

Study on replacement of Hot Rolled Angular Sections in Microwave Tower using Cold formed Sections

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Abstract - Historically, most Microwave towers have been fabricated from hot-rolled steel angles, but the availability of the thinner sections has become limited cold formed sections are readily available in the thinner sections and provide a alternative for more economical structures due to significant saving in weight. Cold formed members enable the engineer to design more cost effectively as it enables the use of various shapes and sizes as per the working conditions. This paper provides a general formulation for the design of cold formed sections other than hot rolled plain angles. To confirm the reliability of cold formed shapes for Microwave tower, a comparison of hot rolled steel angle microwave tower and cold formed angle microwave tower is presented. The analysis is carried out to examine the variable properties of a hot rolled steel section and of cold formed sections, compare the variation of Displacement (mm) at top for different tower and Comparison of Member Stress (N/mm²) at Bottom Leg. In this present study, the wind analysis of 4 legged angled section and cold formed section rooftop telecommunication tower has been studied along with wind analysis as per IS 875 (part 3) 1987. The analysis has been done on tower located on roof of host structure in STAAD software.

IndexTerms - Axial forces, Cold formed sections, Displacement, Hot-rolled steel angles, Microwave towers, Stress.

I. INTRODUCTION

In the contemporary era, the telecommunication industry plays a great role in human societies and thus more attention is now being paid to telecommunication towers than it was in the past. As telecommunication tower are only measure for enhancing both the coverage area and network reliability more and more towers are installed nowadays. The direction and the height of tower along with the antennas mounted on it are completely governed by the functional requirements of network. The most ideal place for tower is on ground but in urban areas the availability of land which would be most ideal is extremely limited giving no alternative but to adopt roof top tower with marginal adjustment in terms of position.

Telecommunication towers are tall structure usually designed for supporting parabolic antennas which are normally used for microwave transmission for communication, also used for sending radio and television signals to remote places and they are installed at specific height. These towers are self-supporting structures and categorized as three-legged and four-legged space trussed structures. The structure engineer faces the challenging job of designing and constructing telecommunication towers to support antenna loads, platform as well as steel ladder loads in open weather with high degree of reliability. The major cause of failures of telecommunication tower throughout the world though still remains to be high intensity winds (HIW).

Generally, the design of self-supporting towers takes into account the effect of wind load as the only source of environmental loads. Except for critical structures built in high seismic hazard areas, earthquake induced loads are generally neglected in design. This practice is mainly due to the fact that the lattice towers built on ground have shown good performance in past earthquakes. However towers mounted on rooftops respond to seismic motions differently than those built on firm ground. It can be time consuming to perform detailed dynamic analysis as a part of regular design project. Thus, simplified design checks need to be developed. The antenna towers are usually analyzed assuming the members to be concentrically connected using hinged joints so that the forces in the angle members are only axial forces.

II. MODELLING AND LOADING DETAILS The telecommunication tower is located in Pune region in Urban Area. It is a roof host structure it is a square tower 15 m high. The general form of tower is shown in Fig.1, which also indicates the panels and sections. In this X-X and K bracing system is used.

The sections adopted are as below

- A tower with legs and bracings as Hot rolled angle sections (M1)
- A tower with legs and bracing system as Cold formed sections (M2)
- A tower with legs as hot rolled angle sections and bracings as cold formed angle sections (M3)

Table 1 Details of Tower

Height of Tower	15m
Height of Building	15m
Height of straight portion	12m
Height of slant portion	3m
Base width	1.5m
Top Width	1m
No. of panels	5

A platform load is 0.75 kN/m^2 is applied at 15m. The weight of ladder and cage assembly is calculated and summed up with antenna loads and distributed evenly to the nodes at the considered heights. The details of antenna are provided in Table 3

Table 2 Details of Antennas

Sr no	Item	Qty	Dia (m)(wxdxh)	Weight (kg)	Location from base
1	GSM	4	2.5x0.3	25	30
2	Microwave Antenna	1	1.8	75	27
3	Microwave Antenna	1	2.4	200	24

Table 3 Member details of tower

Sr. No	Tower Elevation (m)	Member Description	Angle Section for M 1	Angle Section for M 2	Angle Section for M 3
1	0-3	Leg Member	150 x 150 x 10	150LU 150 x 10	150 x 150 x 10
2		Bracing	80 x 80 x 6	80LU80 x 4	80LU80 x 4
3	3-6	Leg Member	150 x 150 x 10	150LU 150 x 10	150 x 150 x 10
4		Bracing	80 x 80 x 6	80LU80 x 4	80LU80 x 4
5	6-9	Leg Member	150 x 150 x 10	150LU 150 x 10	150 x 150 x 10
6		Bracing	80 x 80 x 6	80LU80 x 4	80LU80 x 4
7	9-12	Leg Member	100 x 100 x 10	100LU 100 x 6	150 x 150 x 10
8		Bracing	60 x 60 x 8	80LU80 x 4	80LU80 x 4
9	12-15	Leg Member	80 x 80 x 6	80LU 80 x 4	150 x 150 x 10
10		Bracing	60 x 60 x 8	60LU60 x 4	60LU60 x 4

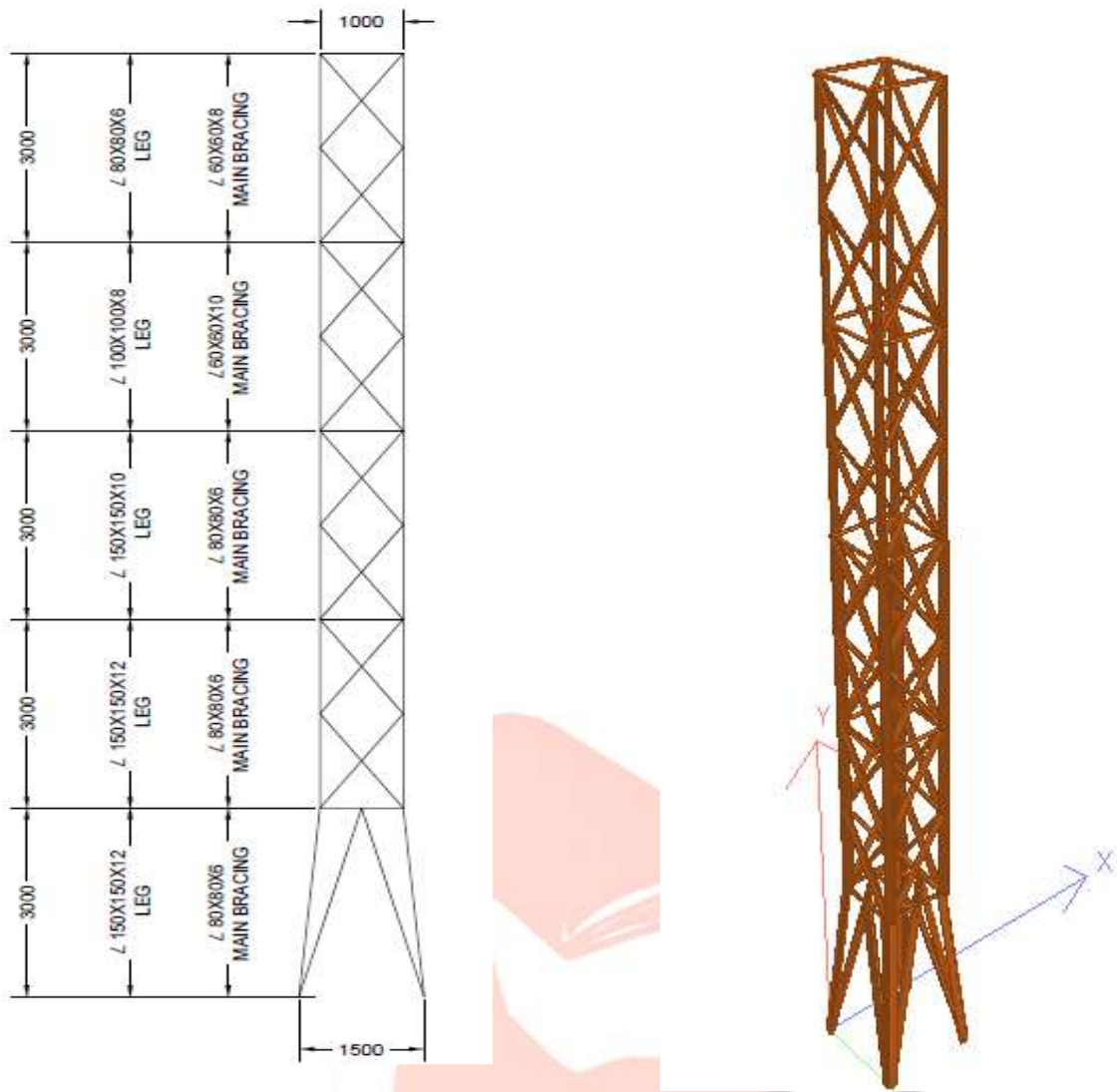


Fig1 Typical Member Section for Microwave Tower

III. ANALYTICAL APPROACH

Loads on a Microwave Tower: -

Generally, loads on a microwave tower are caused by weather, construction and maintenance activities. Loads are calculated on the structure in two directions vertical and transverse.

- The vertical load consists of
 - Dead load of tower (self-weight)
 - Dead load of Microwave Antenna and GSM
 - Load of platform, cables, ladders and other accessories.
- The Transverse loads are caused by
 - Wind load on tower and accessories

Wind load Calculations: -

The wind load acting on Microwave tower is as per IS: 875(Part 3) -1987. As towers are tall and Flexible it is critical under wind load. The wind load is calculated by dividing the tower into different panels of equal heights. The calculated wind is transferred on each joint of the exposed face of the tower. Therefore: 875(Part 3) -1987 recommends the diagonal wind to be 1.2 times the wind blowing normal to the face. The design wind pressure is calculated at increasing height of tower from the mean ground level. The design wind speed is obtained taking into account factors such as risk co-efficient, terrain roughness, height, size of structure and local topography.

Height of Tower	= 30 m	Reference from IS: 875 (Part-3)
Structure Class	= B	5.3.2.2
Basic wind speed V_b	= 39 m/s	Fig. 1
Terrain Category	= 3	5.3.2.1
Risk Co-efficient k_1	= 1.06	Table 1
Terrain, height and structure Size factor k_2	= Varies	Table 2
Topography Factor k_3	= 1	5.3.3-Normal Topography
Force Co-efficient for Ladder C_{fl}	= 2	Flat Sided (Conservative Assumption)

Pnl #	Z-above GL (m)	k ₂	V _d (m/s)	P _z (kN/m ²)	Guess Area of Panel, A _p	Solidity Ratio f	C _f	Panel Load-Face Wind Direction			Panel Load-Diagonal Wind Direction			Nodal Load-Face wind		Nodal Load-Diag Wind	
								Wind Load on Tower (F _{WT}) (kN)	Wind Load on L-ribber (F _{WL}) (kN)	Total Wind Load, F _T (kN)	Wind Load on Tower (F _{WT}) (kN)	Wind Load on L-ribber (F _{WL}) (kN)	Total Wind Load, F _D (kN)	Avg Wind Load on All Nodes (kN)	Wind Load on Each Node (kN)	Avg Wind Load on All Nodes (kN)	Wind Load on Each Node (kN)
5	30.0	1.02	42.27	1.072	3.240	0.278	2.91	10.11	3.93	14.04	12.13	4.72	16.85	7.02	1.76	8.42	2.11
4	27.0	1.01	41.65	1.041	3.240	0.278	2.91	9.82	3.82	13.63	11.78	4.58	16.36	13.84	3.46	16.61	4.15
3	24.0	0.99	41.03	1.010	3.240	0.334	2.63	8.61	3.71	12.32	10.34	4.45	14.78	12.98	3.24	15.57	3.89
2	21.0	0.98	40.41	0.980	3.240	0.334	2.63	8.36	3.60	11.95	10.03	4.31	14.34	12.14	3.03	14.56	3.64
1	18.0	0.95	39.32	0.928	3.990	0.274	2.93	10.85	3.40	14.26	13.03	4.09	17.11	13.11	3.28	15.73	3.93
0	15.0	0.88	36.38	0.794	5.550	0.234	3.13	13.79	2.91	16.70	16.54	3.50	20.04	15.48	3.87	18.58	4.64

Table 4 Wind Load Calculations As Per IS: 875 (Part-3)

Table 5 Platform and Antenna load calculations

Platform & Antenna Loads		Wt (kg)	Wind Load (kN)	For Wind Speed (m/s)	Ant Elv (m)	Wind Speed (m/s)	Wind Load/Antenna (kN)	# of Antennas	Total Load (kN)	Per Node (kN)	Remarks
Platform		300	NA	NA	30	42.27	NA	NA	1.41	0.35	4 Nodes
GSM	2.5mx0.3m	25	1.26	44.44	30	42.27	1.14	4.00	4.57	1.14	4 Nodes
MW	1.8m dia	75	4.34	55.56	27	41.65	2.44	1.00	2.44	1.22	2 Nodes
MW	2.4m dia	200	7.72	55.56	24	41.03	4.21	1.00	4.21	2.11	2 Nodes

Table 6 Load combinations

LOAD COMBINATION	LOAD FACTORS			
	SW	DL	WX (ANT)	WX (TWR)
SW+DL+WX(ANT)+ WX(TWR)---FACE	1.0	1.0	1.5	1.5
SW+DL+WZ(ANT)+ WZ(TWR)---FACE	1.0	1.0	1.5	1.5
SW+DL+DIAG(ANT)+ DIAG(TWR)---DIAG	1.0	1.0	0.85	0.85
SW+DL+WX(ANT)+ WX(TWR)---FACE	1.0	1.0	-0.85	-0.85
FACE WIND X-DIRECTION	1.0	1.0	0.31	0.31
FACE WIND Z-DIRECTION	1.0	1.0	0.31	0.31

IV. RESULTS AND DISCUSSIONS

- Displacement at the Top of Microwave Antenna Tower

In the present analysis, the displacement of microwave antenna tower at the top of 15m (i.e., 30 m of considering the building height) has been considered the main parameter. Fig.2 shows the variation displacement at the top of regular tower for different models

Table 7 Comparison of Joint Displacement (mm)

Elevation (m)	Node no.	Model I	Model II	Model III
		Displacement (mm)		
15	24	102.57	114.045	104.889
6	12	17.332	17.607	16.887

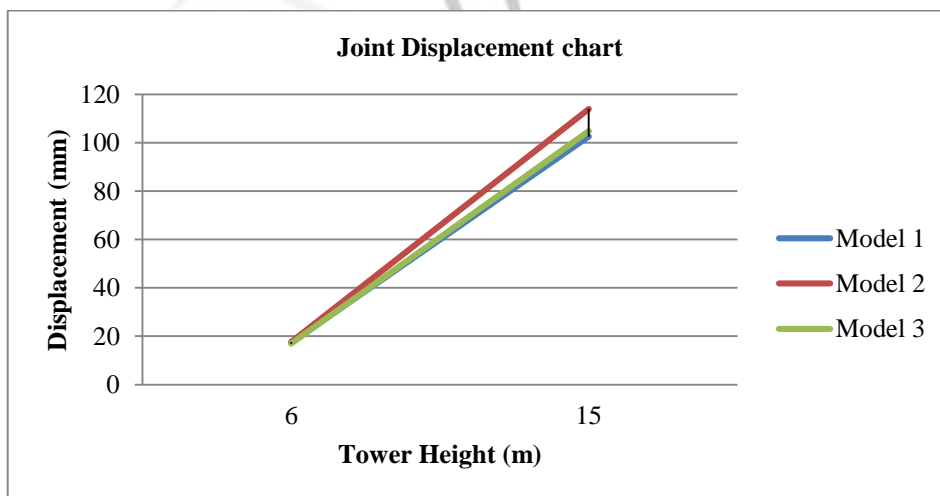


Fig2 Displacement at the Top of Microwave Antenna Tower

- Weight comparison of Microwave Antenna Tower

Table 8 Weight Comparison of Models

Sr.No	Model No	Weight In kN
1	M1	22.51
2	M2	17.935
3	M3	18.616

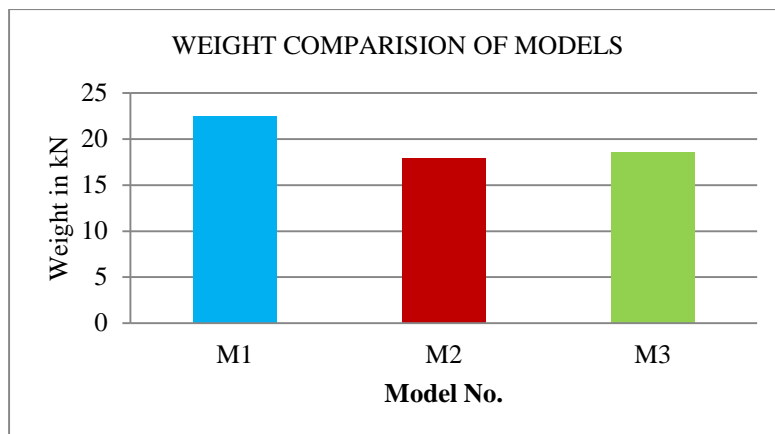


Fig3 Weight comparisons of Models

- Stress comparison of Microwave Antenna Tower

Table 9 Comparison of Member Stresses (N/mm²)

Elevation (m)	Member type	Member Number	Axial Stress		
			I	II	III
3	Leg	8	454.76	452.07	453.07
0	Leg	201	516	515.27	515.5

V. CONCLUSION

Cold formed steel has become a competitive building material as a result of industry wise efforts. To ensure sustained market growth for cold-formed steel in construction, AISI and steel market development institute will continue to play an important role to increase collaboration with different organizations to improve the design specification and to enhance the image and awareness of cold formed steel in the market place.

On the basis of present study, following conclusions can be drawn:

- The wind analysis shows that irrespective of the model materials used for microwave tower does not significantly affect the displacement pattern, specifically the maximum lateral displacement at the top of tower.
- The self weight for the M2 tower made of cold formed sections is found to be approximately 20 % less than other two towers hence a considerable amount of saving in material in case of cold form microwave tower is achieved

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