SSRG International Journal of Civil Engineering Volume 6 Issue 7, 13-16, July 2019
ISSN: 2348 – 8352 /doi:10.14445/23488352/IJCE-V6I7P103

Rectangular Base Plate Design For Supporting Angular Member

Md Arshad Jamal[#1], Karan Sharma[*2] Md Anas [#3], Babli Singh[#4]

[#1]Principal Structural Design Engineer, QACA, New Delhi

[2] Senior Structure Design Engineer, QACA, New Delhi

[3,4] Structure Design Engineer, QACA, New Delhi

Abstract

Design of base plate for the ground base tower and rooftop telecommunications tower, the rectangular base plate is designed to support the annular member. The rectangular base plate design for supporting I-section column can be found in many textbooks and IS code, but design procedure and solutions of rectangular base plate design for supporting angular member is not documented. In this paper, an analytical analysis of the base plate and stiffener plate design was given. The proposed finite element model analysis (FEA) result has been compared with the analytical design.

Keywords — *telecommunication tower, rectangular base plate, annular member, finite element analysis*

I. INTRODUCTION

Base plates are used to distribute the load from the compression member to the supporting concrete foundation. Depending on the column cross-section, base plates can be considered as rectangular or circular shapes. Rectangular base plates are obviously suitable for steel columns with I, W sections, double channel sections, or equal angle section.

Several different loading conditions are considered for the design of base plates. Under an axial load, the bearing pressure is uniformly distributed between the base plate and the supporting concrete. The base plate size and thickness can be easily determined based on the allowable concrete bearing capacity and design bearing stress. A minimum number of anchor bolts should be provided. In the case where the projection is large, or the loads are heavy, or the moments are applied, the thickness of the base plate may be reduced by the use of vertical plates or stiffeners.

The tower is a lattice truss structure which is designed by using equal angle member. Wind load is critical for the design of tower structure, uplift tower reaction has been slightly less than down thrust tower reaction, the base plate has been designed for axial compression, and anchor bolts are designed for axial tension & shear loads.

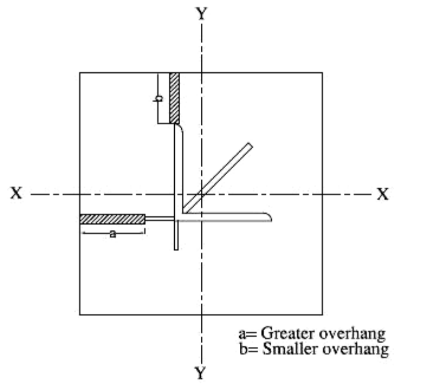
Usually, in transmission towers, basically, angle or dual angle member is embedded in the supporting chimney, and the plate is provided in the footing. Rectangular base plate with anchor bolts is used to support angular member in telecommunication towers, i.e., GBT (Ground base tower) and RTT (Rooftop tower), because telecommunication tower reaction is greater than transmission tower reaction.

II. ASSUMPTION IN ANALYSIS

The following assumptions are used to analyze the rectangular base plate for supporting angular member.

1. A base plate is having elastic behavior.
2. The maximum bearing stress is less than the allowable value of concrete.
3. The c.g (center of gravity) of the plate is matched with the c.g of the angle member.
4. The intensity of bearing stress effect on a full plate.
5. Uniform bearing pressure acts from the bottom of the plate.
6. All anchor bolts are in tension.
7. Shear force is equally distributed to the anchor bolts.
8. Tension force is equally distributed to the anchor bolts.

Load acting on the base plate is either fully axial compression or axial tension; due to this, bearing pressure is not varies and the bearing pressure is considered as uniform pressure. Base plate is bent in out plane bending. Maximum stress occurs at the end of the angle section and at the edge of the angle section. In the design of the plate, the thickness of the plate is calculated as per the cantilever portion of the plate in fig.1, and a stiffener is designed for the out-of-plane bending of the plate. Out of plane bending stiffness is critical, so the section is increased by providing the stiffener plate to counteract the maximum bending. The cantilever portion of the base plate is also managed by providing the stiffener, so stiffener is provided at that portion in the base plate, which helps in reducing the cantilever portion and increasing stiffness at out of plane bending of the plate. The stiffener is also helping to increase the length of the weld between the base plate and angle section. Stiffener added with the main angle section as the smaller overhang from the main angle end and greater overhang from the other side mention in fig1.



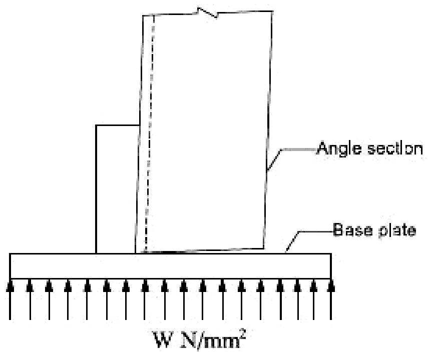


Fig 2

III. ANALYTICAL DESIGN METHODS

Design of base plate according to the philosophy of Limit State Method as per the IS 800:2007.

A. Thickness of plate

Fig. 1 and Fig.2 show the plan and elevation views respectively of the rectangular base plate with the angular member under tower loads. It is assumed that the maximum bending moment occurs at the end of the stiffener. The plate bends simultaneously about the two principal axes of the plate. The stress caused by bending about one axis is influenced by the stress due to bending about the other axis. Poisson's ratio of 0.3 is used to account for this.

The net moment of the plate is

$$M_{\text{net}} = \frac{w}{2}(a^2 - 0.3b^2) \qquad (1)$$

The moment capacity of the plate is

$$M_p = 1.2\frac{f}{\gamma_{mo}}{}_y Ze \qquad (2)$$

The thickness of the base plate is

$$t_s = \sqrt{2.5w(a^2 - 0.3b^2)\frac{\gamma mo}{fy}} \qquad (3)$$

Where w= intensity of bearing pressure from the concrete below the base plate; a=greater overhang projection; b=smaller overhang projection;fy=yield stress of the steel; Z_e=elastic sectional modulus of the plate; γ_{mo} =partial safety factor for material governed by yielding.

In Eq.(1), the net moment of the plate is given for the unit strip in both orthogonal directions shown in fig.1.

In Eq.(2), given the moment capacity of a unit strip of the base plate

The thickness of the base plate determined from Eq.(3) should be more than the thickness of the angular member.

B. Foundation Bolts

Foundation bolts, also called anchor bolts, are generally provided to resist the uplift load. In the design of the tower base, plate uplift load is heavy, so the design of anchor bolts are required to be check; these bolts are either anchored into the foundation by hook or by a washer plate or by some other appropriate load distributing member embedded in the concrete.

Anchor bolts are designed for the maximum uplift and shear load by the tower that is distributed equally in each bolt.

The tensile strength of the bolt,

$$T_{db} = \frac{T_{nb}}{\gamma_{mb}} \qquad (4)$$

$$T_{nb} = 0.9\, f_{ub} A_{nb} < f_{yb} A_{sb} \frac{\gamma_{mb}}{\gamma_{mo}} \qquad (5)$$

where A_{nb}= area of the bolt at the root of the thread (stress area) in mm²; f_{ub}=ultimate stress of bolt;f_{yb}=yield stress of the bolt; γ_{mo} =partial safety factor =1.25

The length of the bolt,

$$l = \frac{d}{4\tau_{bd}} \times \frac{f_y}{\gamma_{mo}} \qquad (6)$$

where d = diameter of the bolt in mm; τ_{bd} =bond stress in N/mm² ; γ_{m0} = partial safety factor =1.10

C. Stiffener

The stiffener is provided for increasing the out plane bending strength of the plate, so it reduces the bending stress in the base plate. In other words, it reduces the thickness of the base plate without violating the allowable stress. When stiffeners are added to the base plate, it alters the rotational behavior towards a more rigid connection. In the analysis of telecommunication, tower supports are pinned, so the base plate is designed for axial compression, tension, and shear load.

The stiffener is part of the main angle section, so no need to be check-in buckling resistance, bearing strength of stiffener . stiffener and connection to main leg is design for the shear force at the stiffener location.

The design shear strength of the plate is

$$V_P = \frac{d \times t \times f_y}{\sqrt{3} \times \gamma_{mo}} \quad (7)$$

where d= depth of stiffener plate; t=thickness of stiffener plate; fy=yield stress of the steel; γ_{mo} =partial safety factor for material governed by yielding.

The size and number of stiffeners are also depends on the out plane bending stiffness along the axis shown in fig3.1-1 and 2-2 is out of plane bending axis.

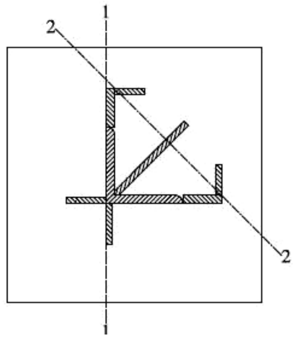


Fig 3

Design bending strength at the critical section

$$M_P = 1.2 \frac{f_y}{\gamma_{mo}} Z_e \quad (8)$$

Where fy=yield stress of the steel; γ_{mo} =partial safety factor for material governed by yielding; Z_e = Sectional modulus of a critical section of the plate.

IV. FINITE ELEMENT METHOD ANALYSIS

STAAD Pro program is implementing for designed finite element model.

Pre - Processing, material properties of steel E 250 (Fe 410 W) A as per IS 2062 are followed; Yield stress Fy=250MPa, Ultimate tensile stress Fu=410MPa; the Unit mass of steel ρ=7.85KN/m³; Modulus of elasticity E=2x105MPa; Poisson ratio,μ=0.3. In this study, a plate element is used to create a model.

Solve –Processing, computer-aid engineering analyses stress and strain, provide area support to the model as allowable stress forgiven grade of concrete.

Processing, the results are displayed in the form of the numerical value of stress and strain. Base pressure, shear stress, and element moment. Check the node displacement of the model.

V. DESIGN MODEL

The model is shown in fig 4, and the size of the base plate and stiffener as follows.

Size of base plate = 500x500mm
The thickness of base plate = 30mm
The diameter of anchor bolts = 36 mm
Number of anchor bolts = 6
Size of stiffener S1 = 80x200x12
Size of stiffener S2 = 80x200x16
Size of stiffener S3 = 60x200x12
Size of stiffener s4 = 200x200x12
Size of angle = ISA150X150X16
Grade of concrete of pedestal M20
Factored downward load = 997kN

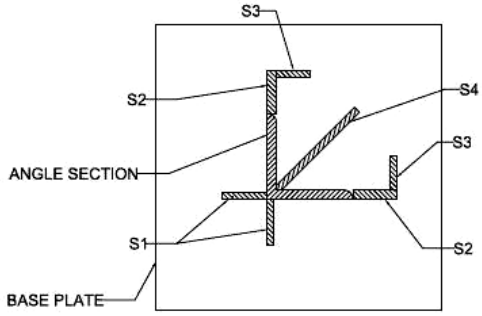
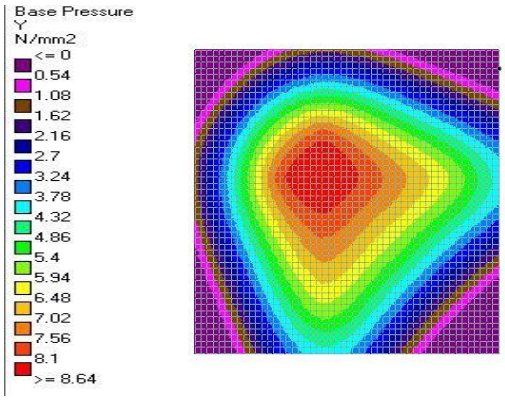


Fig 4

VI. FEM ANALYSIS RESULT

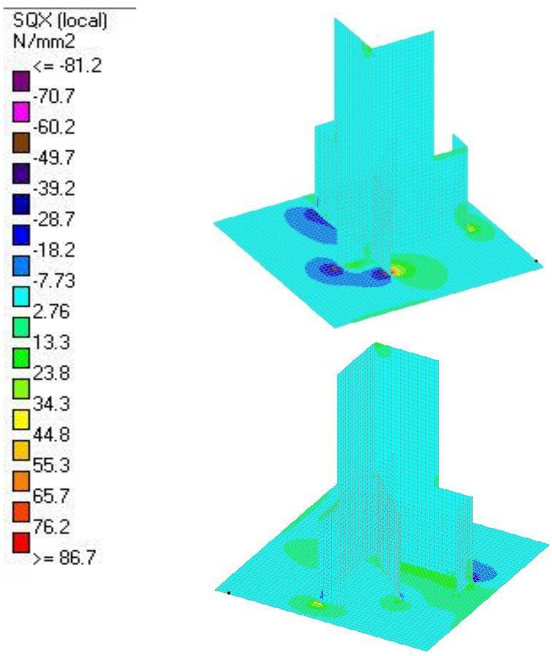
A. Distribution of bearing pressure

Base pressure non uniformly distributed in the plate, but that is less than 9N/mm² for the M20 grade of the concrete pedestal.



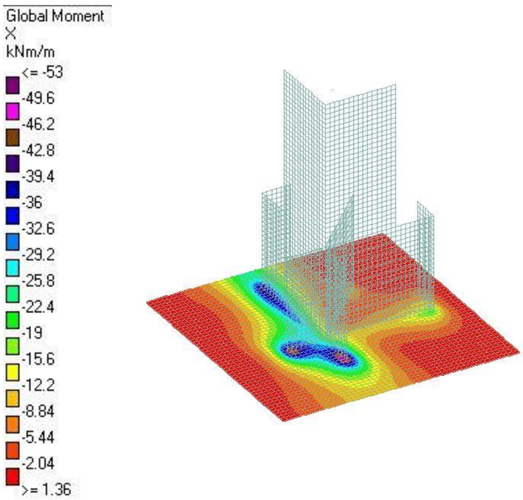
B. Shear stress in the plate

Shear stress in the base plate is less the permissible shear stress that is less than 131.21N/mm² for Fe410.



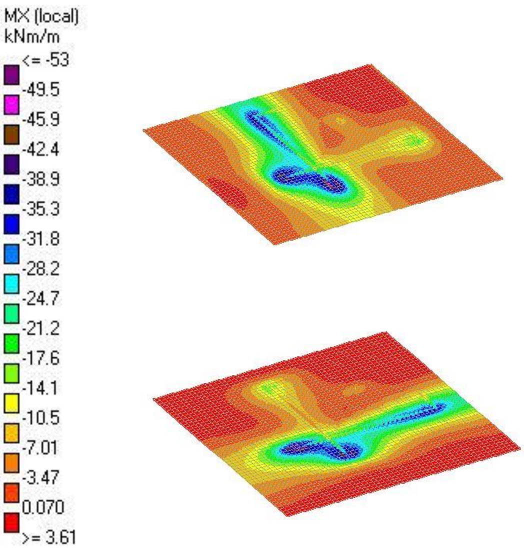
C. Global moment

The stiffener is designed for out of plane bending of the base plate. This value is less than that value calculated in Eqn 8.



D. Plate bending moment

The thickness of the plate can be calculated as per the bending moment of the plate by using Eqn 2.



VII. COMPARISION OF RESULTS

The analytical analysis results compare with the FEM analysis.

TABLE I

Analysis results			
	Units	***Analytical result***	***FEM result***
Bending moment of plate	kNm/m	29.7	31
Global moment	kNm/m	43	42.8

VIII. CONCLUSIONS

The equation is presented for the design of a rectangular base plate for supporting angular member. A plate having out plane bending behavior, design of this base plate stiffener is important for supporting element. After comparison the analysis results, we conclude the both BM is nearly equal. The size of the stiffener has an effect on stress concentration at the base of the column, and the higher stiffener plate results from decreases in stress concentration.

ACKNOWLEDGMENT

The authors would like to thanks the Quality Austria Central Asia, New Delhi, India, Design department for the facility and financial support.

REFERENCES

[1] American Institute of Steel Construction (AISC). (1990). Column base plates, Chicago.
[2] General Construction in Steel (IS 800:2007) –Code of practice.
[3] Ali K Ravari, Ismail Bin Othman and Zainah Binti Ibrahim, Finite element analysis of bolted column base connection without and with stiffeners., International Journal of the Physical Sciences.,6(4),(2011), 1-7.
[4] S. Chaithanya Raja, Dr. J. Rajasankar, Dr. J. Guru Jawahar, Blast Response Studies on Metallic Tube Core Sandwich Panels, SSRG International Journal of Civil Engineering 2(6) (2015) 25-31.
[5] Dajin Liu, Circular base plates with large eccentric loads Practice periodical on structural design and construction, ASCE MAY .,(2004).
[6] Luangsod, Tempiam, Fongsamootr, Chartpuk., Stress analysis of stiffener plate at the base of the overhanging traffic signpost under the effect of vehicle –induced gusts,
[7] Design of steel structure, Eurocode 3 Part 1-1
[8] James M, Lawrence A KLOIBER, Baseplate and anchor rod design, America n Institute of Steel Construction.