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Comparative Analysis and Design of Transmission Line Tower Using Steel Section with Tubular Section

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***Abstract* - Steel structures built up with conventional steel sections lead to massive or lavish budget structures. Tubular steel sections are considered as the best substitution to conventional ones which are useful with better properties. Our project is based on transmission line tower which is a comparative analysis and design using steel section over tubular section. The transmission line tower is analyzed under various loads and designed accordingly. Transmission line tower constitutes about 28 to 42 percentage of the cost of transmission power line project. The embossing demand for electricity can be made enough economical by developing various light weight configuration of transmission line tower's structure is analyzed and designed by using STAAD PRO and IS 800:2007. For optimizing the member sections, the entire wind load computations have to be repeated simultaneously for the analysis and design**.

Keywords: Transmission line tower, Insulator, Conductor, Diagonal Bracing, Static Analysis, Optimized.

I. INTRODUCTION

In every country, both developed and developing, the electric power consumption has continued to rise; the rate of growth is being greater in the developing countries on account of the comparatively low base. This in turn had led to the increase in the number of power stations and their capacities and consequent increase in power transmission lines from the generating stations to the load centers. Interconnections between systems are also embossing to enhance availability and economy. The transmission voltage, while dependent on the quantum of power transmitted, should fit in which long – term system requirement as well as provide flexibility in system operation It should also conform the levels of voltage in national and international standard.

In the planning and design of transmission lines, a number of requirements have to be met from the electrical point of view, the most important requirement is insulation and safe clearances to earthed parts. We should consider the following, joining of the cross–section of conductors, the horizontal and vertical space of conductors, clearance between conductor and ground wire, and foundations. The conductors, ground wires, insulation, towers and foundations constitute the major components of a transmission lines.

II. METHODOLOGY

A double Circuit Transmission Line Tower carrying 220KV Power is analyzed and designed in STAAD PRO. The overall height of tower is 30.3m which determined structural configuration is according to IS 5613 (part 2/sec 1):1995. Towers are modeled by using diagonal bracing by using Indian angle sections and tubular sections. In order to design transmission tower with varying section, IS: 802 (part 1/ Sec1); 1995 has been followed.

III. HEIGHT OF TOWER

According to the electrical Rule, 77(4) 1956, (1) Minimum permissible ground clearance (h_1), (2) Maximum sag (h_2), (3) Vertical spacing between conductors (h_3), (4) Vertical clearance between ground wire and top conductor (h_4).

Thus the overall height of the tower is given by

$H = h_1 + h_2 + h_3 + h_4$

Sag tension for conductor and ground wire

IS codes used for practice a steel sections in transmission line towers have,

The following consideration of sag tension values calculations for the ground wire and the conductor:

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Maximum temp (75°C for ASCR and 53°C for ground wire) with design wind pressure (0% and 36%).

Every day temp (32°C) and design wind pressure (100%, 75 and0%).

Minimum temp (0°C) with design wind pressure (0% and 36%).

IS 802: part 1:sec 1: 1995 states that conductor/ ground wire tension at every day temp and without external load should not exceed 25 % (up to 220 kV) for conductors and 20% for ground wires of their ultimate tensile strength. Sag tension values are calculated by using the parabolic equations as discussed in the IS 5613: Part 2: Sec: 1: 1989 for both the ground wire and conductor. In this paper, we considering the sag value of ground wire as 90% the sag value of the conductor at 0°C and 100% wind condition. The sag tension values are mentioned in the Table1.

Parabolic Equation

$(F2 – (K – \alpha.t.E)) = [(L^2\times \delta^2\times q_2^2\times E) /24]$….(1)

Take, $K = F1 – [(L^2\times\delta^2\times q_0^2\times E) / 24 F_1^2]$……(2)

(ASCR) Temp variation °C	0^0	32^0	75^0
Wind variation %	0	0.75	0
Tension (kg)	2282.5	3108.3	2367.23

Table-1: Sag Tension Values

Tension values are giving factor of safety < 4.

So, we consider the minimum tension (tension for F.O.S = 4.) to find the maximum sagging in all condition.

So, sagging = $wl^2 / 8T^2$

= $[(0.973\times 320^2) / (8 \times 2282.5)]$

=5.46m

By increasing 4% of calculated sag we get

= 5.46 × 4%= 5.70 m.

1. Minimum permissible ground clearance (h_1) = 7.1 m
2. Maximum sag (h_2) = 5.7 m
3. Vertical spacing between conductors (h_3) = 10 m
4. Vertical clearance between ground wire and top conductor (h_4)= 5 m

   Thus the total height of the tower is given by

   H = 7.1 + 5.7 + 10 + 5

   H = 30.3 m
5. Base width = 6 m
6. Top hammer width = 2 m

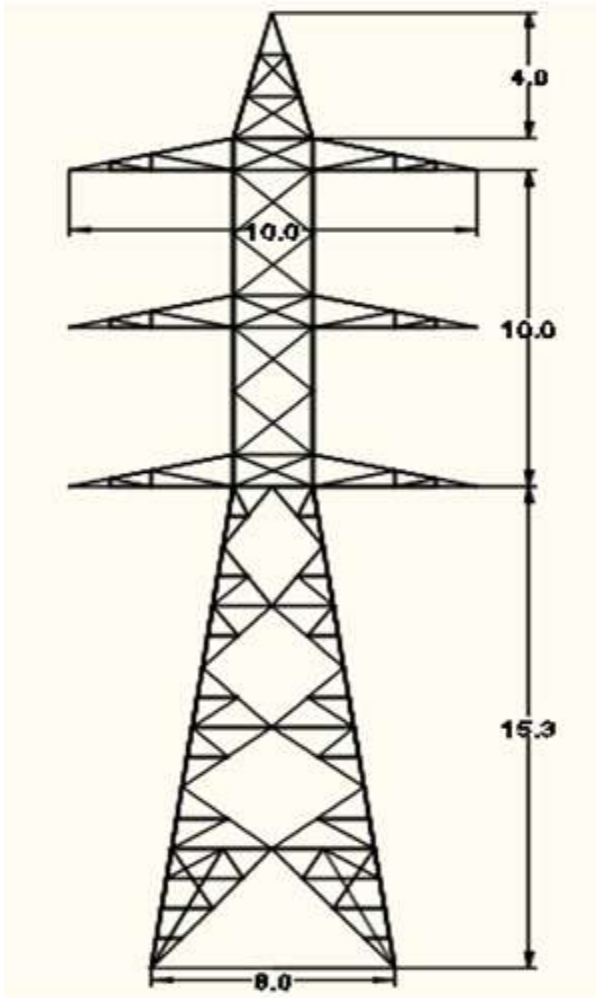

Figure-1: Transmission Tower Dimension

IV. TOWER SPECIFICATION DETAILS

Transmission line voltage: 220 KV

No. of circuits: Double circuit

Tower configuration: vertical conductor configuration

Right way: 320 m

Cross arm: pointed

Tower geometry: Square base tower

Conductor name: Panther

Ground wire: Galvanized steel

Insulator type: I string

Length of insulator string: 2.5 m

Basic wind speed: 39 m/s

Tower Type: Self-Supporting Type "A"

Length of Insulator String: 2,500 mm

Tower Geometry: Square Base Tower

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V. SECTION USED

Structural steel	Tubular section
ISA 75 x 75 x 6	Pip 483H
ISA 80 x 80 x 6	Pip 603H
ISA 80 x 80 x 10	Pip 761H
ISA 90 x 90 x 6	Pip 889M
ISA 90 x 90 x 10	Pip 1016L

VI. WIND LOAD ON TOWER

Wind loads on the towers are calculated separately using excel sheet. The coefficients values for the tower, the solidity ratio values are derived from IS-875: part 3-1987(table 30) in the similar as in the IS 826 (part-1/sec 1)- 1995.

a) Design Wind Pressure

To calculate design wind pressure on conductor, ground wire, insulator and panel.

$Pd=0.6\times Vd^2$

Where,

Pd = design wind pressure in N/m2

Vd = design wind speed in m/s

To calculate design wind pressure,

$Vd = VR\times K1\times K2$

VR = 10min wind speed (or) reduced wind speed

VR = Vb/k0 (5)

Vb = basic wind speed

K0 =1.375 [conversion factor]

K1 = risk coefficient

K2 = terrain roughness coefficient.

b) Wind Loads on Conductor/Ground Wire

To calculate wind loads on conductor and ground wire,

Fwc = wind load on conductor

Fwg = wind load on ground wire

Pd = design wind pressure

Cdc = drag coefficient for ground wire =1.2 drag coefficient for conductor = 1.0

L = wind span

d = diameter of conductor/ground wire

Gc = gust response.

c) Wind Load on Insulator

To calculate wind load on insulator,

$Fw=Pd\times Cdi\times AI\times GI$

where,

AI = 50% area of insulator projected parallel to the longitudinal axis of string

GI = gust response factor for insulator

Cdi = drag coefficient, to be taken as 1.2150 mm

d) Wind Load on Panels

The force due to wind acting at every panel joint of the tower.

To calculate wind load on panels,

$Fw=Pd\times Cdt\times Ae\times GT$

dt = drag coefficient for panel considered against which the wind is blowing

Ae = effective area of the panel

GT = gust response factor for tower

VII. LOAD APPLY ON TOWER USING STAAD PRO

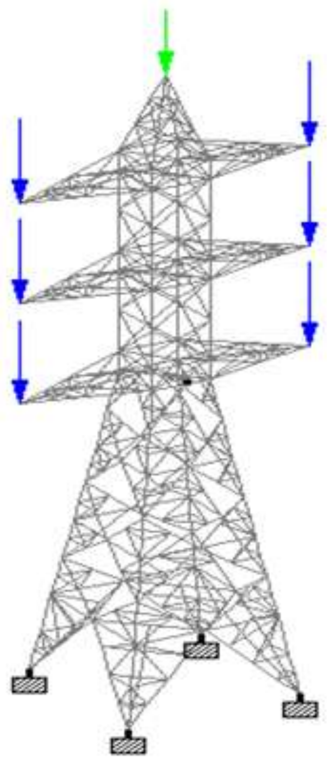

Figure-2: Vertical Load acting on Tower

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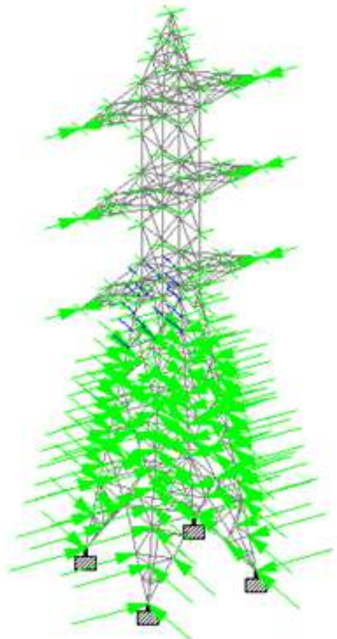

Figure-3: Wind Load acting on Panels

a) Summary Results

Maximum axial force, bending moment and maximum deflection values are obtained by using STAAD pro.

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	425	5 1.5DL+1.5L	276	86.376	-0.099	-0.001	-0.000	-0.000	-0.032
Min Fx	15	5 1.5DL+1.5L	9	-26.511	0.248	-0.001	0.000	-0.014	0.090
Max Fy	418	5 1.5DL+1.5L	72	84.478	1.076	0.002	0.000	-0.001	0.631
Min Fy	694	5 1.5DL+1.5L	204	-0.288	-1.791	-0.144	-0.000	0.016	-0.226
Max Fz	482	5 1.5DL+1.5L	98	13.744	0.211	2.775	-0.002	-2.383	-0.001
Min Fz	460	5 1.5DL+1.5L	87	13.904	0.210	-2.774	0.002	2.383	-0.001
Max Mx	302	5 1.5DL+1.5L	69	-11.596	0.223	0.869	0.006	-0.381	0.061
Min Mx	287	5 1.5DL+1.5L	167	-11.180	0.162	-0.869	-0.006	0.751	0.021
Max My	472	5 1.5DL+1.5L	103	14.214	0.210	-2.774	0.002	2.384	-0.002
Min My	502	5 1.5DL+1.5L	92	14.006	0.209	2.774	-0.002	-2.383	-0.003
Max Mz	418	5 1.5DL+1.5L	72	84.478	1.076	0.002	0.000	-0.001	0.631
Min Mz	418	5 1.5DL+1.5L	251	84.007	0.989	0.002	0.000	0.001	-0.373

Table-2: Result Value of Structural Steel

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	425	5 1.5DL+1.5L	276	79.621	-0.761	-0.001	-0.001	-0.000	0.173
Min Fx	15	5 1.5DL+1.5L	9	-41.462	0.159	-0.000	0.000	-0.010	0.066
Max Fy	418	5 1.5DL+1.5L	72	70.661	3.069	0.007	0.002	-0.005	1.830
Min Fy	694	5 1.5DL+1.5L	204	-0.389	-2.567	-0.244	-0.003	0.029	-0.318
Max Fz	471	5 1.5DL+1.5L	104	13.493	0.442	3.011	0.031	-2.066	0.152
Min Fz	472	5 1.5DL+1.5L	103	13.423	-0.113	-3.011	-0.031	2.396	-0.259
Max Mx	302	5 1.5DL+1.5L	69	-11.053	0.061	0.498	0.238	-0.240	-0.001
Min Mx	287	5 1.5DL+1.5L	167	-10.775	0.197	-0.498	-0.238	0.408	0.088
Max My	472	5 1.5DL+1.5L	103	13.423	-0.113	-3.011	-0.031	2.396	-0.259
Min My	502	5 1.5DL+1.5L	92	13.129	-0.119	3.011	0.031	-2.395	-0.266
Max Mz	418	5 1.5DL+1.5L	72	70.661	3.069	0.007	0.002	-0.005	1.830
Min Mz	418	5 1.5DL+1.5L	251	70.355	3.013	0.007	0.002	0.003	-1.127

Table-3: Result Value of tubular section

VIII. CONCLUSION

The comparison of the weight of circular hollow section with the rolled steel section showed less while they are same in height, bracing and 220KV power tower. In future hollow section may leave a good optimizing design based on economy and weight of various bracing systems and height of tower.

Structural steel	Weight (kg)	Tubular section	Weight (kg)
ISA 75 x 75 x 6	2773	Pip 483H	2147
ISA 80 x 80 x 6	2528	Pip 603H	1784
ISA 80 x 80 x 10	1574	Pip 761H	1525
ISA 90 x 90 x 6	1497	Pip 889M	1053
ISA 90 x 90 x 10	208	Pip 1016L	135
Total	8580	Total	6644

Table-4: Weight Comparison Result

Thus the above tabular column shows the comparison of weight of structural steel and tubular sections of various dimensions.

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BIOGRAPHY

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