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Failure Prediction of Transmission Towers under Various Load Cases

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Abstract—*Transmission line tower is adjunct on low heft philosophy and may failure during obligatory testing required. Various type of untimely failures that were observed after various load cases are applied on same geometry. This type of research advice to use of non-linear finite element method for structural failure simulation. It was use for Structural failure prediction based on software analyze before erection. NX Nastran is very useful software for failure analysis. Utilizing this way, tower design can be easily modified & updated, which gives results in noteworthy time savings, cost and tools.*

Keywords*: Transmission line tower, Finite element method, Structural failure, Primary bracings.*

1. INTRODUCTION

The structural design of transmission tower is generally based on minimum heft basis. The towers are lattice type consisting of legs, primary/secondary bracings, cross-arm, conductors and sometime dampers and spacers used as member. Structural design of the tower is mainly obstructed by wind loads acting on conductor and other loads due to line deviation, BW condition, cascading failure, erection, maintenance etc. Basically, the tower is design as pin jointed space truss. Leg members and primary bracings are considered in the analysis and the redundant are ignored. The members were designed based on the prevailing codes of practice. Different size and material of angle sections are generally used in transmission tower is recommended to verify the design & detailing.

Overhead transmission line tower used in the performance of reliable electrical power system. Transmission towers are momentous components of the lines & precise prediction of tower failure is very important for the trustworthiness safety & cost of the transmission line systems. When such failure took place, it is usually a cascading failure accounting a number of connected members along the Tower. Redesign of collapsed tower is too much costly and time consuming.

The paper describes a non-linear finite element analysis for predicting the transmission tower failure. When a full-scale test of this tower was conducted, the tower experienced middle conductors of both side are fail in close agreement with the non-linear analysis prediction based on software NX 10.

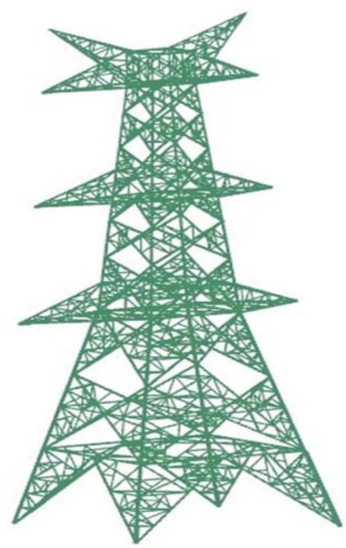


Fig. 1: 3D View of DC Tower

2. FAILURE ANALYSIS OF A DC TOWER

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

2.1 Structural detail of Tower

The design of self-supporting lattice tower with 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

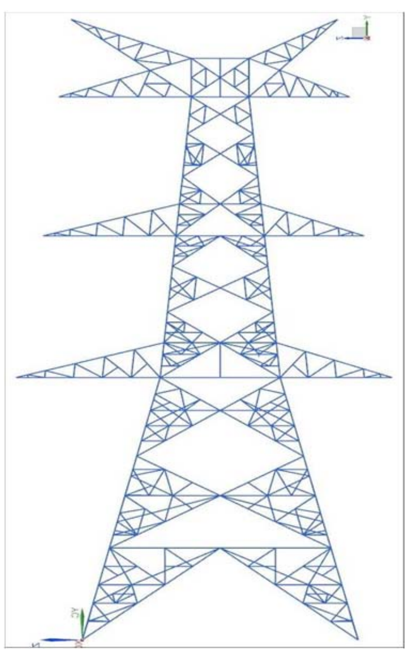


Fig. 2: Front View of DC Tower

Table 3: Material Description

Property	Mild Steel	HT Steel
Yield Strength	250 N/mm^2	350 N/mm^2
Ultimate Tensile Strength	410 N/mm^2	490 N/mm^2
Mass Density	7.85×10^{-6} kg/mm^3	7.85×10^{-6} kg/mm^3
Young's Modulus(E)	2×10^5 N/mm^2	3×10^5 N/mm^2
Poisson's Ratio(μ)	0.30	0.31
Shear Modulus(G)	76920 N/mm^2	11450 N/mm^2
Structural Damping Coefficient	0.02	0.02

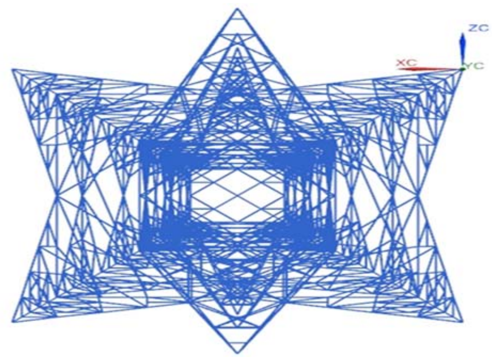
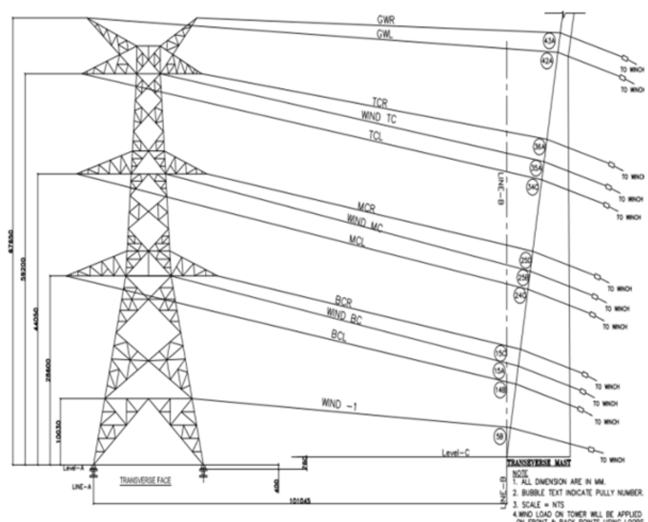


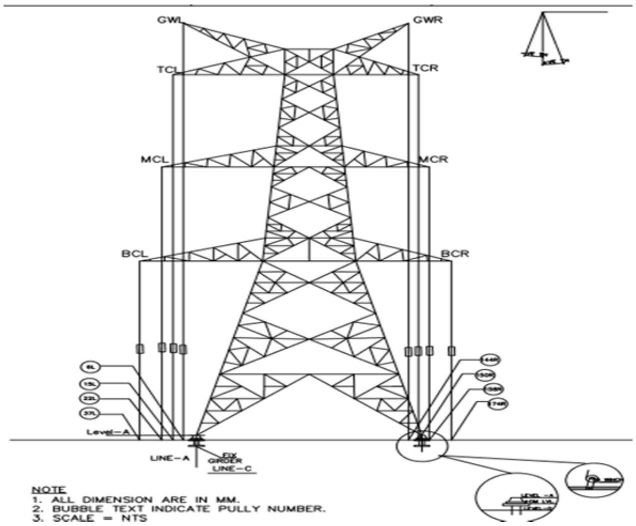
Fig. 3. Top view of Tower

2.2 Tower arrangement at testing center

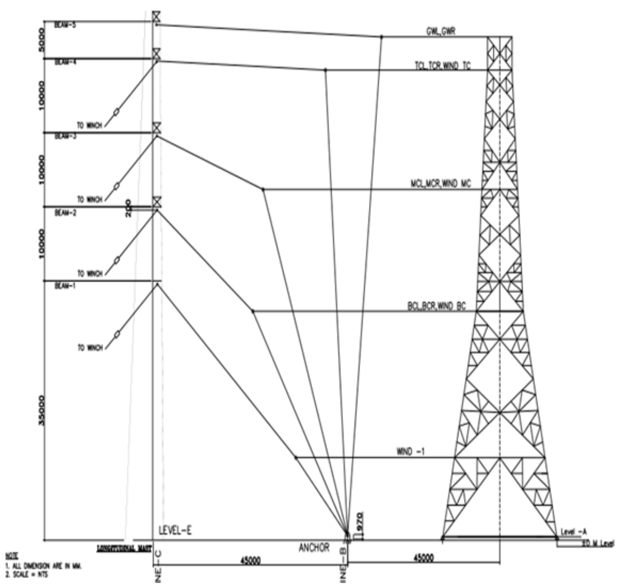
1) Transverse rigging arrangement



2) Vertical rigging arrangement



3) Longitudinal rigging arrangement

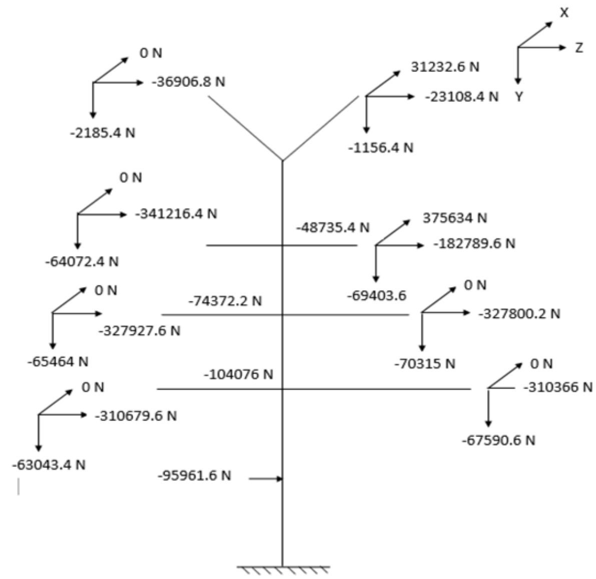


3. LOAD CASES

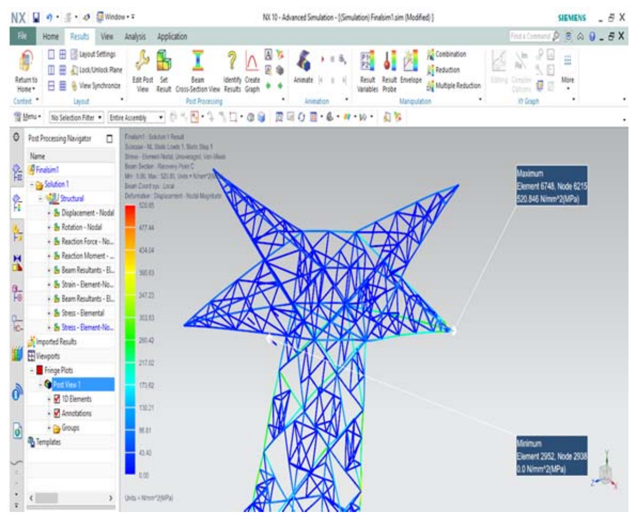
Here, in this paper various types load cases are used for predicting the failure load of the tower. Total 5 various load cases are used.

3.1 Load Case -19

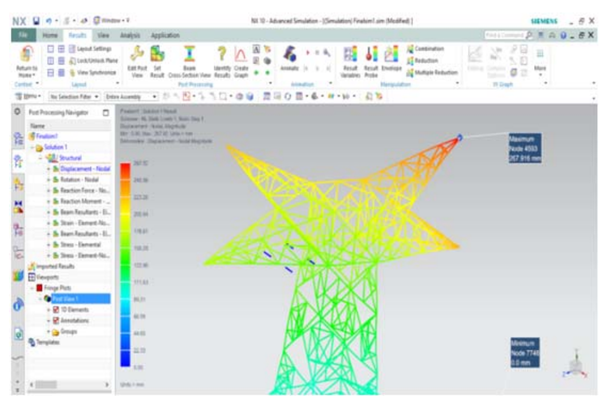
Here, in this load case the "Ground Wire and Top Conductor" on right side are broken. Longitudinal load are applying only on GW & Top Conductor right side.



Load Tree of case -19



Stress Result (N/mm^2) -19



Deflection Result (mm) -19

After applying load in Transverse, longitudinal and vertical direction the results are:

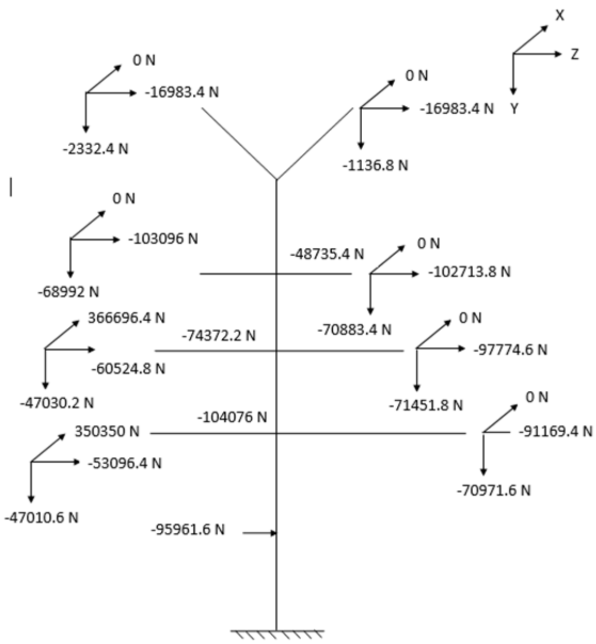
I) Maximum stress = 520.85 N/mm^2

II) Maximum deflection on GWL = 267.92 mm

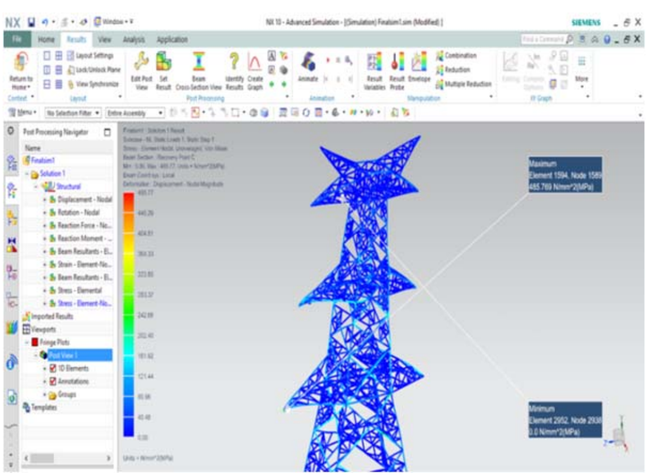
Here, Maximum stress generated on right side top conductor and maximum deflection on right side Ground Wire.

3.2 Load Case -75

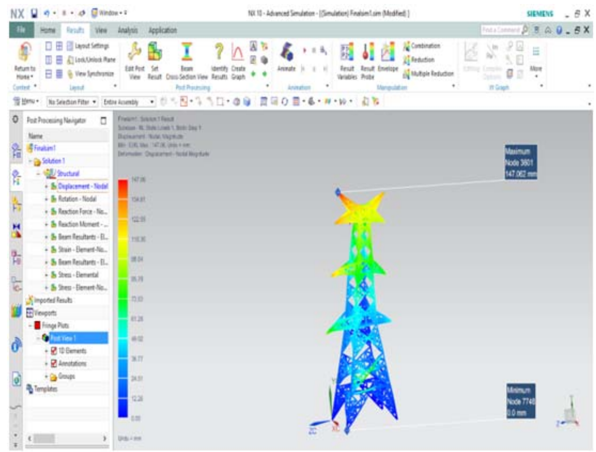
Here, in this load case the "Middle and Bottom Conductor" on left side are broken. Longitudinal load are applying only on Middle & Bottom Conductor left side.



Load Tree of Case -75



Stress Result (N/mm^2) -75



Deflection Result (mm) -75

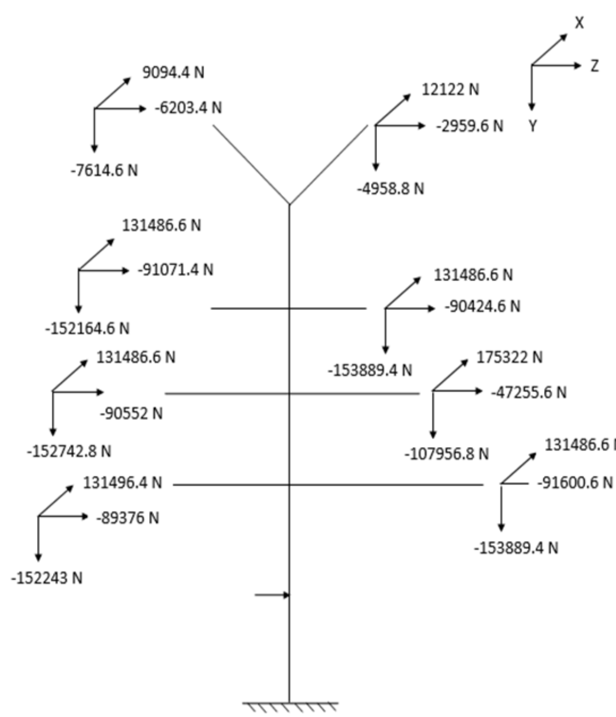
After applying load in Transverse, longitudinal and vertical direction the results are:

I) Maximum stress = 485.77 N/mm^2

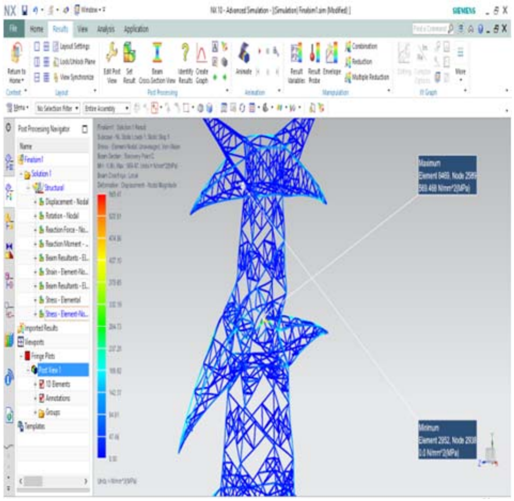
II) Maximum deflection on GWL = 147.06 mm

Here, Maximum stress generated on left side Bottom conductor and maximum deflection on left side Ground Wire.

3.3 Load Case -47

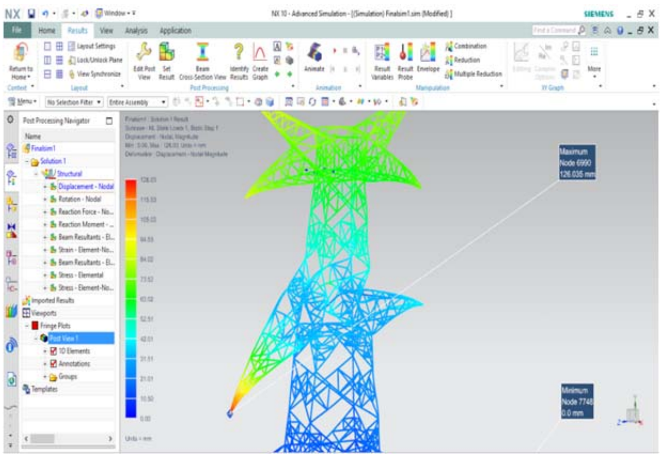


Here, in this load case the "Middle Conductor" on right side is broken. Longitudinal load are applying on every member but wind load are not applied.

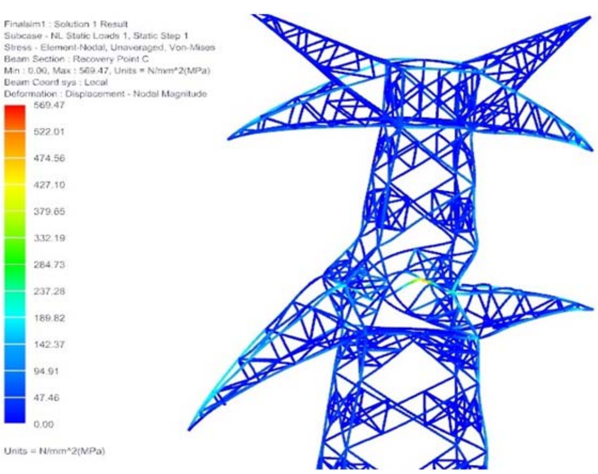


Load Tree of Case -47

Stress Result (N/mm^2) -47



Deflection Result (mm) -47



Front View of Middle Conductor failure

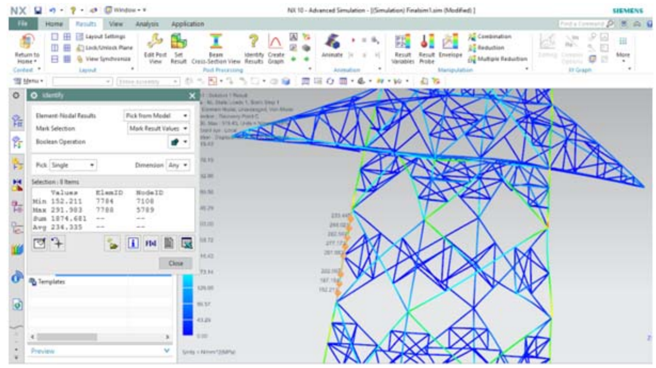
After applying load in Transverse, longitudinal and vertical direction the results are:

I) Maximum stress = 569.468 N/mm^2

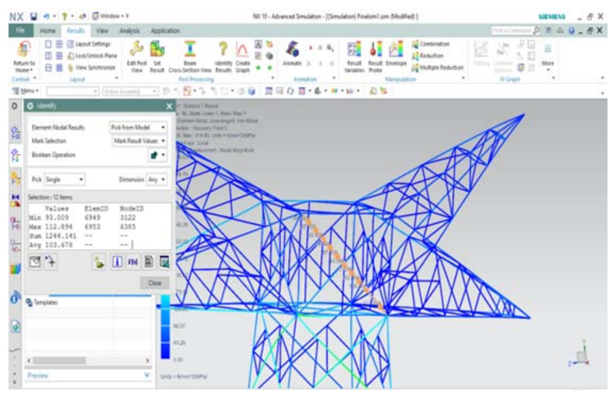
II) Maximum deflection on GWL = 126.03 mm

Here, Maximum stress generated on middle conductor right side and maximum deflection on left side middle conductor.

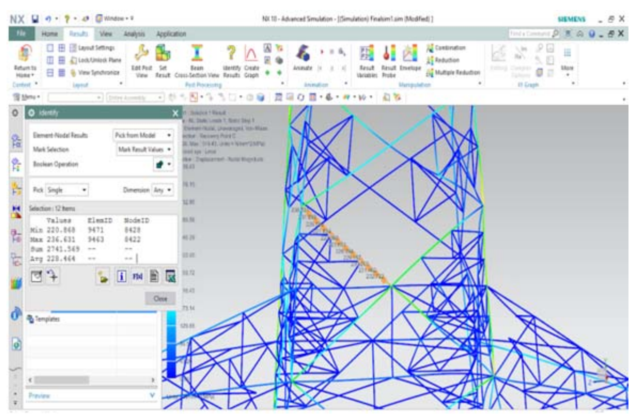
Middle conductor left side fully fail on effect of maximum stress on right side middle conductor.



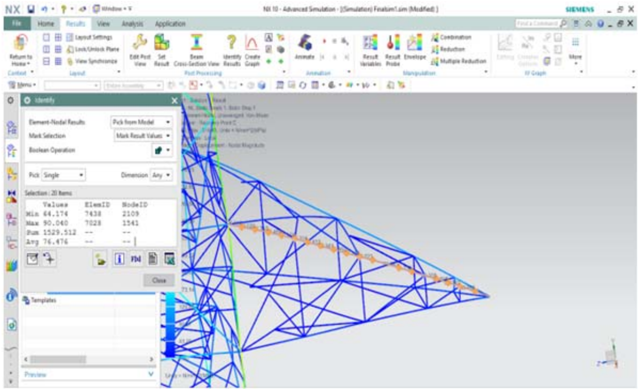
4. RESULT COMPARISON



Comp. Stress on Leg -7



Primary bracing (LLG -1)



Primary bracing (LTR -8)

Top member of middle conductor (MC-UM-R)

Table 4: Section properties

No.	Group Label	Angle Size	Comp. Stress (N/mm^2)	Software Result (N/mm^2)	Difference %
1	LEG-P7	200X200X20	236.952	234.335	1.1
2	LLG-1	90X90X6	104.576	103.67	0.86
3	LTR-8	100X100X7	227.272	228.46	0.52
4	MC-UM-R	90X90X7	76.7016	76.476	0.2

5. CONCLUSION

Various types' untimely failures & the reasons were discussed. The analytical study shows that the Non-linear finite element analysis is useful to understanding the behaviour, load carrying capacity, design deficiencies in the structure. Based on the software results carried on double circuit lattice type of tower, the following conclusions were drawn.

1. These results are conclude that the under load case -19 maximum stress will generate in top conductor of 520.85 N/mm^2 which is greater than 350 N/mm^2, so as per stress result predict that it will failure under this load.
2. As per load case -47 Fig. shows that the maximum stress generate in middle conductor of 569.468 N/mm^2

And result in fail.

So, as per these result we predicted that the 569.468 N/mm^2 is failure stress under load case -47, and all over performance the tower do not carry more than 569.468 N/mm^2 stress.

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