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EDITOR'S NOTE

V.K. Kanjlia
Secretary & Treasurer
CIGRE India

CIGRE the International Council on Large Electric Systems founded in 1921, is leading worldwide Organization on Electric Power Systems, covering technical, economic, environmental, organisational and regulatory aspects. It deals with all the main themes of electricity. CIGRE is the unique worldwide organization of its kind - 14,000 equivalent members in around 90 countries. CIGRE is focused on practical technical applications. The main aim of CIGRE is to facilitate and develop the exchange of engineering knowledge and information, between engineering personnel and technical specialists in all countries as regards generation and high voltage transmission of electricity. CIGRE achieves its objective through the 16 Study Committees, each consisting of about 24 members from different countries. It is a matter of pride for India that we are representing in all the 16 Study Committee of CIGRE.

Besides National Committees in about 60 Countries CIGRE has also constituted its regional chapters in the world. The chapter created for Asia is named as CIGRE-AORC (Asia Oceans Regional Council). CIGRE-AORC is a forum for sharing experience and knowledge regarding pertinent technical issues particularly those affecting power systems in the Asia-Oceana Region. The countries from Asia Oceana Region, who are associated with the forum are Australia, China, Cambodia, Gulf Cooperative Council, Hong Kong, India, Indonesia, Iran, Jordan, Japan, Korea, Malaysia, New Zealand, Taiwan and Thailand.

It is a matter of great honour for India that CIGRE AORC has been chaired by India from 2016-2018. Dr. Subir Sen, ED, POWERGRID was Chairman and Shri P.P. Wahi, Secretary of CIGRE AORC for two year during 2016-18.

CIGRE (India) has been in the administrative Council of CIGRE since 1970 and got seat in Steering Committee this year. The HQ of CIGRE India is Central Board of Irrigation & Power (CBI&P), Malcha Marg, Chanakyapuri, New Delhi. It functions as the National Committee, i.e., CIGRE (India) for CIGRE HQ (Paris). The CIGRE (India) coordinates interest of Indian members; organises National Study Committee (NSC) meetings. It recommends appropriate persons for CIGRE Study Committees. The National representatives are instrumental in providing feed back to CIGRE Study Committees at Paris.

The aims and objectives for which the committee, i.e., CIGRE (India), is constituted, is to implement and promote objectives of the International Council on Large Electric Systems (CIGRE) and accelerate its activities, which include the interchange of technical knowledge and information between all countries in the general fields of electricity generation transmission at high voltage and distribution etc.

All-out efforts are being made to increase the CIGRE membership and activities in India. There was excellent participation from India in CIGRE session 2018 at Paris. Total 22 papers were presented and more than 150 officers from India including CEOs & Sr. Officers from various PSUs, State Electricity Corporation and various Regulatory Commissions participated in CIGRE session 2018 besides six exhibitors.

The Membership of CIGRE from India is also on the rise and in the year 2018 we achieved membership count to 828 Nos.

We are bringing out this Journal on half yearly basis. The last issue was published in the month of July 2018.

This issue covers the informative and useful technical articles and statistical data on the subject.

I am thankful to the Governing Council and the Technical Committee of CIGRE-India for their valuable time and guidance, but for which, it would not have been possible to achieve the above significant progress, appreciated by CIGRE HQ Paris.

I am also thankful to all the senior experts from India and abroad and also to one and all who have supported in the past to realize the goal set forth for CIGRE India and expect the similar support in future too.

V.K. Kanjlia
Secretary & Treasurer CIGRE India

GROUNDING (EARTHING) OF OVER HEAD TRANSMISSION LINE TOWERS IN HILLY AREAS OR AREAS WITH HIGH SOIL RESISTIVITY

Dr. Rajesh Kumar Arora
Delhi Transco Limited

ABSTRACT

The main purpose of grounding over head transmission systems is to provide a suitably low resistance path for the discharge of fault current and provide good performance for lightening. This helps in controlling ground potential rise, and touch and step voltages. This also helps in reducing back flash over in the over head transmission system.

This paper provides overview of different grounding methods for grounding of transmission tower erected in areas of high resistivity or hilly areas (Figure1).

Keywords *: Grounding (Earthing), Soil Resistivity, Safe Potentials, Tower Foot Resistance, Counterpoise*

Fig.1 Over Head Transmission Line in Hilly Areas

1. INTRODUCTION

Grounding means making a connection to the general mass of earth. In case of transmission system, tower is grounded (R_t). Main objectives of grounding of over head transmission line tower are given below [1-5].

1. To provides a low resistance path for power system transients such as lightning and helps in avoiding back flashover.
2. To provides a low resistance return path for fault current which further control touch and step potential.
3. To allow sufficient current to flow safely for satisfactory operation of protection system.

The step and touch potential which may be faced near a transmission line tower during fault in the system is shown in Figure 2.

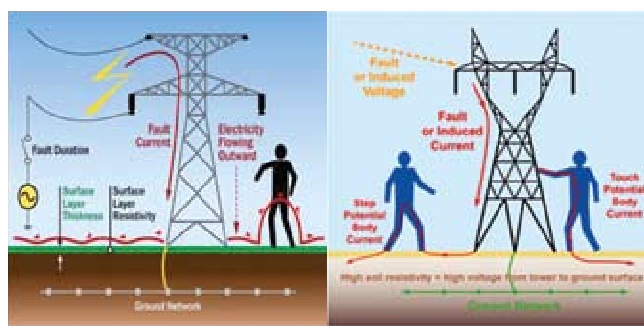

Fig.2 Step and Touch Potential During Fault

We also use ground wire at the top of the transmission tower which is bonded to each transmission tower at the top. The overhead earth wire or ground wire is the form of lightning protection using a conductor or conductors.

The earth wire intercepts the direct lightning strikes, which would strike the phase conductors. The ground wire has no effect on switching surge.

2. BACK FLASHOVER AND ROLE OF TOWER FOOT RESISTANCE

When the lightning strikes an earth wire at mid-span, waves are produced which travel in opposite directions along the line. The waves reach the adjoining tower, which passes them to earth safely. The earth wire is effective only when the resistance between the tower foot and earth is sufficiently low. The arrangement of conductors and ground wire in transmission line tower is shown in Figure 3.

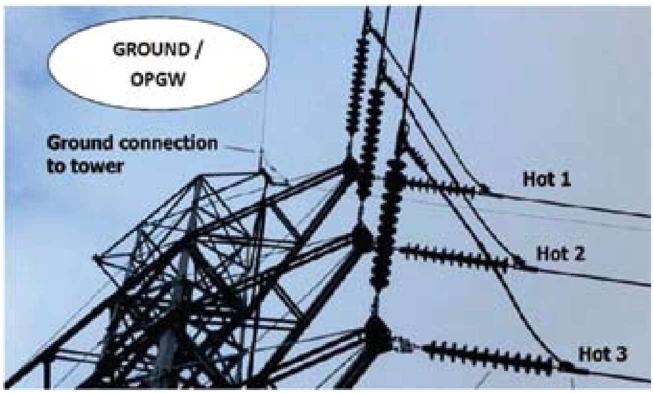

Fig.3 Arrangement of Conductor and Ground wire on Tower

If the resistance between them is not low and the earth wire or tower will be struck by the lighting, then the lighting will be raised to the very high potential, which will cause a flash over from the tower to one or more phase conductors[8]. Such a flashover is known as back flashover. (Refer Figure 4)

It can be minimized by reducing tower footing resistance which depends on the effectiveness of the grounding of the transmission tower. The question arises as to why we should have a low value of tower footing resistance. It is clear that, whenever a lightning strikes a power line, a current is injected into the power system. The voltage to which the system will be raised depends upon what impedances the current encounters. Say if the lightning stroke strikes a tower, the potential of the tower will depend upon the impedance of the tower. If it is high, the potential of the tower will also be high which will result in flashover of the insulator discs and result in a line-to-ground fault. The flashover will take place from the tower structure to the power conductor and, therefore, it is known as back flashover[8].

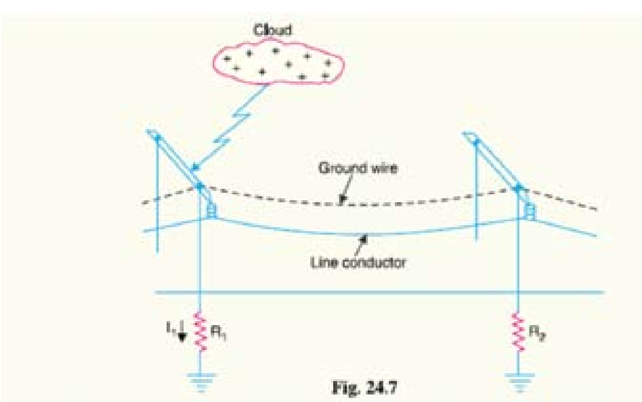

Fig.4 Lightning Strike on Transmission Line

3.0 VARIOUS RESISTANCES OF AN EARTH ELECTRODE

During the flow of fault current through a ground/ earth electrode three types of resistance[1,3,4,7] appear in the circuit as shown in Figure 5.

1. Resistance of the ground electrode itself and connection terminal or hardware fitting joining it with cable or riser.
2. Resistance at the point of contact between the ground electrode and the soil.
3. Resistance offered by the surrounding ground/ earth.

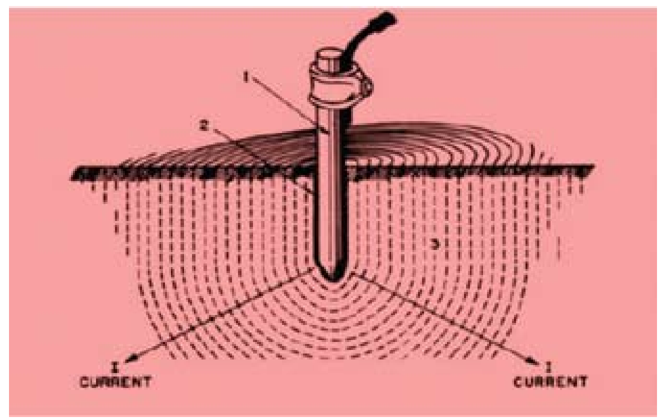

Fig 5 Different Components of Grounding Resistance

1. **Electrode Resistance:** Rods, pipes, strips are usually used for making connections. These connections are made of sufficient size so that their resistance becomes very low and their contribution to the total resistance is negligible.
2. **Contact Resistance of Electrode-Earth/Ground:** This part of resistance is also very less.
3. **Resistance offered by Surrounding Earth:** During the fault the electrode surrounded by soil of uniform resistivity radiates current in all directions. The earth shell touching the electrode offers the smallest surface area and so it contributes the highest resistance. The next earth shell is comparatively larger in size and this shell has less resistance. Finally a distance will be reached where addition of more earth shells does not contribute much to them total resistance of the earth surrounding the electrode.

   Generally, the resistance offered by the earth surrounding the electrode will be the highest of all the components discussed above. The first two factors can be taken as negligible compared to third factor, i.e. resistivity of soil. This is the reason, we generally consider resistivity of the soil only, when we deal with resistance of earth.

4.0 CONCEPT OF SOIL RESISTIVITY

Soil resistivity can be defined as the resistance between the opposite sides of a cube of soil with a side dimension of one meter. Soil resistivity values in vary widely, depending on the type of terrain; e.g., silt on a riverbank may have a resistivity value around 1.5 Ω-m, whereas dry sand or granite in mountainous country may have values higher than 10,000 Ω-m. The factors that affect resistivity may be summarized as follows[1-4]:

Again the resistivity of the soil depends upon the following factors,

1. The electrical conductivity, offered by a soil mainly due to electrolysis. That means the resistivity (or conductivity) of a soil is mainly electrolytic in nature. So, concentration of water, salt and other chemical components in the soil largely determines its resistivity. resistivity may fall rapidly as the moisture content is increased, but after a value of about 20%, the rate is much less. Soil with moisture content greater than 40% is rarely encountered.
2. The chemical composition of the soil is also responsible for its resistivity.
3. The grain size, uniformity of grain distribution and packing of grains in the soil (i.e. inter grain distance) also the factors for resistivity. Since, this factors control the moisture holding capacity of the soil.
4. The temperature of the soil can also be a factor but when it is very close to freezing temperature.

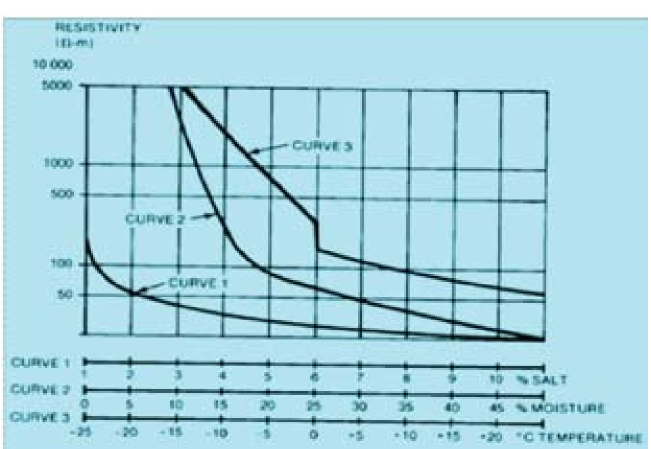

Fig 6 Impact of Salt, Moisture and Temperature on Soil Resistivity

Below, 0°C, the water contained in the soil begins to freeze, which largely affects the electrolysis process in the soil. It is found that, just below the freezing point the resistivity of soil or earth resistivity is tremendously increased.

Figure 6 shows how resistivity varies with salt content, moisture, and temperature. It is found that earth resistivity varies from 0.01 to 1 Ω-m for sea water, and upto109 Ω-m for sandstone. The resistivity of the earth increases slowly with decreasing temperatures from 25°C, while for temperatures below 0°C, the resistivity increases rapidly. In frozen soil, as in the surface layer in winter, the resistivity may be exceptionally high.

4.1 Factors Affecting Ground Resistance

1. Length/Depth of the ground electrode: double the length, reduce ground resistance by up to 40%.
2. Diameter of the ground electrode: double the diameter, lower ground resistance by only 10%.
3. Number of ground electrodes: for increased effectiveness, space additional electrodes at least equal to the depth of the ground electrodes.
4. Ground system design: single ground rod to ground mat as per requirement.

When we find that your earth electrode resistance is not low enough, there are several ways you can improve it:

1. Lengthen the earth electrode in the earth
2. Use multiple rods
3. Treat the soil

5.0 CONCEPT OF CHEMICAL GROUNDING (EARTHING)

It is often impossible to achieve the desired reduction in ground resistance by adding more grid conductors or ground rods. An alternate solution is to effectively increase the diameter of the electrode by modifying the soil surrounding the electrode. The inner shell of soil closest to the electrode normally comprises the bulk of the electrode ground resistance to remote earth. This phenomenon is often utilized to an advantage.[1,3]

Earthing (ground) enhancement materials are high conductivity materials, which are designed to lower ground system resistance and improve grounding effectiveness in high resistivity soil conditions. They can be used in sites installed in areas with poor soil conductivity (such as rocky ground and sandy soil), or on sites where ground rod electrodes cannot be driven to the desired depth. They are also often used when limited space makes achieving the required ground electrode resistance impossible with conventional methods. The concept of chemical earthing is depicted in Figure 7.

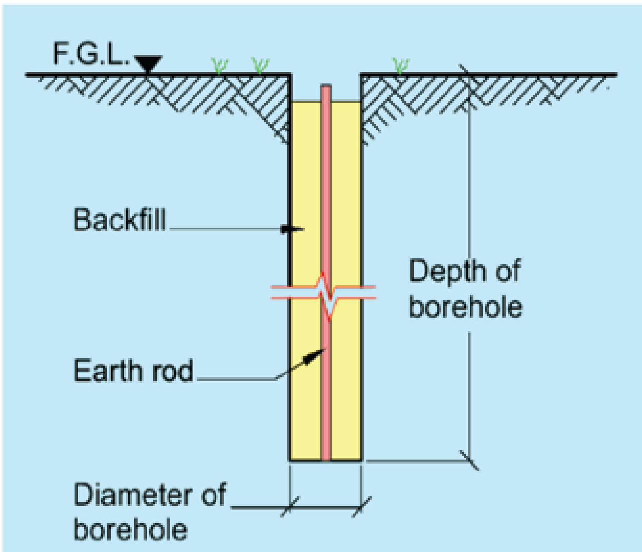

Fig 7 Concept of Chemical Grounding

MAIN CHARACTERISTICS OF CHEMICAL EARTHING ARE

- It should absorbs and retains moisture for long time
- It should have low resistivity
- It should be able to dissipate fault current very fast
- It should maintain compatibility of soil and rod contact
- It should need maintenance for longer time
- It should be able to maintain earth resistance same for longer time even with large temperature variation.

Earthing (ground) enhancement materials are available in many forms. Bentonite clay is sometimes used as an earth enhancement material. Bentonite, naturally occurring clay mostly comprised of the mineral montmorillionite, is hygroscopic and absorbs moisture from the surrounding environment [1,4].

Because of this characteristic, Bentonite requires the presence of moisture in the ground to maintain its properties and may not function well in a very dry environment. Actual chemical earthing is shown in Figure 8.

Several commercially available forms of earthing enhancement materials are available including powders, granules, pellets, gels and cement like mixtures. Many are comprised of carbon-based materials or clays like bentonite (or a mixture of both). Others contain copper sulphate or other copper- based compounds, which may not be environmentally friendly. Some earthing enhancement materials also contain cement, which after installation sets up like concrete. This prevents the earthing enhancement material from leaching into the soil or washing away by groundwater.

6.0 GROUNDING OF OVER HEAD TRANSMISSION TOWERS

The methods normally used for improving the grounds of transmission towers are the use of (i) ground rods, and (ii) counterpoises [6,8].

(a) Ground Rods

Ground rods are used to reduce the tower footing resistance. These are put into the ground surrounding the tower structure (Refer Figs 9 &10).

Fig 8 Actual Chemical Groundings

(b) Counterpoise

Counterpoise grounding consists of conductors buried below the surface of the earth that are connected to a power-system ground point. In the case of a transmission tower, the connection point could be the tower footing or the grounded side of a lightning arrestor. This counterpoise provides a relatively high capacitance and therefore a relatively low impedance path to earth. The counterpoise is sometimes used in medium-and low-frequency applications where it would be difficult to provide an effective ground connection.

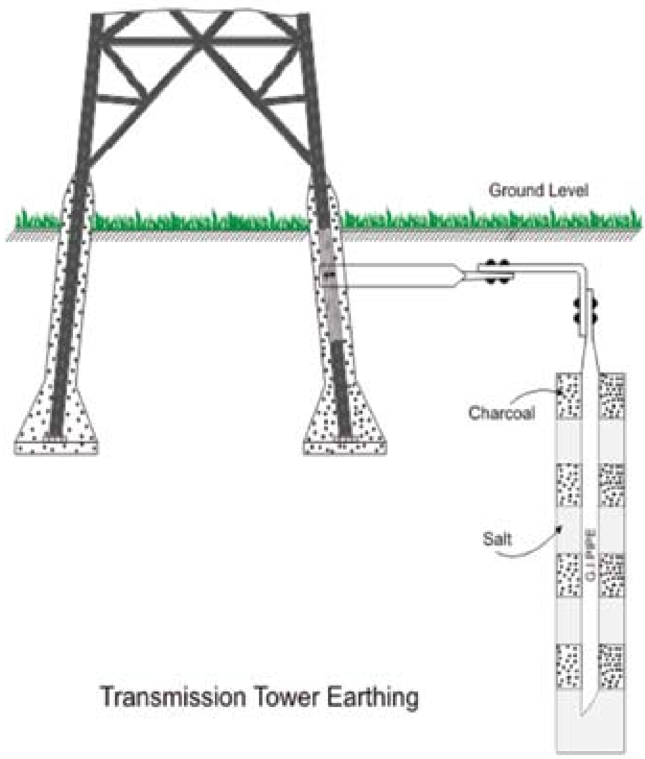

Fig 9 Transmission Tower Grounding (Treated)

Fig 10 Transmission Tower Grounding in the Field

The function of the counterpoise is to lower the transmission in areas where the impedance needs to be lowered. The reduction of impedance will reduce the insulator flashover due to lightning strikes. Since ground rods and mats have been found to be ineffective in high-resistivity soils, some utilities have implemented counterpoise grounding. (Refer Fig. 11)

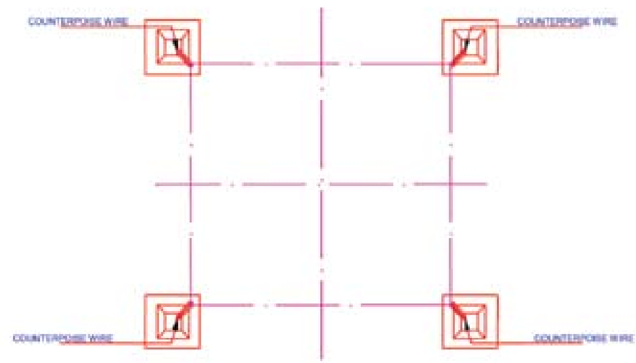

Fig 11 Counterpoise Grounding

7.0 TRANSMISSION LINE TOWER GROUNDING NORMS IN INDIA

Earthing of each tower is done after the foundation has been casted. The earthing connection which was fixed to the stub during concreting of the chimney and taken out horizontally below the ground level is used for earthing. The earthing connection is generally provided on Leg 1 and additional earthing, if required, is provided on Leg 3 for pipe type earthing. [6]

The installation of the earthing shall be done in accordance with

IS : 5613 – 1989 (Part 3 / Section 2) for 400 kV lines or

IS : 5613 – 1985 (Part 2 / Section 2) for 220 kV and 132 kV lines.

(1) Pipe Type Earthing: The pipe type earthing is generally provided outside the base of the tower. A typical example of pipe type of earthing is given in shown in Figure 12. A hole of the required diameter and depth is augured in the earth for the earthing pipe. The earthing pipe is then put inside the hole. A mixture of coke and salt is filled in the hole in which the earthing pipe is provided. The earthing strip which was fitted to the stub of the tower leg is then connected to the earthing pipe. In case of difficult locations, the pipe may be laid horizontally or slanting and within the tower base or foundation pit.

(2) Counterpoise Earthing: Counterpoise earthing consists of four lengths of galvanized steel stranded wires, each fitted with a lug for connection to the tower leg at one end. Galvanized steel stranded wire of the size given below is used for this purpose.

(a) For 400 kV lines : 7 / 3.66 mm

(b) For 220 kV and 132 kV lines : 7 / 3.15 mm

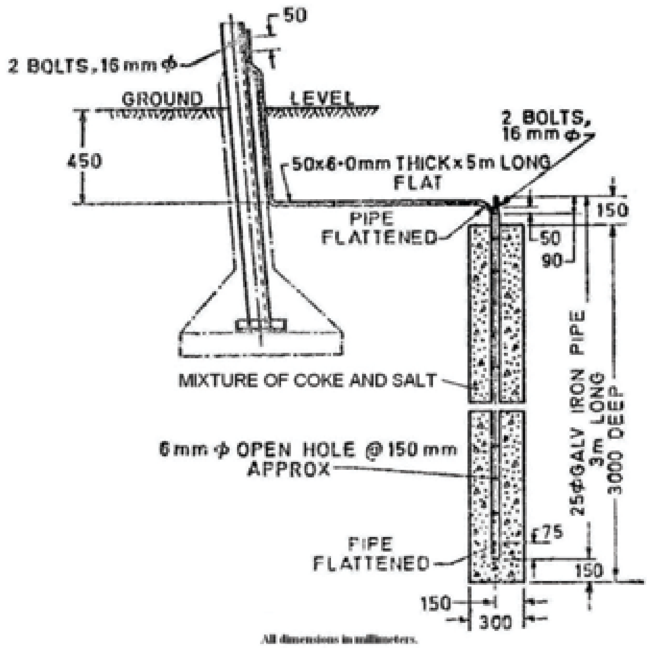

Fig 12 Pipe Grounding (Treated) Specified in India

The wires are connected to each of the legs and taken radially away from the tower and embedded horizontally below ground level. The depth of burial below ground level and the length of each wire are normally kept according to the values given below. However, the length of each wire may be increased if the resistance requirements are not met. The other ends of the earthwire shall be connected to an electrode.

1. 400 kV-Depth - 1000 mm & Length - 25 metres
2. 220 kV & 132 kV–Depth- 450 mm & Length -15 metres

The counterpoise earthing drawing is shown in Figure 13.

NOTE ON TOWER FOOTING RESISTANCE

The tower footing resistance of all towers shall be measured in dry weather after their erection and before the stringing of earthwire. In no case the tower footing resistance shall exceed 10 ohms. In case the resistance exceeds this value, multiple pipe earthing or

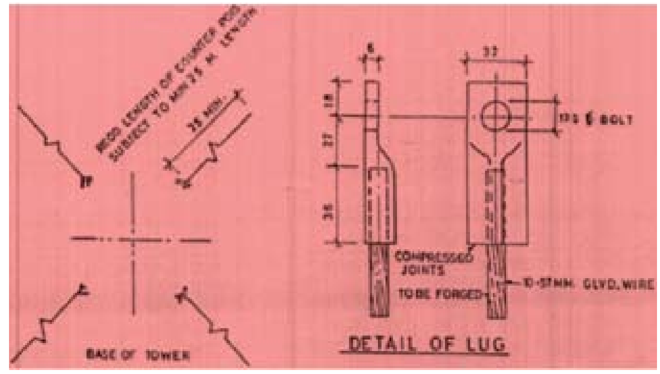

Fig 13 Counterpoise Grounding Specified in India

counterpoise earthing shall be adopted in accordance with the relevant procedure given above.

8. CONCLUSION

Earthing design often becomes difficult when there are physical site constraints of rocks and high soil resistivity. Earthing design is challenging and interesting under difficult conditions as it provides chance for designer to think out of box and give the desired results.

It is very important for an electrical engineer to understand the fundamental and importance of grounding system of transmission line for the safety of persons in the vicinity of towers and for proper performance of transmission line towers for lightning and fault current.

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FAILURE OF POWER TRANSFORMERS AND IT'S PREVENTION

Vijay Srivastava, Kuleshwar Sahu and B Anantha Sarma
Powergrid Corporation of India Ltd.

INTRODUCTION

POWERGRID presently owns and operates 3,24,245 MVA of power transformation capacity at 230 nos. of EHV / UHV substations to facilitate seamless flow of power within and across the geographical regions of India. Western Region I has a share of 21% of the POWERGRID total MVA transformation capacity. There are total 19 nos. UHV/EHV substations in the region having 765/400 kV transformer banks comprising of single phase units as well as 400/ 220 kV three phase transformer units. Transmission system availability of more than 99.75 % is being maintained in the region. Time based, condition based and predictive maintenance actions are performed for the transmission assets to meet high standards of system availability and reliability. The percentage failure rate of power transformers in POWERGRID is 0.37% against global transformer failure rate of 1.2% (CIGRE). Component wise failure rate of power transformers in POWERGRID system is as per Figure 1. About 38% of the failures are attributed to bushings and 33% to windings.

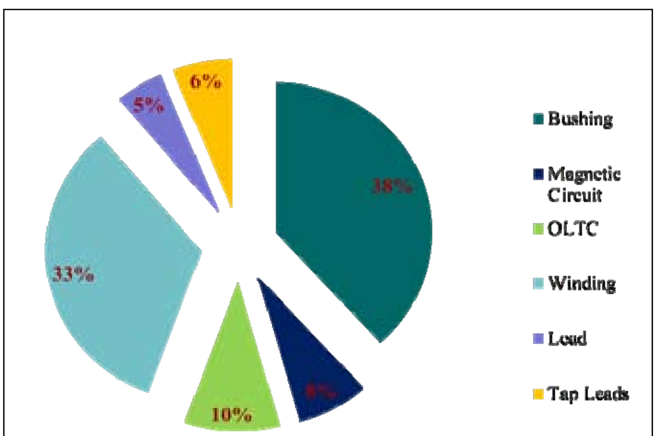

Fig. 1. Component Wise Failure Causes

This paper attempts to identify power transformer failure modes in POWERGRID and discusses their mitigation techniques for maintaining high reliability of power transformers.

Evidence collected by CIGRE working group B5.37 states that 40-55% of failures originate in bushings or terminals, 30-40% in windings, and 15-20% in the core.

In Australia 50% failures of Reactors are due to bushing failures.

FAILURE MODES

Bushing Failures

Over-voltages due to lightning impulses or even due to the switching can bring about very high dielectric stresses on the bushings. Specifically in case of externally generated over-voltages, the bushings will be the first one to suffer the stress. This fact can lead to bushings insulation deterioration. Bushing failure is the most common cause of transformer failure.

Winding Failures

No previous history of DGA violations or other problems were observed prior to failure and all failures were sudden.

All failures were analyzed along with manufacturer and failures were found to be due to dielectric breakdown of the inter turn/ inter disc.

Other Issues

- External flashovers in 765 kV bushing in between top head oil expansion chambers and bushing flange (8 times)
- DGA violation in 765 kV bushings (7 nos. out of 162 nos. bushing)
- Leakage in Transformers.
- Problem with 765kV OLTC and DGA violation in Transformers due to selector contact problem.
- Failure rate is high due to poor OIP bushing performance. Issues with particular makes of OIP bushings.
- Tap Lead failures in 500 MVA Transformer

Risk Mitigation

- Use of RIP Bushing in Transformer and Reactor
- Controlled switching of Transformers and Reactors
- Total 96 nos. bushings are taken up for RTV coating
- Test Tap modifications were carried out in 420 kV bushing
- More than 50 bushings were removed from service based on Bushing DGA and variable frequency Tan delta

- Design review carried out with the help of IIT, Powai and based on the recommendation, tap lead modifications were carried out at site for 01 no. Transformer
- Transient monitoring system for failure investigation
- Supplementary diagnostic techniques for bushings to avoid catastrophic failure.

USE OF RIP BUSHINGS

Pros :

- As they are oil free, there are not likely to catch fire, even during catastrophic failure.
- With polymer type housing specified, the bushing failures are pretty controlled ones and there are no collateral damages.

Cons:

- No Indian vendor.
- Prone to moisture ingress during long term storage.

POWERGRID technical specifications for bushings have been revised and only RIP bushings are specified for all new procurements.

CONTROLLED SWITCHING OF TRANSFORMERS

High inrush currents during power transformer energization may result in high transient over voltages, may further lead to stresses on the transformer bushings and winding insulation (particularly lead exit insulation).

Controlled Switching of transformers has been implemented across POWERGRID to avoid the high inrush currents and it's subsequent affects. With the implementation of controlled switching, the transformer inrush currents have subsided. Switching waveforms are reviewed for every transformer switching. Based on the analysis, further actions towards modifying the switching settings are taken.

TRANSIENT MONITORING SYSTEM FOR INVESTIGATION OF FAILURES

To investigate the failures of transformers in the system as well as to create historical data, transient monitoring systems have been installed at identified locations. These systems take input from the capacitance tap of the bushings and record the same. The magnitude and frequency of the transients are recorded which can provide valuable inputs for design review or failure investigation and also for the corrective actions.

SUPPLEMENTARY DIAGNOSTIC TECHNIQUES FOR BUSHINGS TO AVOID CATASTROPHIC FAILURES

Frequency Domain Spectroscopy is a well acknowledged tool to monitor the insulation of power transformers. However due to EMI/EMC in UHV switchyard, the response gets affected in lower frequency range (below 1 milli Hz). Sweep Frequency Response in 15 Hz to 450 Hz range has been quite useful for detecting the dielectric issues in OIP bushings. The defects identified during the test were validated by carrying out the bushing oil DGA.

FUTURE CHALLENGES

- 25 percent transformers are older than 20 years.
- Integration of green energy corridor.
- Optimization of design and manufacturing processes

DESIGN & CONSTRUCTION OF SRINAGAR -LEH TRANSMISSION LINE IN HIGH ALTITUDE, EXTREME WEATHER, SNOW-BOUND AVALANCHE PRONE AREAS

Karanvir Singh Pundir, Nitesh Kumar Sinha,
A.K. Vyas, Anish Anand and R.N. Singh
Power Grid Corporation of India Ltd.

ABSTRACT

India is a vast country with varied geography & topography having wide range of weather conditions across different parts. Ladakh, a region of Jammu and Kashmir (J&K) state in the Northern part of India is geographically and climatically a peculiar region. It is located at an altitude ranging between 2400 m and 4500 m above mean sea level with rugged topography having steep slopes. The ground access to the region is cut off every winter due to avalanche activities along the roads. The Ladakh region is presently not connected to Indian power grid and for meeting the electricity demand, the region is dependent upon local small hydro and DG generation.

Power Grid Corporation of India Ltd (POWERGRID), a Govt. of India Enterprise & the Central Transmission Utility of the country is responsible for planning and coordination of inter-State transmission system and implements transmission system for evacuation of central sector projects & various Independent Power Producers (IPPs) and grid strengthening schemes across India. POWERGRID presently owns & operates approx. 135,000 ckt kms of transmission lines in the country forming National Grid.

As an endeavour to provide electrical connectivity to Ladakh region, POWERGRID has taken up construction of 220 kV transmission line from Srinagar (Alusteng) to Leh via Kargil, Drass and Khaslti. The transmission line is approx. 350 kms long passing through difficult mountainous terrain having high altitude and extreme climatic conditions (heavy winds, snow & temperature going below -45^{0}C). The line traverses through two major mountain ranges (viz. Great Himalyas & Zanskar) encountering some of the high altitude passes (viz. Zozi-la -3529 m & Fatu-la – 4049 m) and heavy snow & avalanche prone areas (Gagangir, Zozi-la, Gumri, with more than 5 m standing snow). The transmission line also passes through high security, military zones close to LOC with Pakistan. The construction of the line is in progress.

Appropriate selection of transmission line components, design parameters & developing detailed designs has been as challenging as construction of transmission line.

The line route was selected using satellite imagery. Due to inaccebility in some places along the route, digital terrain modelling & fly through techniques have been used to identify most suitable route.

Special features have been considered in design of conductors, OPGW, towers and foundations, insulators & hardwares. As the line passes through the highest wind zone of the country (basic wind speed of 55 m/sec) and heavy snow zone areas, towers has been designed for the high wind speed & ice loading (25 mm radial ice deposition on conductor and earthwire). Tower geometry has been configured for additional electrical clearances due to high altitude and cross arm of towers have been specially designed and staggered to take care of conductor galloping. Specialkind of steel for towers has been used to mitigiate the effect of low temperature. High strength conductor & OPGW has been considered instead of conventional conductors used in normal 220 kV lines. In addition to this, high strength OPGW and double strength insulator strings with additional insulators have been considered.

All efforts has been made to select towers locations free of snow avalanches, despite ,some locations between Minamarg and Zoji La are falling in snow avalanches prone area which may be subjected to impact of fast moving snow alongwith strong wind. Besides envisaged use of general avalanche protection control measures (such as snowrakes, deflecting and retarding structures), foundations of the towers which are to be constructed in these avalanches prone area are designed to take care of snow impact loading alongwith creeping and gliding of snowpack. Special type of chimneys of about 10 m height are designed for these towers to withstand the avalanche load and to provide sufficient height to cables above ground level to avoid avalanche impact.To protect the high raised chimney foundation from snow glide and snow avalanches forces, tiebeamsat two intermediate levels have been provided. These tiebeams have been securely tied with chimney with sufficient reinforcement anchorage to make a perfect monolithic structure.

The paper covers in detail, salient design aspects and special design features of the under construction 220 kV Srinagar-Leh transmission line in high altitude, extreme weather, snow bound areas including analysis & design of foundations for lattice transmission towers in avalanche prone areas.

***Keywords** : Avalanche-Hilly-Transmission Line-Snow*

1. INTRODUCTION

India is a vast country with varied geography & topography having wide range of weather conditions across different parts. Ladakh, a region of Jammu and Kashmir (J&K) state in the Northern part of India is geographically and climatically a peculiar region ,located at an altitude between 2400 m and 4500 m above M.S.L. The topography attracts a lots of tourists during the summer season. The ground access to most part of the region is cut off every winter due to heavy snowfall and avalanche activities along the roads. The state share its boundaries with two neighbouring hostile countries (China and Pakistan).

2. BACKGROUND

The Ladakh region is presently not connected to Indian power grid because of which the following factors advocates its connection:

1. The region is dependent upon local small hydro and DG generation.
2. The present installed generation is only about 26 MW.

- Diesel generating unit (12 MW)
- Micro hydel units (14 MW).

3. During winter seasons the power demand is more due to

- Heating loads
- Hydro units being run of river produce very low power at –25 deg C (due to freezing of water)

4. The power supply is limited to 3-4 hours
5. Due to power shortage the small scale/cottage industries/ tourism have not been developed.
6. Being an area of defense establishment / strategic importance reliable power supply arrangement is very important.

POWERGRID has taken up the construction of 220 kV transmission line from Srinagar (Alusteng) to Leh via Kargil, Drass and Khaslti to connect Ladakh region to Indian power grid.

3. SRINAGAR - LEH TRANSMISSION SYSTEM

As an endeavour to provide electrical connectivity to Ladakh region, POWERGRID has taken up construction of 220 kV transmission line from Srinagar (Alusteng) to Leh via Kargil, Drass and Khaslti having transmission line length of approx. 350 kms. It traverses through difficult mountainous terrain having high altitude, extreme climatic conditions (heavy winds, snow & temperature going below-45°C), major mountain ranges encountering some of the high altitude passes and heavy snow & avalanche prone areas, high security, military zones close to LOC with Pakistan.

Table 1. Components of Srinagar – Leh transmission system

Transmission line	220 kV Single Circuit approx. 350 kms long
Substations	220/66 kV GIS at Drass, Kargil, Khalsti & Leh.
Interconnection System	66 kV Interconnection Lines & Substation Bays at Drass, Kargil, Khalsti & Leh

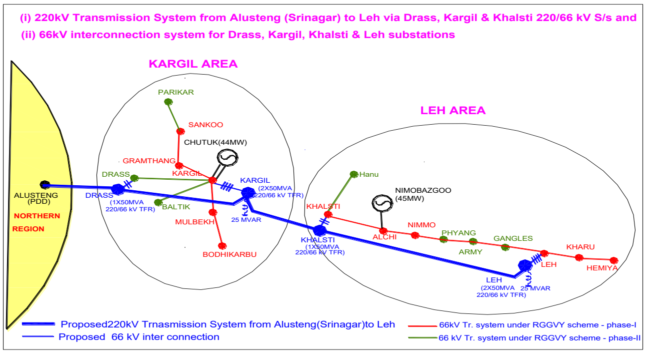

Fig 1. Srinagar – Leh transmission system Map

It caters to the power deficient regions (Ladakh, Leh, Drass and Kargil) of Jammu and Kashmir State.

4. ROUTE OF 220 KV S/C LINE WITH HEAVY SNOW

The line route was selected using satellite imagery. Due to inaccebility in some places along the route, digital terrain modelling & fly through techniques have been used to identify most suitable route. Snow avalanche is a major problem for this line apart from high wind pressure, low temperature, high seismic activity, heavy snow accumulation and high altitude. Portions of line passes through heavy avalanche zones. Despite of efforts, many towers came under avalanche funnel zone Prone to getimpacted by avalanche forces.

Fig 2. Route Map of 220 kV S/C line with heavy snow

5. SPECIAL DESIGN FEATURES

Special features have been considered in design of conductors, OPGW , towers and foundations, insulators & hardwares.

5.1 Tower

As the line passes through the highest wind zone of the country (basic wind speed of 55 m/sec)[1] and heavy snow zone areas, towers has been designed for the high wind speed & ice loading (25 mm radial ice deposition on conductor and earthwire). Tower geometry has been configured for additional electrical clearances [2] due to high altitude and cross arm of towers have been specially designed and staggered [2] to take care of conductor galloping. Special kind of steel[3] for towers has been used to mitigate the effect of low temperature. High strength conductor & OPGW has been considered instead of conventional conductors used in normal 220 kV lines. In addition to this, high strength OPGW and double strength insulator strings with additional insulators have been considered.

Tower Type	Weight Span (m)		Wind Span(m)	Base Width at Normal Tower Level(m)	Wind zone	Ground Clearance (m)	Radial Ice Thickness (mm)	Max Conductor Temp(degrees)
	NC (Max)/ (Min)	BWC (Max)/ (Min)						
220 kV S/C SINGLE ACSR DEER T.T. 'D'	2000/-2000	1200/-1200	500	9.00 x 9.00	6(55m/s)	7.7	25	85

Table 2. Design Parameters of 220 kV S/C Single ACSR DEER T.T. 'D'

Fig 3. 220 kV S/C Single ACSR Deer T.T. 'D' with cross arm staggering

5.2 Tower Foundation

The foundation for avalanche prone area has some special features to take care of snow impact loading due avalanches which are stated below:

(a) Its pedestals are straight as compared to the conventional tower foundations whose pedestals follow the slope of the leg connected to them. This has been done to avoid excessive excavation for the purpose of foundation casting. Moreover the pedestals are also kept circular in shape so as to reduce the effect of snow load on it as the shape factor is less as compared to rectangular or square column.

Fig 4. Special Foundation with Circular straight pedestals and tie beams

(b) Instead of stub the tower leg is connected to the foundation by the anchor bolts and base plate.

(c) Raised chimney of 9.5 m and 6.5 m height provided for sufficient height to cables above ground level to avoid avalanche impact

Fig 5. Raised Chimneys for increased clearance for conductors

(d) As the requirement for the raised chimney is quite high i.e. 9.5 m and 6.5 m due to area's vulnerability towards avalanche, therefore tie beams of four and three numbers respectively have been provided. It has the following purpose.

(i) They are provided at different levels to increase inertial mass of the foundation.

(ii) They make all the four legs as one integral unit to resist the high avalanche impact.

(iii) They are securely tied with pedestal with sufficient reinforcement anchorage to make perfect monolithic structure and to provide effective restraint against avalanche impact

6. DESIGN ASPECTS

6.1 Modelling

Columns and tie beams were modeled in the STADD PRO as shown below. Only 9.5 m RC analysis is shown below as 6.5 m RC analysis is a subset of previous one.

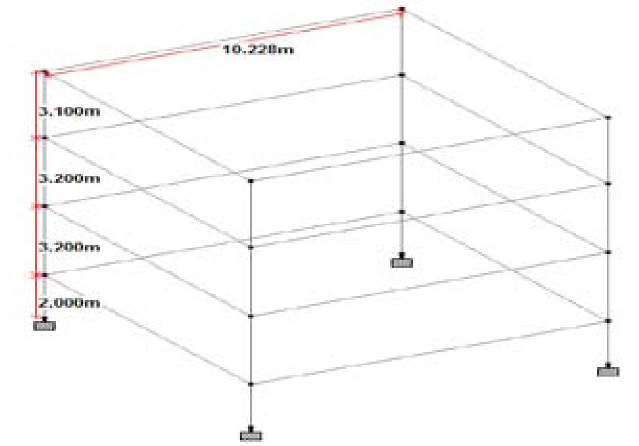

Fig 6. STADD model of column and tie beams for 9.5 m RC.

6.2 Loading

(1) The following loads are considered for the analysis.

(a) Dead Load-Self weight of the structure.

(b) Live Load.

(i) Vertical Loads on beams due to deposited ice of 1.5 m thickness

1.50 x 0.40 = 0.60 t / sq. m

[For thickness of snow = 1.50 m and Density of snow = 0.40 t cu.m]

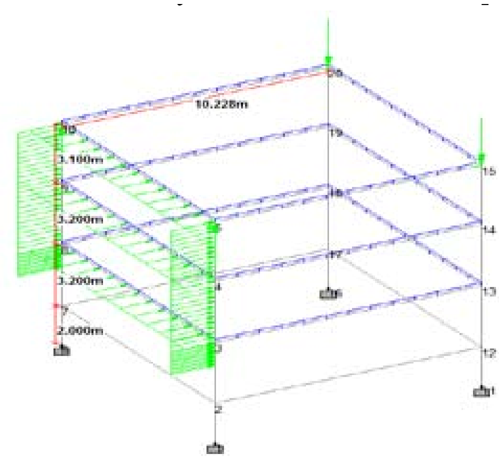

Fig 7. Vertical loads on beams

(ii) Horizontal loads due to avalanche pressure.

Loads have been applied in three directions i.e. Longitudinal, Transverse and Diagonal.

Horizontal load on beam and pedestal= 4.50 t /sq. m

[For density of avalanche debris = 0.45 t / cu.m and velocity of avalanche = 10 m / sec]

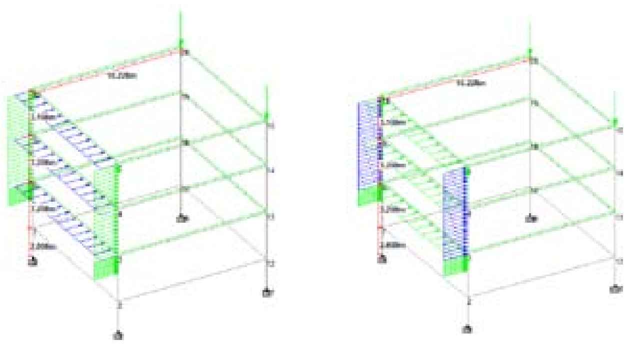

Fig 8. Horizontal loads on beams and pedestals in longitudinal and Transverse direction

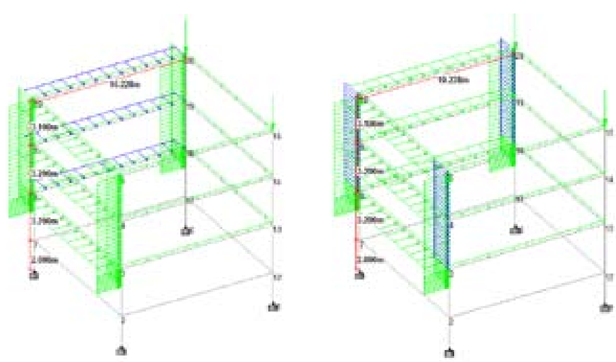

Fig 9. Horizontal loads on beams and pedestals in diagonal direction

(iii) Compression, uplift force and side thrust from the tower have been applied on the pedestals with a factor of safety of 1.1

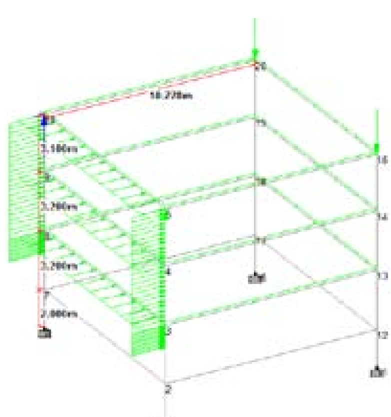

Fig 10. Uplift and compression loads pedestals in Vertical direction

6.3 Analysis

The Modeling as well as the analysis has been done on STADD pro using stiffness matrix method. From the above analysis of the model Bending Moment, Shear Force and Axial Force Diagrams were derived. Some typical results are as follows:

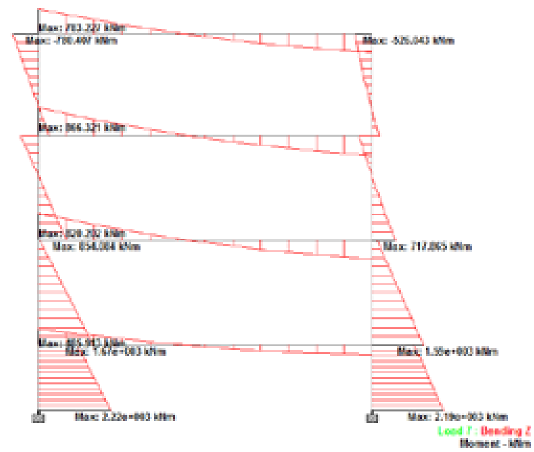

Fig 11. Bending Moment Diagram

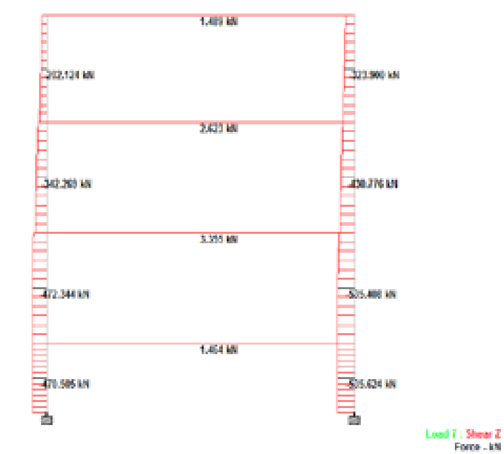

Fig 12. Shear Force Diagram

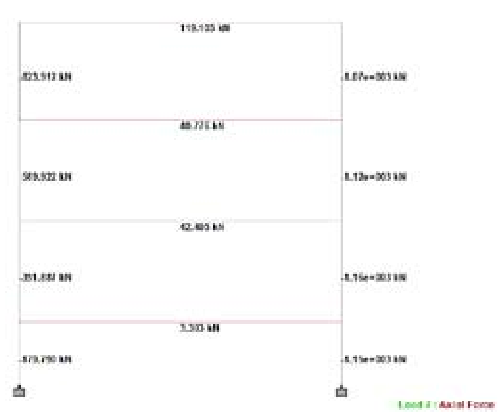

Fig 13. Axial Force Diagram

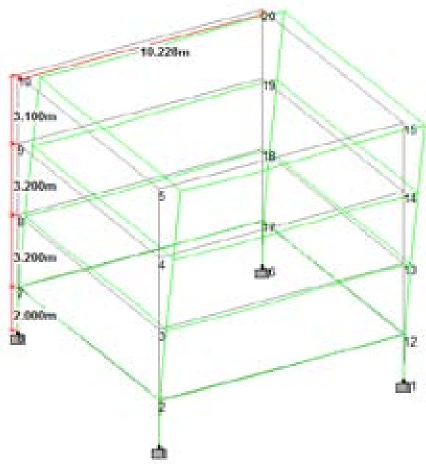

Fig 14. Deflection Diagram

6.4 Finalised Design

According to the analysis the forces were calculated. RCC design was commenced after taking the forces into account. In the design concrete M20 Nominal Mix1:1.5:3 (Cement: Sand: Aggregates) and Steel Fe500 is taken. RCC design done according to IS 456:2000[4].

Result: These are common for both 6.5 m RC and 9.5 m RC except in 6.5 m RC there are only three tie beams whereas in 9.5 m RC there are four of them.

Tie beam i) Size-700mm X 700 mm Column (i) Size-1200 mm (ii) Reinforcement- 20no. 32 (iii) Reinforcement-36 no. 32.

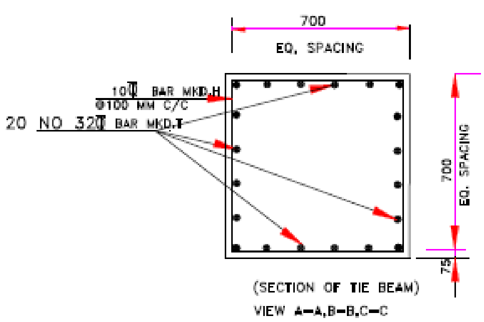

Fig 15. Typical Cross Section for Tie Beam

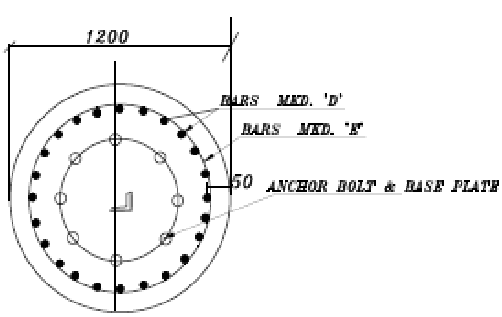

Fig 16. Typical Cross Section of Pedestal

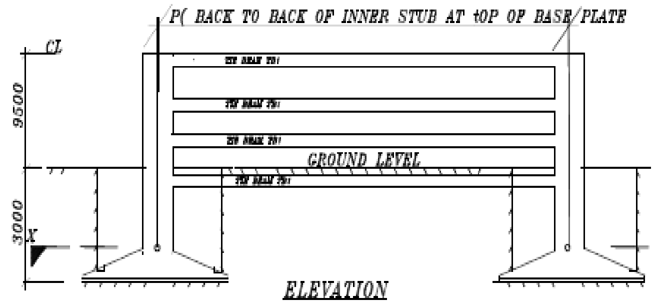

Fig 17. Typical Elevation of foundation showing tie beam arrangements

7. CONSTRUCTION CHALLENGES

As the region is located at an altitude ranging between 2400 m and 4500 m above mean sea level with rugged topography having steep slopes. The conditions are not conducive for the construction activities to take place. The following are the challenges faced during construction activities.:

(i) The ground access to the region is cut off every winter due to avalanche activities along the roads.

(ii) Extreme cold weather and high winds.

(iii) Short working period (July to October)

(iv) Unanticipated snowfall during the end of year

(v) Traversing difficulty due to snow.

(vi) Scorching sunlight at high altitude makes it difficult to see.

(vii) Approachability problem for the construction equipments

Fig 18. Snowfall During Construction

Fig 19. Traversing difficulty

Fig 20. Difficult Approaches

Fig 21. Reinforcement bar tying

Fig 22. Scaffolding Installation

Fig 23. Casting of foundation

Fig 24. Erection of tower

8. CONCLUSION

Despite of severe challenges faced and short working period during construction of the line.

(i) Total of 1100 foundations were casted (out of which 14 were special foundations)

(ii) Erection of towers in a stretch of 350 km between Srinagar to Leh.

(iii) Stringing work completed.

(iv) Part of Srinagar-Leh line was commissioned.

(v) The experience of transmission line design and construction at high altitude and heavy snow areas was very useful. Therefore can be used as a benchmark to tackle similar problems (if occur) in future endeavors.

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Energy Conservation is the Foundation of Energy Independence

FOUNDATION FOR TRANSMISSION LINE TOWERS IN HILLY REGION

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1.0 INTRODUCTION

1.1 Mountain is a cluster of rocks having different contours. Range of mountain have valley, rivers and forest.

1.2 The rocks are broadly classified as follows.

- **Sedimentary Rocks:** They comprise sand, shells, stones, pebbles and other fragmented material in different forms. All such elements clubbed together, is called sediment. With the passage of time (millions of years) the sediments become hard due to overburden and weather effect. This is the process by which sedimentary rock is formed and it is fairly soft. Sometimes fossils are also found. This type of rock is very easy to break.
- **Metamorphic Rocks:** They are formed under the surface of the earth due to constant change in matter (metamorphosis) resulting from intense heart and pressure. Sudden eruption on a large scale, forms the mountains. They may contain minerals and may have shining surface and crystals.
- **Igneous Rocks:** They are formed when rock in the molten form within the earths body (magma) erupts and cools down gradually. Sometimes gas is also trapped within such rocks creating spaces and holes in the rocks.

1.3 Mountain ranges in India and their types are as follows

- **The Himalayan Range:** This mountain range is the youngest range and is in the category of "Fold mountains" which are formed due to collision of two tectonic plates. The mount Everest is highest peak with an altitude of 8848 meters. There are about 100 mountains having an Altitude of 7200 M or more in the Himalayan range. Himalaya falls in the category of Fold Mountain because they have many ridges.
- **The Satpura & Vindhya Range:** This ranges are in central India covering the sates of Madhya Pradesh, Maharashtra, Gujarat, Chhatisgarh and Utter Pradesh. The range falls in the category of "Block mountains" which are characterized by massiveness. They are formed when cracks in the earth pressure forces some blocks out.
- **The Aravalli Range:** This range of mountains is said to be oldest in the world with width ranging from 10 km to 100 km. The range falls in the states of Delhi, Haryana, Rajasthan & Gujarat. This range falls in the category of "residual mountains" which is a combination of weathered rock and hard rock.
- **Western Ghats Range:** This range is 1600 km long from Gujarat to Kanyakumari (Tamil Nadu). This is also called "Sahyadri mountain". It is in the category of "residual mountain". The sizes of these mountains reduce due to weathering.
- **Eastern Ghats Range:** This range runs parallel to Bay of Bengal. This range has mountains with lower Altitude compared to western ghats. It covers states of West Bengal, Orissa, Andhra Pradesh and Tamil Nadu. This is also a type of "residual mountain".

1.4 The type of soil & rock strata in the hill / mountain plays important role in deciding type of foundation to be cast for transmission line.

1.5 In addition to the soil strata, it is also important to consider construction constraint such as

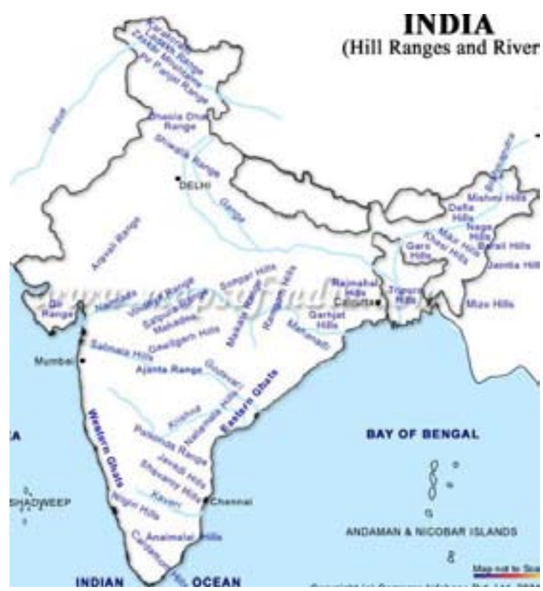

Fig. 1 Shows the location of various mountain ranges in India.

steepness of the hills, flowing rivers and soil erosion, spans between the towers etc.

1.6 Paper here under gives detailed account of foundations to be cast in Hilly Region.

Fig. 2 Shows the area covered by the various mountain ranges in India.

2.0 CONVENTIONAL TYPES OF FOUNDATION SUITABLE FOR HILLY AREAS

2.1 Soft rock foundation: This is used when soft rock such as lime stone, laterite etc. is encountered while excavating the pit. Under cut is provided for better uplift capacity. (Please see Figure-3). The foundation may not have very deep excavation. Normally the soft rock strata is uniform without any layers of other material. However, there can be more than one soft rock layers depending upon the stratification.

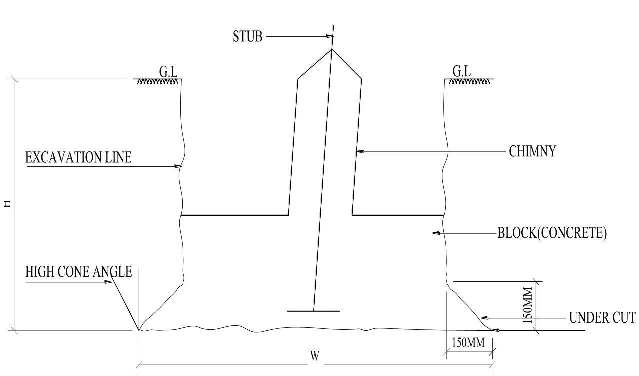

Fig. 3

This type of rock has a high safe bearing capacity (SBC) of the order of 45000 kg to 50000 kg per square meter. This results into lower foundation width, W. Due to good friction between soft rock and the concrete block as well as mobilization of rock mass through high cone angle (say up to 45^{o}), the soft rock foundation offers very good anchorage against up-lift or tension forces. Thus, this type of foundation affords lesser depth compared to other type of foundations cast in soil. This type of foundation may be popular in folded type mountains like Himalaya as well as residual mountain.

2.2 Fissured rock foundation: These types of foundations are designed in the same manner as soft rock except some variation in soil parameters. Normally this type of soil/rock strata is composed of various layers of rock having brittleness and tendency to disintegrate during excavation process. The width and depth of foundations in this type of rock will be more than the soft rock. Under-cut type concrete structure will be most effective. This type of soil strata is available in most of the ranges in India. In many stretches of Himalaya range also it is common.

The fissured rock can be "dry" type or "wet" type. Wet type fissured rock will be encountered when there is a source of water (percolation) or when the location is in the valley/agriculture field. The design parameters for these types of foundations are as follows.

Parameters	Dry fissured rock / soft rock	Wet fissured rock
Limit Bearing Capacity (kg)	62500	62500
Density (kg/cu.m)	1700	940
Limit Bond between Rock & Concrete (kg/sq.cm)	1.5	1.5

It may be pertinent to note that the quantity of Excavation, concrete and steel re-enforcement will be more in wet fissured rock as compared to Dry fissured rock.

2.3 Hardrock foundations: This type of foundation needs blasting. In Himalayan ranges it is difficult to find Hard rock on the surface, at most of the places.

There are two alternatives for casting the foundations in Hard rock. The first one is a Block (friction) type and other is Block and Anchor type. They are shown in Figures 4 & 5 respectively.

It is very important to note that the above types of design depend upon the friction between rock and the concrete, through the block of concrete. Normally the Bond between Hard rock & concrete is of the order 7 to 8 kg/cm^2. However, the CBIP manual indicates a safe valve of 4.5 kg/cm^2. Thus, the Anchorage due to friction in Block (friction) type foundation will be W(cm) x H(cm) x 4 (sides) x 4.5(bond) kgs. In case of Block and the rock Anchor type foundation, this will be H_1(cm) x W_1(cm) x 4(sides) x 4.5 (bond) kgs. Since $H_1 < H$ the value of Anchorage due to block in the Figure 5 will be less than Figure 4. Thus, the balance tension (uplift) load will have to be taken by Rock Anchors. The number of Rock Anchors & their depth will depend upon the requirement of Anchorage. While carrying out the construction work, it is necessary that the design and structural drawing of the foundation are properly translated. The following is note worthy.

- In case of Figure 4, the total Anchorage against the upward force is provided by the bond between Concrete Block and hard rock (as there are no Rock Anchors). When blasting operations are done, it is very difficult to get the dimension of pit as shown in the design (See figure–6). In any case, it should be ensured that the entire width of the excavated pit through height of concrete block (H or H_1), If this is not done there will not be a bond between concrete and the rock. This may cause the foundation failure due to slipping out from the gap (See figure–7).
- If the rock Anchors are used, part of the upward force is taken by the Anchors through the bond between the Anchor bar and the grout and the bond between the grout and the rock.

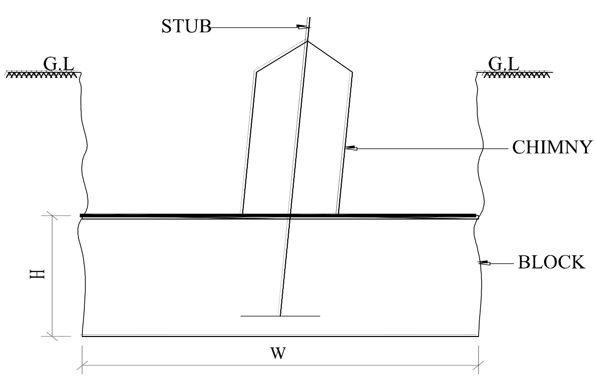

Fig. 4

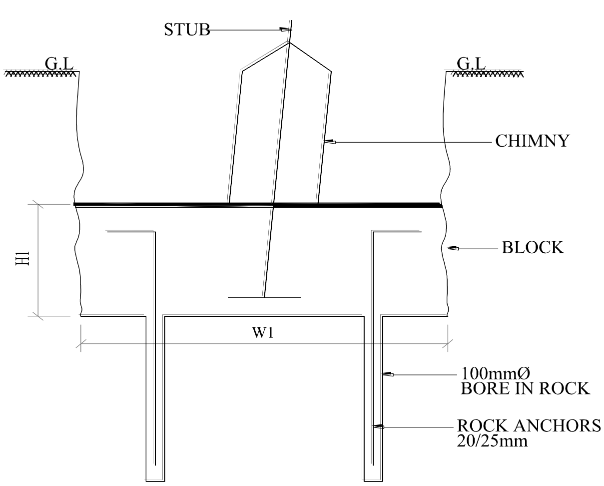

Fig. 5

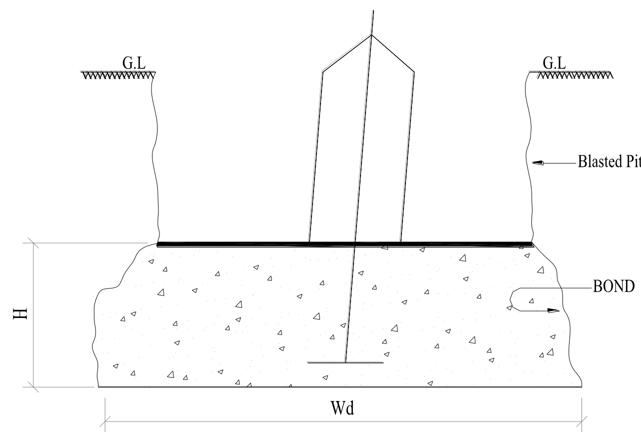

Fig. 6

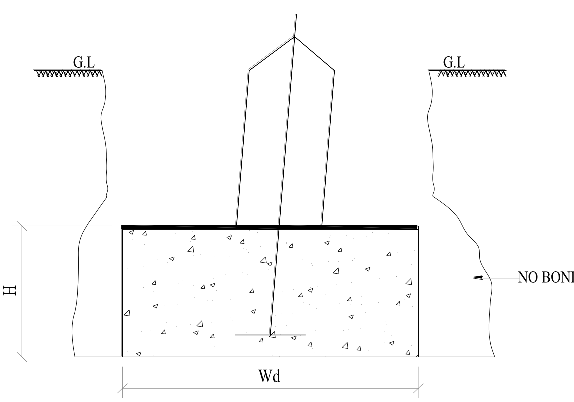

Fig. 7

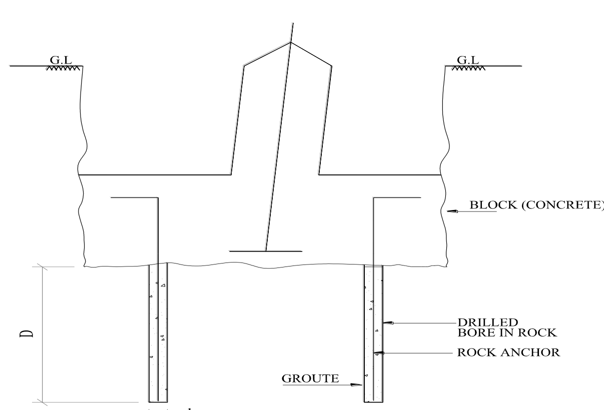

Fig. 8

- If the holes are not drilled with the desired diameter 'd' and the desired depth 'D', there are chances of premature failure of foundation against the upward force.

Parameters	Hard rock
Limit Bearing Capacity (kg)	1,50,000
Limit Bond between Rock & Concrete (kg/sq.cm)	4.0
Limit Bond between Rock Anchor & Grout (kg/sq.cm)	10

- Control blasting is normally resorted to for avoiding excess depth/width of the pit. It also helps in avoiding damage to any nearby structure, trees and accident to human & animal.
- Minimum depth of 1.5 meter from the ground is recommended to ensure that the foundation do not rest an isolated boulder. Otherwise the tower leg along with the boulder will come out from the ground (See Figure–9). This aspect is more relevant in the Himalayan mountains where the excavated pit many times, is composed of boulders and the silt/sand/gravels/stone etc.

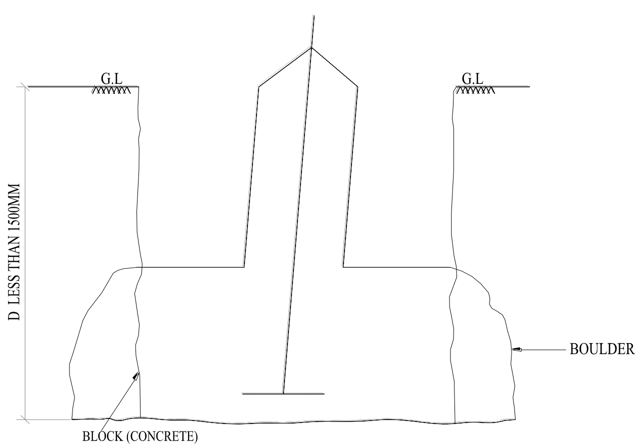

Fig. 9

- The location of tower on hard rock should be selected away from the vertical cliff to avoid blasting off the excavated pit in the valley or exposure of foundation due to weathering.

3.0 UNCOVENTIONAL FOUNDATIONS & SUPPORT STRUCTURES FOR HILLY REGION

3.1 The conventional foundation designs described above are used depending upon the experience and expertise gained by the construction engineers while working in the region. However, there are some un-conventional foundation designs & R.C.C. support – structures for towers located on steep mountain slopes. They are covered in the paras below.

3.2 Steel Grillage Foundation: This is a foundation without any use of cement. This is shown in Figure 10. The stub is connected to a Grid of Girders/Angles laid at the bottom of excavated pit. The assembly is simply lowered in the excavated pits. All the stub tops are properly levelled & the pits are backfilled with excavated soil, rock, boulder etc. Since the buried steel part do not get oxygen there is no corrosion of stub or the grid below.

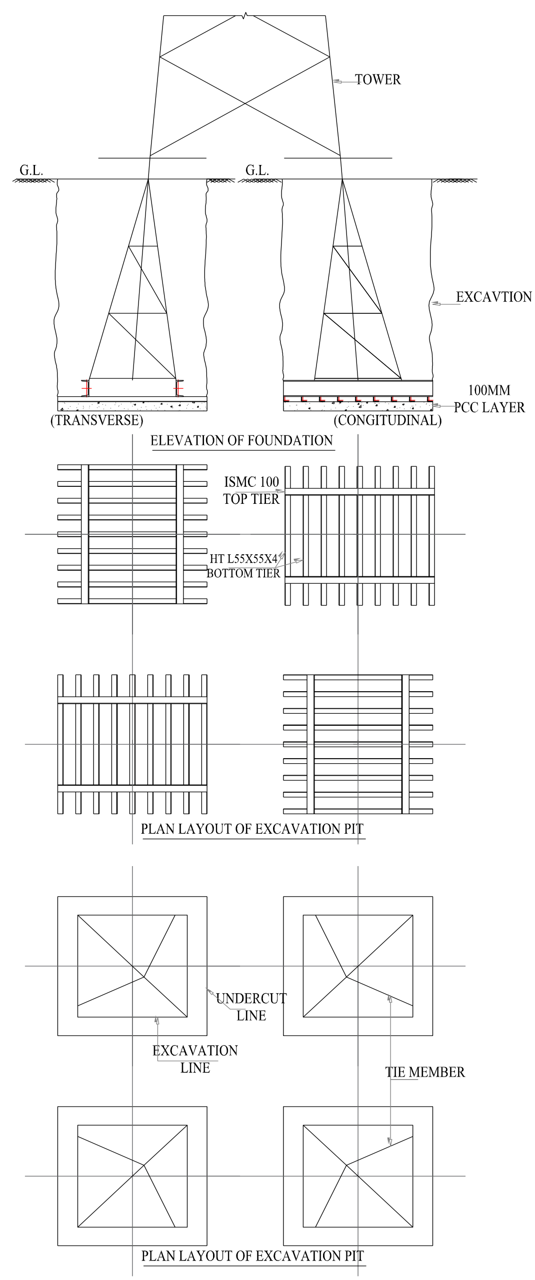

Fig. 10

This type of foundation is very useful where cement is not available freely (in most of the under- developed Africans countries). This type of foundations is also useful where the transmission line is scaling the peaks and foundation work is very difficult due to the requirement of Head loading of material up to the location.

These types of grillage cannot be used when soil strata is highly organic in nature.

3.3 R.C.C. support structure for locations on the slope: Many times the tower is located on slope of tower needing bench cutting. We can avoid bench cutting work by providing a base R.C.C. structure on uneven slopes & still allow all the four legs of the towers to rest at same level. This is shown in Figure 11. This arrangement may not be suitable for very broad base towers.

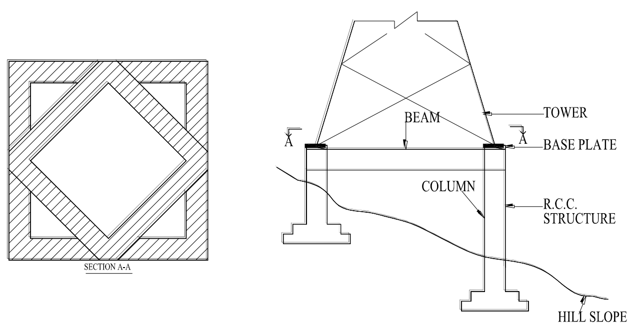

Fig. 11

3.4 Extended Chimney Type Foundation: - Alternative to the R.C.C Structure suggested in 3.3 above, sometimes the constructions crew members prefer to extend the foundation chimneys to match the slope of the hill. This is shown in Figure 12. This arrangement may be suitable to very broad base tower with relatively small gradient. Due to less footprint, they may be preferred in Agriculture fields and orchards along the mountain slopes.

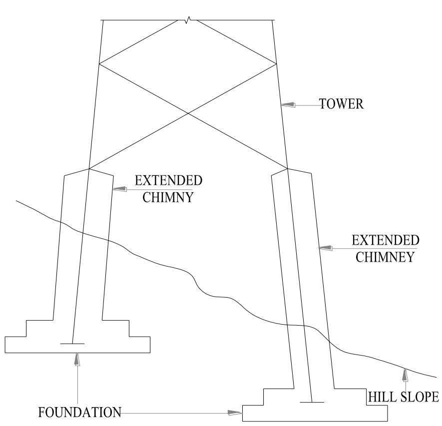

Fig. 12

Sometimes, such chimneys are extended to a height of 6 to 9 Meters. Though this serves the purpose, the size of the chimney increases very much. Besides unsupported length being very high, such chimneys can be vulnerable to torsion under broken wire condition and falling debris.

Where level difference between the legs is of the order of 3 to 4 meters, extended chimneys can serve the purpose.

- It is better to develop hill side extension for towers to be spotted on higher gradients, as shown in Figure 13.

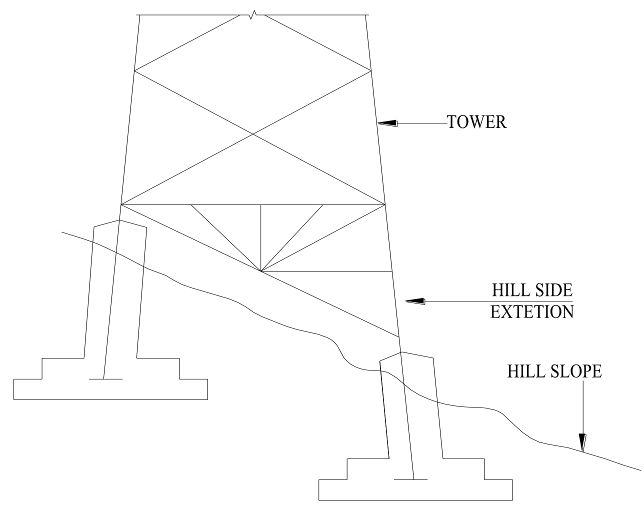

Fig. 13

- Sometimes, all the four legs may be on different contours (levels). In such a situation, the extension has to be suitably modified. A photograph (Figure 14) showing

Fig. 14

4.0 PROTECTION OF TOWER FOUNDATIONS

4.1 The tower foundations in hilly regions need to be protected against the following

- Erosion of soil around the foundation due to water flow and weathering of rocks.
- Land slide around the footing of the foundation.

4.2 The foundation can be protected by providing stone wall/R.C.C wall, stone pitching or coffers all around. The wall height will depend upon the contours around tower.

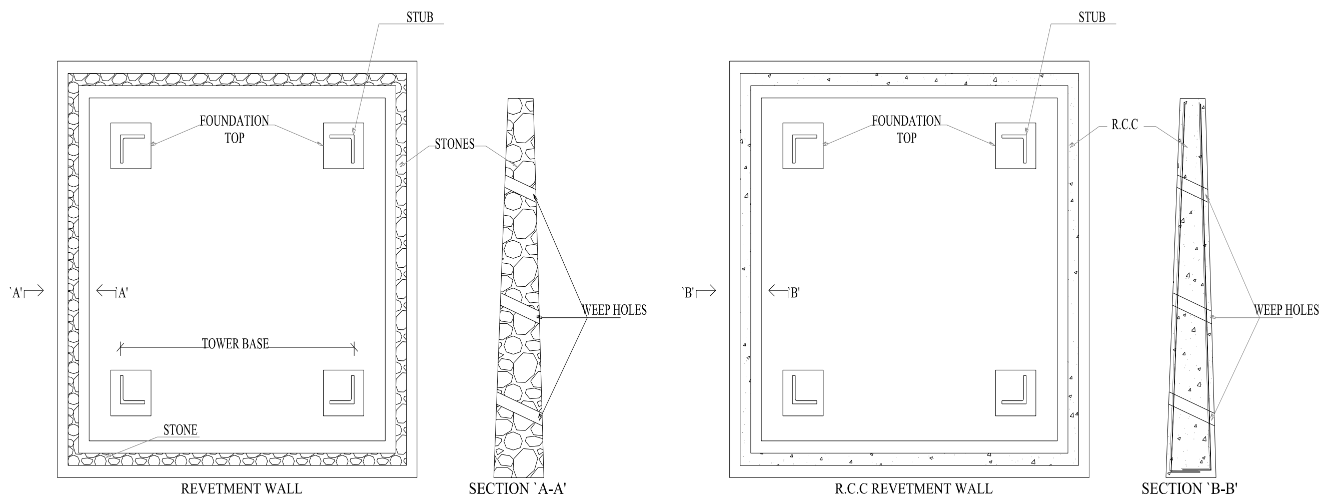

Fig. 15(a) & Fig. 15(b)

4.3 Protection to the foundation can also be secured by providing Gabions around the tower base including the slope. The gabions are the group of stones/boulders (300 mm or more) stocked in wire mesh cage.

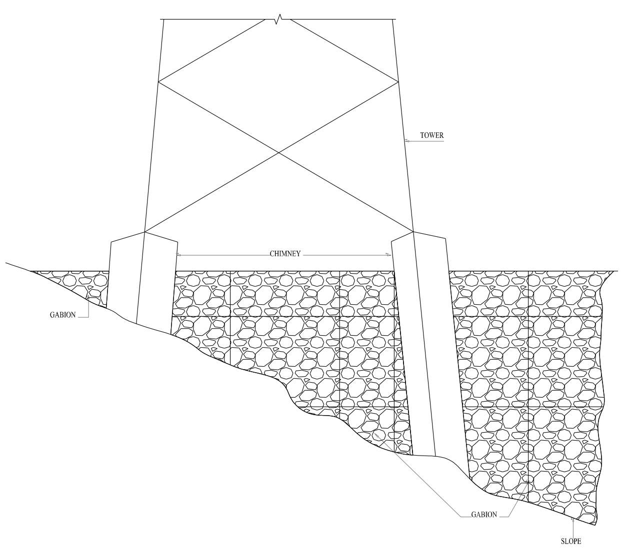

Fig. 16

4.4 If the soil around the foundation is likely to be eroded, protection is secured by providing stone pitching as shown in Figure 17.

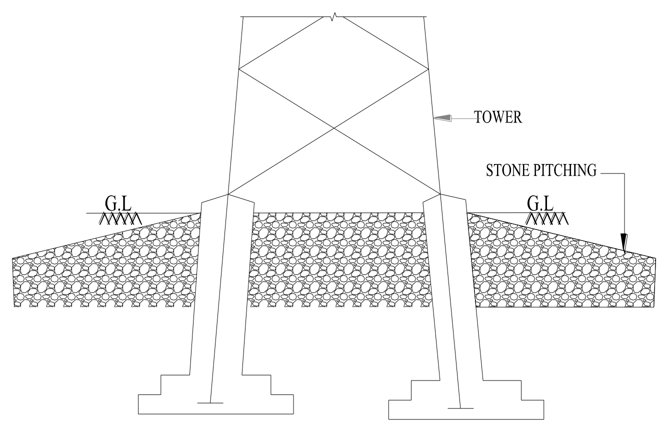

Fig. 17

5.0 CONCLUSION

5.1 Design & Construction of foundations for transmission line towers in the hilly regions is a specialized activity and calls for precision in engineering and construction practice.

5.2 Depending upon the site situation, the foundation design and construction practice has to be modified. Co-ordination of the design and construction engineers goes a long way in the service life of foundation.

MITIGATION OF SWITCHING OVER VOLTAGES IN UHVAC SYSTEM

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ABSTRACT

For transmission voltages above 400 kV, transient overvoltages play a vital role. At greater transmission voltages, switching overvoltages become more significant as the operating voltages of arresters are relatively near to normal system voltage and lines are usually long so that the energy stored in the lines may be large. Switching overvoltages shape and magnitude change according to the system parameters and the network configuration. For reliable operation, the switching overvoltage must be less than 2 p.u. at the receiving end for events such as line energization and re-energization where the highest switching overvoltage occurs. These overvoltages are not desirable and can damage the insulation of the lines and associated equipment. This paper delves into the different methods to mitigate the switching overvoltages and ultimately concludes the best method to reduce the switching overvoltages in a 1200kV system.

Keywords *: Switching Overvoltage, pre-insertion resistors, controlled switching, shunt reactors.*

I. INTRODUCTION

Conventional UHV technology is unable to cater to the needs of the growing demand of electricity consumption of the Indian sub-continent. This calls for a higher EHV voltage level which could make long distance transmission and high capacity power transfer more economical. India is a widespread mass of land and has sporadic distribution of energy sources, which diminishes the development of the grid. India has now created a record of sorts by dedicating the 1200 kV system to the nation. This is a significant advancement in terms of technological advancement in the power sector which promotes and upgrades the other equipment manufacturing industries. Merits of UHV transmission include lesser ROW per MW of power transferred, greater transmission capacity, better conservation of land resources, reduced transmission losses and significant payback in investment.

With an increase in the transmission voltage level one of the most important factor to be considered is the occurrence of switching overvoltages (SOVs). The admissible SOVs depend on the rated voltage of the considered system. For example, a 330 kV system cannot have a Sov multiple greater than 2.2 p.u., similarly for a 500 kV system, it should not be more than 2 p.u. So, greater the rated voltage, severe is the switching voltage limitation[1].

One of the primary causes for SOV generation is the power frequency overvoltage. So, in order to reduce the SOVs, one must reduce the power frequency overvoltage effectively. Owing to the longer length of transmission lines, the consumption of charging power is huge for EHV & UHV lines. A 500kV UHV line consumes 100MVAr/100 km of reactive power while for a 1000 kV transmission line the consumption might go beyond 500 MVAr/100 km. Also, due to the capacitive effect the amplitude of SOVs is higher. So, it is pertinent to address the reactive power issue of a UHV line which is done by installing shunt reactors on the transmission line. Literature also suggests that circuit breakers in conjunction with pre-insertion resistors are often employed to quench the transients due to energization[2]. Pre-insertion resistors (PIRs) are part of a plug system designed to reduce sparking and overvoltage events during connection of power lines and cables. PIRs have now become basic devices to control the switching voltage of the UHV system. Most countries across the globe have adopted the use of PIRs without exception [1]. It is important to assign an appropriate value of PIR to minimize the overvoltages. Controlled switching is a method used to eliminate harmful transients generated by switching operations. In this technique opening or closing commands to the circuit breaker are delayed in such a way that current interruption or initiation occurs at a pre-determined point on an electrical reference signal, i.e. voltage or current waveform.[3]. Synchronized switching or Point-on-wave switching are some of the other names for it. Operational details of controlled switching applications depend mainly on two factors; the type of the load to be switched and the operational characteristics of the circuit breaker to be used.

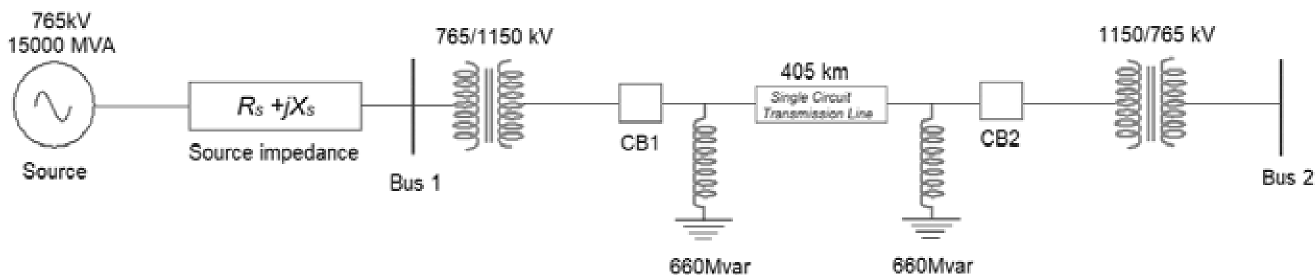

Fig.1 Schematic of 1200kV UHVAC system

II. MODELING OF THE UHV SYSTEM

Complete simulations, data and research have been done on PSCAD [4] for the 1200kV UHVAC Wardha – Aurangabad line which connects the corridors of Eastern and Western India. The schematic of the considered system is shown in Fig. 1. The rated voltage of the system is 1200 kV and considered for a base of 1200 kV.

A. Source Impedance

The source impedance is modeled as a constant voltage source in series with an impedance. The impedances have been taken from[5].

B. Overhead Transmission Line

The overhead line is assumed to be an un-transposed frequency phase dependent line with specifications taken from[6].

C. Transformer

The transformer is modelled as an inductance whose specifications are as given in[7].

D. Circuit Breaker (CB)

The circuit breaker is modelled as a non-ideal switch with pre-insertion resistance of 600Ω.

E. Shunt Reactors

These are modelled as simple lumped inductance connected to the line according to calculations given in[8].

F. Operating Voltage

The bus voltages are 1150 kV for the considered UHVAC system.

III. SIMULATION AND RESULTS

According to IEC, the SOVs must be limited to less than 2 p.u. To do this, there are different methods to reduce the SOVs due to line energization. These methods include the use of pre-insertion resistors, shunt reactors, controlled switching and a combination of the three methods. The simulation cases for the above methods are discussed further.

A. Case 1

First, we observe the magnitude of overvoltages without any mitigation scheme, i.e., not using any pre-insertion resistors, controlled switching and shunt reactors. The analysis is done for the schematic shown in Fig. 1 at different lengths of the considered line and a typical overvoltage is shown in Fig. 2. The SOV values are tabulated in Table 1 and the variation of SOV against the line length is shown in Fig. 3.

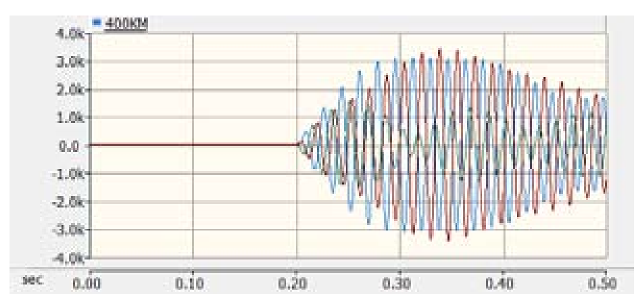

Fig 2: Overvoltage waveform when no control is used

Table 1: Overvoltages without any Mitigation Scheme

Line length (km)	Overvoltage (p.u.)
0	3.032
100	3.230
200	3.374
300	3.462
400	3.491

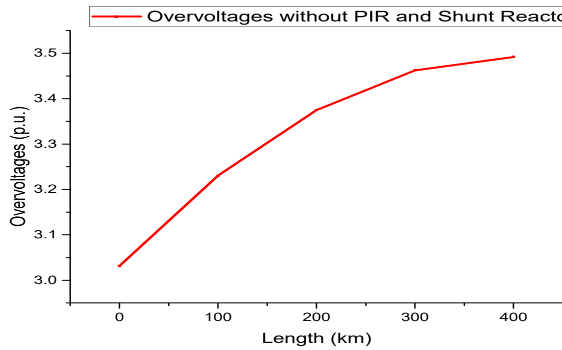

Fig 3: Variation of Overvoltages at various lengths of the line without using any mitigation method

B. Case 2

In this case we introduce the pre-insertion resistors of 600 Ω and an insertion time is 10 ms. The analysis is done for the schematic shown in Fig. 1 at different lengths of the considered line and a typical overvoltage is shown in Figure 4. The overvoltages observed are tabulated in Table 2 and their variation against line lengths is shown in Figure 5.

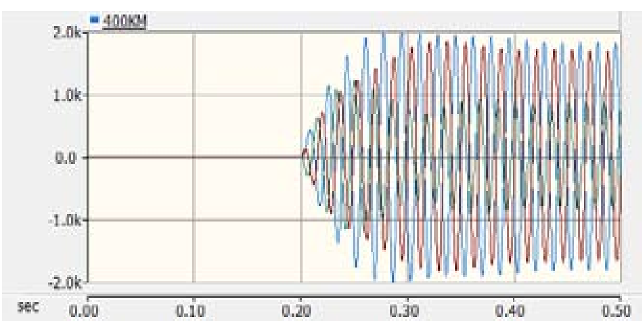

Fig 4: Overvoltage waveform when only PIR is used

Table 2: Overvoltages Using Only PIRs

Line length (km)	Overvoltage (p.u.)
0	2.408
100	2.449
200	2.513
300	2.626
400	2.693

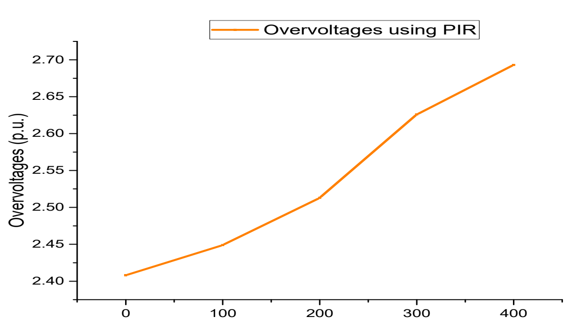

Fig 5: Variation of Overvoltages at various lengths of the line using only PIR

C. Case 3

To diminish the SOVs further, shunt reactors rated at 660MVAr in conjunction with PIRs are used. The analysis is done for the schematic shown in Fig. 1 at different lengths of the considered line and a typical overvoltage is shown in Figure 6. The results when both are used are shown in Table 3 and Figure 7 shows the variation of overvoltages against line lengths.

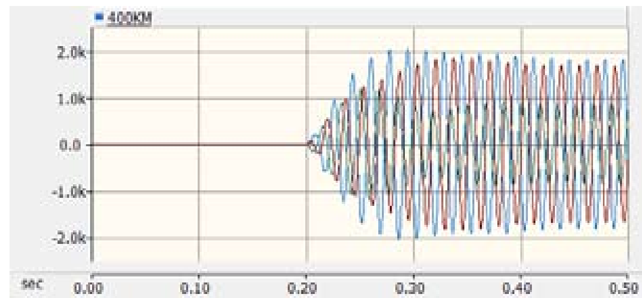

Fig 6: Overvoltage waveform when both PIR and Shunt Reactor is used

Table 3. Overvoltages Using PIRs & Shunt Reactors

Line length (km)	Overvoltage (p.u.)
0	1.839
100	1.940
200	2.013
300	2.057
400	2.071

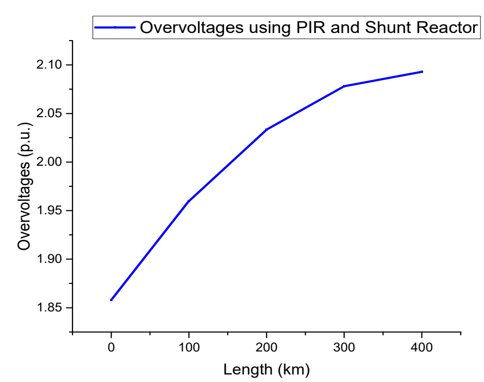

Fig 7: Variation of Overvoltages at various lengths of the line using both PIR and Shunt Reactor

D. Case 4

In the final case we employ a controlled switching scheme for the circuit breaker along withthe pre-insertion resistor and the shunt reactor. The analysis is done for the schematic shown in Fig. 1 at different lengths of the considered line and a typical overvoltage is shown in Figure 8. These results are shown in Table 4-5 and their variation is shown against line lengths in Fig. 9.

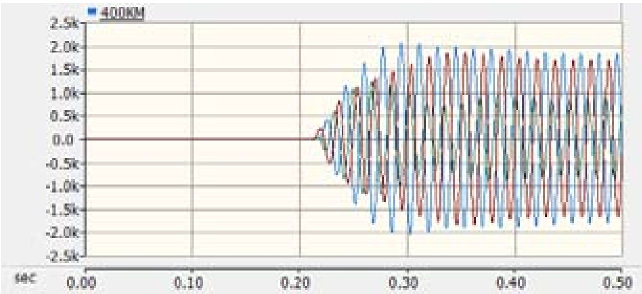

Fig 8: Overvoltage waveform when PIR with controlled switching and shunt reactor is used

Table 4: Overvoltages Using PIRs, Controlled Switching and Shunt Reactors

Line length (km)	Overvoltage (p.u.)
0	1.737
100	1.889
200	1.859
300	1.904
400	1.969

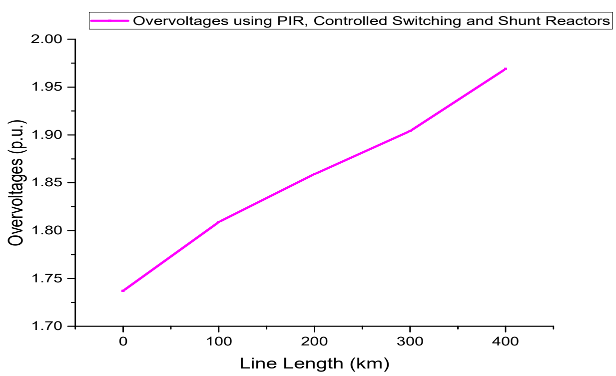

Fig 9: Variation of Overvoltages at various lengths of the line using PIR with controlled switching and shunt reactor

Finally, we compare the results of overvoltages in all the four cases against line length. This is shown in Figure 10.

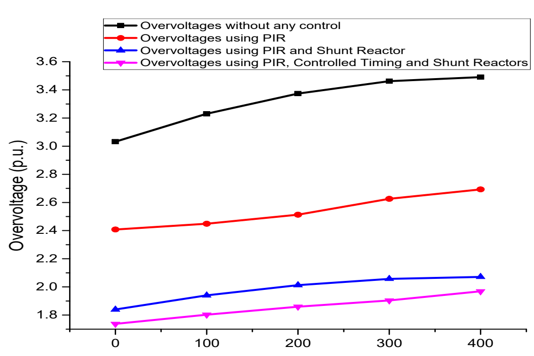

Fig. 10: Comparison of Overvoltage magnitudes for different methods

IV. CONCLUSION

The paper focuses on different methods to reduce the switching overvoltages in the considered 1200 kV system. From the Fig. 10 it is clear that a combination of pre-insertion resistors along with controlled switching and the use of shunt reactors reduced the overvoltage to less than 2 p.u. which is in accordance with the IEC.

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K. Baburao

PRESENT & FUTURE GENERATION DIELECTRIC FLUIDS FOR POWER TRANSFORMERS & SHUNT REACTORS

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Vasanthi R and Sathiesh Kumar. R
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ABSTRACT

Today's transmission and distribution systems are continuously expanding to evacuate ever growing power generation in all parts of the world. Along with the continuous growth in demand for electrical energy the nature of demand has also become more complex. Large and growing urban agglomerations driving economic growth, demands safe uninterrupted quality electrical power. To ensure a high degree of reliability it is of utmost importance that all critical equipments like transformers, shunt reactors, switch gears and capacitors in the transmission & distribution grid perform at rated capacity unfailingly without compromising on the safety aspects.

Mineral oil based dielectric fluids have been integral part of transformers starting from 1890 and continue to be the preferred medium due its track record, good performance and competitive costs. As the generation and transmission systems grew from, LV, MV, HV, EHV & UHV the quality of dielectric fluids also kept pace to conform to the rigid standards, thanks to the technological advancements in refining. Modern catalytic hydro processed mineral dielectric fluids apart from meeting the thermal and electrical stresses constantly varying due to load factors have also proven characteristics to comply with environmental issues; a major factor in the present times. We have the present generation mineral oil based dielectric fluids, synthetic ester and natural ester-based fluids fulfilling all these requirements.

Dielectric fluids have to be chosen based on the specific applications involved. Distribution systems in densely populated areas, traction, marine and coal mines all require high fire point & flash point dielectric fluids with biodegradability. Outdoor substation transformers may demand highly reliable and eco-friendly modern catalytic hydro processed dielectric fluids. Similarly, hermetically sealed Instrument transformers & bushings may require environmentally friendly fluids with gas absorbing property.

In this paper we present the results of our extensive studies carried out on the performance of present & future generation dielectric fluids and synthetic esters in the laboratory condition and through field studies.

***Keywords**: present generation modern dielectric fluids-pfgdf; synthetic esters; natural esters; naphthenic oils; power transformer; oxidation stability; thermal conductivity; biodegradability;*

1. INTRODUCTION

Transformers are the most critical equipments in the transmission & distribution system effectively catering to diverse needs like domestic, indoor and outdoor distribution, medium voltage, high voltage, extra high voltage and ultra high voltage applications. Over the period rapidly expanding power transmission systems involving MV, HV, EHV & UHV equipments, have seen vast changes in the material concept and designs also.

The role of dielectric fluid is critical[1] for the efficient performance of electrical equipments. Primarily Dielectric Fluid has three important functions - insulating the active parts, effectively transferring the heat from conductors to the radiators and providing diagnostic support to assess the health of the equipments through regular monitoring. This is important from the point of view of longer efficient life of the equipment. In the present times while alternative fluids are in use for specific applications, the MCHPDF remain the most widely used dielectric medium considering the advantage in terms of availability, cost, environment and reliability.

The dielectric fluids circulating inside the transformers and reactors are in constant contact with each and every part of the equipment. This naturally enables it to provide a wealth of useful information to evaluate the health of the equipment in active service. From the point of view all stake holders, consumers, producers, power generating companies, transmission agencies the information through diagnostic studies is extremely important and useful.

In this paper we present the results of our extensive studies carried out on the performance of present & future generation dielectric fluids both in the laboratory conditions and through field studies. We have also carried out detailed studies on synthetic ester-based fluids in simulated conditions in our laboratory to assess its advantage for certain applications.

1.1 Dielectric Fluids & Governing Standards

Dielectric fluids (DFs) are the backbone of the insulation systems in the power equipments. Billions of kilolitres of dielectric fluids are in use in power equipments all over the world. Transformers, reactors, resistors, capacitors, cables, bushings, circuit breakers, tap changers, thyristor-cooling in power electronics etc., all require critically dielectric fluids to perform efficiently. We have today a very wide range of dielectric fluids- mineral oils, silicone oils, high-molecular-weight hydrocarbons, synthetic esters, alkyl benzenes, aromatic hydrocarbons – (M/BT, PXE, and MIBP), natural esters, phthalates, cryogenic liquids, nano-fluids, smart fluids and mixed dielectric fluids available for customized applications in the power equipment. These dielectric fluids are functionally identical although it may vary in their chemical structures, viscosities, fire points, gas absorbing behaviors, biodegradability etc. The application of different dielectric fluids in power equipments[2][3] are as shown in Table 1.

Table 1 –Applications of Dielectric Fluids in Power Equipments

Dielectric Fluid Type	Governing International Standard	Critical Property	Type of Power Equipment
Naphthenic Paraffinic Fluids	IEC 60296:12, ASTM D3487:16	Good Oxidation Stability Relative Low Fire Point Low Moisture Tolerance Possible sulfur Corrosion Poor biodegradable	Transformers, Shunt Reactors, Circuit Breakers, Tap Changers, X-Ray tubes, Switches etc.
Isoparaffinic Dielectric Fluids	IEC 60296:12, ASTM D3487:16	Excellent Oxidation Stability, Moderate Fire point, Excellent Cold Temp Props. Free of PCA & PCB Zero Sulfur, Readily biodegradable	Transformers, Shunt Reactors, Circuit Breakers, Tap Changers, X-Ray tubes, Switches etc.
Vegetable Base Fluids	IEC 62770:13 ASTM D6871:17 IEEE C57.147:18	High Flash Point, Poor Oxidation stability, &Readily biodegradable	Transformers & Capacitors
Synthetic Hydro Carbon Dielectric Fluids	IEC 60867:93	Low Dielectric Loss	Cables
		Gas absorbing under partial Discharges & good negative impulse BDV Readily biodegradable	Cables, Bushings & Capacitive Dividers
		Gas absorbing under partial Discharges & Good negative impulse BDV	Capacitors
		Gas absorbing under partial Discharges Readily biodegradable	Capacitors
Silicone Fluids	IEC 60836:15 ASTM D4652:12	High Flash Point & Least biodegradable	Traction, Distribution & Turbine Transformers
Synthetic Ester Base Fluids	IEC 61099:2010	High Flash Point, Excellent Oxidation Stability, High Moisture tolerance & Readily biodegradable	Traction, Distribution, turbine transformers, mobile transformers & Capacitors
Other DFs		Adaptability	Transformers
		Adaptability	Transformers & Capacitors
		Suppression of Joule Heating	Superconductivity & Other Cryogenic Applications

Recent developments in dielectric fluids nanotechnology is gaining increased recognition in many engineering applications for improvement of equipment efficiency. Nano-fluids are actively under consideration for use in applications in a wide range of industries, from transportation to power engineering, in microprocessors and in micro-electro-mechanical systems (MEMS), and in biotechnology[4][5]. They consist of a base fluid in which nano-sized metal oxide particles (1–100 nm) are suspended. These can greatly improve the thermal and dielectric properties of the liquid, more specifically extending transformer lifetime and increasing loading / cooling capacity. Researchers are studying with various nano fluids and dispersants with TiO_2 particles, Al_2O_3 & AlN powders & with nano sized diamond particles to enhance dielectric performance of the fluids. Further it was also observed the nano-fluids with semi conductive nano-particles improve insulation properties and oxidation stability.

The discovery of superconductivity in 1911 had led to the development of high temperature superconductivity in 1986[6]. Use of cryogenic liquids as cooling and insulating agents in super conducting transformers and other equipments is one of the exciting developments. Much research is underway in superconductors cooled by a cryogenic liquid to understand the phenomenon of high current densities without the Joule heating.

Smart fluids[7][8] such as electrorheological and magneto rheological fluids have come into existence. The first one works with semi-conducting particles suspended in the dielectric fluids, while the second one has magnetizable particles suspended in a non magnetizable fluid. In both cases the flow mechanism isthe same; excitation of the fluid by the appropriate field (electricor magnetic) causes polarization and subsequent alignment of the particles suspended within the liquid. It is believed that smart liquids containing multifunctional nano-particles could be customized with specific properties, e.g., reduced dielectric loss, for application in liquid-filled power equipment.

Additives play an important role to improve the dielectric, physical and chemical properties of dielectric fluids. These additives perform as inhibitors, passivators, electron scavengers, or pour-point depressants etc. Addition of small percentage of these additives improves oxidation stability and all other critical properties in the equipments. Present & future generation dielectric fluids are ultra-refined fluids, free from sulfur, nitrogen, oxygen compounds and aromatic compounds. These fluids have excellent response towards antioxident additives and perform with high degree of reliability with least maintenance.

In today's growing environmental concerns, fully biodegradable dielectric fluids, improved with suitable additives will be utmost important.

2. CRITICAL PROPERTIES AND FUNCTION

1.2 Viscosity Profile

Viscosity influences thermal characteristics and impregnation of dielectric fluids. Lower viscosity dielectric fluids have ideal properties for impregnation compared to viscous dielectric fluids like Natural Esters, Synthetic Esters and Silicone fluids. At low temperatures, the resulting higher viscosities of these dielectric fluids will be an adverse factor for the cold start of transformers with poor circulation of oil and the possible risk of overheating at the hot spots. Hence IEC standards have recommended the viscosity at the lowest cold start energizing temperature shall not exceed 1800 mm^2 and 2500 mm^2/s at–30 &-40°C. Hence while choosing the dielectric fluids there are some basic properties that need to be considered. Biodegradable present & future generation dielectric fluid have excellent low temperature kinematic viscosities which are lower than two times of conventional naphthenic oils-CNO ensuring excellent flowability at cold start at all the time. The viscosity profiles of various dielectric fluids are as shown in Figure 1 & 2.

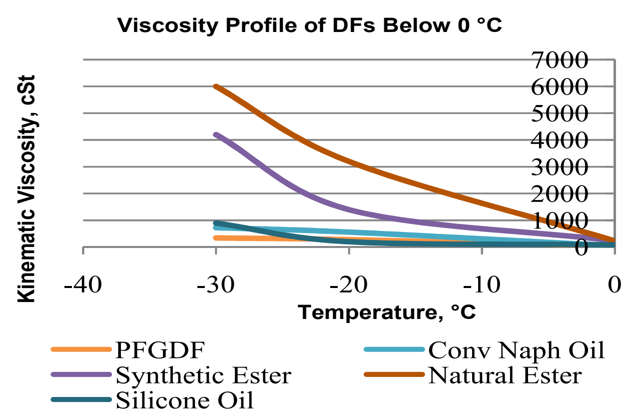

Fig. 1: Viscosity Profile of DFs

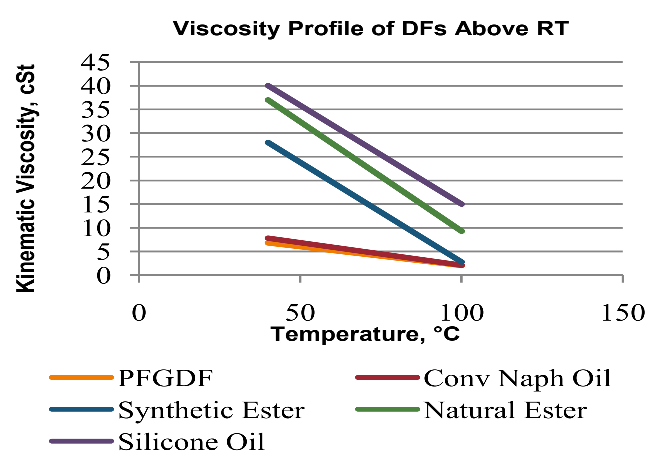

Fig. 2: Viscosity Profile of DFs

2.2 Heat Transfer

Power transformers in operation generate considerable heat at the core and windings. To ensure that the transformer does not suffer premature ageing due to degradation of cellulose paper, it is important that the heat generated thus is quickly and effectively evacuated from the core and winding[9]. In today's scenario with overloading of the system being a regular feature with less reserve capacity available it is important to give maximum attention to the effective management of the equipment.

Heat transfer basically depends on the heat capacity, thermal conductivity and density of the dielectric fluid and is mainly governed by its composition. Biodegradable present & future generation dielectric fluid has excellent heat capacity and higher thermal conductivity at higher temperatures and has low density ensuring excellent heat transfer as shown in Figures 3 & 4.

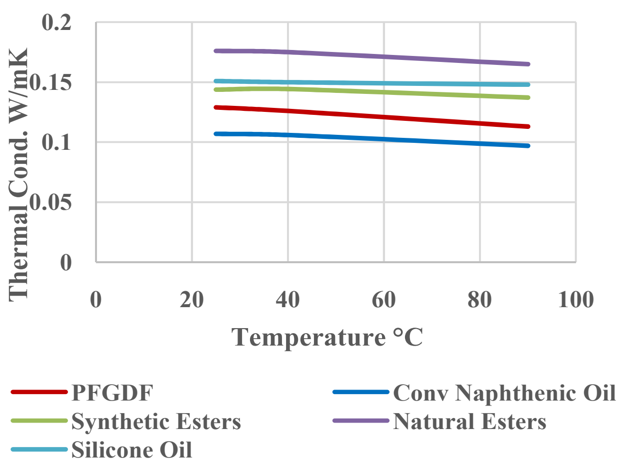

Fig. 3: Thermal conductivity of DFs

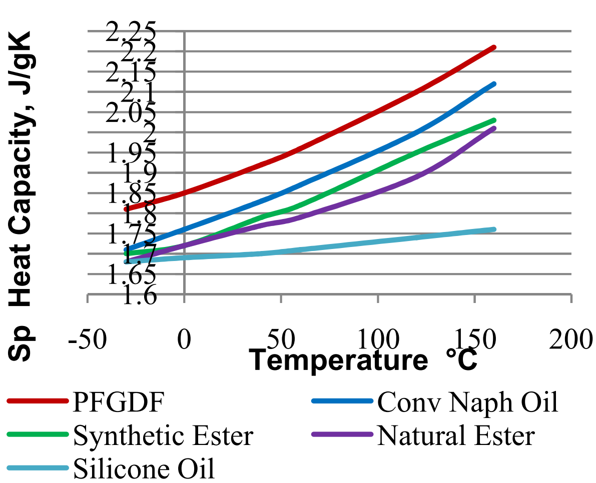

Fig. 4: Specific Heat Capacity of DFs

2.3 Oxidation Stability of Dielectric Fluid

It is very important that the dielectric fluid should be stable and perform efficiently throughout the operating life of the transformer. Oxidation stability is the most important parameter determining the life and performance of the dielectric fluid. The life management of the transformers and other oil filled equipment greatly depend on the health and performance of dielectric fluids.

Present & future generation DFsare inhibited will need relatively low maintenance. Conventionally processed uninhibited naphthenic oils pose threat of corrosive sulfur to the costly equipments. Natural Esters and Silicone fluids have poor oxidation resistant.

We had studied the important property 'Oxidation Stability Test' on present & future generation DF and Synthetic ester dielectric fluid in our laboratory. This test was conducted for 164, 500 & 1000 hours of test duration as per IEC 61125 Method C at 120 °C to understand the formation of harmful oxidation by-products such as polar compounds (acids), insoluble sludge etc, in the oil and its impact on dielectric properties[10]. The properties are as shown in Table 2 & 3 and the graphs as shown in Figures 5 - 8.

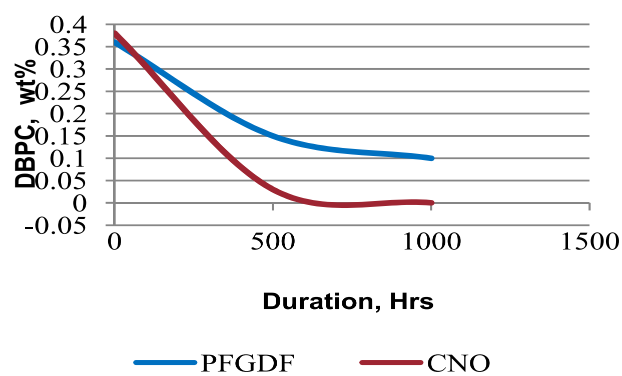

Fig. 5: DBPC Depletion Rate

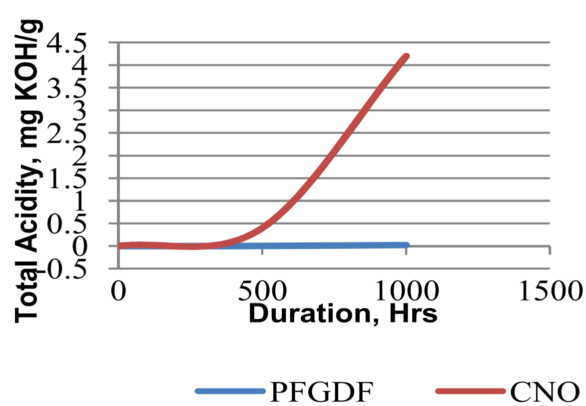

Fig. 6: Total Acidity

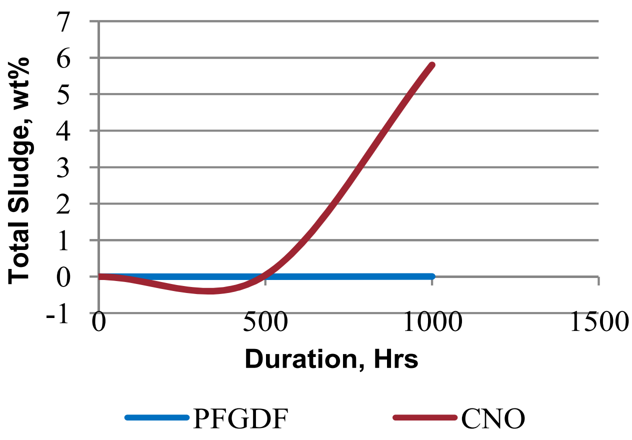

Fig. 7: Total Sludge

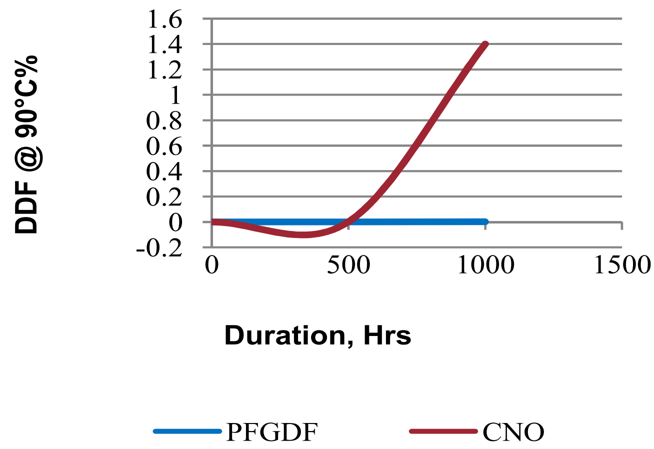

Fig. 8: Dielectric Dissipation Factor

Table 2: Extended Oxidation Stability of PFGDF

Property	Present & Future Generation DF (PFGDF)			Conventional Naphthenic Oil (CNO)		
Test Temp.,°C	120			120		
Test Duration, Hours	0	500	1000	0	500	1000
DBPC, %	0.36	0.15	0.09	0.38	0.03	0
Total acidity, mg KOH/g	0	0.002	0.022	0	0.4	4.2
Total Sludge, %	0	0.001	0.008	0	0.04	5.8
DDF at 90 °C	0.00004	0.0003	0.0016	0.0001	0.0024	1.4
Colour	0	<0.5	<0.5	0	<0.5	4.5

Table 3: Extended Oxidation Stability of Synthetic Ester Based Dielectric Fluids

Characteristics	Before Oxidn.	Typical values After Oxidation		
Duration, Hrs	0	Specified Limits	164	500*
Total Acidity, mg KOH/g	0.012	0.3	0.013	0.013
Total Sludge, by wt %	Nil	0.01	Nil	0.013
DDF @90°C, %	0.012	*No requirement	0.018	0.0214
Resistivity @90°C, 10^{12} Ω-cm	21	*No requirement	10	0.155
Colour Appearance	0	*No requirement	<0.5	1.5

*No requirement

2.4 Biodegradability and Impact on Environment

As per IEC 61100 fire point, net calorific value and biodegradability are the main contents for K Class fluids. Silicone fluid offer high degree of fire safety, but it is least biodegradable and hence non-eco-friendly. Natural and synthetic esters-based fluids can offer a high degree of fire safety, due to their low fire susceptibility. Natural and synthetic esters are classified as readily biodegradable. The tests used for this purpose are the OECD 301 series PFGDF are also readily biodegradable under OECD 301 Series and eco-friendly as shown in Fig 9.

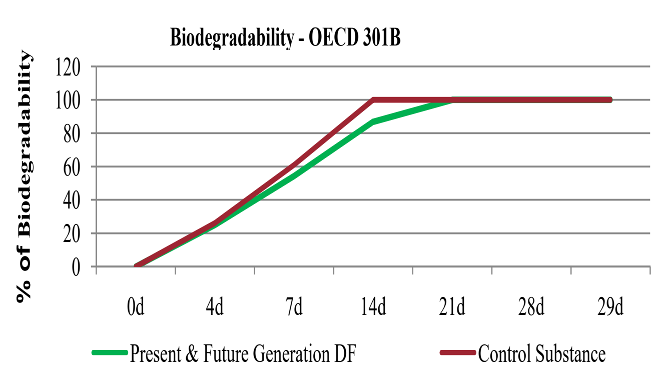

Fig. 9: Biodegradability Curve

2.5 Process and Cost

The use of natural esters, synthetic esters and silicone fluids are restricted to certain applications only. Natural esters are processed from renewable sources and are available any time but costlier as compared to mineral oils. Synthetic esters and silicone fluids are processed from chemicals and available at still a higher cost. Through technological innovations PFGDF are long lasting, easily miscible, and compatible with ester fluids and extremely reliable in power equipments. They are available at affordable cost

3. HEALTH ASSESSMENT THROUGH DIAGNOSTIC STUDIES

Dielectric fluid contains about 70% of the diagnostic information available for power equipment as per experts. The challenge is to access and use this information effectively using dielectric fluid parameters on four functional groups which encourages diagnostic usability.

- Characterization – which gives parameters that can be used to identify the oil status/health.
- Ageing Status – which gives parameters relevant to the ageing process.
- Dielectric Status – which gives parameters used to determine the dielectric safety margin and dielectric characteristics of the insulation spaces.
- Degradation status – which gives parameters relevant to faults, failure and wear through.

3.1 Case Study – Reactor

In one of the EHV Reactor, present & future generation oil in-service was monitored for its regular diagnostic conditions using -characterization of fluid parameters, ageing status, dielectric status, degradation status and key combustible gas concentration). Dielectric properties & DGA were analysed as per IEC 60422 & IEEE-C57.104.The dielectric properties of the fluid were found to be well within the recommended limits as shown in Table 4, 5 & 6.

Table 4 : Load Conditions & Temperatures of EHV Reactor

EHV Shunt Reactor - 80 MVAR						
Year of Commission	2009					
Age in-Service	7 Years					
Quantity of PFGDF	46189 Ltr					
Year of Monitoring	2011	2012	2013	2014	2015	2016
Peak Load, MVAR	80	80	80	80	80	80
Off Peak Load, MVAR	0	0	0	0	0	0
Peak Temperature, °C	90	90	90	84	72	72
Winding Temp. °C	88	68	56	75	78	68

Table 5: Dielectric Fluid Parameters of EHV Reactor

Fluid Based Information						
Hydro Carbon Composition, %	C_A= 04.21, C_P=60.51, C_N=35.28					
Year of Monitoring	2011	2012	2013	2014	2015	2016
Dielectric Status-DDF @ 90°C	0.00076	0.0025	0.0104	0.00259	0.00275	0.00078
-BDV, kV	62	68	72	71	79	66
-Resistivity @90°C, x $10^{12}\Omega$-cm	164	79	39	20	23	189
-Water Content, ppm	14	13	10	10	9	12
Ageing Status-AV or NN, mg KOH/g	0.001	0.001	0.001	0.001	0.001	0.001
-Sludge Content, %	0.001	0.001	0.001	0.001	0.001	0.001
-IFT, mN/m	37	37	36	38	37	42
-2-FAL, ppb	0	0	0	0	0	0
-DBPC Content, %	0	0	0	0	0	0
Degradation Status-Particle Profile-(14/11/8 to 17/15/12) NAS	6	7	7	7	8	8
-Dissolved Metals, %	0	0	0	0	0	0
-2-FAL, ppb	0	0	0	0	0	0

Table 6: Dissolved Gas Analysis -EHV Reactor

Year	CH_4	0_2	N_2	C_2H_6	C_2H_4	C_2H_2	H_2	CO
2011	0	28350	91620	3	10	0	23	158
2012	25	6210	16500	6	17	0	24	296
2013	10	27000	59000	7	13	0	0	138
2014	33	8976	38253	8	14	0	35	381
2015	1	5390	19361	0	0	0	0	8
2016	14	12100	32600	7	4	0	0	341

4. CONCLUSION

- Present & Future Generation Dielectric Fluids plays a significant part in the efficient functioning of the power equipments
- It has excellent heat transfer capability at all temperature gradients including cold start
- It is free from harmful corrosive sulfur, other contaminants and has better stability. Hence relatively reduced maintenance requirements
- Better reliability, less breakdown risks, longer life
- Use of present & future generation dielectric fluids ensure longer life for the asset
- Present & future generation dielectric fluids are environmentally friendly and are readily biodegradable
- Use of present & future generation dielectric fluids in power equipments benefits all stake holders

Acknowledgements

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He is having 23 International, 13 National Publications on the credit. He has filed 18 Indian Patents and One US patent. He got granted few patents on his credit.

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THE IMPACT OF LEG LOADS ON TOWER AND SLOPE STABILITY

Hillol Biswas and Faujdar Yadav

Wapcos Limited

ABSTRACT

The paper is intended to describe the transmission line/tower with and without leg extension and the corresponding position on an uneven position and terrain if in all respects suitable to locate and slope stability would likely to be addressed to assess a degree of criticality of a tower. A brief study have been attempted to identify, understand and possible implications thereof and being presented here. Historically, few failure of transmission towers during monsoon at vulnerable locations understood as possible landslide effected being the basis of this study albeit at much later date in a view of broadly inspecting in the light of contemporary practice in the industry.

INTRODUCTION

The tower spotting of transmission line along the route profile from classical point of view is first to meet the ground clearance. The sag-template curve on transparent plastic sheet were to be used for locating the intermediate suspension towers on the route profile and survey chart on the same scale. However, the practice in hilly terrain is to spot all towers are of tension type and for this purpose the tower positions are first usually identified on the ground by means of the detailed survey.

By virtue of the undulated land profile of the hilly terrain, it's a challenge to obtain an ideal bench to accommodate the tower base width. As per clause 5.6.1, IS 5613, Part 2 sec 2, "If the levels of the pit centres be in sharp contrast with the level of the tower centre (say beyond a slope of 1:4), suitable leg extension may be deployed as required. In that case the amount of benching earthwork required shall be measured accordingly."

TOWER SPOTTING IN UNEVEN OR HILLY TERRAIN AND GENERAL CHALLENGES

While hundreds of kilometres of overhead transmission line have been built historically using the leg extensions of different length either positive or negative, the following aspects have been left the line designers and engineers often pondering:

(1) Are the tower spotted without leg extensions are better option than spotting over a single or double bench/s to accommodate the tower base.

(2) If uplift resistance is being achieved considering natural slope steep and using leg extension since often sufficient areas surroundings the tower stubs are not happens to be made available tow theoretically consider an effective area of earth frustum to act on the tower foundation slab to mobilize the resistive force required for uplift condition.

(3) Is there a Difference in foundation leg load with and without leg extension from design load point of view and moreover.

(4) Are natural slope if left to remain minimum disturbed after the tower erection and stringing, is slope stability an issue especially to identify the critical tower/s along any alignment.

DESIGN STUDY

In hilly terrain typically three type of profiles and tower spotting situations thereof are encountered which the line engineers find often challenging depending upon the degree of hill slope. It's needless to mention that the adjacent towers are likely to be spotted with significant level difference.

Fig 1 depicts an ideal steep angular slope with varying degree either ascending or descending typically found along a route alignment. Fig 2 shows typical top of hill while both forward and backward span possible tower positions are at significantly lower level. Moreover Fig 3 represents possible position at bottom of slope and both the forward and backward towers are likely to be at uphill.

Tower with large valley or deep George crossing with anchor towers on both the side sometimes it is possible to have long span crossings with avoiding of two consecutive towers spotted with significant level difference.

The conventional foundation design approach as per IS 4091 considers that the uplift resistance is achieved

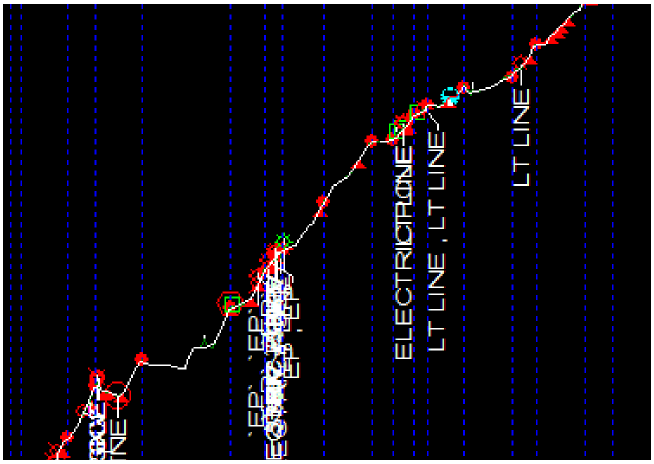

Fig. 1: Ascending or descending hill slope

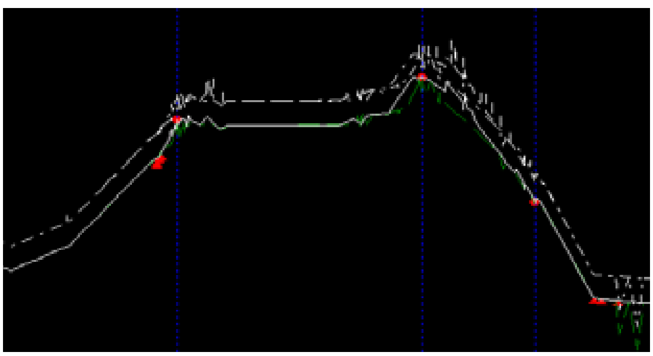

Fig. 2: Hillock or hill top position

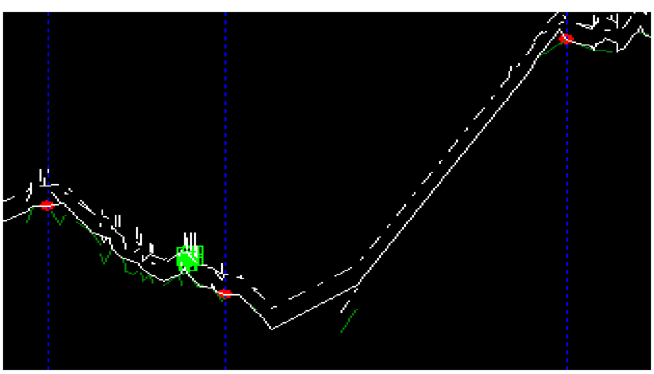

Fig 3: Ascending or descending slope with V type bottom foothill

by the frustum of earth over the bottom slab with the corresponding angle of internal friction that likely to cause a downward force against the uplifting regime of the tower legs as given in Fig 4.

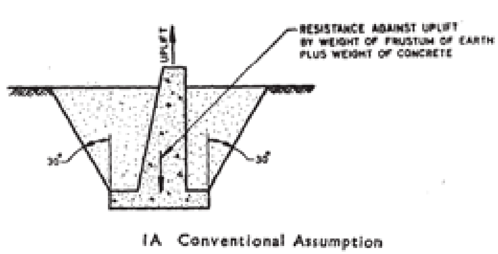

Fig. 4: Conventional uplift resistance

This scenario as in Fig 4 is absolutely achievable in plain terrain however an issue in case of an uneven terrain is especially if it is hilly as can be envisaged in Fig 10,11 and 12 where the adjacent soil profile unlikely to offer a theoretically acceptable position.

In a view of understanding the tower if happen to be located in this type of position and the suitability thereof a brief study have been attempted with tower with different models of body and leg extension and corresponding loading and terrain profile thereof.

The following 220 kV D/C tower models with twin moose and twin earthwire/opgw peaks and loading regime have been considered. The DB+0 type of tower with applicable actual leg extensions worked out from pls-cadd profile and DB+9 type of tower with applicable actual leg extensions as in Fig 5 to 9.

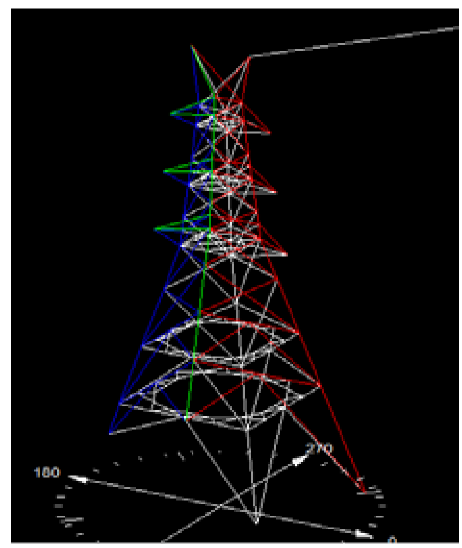

Fig. 5 Db+9 M Tower with leg extensions

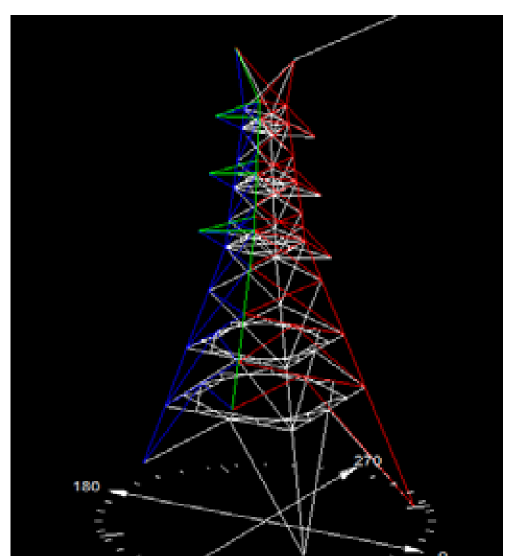

Fig. 6: DB+0 Type of towers with actual leg extensions

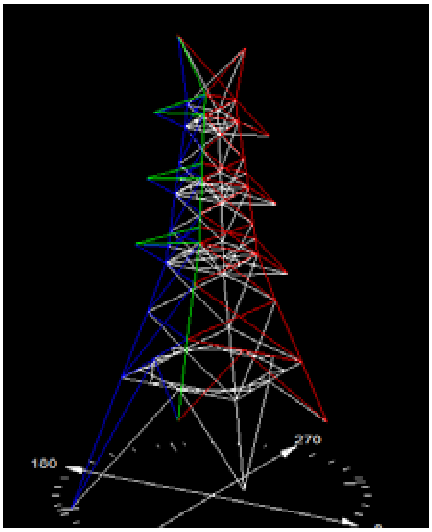

Fig. 7: DB + 0 Tower with LE

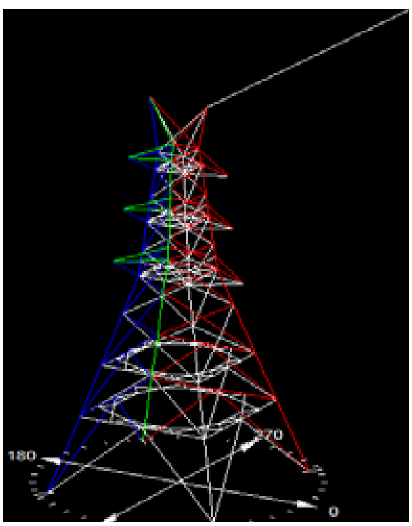

Fig. 8: DB +9 Type of tower

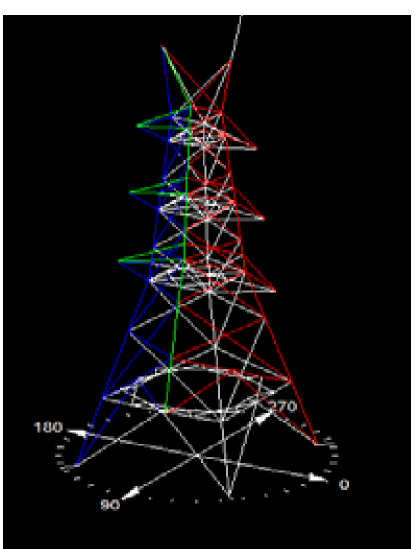

Fig. 9: DB+0 type tower

In the light of above, three assumed following case have been envisaged.

Case 1: DB (0-15) type of tower spotted at ascending hill slope corresponding to Figure 1.

Case 2: DB (0-15) type of towers at hill top position corresponding to Figure 2

Case 3: DB (0-15) type of at foothill position corresponding to Figure 3

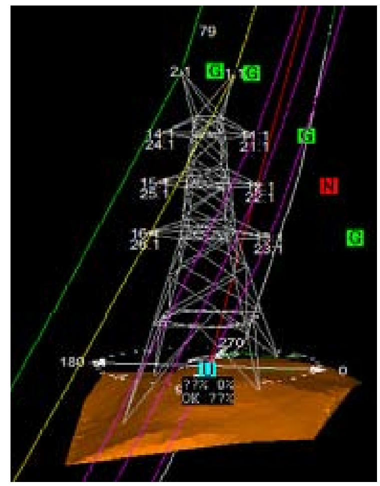

Fig 10: Tower at location number 79 with leg extensions on TIN ground profile

The corresponding towers as given in Fig 10, 11 and 12 exhibits the leg extensions on the TIN modelling made thereof.

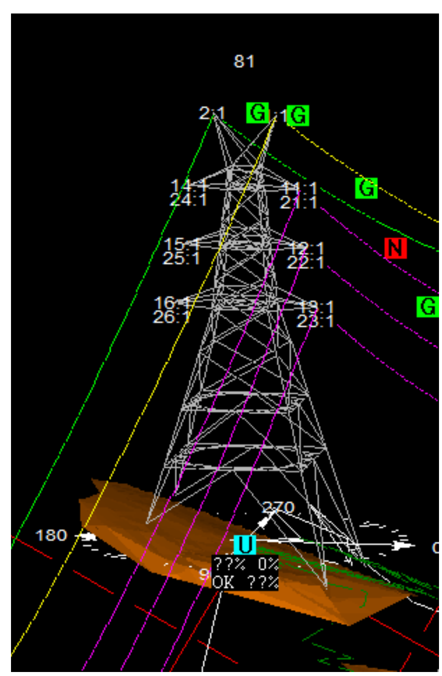

Fig 11: Tower at location number 81 with leg extensions on TIN ground profile

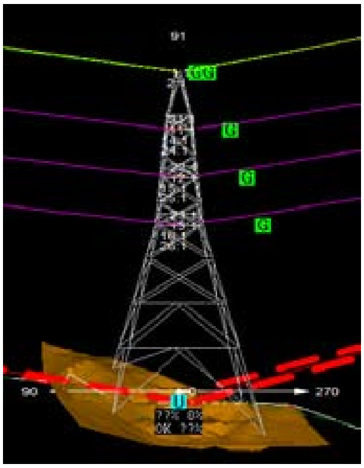

Fig 12: Tower at location number 91 with leg extensions on TIN ground profile

The following weather cases have been considered for calculating sag tension and corresponding load cases.

Reliability condition under everyday temperature and full wind scenario as per IS 802 both wind at positive normal and negative normal condition with tower spotted as per the ground profile with usual horizontal angle of deviation.

However it is also to be noted that electrical rating of a given conductor at maximum operating temperature i.e. 85 degree C at 1 m/s corresponding to which as per the heat balance equation ampacity of the conductor is ideally calculated and it is likely the line will remain operational most of the lifespan being subjected to this corresponding weather case. Though Uplift condition at minimum temperature and nil wind is also not unlikely however could be of lesser time duration.

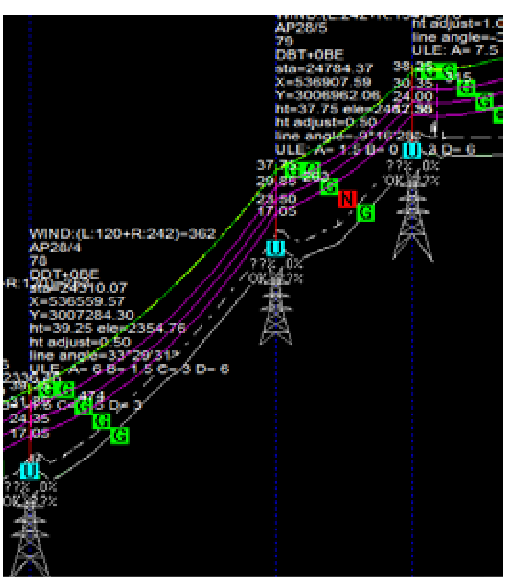

Fig 13: Tower 79 without leg extension

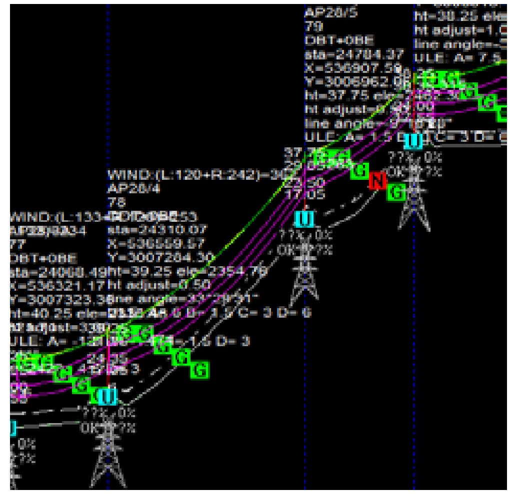

Fig 13A: Tower 79 with leg extension

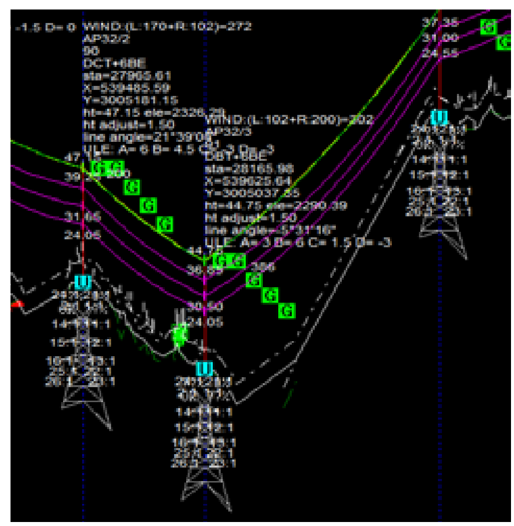

Fig 14: Tower 91 with leg extension

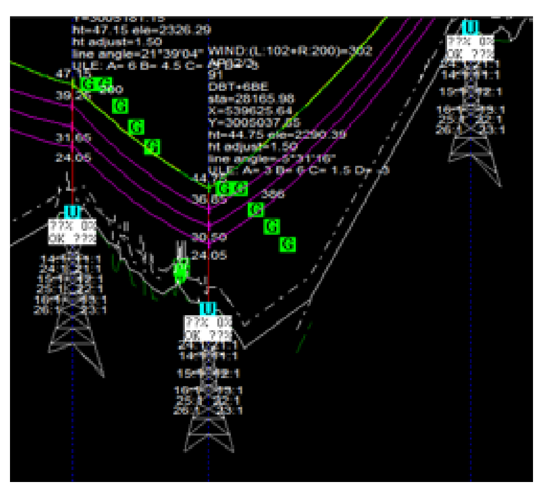

Fig 14A: Tower at 81 without leg extension

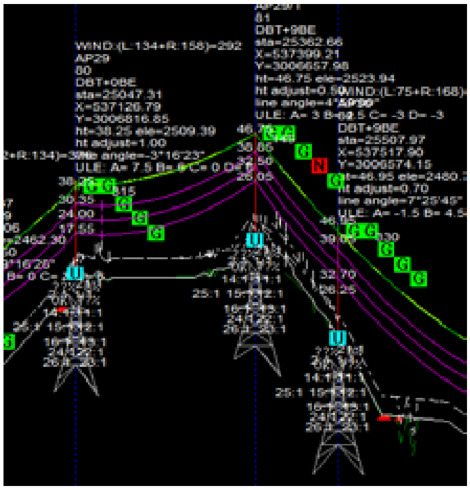

Fig 15: Tower 81 with leg extension

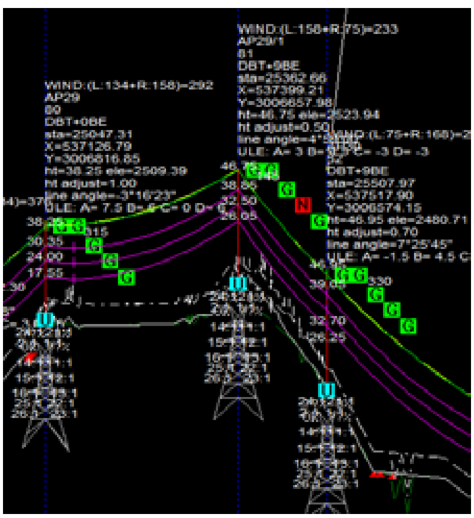

Fig 15A: Tower 81 without leg extension

Considering likelihood of simulations occurrence of broken wire condition and slope stability issue especially in monsoon is less no security condition of loading at this moment have not been envisaged. No icing event has been considered for the study.

Therefore three towers at 79, 81 and 91 all DB type with corresponding body and leg extension have been analysed with different loading regime. In all the three cases, four scenario with tower and applicable leg extension with actual load with, design load, tower without leg extension with design load and vis-à-vis actual load have been analysed and the corresponding leg loads have been tabulated below as in Tables 1, 2 and 3.

TOWER LEG LOADS AND SLOPE STABILITY

A quick comparison of the three tabulation is observed as below.

Looking at Table 1, case 1 where tower is spotted on the ascending slope of the profile, the DB+0 type of tower without leg extensions modelled with design load case for the applicable tower loadings the leg loads are almost same for the two compressions legs i.e. 869.872 kN each as well as for two uplift legs -621.21 each, however, the addition of leg extension causes 378.276 kN, 271.378 kN, -141.513 kN & -35.580 kN respectively each are of significantly different values. Similarly the towers with applicable leg extensions of 1.5 m, 0 m, 3 m & 6 m at respective legs with design loads and actual loading regime also causes differently though the pattern is found same. However, it is conspicuous to mention that due to spotting position of the location the uplift leg loads are

Table 1: Tower number 79 on middle of the slope

Case 1	dbt+0be-+1.5+0+3+6 actual load	dbt+0be-+1.5+0+3+6 design load	dbt±0b_±0_±0_±0_±0 design load	dbt+0be actual load
80S	370.101	843.548	869.872	378.276
81S	267.075	922.849	869.87	271.378
82S	-138.697	-669.625	-621.21	-141.513
83S	-30.391	-584.671	-621.211	-35.580

Table 2: Tower 81 at the hill top

Case 2	dbt+9be-+3+4.5-3-3 actual load	dbt+9be-+3+4.5-3-3 design load	dbt+9b_±0_±0_±0_±0 design load	dbt+9be actual load
14S	639.831	958.05	948.18	641.342
15S	10.954	-683.829	-664.481	13.778
16S	-326.819	-654.141	-664.48	-284.132
10S	365.144	928.779	948.179	345.402

Table 3: Tower 91 at the foothill location with lower altitude

Case 3	dbt+0be-+1.5+0+3+6 actual load	dbt+0be-+1.5+0+3+6 design load	dbt±0b_±0_±0_±0_±0 design load	DB+0 actual load
14S	196.332	993.578	930.6	
15S	-238.220	-729.038	-653.049	-187.770
16S	-28.562	-596.336	-653.049	-30.140
10S	322.566	871.714	930.599	326.712

of the range of -138 kN and - 30 kN compared to significant value of compression leg loads of 370 kN and 260 kN respectively. Nonetheless two legs each are under compression and uplift.

Further looking at Table 2, case 2 where tower is spotted on top hill with consecutive towers are of significant lower level difference; the conspicuous is that only one leg is under uplift compared to the general convention that two legs each shall be under compression and uplift. The uplift leg is experiencing only 10 kN of leg loads for the particular weather case of everyday tension and full wind. Moreover significant difference of Uplift -326.819 kN compared to -284.132 kN and compression 365.144 kN compared to 345.402 kN in model of tower with and without leg extension have been observed.

The Table 3, case 3 where tower is spotted at the bottom of the ditch by virtue of the terrain is also similar to that of case 1 however, one uplift leg is on the marginal side experiencing only -28 kN of leg loads. Similarly as in Table 2, significant difference of Uplift -187.770 kN compared to -238.220 kN and compression 196.332 kN compared to 169.690 kN in model of tower with and without leg extension have been observed.

In hill areas normally three type of failure modes are stipulated as per IS 11315 i.e. plane failure, wedge failure and toppling failure. The plane failure is a special case of wedge failure and the toppling failure either minor toppling or deep toppling both of which are not prone to sudden rock falls. It isn't unusual not to consider the uplift scenario in the conventional slope stability analysis with or without the use of software since the usual assumption is to consider a UDL or concentrated load as in Fig 16 to be acting over an area of concern to find out if that would be sufficient to trigger a slope stability issue and slip circle thereof. Though the usual practice is to provide protection measures like retaining wall however, IS 14458 cautions that the retaining walls are normally not intended to stabilize slope failures. They are mainly meant to support the active or passive earth pressure from the assumed failure wedge above the base of the wall. The stabilization of existing or probable failure

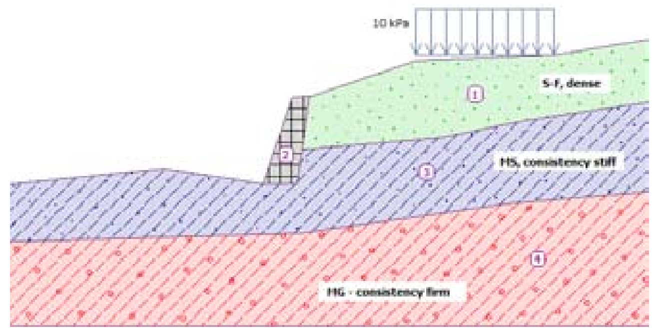

Fig 16: Typical slope stability study assignment

planes caused by landslides flows and falls require separate treatment and specific design approaches. Only the fill slopes and cut slopes could be stabilized/ retained by retaining walls.

Transmission tower by virtue of its own intricacy are subjected to both compression and uplift depending upon the weather case owing to the climatic condition of the area/zone/country thereof. From classical transmission engineering point of view ideally two legs shall be under compression and the other two legs shall be under uplift condition for a reliability condition. In earlier days overhead transmission tower foundation design in United Kingdom in 1930's the compression legs are often designed for shallower depth of about 1.5 meter while the uplift legs were of 2.5 meter or more, however in these days worldwide all the four legs are provided the same type of foundation. In India climatic condition which is at 32 degree C temperature and full wind corresponding to the particular wind zone. In hill areas though, depending upon the lower value of the minimum temperature the everyday temperature can be considered as 15 degree C though the full wind condition are normally considered applicable for this everyday temperature as well.

However, it is observed that tower at location number 81 as in Fig 17, spotted with +3M, +4.5 M, -3M & -3M leg extensions at respective legs, and only one leg is under uplift while rest three legs are under compression in the reliability condition and by virtue of the horizontal angle of deviation and location of spotting thereof being

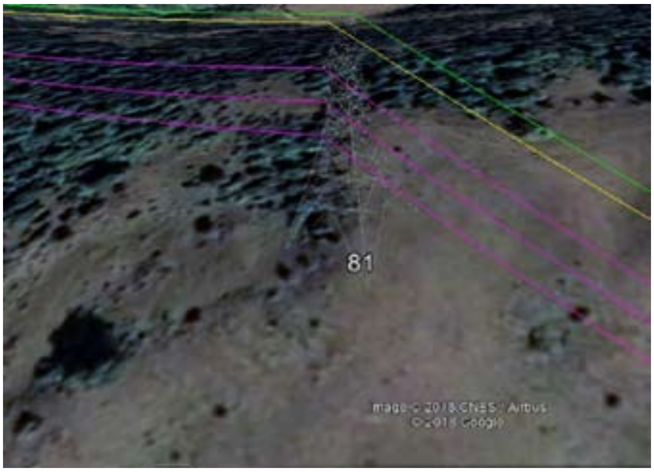

Fig 17: A google earth overview of tower 81

Fig 18: Overview of stretch of towers 79 to 91

on the hilltop and the forward and backward towers are both at lower level of elevation.

The actual loading regime yielding lesser than theoretical leg loads and further possibility of uplift leg load anticipated in the design converted to compression leg load by virtue of its position of spotting is therefore may be construed as a reason that in hilly terrain tower having little earth mass that would ideally require to act as uplift resistance appears to be sufficient that address the query that being attempted in the beginning to realistically understand in point number 2. Moreover, tower by virtue of its position of spotting, tower without benching likely to offer a slightly different leg load scenario which is possible to inspect should a situation arises with respect to a particular line, tower and terrain thereof. Another point could be likely that for any tower leg uphill side earth mass contribute some degree of resistance by means of the excess earth that appears included in a theoretical angle of internal friction or angle of repose line probably compensating the lower hill side absence of earth depending upon the location and degree of undulation thereof.

In general the slope stability analysis considers either a point or UDL as in Fig 16 however it is being viewed as imperative to consider the tower leg loads by virtue of compression and uplift as the case may be to accurately consider the intricacy of the tower location situation. The stretch or section for example in Fig 18 from tower 79 to 91 of a given alignment which likely to be susceptible to a concern should also be inspected on desktop and further at field if necessary to realistically assess the degree of at-risk.

Slope stability of this type of tower could be a concern particularly in monsoon if other conditions are also conductive to strike instability in that region in the vicinity.

CONCLUSION

The towers are designed both for reliability, security and safety conditions and put to test bed for load testing. A successfully tested tower in the field is subjected to weather case peculiar to the climatic area and terrain thereof and most of the time remain operational under either everyday temperature condition corresponding to electrical loading leading to either maximum operating temperature of nearing temperature of it and thus well below the tower strength capacity. However, the most essential loading regime that it is likely to be prepared for throughout the lifespan is reliability condition i.e. as per Indian climatic condition, everyday temperature and full wind condition. However, it won't be unwise to consider that the most of the life span of the line and that of the towers the prevailing weather case would be everyday temperature and nil wind condition and further logically to envisage at max operating temperature and nil wind though the electrical conductor rating is evaluated as 0.6 m/s to 1 m/s using the heat balance equation. Therefore the usual expected daily mechanical loads being much lower and consequent leg loads also proportionality lesser than the reliability condition loading regime tower even if critically located unlikely to pose a high degree of severity in usual climatic conditions. A slope stability study though would be ideal for any critically located tower. Moreover, the compression and uplift leg loads at each two number of tower legs would be effective within an area confined around the tower base width that should be mindful while carrying out the slope stability studies. In plain terrain the anticipated scenario is pretty straight forward however different in hilly terrain. Failure of transmission tower at monsoon is not highly uncommon in hilly areas though frequency are insignificant however, in challenging terrain if it occurs that could lead to catastrophic event leading to generation loss and time to recover having the potential to take into account reliability indices like MTTR and corresponding to annual outage hours. Modern software could be helpful to further refine the studies, knowledge and experience to foresee situations and towers could be categorised as critical, semi-critical or sub-critical while require to spot in challenging hilly/mountainous terrain. However, it is imperative to take into account the leg loads corresponding to the most or series of stringent weather case coupled with the usual practice of considering slope failure scenario and stability thereof. Use of leg extension is normally preferred in hilly terrain owing to avoid huge earthwork, earth management, environmental consideration etc however, a tower spotting with leg extension and without leg extension could lead to different leg load scenario depending upon the observed pattern that the foundation and the slope at the location thereof should have to be vis-à-vis evaluated especially to identify any at-risk tower or tower likely to be considered critical during monsoon season.

However it is being felt that scope exists to consider further study in this regard using slope stability software.

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BIOGRAPHICAL DETAILS OF THE AUTHORS

Hillol Biswas have been graduated from University of North Bengal in the year of 1993 and having 25 years of transmission engineering experience in countries in Asia, Europe and Africa now in Wapcos advises for their India and overseas transmission line projects as well possible offshore wind development initiatives. He has been a member of Institution of Engineers, Indian Wind Engineering Society, Indian Association of structural engineers, Computer society of India and have been an individual member of Cigre. Email: hillolbiswas@wapcosindia.com

Faujdar Yadav passed out B. Tech from UPTUVIET GB Nagar in EEE in 2011 and having experience of 7 plus years in Wapcos, PGCIL and others. Currently in Wapcos for last 3 years he has been working as Transmission line engineer for Indian and overseas projects.

LIFE IS A COMBINATION OF SUCCESS AND FAILURE BOTH ARE NEEDED

CIGRE INDIA SESSION 2018

National Conference on

POWER SECTOR DEVELOPMENT – MODERN TRENDS & INNOVATIONS AT INTERNATIONAL LEVEL

(Pre CIGRE (Paris) Session)

26-27 July 2018, New Delhi

The International Council on Large Electric Systems, known as 'CIGRE' (Conseil International des Grands Réseaux Électriques - International Council on Large Electrical Systems), headquartered at Paris, is a world renowned and international organization dedicated to the constant improvement of the power system technologies. The objective

(L-R) Mr P. P. Wahi, Director, CBIP; Mr V. K. Kanjlia, Secretary, CBIP; Ms. Seema Gupta, Director-Operations, POWERGRID; Mr. Gurdeep Singh, CMD, NTPC Ltd.; Mr A.S. Bakshi, Former Member, CERC; Mr Pankaj Batra, Chairperson, CEA & Ex-officio Secretary to GOI.; Mr. I.S. Jha, President CIGRE India & CMD, POWERGRID; Mr S.N. Sahai, Addl. Secretary to GOI, Ministry of Power; Mr. Balraj Joshi, CMD, NHPC Ltd.; Mr Nand Lal Sharma, CMD, SJVN Ltd.; Mr R.P. Singh, Chairman, Arunachal Pradesh State Electricity Regulatory Commission; Mr A.K. Gupta, Vice President CIGRE India & Director, NTPC Ltd. and Mr K.V.S. Baba, CMD, POSOCO during inaugural session

of CIGRE is to facilitate and promote the dissemination of technical knowledge and information on all the main themes of the field of electricity amongst the 95 Member countries, including India. CIGRE functions through its 16 Study Committees constituted for in-depth research and progress in specific areas of power system domain at the international level. It is a matter of pride that India is represented in all the sixteen (16) CIGRE Study Committees. In addition, some more experts from India are members of the Working Groups/ Task Forces formed by these Study Committees.

CIGRE organizes its sessions every even year in Paris. The Technical Discussions/ Meetings held during the Conference deliberate the technical papers presented in the parallel sessions in details for five days at Paris. The next (47th) session of CIGRE is going to be held at Paris on 26-31 August 2018. About 5000 delegates from all over the world will attend the session and about 500 technical papers, including twenty-two (22) from India, linked to the most up-to-date technical themes in the world of electricity, are going to be presented in the session at Paris in 2018. Beside one paper from Mr. N.S. Sodha, Former ED, POWERGRID under International category and 3 papers from Young Members. There were more than 100 participants from India in the last Session held at Paris in 2016 and we are expecting about 150 participants this year from Central, State and Private sector utilities, Regulatory Commissions and other organizations from India to participate.

The Committee for CIGRE-India, an affiliate of Central Board of Irrigation & Power, is the Indian Committee of CIGRE and co-ordinates the activities of CIGRE in India.

The Committee for CIGRE-India in its capacity as the National Committee for CIGRE has organized the CIGRE-India session on 26-27 July 2018 about one month before the CIGRE session 2018, to be held in Paris on 26-31 August 2018, with the following aims & Objectives:

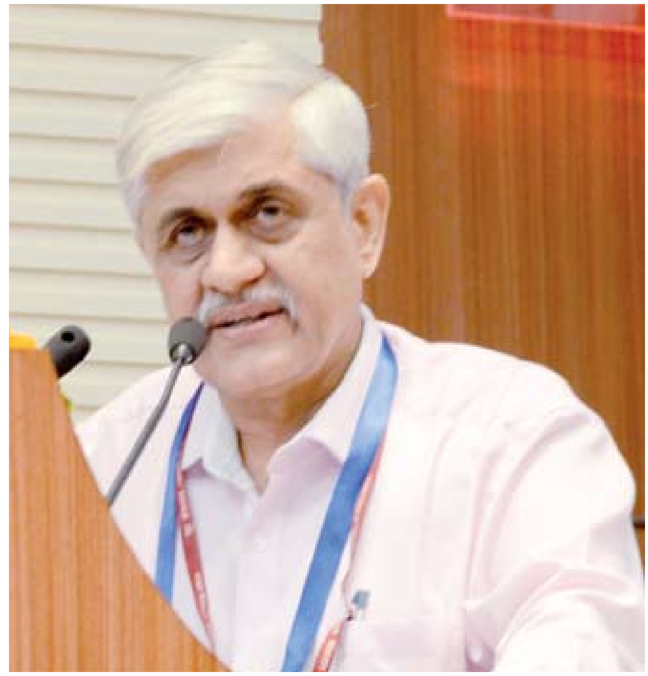
- To share the experience and update the knowledge on Technological Developments & Innovations in the Power System in the country.

- To have the input and the considered opinion from the experts within the country on the various topics indicated in the bulletin, as well as, on the technical papers being presented at CIGRE session 2018 in Paris.
- To propose replies on the various questions put up by the special reporters of the technical session of CIGRE Session at Paris, which could be raised and discussed with the international experts during the session at Paris in August 2018.
- To plan out the strategy to be adopted by the Indian delegates attending the CIGRE Paris Session 2018, to ensure the maximum benefits of the technical inputs for the Indian Engineers.

The idea is not just to foster the knowledge exchange, but also to ensure presentation of the ‘State of the Art’ at International Level.

CIGRE has 16 study groups, each specializing in one specific domain. India has a member in each of these groups.

Mr. S.N. Sahai, Addl. Secretary to GOI, Ministry of Power addressing the participants during inaugural session



Mr. Pankaj Batra, Chairperson, CEA & Ex-officio Secy. to GoI, addressing the participants during inaugural session

Accordingly, CBIP/ CIGRE-India divided this two-day conference into sections. The respective CIGRE Group member or his representative took the responsibility of sharing the relevant part of the deliberations.

The participants were acquainted with the papers selected by CIGRE Group, a summary presentation of each paper; the queries raised there to and sought the responses there to. The audience was then encouraged to interact there on, including, any India-specific issues. The participation was open to the Indian Power Sector, irrespective of their membership status. This was to allow even the non-members to take advantage of the knowledge exchange, as well as, to contribute to the common knowledge pool. With a large participation, and an extremely lively debate all through, the aim of this National Conference was very well achieved. All the participants deserve thanks and acknowledgement for their contribution.

INAUGURAL SESSION

The conference started with the Inaugural Session with the following dignitaries on the dais:

- Mr Pankaj Batra, Chairperson, CEA & Ex-officio Secretary to GOI.
- Mr S N Sahai, Addl. Secretary to GOI, Ministry of Power
- Mr A S Bakshi, Former Member, CERC
- Mr R P Singh, Chairman, Arunachal Pradesh State Electricity Regulatory Commission
- Mr Gurdeep Singh, CMD, NTPC Ltd.
- Mr Balraj Joshi, CMD, NHPC Ltd.
- Mr I S Jha, President CIGRE India & CMD, Power Grid Corporation of India Ltd.
- Mr Nand Lal Sharma, CMD, SJVN Ltd.
- Mr K V S Baba, CMD, Power System Operation Corporation Limited
- Mr A K Gupta, Vice President CIGRE India & Director, NTPC Ltd.
- Ms Seema Gupta, Vice President CIGRE India & Director – Operations, Power Grid Corporation of India Ltd.
- Mr V K Kanjlia, Secretary, CBIP & CIGRE-India
- Mr P P Wahi, Director, CBIP

Mr I S Jha, President CIGRE India & CMD, POWERGRID addressing the participants during inaugural session

Mr Gurdeep Singh, CMD, NTPC Ltd. addressing the participants during inaugural session

Mr Wahi conducted the session.

The distinguished penal lauded the aim of the conference and exhorted the participants to take advantage of the opportunity presented and contribute to the aim of the conference, which is a bi-annual event, preceding the main CIGRE conference in Paris.

Mr Kanjlia presented the Welcome Address and introduced all the dignitaries on the Dais. He expressed his delight that there was participation of over 60 organizations in the conference.

Further, he explained the reason and the aim of the conference. He also explained the aim and the charter of CIGRE which is one of the largest and the most prestigious association of its kind for Electrical Engineers. He also described the activities of CIGRE-India, the Indian arm of the international body and its association with CBIP. Mr Kanjlia took the opportunity to explain the benefits of CIGRE memberships and requested the participants to take up the membership for the common benefit of all.

At the end of his talk, Mr Kanjlia once again welcomed everyone and asked them to make full use of the conference by their active participation.

Mr Nand Lal Sharma reminded everyone about the great opportunity to play a significant role in the power sector. He stated that CIGRE was dedicated to the development the power sector. The event presented a great opportunity of share knowledge. Thereafter, he talked about Satluj Jal Vidyut Nigam Ltd. (SJVNL) and its diversification to Renewable Energy Domain as well as Thermal Power arena even though it originally started in the Hydro-power domain. He described Nathpa-Jakhari Hydro Power station as the largest hydro power station in the country. With the addition of the Rampur downstream, which operates only in tandem with the NJHPS, the total capacity has gone up to 2000 MW. Over the years, due to the heavy silt in Satluj, SJVNL has also gained expertise in the art and science of Hard-coating of the turbine blades. He also informed that SJVNL has grown beyond the national boundary by spreading its wings to Bhutan and Nepal, as well.

Mr K.V.S. Baba praised CIGRE and its aims in general. He referred to the gatherings as “Congregation’’ of the like-minded people rather than a ‘Conference’. He felt that there was a whole lot of enthusiasm among the delegates and such congregation provides knowledge to everyone, whoever attends it.

Mr Balraj Joshi started off by recounting his experience of ICOLD (society relevant to the Dams). He was of the opinion that we should increase our involvement, when it comes to CIGRE. While agreeing to the opinions expressed by Mr Baba, he wanted the participants to make full use of the conference through their active interaction on the various

Mr Balraj Joshi, CMD, NHPC Ltd., addressing the participants during inaugural session

Mr A S Bakshi, Former Member, CERC, addressing the participants during inaugural session

presentations and gain from the opportunity. He also felt that we should showcase the technical prowess India to the world. He also talked of NHPC and uniqueness of its power stations such as URI 2 power station, which is located very close to the Line of Control in Jammu & Kashmir state.

Mr Gurdeep Singh greeted all the dignitaries and spoke about importance of NTPC as a prime power generator in the country. He too advised the delegates to take full opportunity of the proceedings. He was optimistic that the deliberations there would cover all the relevant aspects.

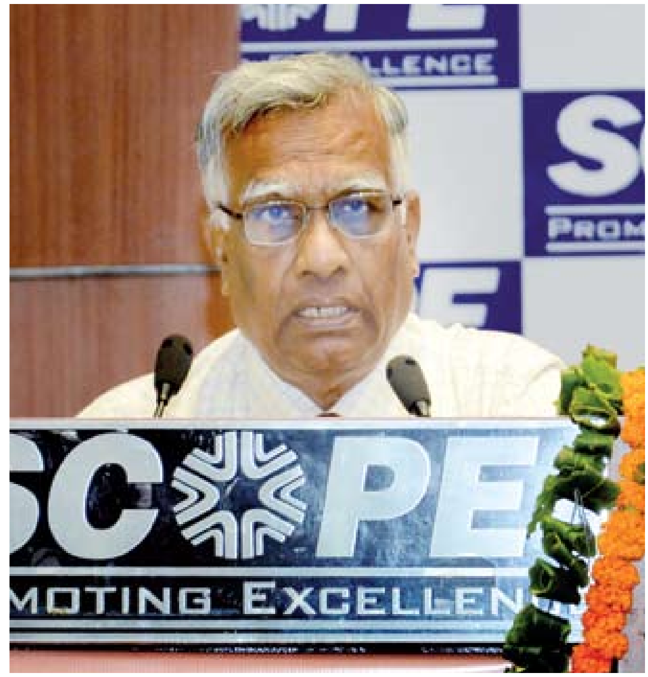
Mr I.S. Jha congratulated and thanked CBIP for organizing this conference. He pointed out that the power system in the country had seen many innovations in the recent time namely, 800 kV DC transmission, development of 1200 kV transmission equipment indigenously etc.

He felt that such conferences facilitate the participants to exchange the latest knowledge and the relevant experiences held by them. He wished everyone present should have an aim to showcase their leadership position in technology to the world. The need was for the young engineers to be participative, be involved, contribute and take an active role. He articulated about the aim of Power Sector to provide 24x7 affordable power to all. He stated that though the country has a great transmission system, but some enhancements were called for to take up the transmission of Renewable Energy. The RE power integration brings up the need for balancing power. Regarding the activities of CIGRE and its Indian arm he felt that CIGRE was an important forum and that every effort should be put in to increase its membership. In the end, he advised everyone to innovate continuously and thanked everyone once again.

Mr Pankaj Batra felt that everyone ought to be aware of CIGRE. He reminded the audience that CBIP is CIGRE-India, which has organized some 1700 events, such as this conference, till date. He stated that there were many great achievements in Indian Power Sector. The present pre-CIGRE event was very important for the power engineering community and it is a matter of pride that 150 delegates from India scheduled to attend the CIGRE Paris session. He felt that this was all due to the tireless efforts of CBIP. The participants of the present conference had a whole lot of opportunity to learn by participating actively. Lastly, he thanked CBIP for organizing the event.

Mr S N Sahai stressed the need of requirement of innovations in this field of power system. He held the opinion that technology reduces cost of operation. Although, at some stage market forces do take over. He quoted the classic Hindi movie 'Naya Daur' to emphasis his contention. As he quoted from the movie, the newer motorized Bus pushes the old technology horse-cart out of business. Similarly, he contended that the latest technology would takeover even in power sector. He listed various government sponsored schemes active in the field of power system. At the end he thanked CBIP, the dignitaries and the audience for conducting this conference.

Mr. Nand Lal Sharma, CMD, SJVN Ltd., addressing the participants during inaugural session



Mr. V.K. Kanjlia, Secretary, CBIP delivering welcome address during inaugural session

Mr Wahi thanked all the speakers. Further, he shared that CIGRE awards Distinguished Member status to members of over ten years standing with their active participation in various CIGRE activities. This year four CIGRE members has been awarded this honor. They were:

- Mr B N De Bhowmick, Chairman CIGRE NSC C3 on System Environmental Performance & ED, POWERGRID
- Mr R K Tyagi, Chairman CIGRE NSC A3 on High Voltage Equipment & GM, POWERGRID
- Mr M N Ravinarayan, MD, Taurus Powertronics Ltd., Individual Member CIGRE
- Mr V K Kanjlia, Secretary, CBIP & CIGRE India

All the four were handed over their awards.

Thereafter Mr A S Bakshi, Former Chairman, CEA & Former Member, CERC, in his address stated that he believed in the importance of the power sector as a whole. He pointed out that over the years, many new policies have led to major improvements in this sector. He also emphasized the importance of CIGRE and benefits of its membership for the advancement of the sector.

In the end, Mr P P Wahi thanked everyone for their participation in his vote of thanks address.

With this the Inaugural Session ended.

TECHNICAL SESSIONS

Subsequent to the Inaugural session, the technical sessions commenced. In view of the large number of topics and the 16 CIGRE committees, the technical sessions were divided into two streams of 8 sessions each. These were conducted in two different rooms over the two days of the conference.

All the technical sessions were lively and highly interactive. Apart from the printed versions of the various supporting documents, the presentations made during the sessions were uploaded on to the CBIP website. The participants were free

Mr. P.P. Wahi, Director, CBIP proposing vote of thanks during inaugural session

PRESENTATION OF CIGRE DISTINGUISHED MEMBERSHIP AWARDS

Shri B.N. De Bhowmick, Chairman CIGRE NSC C3 on System Environmental Performance and ED, POWERGRID being honored with Distinguish Membership Award by Shri S.N. Sahai, Additional Secretary, Government of India, Ministry of Power during Pre-CIGRE Session held on 26-27 July 2018 at SCOPE Auditorium, New Delhi.

Shri R.K. Tyagi, Chairman CIGRE NSC A3 on High Voltage Equipment and General Manager, POWERGRID being honored with Distinguish Membership Award by Shri S.N Sahai, Additional Secretary, Government of India, Ministry of Power during Pre-CIGRE Session held on 26-27 July 2018 at SCOPE Auditorium, New Delhi.

Shri M.N. Ravinarayan, MD, Taurus Powertronics Ltd. being honored with Distinguish Membership Award by Shri S.N Sahai, Additional Secretary, Government of India, Ministry of Power during Pre-CIGRE Session held on 26-27 July 2018 at SCOPE Auditorium, New Delhi.

Shri V.K. Kanjlia, Secretary CIGRE-India & CBIP being honored with Distinguish Membership Award by Shri S.N Sahai, Additional, Secretary Government of India, Ministry of Power during Pre-CIGRE Session held on 26-27 July 2018 at SCOPE Auditorium, New Delhi.

Ms. Seema Gupta, Chairperson NSC A2 on Transformers conducting the session

Mr. Anish Anand, Chairperson NSC B2 on Overhead Lines conducting the session

to download the same for their personal use. Detailed information on the sessions is available through the printed material distributed and the content uploaded.

All the technical sessions were chaired by the CIGRE-India chairperson or a representative of the respective Study Committee. In most sessions, the Chairperson took it upon himself to share the gist of the expected deliberations at the Paris session. However, to supplement this, other presenters were also called upon to give more details.

26. JULY 2018 (FIRST DAY)

(MAIN AUDITORIUM)

Study Committee A2 - Transformers

- Chaired by: Ms Seema Gupta, Director, POWERGRID & NSC A2 Chairperson

Ms Seema Gupta gave a brief on the scope of the SC A2 and also explained the three Preferential Subjects of the CIGRE 2018 session under A2 namely Thermal Characteristics of transformers, Advances in Diagnostics & Modeling and Site Commissioning Tests. She summarized the papers on Site Commissioning Tests for the audience. The remaining papers were summarized by Mr. Amandeep Singh, Manager, POWERGRID and Mr Sumit Ray, Dy. Manager, POWERGRID. There was good interaction with the participants during the entire session. The accepted paper from POWERGRID for the Paris session on Bushing Fault Diagnosis was very well received. There were also valuable inputs from Mr. R.K. Tyagi, GM and Mr. Adish Gupta, DGM, POWERGRID during the session. The relevant questions were briefly touched upon but due to paucity of time the participants were requested to send any remaining queries to Chairman National Study Committee and the original authors of the paper.

Study Committee B2 – Overhead Lines

- Chaired by Mr Anish Anand, GM, POWERGRID & NSC B2 Chairperson

Mr. B.N. De Bhowmick, Chairperson NSC C3 on System Environmental Performance conducting the session

Mr. B.B. Chauhan, Chairperson NSC C4 on System Technical Performance conducting the session

Mr. N.S. Sodha, Chairperson NSC D2 on Information Systems & Telecommunications conducting the session

Mr. P.K. Agarwal Chairperson NSC C5 on Electricity Markets & Regulations conducting the session

Mr. Anand briefed the gathering on SC B2, and also gave comprehensive presentation on various papers under SC B2 selected for presentation at the Paris session. There was lively interaction with the audience on some papers relevant to Indian scenario & context. Then he requested Mr Karanvir Singh Pundir, the Young Engineer from POWERGRID to give a brief presentation on the paper titled 'Construction of Transmission Line in High Altitude, Extreme Weather, Snow-bound Avalanche Prone Areas - Design Challenges & Solutions'. This paper has been selected by CIGRE for presentation under young member show case category. Shri Pundir informed about the severe challenges faced during construction of POWERGRID's Srinagar-Leh transmission line, special foundation designs measures for snow avalanche areas.

Study Committee C3 – System Environmental Performance

- Chaired by Mr B N De Bhowmick, ED, POWERGRID & NSC C3 Chairperson

Mr Bhowmick first gave a brief on the activities of SC C3, and then gave an informed analysis of the papers to be presented at the Paris session. As the name of the study committee suggests, this SC C3 mainly delas with the environmental impacts of power system, including Hydro stations, Transmission lines etc. The C3 session was divided into three preferential segments, namely PS1- Effectiveness of environmental performance (Total 11 papers), PS2 -Mitigation of the Visual Impacts of Electrical Assets to Increase Public Acceptance (total 6 papers) and PS3 - Technical and Environmental aspects of OHL (Joint PS with B2) (Total papers 5 including 1 withdrawn).

The questions were taken up to a limited extent, while requesting the audience to send in their response for collation.

Study Committee C4 – System Technical Performance

- Chaired by: Mr B B Chauhan, MD, GETCO & NSC C4 Chairperson

Mr Jithin Sunder, Chairperson NSC D1 on Materials & Emerging Test Techniques conducting the session

Mr. Subhash Thakur, Chairperson NSC B5 on Protection & Automation conducting the session

Mr R K Tyagi, Chairperson NSC A3 on High Voltage Equipment conducting the session

Mr. D.K. Chaturvedi, Chairperson NSC A1 on Rotating Electrical Machines conducting the session

After briefing on the SC C4, Mr Chauhan summarized the topics of papers for Paris presentation. Papers are divided in three preferential subjects namely (a) Challenges due to effect of high level of integration of Power Electronics based generation, mitigations and significance of PQ monitoring, (b) Evaluation of lightning performance and insulation coordination and (c) Tools, methods and modelling and analysis of system technical performance.

Mr. Chauhan presented papers of part (a) and he then requested Mr Nihar Raj, VP, ABB and Prof. Himanshu Bahirat, IIT Bombay to present papers of part (b) and part (c) respectively. The gist of papers relevant to Indian condition as per their area of experience on the subject are discussed.

It is also emphasized by Chairperson that; the way we look at the power system is needs to be changed as the dynamics of power system are changing rapidly bringing new challenges as well as opportunities. Utility, OEM and Academia needs to come together for study and analysis of new challenges and to derive amicable solutions for developing power grid in new scenario.

After their presentation, Mr. Chauhan asked for the response to the questions to be sent in for collation.

(MIRZA GALIB HALL)

Study Committee D2 – Information Systems & Telecommunications

- Chaired by: Mr N S Sodha, Former ED, POWERGRID & NSC D2 Chairperson
- Co-Chaired by Ms Sunita Chauhan, DGM, POWERGRID

Mr Sodha presented his brief report on the SC D2. Thereafter, Ms Chauhan gave a gist of the 5 papers to be presented at the Paris session. After that, the questions raised on these papers by SC D2 were discussed. The questions will be taken up at the Paris session.

Dr. Subir Sen, Chairperson NSC C6 on Distribution Systems & Dispersed Generation conducting the session

Mr. R.K. Chauhan, Chairperson NSC B4 on HVDC & Power Electronics conducting the session

Mr Ashok Pal, Chairperson NSC C1 on System Development & Economics conducting the session

Mr. K.V.S. Baba, Chairperson NSC C2 on System Operation & Control conducting the session

Then, Mr A K Mishra, Director, NSGM gave a comprehensive presentation on Smart Grid status in India. He spoke on such topics as why Smart Grid, the current status, some statistics and the further steps.

A byte from Mr Sodha: "If you are on a moving treadmill, you have to run to remain where you are!".

Study Committee C5 – Electricity Markets & Regulations

- Chaired by: Mr P K Agarwal, Director, POSOCO & NSC C5 Chairperson

On a request by Mr Agarwal, Ms Shruti of POSOCO shared a summary of the SC C5 proceedings.

Thereafter, 7 officers from POWERGRID gave a summary of the 29 papers in 3 streams to be taken up at the Paris session. Due to paucity of time, the related questions could only be touched upon briefly.

Study Committee D1 – Materials & Emerging Test Techniques

- Chaired by: Mr Jithin Sunder, ED, BHEL & NSC D1 Chairperson

After giving his brief report of the SC D1 proceedings, Mr Sunder shared his thoughts on the subject of new technology in the area of materials and testing.

Afterwards, Mr Sunder called upon 8 officers from BHEL to present briefly the 39 papers in 3 streams, to be presented at the Paris session. In view of the large number of papers, Mr Sunder requested the participants to take time to go through the questions, which were listed in the documentation provided, and to communicate their response to him in the next few days, so that he could collate the same as part of his preparation for the Paris session.

Study Committee B5 – Protection & Automation

- Chaired by: Mr Subhash Thakur, AGM, NTPC & NSC B5 Chairperson

Mr Thakur called upon Mr Abhishek Khanna of NTPC to brief the gathering. Mr Khanna presented a summary.

Ms Neha Gupta, NTPC summarized the 16 papers to be presented under SC B5. Again, due to paucity of time, the participants were requested to forward their response to Mr Thakur for collation.

There was a reasonable amount of interaction during the session. Mr Soni of GETCO initiated a lively debate on IEC 61850. In response, Mr Awasthi gave example of the FAT at Power Grid Chandigarh GIS and Malerkotla substations. He also explained the interconnection of the IEDs over PRP Network.

27 JULY 2018 (SECOND DAY)

(MAIN AUDITORIUM)

Study Committee A3 - High Voltage Equipment

- Chaired by: Mr R K Tyagi, GM, POWERGRID & NSC A3 Chairperson

Mr R.K. Tyagi presented in brief the scope of SC A3, and gave an overview of the work that has been done by NSC A3. He then proceeded to summarize the finally accepted papers for presentation at the Paris session for this

Mr. Lalit Sharma, Chairperson NSC B1 on Insulated Cables conducting the session

Mr Rajil Srivastava, Chairperson NSC B3 on Substations conducting the session

Study Committee. He was well assisted by Mr Amandeep Singh, Manager, POWERGRID who also explained the gist of the papers. There are two papers from India in the Paris Session and there was very good interest shown by the audience for these papers. The papers were regarding the optimization of NGR ratings and implementation of Controlled Switching Device. There were many queries on the topic of implementation of Controlled Switching Device by various participants. The relevant questions were briefly touched upon but due to paucity of time the audience was requested to send any remaining queries to Chairman National Study Committee or the original authors of the paper.

Study Committee A1 – Rotating Electrical Machines

- Chaired by: Mr D. K. Chaturvedi, GM, NTPC & NSC A1 Chairperson

Mr. D.K. Chaturvedi took it upon himself to brief the gathering about SC A1, as also, the summary of papers for presentation at the Paris session. As a subject expert, he was able to expound on certain aspects. He appraise delegates on SC-A1 initiatives. This year SC A1 has focus on 'Generation Mix of the future'. There are more than 10 papers in SC-A1 Paris session, which talks of renewable mix generation.

While he did touch upon some of the questions in general, he sought response from the participants. He briefly covered the Indian paper on 'Generator as Synchronous Condenser', which could play a vital role in ensuring power quality even with large renewable grid integration.

Mr. D.K. Chaturvedi then requested Mr. Harsh V Senghani NTPC to present the gist of other papers relevant to Indian conditions.

Study Committee C6 – Distribution Systems & Dispersed Generation

- Chaired by: Dr Subir Sen, ED, POWERGRID & NSC C6 Chairperson

Dr Sen presented an overview of renewable integration in Indian power system along with the role of energy storage, renewable forecasting, dynamic compensation and smart grid. He also summarized the 34 papers contributed by 14 different countries for CIGRE 2018, SC C6. He also touched upon the impact of E-mobility on the grid and need for charging infrastructure to facilitate in adoption of Electric Vehicle (EV). In this, he was ably assisted by Mr. Rajesh Kumar, Assistant General Manager, POWERGRID, who explained the gist of the papers and its significance in Indian context. Even the questions could only be touched upon briefly, with a request to the participants to send in their response for collation.

Study Committee B4 – HVDC & Power Electronics

- Chaired by: Mr R K Chauhan, ED, POWERGRID & NSC B4 Chairperson

Mr Chauhan presented in brief the SC B4, and gave a brief overview of the papers for presentation at the Paris session. He was well assisted by Mr Puneet Tyagi, DGM, POWERGRID, in this. Mr Tyagi gave a gist of all the papers, and also of the questions.

The audience was requested to send in their response for collation

(MIRZA GALIB HALL)

Study Committee C1- System Development & Economics

- Chaired by: Mr Ashok Pal, GM, POWERGRID & NSC C1 Chairperson

Mr Pal called upon Mr Anupam Kumar of POWERGRID to brief the gathering on SC C1.

Thereafter, 5 officers from POWERGRID were tasked with presenting a summary of a total of 38 papers in 3 streams listed for the Paris session. Even in this session, the participants were requested to forward their response to the session chair for collation.

A view of the participants

Study Committee C2 – System Operation & Control

- Chaired by: Mr K V S Baba, CMD, POSOCO & NSC C2 Chairperson

After the opening remarks by Mr Baba, Mr Mohit from POSOCO was called upon to brief the gathering in SC C2. Then Mr Baba and Mr Mohit informed that there were a total 45 papers to be presented under this group. These were then categorized under 11 headings.

Seven officers from POSOCO presented a summary report on the papers. The audience to again requested to respond to the questions and send in their response.

Study Committee B1 – Insulated Cables

- *Chaired by: Mr Lalit Sharma, COO, KEI & NSC B1 Chairperson*
- Co-Chaired by Mr Deepal Shah

Mr Sharma is taking over the chairmanship of the NSC B1 from Mr Deepal Shah. In deference to the vast experience of Mr Shah with the topic and with SC B1, Mr Sharma requested Mr Shah to brief the audience. Accordingly, Mr Shah informed of the work of SC B1. He, further, informed that there were 41 papers in three steams to be presented under this SC. Thereafter, he gave a quick overview of all the 41 papers. One paper, No. 102, referring to the storage of a spare cable was taken up in detail. There was a good amount of interaction with the audience on this.

There was a lively discussion between the chair and some delegates representing some distribution companies on the topic of difficulties encountered in laying of the cables, especially, in regard to the Right of Way and getting permissions from the authorities. There were a number of difficulties expressed in this regard.

Mr Shah referred the participants to the CBIP manual on Underground Cables. He agreed that the manual could do with some additional clarity on the issues raised. He agreed that there should be a Guideline on how to lay the Underground Cable.

There was also an interaction on the protection of and finding the fault location in case of a mixed line, i.e., a combination of Overhead and underground lines. It was agreed that even this topic could do with some additional clarity.

A view of Exhibition

Study Committee B3 – Substations

- Chaired by: Mr Rajil Srivastava, AGM, POWERGRID & NSC B3 Chairperson

Mr Srivastava first briefed the gathering, then he called upon Mr Anuj Bhutani of POWERGRID to brief the audience on the papers to be presented at the Paris session. He informed that there were a total of 41 papers in three streams.

Mr Bhutani selected 19 papers and shared its summary with audience. The topic being substations, there was a good interaction with the participants from the distribution and transmission sectors.

Even in this session, there was little chance of taking up the questions for the Paris session. Accordingly, the audience was again requested to send in their response for collation.

POSTER SESSION

A Poster session for all the papers selected from India was also organized during the two days conference.

EXHIBITION

The organizations like Supreme & Co. Pvt. Ltd., SCOPE T&M Pvt. Ltd., Finolex Industries Limited, NHPC Ltd., UE Systems IMENA Pvt. Ltd., Motwane, POWERGRID & CBIP participate and displayed their services in the 2 days Exhibition organised parallel to the Pre-CIGRE conference.

CONCLUDING SESSION

Mr P P Wahi, Director, CBIP, thanked every person present for their whole-hearted participation in this major exercise in information exchange. He was appreciative of the depth of knowledge shared and the dedication displayed by every participant to ensure the success of the event.

Mr Wahi again reminded the delegates of the importance of CIGRE and benefits of its membership for the power-sector professionals. He expressed his satisfaction with the current level of memberships. However, he desired further growth of CIGRE membership, in the interest of the power community as whole.

He once again thanked the delegates, the speakers, NSC chairmen's, the SCOPE administration and also the officers of CBIP, who made the event possible.

This was the end of this conference.

Mr. Y.V. Joshi, President, ERDA, Mr. Nihar Raj, VP-ABB Ltd., Mr. B.B. Chauhan, MD, GETCO, Mr. P.P. Wahi, Director, CBIP and other participants during Pre-CIGRE session

CIGRE Session 2018

26th - 31st August 2018, Paris

A Report by CIGRE-INDIA

47 Session of CIGRE, the bi-annual technical congress was held in Paris from 26th to 31st August 2018

ABOUT CIGRE

CIGRE (International Council on Large Electric Systems) is a permanent, non-governmental and non-profit international association founded in 1921. Since its foundation, CIGRE has provided an international technical forum for the industry's system operators, equip¬ment manufacturers and research establishments to discuss and provide solutions for all the major technical issues. CIGRE is dedicated to the development of solutions to electricity sector. CIGRE has Members in more than 95 countries; it is the leading worldwide organisation on electric power systems, covering the technical, economic, environmental, operational, organizational and regulatory aspects.

Held every two years, the CIGRE Session has a reputation for providing a unique opportunity for the del-egates and exhibitors to share their knowledge and experience.

The 47th Paris Session was very successful, with a record number of about 4,900 delegates among from 98 countries, **including 150 participants from India.**

OPENING CEREMONY

The opening ceremony took placed on Sunday, Aug. 26th. The keynote speaker of the opening ceremony, attended by 3700 delegates in the Grand Amphitheatre of the Palais des Congrès of Paris on Sunday, was Audrey ZIBELMAN, President and CEO of the Australian Energy Market Operator, who delivered her vision of the electricity markets and business models of the future.

CIGRE Inaugural Session at Paris 2018

After her speech, the President of CIGRE, Rob STEPHEN, handed over the distinctions to the new Honorary Members (7), CIGRE Fellows (5) and the CIGRE Medal to Klaus FRÖHLICH from Switzerland and Clark GELLINGS from the United States of America, in recognition of their outstanding contributions to the technical and administrative activities of CIGRE.

Among the new initiatives taken during this Session, was the increased number of Session papers from 500 in 2016 to 543 in 2018, with the related poster sessions, the organisation of 16 tutorials from Monday to Thursday with a total attendance of 3,700 and the introduction of electronic poster sessions attended by more than 6,800 participants.

The opening panel on Monday morning, on the electrical system of the future and its challenges in contributing to a sustainable world, opening up to disruptive developments, and guaranteeing safe operation, got the attention of 1200 attendees. With more than 300 exhibitors, the technical exhibition was very successful and attended by more than 9,600 visitors and delegates. The Session program also included a forum on CIGRE Women in Engineering attended by 220 persons, a Next Generation Network forum, a National Committees forum, and last but not least a memorable cocktail party at La Cité de la Mode et du Design.

TECHNICAL PROGRAM

The technical program included formal presentations, panel discussions, technical meetings and poster ses¬sions, workshops & Tutorials to address various issues and challenges in the power sector.

The latest developments linked to key components of the transmission system, namely, rotating machines, substations, transformers, overhead lines and cables were discussed to¬gether with system design, operation, control and system performance.

The technical program was spread over a period of five days in parallel with the exhibition, which at¬tracted number of the electricity industry's key international manufacturers, network operators, consul¬tants and service providers.

The technical conference was well structured, addressing all the major issues, and every session offered participants the opportunity to contribute and benefit from the assembled industry experts.

The event attracted 543 number of technical papers, 500+exhibitors from around world.

OTHER MEETINGS

Besides above, CIGRE Administrative Council meeting, 16 Study Committee and its; Working Group meetings; National committees and Regions Meetings were also held during the session.

Mr. I.S. Jha, President CIGRE India, member of CIGRE administrative Council from India attending the administrative Council meeting at Paris
CIGRE Administrative Council is the advisory body which supervises the operation of CIGRE.

PARTICIPATION FROM INDIA IN CIGRE SESSION 2018

Mr. I.S. Jha, CMD, Power Grid, President CIGRE-India lead the delegation of more than 150 participants from India to CIGRE session 2018 from POWERGRID, POSOCO, NTPC, BHEL, NHPC, ISGF, Regulatory Commission of DELHI, Punjab, Maharashtra, Sikkim, ABB, Adani Power Transmission, Apar industries, Cargil India Pvt. Limited, CESC, CTR, ERDA, KalkiTech, PowerTech Global, Scope T&M, Siemens, Sterlite Power Transmission, Supreme & Co, Suzlon Power, Tata Power, Transformers & Rectifiers.

A meeting of the Administrative Council was held at Paris during CIGRE session 2018 on 25th & 28th August 2018. Mr. I.S. Jha, as member of CIGRE administrative Council from India, attended CIGRE Administrative Council Meeting on 28th Aug. 2018 along with the representative of about 58 other member countries. The meeting on 25th August 2018 was attended by Mr. V.K. kanjlia, Secretary, CIGRE India along with Mr. P.P. Wahi, Director, CIGRE-India.

In view of the excellent performance of CIGRE-India as National Committee as far as activities and membership are concerned, **India got seat in the Steering Committee, which is top executive body of CIGRE.**

Participation of India in CIGRE Session 2018

CIGRE - AORC Meeting in progress

CIGRE ASIA OCEANA REGIONAL COUNCIL MEETING ON 29TH AUGUST 2018 CONDUCTED BY DR. SUBIR SEN, ED, POWERGRID CHAIMEN AND SHRI P.P. WAHI, SECRETARY, CIGRE AORC.

CIGRE-AORC (Asia Oceans Regional Council) is a forum for sharing experience and knowledge regarding pertinent technical issues particularly those affecting power systems in the Asia-Oceana Region. The countries from Asia Oceana Region, who are associated with the forum are : Australia; China; Cambodia; Gulf Cooperative Council; Hong Kong; India; Indonesia; Iran; Jordan; Japan; Korea; Malaysia; New Zealand; Taiwan; and Thailand.

An administrative meeting of CIGRE AORC was held at Paris during CIGRE session 2016.

Since India is Chair for AORC, the meeting was convened by India. Dr. Subir Sen, ED, POWERGRID Chaired the meeting and Shri P.P. wahi, Secretary, CIGRE AORC conducted the meeting.

India handed over the chairmanship to Japan during the meeting for next term.

PARTICIPATION OF INDIA IN TECHNICAL SESSION/ POSTER SESSION

22 technical papers accepted from India were presented in the technical session. Authors also participated in the poster session for detailed interaction with the participants on their papers.

PARTICIPATION IN THE EXHIBITION

The following Exhibitors participated in the exhibition and displayed their services to the industry:

Scope T&M	- Stand No. 168
CTR Manufacturing Co.	- Stand No. 125
KalkiTech	- Stand No. 131
Karamtara Engineering Pvt. Ltd	- Stand No. 276 – did not participate
KSE Electricals	- Stand No. 241
Tag Corporation	- Stand No. 169

The participants availed the excellent opportunity to update their knowledge by visiting exhibition and interacting with the exhibitors about their innovations and latest development.

PARTICIPATION IN CIGRE STUDY COMMITTEE MEETINGS

Participation in CIGRE Study Committee Meetings:

CIGRE operated through 16 study Committees comparising experts from about 24 different countries. India is represented in all the sixteen study committees of CIGRE. All the study committee meetings were attended by the member or their representative from India.

The preparations for the following study committee meetings planned in India was presented in respective CIGRE Study Committee

CTR Manufacturing Co. Exhibitor from India

KalkiTech Exhibitor from India

- Meeting of SC A1 on Rotating Electrical Machines is going to be held 23 - 28 Sept. 2019 at Hotel Vivanta by Taj, New Delhi.
- Joint meeting of following Study Committee will be held from 18 - 23 Nov. 2019 at Hotel Le Meridian, New Delhi:
  - SC A2 (Transformers); SC B2 (Overhead Lines) and
  - SC D1 (Materials) – in Nov. 2019 in New Delhi.
- The proposal to host the SC meeting in India in 2021 for SC A3, SC B3, SC B5, SC C2 & C5 were submitted during respective SC Meetings.

SC A3 Tentatively agreed to hold in 2021, 2023 allotted to Moscow

SC B3 Tentatively agreed to hold in 2023 as 2021 is already booked

SC B5 Tentatively agreed to hold in 2021. The final decision will be in the next meeting of SC.

SC C2 Since 2021 is already allotted to Japan the request was register for 2023.

SC C5 The proposal was from Japan & India. The decision is to be taken in the next meeting of SC

- Mr. N.S. Sodha, member of CIGRE SC D2 acted as Secretary for one of the preferential subject during Session and also selected as member in SC D2 Advisory Group and SC D2 Africa Group.
- In Study Committee A1-India dominated the meeting of Advisory Group. Out of total seven working groups, convener for the three WGs is selected from India.
- CIGRE is looking at India for more and more technical contribution. The expectations from the Chairman of almost all the study committees were that, India should have representation in all the working groups.

Dinner Hosted by CIGRE-India & ISGF at Paris on 23rd August 2016

A dinner was hosted by CIGRE India & ISGF, Sr. Dignitaries from India and office bearers of CIGRE i.e., President, Secretary General and Technical Committee members attended the dinner. The networking dinner was sponsored by M/s. ABB Ltd., Raychem RPG (P) Ltd., Secure Meters Ltd., CTR Manufacturing Industries Ltd., Taurus Powertronics Pvt. Ltd., CESC Ltd., Shemar, KEI Industries Ltd. and SCOPE T&M Pvt. Ltd.

GLIMPSIS OF NETWORKING DINNER

Activity Report of
CIGRE-INDIA AFTER CIGRE SESSION IN AUGUST 2018

CIGRE-India entered in Steering Committee (the top decision making body) of CIGRE

Shri I.S. Jha, President CIGRE-India

Steering Committee of CIGRE is the body made up of high level stakeholders and/or experts who provide guidance on key issues such policy and objectives, budgetary control, marketing strategy, resource allocation, and decisions involving large expenditures.

It is a matter of pride for India that we have got a seat in the Steering Committee of CIGRE and Shri I.S. Jha, President CIGRE India & Chairman & Managing Director, POWERGRID is the member from India in this high level council of CIGRE.

This is going to help India taking maximum advantage of the activities of CIGRE at International Level for knowledge accentuation of prefesionals.

About CIGRE-India

CIGRE-India functions as the National Committee for CIGRE and coordinates CIGRE activities in India. It Organizes National Study Committee (NSC) meetings and Events at National Level. Affairs of CIGRE-India are administered by the General Body / Governing Council

Governing Body of CIGRE India

President	: Mr. I.S. Jha, Chairman & Managing Director, POWERGRID
Vice President	: Mr. A.K. Gupta, Director, NTPC
	: Ms. Seema Gupta, Director, POWERGRID
	: Mr. Amitabh Mathur, Former Director, BHEL
Technical Chair	: Mr. R.P. Sasmal, Former Director, POWERGRID
Vice Chair-Tech.	: Mr. N.N. Misra, Former Director, NTPC
Secretary&Treassurer	: Mr. V.K. Kanjlia, Secretary, CBIP

CIGRE AORC

- CIGRE-India had a privilege to Chair CIGRE-AORC for 2016-18.

  Dr. Subir Sen, was, Chairman of CIGRE-AORC and Mr. P.P. Wahi was the Secretary.

  CIGRE-India Conducted CIGRE-AORC Administrative Meeting at New Zealand in Sept 2017 and at Paris in August 2018. We also organized CIGRE-AORC Technical meeting at Gangtok, Sikkim, India in May 2018.

Major activities of CIGRE India

Growth of Membership

In the year 2016 - 594 nos. equivalent members and

In the year 2017 - 768 nos. equivalent members

In the year 2018 - 828 nos. equivalent membersr

Participation of CIGRE India at international level

- India got seat in Steering Committee (Executives Body) of CIGRE

- Delegates Attended from India in CIGRE Session 2018 - 145 Nos.
- Total papers presented in 2018 session at Paris from India - 22, 1 paper under Intl. Category, and three papers by Young members.
- Exhibitors from India during Paris session
- Scope T&M - Stand No. 168
- CTR Manufacturing Co. - Stand No. 125
- KalkiTech - Stand No. 131
- Karamtara Engineering Pvt. Ltd - Stand No. 276 – did not present
- KSE Electricals - Stand No. 241
- Tag Corporation - Stand No. 169
- AORC Meeting convened & chaired by India and charge for next term handed over to Japan.
- Participation in CIGRE Study Committee meetings during Session (26th - 31st Aug. 2018) : As per feedback received all the CIGRE SC Meetings during session were attended by Members/ their representatives.
- Presentations about preparations for SC Meeting & Colloquium in India in 2019 for SC A1- in Sept.; and SC A2, B2 & D1 in Nov. 2019 were made in respective Study Committee meetings.
- The proposal to host the SC meeting in India in 2021 for SC A3, SC B3, SC B5, SC C2 & C5 were submitted during respective SC Meetings.

SC A3	Tentatively agreed to hold in 2021, 2023 allotted to Moscow
SC B3	Tentatively agreed to hold in 2023 as 2021 is already booked
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- In Study Committee A1-India dominated the meeting of Advisory Group. Out of total seven working groups, convener for the three WGs is selected from India.
- CIGRE is looking at India for more and more technical contribution. The expectations from the Chairman of almost all the study committees were that, India should have representation in all the working groups.

Participation in CIGRE SC Meetings by Indian Representative in 2017

SC B2; C1; C2; C5 & C6 in May 2017	at Dublin
SC A1 in Sept. 2017	at Vienna
SC A2; in Oct. 2017	at Poland
SC A3; and B4 in Sept. 2017	at Canada
SC 1 in Oct. 2017	at New Delhi
SC B3 in Sept. 2017	at Brazil
SC B5 in Sept. 2017	at New Zealand
SC C3 in Sept. 2017	at Korea
SC D2 in Sept. 2017	at Moscow

All the study committee meetings in 2018 were attended at Paris during CIGRE session 2018.

Upcoming CIGRE Study Committee meetings

Study Committee (SC)		2017	2019
1	A1 Rotating Machine	Vienna, Austria	India (22-28 Sept. 2019)
2	A2 Transformers	Poland	India (18-23 Nov 2019)
3	A3 High Voltage Equipment	Winnipeg Canada	Bucharest Romania (7-13 Sept 2019)
4.	B1 HV Insulated Cables	India	Aalborg Denmark (3-6 June 2019)
5	B2 Overhead Lines	Dublin Ireland	India (18-23 Nov 2019)
6	B3 Substations	Brazil	Japan (23-26 April 2019)
7	B4 HVDC Link and AC Power Electronic Equipment	Winnipeg Canada	Aalborg Denmark (3-6 June 2019)

8	B5 Power System Protection and Local Control	New Zealand	Norway- (24-28 June 2019)
9	C1 Power System Planning and Development	Dublin Ireland	Aalborg Denmark (3-6 June 2019)
10	C2 Power System Operation and Control	Dublin Ireland	Aalborg Denmark (3-6 June 2019)
11	C3 System Environmental Performance	Seoul	Aalborg Denmark (3-6 June 2019)
12	C4 System Technical Performance	Ireland	Aalborg Denmark (3-6 June 2019)
13	C5 Electricity Markets and Regulation	Dublin Ireland	Canada
14	C6 Distribution Systems and Dispersed Generation	Dublin Ireland	Aalborg Denmark (3-6 June 2019)
15	D1 Material for Electrotechnology	Winnipeg Canada	India (18-23 Nov 2019)
16	D2 Information Systems & Telecommunications for System	Moscow	Finland (11-14 June 2019)

CIGRE National Level Activities – after June 2018

S. N.	Event	Dates	Venue
1	Conference on Global trends and Innovation in Development of Power Sector	28-29 July 2018	New Delhi
2	Coordination for CIGRE Paris session	21-26 August 2018	Paris
3	Conference on International Practices on usage of Insulators in EHV/UHV Transmission System	Nov, 12th 2018	New Delhi
4	National Conference on 'Challenges in construction of transmission lines in the Hilly Regions'	Nov. 29-30, 2018	Shimla
5	11th National Conference on Earthing Systems	Dec, 13-14 2018	New Delhi
6	Conference on 'Renewable Energy Technologies and its Integration with Grid'	Dec. 20-21, 2018	Vadodara
	Event planned		
1	Conference on Modern Technology trends in Power Transformers including OLTC, Bushings etc.	February, 27-28 2019	New Delhi
2	GRIDTECH 2019 – conference 2 - on International Conference on "Integration of Renewable with Synchronous Grid"	April, 3-4 2019	New Delhi
3	CIGRE SC A1 Colloquium on Rotating Machines	Sept. , 22-28, 2019	New Delhi
4	CIGRE SC A2; B2 & D1 Joint Colloquium	Nov., 18-23 2019	New Delhi

CIGRE Events Planned in India in 2019

- Meeting & Intl. Conf. of SC A1 on Rotating Machines - proposed from 23 - 28 Sept. 2019 at New Delhi.
- Meeting & Intl. Conf. of three Study Committee i.e. SC A2 (Transformers)/ B2 (Overhead Lines) / D1(Materials) – in 18-23 Nov. 2019 in New Delhi.
- CIGRE-India plan to hold minimum one event by each National Committee (tutorials /workshop/ conferences) in a year at National Level.
- C6 - Conference during GRIDTECH April 2019.

Strategy for Participation in CIGRE session 2020

- Submission of Quality Papers
- Maximum number of Participants for Session
- Planning for India Pavilion during Exhibition (Space for 150 sq. M. – plan for about 15-20 Exhibitors; like, CPRI, NSPTCL, POWERGRID, BHEL, Tata, & Pvt Cos.)
- Space for National Committee office at the venue of Session
- Key address from India in opening session.

CIGRE MEMBERS FROM INDIA IN 2018

(As on December 2018)

Institutional Members

S. No	Organization
1.	Bihar Electricity Regulatory Commission
2.	CIGRE INDIA- COE,Centre of Excellence
3.	Delhi Electricity Regulatory Commission
4.	ELECTRICAL RESEARCH & DVPT ASSO. (ERDA)
5.	Gujarat Electricity Regulatory Commission
6.	H P Electricity Regulatory Commission
7.	IEEMA
8.	Indian Inst. of Technology- Kanpur
9.	Indian Institute of Technology- Bombay
10.	Karnataka Electricity Regul. Commission
11.	Maharashtra Electricity Regulatory Commission
12.	National Institute of Technology- Calicut
13.	Odisha Electricity Regulatory Commission
14.	Punjab State Electricity Regulatory Commission
15.	Sikkim State Electricity Regulatory Commission
16.	U.P. Electricity Regulatory Commission
17.	Uttarakhand Electricity Regulatory Commission

Individual Membership

S. No	Name	Organization
1	Abhaya Pankaj Mishra	Hindalco
2	Abhishek Rathi	Powergrid Corporation of India Ltd.
3	Aditya Korde	Diagnostic Technologies India Pvt Ltd
4	Alok Roy	Reliance Power Transmission Ltd
5	Anagha Dixit	EMCO Ltd.
6	Anantha Sarma Boppudi	Powergrid Corporation of India Ltd.
7	Anchal Pahwa	India Infrastructure Publishing Limited
8	Anil Jain	Powergrid Corporation of India Ltd.
9	Anil Kumar Jha	Damodar Valley Corporation
10	Anil Kumar Vyas	Powergrid Corporation of India Ltd.
11	Anil Rawal	Sterlite Power Transmission Ltd.
12	Anish Anand	Powergrid Corporation of India Ltd.
13	Anjani Kumar	Powergrid Corporation of India Ltd.
14	Ankur Shah	Gujarat Energy Transmission Co. Ltd
15	Aradhana Ray	Laxmi Associates
16	Arogya Raju Pudhota	TS Transco
17	Arun Kumar Mishra	Power Grid Corporation of India Ltd
18	Arvind GUPTA	Adani Power Limited
19	Arvind Kumar Sharma	Reliance Infrastructure Ltd.
20	Asha M Agravatt	Gujarat Energy Transmission Co. Ltd
21	Ashok F Bhavsar	EL PE Engineers
22	Ashok Kumar J. Chavda	Gujarat Energy Transmission Co. Ltd.
23	Ashok Kumar J. Chavda	Gujarat Energy Transmission Co.Ltd.
24	Ashok Pal	Powergrid Corporation of India Ltd.
25	Ashwini Jharwal	Powergrid Corporation of India Ltd.
26	BaburaoKeshawatkar	Raj Petro Specialties Pvt Limited
27	Bankim Pravinchandra Soni	Gujarat Energy Transmission Co. Ltd
28	Bapuji Palki	ABB Limited

29	Barindra Narayan De Bhowmick	Power Grid Corporation of India Ltd
30	Bhadresh B. Chauhan	Gujarat Energy Transmission Co. Ltd
31	Bhadreshkumar B.Mehta	Gujarat Energy Transmission Co. Ltd
32	Bipin B. Shah	Adani Transmission Ltd.
33	C P Biju Krishnan	Tata Power
34	Chandra Kant	Power Grid Corporation of India Ltd.
35	Deepak Kumar Saxena	Welspun Energy Ltd.
36	Deepak Lakhapati	Sterlite Power Transmission Ltd.
37	Deepal Shah	PFISTERER
38	Dhananjay Kumar Chaturvedi	NTPC Ltd.
39	Dinesh Babu Nagalingam	Megger
40	Dipak Kumar Patel	Gujarat Energy Transmission Co. Ltd.
41	Dr. Burjupati Nageshwar Rao	Central Power Research Institute
42	E.V.Rao	KEC International Limited
43	Firoz Ahmed	GE Grid Solution
44	Gopal Ji	Angelique International Limited
45	Habib Chowdhary	J&K Power Development Department
46	Hillol Biswas	WAPCOS Ltd.
47	Hrushaabh Prashaant Mishra	Syselec Technologie Private Limited
48	I. R. Rao	NIT- Karnataka
49	Indu Shekhar Jha	Powergrid Corporation of India Ltd.
50	Jaspaul Kalra	Rajasthan Test & Research Centre
51	Jayesh Gandhi	Gujarat Energy Transmission Co. Ltd
52	Jora Gonda	NIT Karnataka
53	K N Ganesan	GE T&D India Ltd.
54	Karma Dinesh Kumar	Powergrid Corporation of India Ltd.
55	Kaushik Tarafdar	Hindalco
56	Konkimalla Venkata Srinivasa Baba	POSOCO
57	Krishnan S. Balasubramanian	Consultant
58	Lalit Sharma	KEI Industries Ltd
59	Lee Yong Woo	Hyosung T&D India Pvt. Ltd.
60	Loveleen Kaur Taneja	Panjab Engineering College (Deemed Uni.)
61	M S Shanthakumar	ABB India Ltd.
62	M. Muhammad Abdul Jaleel Muhammad	Dubai Electricity and Water Authority
63	Madhu Sudan	GE T&D India Ltd.
64	Madhuryya Prosad Chakravorty	Energy Infratech Pvt. Ltd
65	Manishkumar K. Jani	Gujarat Energy Transmission Co. Ltd
66	Manoj Kumar Muthayala	WAPCOS Ltd.
67	MaryKarammel	EMCO Ltd
68	Mata Prasad	Consultant
69	Milind Nene	Kalpataru Power Transmission Ltd.
70	Mohana Rao Mandava	BHEL
71	Monal Patel	Map Power LLP
72	Mrs. Meenakshi	NTPC Ltd.
73	Mukund Hosalli Bhashyam	FREE LANCE
74	Muthuraj Ramaswamy	Megawin Switchgear P Ltd
75	N. S. Sodha	Former Powergrid
76	Nagarajan Packirisamy	Dubai Electricity and Water Authority
77	NalinNanavati	Raj Petro Specialties Pvt Limited
78	Narasimhan Ravinarayan Makaram	Taurus Powertronics Pvt. Ltd.
79	Narendra Nath Misra	NTPC (Former Director)
80	Naresh Kumar Panchal	Suzlon Power Infrastructure Ltd.
81	Naveen Kumar NADA	WAPCOS Ltd.
82	Neelesh Arora	Ayanza Epsilon Elektro Pvt. Ltd.

83	Nikunj Kumar Makwana	Gujarat Energy Transmission Co .Ltd.
84	Nilesh Sheth	Gujarat Energy Transmission Co. Ltd
85	Nitin Kumar Patel	Kalpataru Power Transmission Limited
86	Pankajbhai Suthar	Gujarat Energy Transmission Co. Ltd.
87	Parantap Krishna Raha	Sterlite Power Transmission Ltd.
88	Parind Munsif	Gujarat Energy Transmission Co. Ltd
89	Pervinder Singh Chowdhry	Kalpataru Power Trans. Ltd
90	Pradeep Kumar	NIT Kurukshetra
91	Praful K. Varasada	Gujarat Energy Transmission Co. Ltd
92	Pramod Rao	Consultant
93	Praveen Kumar Agarwal	Power System Operation Corporation
94	Pravinchandra Mehta	Persotech Solutions
95	Puneet Gupta	Raychem RPG
96	Purshottam Kalky	GE T & D India Limited
97	Pydi Ramanamurthy	Powergrid Corporation of India Ltd.
98	Radhey Shyam Meena	Ministry of New & Renewable Energy
99	Rajeev Kumar Chauhan	Power Grid Corporation of India Ltd
100	Rajendra Prasad Sasmal	Powergrid(Ex Director –Operation)
101	Rajendra Vinayak Saraf	The TATA Power Co. Ltd.
102	Rajesh Kumar	Consultant
103	Rajesh Kumar	Power Grid Corporation of India Ltd
104	RajeshSuri	GE T&D India Limited
105	Ramesh Bongu	WAPCOS Ltd.
106	Ramesh Dattaraya Suryavanshi	Alfa Consultants
107	Rameshchandra P. Satani	Gujarat Energy Transmission Co. Ltd
108	Rashi Tyagi	SJVN Ltd.

109	Rashmi Pant Joshi	Powergrid Corporation of India Ltd.
110	Ravi Kumar Puzhankara	DNV-KEMA
111	Ravi Shanmugam	Powergrid Corporation of India Ltd.
112	Ravindra Bhanage	TATA Power -DDL
113	Ravindra Vishnu Talegaonkar	CTR Manufacturing Industries Ltd.
114	S. V N Jithin Sundar	BHEL
115	S.R. Narasimhan	Power Grid Corporation of India Ltd
116	Sachin Srivastava	ABB India Ltd.
117	Samir Chandra Saxena	POSOCO
118	Samsul Ekram	Raychem RPG (P) Ltd.
119	Sanil Namboodiripad	Sterlite Powergrid Ventures Ltd.
120	Sanjay Garg	Powergrid Corporation of India Ltd.
121	Sanjay Patki	Tata Power
122	Sanjib Mishra	General Electric
123	Sanjib Sahoo	NTPC Sail Power Co. Ltd.
124	Santhosh Kumar Artham	Powergrid Corporation of India Ltd.
125	Santosh Kumar Jain	POSOCO
126	Sarasij Das	Indian Institute of Science
127	Sardar Biplob	ABB India Ltd.
128	Sarveshkumar Virendrakumar Gupta	KEC International Limited
29	Satish Chetwani	ERDA
130	Satyajit Ganguly	ONGC Tripura Power Company Ltd.
131	Seema Gupta	Power Grid Corporation of India Ltd
132	Sheri Abhishek Reddy	Mahatma Gandhi Institute of Technology
133	Singaram Christian Johnson	Blessings Power and Civil Consultancy
134	Sita Rama Rao Gandham	Powergrid Corporation of India Ltd.

135	Sivaji Burada	Sleepwalkers
136	Srinivasa Maredipudi Rao	Powergrid Corporation of India Ltd.
137	Sriramsriram A B	Dubai Cable Company Pvt. Ltd.
138	Subhash Chandra Takalkar	Takalkar Power Engin. & Consult. Pvt Ltd
139	Subhash Sethi	Consultant
140	Subhash Thakur	NTPC Limited
141	Subhasis Jhampati	GE T&D India Ltd.
142	Subir Sen	Powergrid Corporation of India Ltd.
143	Sudalai Shunmugam Sundaram	Associate Professor
144	Sukhbir Kapoor	GE T&D India Ltd.
145	Sunil Bhanot	KEC International Limited
146	Sushil Chaudhari	Raj Petro Specialities Pvt Ltd
147	Sushil Kumar Soonee	Power Grid Corporation of India Ltd
148	TonyMartens	Polycab
149	Uday Deshmukh	BSES Rajdhani Power
150	Udaya Kumar	Indian Institute of Science
151	Udaybabu Ratanchand Shah	Mahati Industries Pvt. Ltd.
152	UmeshMaharaja	Tata Power Skill Development
153	Urmil Parikh	ABB India Ltd.
154	Usa Savadamuthu	Anna University
155	V V S Ganesh Balusu	NTPC Ltd.
156	V. K. Kanjlia	Central Board of Irrigation and Power
157	Venkata Chalapathichendur Venkatarao	Balfour Beatty Insfra. India Pvt Ltd.
158	Venkata Satya Narsimha Raju Dandu	WAPCOS Limited
159	Vigneswaran Jagadeesan	Burndy Technology
160	Vijayakumaran Moorkath	Prime Meiden Limited
161	Vikas Shahaji Jagadale	Shreem Electric Ltd.
162	Vikrant Joshi	CG Power and Industrial Solutions Ltd
163	Vinod Kumar Agrawal	Regen Powertech Private Limited
164	Virendra Kumar Lakhiani	Consultant
165	Vishnu Agarwal	Technical Associates
166	Vivek Pandey	POSOCO-WRLDC
167	Vivek Thiruvenkatachari	TAG Corporation
168	Wakchaure Vijaykumar	CTR Manufacturing Industries Ltd.
169	Yogesh Vishnu Joshi	Gujarat Energy Transmission Co. Ltd

Young Members

S. No	Name	Organization
1	Abinash Panigarhi	Hindalco Industries Ltd.
2	Aishwarya Dixit	Hyosung T&D India Pvt. Ltd.
3	Akanksha Ranjan	Tata Consulting engineers Ltd.
4	Alwin Selva Paul Yesudass	DUCAB -HV
5	Amit Kumar	GE T&D India Ltd.
6	Animesh Moji	Adani Group
7	Atma Ram Gupta	NIT Kurukshetra
8	Bhabani Panda	Balco (vedanta)
9	Devarapalli Pradeep	Power Grid Corporation of India Ltd
10	Dinesh Raja Ponamalli Chandrasekhar	WAPCOS Limited
11	Dony C S	Kerala State Electricity Board Ltd.
12	Dwaipayan Sen	Power Grid Corporation of India Ltd
13	Gaurang Rohitbhai Patel	Patronics Services (R) Ltd.
14	Gulab Shinde	Power Grid Corporation of India Ltd

15	Jitendra Kumar	Shell India Market Pvt Ltd.
16	Karanvir Singh Pundir	Power Grid Corporation of India Ltd
17	Madhav Beni	Power Grid Corporation of India Ltd
18	Madhusagar Singh	WAPCOS Ltd.
19	Mahesh Kumar Krishna	Power Grid Corporation of India Ltd
20	Manash Jyoti Baishya	Power Grid Corporation of India Ltd
21	Manoj Kumar Monu	GE T&D INDIA LTD.
22	NVV Somukha Anjeneyulu Matta	Power Grid Corporation of India Ltd
23	Priyanka Swain	Tata Consulting Engineers Limited
24	R. Venkatesan	E4 Energy Solution
25	Ramaprasad Pinakana	Power Grid Corporation of India Ltd
26	Richa Sharma	GE T&D India Ltd.
27	Saibal Gosh	POSOCO- ERLDC
28	Sathi Babu Modi	Power Grid Corporation of India Ltd
29	Sreeharsna Chunduri	Power Grid Corporation of India Ltd
30	Suresh Maturu	ABB Global Industries&Services Pvt. Ltd.
31	Vaibhav Parganiha	Power Grid Corporation of India Ltd
32	Venkata Jagadeesh Yarramsetty	WAPCOS Limited
33	Venkata Rajesh Sangana	Power Grid Corporation of India Ltd
34	Vikas Pandey	Eaton India Innovation Centre
35	Vinod Sharma	Power Grid Corporation of India Ltd

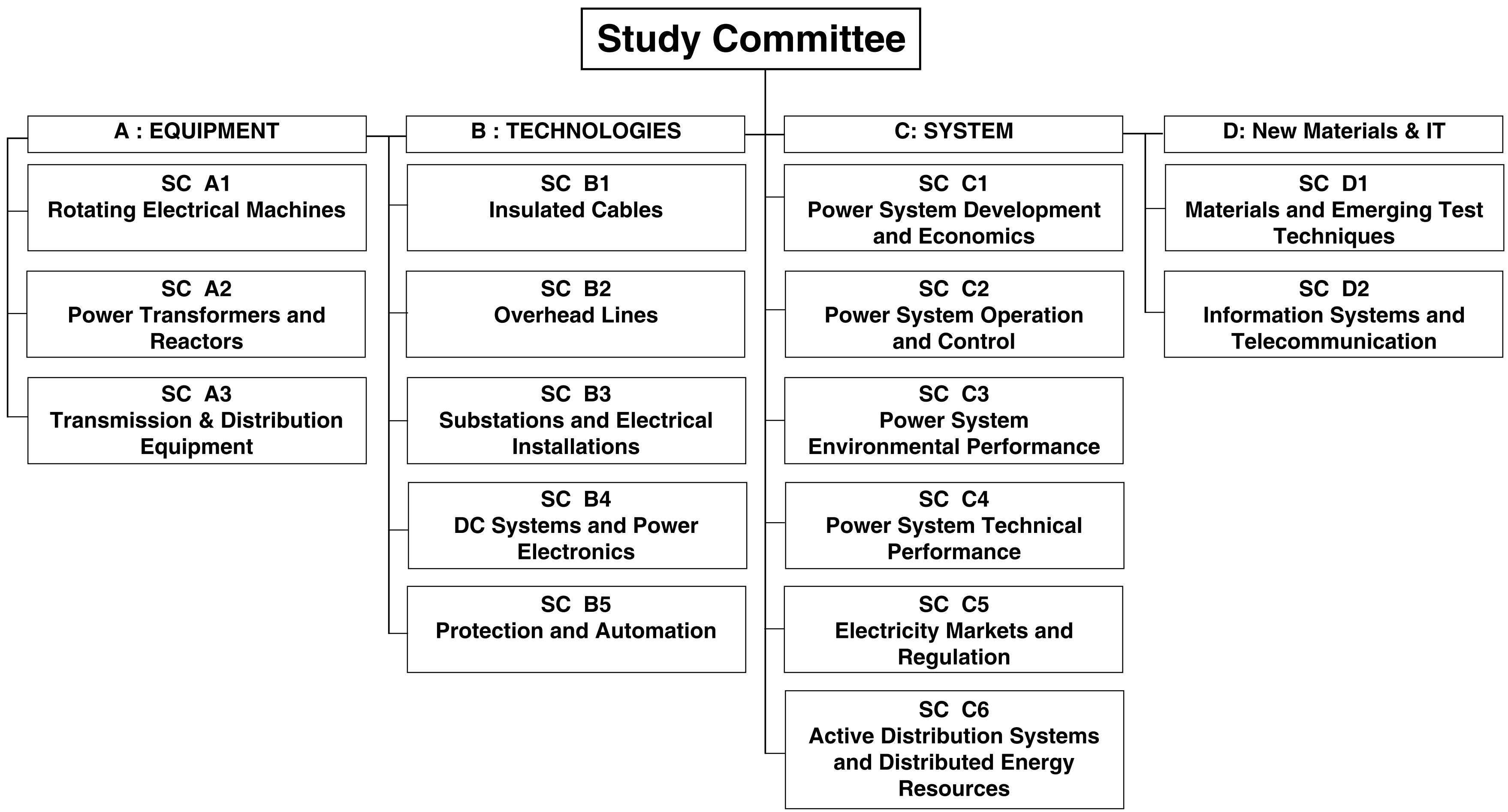
Organizational Members

1	ABB India Limited
2	Adani Transmission Limited
3	APAR Industries Limited
4	Associated Power Structures Pvt. Ltd.
5	Atlanta Electricals Pvt.Ltd.
6	Bajaj Electricals Ltd.
7	Bhakra Beas Management Board
8	Bharat Heavy Electricals Ltd- Bangalore
9	Bharat Heavy Electricals Ltd- H.Q.
10	Bharat Heavy Electricals Ltd- Haridwar
11	Bharat Heavy Electricals Ltd, Bhopal
12	Bharat Heavy Electricals Ltd-R&D
13	Cable Corporation of India
14	Central Electricity Authority (CEA)
15	Central Power Research Institute
16	CESC Limited
17	CG Power and Industrial Solutions Ltd.
18	Deccan Enterprises Limited
19	Delhi Metro Rail Corporation Ltd.
20	Goldstone Infratech Ltd.
21	Grasim Industries Ltd. (Aditya Birla)
22	Gupta Power Infrastructure Limited
23	Hyosung T&D India Pvt. Ltd.
24	India Smart Grid Forum (ISGF)
25	JSK Industries Pvt. Ltd.
26	KEI Industries Ltd.
27	Kreate Energy (I) Pvt. Ltd
28	Larsen & Toubro Limited- Construction
29	Maharashtra State Elect. Trans. Co. Ltd.
30	NHDC Ltd.
31	NHPC Limited
32	North Eastern Electric Power Corp. Ltd
33	NTPC -Anta Gas Power Station
34	NTPC -Auraiya,
35	NTPC –Badarpur
36	NTPC -Barh STPP, Patna
37	NTPC -Bongaigaon TPP
38	NTPC -Dadri SSTP
39	NTPC -Farakka STPS
40	NTPC –Faridabad
41	NTPC -Jhanor-Gandhar GPP
42	NTPC -Kahalgaon STPS
43	NTPC -Kawas GPP

44	NTPC -Koldam Hydro Power Project
45	NTPC -Korba STPS
46	NTPC Limited- H.Q.
47	NTPC -Mouda STPP
48	NTPC - Ramagundam STPS
49	NTPC -Rajiv Gandhi Combined Cycle Power
50	NTPC -Rihand STPP
51	NTPC -Sail Power Company Pvt. Ltd.
52	NTPC -Simhadri STPP
53	NTPC -Singrauli STPS
54	NTPC -SIPAT STPS
55	NTPC -Talcher STPS
56	NTPC -Talcher TPS
57	NTPC –Tanda
58	NTPC -Unchahar
59	NTPC -Vindhyachal STPS
60	ONGC Tripura Power Company Ltd.
61	Polycab Wires Pvt. Ltd.
62	POSOCO- ERLDC
63	POSOCO- NERLDC
64	POSOCO- SRLDC
65	POSOCO- WRLDC
66	POSOCO-H.Q.
67	Power Tech Global Pvt. Ltd.
68	Powergrid - Western Region Transmission System –I
69	Powergrid- Eastern Region-II
70	Powergrid -H.Q.
71	Powergrid- HVDC, Kurukshetra
72	Powergrid- Northern Eastern Region Transmission System
73	Powergrid- Western Region-II,.

74	Powergrid-Eastern Region Transmission System –I
75	Powergrid-NERSIP & Comprehensive Scheme
76	Powergrid-Northern Region Transmission System –I
77	Powergrid-Northern Region Transmission System –II
78	Powergrid-Northern Region Transmission System –III
79	Powergrid-Odisha Project
80	Powergrid-RPT HVDC-
81	Powergrid-South Region Transmission System-I
82	Powergrid-South Region Transmission System-II
83	Reliance Infrastructure Ltd. M.T.B.
84	Savita Oil Technologies Ltd.
85	Scope T&M Pvt Ltd
86	Siemens Ltd
87	SJVN Limited
88	Solar Energy Corporation of India Ltd.
89	Sterlite Power Grid Ventures Limited
90	Sterlite Power Transmission Limited
91	Tata Power Delhi Distribution Limited
92	Taurus Powertronics Pvt. Ltd
93	The Motwane Manufacturing Co. Pvt Ltd
94	The Tata Power Company Ltd.
95	Toshiba Trans.& Dist. Systems (I) Pvt Ltd
96	Transformers & Rectifier (India) Ltd.
97	Transrail Lighting Limited
98	Universal Cables Limited

Four Group of CIGRE Study Committees



FIELDS OF ACTIVITY OF CIGRE STUDY COMMITTEES

Study Committees No.	Scope
A1	**Rotating Electrical Machines** : The SC is focused on the development of new technologies and the international exchange of information and knowledge in the field of rotating electrical machines, to add value to this information and knowledge by means of synthesizing state-of-the-art practices and developing guidelines and recommendations.
A2	**Power Transformers and Reactors** : The scope of SC A2 covers the whole life cycle of all kind of power transformers, including HVDC transformers, phase shifters, shunt reactors and all transformer components as bushing and tap-changers.
A3	**Transmission & Distribution Equipment** : The scope of the SC A3 covers theory, design, construction and operation for all devices for switching, interrupting and limiting currents, surges arresters, capacitors, busbars, equipment insulators and instrument transformers used in transmission and distribution systems.
B1	**Insulated Cables** : The scope of SC B1 covers the whole Life Cycle of AC and DC Insulated cables for Land and Submarine Power Transmission, which means theory, design, applications, manufacture, installation, testing, operation, maintenance, upgrading and uprating, diagnostics techniques. It has been focused on HV & EHV applications for a long time. Nowadays MV applications are more and more taken into consideration.
B2	**Overhead Lines** : The scope of the Study Committee SC B2 covers all aspects of the design and refurbishment of overhead power lines. The Study Committee's strategic goals include: increased acceptance of overhead lines; increased utilization of existing overhead lines; improved reliability and availability of overhead lines.
B3	**Substations and Electrical Installations** : The scope of work for SC B3 includes the design, construction, maintenance and ongoing management of transmission and distribution substations, and the electrical installations in power stations, but excluding generators.
B4	**DC Systems and Power Electronics** : The scope of SC B4 covers High Voltage Direct Current systems and Power Electronics for AC networks and Power Quality improvement. Overhead lines or cables, which may be used in HVDC systems are not included in the scope, but are the responsibility of SC B2 and SC B1 respectively. The members of B4 come from Manufacturers, Utilities, transmission system operators (TSOs), Consultants and Research Institutes. SC B4 is active in recruiting young engineers to participate in its activities.
B5	**Protection and Automation** : The scope of the Committee covers the principles, design, application and management of power system protection, substation control, automation, monitoring, recording and metering – including associated internal and external communications and interfacing for remote control and monitoring.
C1	**Power System Development and Economics** : The SC's work includes issues, methods and tools related to the development and economics of power systems, including the drivers to: invest in expanding power networks and sustaining existing assets, increase power transfer capability, integrate distributed and renewable resources, manage increased horizontal and vertical interconnection, and maintain acceptable reliability in a cost-efficient manner. The SC aims to support planners to anticipate and manage change.
C2	**Power System Operation and Control** : The scope of the SC C2 covers the technical, human resource and institutional aspects and conditions needed for a secure and economic operation of existing power systems under security requirements against system disintegration, equipment damages and human injuries.
C3	**Power System Environmental Performance** : The scope of this Study Committee is focused on the identification and assessment of electric power systems environmental impacts and the methods used for assessing and managing these impacts during the all life cycle on the power system assets.
C4	**Power System Technical Performance** : The scope of SC C4 covers system technical performance phenomena that range from nanoseconds to many hours. SC C4 has been engaged in the following topics: Power Quality, EMC/EMI, Insulation Coordination, Lightning, and Power systems performance models and numerical analysis.
C5	**Electricity Markets and Regulation** : The scope of the Study Committee is "to analyze the different market approaches and solutions and their impact on the electric supply industry in support of the traditional economists, planners and operators within the industry as well as the new actors such as regulators, traders, technology innovators and Independent Power producers.
C6	**Active Distribution Systems and Distributed Energy Resources** : SC C6 facilitates and promotes the progress of engineering, and the international exchange of information and knowledge in the field of distributions systems and dispersed generation. The experts contributes to the international exchange of information and knowledge by the rizing state of the art practices and developing recommendations.
D1	**Materials and Emerging Test Techniques** : The scope of Study Committee D1 covers new and existing materials for electrotechnology, diagnostic techniques and related knowledge rules, as well as emerging test techniques with expected impact on power systems in the medium to long term.
D2	**Information Systems and Telecommunication** : The scope of this SC is focused on the fields of information systems and telecommunications for power systems. SC D2 contributes to the international exchange of information and knowledge, adding value by means of synthesizing state of the art practices and drafting recommendations.

Technical Data

HIGHLIGHTS OF POWER SECTOR

GROWTH OF INSTALLED CAPACITY

(Figures in MW)

	At the end of 12th Plan (March 2017)	As on 30.11.2018
THERMAL	218330.00	222427.34
HYDRO	44478.00	45399.22
NUCLEAR	6780.00	6780.00
RENEWABLE ENERGY SOURCES	57244.00	72012.81
TOTAL	**326832.00**	**346619.37**

Source : CEA

ALL INDIA REGION WISE INSTALLED CAPACITY

As on 30-11-2018

(Figures in MW)

Region	Thermal	Nuclear	Hydro	RES	Total
Northern	57061.46	1620	19707.77	13633.91	92023.14
Western	82675.11	1840	7547.50	21024.18	113086.79
Southern	53017.26	3320	11774.83	35971.07	104083.16
Eastern	27301.64	0	4942.12	1083.64	33327.40
N. Eastern	2331.83	0	1427.00	287.45	4046.28
Islands	40.05	0	0.00	12.56	52.61
All India	**222427.34**	**6780**	**45399.22**	**72012.81**	**346619.37**
Percentage	**64.17**	**01.96**	**13.10**	**20.77**	**100**

Source : CEA

SECTOR WISE INSTALLED CAPACITY AND GENERATION

As on 30-11-2018

Sector	Installed Capacity (MW)					Percentage Share	Net Capacity added
	Thermal	Nuclear	Hydro	RES	Total		During Nov. 2018
STATE	71739.13	0.00	29878.80	1983.87	103601.80	29.89	571.8 MW
PRIVATE	87200.30	0.00	3394.00	68501.64	159095.94	45.90	
CENTRAL	63487.91	6780.00	12126.42	1527.30	83921.63	24.21	
TOTAL	**222427.34**	**6780.00**	**45399.22**	**72012.81**	**346619.37**	**100**	

Source : CEA

GROWTH OF TRANSMISSION SECTOR

	Unit	At the end of 12th Plan (March 2017)	As on 30.11.2018	Addition during 13th Plan (up to Nov. 2018)
TRANSMISSION LINES				
HVDC	ckm	15556	15556	36353
765 kV	ckm	31240	38113	
400 kV	ckm	157787	177108	
220 kV	ckm	163268	173427	
Total Transmission Lines	**ckm**	**367851**	**404204**	**36353**
SUBSTATIONS				
HVDC	MW	19500	22500	131673
765 kV	MVA	167500	204500	
400 kV	MVA	240807	302062	
220 kV	MVA	312958	343376	
TOTAL	**MW/ MVA**	**740765**	**872438**	**131673**

RURAL ELECTRIFICATION / PER CAPITA CONSUMPTION

Total no. of Villages	597464
No. of Villages Electrified	597464
% of Villages Electrified	100.00
No. of Pump-sets Energized (At the end of 12th Plan)	21212860
Per Capita Consumption during 2017-18	1149 kWh

RE SECTOR IN INDIA: POTENTIAL AND ACHIEVEMENTS (Upto November 2018)

GRID-INTERACTIVE POWER Sector	FY 2018-19 Target (MW)	FY 2018-19 Achievement (April-July 2018)	Cumulative Achievements (MW)
Wind	4000.00	871.85	35016.85
Solar Power (SPV)	11000.00	2915.91	24567.37
Small Hydro (up to 25 MW)	250.00	24.65	4510.45
Bio Power (Biomass & Gasification and Bagasse Cogeneration)	350.00	373.70	9737.31
Waste to Power	2.00	0.00	138.30
Total (Approx)	**15602.00**	**4186.11**	**73970.28**
OFF GRID/CAPTIVE POWER	**219**	**137.45**	**1144.37**

Source : MNRE

BHEL FULLY COMMISSIONS 120 MW PULICHINTALA HYDRO POWER PLANT IN TELANGANA

State-owned engineering giant BHELNSE -0.68 % said Monday that with the completion of fourth and final 30 MW unit, it has completely commissioned 120 MW Pulichintala Hydro-Electric Project (HEP) in Telangana. The other three units of the 4x30 MW Pulichintala HEP, commissioned earlier by the BHEL have been operating successfully, BHEL said in a statement.

According to the statement, located in Suryapet district of Telangana, the greenfield project was set up for Telangana State Power Generation Corporation Ltd (TSGENCO) on river Krishna.

Power generation from Pulichintala HEP will contribute significantly in reduction of greenhouse gas emissions towards achieving a low carbon development path for the nation.

BHEL was entrusted with execution of the Electro-Mechanical (E&M) package for the project comprising supply and supervision of erection & commissioning of 4 sets of Vertical Kaplan Turbines and Generators of 30 MW capacity each along with the associated auxiliary equipment.

The equipment for the project has been manufactured and supplied by the units at Bhopal, Jhansi, Rudrapur and Bengaluru, while the erection & commissioning on site has been carried out under the supervision of the company's power sector Southern Region construction division.

BHEL has commissioned 1,073 MW of hydro projects in Telangana so far. In addition to hydro power projects, the BHEL has also commissioned seven Lift Irrigation Schemes (LIS) of various ratings aggregating to 521 MW, comprising 25 Pump-Motor sets. BHEL is presently executing another 40 Pump-Motor sets of 5,356 MW, including Palamuru Rangareddy LIS Stage - 2 & 3 of 2,610 MW (2 stages of 9x145 MW each), in the state.

Source : PTI, Nov 12, 2018

MANUFACTURING-LINKED SOLAR TENDER GETS LUKEWARM RESPONSE AS DEADLINE ENDS

A 10 GW solar tender that required power generators to set up equipment manufacturing facility received lukewarm response despite the government raising the ceiling tariff, sparking speculations of the tender being scrapped. The final date of bid submission was Monday.

The manufacturing-linked tender was first floated by Solar Energy Corporation of India (SECI) in May this year in a bid to boost local manufacturing of solar equipment, but the industry has not been keen on the model, forcing the bid submission to be postponed six times.

"SECI will take a call whether to cancel the tender," a government official told ET on the condition of anonymity. "The final set of changes has already been made to the tender conditions. It is unlikely that the bid submission deadline will be further extended."

According to sources aware with developments, Azure Power bid for 2,000 MW power project linked with 600 MW solar equipment manufacturing capacity, while most of the other large industry players stayed away from tender. An SECI official told ET that officials are yet to evaluate the response on the tender.

The government had tweaked the tender several times to make it attractive for the industry. Recently, it increased the ceiling tariff for the tender by 10 paise to Rs 2.85 per unit after the industry complained of rising interest costs and rupee depreciation dampening the economic viability of the projects required to be set up under the tender, as ET reported on November 12. This increase was apparently not enough to woo the industry that had raised concern that the government is forcing developers to enter into manufacturing business, and the risks involved in both are completely different.

"Lenders see manufacturing as a risk — especially putting together manufacturing and generation in the same bid is a huge risk they would have to take on," said a developer who requested not to be identified. "Manufacturing requires high equity and low lending, project generation requires low equity and high lending — the two do not work together."

Another industry official said manufacturers and project developers had the same set of issues around tariffs and the basic model of linking power project with manufacturing, which kept most players away from the tender.

Some industry experts believe SECI may now scrap the tender. "The bid may be scrapped in its present form if there no takers," said an industry insider. "There is no interest from the industry and SECI has said it would not make any more changes to the bid conditions."

ET had reported on November 15 that the government was unlikely to further relax the terms of the tender.

The industry had not received any official word on further extension for bid submission till 6 pm on Monday, which was the final deadline for the same, multiple industry players said.

Source : Nov 20, 2018

International Council on Large Electric Systems (CIGRE)

International Headquarters:

International Council on Large Electric Systems (CIGRE), 21 Rue d'Artois, 75008 Paris, France
Tel: **+33 1 53 89 12 90;** Fax: **+33 1 53 89 12 99**
Email of Secretary General: philippe.adam@cigre.org

Date of inception : CIGRE was founded in 1921 with its HQ at PARIS

Aims and Objectives:

CIGRE (International Council on Large Electric Systems) is one of the leading worldwide Organizations on Electric Power Systems, covering their technical, economic, environmental, organisational and regulatory aspects.

A permanent, non-governmental and non-profit International Association, based in France, CIGRE was founded in 1921 and aims to:

- Facilitate the exchange of information between engineering personnel and specialists in all countries and develop knowledge in power systems.
- Add value to the knowledge and information exchanged by synthesizing state-of-the-art world practices.
- Make managers, decision-makers and regulators aware of the synthesis of CIGRE's work, in the area of electric power.

More specifically, issues related to planning and operation of power systems, as well as design, construction, maintenance and disposal of HV equipment and plants are at the core of CIGRE's mission. Problems related to protection of power systems, telecontrol, telecommunication equipment and information systems are also part of CIGRE's area of concern.

Establishment of Indian Chapters:

CIGRE India was set up as society on 24.07.91 with CBIP as secretariat.

Membership:

(I) Collective Members (I) - (companies of industrial and commercial nature)

(II) Collective Members (II) - (Universities, Engineering Colleges,Technical Institutes and regulatory commission)

(III) Individual Members -

(In the engineering, teaching or research professions as well as of other professions involved in the industry (Lawyers, economists, regulators...)

(IV) Young Members (Below 35 Years of Age) -

(In the engineering, teaching or research professions as well as of other professions involved in the industry (Lawyers, economists, regulators...)

CIGRE - HQ

President	**Chairman TC**	**Treasurer**	**Secretary General**
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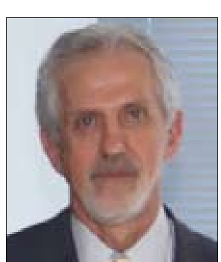
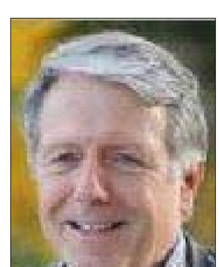
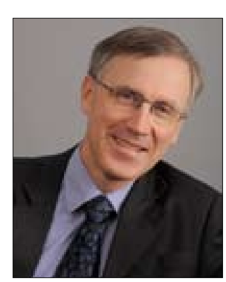
			

INTERNATIONAL COUNCIL ON LARGE ELECTRIC SYSTEMS

TO BE SENT TO NATIONAL COMMITTEE (i.e Central Board of Irrigation and Power)

MEMBERSHIP APPLICATION FORM – for the year 2019

Please fill in the column of the relevant MEMBER CATEGORY.

MEMBERSHIP RENEWAL ☐ **NEW MEMBERSHIP** ☐ **Membership Number** ☐

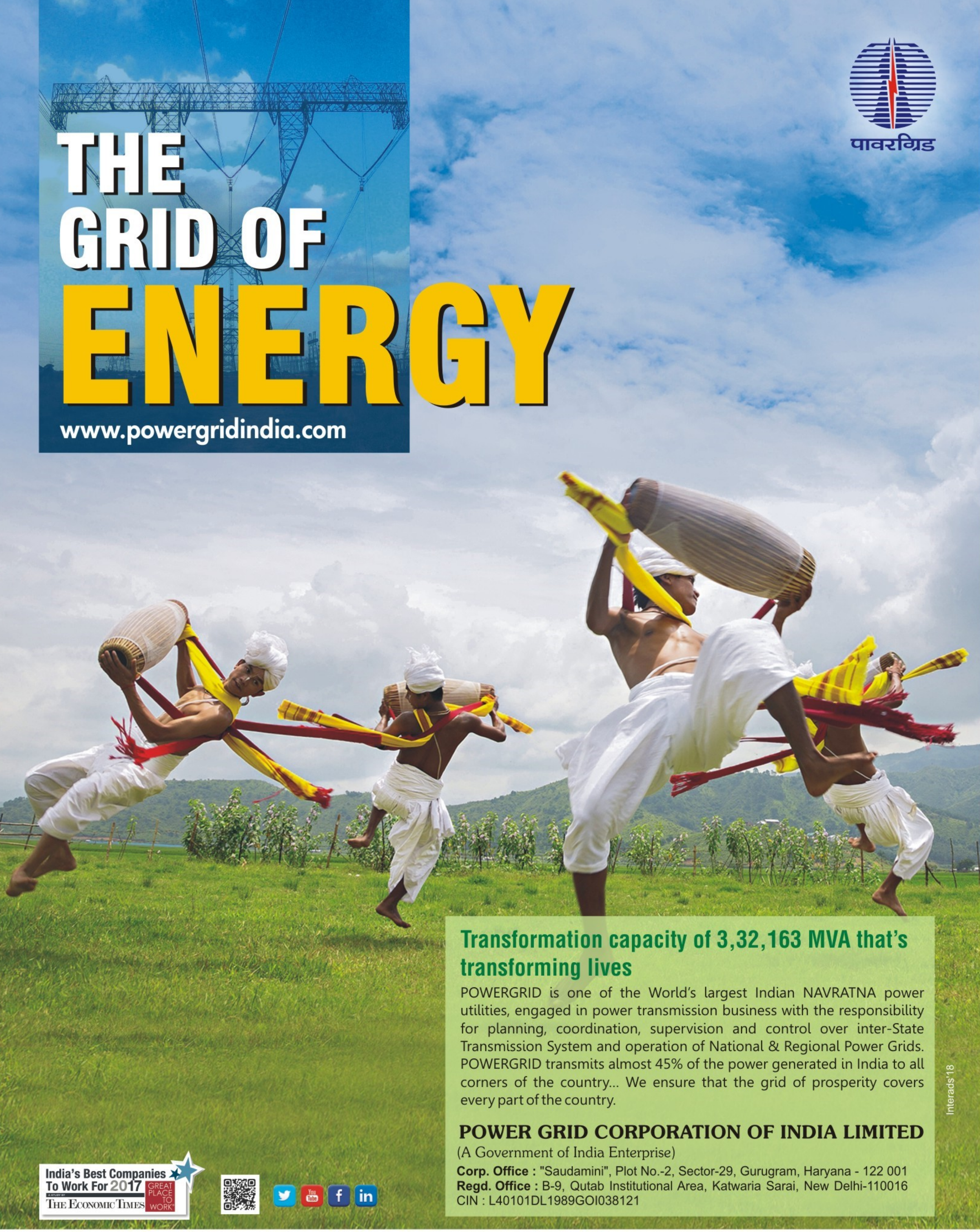
☐ *INDIVIDUAL MEMBER I* ☐ *INDIVIDUAL MEMBER II* (*Young Member under 35 years*)	*COLLECTIVE MEMBER I* *Administrative bodies, scientific and technical organisations, research institutes, public or private Companies industrial and/or commercial.*	*COLLECTIVE MEMBER II* *Universities, Educational Bodies only.*
Family Name …………	NAME of COMPANY ………… …………	NAME of UNIVERSITY ………… …………
Forename …………	Person or Department to receive ELECTRA journal. ………… …………	Person or Department to receive ELECTRA journal . ………… …………
Position, Dept. …………	Full Address ………… ………… …………	Full Address ………… ………… …………
Company, Organisation …………	TEL …………	TEL …………
Full Address ………… ………… …………	Mobile no. …………	Mobile no. …………
TEL ………… Mobile no. …………	FAX …………	FAX …………
FAX …………	E-Mail…………	E-Mail…………
E-Mail…………		
Year of Birth …………		

S.no	Category	Fees	Fee incuding GST 18% to be paid
1	Collective I	Rs. 67,000/-	Rs. 79,060/-
2	Collective II (Universities & Regulatory Com.)	Rs. 26,500/-	Rs. 31,270/-
3	Individual	Rs. 8,000/-	Rs. 9,440/-
4	Young - below 35 years of age	Rs. 4,000/-	Rs. 4,720/-

Fee can be paid through cheque/ DD in favour of CIGRE India or through bank transfer

Vender Name	THE COMMITTEE FOR THE INTL CONF ON LHVES		
Bank Name & Branch	Canara Bank/ Delhi Diplomatic Enclave		
Branch Address	7/48, Malcha Marg, Chanakyapuri, New Delhi-110021		
IFSC code of branch	CNRB0000157	**MICR No.** : 110015007	**Account No.** : 0157101031491
Type of account	Special Saving Account		**PAN No**. : **AAAAZ0260A** **GSTIN : 07AAAAZ0260A1Z1**

For information pl contact – Vishan Dutt, CIGRE India, CBIP Building, Malcha Marg, Chanakyapuri, New delhi – 110 021 : Mobile – 9811431554 ; vishandutt@cbip.org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