

FAILURE ANALYSIS OF TRANSMISSION LINE TOWERS

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Abstract- Transmission line towers, though designed per code provisions, may fail during mandatory testing required in many countries, which leads massive damage to power system. Different types of premature failures that are observed during various full-scale testing of transmission line towers and their results are discussed in detail. Importance of design assumptions and connection detailing in overall performance of towers were studied. Importance of secondary member design and connection detail in overall performance of the tower was studied. Non-linear finite element analysis is useful in understanding the system behavior and for prediction of failure pattern and ultimate load. Based on the test results the importance of studying the failures is highlighted. The need for implementing various failure prevention strategies in transmission line towers has also been emphasized lucidly.

Keywords-: *transmission lines, operation, failure, prevention, strategies.*

I. INTRODUCTION

An electric power system consists of generators, transformers, transmission lines etc. Most of the faults which occur in the transmission lines can cause flow of heavy current associated with the short circuits. Due to which there are increased chances of fire, damage to the equipments, and imbalance of the power supply etc. Thus there is need for protective system to be installed in the electric power system which can protect the transmission lines and various equipments from getting damaged. Transmission lines stand forth as lifelines of humans by enlightening their daily lives. Their hampered transmission can darken our brightening, awakened and easy going activities and can land us into a disastrous situation presenting a grim scenario of day. Despite presence of various reasons of failure of transmission lines, installation of new methods of prevention of transmission lines can benefit a power system by improving transient stability, increasing power transfer capability, preventing huge loss of energy and eliminating the need for more parallel and uneconomical transmission methods. In need of power saving options and in dearth of much of the available studies on transmission lines, this paper is an attempt to eventually present a meta-analysis having following objectives.

II. AIMS AND OBJECTIVES

1. To highlight the most important reasons of failure of transmission lines.
2. To emphasize various prevention strategies for transmission lines.

III. METHODOLOGY

A systematic review of various papers, reports and articles available on transmission lines was done and finally a meta- analysis showing the reasons of failure of transmission lines and their best preventive strategies is being presented here.

IV. Failure analysis of a DC Tower

A non-linear analysis of the tower design for a 765 KV double circuit transmission line tower were conducted. The aim to analyse was to predict the tower behaviour under static load conditions specified by requirement. The condition accounts for various facet of loading expected during the tower operation & the ranging effect from line stringing to DC angle cessation with Wind load.

1. 4.1 Structural detail of Tower

The design of a self-supporting lattice tower with a 23×23 m four legs and height of 67.88 m to the ground. The members in tower was used to Mild Steel and High Tensile Steel angle section grades of 250 Mpa and 350 Mpa respectively conform to IS: 2062. The model is shown in Fig. 2 indicating the Transverse (Z), Longitudinal(X), and vertical(Y) directions respectively.

Table 1. Leg member Angle Sections

Leg No.	Section Size(mm)
Leg 1	100×100×7
Leg 2	110×110×8
Leg 3	130×130×12
Leg 4	150×150×12
Leg 5	150×150×15
Leg 6	200×200×20
Leg 7	200×200×22
Leg 8	150×150×16
Leg 9	150×150×18
Leg 10	150×150×18

Table 2. Primary Bracings

Bracing No.	Section Size(mm)
1	90×90×6
2	100×100×6
3	100×100×6
4	90×90×6
5	110×110×8
6	100×100×10
7	90×90×7
8	100×100×8
9	90×90×6
10	100×100×6

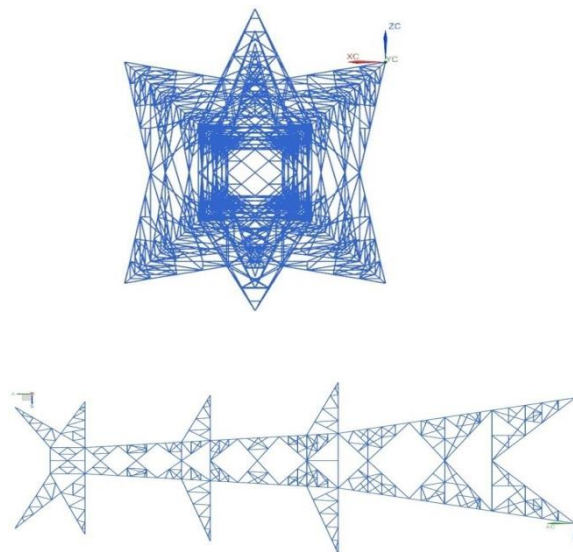


Figure 1. Tower front and top view

DESIGN LOAD			
CONDITION	LOAD CASE – 13(N)—Applied Load		
Wire Condition	T	V	L
GWL	36906.8	2185.4	0
GWR	36906.8	2557.8	0
TCR	340814.6	69403.6	0
WIND TC	48735.4	0	0
TCL B	182652.4	44011.8	375634
MCR	327800.2	70315	0
WIND MC	74372.2	0	0
MCL B	175567	44923.2	363570.2
BCR	310366	67590.6	0
WIND BC	104076	0	0
BCL	310679.6	63043.4	0

Table:3 Load scale for full tower

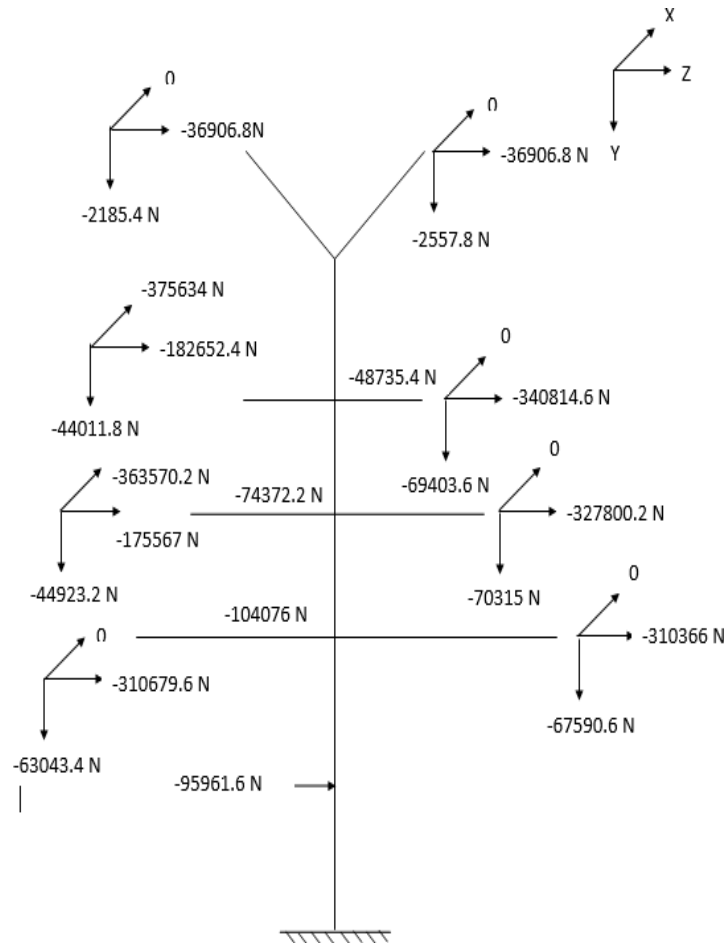


Figure 2. Loading Tree

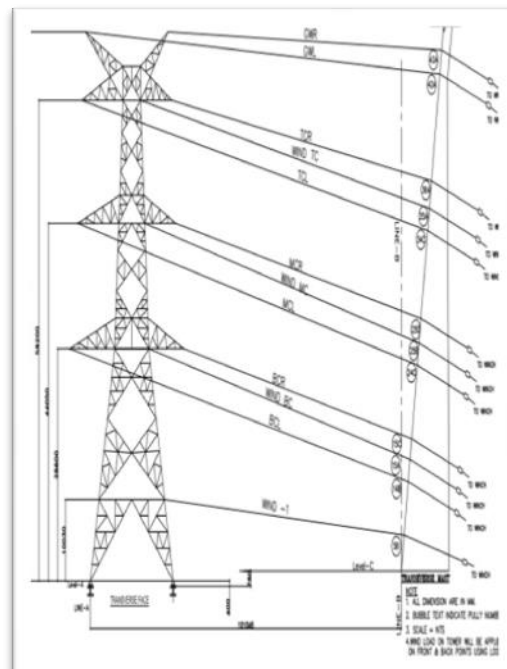
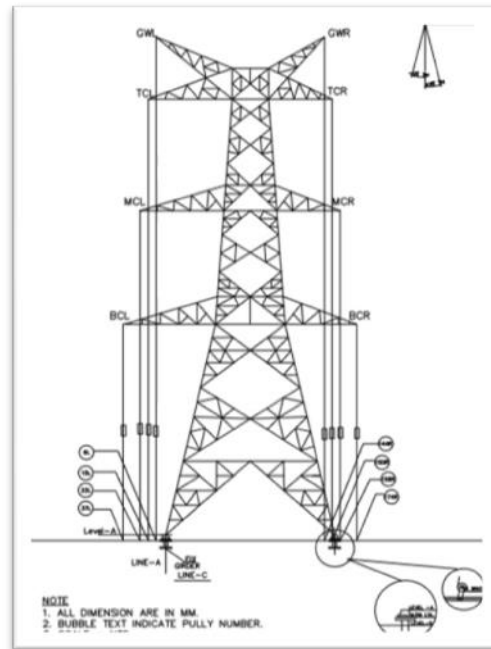


Table:4 Comparative stress result analysis

Fail Member	Experiment result(N/mm ²)	Software result(N/mm ²)
7 th panel x-bracing from top	205.04	207.41
7 th panel leg member	236.95	287.8
2 nd panel x-bracing from bottom	143.968	139.565
TC right side top member	138.72	136.77
MC right side top member	76.701	76.476
BC left side bottom member	152.47	152.12

V. Reasons for failure of transmission lines FACTORS OF A TRANSMISSION LINE FAULT

The transmission lines are mostly exposed in the air to the harsh environment of nature which produces various types of failures. Thundering, rain, lightning phenomena, flashover, winter ice, fog, fog stick on the insulator, and pollution cause poor contact insulators and transmitters.

1. *Lightning factors*

Lightning frequency in the River Delta region, in the spring, summer is very high. Thunder and lightning cause transmission line failure, causing the accident trip of the substation, the cause of the accident is basically because of the lightning over-voltage resulting in short circuit this led to the failure of the lines.

2. *Overlying ice factors*

Transmission Line Icing caused by line break accident although this fault only occurs in the winter, but can be seen from the results of the accident that in the event of the ice cover the intensity of work, repair and maintenance takes relatively longer time as compared to the other places. Moreover repair and maintenance is not easy for the maintenance staff. The formation of ice cover is because of cold weather, air and humidity and when ice cover is formed the overall weight of the transmission line increases which led to the failure of the line.

3. *Filthy factors*

Pollution flashover of transmission lines damages the insulation coating. It will result in flashover incidents caused by such accidents, mainly due to the insulator surface is not scheduled to dust, especially wind and rain days, the accumulation of dust on the insulators and line will cause dirty ionization Flashover occurs.

4. *External damage factor*

Various factors can cause the external damage to the transmission lines, such as gale days, broken trees, large tracts of trees fallen on the road, increase the load on the line to be broken and theft of low voltage lines, collision of automobiles with the poles the occurrence of such

incidents is one of the reasons for the creation of the fault in the transmission lines.

VI PROTECTION STRATEGIES

Transmission lines have to be protected for a smooth working of the power system and to reduce the risk of damage to the normal working components. Some of the measures for prevention of the lines are discussed in the following points:

1. ***Improve the quality of the electrical design*** Improvement in the quality of the electrical design will maximize the security. The design of various electrical equipments is according to the operation without considering the surrounding of installation. The design of transmission lines such as towers, conductors, insulators, and auxiliary fittings remains same throughout the transmission of the power system without considering the surrounding conditions. The calculation and selection of Ray devices is very important to the designers who just only mechanically copy, copy the typical design and design specifications. As mentioned above, lightning factor after the accident of the lightning cause the fault, which can be protected by adopting specific design, the designer according with local surrounding take the appropriate lightning protection measures, copying the design specification, resulting in protection from the lightning factor. Later in the installation of surge arresters on towers, the accident was rarely the same time, the power lines must also be reasonable design in order to better exercise its duties. In the design work of the transmission line there is great need of careful calculations, site survey and line path selection of the topography and line the path. These measures

possibly avoid all kinds of accidents, to ensure the normal operation of the transmission line.

2. ***Lightning protection measures***

Lightning protection and grounding work is undoubtedly more important for the transmission line, generally select the lightning conductor transmission line lightning over-voltage protection, it is the most commonly used anti- Ray device. But we can also reduce the tower grounding resistance, to achieve the purpose of lightning protection.

3. ***Tower location and the correct choice of the rod***

Initially it should be quickly and carefully investigated the climatic conditions and terrain, try to avoid erecting tower in adverse terrain and geographical location, and should strengthen the mechanical strength of the tower, try to use a steel bar or strengthen the type of concrete pole cross arm can be thicker. Selecting a different structure for the cross arm installed on the pole in the prone areas. Structure of the insulator should be with the hydrophobic properties of the coating.

4. ***Prevention of pollution flashover***

Pollution Flashover cause number of accidents and the impact leads to the creation of fault. The prevention of lines with pollution flashover is to improve the power system for the safe use of electricity distribution, continuing the important work of the electricity by increasing the creep age distance and the use of synthetic insulators can effectively prevent the pollution

flashover occurred, or the use of anti- pollution flashover coating, thereby limiting the occurrence of leakage current accident.

5. *External damage prevention*

External damage to the transmission line, the strong winds make the trees fall overwhelming line. Furthermore, it is increasingly rampant theft and frequent traffic accidents. So it should be to optimize the electrical design and power transmission lines so as not to too close and woods, to take full account of brought to the tree growth rate "hazard" and the road to keep the proper distance, and in accordance with the specific location of the tower, additional protection pier, and finally painted with eye-catching protective signs. For external damage to the transmission line fault analysis, may take the following steps to protect the transmission lines:

Increase the protection of power facilities and efforts to do the publicity and education work of the electricity users and the establishment of a strict line inspection system.

To constantly improve the electricity regulations to strengthen the power of law enforcement efforts. Co- organized with the relevant departments of electrical safety a speech contest and knowledge contests and other activities to promote electrical safety regulations, so that we fully understand the dangers of electricity, so that those desperate daunting, quit.

To develop practical methods and measures, and implementation of practical work.

Training and to build a tough, good tough fight, a professional technical team is to protect the transmission lines necessary to ensure safety.

VII RECOMMENDATIONS THE PROBLEMS MENTIONED IN THE PAPER CAN BE PREVENTED BY ADOPTING THE FOLLOWING METHODS:

a. *Transmission line structure*

Tabular structure should be preferred instead of the lattice type or H-type transmission structure. Reasons that made tabular transmission structure preferable over other structure are tabular structure can be built in 30 feet long section in wide range of diameter sizes and material thickness. Tabular structure can be supplied with a hot dip galvanized coating or metallic paint specifically formulated for excellent weathering over an extended period of time.

b. *Type of conductor to be used*

Aluminum conductors reinforced with steel (ACSR) were used in the transmission lines but they can be replaced by the modern conductor that offers reduced thermal sag is known as ACCC ("Aluminum Conductor Composite Core"). In lieu of steel core strands that are often used to increase overall conductor strength, the ACCC conductor uses a carbon and glass fiber core that offers a coefficient of thermal expansion about 1/10 of that of steel. While the composite core is nonconductive, it is substantially lighter and stronger than steel. Its lighter weight allows the incorporation of 28% more aluminum (using compact trapezoidal shaped strands) without any diameter or weight penalty. The added aluminum content helps reduce line losses by 25 to 40% compared to other conductors of the same diameter and weight, depending upon electrical current. The ACCC conductor's reduced thermal sag allows it to carry up to

twice the current compared to AAC ("All Aluminum Conductor") or ACSR ("Aluminum Conductor Steel Reinforced").

c. *Distance and shape of the poles*

By decreasing the distance between the poles more strength can be provided to the transmission line system. Using a triangle shaped cross arm in the ice prone area will decrease the accumulation of the ice on the pole which does not lead to the increase of the overall weight of the transmission pole. Increasing the thickness of the cross arm and using tabular structure will increase the strength of the power distribution system.

d. *Installing lightning arrester*

A lightning arrester is placed where wires enter a structure, preventing damage to transmission lines within and ensuring the safety of individuals near them. Lightning arresters, also called surge protectors, are devices that are connected between each electrical conductor in a power system, and the Earth. They prevent the flow of the normal power or signal currents to ground, but provide a path over which high-voltage lightning current flows, bypassing the connected equipment. Their purpose is to limit the rise in voltage when a communications or power line is struck by lightning or is near to a lightning strike.

e. *Corrosion evaluation methods for power transmission lines*

The power transmission design of individual components has changed but the materials of construction remained virtually the same. Thus, by using steel and cast iron (bare, painted or galvanized), aluminum alloys and copper alloys. To enhance the corrosion resistance of these materials various treatments, coatings and inhibitors are applied which enhance the life of the transmission lines.

f. *The transmission line design process* Recent developments in surveying technologies have allowed the industry to re-think about the station- elevation-offset formats that designers have traditionally used for transmission line profile modeling. This method of surveying is some form of three-dimensional geographical information system (GIS) type representation. Data are usually collected in electronic format, and the transmission line software is capable of reading the data intelligently in any form. Total Station, Geographical Positioning System (GPS), Photogrammetric, electronic topographical maps (USGS), and scanned or digitized existing profile drawings have all been employed to develop quick and relatively accurate land models for transmission lines. This can be efficiently use for the detection of the fault in the transmission line throughout the stretch of the line.

g. *Using Underground transmission lines* Underground cables take up less right-of-way than overhead lines, have lower visibility, and are less affected by bad weather. However, costs of insulated cable and excavation are much higher than overhead construction. Underground lines are strictly limited by their thermal capacity, which permits fewer overloads or re-rating than overhead lines. Thus, we can use underground transmission lines in areas where the environmental condition is not suitable for overhead transmission line.

VIII CONCLUSION

By analyzing the prevention methods of transmission line. It can be concluded that the need of protective

system is an important part of power system. Transmission line protection method from fault mentioned in the paper can be achieved by adopting the methods mentioned. Electrical power plays a very important role in the country's economy and hence the need for prevention of transmission line increases many more times than that of any other type of energy.

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