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NUMERICAL SIMULATION OF COMPOSITE COLUMNS

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Abstract

Structural columns that are made up of two or more different materials are known as composite columns. Studying composite structures is beneficial since it is a new and modern way to build structures and benefit from materials in a different way. Concrete-filled steel tubular structures makes the composite column a very stiff, more ductile, cost effective (as compared to reinforced concrete structures) and consequently a structurally efficient member in building and bridge constructions

In this study numerical simulations of composite columns were conducted, In order to achieve the study objectives, Finite Element Method (FEM) based software (ABAQUS) was used due to many advantages including saving time of the calculation and providing a simulation of the behavior of the member.

Different mesh sizes (15, 25, and 30 mm) were applied on a rectangular model to study the effect of the change on the load-deflection curve. Negligible change was observed. However, reducing the mesh size can improve the results accuracy.

A load-deflection curves of square and circular composite column were plotted by considering the stress-strain curve of normal concrete and compared with the experimental results. It was found that the load capacity was less than that of experimental results. The reason of this underestimation was the confinement effect.

A correction factor for lateral confining pressure of 1.5 was found for circular sections since the equation used for confining pressure obtain from literature was applicable to square composite columns.

Different square composite columns were made with different B/T ratios (fixed width over different values of steel wall thickness) to study the effect of B/T on the load capacity. Changing the B/T ratio of a column changed its load capacity. Hence, an equation was developed to estimate the load capacity of different B/T ratios.

Objectives of the thesis

- Understanding and working on numerical simulation.
- Observing the effect of changing the mesh sizes of a model.
- Understanding the confinement effect and how to apply it for different sections.
- Observing the effect of changing B/T ratio on the load capacity.

Methodology

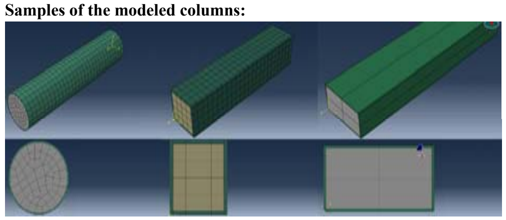
Various computer packages are available now a days and finite element analysis can be done with high accuracy. So due to the high accuracy, economy and multi-functional capability, ABAQUS was chosen.

Scope of work

First of all, a simple column 100 mm wide and 20 mm thick CFT specimen was simulated using ABAQUS. Secondly, three models were analyzed from Schneider et al. and compared with the experimental results. In the table below is the data used in the conducted simple FEA model and the adopted sections.

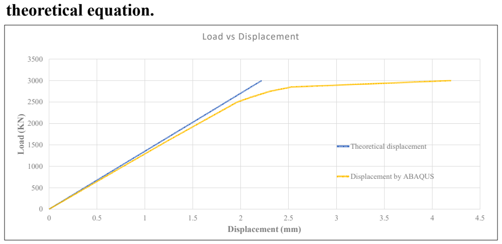
	Column	Dimensions (mm)	T (mm)	B/T	Length (mm)	Steel tube Fy (MPa)	Concrete fc` (MPA)	Source
GP1	Sq1	100 × 100	20	5	1000	420	23.80	-
	Experimental models							
GP2	S5	127 × 127	7.47	17	609.6	347	23.8	Schneider et al.
	C1	140	3	47	602	285	28.18	Schneider et al.
	R1	76 × 152	3	50.8	608	430	30.454	Schneider et al.

Samples of the modeled columns:



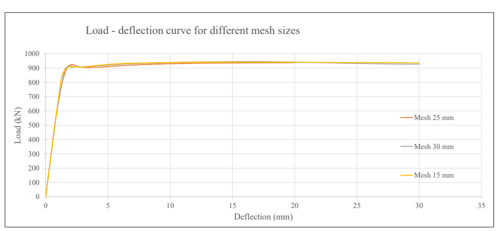
Simulation of simple column Sq1

A load-displacement curve was found and compared with the theoretical equation.



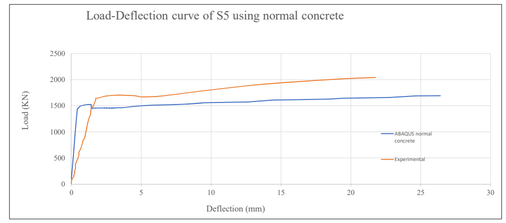
Simulation of rectangular composite column R1

Firstly, different mesh sizes were used (15, 25, and 30mm) to study the effect of changing the mesh size on the load-deflection curve.

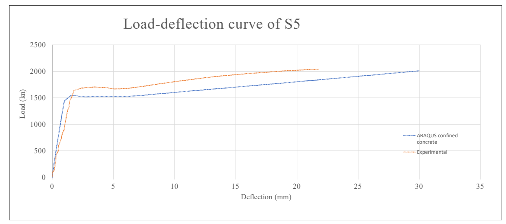


Simulation of square composite column S5

A load-deflection curve was plotted by considering the stress-strain curve of normal concrete as shown below:

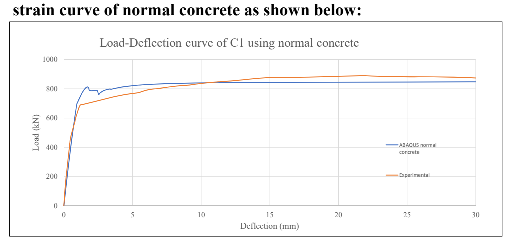


A load-deflection curve was plotted for S5 by considering the stress-strain curve of confined concrete as shown below:



Simulation of circular composite column C1

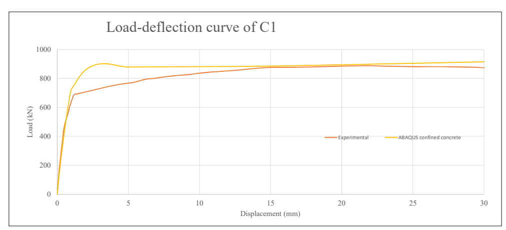
load-deflection curve was plotted for C1 by considering the stress-strain curve of normal concrete as shown below:



A correction factor of 1.5 was found by hit-and-trial. Therefore, the lateral stress f_l for circular column is:

$f_{l,cr} = C\, f_{l,sq}$.

Where $f_{l,cr}$ = confining pressure for circular section, and C = 1.5.

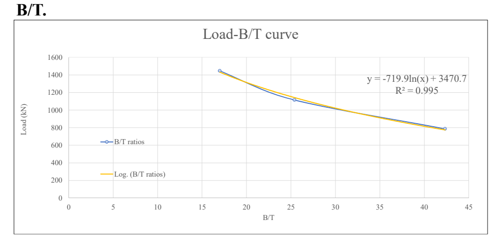


Studying the effect of changing B/T ratio on the confinement pressure for S5

To study the effect of B/T on the load capacity, different square models were made with different B/T ratios as following:

For a fixed width B= 127 mm		
Case/Thickness	T (mm)	B/T
Case 1	7.47	17
Case 2	5	25.4
Case 3	3	42.3

A load – B/T curve was plotted and an equation was developed to estimate the failure load – in terms of yielding- for a specified B/T.



An equation was developed to calculate the failure load –in terms of yielding- of a section using B/T ratio as the following:

$F = -719.9 ln(x) + 3470.7$ kN. (Where x is the B/T ratio).

CONCLUSIONS

- The theoretical displacement resulted a linear relationship, but in ABAQUS a non-linear relationship was found. That occurred because the equation used in theoretical displacement is applicable in the elastic region, where ABAQUS simulated the elastic and non-elastic behavior.
- Different mesh sizes does not affect the load-deflection curves of a model.
- A load-deflection curves of square and circular composite column were plotted by considering the stress-strain curve of normal concrete and compared with the experimental results. It was found that the load capacity was less than that of experimental results. The reason of this underestimation was the confinement effect.
- A correction factor for lateral confining pressure of 1.5 was found for circular sections since the equation used for confining pressure was applicable to square sections.
- Changing the B/T ratio of a column changed its load capacity. Hence, an equation was developed to estimate the load capacity of different B/T ratios for square column.