.99	19.713	8.2037	144629	72315	13.4
50′-N2	50	8.59	15.105	1169.0	7.0	14.19	40.83	19.739	8.8548	177887	88944	14.3
55′-N2	55	8.59	15.561	1169.0	7.5	14.61	45.93	21.697	8.8477	196276	98138	14.8
60′-N2	60	8.59	16.022	1169.0	8.0	15.03	51.19	23.639	8.8419	215889	107945	15.3

Table- 9.8

Total Wind Load on Grosbeak or Mallard and on SYP Pole for RS- 150′

Item No. & Pole Size	Pole Height In feet	Setting Depth in feet	Horizontal Load applied 2 ft. from top of the pole	Working Load	Wind Load on pole in lbs	Total wind load for 3-Grosbeak, OHGW & on pole for RS-150′, lbs	Total wind load for 3-Mallard, OHGW & on pole for RS-150′, lbs	Total wind load for 3-Grosbeak, OHGW & on pole for RS-200′, lbs	Total wind load for 3-Mallard, OHGW & on pole for RS-200′, lbs
1	2	3	4	5	6	7	8	9	10
R-43; 35′-N6	35	6.0	1900	475	166.2	465.6	521.3	603	677.3
R-44; 35′-N5	35	6.0	2400	600	181.7	467.4	523.1	605	679.0
R-45; 40′-N5	40	6.0	2400	600	231.3	472.9	528.6	610	684.5
R-46; 40′-N4	40	6.0	3000	750	239.4	473.8	529.5	611	685.4
R-47; 45′-N4	45	6.5	3000	750	277.2	478.0	533.7	615	689.6
R-48; 50′-N4	50	7.0	3000	750	316.4	482.3	538.0	620	693.9
R- ; 55′-N3	55	7.5	3700	925	385.2	490.0	545.7	627	701.6
R-49; 60′-N2	60	8.0	4500	1125	460.7	498.4	554.1	636	710.0
35′-N4	35	6.0	3000	750	197.3	469.1	524.8	606	680.7
35′-N3	35	6.0	3700	925	213.1	470.9	526.5	608	682.5
40′-N3	40	6.0	3700	925	257.7	475.8	531.5	613	687.4
40′-N2	40	6.0	4500	1125	276.0	477.8	533.5	615	689.5
45′-N3	45	6.5	3700	925	300.3	480.5	536.2	618	692.2
45′-N2	45	6.5	4500	1125	320.7	482.8	538.5	620	694.4
50′-N3	50	7.0	3700	925	341.9	485.2	540.9	623	696.8
50′-N2	50	7.0	4500	1125	367.5	488.0	543.7	625	699.6
55′-N2	55	7.5	4500	1125	413.4	493.1	548.8	630	704.7
60′-N2	60	8.0	4500	1125	460.7	498.4	554.1	636	710.0

The above table gives data due to wind load on conductor and on SYP pole

Table- 9.9

BM at GL for Wind Load on Grosbeak or Mallard & Pole in ft-lb & Min^{m} Plantation Depth Required for SYP Pole with Grosbeak & Mallard Conductor for Span 150′

Item No. & Pole Size	Pole Height In feet	Setting Depth in feet	BM at GL for Wind Load on Grosbeak ft-lb	BM at GL for Wind Load on Mallard ft-lb	BM at GL for Wind Load on Pole ft-lb	BM at GL for Wind Load on Grosbeak & Pole ft-lb	BM at GL for Wind Load on Mallard & Pole ft-lb	Design BM at GL on Working Load with safety factor 4, ft-lb	Main Dia of embedded portion, D in inch	Min^{m} Plantation Depth required for Grosbeak, t ft	Min^{m} Plantation Depth required for Mallard, t ft
1	2	3	4	5	6	7	8	9	10	11	12
R-43; 35′-N6	35	6.0	10171	11402	2242	12412	13644	12825	9.56	4.310	4.41
R-44; 35′-N5	35	6.0	10171	11402	2459	12630	13861	16200	10.4	4.241	4.34
R-45; 40′-N5	40	6.0	12406	13916	3588	15994	17504	19200	11.9	4.349	4.45
R-46; 40′-N4	40	6.0	12406	13916	3772	16178	17688	24000	11.8	4.367	4.47
R-47; 45′-N4	45	6.5	14419	16179	4914	19332	21092	27375	12.3	4.524	4.62
R-48; 50′-N4	50	7.0	16431	18442	6227	22658	24668	30750	12.7	4.666	4.77
R- ; 55′-N3	55	7.5	18443	20705	8343	26786	29048	42088	14.1	4.739	4.84
R-49; 60′-N2	60	8.0	20456	22968	10890	31346	33858	56250	15.5	4.813	4.91
35′-N4	35	6.0	10171	11402	2677	12847	14079	20250	11.2	4.180	4.28
35′-N3	35	6.0	10171	11402	2896	13067	14298	24975	12.0	4.123	4.22
40′-N3	40	6.0	12406	13916	4071	16477	17987	29600	12.6	4.315	4.41
40′-N2	40	6.0	12406	13916	4370	16776	18286	36000	13.4	4.268	4.36
45′-N3	45	6.5	14419	16179	5328	19746	21507	33763	13.3	4.461	4.56
45′-N2	45	6.5	14419	16179	5709	20127	21887	41063	14.0	4.418	4.51
50′-N3	50	7.0	16431	18442	6740	23171	25182	37925	13.7	4.607	4.70
50′-N2	50	7.0	16431	18442	7253	23684	25695	46125	14.6	4.553	4.65
55′-N2	55	7.5	18443	20705	8969	27412	29673	51188	15.1	4.688	4.78
60′-N2	60	8.0	20456	22968	10890	31346	33858	56250	15.5	4.813	4.91

Each cell of column-9 is greater than column-7 i.e. for Grosbeak. Again each cell of column-9 is greater than column-8 except, except R-43. So from R-44 to R-49 and 35-2, 40-2, 40-1, 45-2, 50-2, 50-1, 55-1 & 60-1 are suitable and safe as regards the bending moment due to transverse load for span 150 ft. Again setting depth of pole is higher than the required plantation depth for Grosbeak as well as Mallard conductor for span 150 ft. So each pole is also safe from overturning.

Table- 9.10

(Md. Mozibur Rahman)
Consultant, TAPP, BREB

(Md. Duhidul Islam)
Consultant, TAPP, BREB

(Md. Mozammel Huq)
Consultant, TAPP, BREB

(Md. Abdul Khaleque)
Consultant, TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant TAPP BREB

(Debasish Chakrabortty)
PD, TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB

BM at GL for Wind Load on Grosbeak or Mallard & Pole in ft-lb & Min^{m} Plantation Depth Required for SYP Pole with Grosbeak & Mallard Conductor for Span 200′

Item No. & Pole Size	Pole Height In feet	Setting Depth in feet	BM at GL for Wind Load on Grosbeak ft-lb	BM at GL for Wind Load on Mallard ft-lb	BM at GL for Wind Load on Pole ft-lb	BM at GL for Wind Load on Grosbeak & Pole ft-lb	BM at GL for Wind Load on Mallard & Pole ft-lb	Design BM at GL on Working Load with safety factor 4, ft-lb	Main Dia of embedded portion, D in inch	Min^{m} Plantation Depth required for Grosbeak, t ft	Min^{m} Plantation Depth required for Mallard, t ft
1	2	3	4	5	6	7	8	9	10	11	12
R-43; 35′-N6	35	6.0	13302	14943	2242	15544	17185	12825	9.56	4.559	4.68
R-44; 35′-N5	35	6.0	13302	14943	2459	15762	17403	16200	10..4	4.483	4.60
R-45; 40′-N5	40	6.0	16225	18237	3588	19812	21825	19200	11.9	4.588	4.70
R-46; 40′-N4	40	6.0	16225	18237	3772	19996	22009	24000	11.8	4.604	4.72
R-47; 45′-N4	45	6.5	18855	21202	4914	23769	26116	27375	12.3	4.764	4.88
R-48; 50′-N4	50	7.0	21486	24167	6227	27712	30393	30750	12.7	4.907	5.02
R- ; 55′-N3	55	7.5	24116	27131	8343	32459	35474	42088	14.1	4.972	5.08
R-49; 60′-N2	60	8.0	26747	30096	10890	37637	40986	56250	15.5	5.038	5.15
35′-N4	35	6.0	13302	14943	2677	15979	17620	20250	11.2	4.414	4.52
35′-N3	35	6.0	13302	14943	2896	16198	17840	24975	12.0	4.351	4.46
40′-N3	40	6.0	16225	18237	4071	20295	22308	29600	12.6	4.546	4.65
40′-N2	40	6.0	16225	18237	4370	20594	22607	36000	13.4	4.492	4.60
45′-N3	45	6.5	18855	21202	5328	24183	26530	33763	13.3	4.693	4.80
45′-N2	45	6.5	18855	21202	5709	24564	26911	41063	14.0	4.643	4.75
50′-N3	50	7.0	21486	24167	6740	28226	30907	37925	13.7	4.840	4.95
50′-N2	50	7.0	21486	24167	7253	28739	31420	46125	14.6	4.779	4.89
55′-N2	55	7.5	24116	27131	8969	33085	36100	51188	15.1	4.914	5.02
60′-N2	60	8.0	26747	30096	10890	37637	40986	56250	15.5	5.038	5.15

As regards pole size from R43 to R48 is not suitable for 200 ft span. Pole size 35-3, 35-2, 40-3, 45-3, 50-3 & 60-2 are safe as regards the bending moment due to transverse load for span 200 ft. for both Grosbeak and Mallard conductor as column-9 is greater than column-7 & column-8. The pole R-49 and pole 55-3 are suitable for only Grosbeak conductor. Again setting depth of pole is higher than the required plantation depth for Grosbeak as well as Mallard conductor for span 200 ft. So each pole is also safe from overturning.

(Md. Mozibur Rahman)
Consultant TAPP BREP

(Md. Dulidul Islam)
Consultant, TAPP, BREP

(Md. Mozammel Huq)
Consultant TAPP BREP

(Md. Abdul Khaleque)
Consultant TAPP. BREP

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant,TAPP BREB

(Debasish Chakrabortty)
PD,TAPP, BREP

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB.

Embedment for SYP Pole:

By another equation, minimum plantation depth or embedment depth required for allowable working load can be determined. Followings are the equation-

$P = S_e D_e^{3.75})/ (L - 0.6096 - 0.662D_e)$	**SI Unit**	**Equation- 9.2**
$P = S_e D_e^{3.75})/ (L - 2.0 - 0.662D_e)$	**FPS Unit**	**Equation- 9.3**

Where:

P = Horizontal force in Newton(pounds), 0.6096 meters(2.0 feet) from the top of the pole which will just overturn the pole. If the total ground line moment is available, it can be found by dividing ground line moment with the lever arm less 0.6096 meters (2 feet) from the top.

S_e = Soil Constant.

1119.7 (140)) for good soil, 559.8 (70) for average soil, and 279.9 (35) for poor soil

D_e = embedment depth of pole in meters (feet)

L = total length of pole in meters (feet)

From the above equation, D_e i.e. embedment depth can easily be determined. The D_e calculated below considering worst case (i.e. if the soil is poor) with designed working load. But if the soil is of average quality or if the applied load is less than the allowable working load, required embedment depth will be much lower.

Table- 9.11A
Embedment for SYP pole

Item No. & Pole Size	Pole Height In feet	Designed Setting Depth in feet	Embedment depth just overturn the pole in feet D_e	Embedment depth of pole in meeter D_e	$D_e^{3.75}$ FPS system	Breaking load in lbs	Soil constant for poor soil	$P\times(0.662\times D_e)/S_e$	$P\times(L-2)/S_e$	Should be near to zero
1	2	3	4	5	6	7	8	9	10	11
R-43; 35′-N6	35	6.0	7.077	2.1575	1537.5	1900	35	254.31	1791	0.40
R-44; 35′-N5	35	6.0	7.510	2.2896	1922	2400	35	340.91	2263	-0.40
R-45; 40′-N5	40	6.0	7.883	2.3881	2250	2400	35	355.57	2606	0.11
R-46; 40′-N4	40	6.0	8.292	2.5281	2786	3000	35	470.52	3257	-0.56
R-47; 45′-N4	45	6.5	8.602	2.6226	3197	3000	35	488.10	3686	-0.57
R-48; 50′-N4	50	7.0	8.885	2.7088	3610	3000	35	504.16	4114	-0.47
R- ; 55′-N3	55	7.5	9.654	2.9432	4927	3700	35	675.60	5603	0.15
R-49; 60′-N2	60	8.0	10.424	3.1779	6570	4500	35	887.19	7457	-0.17
35′-N4	35	6.0	7.949	2.4235	2378	3000	35	451.05	2829	0.26
35′-N3	35	6.0	8.383	2.5558	2902	3700	35	586.67	3489	0.43
40′-N3	40	6.0	8.748	2.6671	3405	3700	35	612.21	4017	0.39
40′-N2	40	6.0	9.194	2.8030	4103	4500	35	782.54	4886	0.21
45′-N3	45	6.5	9.077	2.7674	3911	3700	35	635.23	4546	0.48
45′-N2	45	6.5	9.542	2.9091	4717	4500	35	812.16	5529	0.39
50′-N3	50	7.0	9.377	2.8588	4418	3700	35	656.23	5074	0.09
50′-N2	50	7.0	9.859	3.0058	5332	4500	35	839.14	6171	-0.49
55′-N2	55	7.5	10.152	3.0951	5951	4500	35	864.08	6814	0.50
60′-N2	60	8.0	10.424	3.1750	6570	4500	35	887.19	7457	-0.17

As the breaking load shown in column-7 is greater than the actual load, so with this breaking load in poor soil it requires deeper embedment as shown in column-4. Otherwise it will overturn.

Now if the soil is of average type and the designed load is consider, then the embedment depth will be-

Table- 9.11B

Embedment for SYP pole

Item No. & Pole Size	Pole Height In feet	Designed Setting Depth in feet	Embedment depth just overturn the pole in feet D_e	Embedment depth of pole in meeter D_e	$D_e^{3.75}$ FPS system	Breaking load in lbs	Soil constant for poor soil	$P\times(0.662\times D_e)/S_e$	$P\times(L-2)/S_e$	Should be near to zero
1	2	3	4	5	6	7	8	9	10	11
R-43; 35′-N6	35	6.0	5.923	1.8058	788.9	1900	70	106.43	896	-0.37
R-44; 35′-N5	35	6.0	6.290	1.9177	988.4	2400	70	142.77	1131	-0.25
R-45; 40′-N5	40	6.0	6.555	1.9985	1154	2400	70	148.78	1303	-0.23
R-46; 40′-N4	40	6.0	6.943	2.1168	1432	3000	70	196.98	1629	-0.05
R-47; 45′-N4	45	6.5	7.198	2.1945	1639	3000	70	204.22	1843	0.23
R-48; 50′-N4	50	7.0	7.430	2.2652	1846	3000	70	210.80	2057	.-0.44
R- ; 55′-N3	55	7.5	8.072	2.4610	2519	3700	70	282.45	2801	-0.26
R-49; 60′-N2	60	8.0	8.715	2.6570	3357	4500	70	370.89	3729	-0.29
35′-N4	35	6.0	6.661	2.0308	1225	3000	70	188.98	1414	0.08
35′-N3	35	6.0	7.028	2.1427	1498	3700	70	245.92	1744	0.00
40′-N3	40	6.0	7.327	2.2338	1752	3700	70	256.38	2009	-0.43
40′-N2	40	6.0	7.705	2.3491	2115	4500	70	327.90	2443	0.47
45′-N3	45	6.5	7.598	2.3165	2007	3700	70	265.86	2273	0.35
45′-N2	45	6.5	7.990	2.4360	2424	4500	70	340.03	2764	-0.15
50′-N3	50	7.0	7.845	2.3916	2263	3700	70	274.49	2537	0.01
50′-N2	50	7.0	8.251	2.5155	2735	4500	70	351.14	3086	0.06
55′-N2	55	7.5	8.492	2.5889	3046	4500	70	361.38	3407	0.24
60′-N2	60	8.0	8.715	2.6570	3357	4500	70	370.89	3729	-0.29

With average soil, while load is as per column-7, most of the pole required embedment more than column-4.

Deflection of SYP Pole:

The maximum fiber stress for tangent wood poles should not exceed 25% of the ultimate strength at the ground line or at the point of guy attachment, where guys are installed.

When a horizontal force is applied near the top an of an unguyed pole, the top of the pole will deflect. The equation used for finding the deflection of pole is as follows-

(Md. Mozibur Rahman)
Consultant TAPP BREB

(Md. Duhidul Islam)
Consultant, TAPP BREB

(Md. Mozammel Huq)
Consultant, TAPP, BREB

(Md. Abdul Khaleque)
Consultant,TAPP, BREB

৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Md. Ahsanul Haque)
Consultant,TAPP, BREB

(Debasish Chakraborty)
PD,TAPP BREB

(Kamrul Ahsan Mollik)
Asst. Secy. (Board), BREB