**Advances in UHV Transmission and Distribution**
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**Lecture - 22**
**Introduction to 1100kV HVDC**

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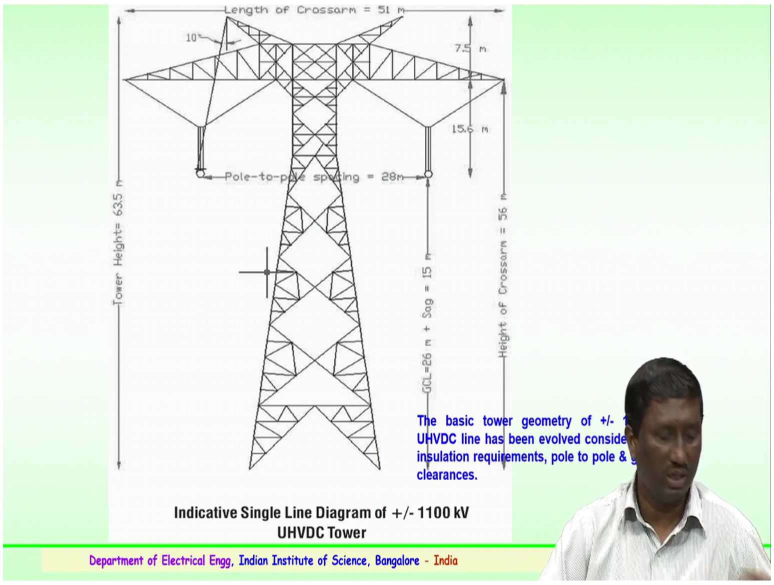


This is again further we were discussing about the 800 kilo volts DC line a 1200kV AC line. So, further in the country there is a thought, where the HVDC lines for long distance transmission are much more economical and more power could be transferred going in for HVDC lines. So, it is thought by the utility and the government to further in case of large power transfer. So, going in for 1100 kilo volts UHVDC; Ultra High Voltage DC could be much more economical and how beneficial to the country.

So, for the considering this point a study has been conducted and research is in progress experimental have to be proved before actual commissioning of the 1100 kV towers on transmission UHVDC transmission. So, a brief idea what is thought which in case if a 1100 kV UHVDC transmission is to be conducted the benefits of going in for this. This shows a single line diagram of plus minus 1100 kV, the minimum total height of the tower as been shown around 64 meter 63.5 meters is approximate estimated length and several clearances the minimum clearances from the metal to the conductor all these are indicative single line diagram, this is not yet being taken up in a full scale. So, preliminary design aspects are under progress by the government.

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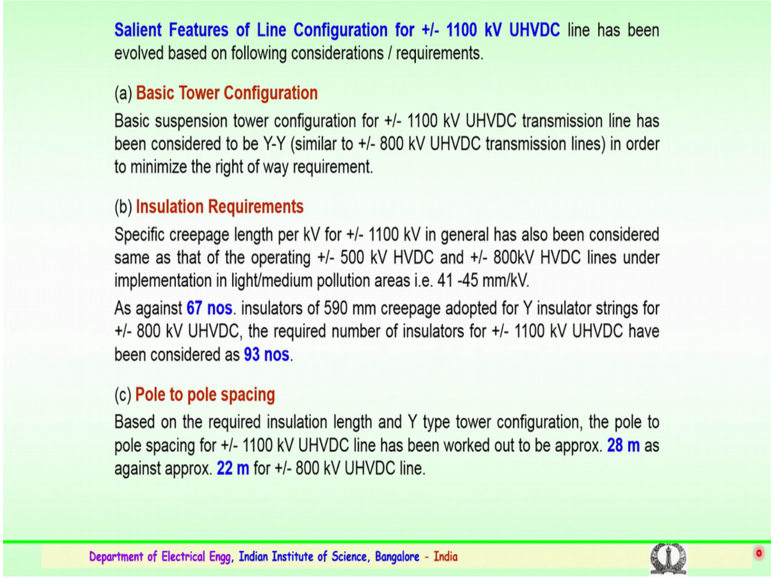


Some information pertaining to this; so, the salient features going in for a 1100 kV UHV line has been evolved based on the consideration some requirements. So, what are the basic requirements of a tower configuration; so, the basic suspension tower particularly for 1100 kV, a ultra high voltage DC transmission to be considered should be of a Y-Y configuration, similar to plus minus 800 kV which is being presently used; this will minimize the right of a requirement if you going for this Y type of configurations.

Second is insulation requirements very important, the specific creepage per kilo volt for plus minus 1100 kV has to be considered same that of operating of plus minus 500kV DC or plus minus 800 kV lines which are under implemented like at different pollution zones light, medium areas which are normally assumed to be 41 to 45 mm per kV in case of medium or light pollution.

Here the 67 insulators of 590 mili meter creepage are being used for a Y type of insulator strings for 800 kV. In case of 1100, you may have to use 93 numbers of insulators, so the insulators number will increase; the clearances will increase, the pole to pole spacing for 800 kV is typically 22 meters; which is being followed presently. If you go for 1100 kV the pole to pole will be approximately 28.

So, several of these things have been as are under study and estimated so that information is required in case if you go for 1100 kV, a lot of manufactures have to come across; in India again manufacturing the equipment at this level is very very important. So, further maybe decades so a 1100 kV HVDC line could be transmitting the power much more than the 6000 or 6500 megawatts; which is being used by 800 this will definitely be much more helpful for transmission large sense of a power for long distances.

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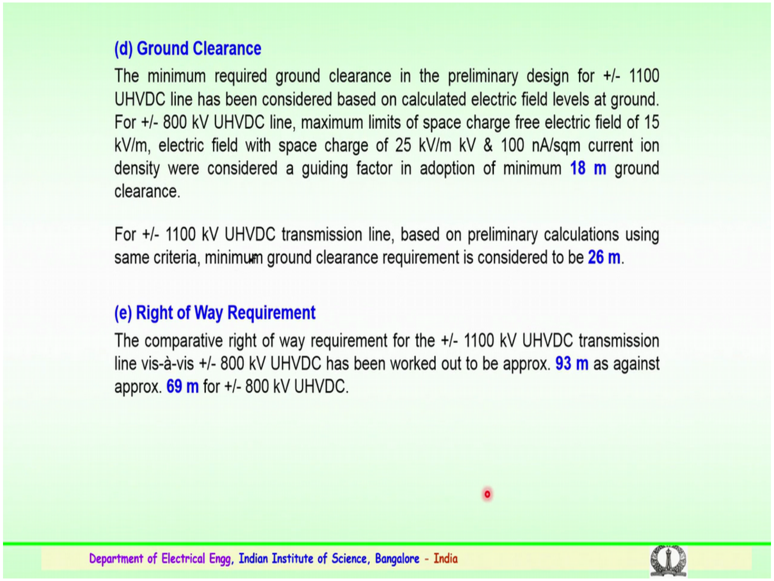


So, what is the ground clearances in case of a 800 kilo volts HVDC? We know that the minimum ground clearances; is 18 meters and for 1100 kV, it is estimated to be 26 meters. So, the factor of more than 8 meters have to be increased comparison from 800 kV DC to 1100 kV DC. So, lot of activities is being done then right of way the minimum requirement for 800 kV somewhere around 69 to 70; you can see here, but when you go for a 1100 kV, you have to be looking for right of way somewhere around 93 meters. 93 meters is roughly around 280 to 290 feet; 300 feet roughly, so it is a very high a space which is required.

So, several towers are likely to come long distance 1000s of kilometer line, several aspects have to be considered before the final designs are to be cleared. So, right of way requirement will be 93 meters; in leave of 69 for 800 kV on the ground clearances will go a high by 26 whereas, for 800 kV; it is 18 meters. So, there is again a typical similar thing which have indicated; the same clearances tower.

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**Table 2 :** Conductor Surface Gradients & Corona Onset Gradients for +/- 1100 kV UHVDC Line

| Alt | Conductor-bundle | Maxm. Conductor Surface Gradient (kV/cm) | Corona On-set Gradient (kV/cm) [+ve Pole] |
|---|---|---|---|
| 1 | Hexa Lapwing | 27.29 | 25.17 |
| 2 | Octa Moose | 26.03 | 25.54 |
| **3** | **Octa Bersimis** | **24.03** | **25.34** |
| **4** | **Octa Lapwing** | **22.45** | **25.17** |
| **5** | **Deca Moose** | **22.38** | **25.54** |
| Hexa Lapwing (+/- 800 kV HVDC Line) | | 21.10 | 25.17 |

**Table 3:** Conductor Current Carrying Capacity & Thermal Rating of +/- 1100 kV UHVDC Line

| Alt | Conductor-bundle | Conductor Current carrying capacity (Amp) -Ambient Temp. 45 deg C | | Thermal Rating of +/- 1100 kV Line (MW) | |
|---|---|---|---|---|---|
| | Maxm. Conductor Temp. | 75 deg C | 85 deg C | 75 deg C | 85 deg C |
| 1 | **Octa Bersimis** | 729 | 941 | 12830 | **16562** |
| 2 | **Octa Lapwing** | 793 | 1032 | 13957 | **18163** |
| 3 | **Deca Moose** | 627 | 802 | 13794 | **17644** |
| Thermal Rating of +/- 800 kV HVDC line with Hexa Lapwing conductor-bundle (with 85 deg C maxm. temp) : 9888 MW. | | | | | |



And what are the conductor surface at the gradients and corona onset gradients going in for 1100 kV UHVDC line very important here. So, here various conductor bundles the studies have been carried out; with various conductors bundles using different configuration like Hexa 6 bundle conductors; of Lapwing 38.05 dimensions, you see the maximum conductors surface gradients being 27.29; in corona onset the gradient that is kV per centimeter 25.17 kV per centimeter per positive pole. I using the moose conductor with octa that is 8 conductor bundle; you get 26.03kV per centimeter.

I am going in for 8 conductor Bersimis; you get 24, I am going for octa that is 8 conductor Lapwing conductors, you get 22.38 and going in for 10 conductor moose bundle; that is a 10 conductor moose bundle you get 22.38. These are the estimated values for maximum surface gradient and corona onset gradients for a 1100 kV; lot of studies are in progress.

So, similarly conductor current carrying capability and thermal rating for when you go for 1100 for that power rating, you see at the maximum conductor temperature 75 degrees; in case if it goes to 85, 75 and 85; the thermal rating, the various conductors performance you can see that for octa Bersimis; these are the values and Lapwing 8 conductor, 10 conductor these are the values which are being estimated.

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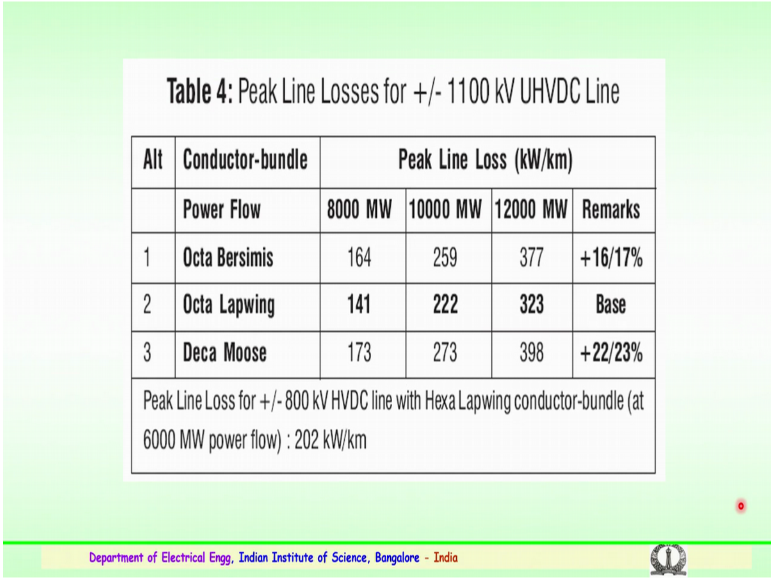


**Table 4:** Peak Line Losses for +/- 1100 kV UHVDC Line

| Alt | Conductor-bundle | Peak Line Loss (kW/km) | | | |
|---|---|---|---|---|---|
| | Power Flow | 8000 MW | 10000 MW | 12000 MW | Remarks |
| 1 | Octa Bersimis | 164 | 259 | 377 | +16/17% |
| 2 | Octa Lapwing | **141** | **222** | **323** | **Base** |
| 3 | Deca Moose | 173 | 273 | 398 | +22/23% |
| Peak Line Loss for +/- 800 kV HVDC line with Hexa Lapwing conductor-bundle (at 6000 MW power flow) : 202 kW/km | | | | | |

So, several information lot of studies are being carried out, to find out the feasibility for going in for 1100 kV UHVDC line in the country. So, if it is used, so then how the line losses the conductor bundle for various configurations, the power flow using 8 conductor Bersimis conductor; what will be the peak line loss which is estimated watt per kilo meter. So, if the 1100 kV UHVDC line is being used with 8 conductor Bersimis and carries a power of 8000 mega watts.

So, what will be the loss one 64 mega watts; in case of 8 conductor Lapwing, the loss will be 141 and in case of 10 conductor moose, the loss will be 173 mega watt sorry kilo watt per kilo meter loss will be kilo watt per kilo meter. This is for transfer capability of 8000 mega watts; in case the power transmitted to be 10000 mega watt; then the loss will be 259, 222 and 273 respectively kilo watt per kilo meter for three different conductors and if the transmission system is transmitting power of 12000 mega watts, if the power flow is made to be 12000 mega watts; the loss kilo watt per kilo meter will be 377, 323; for Lapwing 8 conductors bundle and 398 in case, if you use the 10 conductor bundle of moose conductor.

So, this is how the estimation or a peak line loss estimation is being done for various power flow conditions.

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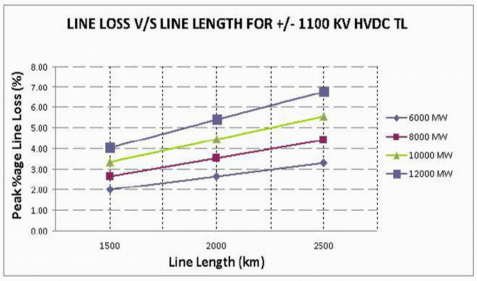
**Table 5:** Audible Noise & Radio Interference for +/- 1100 kV UHVDC Line

| Alt | Conductor-bundle | Audible Noise in Fair Weather (dBA) | | Radio Interference (dB above 1 uV/m) | |
|---|---|---|---|---|---|
| | | Max | At edge of ROW | Max | At edge of ROW |
| 1 | **Octa Lapwing** | **45** | **43** | **49** | **43** |
| | Hexa Lapwing (+/- 800 kV HVDC Line) | 41 | 39 | 49 | 42 |




So, similarly audible noise and radio interference limits have been also estimated for 1100 kV. Here again comparing with 8 conductor Lapwing type of conductor arrangement which is 38.05 dimension; you see that audible noise, the maximum estimated should not be increase 45 decibels and at the edge of the right of way, it should not increase more than 43 is a estimated value and going in for hexa; that is a 6 a bundle Lapwing presently which is being used for a 800 kV, the value is 41 and 39.

So, a marginal increase as been seeing by using the 8 conductor Lapwing conductor. So, this will again adhere to the international norms of not crossing the 60 micro volt or 60 decibel sorry 1000 micro volt are 60 decibel for radio interference. So, here you can see going in for octa Lapwing conductor less than 50 maximum of 50 decibels and 43 at the edge is being obtained. Whereas, for 800 kV presently it is 49 and 42 respectively.

So, the line losses verses the line a length for 1100 kV high voltage are ultra high voltage a transmission estimated is shown here, as you very clearly see this is the line length in kilometer and this is the percentage or peak line losses in percentage. This very clearly shows as a line length increases more than 2500 kilo meters, for various power ratings the performance of the line is shown here for 12000 mega watts, this being 8000 mega watts, 6000 and 10000 mega watts; how the line losses are seen.

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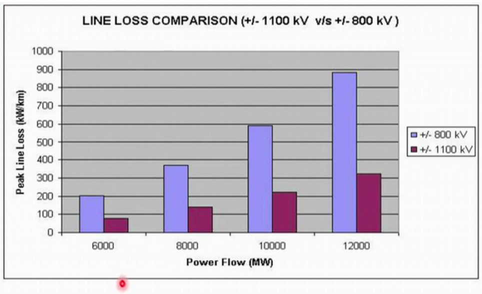


**Table 6:** Power Flow Comparison per Unit ROW

| UHVDC Line | ROW Requirement (m) | Power Flow (MW) | Power Flow per Unit ROW (MW/m) |
|---|---|---|---|
| +/- 800 kV | 69 | 6000 | 87 |
| +/- 1100 kV | 93 | 10000 - 12000 | 107 - 129 |

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This gives a line losses comparison for both 800 kV and 1100 kV DC, you can very clearly see for transmission of 6000 megawatts; comparison between 800 and 1100 HVDC lines, very clearly this is the peak line losses which you see kilo watt per kilo meter is a Y axis and X axis being powerful in mega watts.

So, comparison very clear comparison is shown here for 1100 and 800kV, so 800 kV a the blue is for 800 and the red is for the 1100 kV. You can see the as the power rating of the transmission system goes higher and higher for 8000kV there will be a reduction in the a peak line losses for built various power transmission. For 6000, the values is 50 percent of the 800 kV; similarly it is 30 to 40 percent in case of 8000 megawatts and ten 10000, you can see this 30 percent or in case of 12000 mega watts, you can see much more lesser than the line losses which are occurring at 800 kV HVDC line.

So, this very clearly points out going in for long distance a very high voltage DC line is will be much more economical true transfer a large amount of power for over a long distances. So, the powerful of comparison per unit right of way gives a idea here for plus minus 800 kV ultra high voltage DC line and 1100 kV line; right of way requirement will be 69 meters in case of 800 kV HVDC. In case of 1100; it is 93 meters, whereas the power flow in mega watts for 800 kV, you can transmit anywhere around 6000 mega watts and power flow power unit that is a mega watts per meter is 87, but for 1100 kV you can transmit up to 12000 mega watts; that is very important.

So, the double the power could be transmitted going in for a 800 to 1100 kV; HVDC that is one of the major advantages benefits for going in for higher UHVDC of a 1100 kV which is being a presently thought and of the studies are being conducted.

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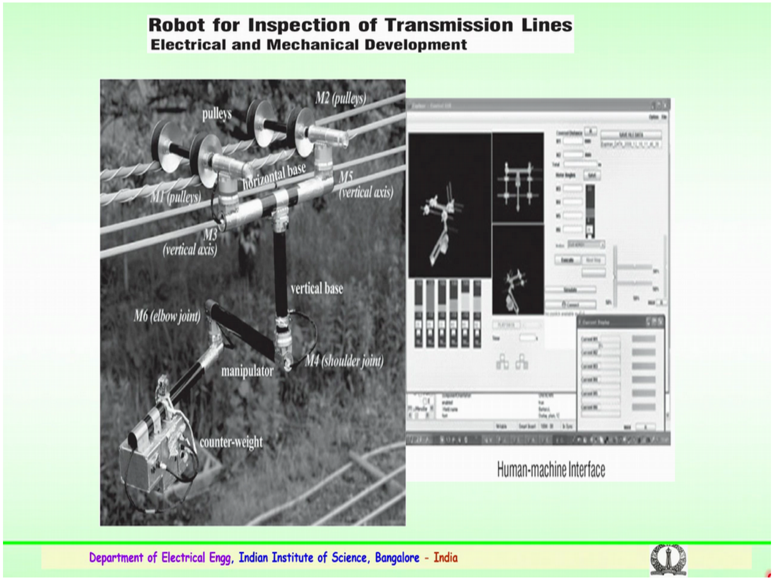


So, we were discussing about the various transmission aspects high voltage a AC high voltage DC, which is more beneficial going in for DC for long distance transmission. How much is a power could transmitted, several advantages of going in for HVDC the tower various tower configurations, various electrical clearances which are to be adopted for the various tower for ultra high voltage a AC and DC aspects and various types of conductors which are generally used for a transmission a very high voltage AC and DC transmission. Several type of conductors have been discussed which are in use in the country and the technology advancements particularly at very high voltages; which is essential for the country have also been discussed.

Now, some important component that is inspection tools for the high voltage transmission like the conductors which are over head conductors which are in the transmission towers; in case few of the strands are damaged. So, the conductor becomes ages over a period of time and it requires the maintenance. So, for such there are several tools have been developed and at regular inspection of the hot line maintenance, these conductor issues have to be rectified for the smooth transmission of a power.

So, for such recently equipment or the gadgets one like the robot particularly for the inspection of a transmission conductors; or lines is being used, both for electrical and mechanical related issues. Here this robot basically acts as a human machine interface from the tower to tower, the robot is being used and it tries to identify the mechanical deformities or the conductors strands and the distances which the conductors are being placed and get gives the information to the computer, where it could be very helpful in trying to rectify the damages which are occurred over the period on the conductors, so very important development which are being used.

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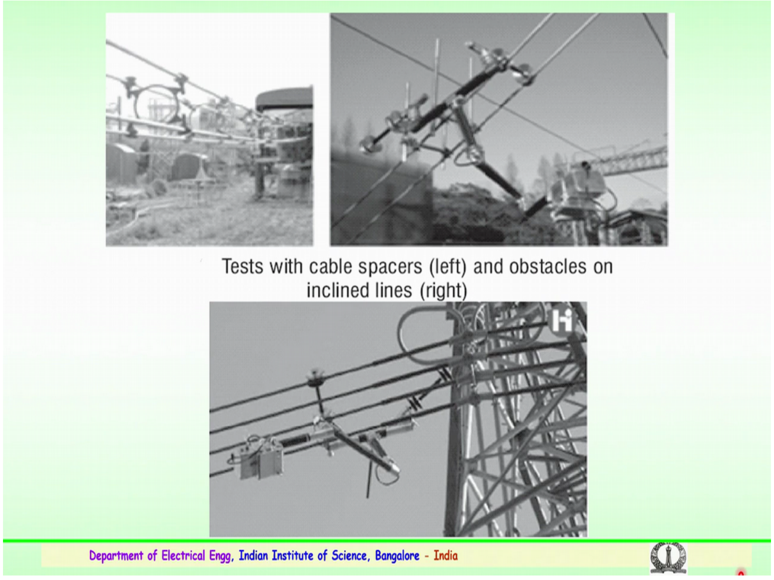


So, the tests with cable a spacers and obstacles in the lines are been rectified using this various gadgets which have been developed for the over head transmission lines. Some of them are shown here, so this from tower to tower this gadgets will be moved and the information will be connected over the PC and this information will be given to take proper a corrections; in case the conductors are damaged or the spacer alignment or the spacer mechanically, mechanically if the spacer is to be removed or it is to be replaced or the conductors have to be properly check.

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So, this will be very helpful one such robot is again shown here for the very high a transmission aspects; which has been recently developed and which is very very useful for the transmission utility engineers to rectify the conductors, the spacing arrangements in mechanical damages happened to the conductor of the spacers or to any other hardware component on the transmission towers.

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So, this is how the robot is being used to see and check the starters of the conductor, the healthiness of the conductor and the information is been given to the utility engineers through the arrangement; which proper sensing mechanism very useful for to find out the healthiness of the high voltage a conductors.

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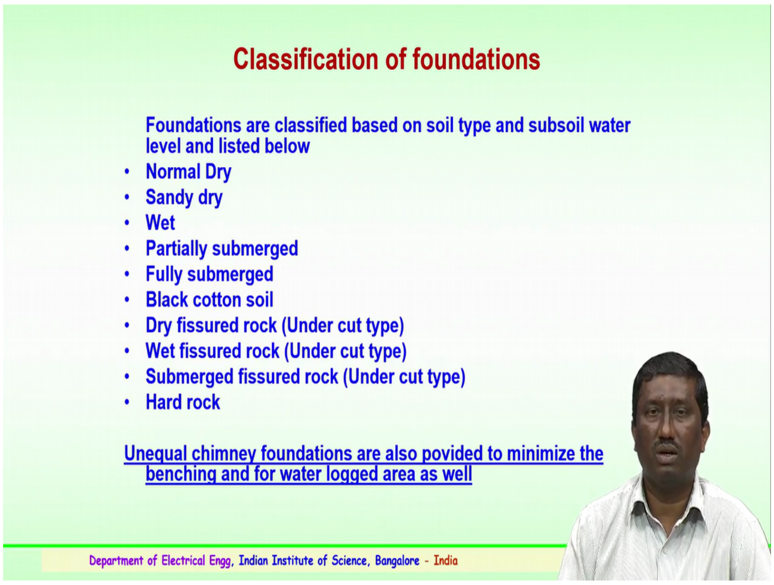


So, that was about the various towers; the conductors some advances which are happen and how the gadgets are helpful for the rectification of the conductors or hardware and the line; hot line maintenance aspects several of this things. Some basic information about the tower foundation is also very important. So, as I was mentioning the towers are very important components apart from the conductors and the insulators.

The foundation again civil engineering aspect is very very important for the long run and this foundation play a very vital role for the towers to sustain for period of the life of the tower; which includes several normal conditions. The conditions because of the natural calamities, the wind and several natural conditions, the tower has to be able to sustain

So, the classification of foundations the tower foundations is at most importance and this foundations which are to be carried out; again depends upon several factors and this foundations are classified based on the soil type and the subsoil content of water level which are general listed here. So, in case of normal dry condition of the soil, the type of classification of foundations which are to be carried out; in case if it is the sandy type and a dry condition, what type of foundations have to be made for the tower; again the tower foundations depends on the voltage level the height of the tower, total stage structure, total mechanical load, wind consideration, insulators, conductors several of these aspects have been considered.

So, both mechanical, electrical, clearances and also the civil engineering place a dominant role for the transmission system. So, the foundation is a very important aspect, so the conditions whether the soil is dry or wet or partially submerged with water or fully submerged in water. Whether it is a black cotton type of soil or dry fissured rock; which is under cut type or wet fissured rock or if the soil content a submerged a fissured rock, so is the place having a hard rock or a mountainous area.

So, depending upon several of this classification the foundations of towers are been considered and for each aspect, the suitable foundations have to be laid so that the tower strength and the tower has to be working for the long period of its life; so, very important aspect. So these classification of foundations a play a role to suitably going for particular foundation for that area.

So, unequal type of chimney foundations are also some times provided to minimize the benching and for water logged areas, where the planar land or the area is not available; in such cases this chimney foundations are also provided for the construction of tower.

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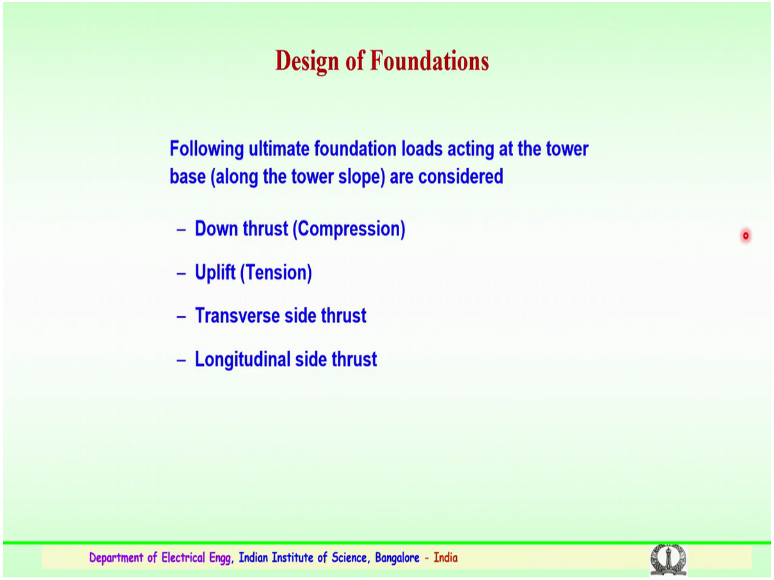


How the design of foundations? Again considering various aspects following ultimate foundation loads which acts on the tower; at the tower base, along the tower slope are also considered like the compression loads there is a down word a thrust; which the tower sees. The uplift that is a tension loading which comes to the tower, the transfer or transverse are a side moment or thrust, then the longitudinal side thrust. Several of these aspects have to be considered apart from other dynamic changes which the tower sees.

So, all these are to be considered for the design of the suitable foundation which is very important for the tower. So, thank you we have looked into the tower aspects and very briefly about the foundations which are essential for the UHV or Ultra High Voltage transmission system. We have discussed about the insulators, line conductors, importance of the towers, the clearances, electrical, mechanical clearances and the foundation aspects. So, we will further see about the aspects pertaining to the substation in the next class.

Thank you.