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Analysis and Design of Column Piers of Non-Conventional Sections using MATLAB

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ABSTRACT

This project proposes to develop the interaction diagram for nonconventional column piers. Design charts will be developed for bridge piers subjected to axial compression and any axial bending for Indian Road Congress IRC: 112-2011 using MATLAB software for all grades of concrete and steel. The behavior of column subjected to axial compression with any axial bending is understood from collected literatures. The rectangular stress block will be considered for concrete to the design calculations as per IRC: 112-2011 cl 8.2 (A-2). Charts are will be created for four side arrangement. The MATLAB coding will be done for various neutral axis and percentage of reinforcements. Sections considered are hollow rectangular, hollow circular, which can be used in the bridge piers as an alternative to the conventional sections like square, rectangular, circular, etc. After preparing the design charts, the solid and hollow sections are compared.

Keywords: Interaction diagram, bridge piers, neutral axis, reinforcements, MATLAB, hollow rectangular, hollow circular.

1 Introduction

A column or pier is generally a compression member supporting beams, slabs and decks in a structural system. If the column in a structural system gets failed, then the structure may collapse. So we have to be careful in analysis and design of columns. Structural members carrying vertical loads in bridges withstand normal force and biaxial moments caused by eccentricity of traffic load. For biaxial moments, the analysis and design of compression member is complex. Because the neutral axis and its inclination have to be found in order to satisfy the equilibrium equations. Therefore, the design of equations in design is impractical without that aid of a computer program. The method of designing reinforced concrete column has followed a zigzag course during the past years. When the elastic theory was adopted for the design of flexural members, it was seemed consistent to accept the same theory for the design of compression members. As the shortcomings of the elastic theory were gradually recognized, the ultimate strength method was again introduced on a limit state basis as IRC: 112-2011. This study uses a computer program to design reinforced concrete short columns under axial load, uniaxial and biaxial bending. This study presents the method in its simplest form with the equations of the analysis, the derivations, and the computer program based on MATLAB, the interaction diagrams to aid in their application. The interaction diagrams have



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been used as practical tool for a design engineers.

2 Recent Works

A brief review of literature on analysis and design of compression and bending is presented in the following sections reported and discussed. Agha et al., (2018), carried an investigation work on effect of load eccentricity on the strength of concrete columns. The objective of this study is to investigate the effect of load eccentricity on reinforced concrete column strength taking into account the variables. Minnet et al, (2006) focused on the MATLAB programming which encourages a more logical approach for problem solving. They chose MATLAB programming for the flexibility in data presentation and interactivity. Gigliotti et al., (2008) a new analytical formulation of stress block parameters for confined concrete evaluated the rectangular stress block parameters by using classic section analytical model for different type of transverse reinforcements. Symbolic et al., made the new interaction diagrams by using equilibrium method for circular cross section for high strength concrete grades according to HRN EN 1992-1-1.

3 Materials and Methods

This part briefly explains the methodology adopted in this experimental work. It also includes collection design charts of uniaxial and biaxial bending in for different characteristic strength of concrete. Amount of reinforcement, moments, axial loads, neutral axis and area of concrete. We can design the column section by using these charts. Coding is done in the script option in MATLAB software.

4 Results and Discussion

4.1 Comparison of both Solid and Hollow Rectangular and Circular Sections

In this section, we can compare both solid and hollow sections using same dimension, grade of concrete, grade of steel, and percentage of reinforcement values. We can find the area of reinforcement, load and moment for both sections. By using the reinforcement value we can compare which section is economical.

Table 1: comparison of solid and hollow rectangular section

Details	Solid section	Hollow section
Breadth of pier	1000mm	1000mm
Depth of pier	1500mm	1500mm
Grade of concrete	M30	M30
Grade of steel	Fe550	Fe550
d'/D	0.02	0.02



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% of reinforcement	0.5%	0.5%
Area of steel	7500mm ²	5700mm ²

Above the table, we obtaining the area of reinforcement values for both solid (existing chart) and hollow (developed chart) rectangular section by using same breadth and depth. Now we have taken the same area of cross section of both solid and hollow rectangular section. The area is taken as 5700 mm². We find the load and moment for both solid and hollow sections by using the same cross section. The load and moment variations for different grade of steel is given below as the bar chart.

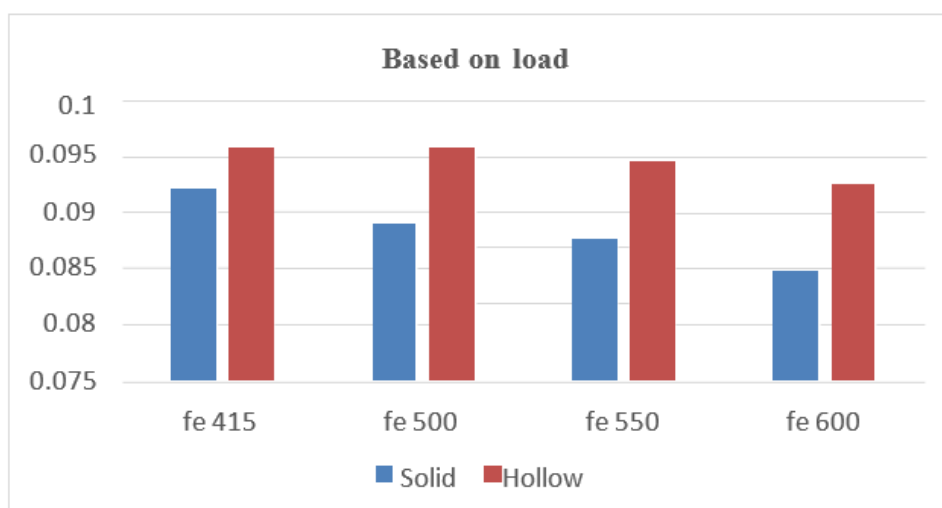


Figure 1: Bar chart for hollow rectangular section based on moment

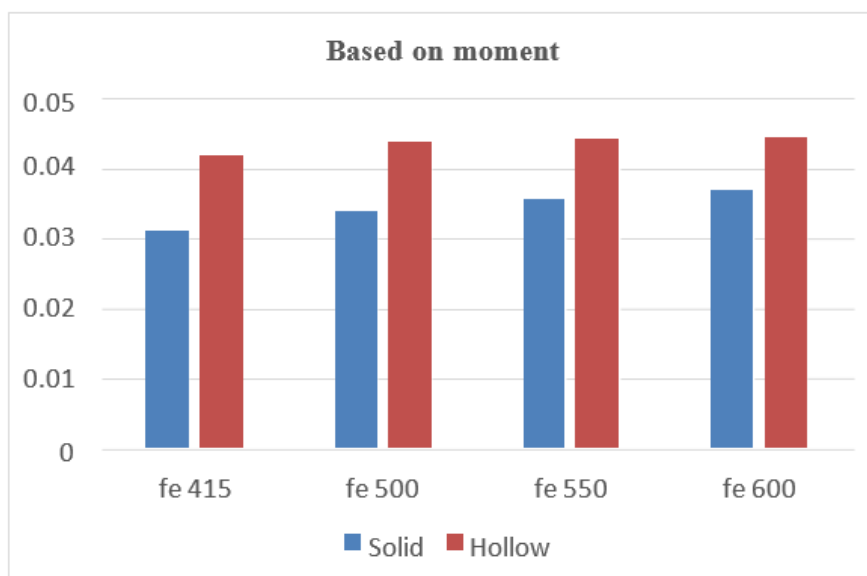


Figure 2: Bar chart for hollow rectangular section based on load



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Above the bar charts, we obtaining by using the same area of steel the load and moment in the hollow section is more than the load and moment in the solid section. By conclude using above chart values hollow rectangular section is more economical than the solid rectangular section.

4.1.1 Solid and Hollow Circular section Comparison

Table 2: comparison of solid and hollow rectangular section

Details	Solid section	Hollow section
Diameter of pier	1000mm	1000mm
Grade of concrete	M35	M35
Grade of steel	Fe550	Fe550
d'/D	0.02	0.02
% of steel	1%	1%
Area of steel	7854mm ²	5890mm ²

4.1.2 Solid and Hollow Circular section Comparison

Table 3: Comparison of solid and hollow circular section

Details	Solid section	Hollow section
Diameter of pier	1000mm	1000mm
Grade of concrete	M35	M35
Grade of steel	Fe550	Fe550
d'/D	0.02	0.02
% of steel	1%	1%
Area of steel	7854mm ²	5890mm ²



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Figure 3: Bar chart for hollow circular section based on load



Figure 4: Bar chart for hollow circular section based on moment

Above the bar charts, we obtain by using the same area of steel the load and moment in the hollow section is more than the load and moment in the solid section. By conclude using above chart values hollow circular section is more economical than the solid circular section.

5 Conclusion

Literature study has been done and from this I understand the behavior of short column/pier under axial load and any-axial moments. I have selected the parameters required for the derivations from the studied literatures. Computer programs and design charts have been done for both hollow rectangular and hollow circular sections under axial, uni-axial and bi-axial columns. The computer programs .By developing the design charts for hollow Sections are compared to the solid sections by using the bar charts based on load and moment. This comparison conclude the hollow sections are more efficient than the solid



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sections. In the hollow sections, the empty space we filled with some inert materials. That materials are economic and free from environment. By using the computer program, we can simplify the design procedure and increase the accuracy. The developed MATLAB coding can be used as a design tool.

References

1. Agha et al., Year: 2018, "Effect of Load Eccentricity on the Strength of Concrete Columns", Journal of civil and environmental engineering.
2. Bresler, Year: 1960, "Design Criteria for Reinforced Columns under Axial Load and Biaxial Bending", Journal of the American Concrete Institute, Vol: 57, no. 5, pp. 481- 490.
3. Corrado et al., Year: 2012, "Size- Scale Effect on Interaction Diagrams for Reinforced Concrete Columns", Construction and Building Materials, Vol. 27, pp. 271-279.
4. Gigliotti et al., Year: 2008, "An Analytical Formulation of Stress Block Parameters for Confined Concrete", the Open Construction and Building Technology Journal, Vol: 2, pp. 137- 182.
5. Helgason, Year: 2010, "Development of a Computer Program to Design Concrete Columns for Biaxial moments and Normal force", Division of structural engineering.
6. Menon et al., Year: 2009, "Reinforced Concrete Design", McGraw Hill Education (p) Ltd, pp. 608-715.
7. Minett et al., Year: 2006, "Programming for Civil and Building Engineers using Mat lab", Joint International Conference on Computing and Decision Making in Civil and Building Engineering.
8. Nirkhe, Year: 2016, "Design of Flat Slab with MATLAB", International Journal of Engineering Research, Vol: 5, no.3, pp.537-540.
9. Ozbakkaloglu et al., Year: 2004, "Rectangular Stress Block for High-Strength Concrete", ACI Structural Journal, Vol: 101, no.47, pp. 475-483.
10. Petrone et al., Year: 2019, "Unified Code-Compliant Equations for Bending and Ductility Capacity of Full and Hollow Rectangular RC Sections", Engineering structure, Vol: 183, pp. 805-815.
11. Smolcic et al., Year: 2012, "Interaction Diagrams for Reinforced Concrete Circular Cross Section", UDK 624.043.001.4:69.009.182, pp. 23-31.