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## The Effect of Opening Position in the Rectangular Concrete Beams on the Size and Weight of Steel Consumption

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### Abstract

In the construction of modern buildings, many pipes and ducts are necessary to accommodate essential services like water supply, sewage, air-conditioning, electricity, telephone, and computer network usually these pipes and ducts are placed underneath the soffit of the beam and, for aesthetic reasons, are covered by a suspended ceiling, thus creating a dead space that adds to the overall building height depends on the number and depth of ducts to be accommodated. To avoid increasing the height of the ceiling and dead weight floor, it is better that pipes and ducts pass from the beams of ceiling for this purpose beams should be designed in the form of opening. In this paper, opening position is beam height. Also in this article is investigated, the effect of the presence or absence of openings in the beam height on the tensile, compressive and shear steel in reinforced concrete beams. For this purpose, the program is provided by matlab. The results show that changes in cross-sectional dimensions and position of opening cause to change the amount of area tensile, compressive and shear steel, and the total weight of the steel in reinforced concrete sections.

**Keywords:** reinforced concrete beam with opening, the amount of used steel.

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### 1. Introduction

In modern building construction, transverse openings in reinforced concrete beams are often provided for the passage of utility ducts and pipes. These ducts are necessary in order to

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accommodate essential services such as water supply, electricity, telephone, and computer network. These ducts and pipes are usually placed underneath the soffit of the beam and for aesthetic reasons, a recovered by a suspended ceiling, thus creating a dead space. In each floor, the height of this dead space adds to the overall height of the building depending on the number and depth of ducts. Therefore web openings enable the designer to reduce the height of the structure, especially with regard to tall building construction, thus leading to a highly economical design.

The presence of transverse openings will transform simple beam behaviour into a more complex behaviour, as they induce a sudden change in the dimension of the beam's cross section. However, as the opening represents a source of weakness, the failure plane always passes through the opening. The ultimate strength, shear strength, crack width and stiffness may also be seriously affected.

Furthermore, the provision of openings produces discontinuities or disturbances in the normal flow of stresses, thus leading to stress concentration and early cracking around the opening region. Similar to any discontinuity, special reinforcement or enclosing of the opening close to its periphery, should therefore be provided in sufficient quantity to control crack widths and prevent possible premature failure of the beam. This section presents the classification of Reinforced Concrete (RC) beams with circular openings based on the opening's size and position.

### **The method used in this paper:**

1. The algorithm for the design of concrete beams with openings based on regulations Iran.
2. To avoid from this, it considered that shear force is limited according to regulations Iran to prevent increasing the diameter of the hole.

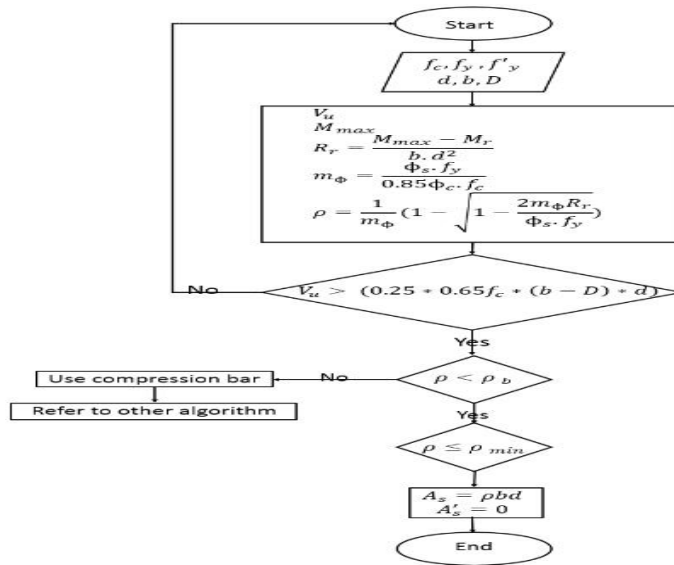


Figure 1: Rectangular concrete beam design algorithm

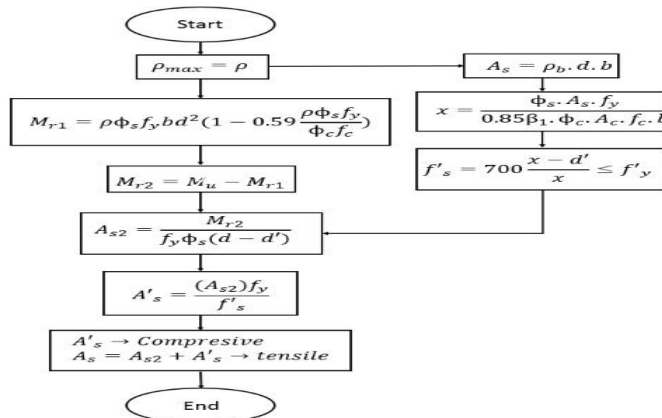


Figure 2: Rectangular concrete beam design with compressive bars algorithm

3. The use of shear force to obtain stirrups area and Rebar reinforcement.

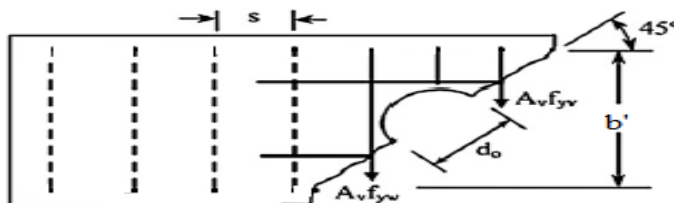


Figure 3: shear resistance  $V_s$  provided by shear reinforcement at an opening

Shear across the failure plane are those by the sides of the opening within the distance of  $(b' - d_o)$  :

$$V_s = \frac{A_v f_{yv}}{S} (b' - d_o)$$

Where  $b'$  is width of beam width and  $d_o$  is diameter of opening  $A_v$  is area of shear stirrups and  $f_{yv}$  is yield strength of stirrups. According to references of (2).

## Results and Discussion

As can be seen by increasing the diameter of the hole due to limitations intended to diameter hole cut in the area of tensile steel was low at the beginning of beam and in the middle of beam with increases bending and decreases of shear it will increases. But the area of compressive steel beam is zero because diameter hole is small. Also in the area of shear steel will increases at the beginning of beam and in the middle of beam with increases bending and decreases of shear it will decreases also this method is true for the weight of shear steel at the beam. And also by increasing the diameter of the hole can be seen that the total amount of steel consumption increases.

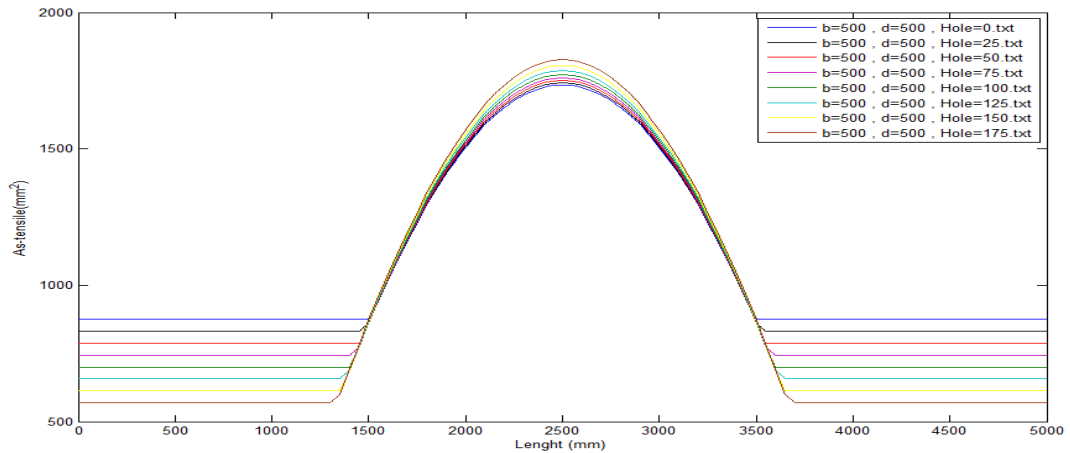


Figure 4: The area of tensile bars ( $mm^2$ ), according to length (mm)

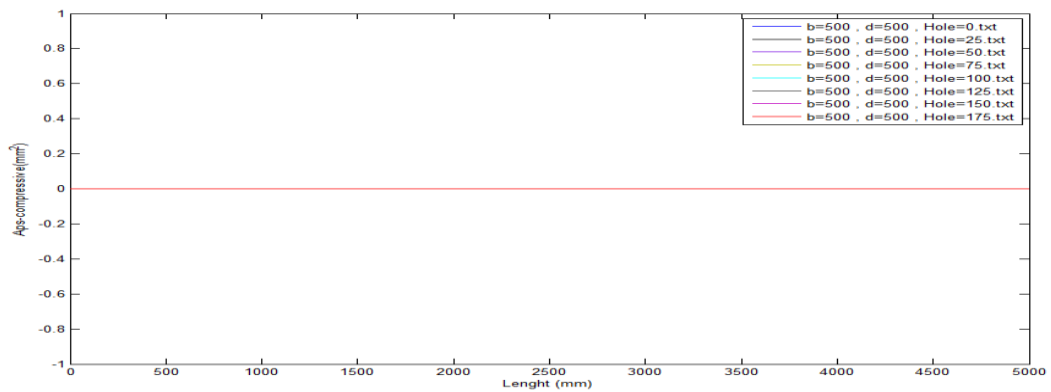


Figure 5: The area of compression bars ( $mm^2$ ), according to length (mm)

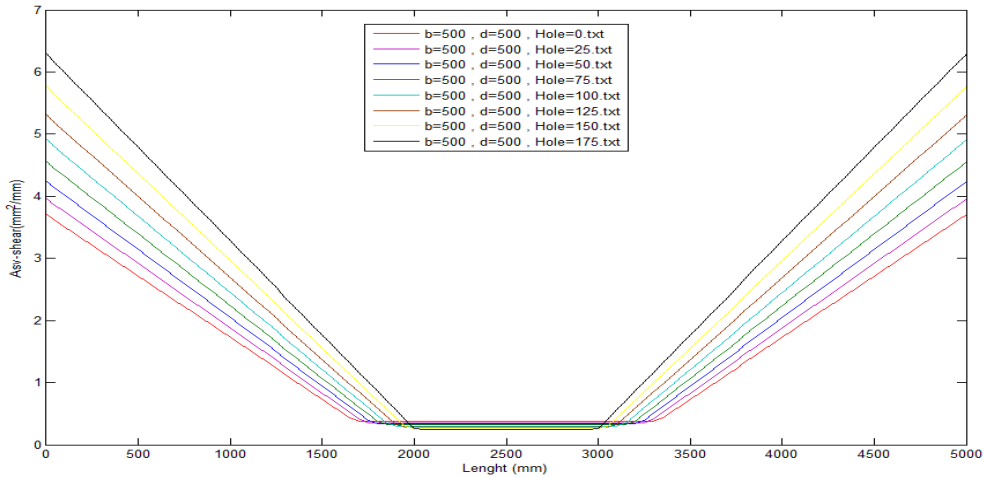
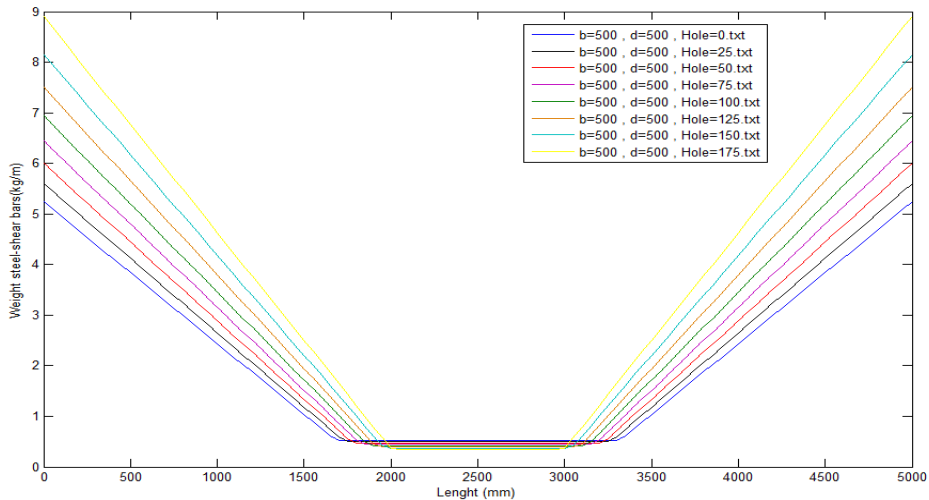


Figure 6: stirrups area and Rebar reinforcement (mm<sup>2</sup>/mm), according to length (mm)



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Figure 7: The weight of stirrups area and Rebar reinforcement (kg/m), according to length (mm)

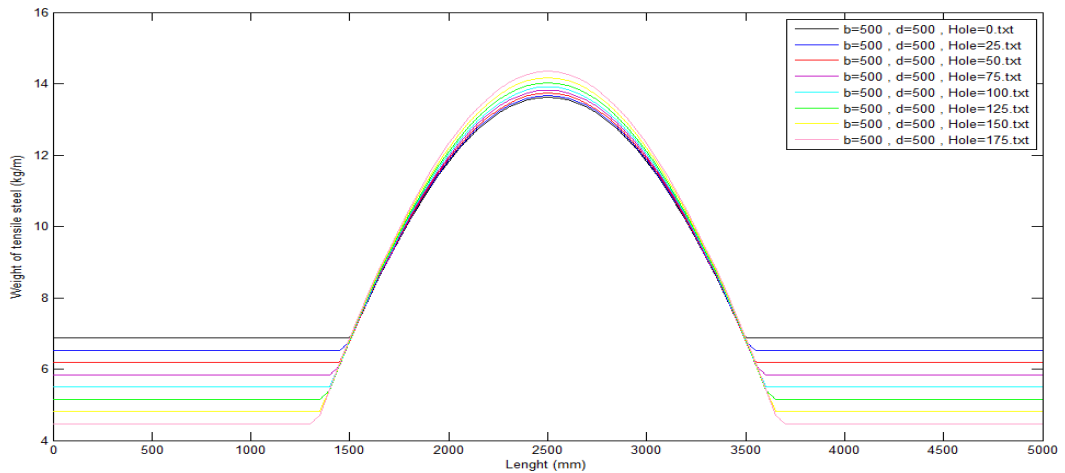


Figure 8: The weight of tensile steel (kg/m), according to length (mm)

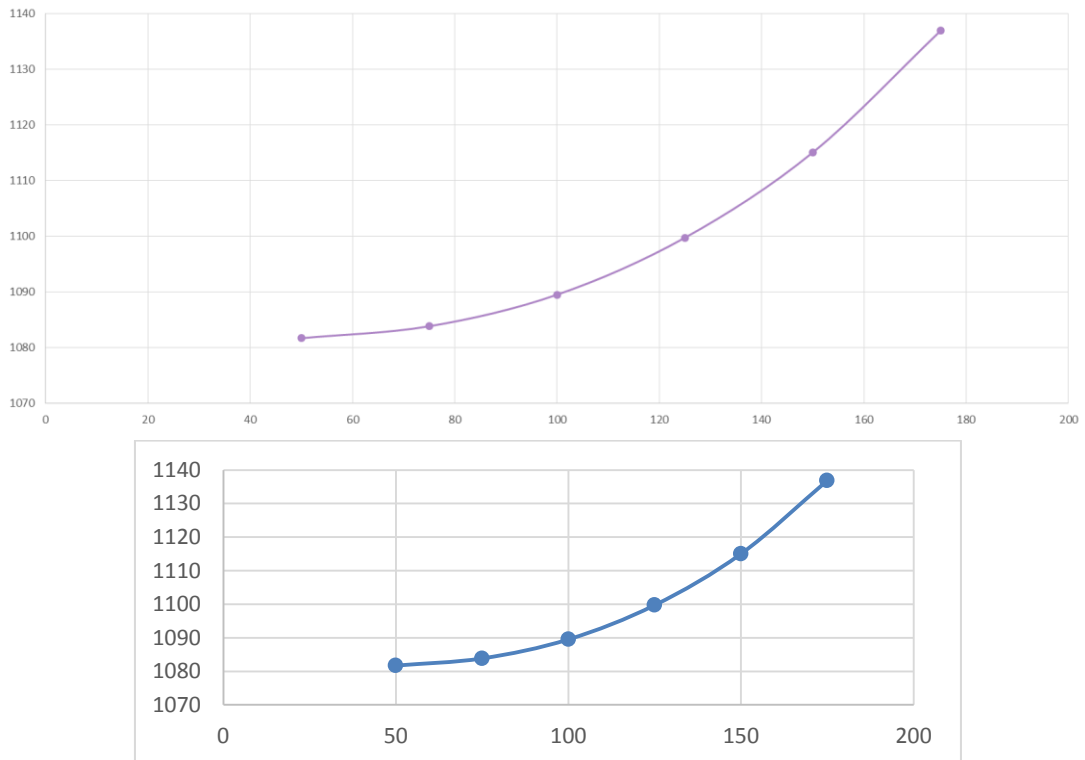


Figure 9: The total weight of steel (kg/m), according to diameter (mm)

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