Re-design and Analysis of 220 KV Multi – Circuit Transmission Tower

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Abstract. A transmission tower or power tower is a tall structure, typically a steel lattice tower, which is employed to support an overhead power line. Economic losses will be the consequence of any transmission line system failure that disrupts the energy supply. This article describes the MD (300-600 Dev./D.E.-00) NT +9M body extension redesign and structural analysis for a 220 kV multi-circuit transmission tower. This paper pertains to the failure transmission tower structure and implementation of the failure structure through the use of CAD, ANSYS, and analytical and experimental testing. Experimental testing in 2018 resulted in the failure of this MD type transmission tower. The research conducted in this paper is the first to analyse and track the progression of failure of a segment of a transmission structure, in contrast to previous studies that have examined the behaviour and failure of a single tower. To accomplish this, a distinctive CAD/numerical model is developed in this paper. This article will provide a comprehensive discussion of the formulation and validation of the various components of this CAD/numerical model, which are reported in various sections of paper. This study helps build transmission towers to handle rising voltage and power demands in electrical networks.

1 Introduction

A transmission tower, which is also referred to as a power transmission tower, power tower, or electricity pylon, is a tall structure that is typically constructed of steel lattice [1]. Its purpose is to accommodate an overhead power line [2-3]. Utility poles support lower-voltage sub-transmission and distribution lines that carry power from substations to customers [4]. They carry high-voltage trans-mission lines that transfer bulk electric power from producing units to substations in electrical networks [5-7]. To guarantee the transmission line system's reliability and economic efficiency, it is imperative that they are meticulously designed [8–10]. Failure analysis of transmission line towers is the most critical component of transmission line crane design [11-14]. The tower may fail in specific circumstances, despite the fact that it is meticulously designed in accordance with a variety of codal provisions [15–

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17]. Hence a designed transmission tower must be tested either experimentally or analytically before implementing the actual design in the field [18–20].

Research objectives are
- To Design of exiting transmission truss structure tower
- To computer modelling of MD type transmission truss structure tower
- To Analysis 0f MD type transmission structure tower
- To Fabricate the transmission tower Experimental Testing of Structure
- Both the results from the experimental and analytical works will be compared to finalize the cause of the failure of the tower

2 Experimental Testing

The detailed process for Experimental Testing Tower Structure
- First assemble the tower as shown in Figure.
- After that Hanging the Wire rope with load cell, load cell connected with control room.
- Applied the load according load chart with help of control room controller
- Note down the load and deflection of tower in your note pad
- Deflection measured by Total station machine on each node of element and load measure by load meter
- Once the all load applied on the tower structure according to load chart & the tower will standing itself within the limit , then tower testing was passes
- Where the deflection is more we can check that element yield load by practically by using Universal testing machine

Experimental Testing Tower Structure yield load and deflection as per below Table 1.

Table 1. Experimental Testing Tower Structure yield load and deflection

No	Mark No	Angle Size	Experimental Yield result (N/mm^2)	Experimental Deflection Value (mm)
1	MD-562	90X90X8	330	4.88
2	MD-563	10 mm PLATE	297	7
3	MD-560	45X45X4	291	8.8
4	MD-506	100×100×8	335	10.5
5	MD-540H	130×130×10	335	14.5
6	MD-535H	150X150X20	312	14
7	MD-538	200X200X20	309	11

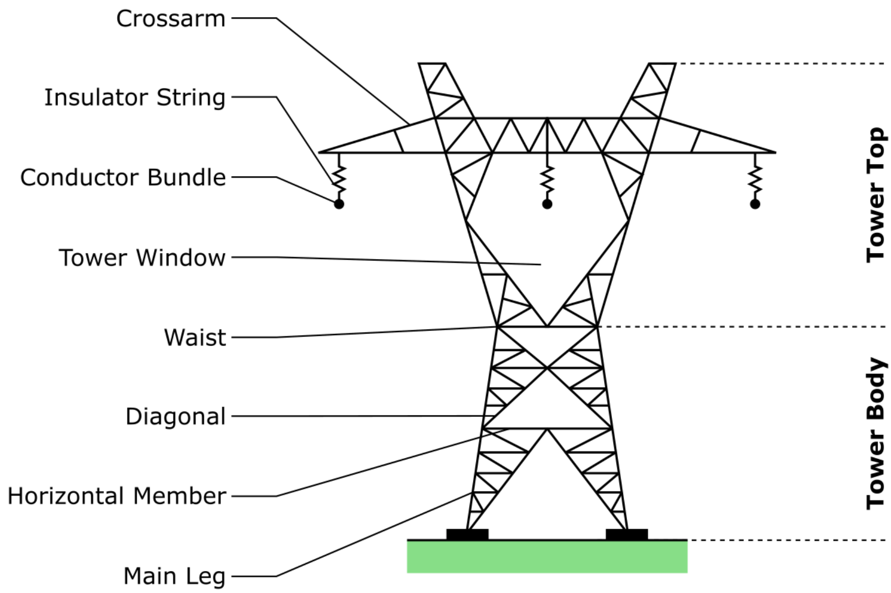

Fig. 1. Transmission Tower Structure

3 Analytical Calculation

In this investigation independent and dependent parameters for studies were identified as shown in Table 2. There are total Ninth parameter to calculate from the experimental testing procedure [21] by using the UTM (Universal testing Machine). (1) Width –W, (2) Thickness-T, (3) Area- A, (4) Initial Gauge Length- IGL, (5) Final Gauge Length-FGL, (6) Yield Load-YL, (7) Ultimate Load-UL, (8) Yield Stress-YS, (9) Ultimate Stress-UTS. The results obtained by experimentations are shown in Table 3.

Table 2. Experimental Testing Tower Structure yield load and deflection

Parameters	Formula
Area	Width x Thickness
Initial Gauge Length	Sq. root (Ax5.65)
Final Gauge Length	(FGL-IGL)IGL*100
Yield Load KN	Getting from UTM Machine
Ultimate Load(KN)	
Yield Stress (N/mm^2)	Yield Load/area
UTS (N/mm^2)	Ultimate Load/area

Table 3. Experimental results

Sr. No	Mark No	Section	Width (MM)	Thickness	Area (MM2)	Initial Gauge Length	Final Gauge Length	Yield Load KN	Ultimate Load(KN)	Yield Stress (N/mm2)	UTS (N/mm2)	% elongation
1	MD-562	90X90X8	20.7	8.2	169.74	74	94	56	84	330	493	27
2	MD-563	12 mm PLATE	21.4	12	256.8	91	114.7	76	123	297	480	26
3	MD-560	45X45X4	26.36	4.43	116.77	61	81.5	34	48	291	414	33.6
4	MD-506	100×100×8	22.4	8.1	181.44	76	96.5	61	88	335	486	27
5	MD-540H	130×130×10	22.1	10.2	225.42	85	111.4	76	110	335	488	31
6	MD-535H	150X150X20	20.5	20	410	114	150.5	128	203	312	495	32
7	MD-538	200X200X20	19.8	20.1	397.98	113	144.6	123	196	309	492	28

4 Finite Element Analysis

In order to solve a problem when conducting a finite element analysis [22, 23], it is necessary to accomplish specific duties, which can be viewed as the steps necessary to complete the analysis [24-27]. The analysis must be completed by performing these same duties, irrespective of the FEA instrument being employed [28–30]. The following are the duties.

1. Produce the lattice.
2. Define/Assign material properties
3. Specify the form of analysis.
4. Establish boundary and loading conditions.
5. Resolve
6. Evaluate the findings

In order to gain a more comprehensive understanding of the operation of FEA, it is crucial for individuals who are new to the field to be familiar with these tasks. Figure 2 shows the Yield test result in N/mm^2.

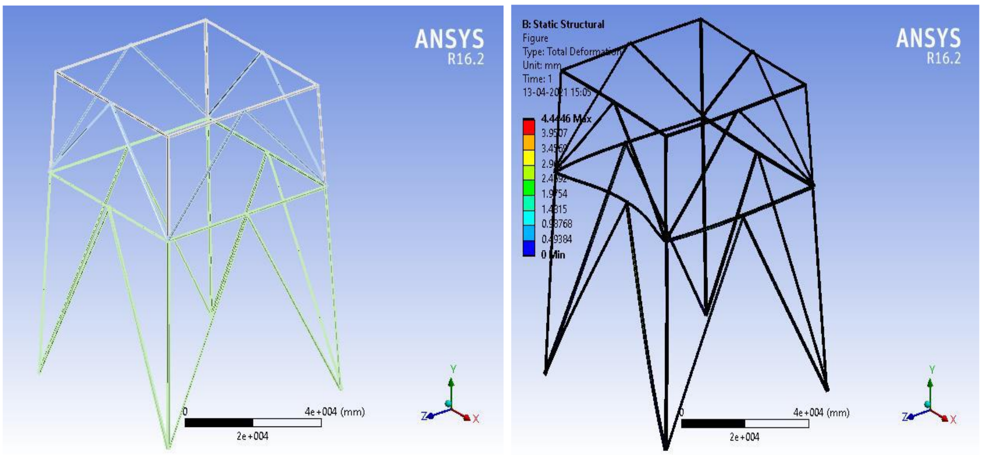

Fig. 2. Yield test result (N/mm^2)

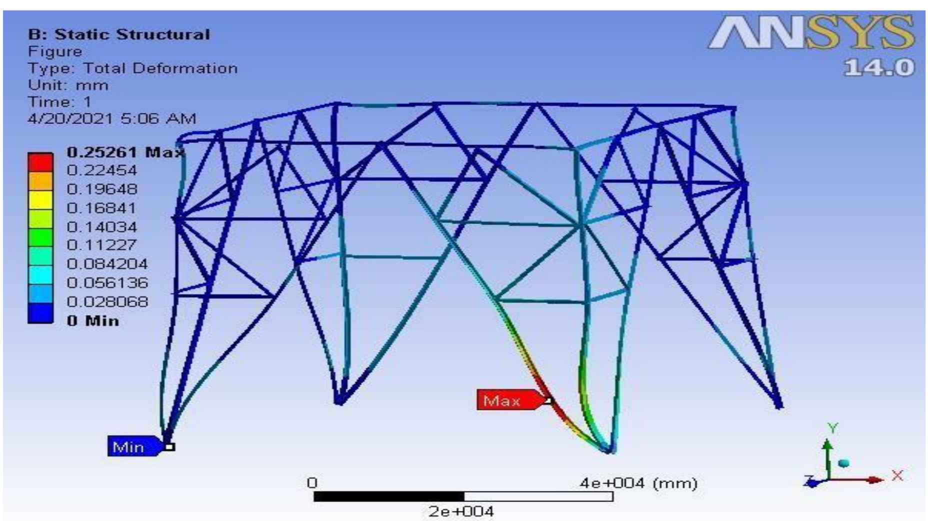

Fig. 3. Static Structural Deformation

5 Results and discussion

5.1 Statistical Comparison between Experimental Model, ANSYS Software, Analytical Calculation

Table 4 presents a comparison among the Experimental Model, ANSYS Software, and Analytical Calculation for yield.

Table 4. Compares experimental model, ANSYS software, and analytical calculation for yield.

No	Mark No	Angle Size	Experimental result (N/mm^2)	Software Result	Difference %
1	MD-562	90X90X8	330	335.76	1.72
2	MD-563	10 mm PLATE	297	300.43	1.14
3	MD-560	45X45X4	291	280.87	3.6
4	MD-506	100×100×8	335	349.7	4.2
5	MD-540H	130×130×10	335	345.21	2.95
6	MD-535H	150X150X20	312	327.87	4.84
7	MD-538	200X200X20	309	305.67	1.08

5.1 Comparison of Deflection between Experimental Model, ANSYS Software, Analytical Calculation

Table 5 shows the result of Deflection Comparison between Experimental Model, ANSYS Software, and Analytical Calculation

Table 5. Compares experimental model, ANSYS software, and analytical calculation for deflection.

Sr. No.	Diffèrent Node Point	Angle Size	Expérimental Déflection Value (mm)	software Value (mm)	Différence %
1	MD-562	90X90X8	4.88	4.444	8.93
2	MD-563	10 mm PLATE	7	6.66	4.85
3	MD-560	45X45X4	8.8	8	9.09
4	MD-506	100×100×8	10.5	10	4.76
5	MD-540H	130×130×10	14.5	14	3.44
6	MD-535H	150X150X20	14	13	7.14
7	MD-538	200X200X20	11	11.87	7.91

The results are performed in three ways i.e. in experimental basis and validate by using FEM software testing including Analytical. The below images shows that the test which is conducted by applying various at different element as mentioned in the previous chapter. The results are obtained under specially test vision persons. The horizontally and vertically assembly of test prototype was inspected and tower was erected on the test bed successfully. Similarly it is test by using virtual software like ANSYS. This is the well-known software used in the industry for structural analysis and many more type of analysis. Here after applying loading and boundary condition as per mentioned in the chart i.e loading chart as per element. And here also results are within the safe zone. Also Analytical calculation done, with reference of Experimental & software basis

6 Conclusions

Designing and testing the 220 kV multi-circuit transmission tower's MD (300-600 Dev./D.E.-00) NT +9M body extension improved structural performance and load-carrying capacity. FEA and optimized design amendments stabilized the tower under wind and seismic load. Power transmission networks with expanding electrical load demands can use the taller tower, which meets safety and efficiency standards. This study shows that large energy grids can build reliable, long-lasting high-voltage transmission infrastructure using the same design principles. The results enable more efficient and robust power transmission networks for future energy needs.

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