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Bearing Capacity Analysis of N90T20 Rack Column Under Eccentric Compression

Jianing HAO
Sichuan College of Architecture Technology, Deyang, Sichuan, 618000, China
xd1988719@163.com[1]

Abstract. The bearing capacity of cold-formed porous steel N90T20 rack column is studied, the eccentric positions, the spacing between holes, column thickness are discussed in details. The results obtained from this study demonstrate that when eccentric space is small, eccentric compression weaken column ultimate bearing capacity is small. From the results, it is clear that when eccentric space is large, eccentric compression can cause the column ultimate bearing capacity of plummeting. If the eccentricity is close proximity to the web, the ultimate bearing capacity declines to be smaller than the eccentric near the curling side of the column. The spacing of the holes on the column web do not present significant effect to the ultimate bearing capacity of the column. The wall thickness of column component greatly influence on the ultimate bearing capacity of the columns. This study makes contribution to the N90T20 rack design in the engineering practice and research areas.

1. Introduction

N90T series of Cold - formed porous steel is widely used in society, it has many advantages, like high space utilization, good accessibility, and low cost. Eccentric compression will decline the ultimate bearing capacity of the column, especially with a large eccentricity. When the column has a large eccentric compression, the column's ultimate bearing capacity will decline a lot, it will also affect the column's stability[1-2]. In this paper, the bearing capacity of the cold-formed porous steel N90T20 rack column is simulated by using the finite element simulation software ANSYS. The influence of different eccentric position, the distance between the holes and the thickness of the component on the ultimate bearing capacity is studied.

2. Finite Element Model

Section Dimension. The N90T20 rack column is made of cold-formed steel, its section symmetries along the axis of the single axis. There is a 8mm height rib stiffener on the web plate, fillet radius is 4mm, component thickness is 2mm. A diameter of 10.5mm hole is in the front flange and the rear flange. A 16x22 rectangle + a 8mm radius semicircle hole is in the web plate, the distance between the two holes is 45mm, the length of the column is

* Corresponding author:xd1988719@163.com

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1000mm. The section of the N90T20 rack column is shown in Figure 1, the holes in N90T20 rack column web plate is shown in Figure 2.

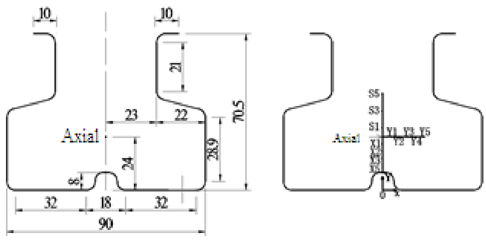

Fig 1 Section and eccentric position of N90T20 column

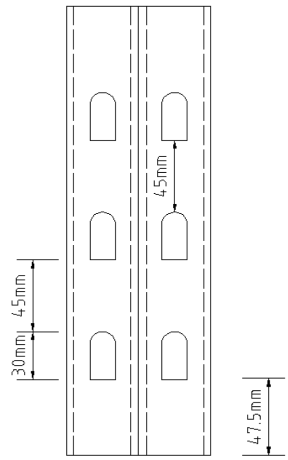

Fig 2 The opening situation in the web of rack N90T20 rack column

Establishment of the Model. ANSYS provides a lot of Shell Elements which is convenient used for the modeling of the thin-walled structures, and can get accurate results. According to the experimental method and the components' properties, Shell Element SHELLI81 is selected. The model is built on the XY plane, Z direction is along the length. Using bottom-up modeling method, first create the key point according to the column section size, then create the line, drag the line to form the surface, finally using Boolean operations to open holes. For eccentric loading more easily, a cover plate is added to the two ends of the column[3].

Column component::Elastic Modulus E=200000Mpa, Poisson Ratio μ=0.3, Yield Strength fy=245Mpa, Tangent Modulus Et=0.02E. The cover plate on the two ends of the column: Elastic Modulus E=200000000Mpa, Poisson Ratio μ=0.3, Yield Strength fy=245Mpa, Tangent Modulus Et=0.02E.

The coordinate system is set up on the cross section of the column, as shown in Figure 1. The section axis coordinate is (0, 24). Since the cross section is symmetric along the Y axis, choice five eccentric points Y1-Y5 along the X axis positive direction. The distance between each point is 37.5mm. Choice three eccentric points S1, S3, S5 along the Y axis positive direction, the distance between S1 and axis is 3.86mm, the distance between S3 and S1 is 7.78mm, the distance between S5 and S3 is 7.78mm. Choice four eccentric points X1, X2, X3, X5 along the Y axis negative direction, the distance between axis, X1, X2, X3 is 3.22mm; the distance between X5 and X3 is 6.44mm.

When divide the mesh, the place nearby the holes in the web plate and the flange will exist stress concentration, the stress is more complex, and the stress change a lot. Therefore, the mesh surround the holes is divided more dense in order to adapt to the change of stress gradient. The structure's finite element model is show in Fig 3.The column is hinged at both ends, and the two ends of the column can't occur horizontal sliding and warping. The X, Y direction movement of all nodes in the upper section of the model is prevented. The X, Y, Z direction movement of all nodes in the lower end section of the model is prevented.

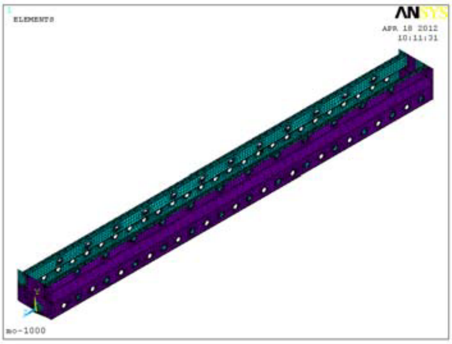

Fig 3 The structure's finite element model

3. Calculation Result Analysis

The load displacement curve of the structure under axial pressure is shown in Fig 4. The structure' s ultimate bearing capacity with different load position are shown in Fig 5 ~ Fig 7.

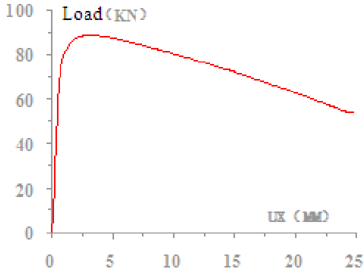

Fig 4 Axial load displacement curve

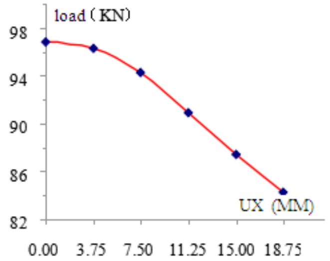

Fig 5 X axis eccentricity ultimate load curve

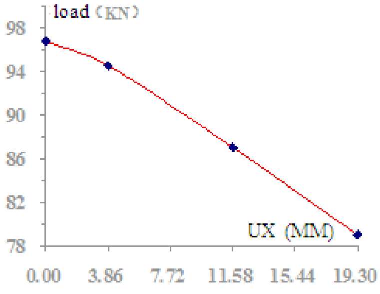

Fig 6 Y axis positive direction eccentricity ultimate load curve

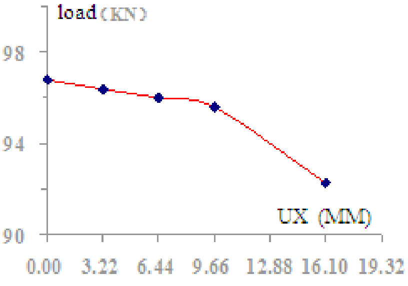

Fig 7 Y axis negative direction eccentricity ultimate load curve

According to Fig 5 and the calculation of the ultimate bearing capacity, when the eccentric along the X axis is short, the bearing capacity of the column reduce little.; when the eccentricity greater than 7.5mm, the bearing capacity of the column decreases obvious. With the increase of eccentricity, the decrease rate of the ultimate bearing capacity is increasing.

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From Fig 6 and Fig 7, when the eccentric changes along the Y axis direction, the column's bearing capacity drop rate increases with the increase of eccentricity. From Y axis positive direction and negative direction eccentricity ultimate load curve, the ultimate load decreases more serious when the eccentric near the edge of the roll than the eccentric near the web plate. When the eccentricity move along the web plate, the column's bearing capacity decreases slowly. So it can be concluded that when the eccentric moves along the edge of the roll, its impact on the decrease of the column's bearing capacity is more greater. In real design and use, we should try to avoid the eccentric move to the edge of the roll, resulting in the column's bearing capacity decreases rapidly.

Maintain the thickness of the components of 2.0mm, change the web plate hole spacing, the hole spacing is 30mm, 45mm, 60mm, analysis their ultimate bearing capacity. The influence of different eccentric and web plate hole spacing on the load displacement curve are shown in Fig 8 ~ Fig 9.

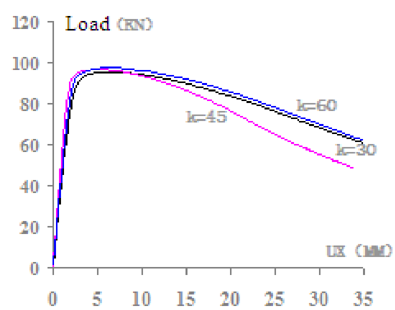

Fig 8 Load displacement curves of different hole spacing under axis load

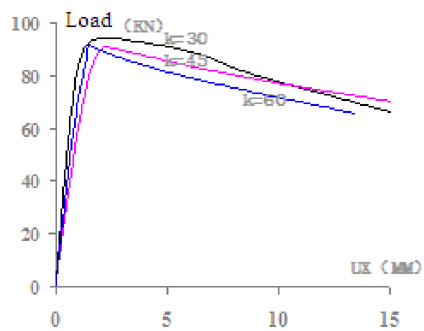

Fig 9 Load displacement curves of different hole spacing in eccentric Y3

From Fig 8 ~ Fig 9, it can be found that the ultimate bearing capacity changes little while the hole spacing changes. The three hole spacing's load displacement curves basically coincide under the axis load and eccentric load. It can be concluded that the hole spacing has little effect on the axial and eccentric bearing capacity of the column, which can provide a theoretical support for the variety of hole spacing.

In fact, the column's wall thickness has many types, this is based on the use of its functions. Keep web plate hole spacing 45mm, analysis the column's ultimate bearing capacity with three wall thickness: 1.5mm, 2.0mm, 2.5mm. The influence of different eccentric and wall thickness on the load displacement curve are shown in Fig 10 ~ Fig 11.

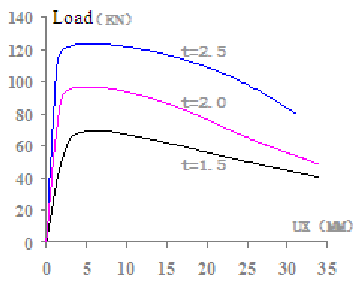

Fig 10 Load displacement curves of different wall thickness under axis load

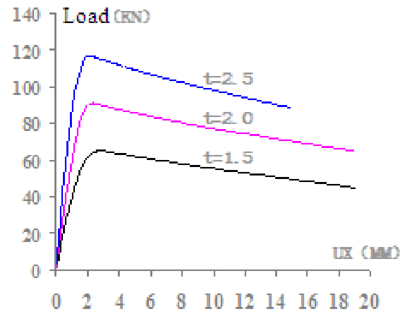

Fig 11 Load displacement curves of different wall thickness in eccentric Y3

From Fig 10 ~ Fig 11, it can be found that the curves are basically parallel to the line. The wall thickness difference 0.5mm, the ultimate bearing capacity difference 20~30kN, it shows that the wall thickness of the rack column has great influence on the axial and eccentric ultimate bearing capacity.

4. Conclusions

1. With the increase of eccentricity, the ultimate bearing capacity of the column is decreased. When the eccentricity is short, the bearing capacity of the column reduce little.; when the eccentricity greater than 7.5mm, the bearing capacity of the column decreases obvious.

2. The ultimate bearing capacity of the column decreases more when the eccentric near the edge of the roll than the eccentric near the web plate. Therefore, in the design and use, the eccentric position should avoid moving to the edge of the roll.

3.The hole spacing in the web plate has little influence on the ultimate bearing capacity of the column.

4.The wall thickness has great influence on the ultimate bearing capacity of the column. The wall thickness difference 0.5mm, the ultimate bearing capacity difference 20~30kN.

In this paper, the influences of the eccentricity on the ultimate bearing capacity of the column should be considered in the engineering practice. If we need to save the material, we can reduce the hole spacing in the web plate, that is, increase the number of holes in a reasonable range.

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