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Impact of high soil resistivity in lightning prone area in 400kVline of NETC in North Eastern Region and its mitigation– A case study

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1.0 ABSTRACT

The earthing system hasan important role in safe operation of Transmissionlines. In the hilly terrain / terrain of high soil resistivity or lightning prone areas, lightning over voltage causes flashovers and subsequent tripping in transmission lines. Reduction of grounding resistance is one of the efficient ways to prevent occurrence of such flashovers. The primary object ofsafeearthing design of a transmission line is to provide low resistance path to lightning current. 400 kV transmission linesof NETCtraverses through areas having highsoil resistivity (10–10,000 Ωm) and highisokerauniclevels. (i.e. 150 kA) in addition to other severe environmental conditions of North Eastern Region. NETC is continuously adapting innovative measures to mitigate impact of such a severe environmental condition based on its in-house analysis. This paperpresentsaCase Study on the impact of high soil resistivity in lightning prone area and mitigation measures being adopted in 400KV D/C Silchar (Assam)-Byrnihat (Meghalaya) transmission line of NETC.

2.0 INTRODUCTION

North East Transmission Company Limited (NETC) is a Joint Venture Company of POWERGRID, OTPC and Six states of North Eastern region. The main objective of the company is to evacuate 726.6 MW power from Gas Based Combined Cycle Power Project (GBCCPP) of OTPC at Palatana in Tripura. NETC is operating 400kV D/C Palatana-Silchar-Bongaigaontransmission line of 662.8kMtraversing through the states of Tripura, Meghalaya and Assam. One circuit of 400kV Silchar –Bongaigaondouble circuit line is looped -in looped- out at Byrnihat substation in Meghalayaand another circuit is looped- in looped -out at Azarasubstation in Assam.

3.0MAJORCONSTRAINTS IN OPERATION AND MAINTENANCE OF TRANSMISSION LINE IN NORTH EASTERN REGION

The Operation and maintenance of transmission line in North Eastern Region is a big challenge due to following major constraints

i) Dense forest, Hilly terrain, fast growing vegetation, Agricultural Cultivation fire (Jhoom Burning), pockets of open coal mines.
ii) Frequent land sliding & road blockage due to heavy rainfall. The rain fall in NER isabout 7-10 times more than all India average rainfall.
iii) The acute ROW issues and theft prone area in some part of Assam.
iv) Severe lightning in some portion of transmission line.
v) Difficulty in the movement of men and material in hilly terrain

4.0 OUTAGES ANALYSIS:-

Based on the available operational data, it has been observed that outages in a particular section of 400 kVSilchar -Byrnihat/ Azara line is comparatively high than other section of lines. Average tripping in this area wasfoundaround 6- 8 numbers in spite of regular maintenances of the lines during monsoon. The cause of tripping was attributed to lightning during and on set of monsoons. The complete 400 kV double circuit transmission line is having earth wire all along the line at the top of tower to protect it from lightning.

To minimize the impactof lightning effect, following options were analyzed.

i) Providing additional earthing of towers through PG clamp with separate earthpit.
ii) Providing spike on tower top to capture lightning strikes.
iii) Providing one more additional insulator disc to protect against Back flashover.
iv) Measures to reduce tower footing resistance using chemical earthing.
v) Installation of Transmission Line Arrestors (TLA)

Out of the above options, option (iv) was considered to be techno economical and it did not require any outages of the lines. Therefore, tower footing resistance (TFR) was re-measured at 588 locations. In 20 % of the locations, the tower footing resistance was found more than 10 ohms. The resistivity of soil strata of the area was very high as there were hilly terrain and open redundant coal mines ***(Refer Fig 1)***

Fig-1

5.0 NETC FIELD EXPERIENCE FOR IMPROVEMENT OF TOWER FOOTING RESISTANCE (TFR)

Whenever lightning strikes the top of a transmission tower or earth wire, a lightning current flow towards bottom of the tower and causes voltage rise to a tower which results in back flashover across the insulators of transmission line or causes phase to ground fault. The probability of flashovers can be minimized if the lightning current gets the least resistance path to ground, which can be achieved by reducing TFR.

5.1 TYPES OF CHEMICAL EARTHING

Following typeof Chemical earthing compound is commonly used forreducing the soil resistivity

a) Bentonite
b) Marcionite.

Bentonite and Marcionite have certain similarities and both are used as ground improvement materials (GIM) to reduce earth resistance. NETC considered Bentonite due to its cost effectiveness over Marcionitefor improvement of lightning performance of Transmission line.

5.2TYPES OF BENTONITE:

Two types of Bentonite is commonly available

i) Sodium Bentonite.
ii) Calcium Bentonite

Sodium bentonite is having properties of swelling while calcium bentonite is non swelling in nature. NETC has used the sodium bentonite as it can absorb water up to 5 times of its original weight and swells up to 13 times of its dry volume.

6.0 BENTONITE CHARACTERISTICS.

Bentonite usually forms from weathering of volcanic ash with high content of silica.

Bentonite clay is anatural earth soil (Clay) containing the mineral montmorillonite. Dueto its high moisture characteristics, resistivityof soil decreases.

The major characteristics of bentonite are as under

i) Better resistance reducing agent, Compactablewithcrystalline structure having highmoisture retainingCapability&low resistivity.

ii) Able to maintain low grounding resistance with minimal fluctuations for long period of time.

iii) Hydrophilic in nature, insoluble in water and does not leachaway in to soil.

iv) By adding the bentonite in the soil electrolytic layer formed which has ability to trap charges and serves as pathway for dispersion oflightning charges.

7.0 TYPES OF EARTHING USED IN NETC TRANSMISSION LINE

7.1 Two types of earthinghave been used by NETC for earthing of transmission line

i) Pipe earthing and

ii) Counter poise earthing implemented inNETC line.

7.1.1 Pipe Earthing

In case of pipe earthing system, galvanized steel pipe of diameter 25 mm and of length 3 meters has been buried vertically in the soil in such a manner that the top of the pipe shall be 1 meter below the groundlevel. In this case, alternating layers of charcoal and salthas been used in thesurroundings of the pipe.

7.1.2Counterpoise Earthing

NETC has used 10.97 mm dia galvanized wire for thepurpose of counterpoise earthing**,** the galvanized wire (minimum 30 meter in length) is connected with each leg of the tower. The wire is buriedtangentiallyat a depth of minimum600 mm.

7.2 Bentonite treatment in counter poise earthing of transmission line of NETC

While implementing chemical earthing,Existing old earthwire dug outsodium bentonite slurry ***(Refer- Fig 2B&2C)***was laid at a depth of 900 mm using new galvanized steel stranded Wires(10.97mm dia) with proper compaction by means of ramming of soil after every 400 mm back filling. In each leg approximately 125 Kg Sodium Bentonite. has been used in the ratio(Bentonite:water) 1:3 The length of galvanized steel wire was kept up to 30 meters.

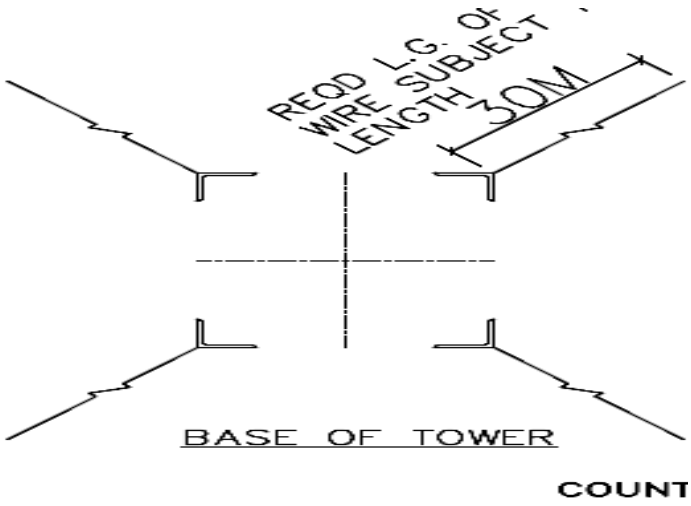


Fig2A- Tower base with counter poise earthing.

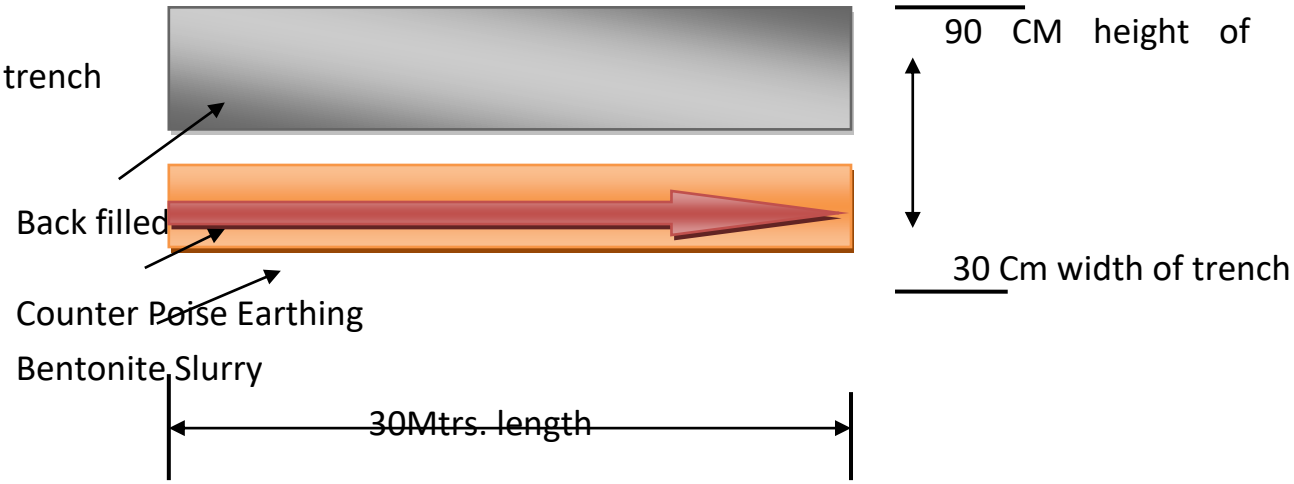


Fig 2B - Chemical earthing

Fig 2C- Bentonite Earthing

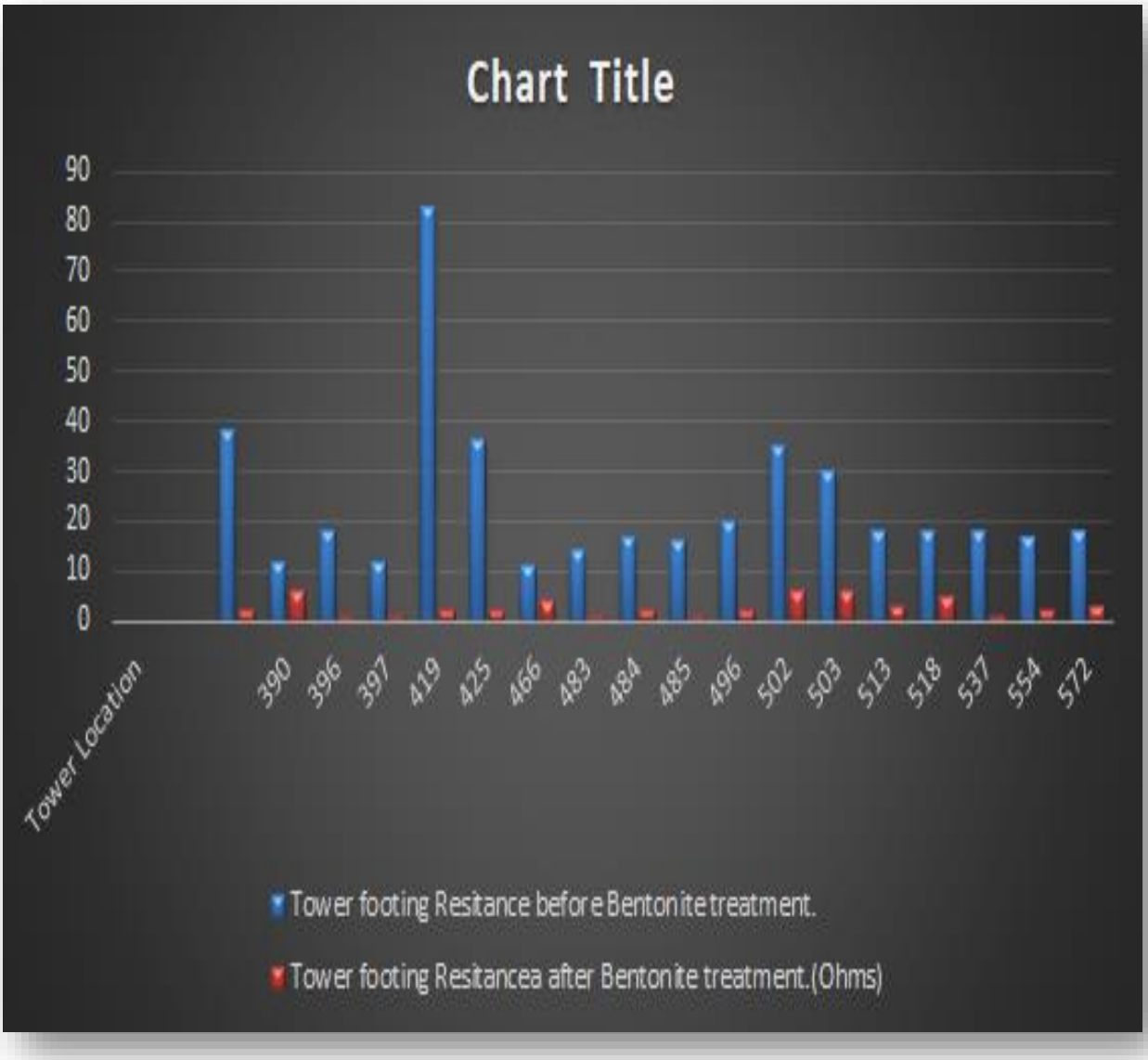
7.3 Improvement of in Tower Footing Resistance

The chemical earthing of all towerlocations having more TFR, has been carried out successfully. After using sodium bentonite, there is remarkable improvement in tower footing resistance. Further there is reduction in tower footing resistance upto 80 % after adopting sodium bentonite in identified locations. The results showing values of tower footing resistance before and after application of sodium bentonite is indicatedin ***Table 1***below. The performance of line is under observation and NETC is continuously accessing impact of each lightning on the lines.

Table 1-Results of TFR before and after application of Sodium Bentonite

S.N	Tower Location	Tower footing Resistance before Bentonite treatment. (Ohms)	Tower footing Resistance after Bentonite treatment. (Ohms)
1	236	38	2
2	390	12	6
3	396	18	1
4	397	12	1
5	419	83	2
6	425	36	2
7	466	11	4
8	483	14	1
9	484	17	2
10	485	16	1
11	496	20	2
12	502	35	6
13	503	30	6
14	513	18	3
15	518	18	5
16	537	18	1
17	554	17	2
18	572	18	3

The Graph showing the improvement of TFR before and after Bentonite Treatment.
(X- axis indicates tower locations & Y-axis indicates Resistance in OHMs)



7.4 FUTURE PLANS

NETC is exploring the idea ofinstallation ofTransmission Line Arrestors (TLA)in 400 kV Silchar– Byrnihatline. TLAs are installed on the conductors, electrically in parallel toinsulator strings. In the event of lightning, instead of back flash over across insulator string, TLA conducts and provide path to the lightning current towards phase conductors. It not only avoids flashover but prevents tripping in the transmission line. It is worth mentioning that application of TLA nullifies any impact of higher tower footing resistance.

It is understood from market survey that production of 400 kV TLA is yet to bestarted in India&export of TLA from foreign countries entails substantial financial involvement. Presently nopower transmission utility in India has installed 400 kV TLA in their system. Only on transmission lines up to 220 kV voltage level, TLAshave been used. It require proper study using EMTP / ATP type software for economical utilization of TLAs in transmission line. The results (typical) of lightning mitigation study done for 220 kV TLA are shown in ***Table 2***. The study of installation of TLA in NETC line is under progress as one of the innovativemeasures to reduce the tripping.

Table 2- Probability of flashover under different configuration

Flashover probability for 220 kV vertical structure configuration and a ground resistance of 30 ohm when struck by lightning		
Sl. No.	**TLA Location**	**Probability of Flashover**
1.	No shield and no TLA	100%
2.	TLA on top phase only on every other structure	88%
3.	TLA on all phases on every other structure	82%
4.	No TLA, only a shield wire	21%
5.	TLA on top phase of every structure	18%
6.	TLA on all phases of every structure	0.00%

8.0 CONCLUSION AND LESSONS LEARNT

Based on the above field experience of NETC, it can be concluded

8.1Earthing System is a critical element of all the Transmission Network. The

performance of transmission line depends on the performance of the earthing. It is essential to reduce the tower footing resistance to minimise the trippingof lineduring fault condition & Lightning stroke on transmission line. This paper mainly aimed to discuss various measure toimprove theTower Footing Resistance. Using Sodium Bentonite as aGround EnhancementMaterial (GIM) in 400 KV D/C Silchar – Byrnihat(214KMs) section, the tower footing resistance (TFR) has improved significantly andoutages of line has reduced.

8.2 In lightning prone areas where reduction of tower footing resistance does not improve performance of transmission line, application of TLA may be better option but it should be judiciously selected.

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