Biaxial Interaction Diagrams of Elliptical Concrete Column Sections Reinforced with GFRP Bars

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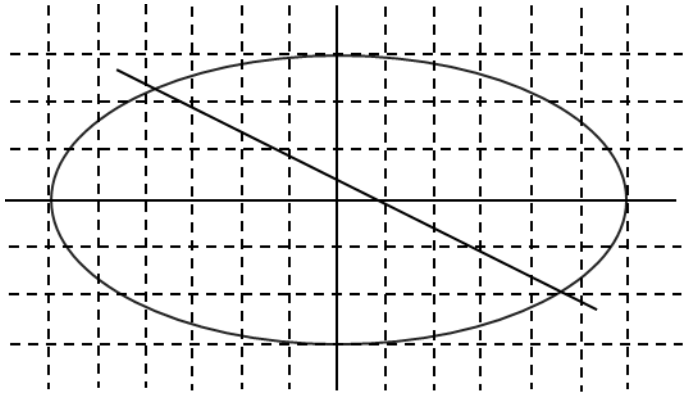
Objectives

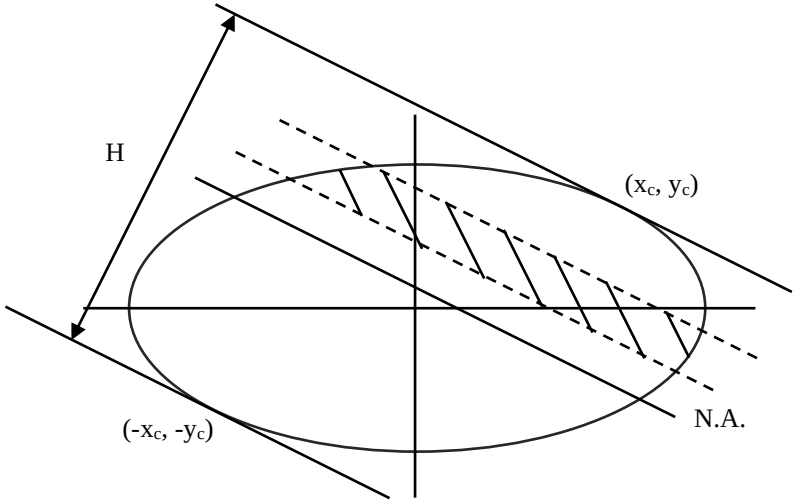
- Formulating the equations necessary to compute the biaxial interaction diagrams
- Testing the solution after implementing it into an advanced software design tool

Introduction

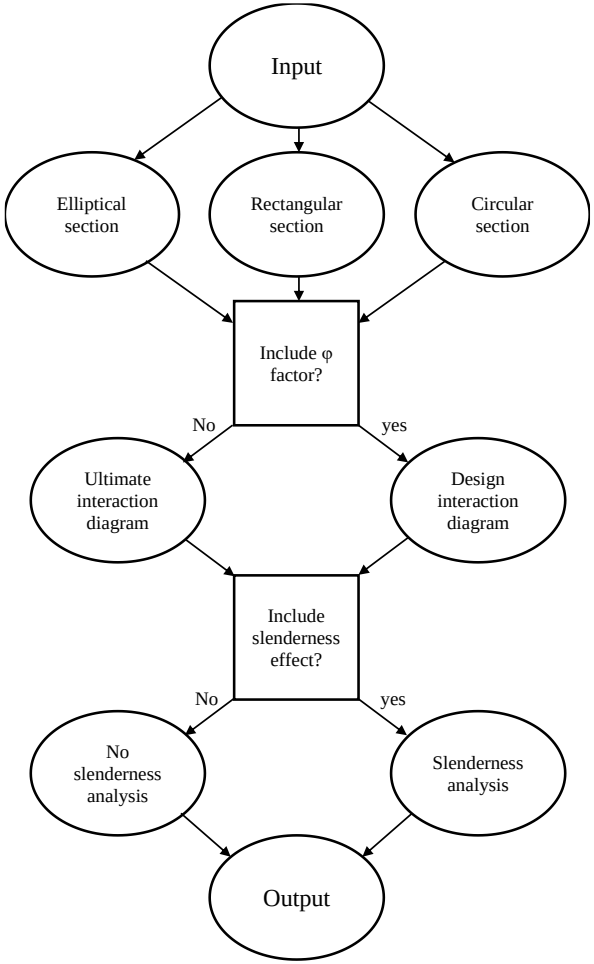
- Release of ACI 440.11-22
- Need for advanced design tools
- GFRP vs steel rebars
- Elliptical (atypical) vs standard sections
- Biaxial vs uniaxial moment
- Need to formulate efficient solutions

Section Discretization



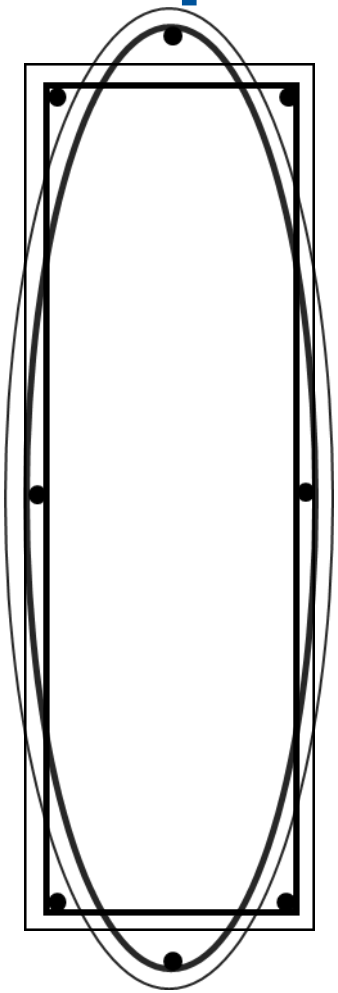


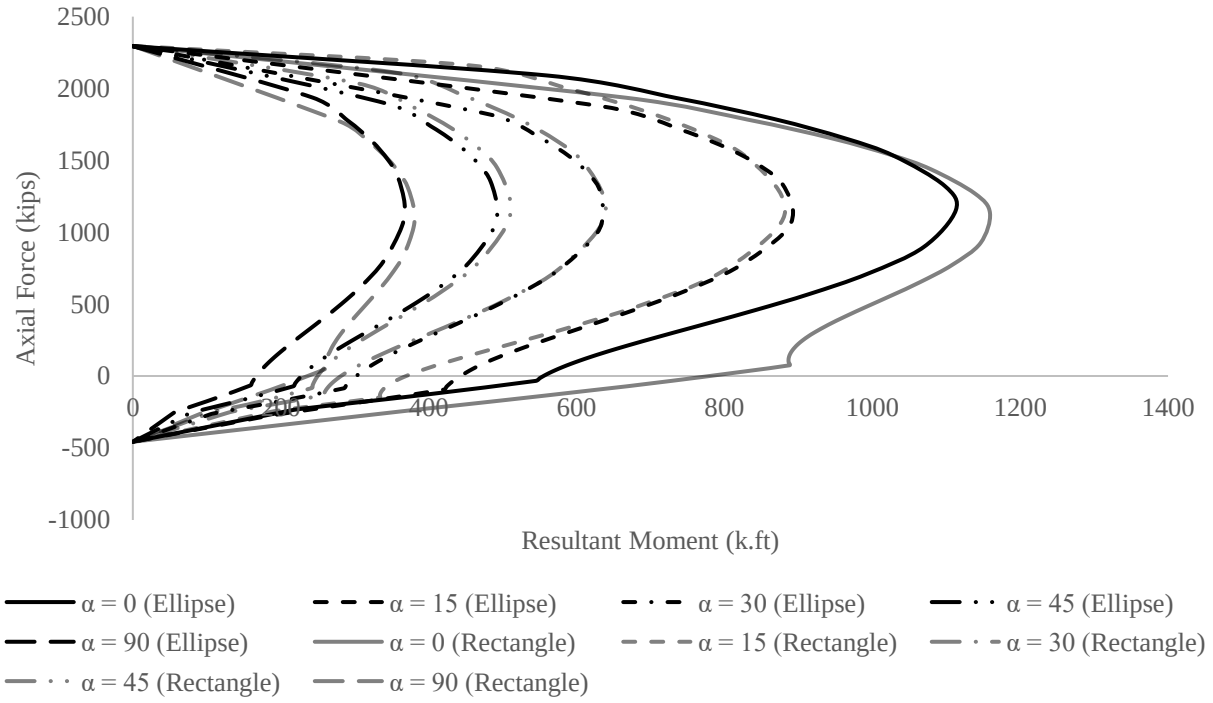
Software Implementation



- The formulation was implemented into a desktop application using the C# language

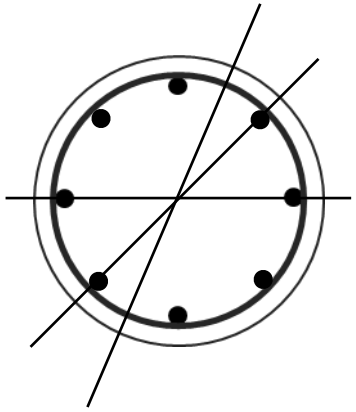
Elliptical vs Rectangular Sections





Same aspect ratio and area

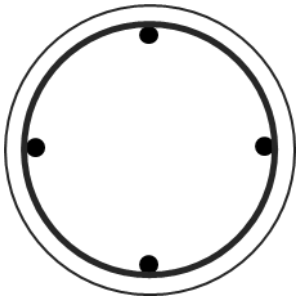
ACI 440.11-22 R10.7.3.1



R10.7.3.1 At least four longitudinal bars are required when bars are enclosed by rectangular or circular ties. For other tie shapes, one bar should be provided at each apex or corner and proper transverse reinforcement provided. For example, tied triangular columns require at least three longitudinal bars, with one at each apex of the triangular ties. For bars enclosed by spirals, at least six bars are required.

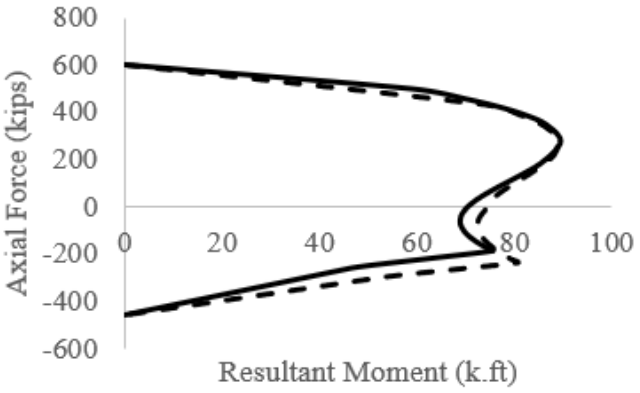
If the number of bars in a circular arrangement is less than eight, the orientation of the bars may significantly affect the moment strength of eccentrically loaded columns and should be considered in design.

ACI 440.11-22 R10.7.3.1

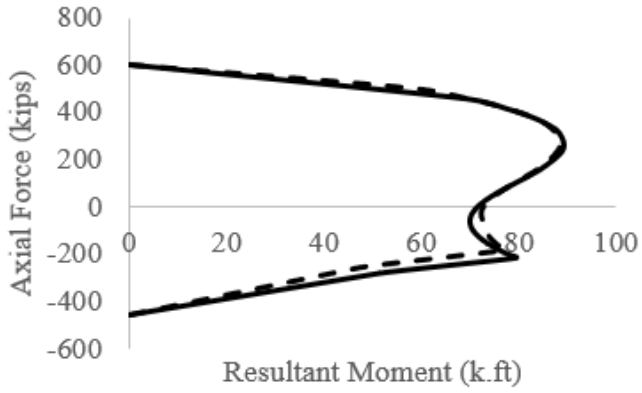


4 GFRP rebars

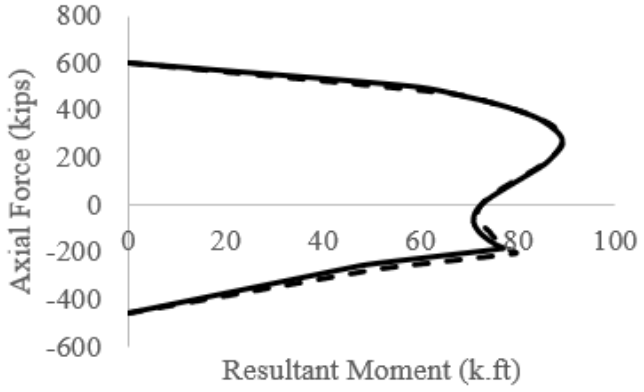
Fixed section area and GFRP ratio



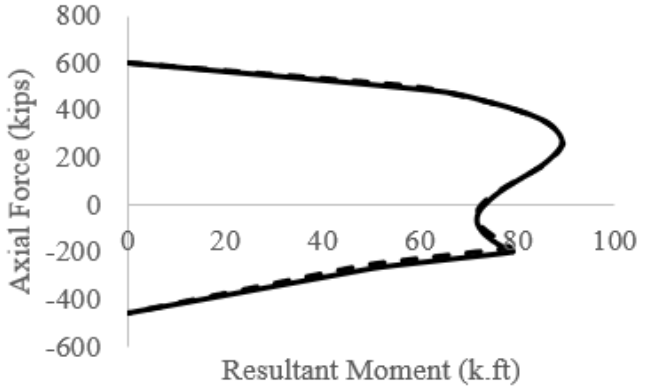
(a) 4 bars



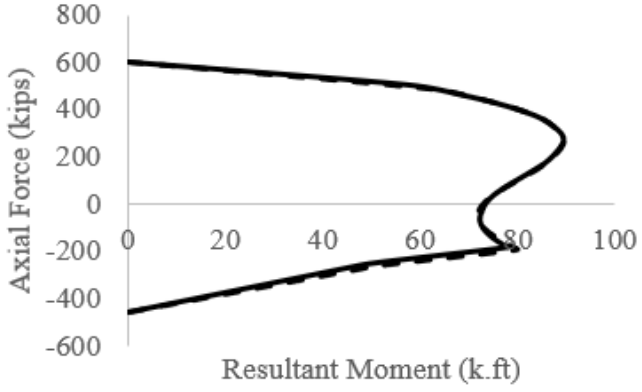
(b) 5 bars



(c) 6 bars

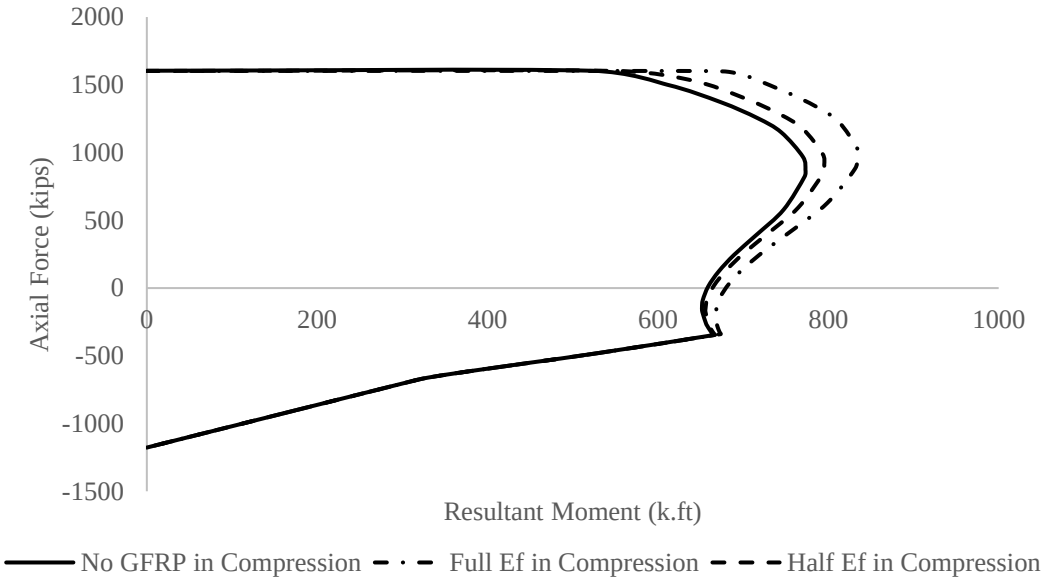


(d) 7 bars



(e) 8 bars

Neglecting GFRP in Compression



Concluding Remarks

- Theoretical formulation and software implementation for computing biaxial interaction diagrams of elliptical column sections reinforced with GFRP bars was successfully carried out
- The introduction of inclined concrete layers parallel to the neutral axis orientation yielded far more computationally efficient solution compared to the traditional rectangular fiber-based discretization of the section
- Comparisons with rectangular sections verified the results are reasonable
- ACI 440.11-22 R10.7.3.1 comment regarding the need to consider bar orientation for circular sections with less than 8 bars was tested and is believed to be at least relaxable if not ignorable
- ACI 440.11-22 recommendation to neglect the action of GFRP bars in compression was tested and found to be reasonably conservative, especially if only 50% of the elastic modulus is applied in compression

Questions?