Advances in UHV Transmission and Distribution
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Lecture – 21
Design Optimization for UHV towers

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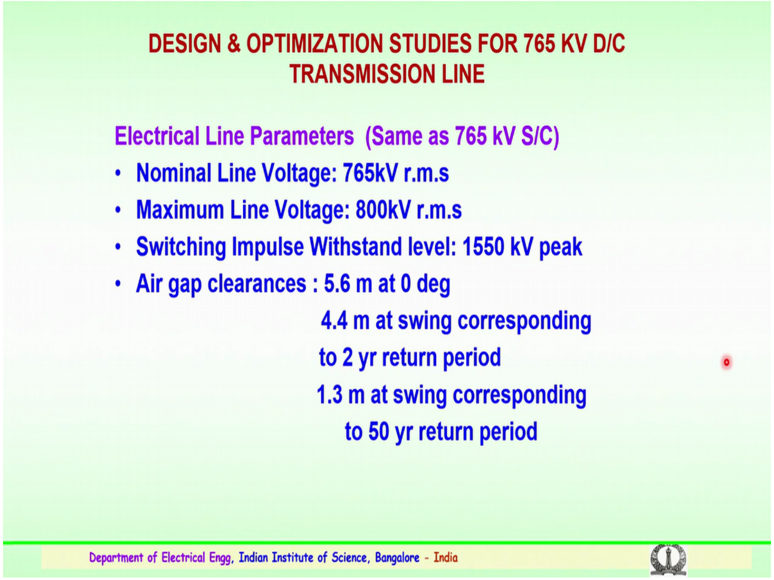

So, how the design and optimization studies were carried out for the first line, so electrical line parameters was similar to a 765kV single circuit line. This was; when the line or thought for the double circuit, so what was the optimization which was done and how the idea was used for the similar idea for the single circuit, there is C is the single circuit, DC is the double circuit. So, design optimization for 765kV double circuit transmission line was with reference to the single circuit line data which was available.

So, the nominal voltage again 765kV and maximum operating voltage was 800kV, switching surge was similarly in single circuit 1550kV peak was applied. The air gap clearances 5.6 meter at 0 degree 4.4 meter at swing corresponding to 2 year return period and 1.3 meter at swing corresponding to 50 year return period was adopted.

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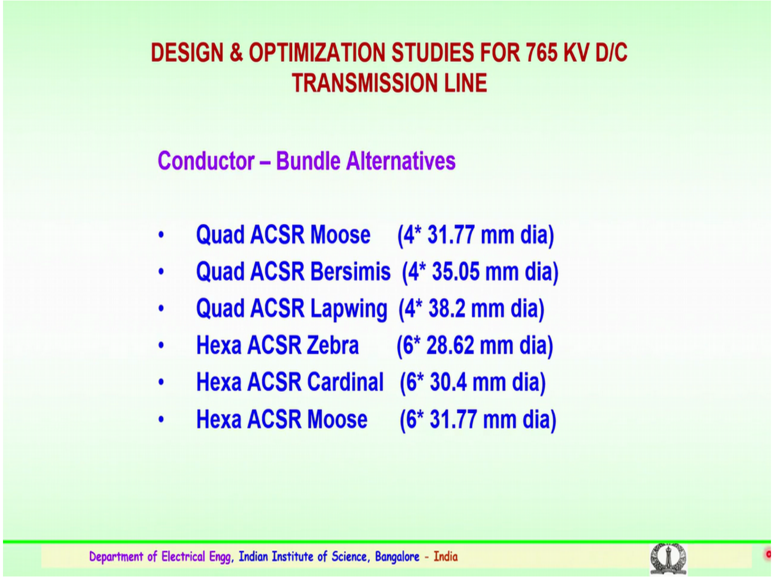

And conductors bundle alternatives, which were employed for the double circuit again the data was from the previous single circuit lines and here the adoption for double circuit was they have adopted quadruple that is a 4 conductor ACSR; all aluminum steal reinforce, the moose conductor. The moose is 31.77 is a diameter of the conductor 4 being; 4 conductors of 31.77 dia were used, when the moose were employed.

Similarly, many alternatives are were tried out; they have also used quadruple that is a four ACSR Bersimis conductor; again Bersimis being 35.05 mm. Further lapwing conductor of 38.2 mm dia, Zebra of 28.62; here they use 6 conductors. You can see the hexagonal arrangement of zebra conductors with dimension of 28.62 was employed. Similarly, hexagonal is ACSR cardinal conductor of dia cardinal conductor is 30.4 mm dia and further hexagonal ACSR moose conductor was also tried out.

So, several of this combination with 4 conductors here moose; there is a quadruple what we call, the hexagonal arrangement also was tried out for the better optimization. So, studies were conducted for double circuit and lot of data was available so that before the actual construction of the tower and before actual stringing, this has helped for the proper optimizing the various combinations.

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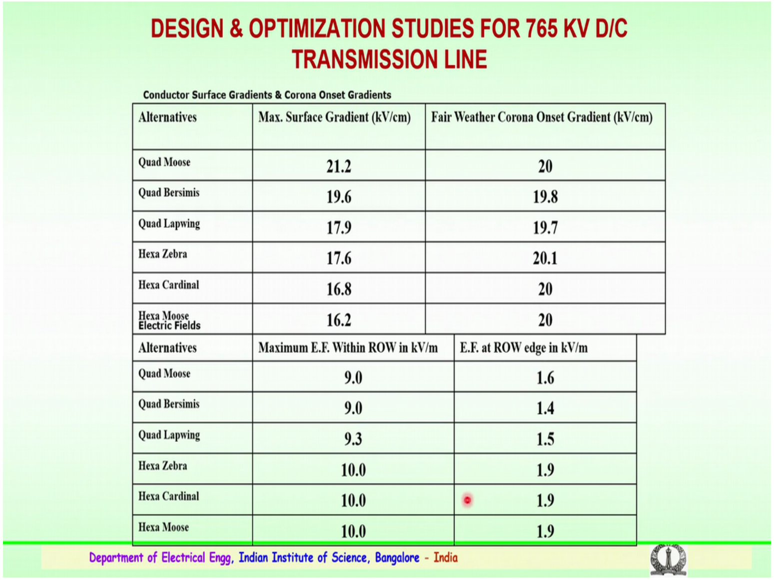

DESIGN & OPTIMIZATION STUDIES FOR 765 KV D/C TRANSMISSION LINE

Conductor Surface Gradients & Corona Onset Gradients

Alternatives	Max. Surface Gradient (kV/cm)	Fair Weather Corona Onset Gradient (kV/cm)
Quad Moose	21.2	20
Quad Bersimis	19.6	19.8
Quad Lapwing	17.9	19.7
Hexa Zebra	17.6	20.1
Hexa Cardinal	16.8	20
Hexa Moose	16.2	20

Electric Fields

Alternatives	Maximum E.F. Within ROW in kV/m	E.F. at ROW edge in kV/m
Quad Moose	9.0	1.6
Quad Bersimis	9.0	1.4
Quad Lapwing	9.3	1.5
Hexa Zebra	10.0	1.9
Hexa Cardinal	10.0	1.9
Hexa Moose	10.0	1.9

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So, design and optimization which was carried again for 765kV double circuit transmission line, gives the values maximum surface gradient which is given here kilo volt per centimeter and fair whether corona onset voltage kV per centimeter. So, this is maximum surface gradient, this is clean condition the onset that is inception corona gradient which is in kV per centimeter. Again for various type of conductor alternatives that is using 4 conductor quad most type of conductor, Quadruple Bersimis, Quadruple Lapwing, Hexagonal six conductor Zebra, six conductor Cardinal or hexagonal moose type of conductor.

Several of this options were tried out and you can see the surface gradient studies which have been conductor; show the values from 21.2 to 16.2 kV per centimeter and the corona onset gradients were seen to be anywhere between 19.7 to 20.1kV per centimeter.

So, further the electric fields were also tried to measure sorry studies, this electric fields with various again conductor combinations were tried to see and the values which are reported here. The maximum electric field within the right of way in kV per meter and electric field at right of way edge; what was the edge. So, within inside and outside at the edge are the values are given for various conductor configuration, so for moose with 4 conductors 9 kV per meter.

In case of Bersimis again it is 9; lapwing it is 9.3 the hexagonal zebra; it is 10kV per meter, further cardinal and moose also have given the similar values of 10. Here the reputation of electric field at right of way edge in kV per meter gives anywhere between 1.6 or 1.4 in case of bersimis with this is slightly higher diameter conductor and lapwing becomes much more, but the values shows 1.5, further hexagonal arrangement the right of way edge, the electric field may estimated was seen to be 1.9 kV per meter. So, these are design and optimization studies which have been carried out for double circuit 765kV transmission a line.

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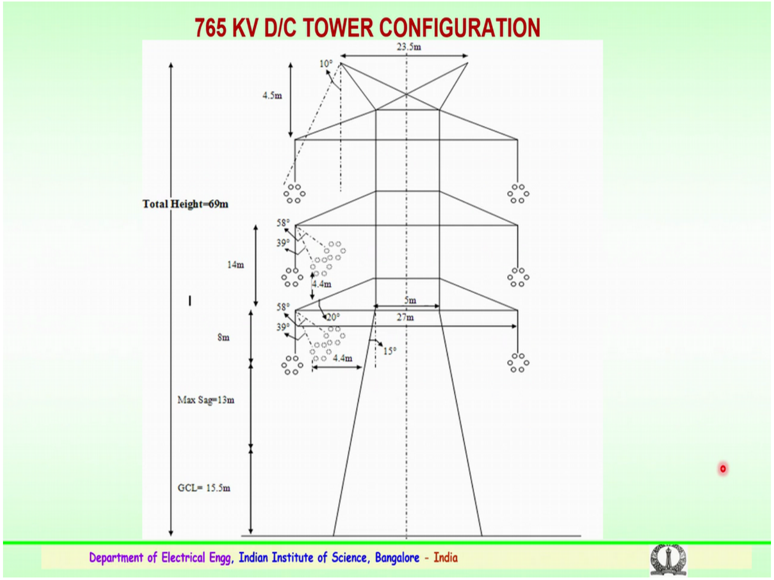

So, this gives the line diagram of the tower configuration of 765kV DC tower which is been used. So, you can see the total height and the maximum sag which would be and the minimum clearances and number of conductors which are employed the hexagonal type of arrangement you can see and what is a minimum clearances from the ground to the phase metal part; that is a tower edge minimum of 4.5 and the ground to ground is 23.5 meters.

So, this is how the typical 765kV; double circuit tower configuration was designed or estimated for the construction.

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This is again for same first project which was executed from Kishenpur to Moga; the 765, 800kV horizontal configuration. This was the first towers which were constructed with 85 meter right of way, various tower configuration; so, in towers we have different types A, B, C, D and various configurations. So, this first shows the tension arrangement V suspension string, here it shows tension arrangement. So, these are various configuration for 800kV of tower type a; this is a tower type a and this is tower type d, so various configuration for a single circuit transmission system.

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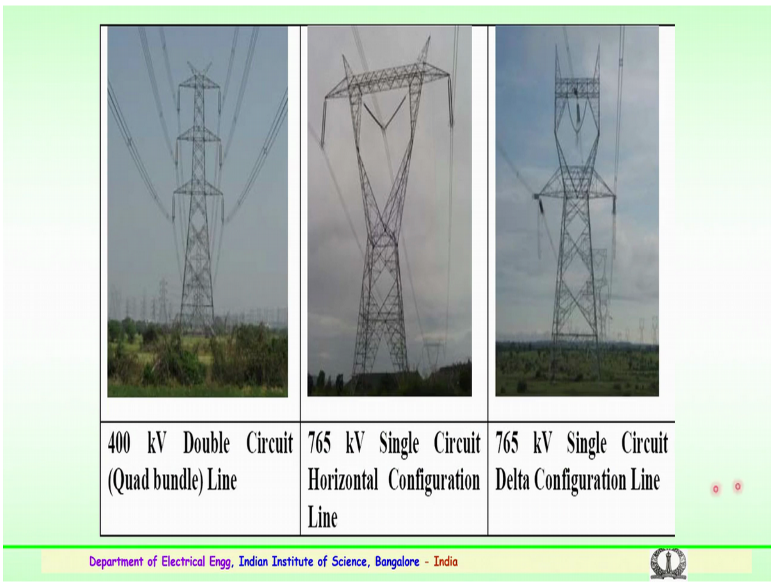

This shows a 400kV, a double circuit you can see double circuit again r Y b or 3 conductor in one arm; 3 more conductors has another set. So, this is entire thing a single circuit one more circuit double circuit; each phase again consisting of 4 conductor bundles. So, that is what quadruple bundle in; so, this entire 4 conductor bundle forms a single phase. You have two circuits here; this is again a tower configuration for 765kV single circuit with horizontal configuration as shown.

This is at typical delta type of configuration, again for the 765kV. So, lot of modifications, design aspects have been carried out over the period and the optimization has been done this is mainly to see the right of way; which is 85 meters, which is required for 765kV could be reduced. So, the tower configuration, the advances in the technology going in for different towers have also parallely happened, lot of work has been conducted in this to reduce the overall weight, the economy and also the distance that is a right of way has been carried out.

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So, this is again a example of delta vertical single circuit tower here, this is again delta vertical arrangement for a double circuit tower. This is important the represent transmission system in the country is being witnessing a lot of advances are happening.

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So, we are talking about 765kV transmission in the country, so now the power requirement has drastically gone up. So, lot of long distance transmission both at ultra high voltage AC and ultra high voltage DC lines are being constructed and several advantages in going for a long distance DC transmission. So, 800 kilovolts DC lines are being constructed across the country and DC and AC transmission of 1200 kV also is being thought for lost 4 to 5 years.

Presently we have an experimental facility at Bina in Madhya Pradesh where 1200 kV test line is being energized and this facility in conjunction with power utilities manufactures and the RND institution is being carried out for period of 4 years and the experimentation for all these equipments insulator strings the conductors, the towers are being done. So, very important for the ultra high voltage transmission; very soon we will be able to see the 1200 kV transmission in AC in the country.

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So, this is a representative tower which is used for a single circuit and double circuit. So, such a big gigantic tower with lot of right of way clearances has to be a maintained, so lot of technology improvement aspects are advances in the high voltage and ultrahigh voltage transmission, do cater the needs of the requirement of power and also domestic and also the industrial requirements.

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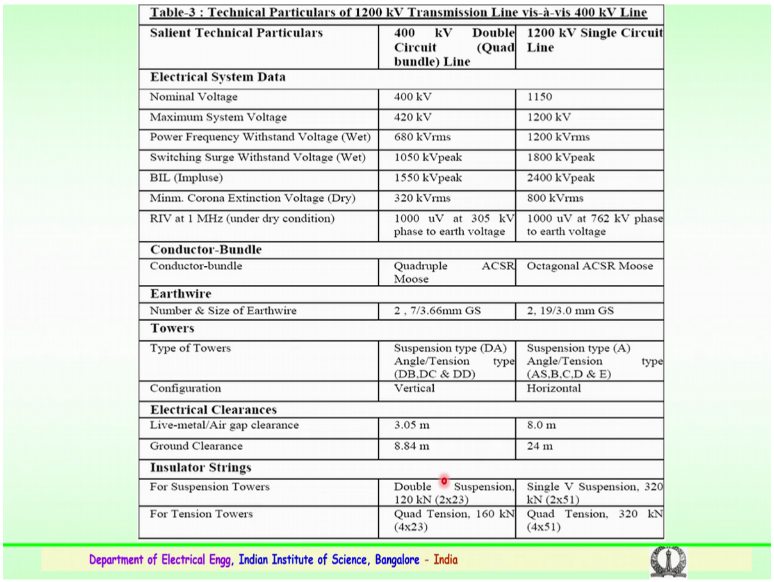

Table-3 : Technical Particulars of 1200 kV Transmission Line vis-à-vis 400 kV Line

Salient Technical Particulars	400 kV Double Circuit (Quad bundle) Line	1200 kV Single Circuit Line
Electrical System Data		
Nominal Voltage	400 kV	1150
Maximum System Voltage	420 kV	1200 kV
Power Frequency Withstand Voltage (Wet)	680 kVrms	1200 kVrms
Switching Surge Withstand Voltage (Wet)	1050 kVpeak	1800 kVpeak
BIL (Impluse)	1550 kVpeak	2400 kVpeak
Minm. Corona Extinction Voltage (Dry)	320 kVrms	800 kVrms
RIV at 1 MHz (under dry condition)	1000 uV at 305 kV phase to earth voltage	1000 uV at 762 kV phase to earth voltage
Conductor-Bundle		
Conductor-bundle	Quadruple ACSR Moose	Octagonal ACSR Moose
Earthwire		
Number & Size of Earthwire	2 , 7/3.66mm GS	2, 19/3.0 mm GS
Towers		
Type of Towers	Suspension type (DA) Angle/Tension type (DB,DC & DD)	Suspension type (A) Angle/Tension type (AS,B,C,D & E)
Configuration	Vertical	Horizontal
Electrical Clearances		
Live-metal/Air gap clearance	3.05 m	8.0 m
Ground Clearance	8.84 m	24 m
Insulator Strings		
For Suspension Towers	Double Suspension, 120 kN (2x23)	Single V Suspension, 320 kN (2x51)
For Tension Towers	Quad Tension, 160 kN (4x23)	Quad Tension, 320 kN (4x51)

So, this gives some technical particulars of the 1200 kV transmission line; in comparison to the 400kV transmission system. You can see the electrical system data here whereas, technical parameter which are been given here. This column gives the details of the technical accepts for a 400kV double circuit; 4 bundle conductor, that is a 4 bundle quadruple bundle transmission line and the final column here it gives the details of the technical accepts for the 1200 kV; a single circuit line are comparison could be made and the advantages could be summarized.

Here in case of electrical system data, you see the nominal operating voltage being 400. here it is 1150 kilovolts maximum system operating voltage is 420kV, here it is 1200 kilovolts for 1200 kV system. The power frequency withstand wet that is during the rain condition the insulation requirement 680kV at fifty hertz, here it is 1200 kV RMS.

Switching surge withstand voltage requirement is 1050 kilovolts peak that is a wet condition; here 1800 kilovolts peak is a required for switching surge. Lightning impulse or the basic insulation level are required for 400kV is 1550kV peak; whereas, for 1200 kV it is 2400kV peak and the minimum corona extinction voltage in case of laboratory dry conditions, claim conditions requirement is 320 in case of 400kV and for 1200 kV, the requirement is 800kV.

So, 800kV or 810kV is a minimum required corona extinction voltage under laboratory conditions. So, the RIV or Radio Interference Voltage measured at 1 megahertz under dry conditions could never exist 1000 micro volts at 305kV between phase to earth voltages. This is again same for 1000 micro volts at 762kV phase to earth, so at 305; 1000 micro volts is permitted. Even at 765; 1000 micro volts. How good is the hardware is very important, the conductor’s hardware; the corona control rings, the proper design plays a role here as the voltage level goes higher, the radio noise; audible noise have to be at the same level similar to a 400kV or a 765kV system.

So, conductor bundles what type of conductors here 4 conductor that is a quadruple; 4 conductors all aluminum conductor steel reinforcement, moose type of conductor is being used. Here octagonal 8 conductors of ACSR moose are being used for 1200 kV, earth wire; number of earth wires and size for 400kV typically 2 numbers of earth wire with 7 strands of 3.6 mm dia of galvanized steel are used. Similarly, for 1200 kV again 2 numbers of earth wires with 19 strands of 3 mm dia are being used of galvanized steel.

So, towers what type of towers in comparison to 400 and 1200 you can see; types of towers either if it is a suspension type; type known as DA is used for 400, for tension used DB, DC and DD. These are the various types used for tension configurations, for suspension in case of 1200 kV tower type A is used and for tension tower types of AS, BC, D and E are employed. So, configuration either for 400kV; it is vertical configuration here it is horizontal configuration of the towers. What are the electrical clearances important; so, electrical clearances live metal that is a conductor or the corona control rings of the conductors, the minimum air gap clearances have to be maintained is 3.05 meters in case of 400kV and in case of 800kV; it is minimum of 8 meters that is around 24 feet.

So, the ground clearances very important for 400kV towers and the ground clearances is 8.84 meters is the minimum ground clearance to be employed and in case of 1200 kV towers, the minimum distance is 24 meters; anywhere around 75 feet is the minimum requirement for 1200 kV. So, very important point; insulator strings the type of insulator strings which are employed both for suspension towers and tension towers are follows. For suspension towers; 120 mechanical strength that is a Kilo Newton insulators of 2 into 23 insulator; 23 is a number of insulator; 2 strings of 23 are employed; double suspension two vertical suspension consisting of 23 insulators in each arm are used and for case of single V suspension, we have to consider 320 kilo Newton mechanical strength; again with 2 arms of 51 insulator each for 1200 kV are used. So, for tension 4 conductors 160 kilo Newtons of 23 insulator; that is 4 into 23; parallel strings of consisting of each consisting of 23 insulators 4 into 23 employed; for a 1200 kV it is 4 into 51.

So, 200; 4 insulators in one quadruple string of 1200 kV; you can imagine, so 200 insulators; each insulator typically ways around 12 to 15 KGs. So, you can estimate the total weight of an insulator string including the line hardware, the yoke clade, the corona control rings near the tower. So, every important aspects these are is to be consider for the mechanical loading of the tower, the estimation of the tower, the height the clearances so on so forth.

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So, now coming to HVDC towers; there is a difference in case of a HVAC transmission line and HVDC transmission line. So, here the configuration varies with the load requirement; mechanical load changes here the conductors are employed or a different and the tower configuration also changes depending upon the clearances. So, these towers which are indicated here or for the high voltage DC transmission system; so, we have earlier looked into the AC transmission tower.

So, there is a design a change in comparison with AC transmission; so, this typically are used for plus minus 500 kilovolts; the details of the technical details will be looking into this.

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Table-1 : Technical Particulars of +/- 500 kV HVDC Lines	
Conductor-Bundle	
Conductor-bundle	Quad ACSR Bersimis/ Lapwing (457 mm spacing)
Towers & Span	
Type of Towers	Suspension type (A) Angle/Tension type (B,C & D)
Normal Span	400 m
Electrical Clearances	
Live-metal clearance	3.75 m
Pole to Pole Spacing	12.5 – 13.5 m
Ground Clearance	12.5 m
Insulator Strings	
For Suspension Towers (V – V)	Single V Suspension, 160/210 kN (2x38/41)
For Tension Towers	Quad Tension, 160/210 kN (4x38/41)

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So, you see the technical particulars, particularly for plus minus 500 HVDC lines which we have seen here; the tower clearances, the tower details, number of insulator strings, number of conductors which are being employed are given here. So, the conductor bundle employed in case of 500kV, plus minus configuration for HVDC transmission is again 4 conductor bundle.

You can see the 4 conductors in a bundle are here; the 4 conductor bundle is employed with aluminum conductor steel reinforced either Bersimis or Lapwing conductor is employed with each conductor bundle space at 457 mm spacing. What type of towers and the span; again the type of towers for 500kV system, for HVDC transmission is suspension type; A type of towers or in case of tension B, C and D are normally employed.

For the normal span is 400 diameters that is the tower distance used for 500kV HVDC is 400 meters. The electrical clearances from the metal part that is live metal clearances from the conductors is minimum of 3.75 meters. Then pole to pole spacing is 12.5 to 13.5 meters. So, that is the pole to pole spacing that is one to other is 13.5 meters and the ground clearances is minimum ground clearances from the conductor; that is from the conductor to the ground. This minimum clearances is used is 12.5 meters for 500kV transmission HVDC towers.

So, for what the insulators which are being used without for various configuration the use suspension type for towers either V configuration; single V or a double V in case of single V 160 kilo Newton and 210 kilo Newton insulators consisting of 2 arms 1 V is 1 arm other V other side is 1 more arm; consisting of 2 arms of either 38 insulators of 160 kilo Newton or 41 of 210 kilo Newton are normally used. It should be 38 of 210 and 41 of 160 kilo Newton.

So, you have to consider 2 arms of this insulators being used; for suspension for tension towers again 4 conductor bundle quadruple tension is employed here again 160 and 210 kilo Newtons are insulators are used; in case of 210 kilo Newtons; 38 numbers will be used and in case of 160; 41 will be used. We have to consider that 210 is 38; 160 is 41 of 4 strings. So, 4 strings parallely consisting of 38 numbers will give you 210 kilo newton for a tension of 500kV plus minus HVDC towers.

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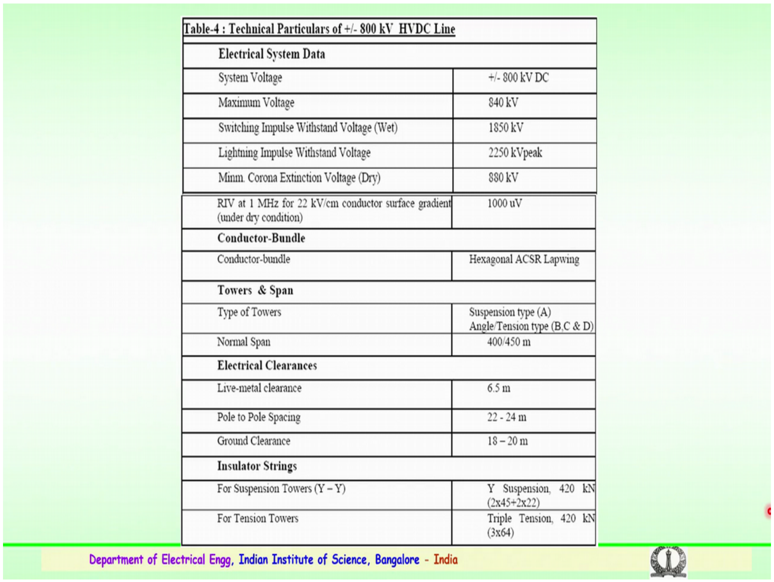

Table-4 : Technical Particulars of +/- 800 kV HVDC Line	
Electrical System Data	
System Voltage	+/- 800 kV DC
Maximum Voltage	840 kV
Switching Impulse Withstand Voltage (Wet)	1850 kV
Lightning Impulse Withstand Voltage	2250 kVpeak
Minm. Corona Extinction Voltage (Dry)	880 kV
RIV at 1 MHz for 22 kV/cm conductor surface gradient (under dry condition)	1000 uV
Conductor-Bundle	
Conductor-bundle	Hexagonal ACSR Lapwing
Towers & Span	
Type of Towers	Suspension type (A) Angle/Tension type (B,C & D)
Normal Span	400/450 m
Electrical Clearances	
Live-metal clearance	6.5 m
Pole to Pole Spacing	22 - 24 m
Ground Clearance	18 – 20 m
Insulator Strings	
For Suspension Towers (Y – Y)	Y Suspension, 420 kN (2x45+2x22)
For Tension Towers	Triple Tension, 420 kN (3x64)

So, this is the technical particulars for plus minus 800kV; HVDC line earlier we have seen plus minus 500kV transmission towers. So, now we have recently energized from Agra to Arunachal Pradesh 800kV HVDC line, which can carry the power of 6000 megawatts. So very important advances or the advancement in the high voltage DC transmission technology which has happened in the country.

So, this plus minus 800kV HVDC transmission line has following electrical system parameters. The system voltage is operating is plus minus 800kV DC; the maximum voltage again is 840kV for 800kV system. The switching surge or the switching impulse withstand that is for rain condition or wet condition is 1850 kilovolts and in case of lightning impulse or lightening surge with stand voltage is 2250 kilovolts peak DC.

The minimum corona extinction voltage should not be less than 880 kilovolts for a 800kV transmission and RIV at 1 mega hertz for 22kV per centimeter conductor surface gradient, under dry condition should not exceed more than again 1000 micro volts. So, the voltage level increases the radio noise is; again restricted to 1000 micro volts. The conductor bundle which is employed is again hexagonal consisting of aluminum conductor steel reinforcement; Lapwing is 38 mm dia conductor hexagonal is 6 conductor of ACSR Lapwing conductor.

So, towers type of towers employed in case of suspension configuration A and for tension B, C and D are adopted for the 800kV HVDC line. The typical span that is normal span from tower to tower used these between 400 to 450 meters; the normal span which is used for this line. The electrical clearances minimum metal clearances from the conductor to any of the other side is 6.5 meters. Then pole to pole spacing here is anywhere between 22 to 24 meters, the ground clearances is between 18 to 20 meters.

So, 18 meter is minimum and which is employed and insulator strings which are adopted for 800kV DC transmission or of Y suspension type consisting of 420 kilo Newton mechanical strength consisting of 2 arms of 45 and 2 arms of 22. So, this is a Y configuration which consists of the V and suspension Y; it can be assumed as V and suspension. So, V 2 into 45 and this I is 2 into 22, so this number of insulators of 420 kilo Newtons are being used for the tower and in case of tension tower, we have a triple tension 3 conductors consisting of 420 kilo Newton mechanical strength employing 64 insulators in each arms, so 64 into 3 are used for 800kV a line transmission line.

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So, this is the line which I was mentioning very recently this line was energized plus minus 800kV HVDC, this is from Biswanath Chariyali that is in Arunachal Pradesh and the line reaches Agra. So, Arunachal Pradesh to Agra is a line which is more than 2000 kilometers length and which carries a power of 6000 megawatts, so very important advancement in the country which is transmitting the power at very high rating. So, 6000 megawatts is power capability where this line could carry and it is being energized very recently.

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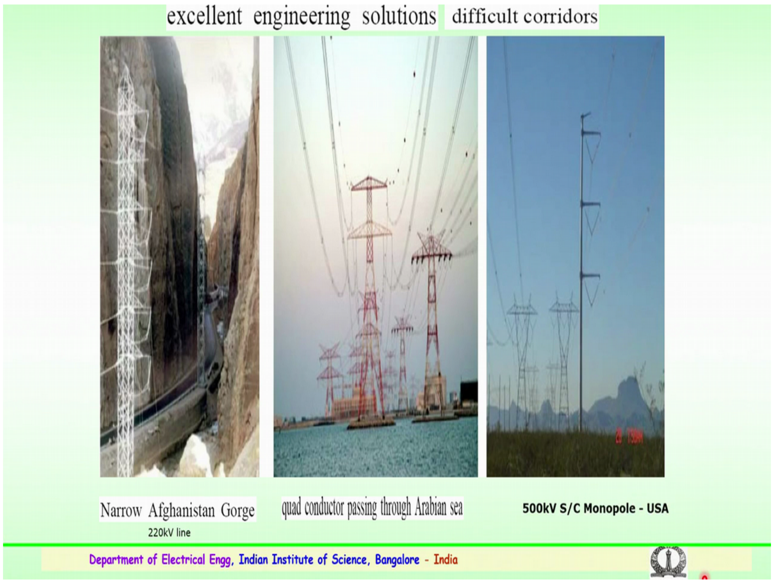

So, what happens in case of the towers or the transmission has to be carried out at various location which are very difficult like a normal flat conditions. So, again the engineering have to be looked into about the configuration, a proper estimation of the clearances these things have to be different in case if it is mountain area and the tower has to passed in between mountains rocks so that time the configuration do changes and you have to adopt different type of technology for transmission of power.

These are few examples which are being employed across the globe and doing the various locations particularly in the mountains part this and in case if it has to pass through the sea. So, the tower configuration how it is being employed, so these are few examples; which are normally deviation to the calculation which we have discussed till now for the 760 for 800 for the lower voltage levels. So, such cases a special design aspect have to be considered and the estimation have to be done and the configuration of the towers have to be thought.

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Voltage	400 kV	765 kV S/C	765 kV D/C	500 kV HVDC	800 kV HVDC	1200 kV
ROW (m)	46	64	70	52	70	90
Capacity (MW)	600-700	2500-3000	5000-6000	2000-2500	6000-6400	6000-8000
MW/m	15	45	65	48	90	90

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So, this again is a reputation of the thing which have mentioned earlier the slide, which shows the important of the various voltage level, you can see here very important. So, from the 400kV, 765kV, single circuit 765kV, double circuit 500 kV HVDC, 800kV HVDC and 1200 kV AC. So, comparison for the right of way in meters, you can compare 46 meters is a minimum requirement for 400kV, transmission for 765kV single circuit minimum requirement of 64 meters for 765kV; double circuit the requirement of the right of way 70 meters and 500kV DC; HVDC is 52 meters 800kV HVDC it is 70 meters.

So, not much of difference in right of way between the 765kV double circuit and 800kV HVDC and in case of 1200 kV HVAC; it is 90 meters; is a minimum right of way. So, now we look into the power capability that is the power transfer capability of the transmission lines. Now, we can very clearly see the capacity where a 400kV transmission system could carries 600 to 700 megawatts is the maximum and if it is a 765kV with single circuit; anywhere between 2500 to 3000 is a maximum power it can carried and for double circuit 6000 or 5000 anywhere between two circuit; that is single circuit of 2000 becomes 5000 or 3000 become 6000, so this is 5000 to 6000 is the double circuit 765kV. What happens in case of HVDC? You can see that the power at 500kV could be 2000 to 2500.

So, the high voltage AC transmission at 765kV; the power carrying capability is almost equal into 500kV DC system carry similar amount of power. That is one of the reason for long distance transmission high voltage DC becomes much more economical, after 400 kilometers line length; that is where the advantages of going in for higher DC to transfer large junks of power for long distances.

So, HVDC becomes much more economically you can see here; in case of 800kV that is a similar comparison to 800kV double circuit line, you can see 800kV HVDC line almost could carry 6000 to 6400 megawatts; this is what the recently line which is coming from Arunachal Pradesh to Agra has been energized and which can transmit power of 6000 megawatts.

So, in case of 1200 kV again you can transmit the power 6000 to 8000 megawatts, so this is the how the information is very important and what is the megawatt per meter; this again gives the idea for 400kV; it is 15 megawatt per meter. If you compare, you can see for 765kV; it is 65 megawatt per meter and for HVDC, it is 90 megawatt in comparison to the 1200 kV. So, this figures give an idea that HVDC importance and going in for HVDC becomes much more economical that is where for long distance; HVDC is much preferred in comparison to the HVAC transmission systems.

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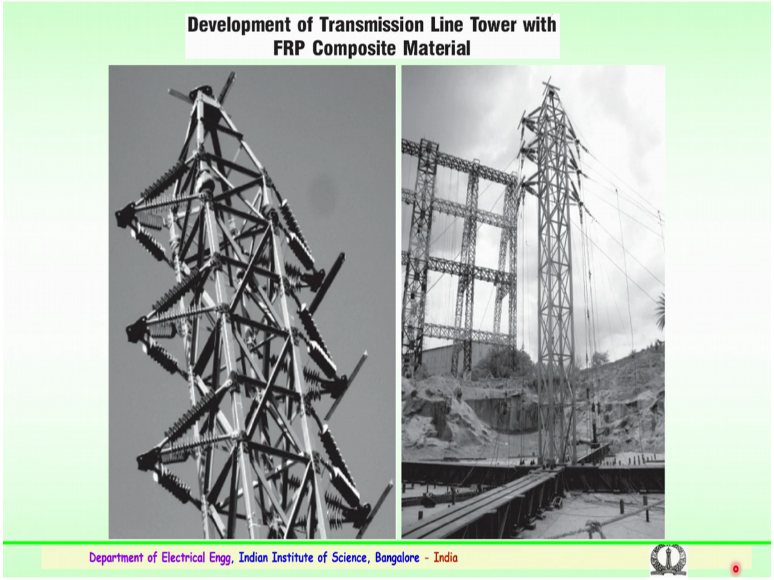

So, some developmental aspects particularly for transmission line towers, so lot of changes are being happening, lot of research activities is being conducted to bring down the mechanical strength and mechanical steel structure. So composite type of materials are also being tried out for the high voltage towers so that the weight of the material could be reduced and the tower economy not only the construction the mechanical load, the cost could be reduced. So, lot of activity is also going towards this end for the development of fiber reinforced plastic composite material being adopted. So, research is in progress towards especial towers for very high voltage and, but for transmission systems.

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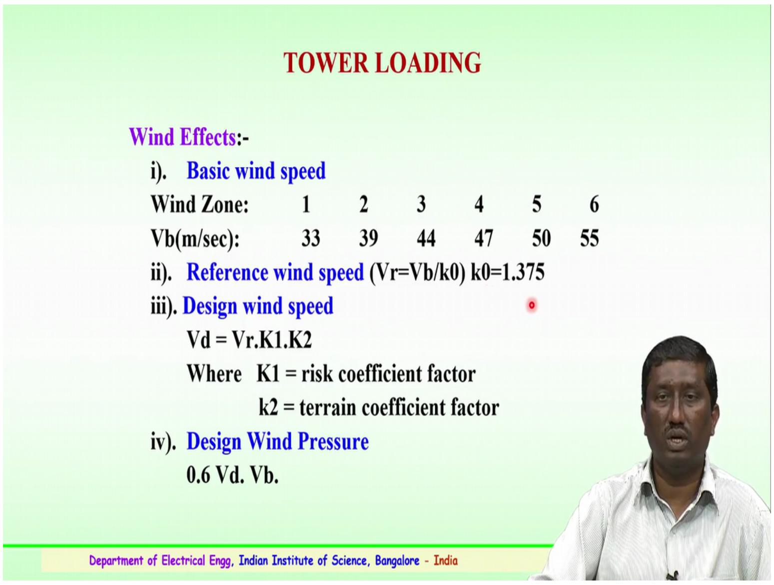

So, how to consider the tower loadings very important aspects we have discussed about the conductor mechanical loads, insulator strings, the wind effects, some of the zones where the transmission towers are been constructed. So, these wind effects for the tower loading have to be considered before the estimating the actual tower loading apart from the insulators, the line conductors, several accessories, wind aspects.

So, this gives an idea for the basic wind speed; again the wind zones you have categorized the wind zones have been categorize under 6 different zones. So, this is the velocity which it sees per second; that is meters per second, where it is given the figure stating depending upon the wind zone to the various locations and the reference wind speed is typically given as Vr being equivalent to Vb by k naught; where k naught is assumed to be 1.375 and for designing the wind speed; the factor Vd winds is equivalent to Vr and k 1 and k 2 are the factors; k 1 being the risk coefficient factor and k 2 being the terrain coefficient factor; what type of terrain whether (Refer Time: 33:47) or it is been flat or it is a mountains area.

So, these factors have a suitable factors to be considered for the tower loading. Then design of wind pressure considered is 0.6 into Vd and Vb which are specified for various zones, this particular values are assumed and the effect of total tower loading is estimated.

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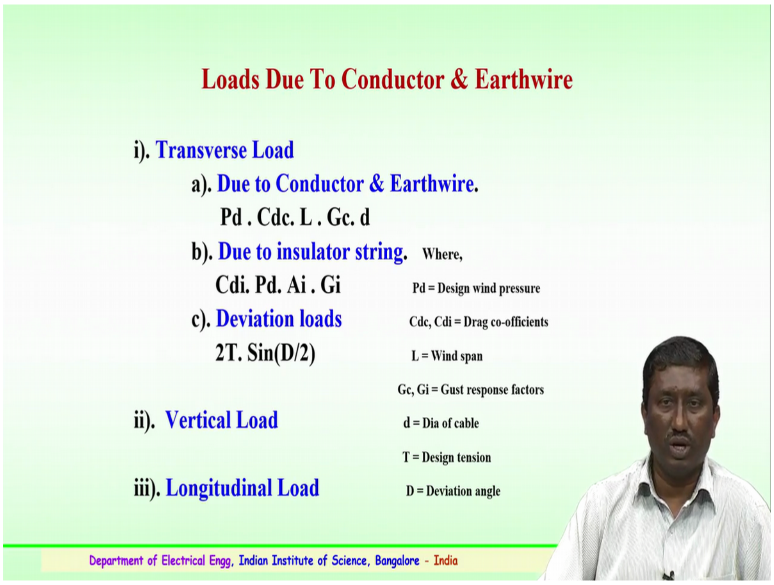

And the loads due to conductor earth wire and insulator strings have also to be considered. Again this type of loads whether the loads are towards the transfers load or it is due to the conductor and earth wire or due to the insulator string or due to the deviation of the loads because of the wind at that area, what type of vertical loads or it is loads because of longitudinal compression tension.

So, several of these aspects have to be considered for the total estimation of the loads which the tower has to take in case of the regular operation and also in case of the over loading aspects. So, several of this factors which are very clearly defined the Pd being the design wind pressure; at that location where the tower is situated Cd; C and the Cdi being the drag coefficients because of the wind, L being the wind span.

Then Gc and Gi being the guest response factor and d being the diameter of the conductor and T being the design tension and d being the deviation angle where the conductor swings. So, several of this factors have to be considered to estimate the actual load where the tower seas and so depending upon the tower loading unnecessary foundations have to be thought and estimated so that several of these factors have to be considered before foundation aspects.