International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 05, May-2019

COMPARITIVE STUDY OF FOUR LEGGED TRANSMISSION TOWER WITH DIFFERENT SECTIONS

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ABSTRACT
To carry power lines from one place to another place at sufficient and safe distance from ground level transmission towers are constructed. This paper presents the most economical and efficient section as per Indian standard IS 800 for design of tower. The present work describes about analysis and design of four legged self-supporting transmission tower with different sections such as angular and tubular sections. The transmission tower has a height of 35m and base width of 10m. The wind force plays an important role on the tower elements besides the self-weight. This study shows that the tower with the angular section is most effective and economical section compared to tubular section for different bracing such as X, K and W.

Keywords - bracings, section, deflection, bending moment, steel take off.

I. INTRODUCTION

A Transmission tower is a very high structure which supports the overhead power lines. They have wide variety shapes and sizes and used in AC and DC systems. The maximum height of transmission tower lies between 15 to 55m. As the population increasing rapidly the requirement of transmission tower becomes more important. Transmission towers have different shapes, sizes, materials, bracings and sections. Optimum section connecting with perfect bracing gives the most economical tower. Transmission tower should be stable and carefully designed so that they do not get effected by any natural disaster.

Generally transmission tower is designed for wind force in transverse direction but in some parts of sub-continent earth quake force is also considered in earth quake region. However the major concern (in Visakhapatnam region) is about wind force as it causes large displacement of tower and cables so that the cables may touch each other and touch surrounding objects and causes power failure and accidents. Hence, transmission tower should be stable and carefully designed so that they do not get effected by any natural disaster.

II. LITERATURE REVIEW

Shinde and Ghugal (2013) evaluated steel lattice transmission tower with different wind loads with considering a 230 kV self-supporting, double circuit, suspensions and lattice type transmission tower. D.C suspension type transmission tower is evaluated with wind speed of 80 kmph & 100 kmph and analyzed by using STAAD PRO. The axial forces are increased by 47.2% in 100 kmph wind speed as compared with 80 kmph wind speed. Bolted connections are used for joint design. Shear capacity and Bearing capacity are greater than maximum axial force in each panel.

Hadimani (2013) performed static and dynamic evaluation of transmission line tower (X form of bracing). The analysis and modelling of tower is executed with the use of ANSYS software. The loads performing on the tower taken into consideration are dead load, live load and dynamic load. The maximum deformation, combined stresses, herbal frequencies and direct strain are acquired and plotted graphically.

Varakavi (2004) studied that transmission towers must be designed considering each structural and electrical requirement for a safe and affordable layout. Also studied loose vibrational (or) modal analysis characteristics of the transmission tower by determining the frequencies and mode shapes of transmission tower.

Harshil Patel (2011) performed comparative analysis of round monopole towers between two extensively used configurations straight and tapered. The tapered round section is more beneficial as compared with straight round phase. For the tapered section there is a much less general deformation as well as lesser quantity of normal stress.

Archana and Aswath (2016) determined the most economical section of a tower and its configuration as per IS 800. Analysis and design of four legged self-supporting 220 KV double circuit steel transmission line towers models with different sections. Towers with angle sections are most economical and effective section compared to other two sections (tabular, channel).

Avinash and Rajasekhar (2013) studied Analysis and designing of transmission tower using STAAD.PRO. Transmission tower optimized with employing the ‘X’ & ‘K’ bracings and by varying the sections examined using static analysis. Displacements are higher 96.44 mm in X direction in case of transmission tower modeled using K- bracing when compared to X bracing 89.36 mm.

Shiva Kumar and Vinay (2016) discussed about both guyed and free standing towers. The lattice towers are modelled in three different shapes and two different sections (pipe & angle). The objective is to produce a safe stable and optimum design. Different shapes and comparison of lattice towers are presented and conclusion is heavier towers are costlier have low displacement and frequency values.

Bharat Kumar and Rasagnya (2015) did analysis on how tower is modeled using constant parameters such as height, bracing system, angle sections, base widths, wind zone span, conductors and ground wire specifications. After completing the analysis, the study is done w.r.t deflections, stresses, axial forces, slenderness effect, critical sections and weight of tower. The transmission line tower structure is optimized for a 132KV double circuit w.r.t configuration and different materials as variable parameters

After review of the above literature, the model of the tower is restricted to a certain height (35m) and designed for different bracings (X, K and W bracing) with different cross sections (Angular and tubular).

III. MODELLING OF TOWER

The software used in this design is STAAD.Pro. It is more versatile and user friendly that offers features like static analysis, dynamic analysis, non- linear static analysis and non- linear dynamic push over analysis. In the study, from the loading point of view, dead load and wind load have taken into account. For generation of the model, analysis, design and verification of result, STAAD.PRO is the necessary choice. The wind load analysis is carried out based on IS 802 Part1- 1995. In this study, two different sections such as angular and tubular are considered for different bracing. Only angular and tubular sections are compared because they show small variation in the values in comparison of moment, displacement and steel take off when compared to other sections.

A. PLAN AND DIMENSION DETAILS

The specifications of tower of four legged self-supporting tower is as shown in Table I. The bracings used are X, K, W and the sections used as angular and tubular. Figure 1and 2 shows the plan and elevation of the tower for X-bracing. Figure 3 and 4 shows elevation of the tower.

Table I
Specifications of tower

Type of tower	220 kV double circuit 4 legged tower
Height of tower	35 m
Base of tower	10 m X 10 m
Vertical space between conductors	9 m

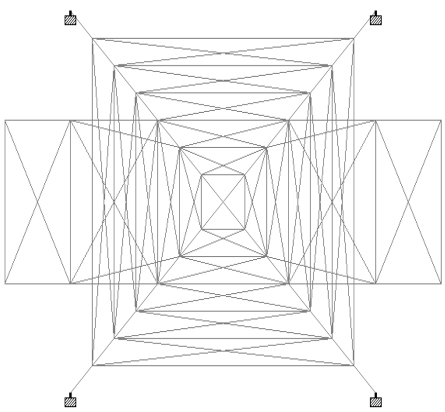

Fig. 1 Plan of the tower with X bracing

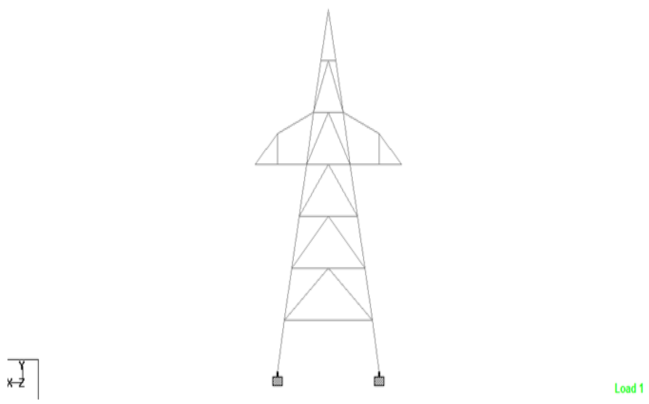

Fig. 2 Elevation of the tower

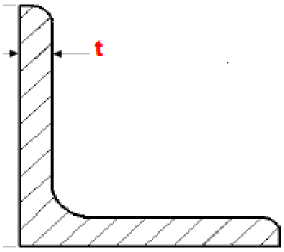

Fig. 3 Basic view of Angular section 200 mm X 200 mm X 25 mm

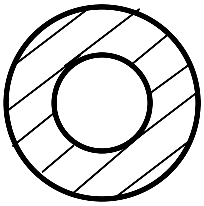

Fig. 4 Basic view of Tubular section 150mm diameter and 6 mm thickness

B. ASSIGNING SUPPORTS

Fixed supports are provided at the four legs of the tower of the transmission tower which are rigidly fixed to the foundation.

C. ASSIGNING LOADS

The load acting on the towers are:

1. Dead load. Self-weight of the tower and the conductors and wires. Figure 5 shows the assigning of dead load.
2. Wind load calculated as per IS 802 (Part1/sec 1): 1995

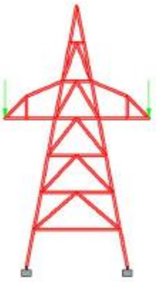

Fig. 5 Assigning dead load

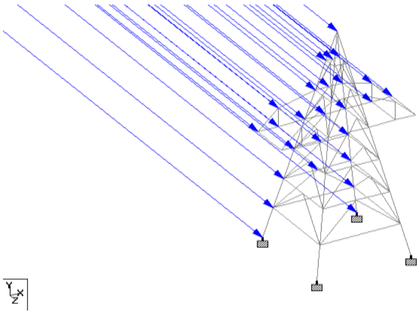

Fig. 6 Assigning Wind load in Z- Direction

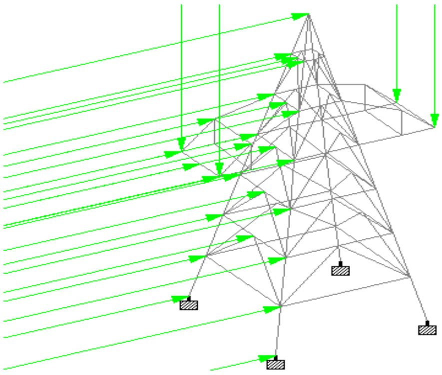

Fig. 7 Assigning of combination load

D. WIND LOAD CALCULATION

Metrological Reference wind speed (Vr)

Vr = Vb / Ko

As per IS 802, Visakhapatnam comes under Zone 5.

The average wind speed in Visakhapatnam is 9.6 miles per hour (50 m/s).

Vr = 50/ 1.375 = 36.36 m/s

K1 = 1.0 (reliability level 1 as voltage is less than 400 kV)

K2 = 1.08 terrain category 1

Vd = 36.36 x 1.0 x 1.08 = 39.27 m/s

Pd = 0.6 x 39.27 x 39.27 = 925 N/m2

Wind load on insulator wire (height of tower =35m) is 11.75 Kn

E. COMBINATION OF LOAD

The load combination has been created with the command of define combinations. As per Indian code, generate loads and assign to the structure. In this combination, the wind load in one direction (X or Z) is taken along with dead load. Figure 7 shows assigning of combination load.

F. ANALYSIS OF TOWER

After assigning the loads to the structure, analysis is done to evaluate the displacement, moment and steel take off for determining the economic section. After analysis, design can be obtained using STAAD. Pro

IV. RESULTS AND DISCUSSION

1. Fig 8 shows maximum bending moment for different types of sections for K-bracing. Tubular section has maximum value of 118975.5 N-mm than the remaining bracings. Angular section has less moment of 94318.5 N-mm. Angular section has 20.17% less moment than tubular section.
2. Fig 9 shows maximum bending moment for different types of sections for X-bracing. Tubular section has maximum value of 95100 N-mm than the remaining bracings. Angular section has less moment of 85984 N-mm. Angular section has 20.17% less moment than tubular section.
3. Fig 10 shows maximum bending moment for different types of sections for W-bracing. Tubular section has maximum value of 86866.4 N-mm than the remaining bracings. Angular section has less moment of 60799.4 N-mm. Angular section has 30% less moment than tubular section.
4. Fig 11 shows maximum displacement in X-direction for different types of sections for K bracing. Tubular section has maximum value of 2.96 mm than the remaining bracings. Angular section has less displacement of 2.85 mm. Angular section has 3.71% less displacement than tubular section
5. Fig 12 shows maximum displacement in X-direction for different types of sections for X bracing. Tubular section has maximum value of 4.75 mm than the remaining bracings. Angular section has less displacement of 4.06 mm. Angular section has 15.15% less displacement than tubular section.

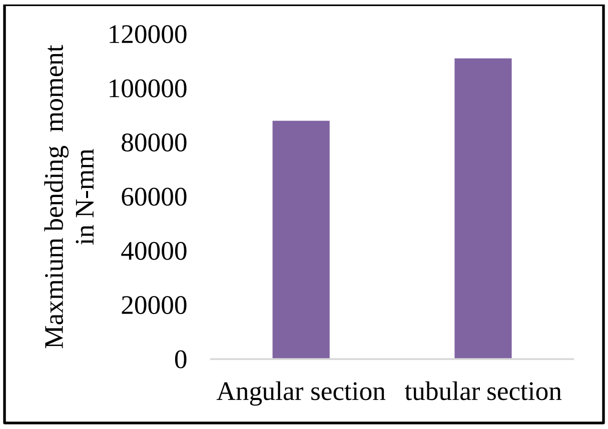

Fig. 8 Maximum bending moment in tower with K bracing for different sections

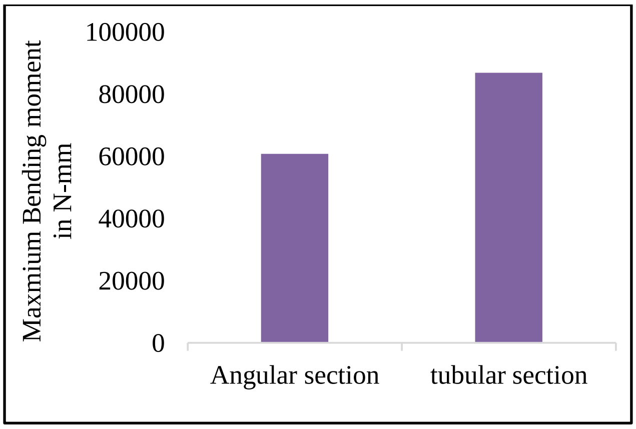

Fig. 9 Maximum bending moment in tower with X bracing for different sections

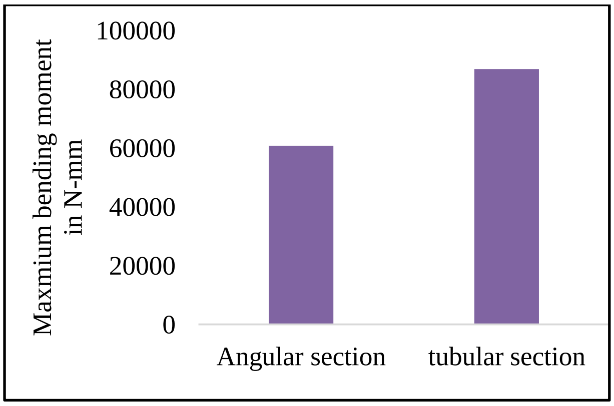

Fig.10 Maximum bending moment in tower with W bracing for different sections

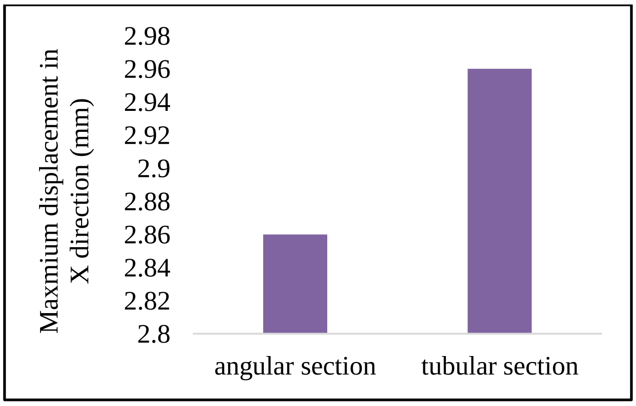

Fig. 11 Maximum displacement in tower with K bracing for different sections

6. Fig 13 shows maximum displacement in x-direction for different types of sections for W bracing. Tubular section has maximum value of 3.61 mm than the remaining bracings. Angular section has less displacement of 2.6 mm. Angular section has 27.97% less moment than tubular section. Angular section is efficient.
7. Fig 14 shows maximum displacement in Z-direction for different types of sections for X bracing. Tubular section has maximum value of 5.85 mm than the remaining bracings. Angular section has less displacement of 5.71 mm. Angular section has 2.56% less moment than tubular section. Angular section is efficient.

8. Fig 15 shows maximum displacement in Z-direction for different types of sections for W bracing. Tubular section has maximum value of 5.35 mm than the remaining bracings. Angular section has less displacement of 4.02 mm. Angular section has 24.8% less moment than tubular section. Angular section is efficient.
9. Fig 16 shows maximum displacement in Z-direction for different types of sections for K bracing. Tubular section has maximum value of 4.09 mm than the remaining bracings. Angular section has less displacement of 4.0 mm. Angular section has 2.2% less moment than tubular section. Angular section is efficient.
10. Fig 17 shows maximum Steel take off for different types of sections. Tubular section has maximum value of 168 kN than the remaining bracings. Angular section has less steel take off 141.3 kN. Angular section has 16.62% less steel take off compared to tubular section. Angular section is economical.

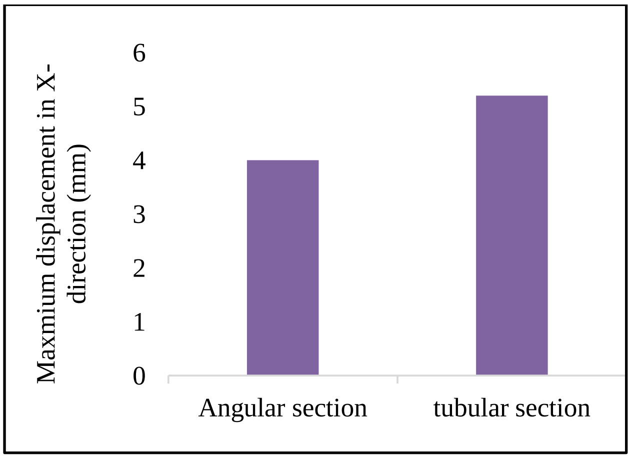

Fig. 12 Maximum displacement in tower with X bracing for different sections

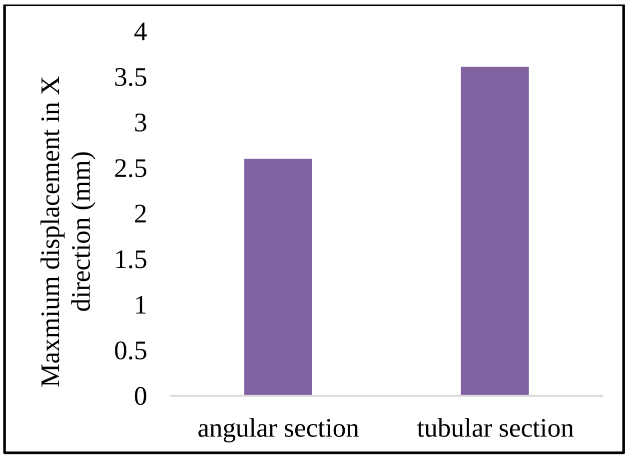

Fig. 13 Maximum displacement in tower with W bracing for different sections

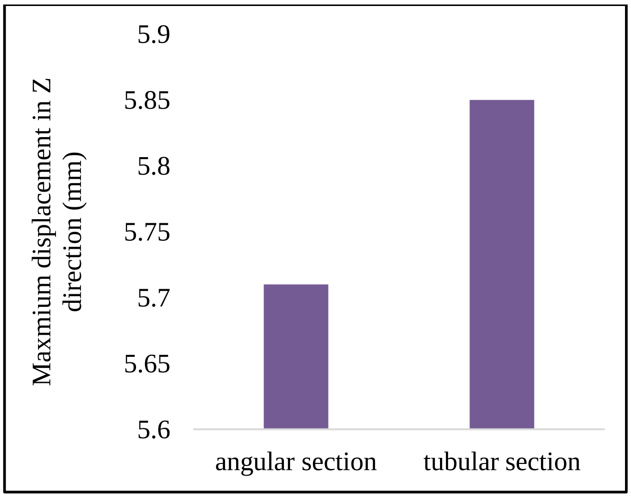

Fig. 14 Maximum displacement in tower with X bracing for different sections

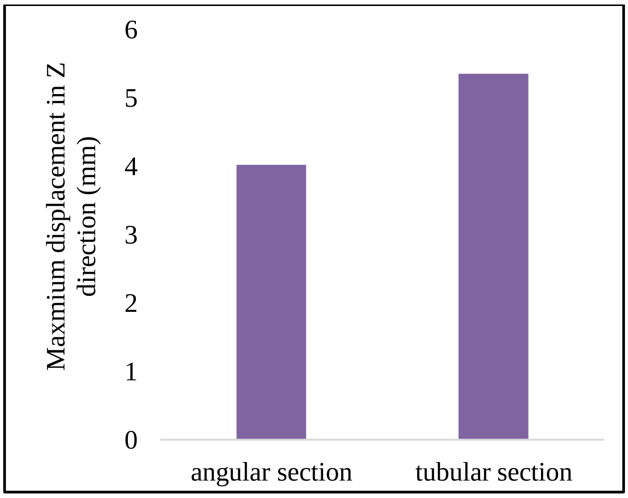

Fig. 15 Maximum displacement in tower with W bracing for different sections

11. Fig 18 shows maximum Steel take off for different types of sections. Tubular section has maximum value of 150 kN than the remaining bracings. Angular section has less steel take off 135.3 kN. Angular section has 14.62% less steel take off compared to tubular section. Angular section is economical.
12. Fig 19 shows maximum Steel take off for different types of sections. Tubular section has maximum value of 160 kN than the remaining bracings. Angular section has less steel take off 110.3 kN. Angular section has 16.62% less steel take off compared to tubular section. Angular section is economical

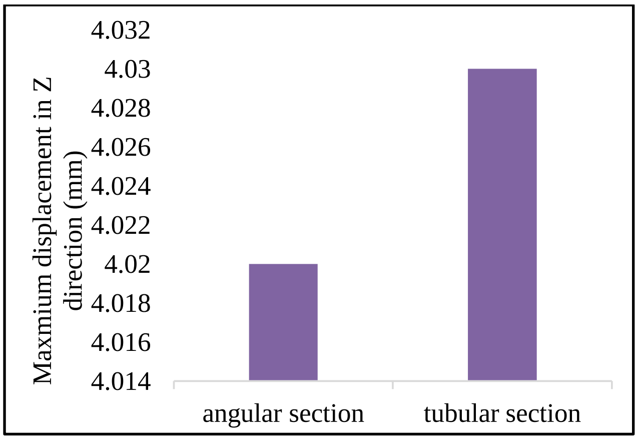

Fig. 16 Maximum displacement in tower with K bracing for different sections

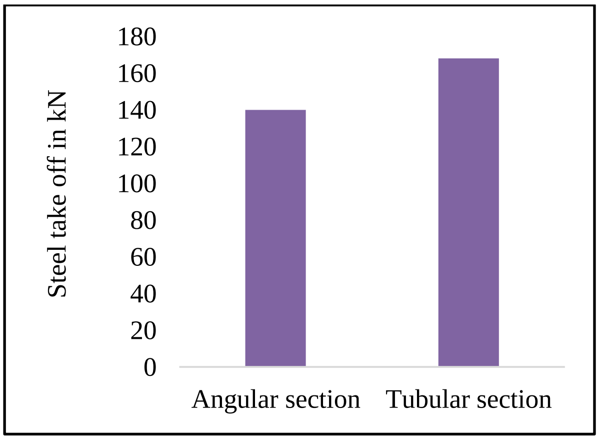

Fig. 17 Steel take off comparison of angular and tubular section for W bracing

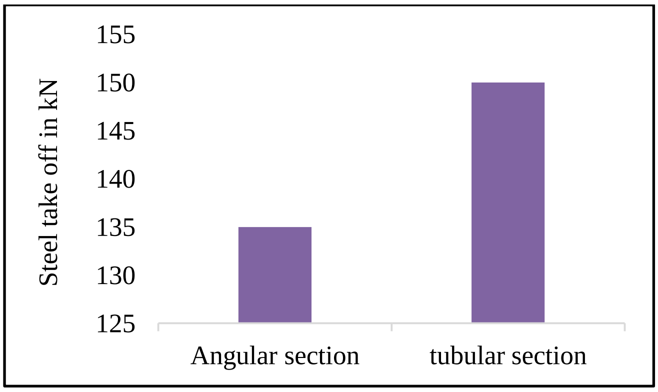

Fig.18 Steel take off comparison of angular and tubular section for K bracing

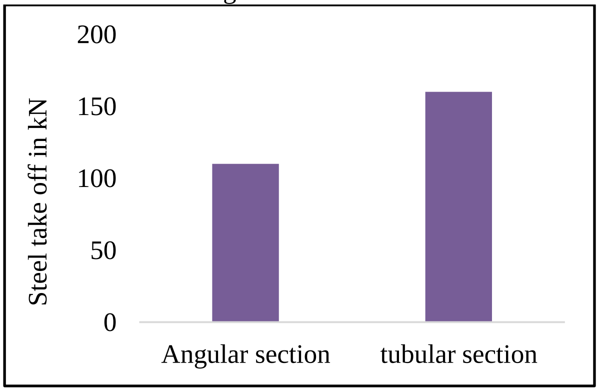

Fig.19 Steel take off comparison of angular and tubular section for X bracing

V. CONCLUSION

As all the towers are analyzed and designed, the following conclusions are made they are as follows:

1. The steel takeoff of the angular section is found to be 141.652 kN less than that of the tubular section which is found to be 168.54 kN.
2. Angular section saving a steel weight as 16.62% compared to tubular section.
3. The angular section is more economical than the tubular section.
4. The angular section is found to have the lesser amount of displacement throughout the height of the tower as compared with the tubular section. This implies that this section behaves more rigidly than the other section tower.
5. The angular sections are found to have lesser amount of moments in comparison with the other section of tower.

From the above analysis, it is concluded that angular section is more economical and more effective section than tubular section.

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