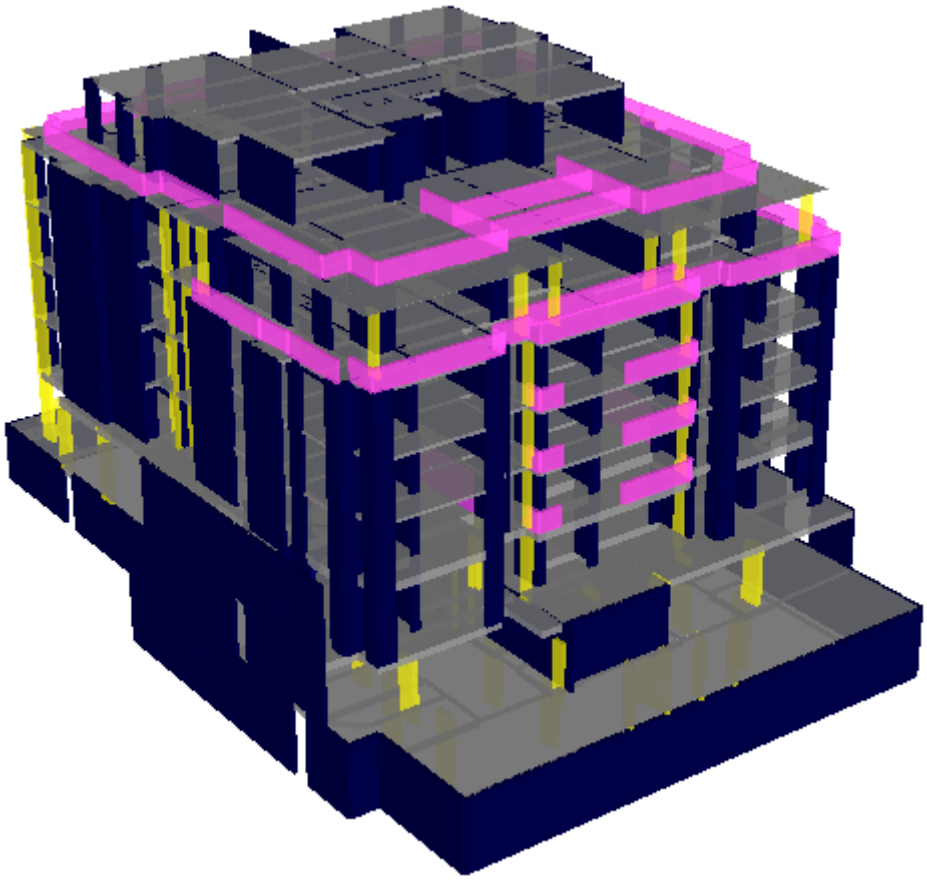
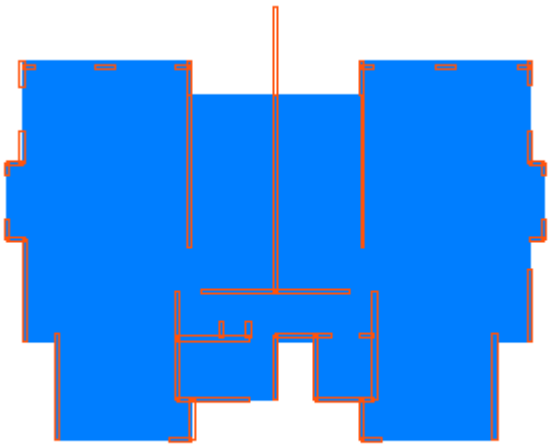
Comparisons between Static Analysis and Floor Area

A common question when extracting results using R/C Building is why are the Static Analysis and Floor Area reactions so different?
To address this question, a typical model has been used as a general example. An individual column in the model is then isolated when comparing the actual reactions by the different methods. The loads shown are based on the un-factored Self-Weight and super Imposed Dead Load.

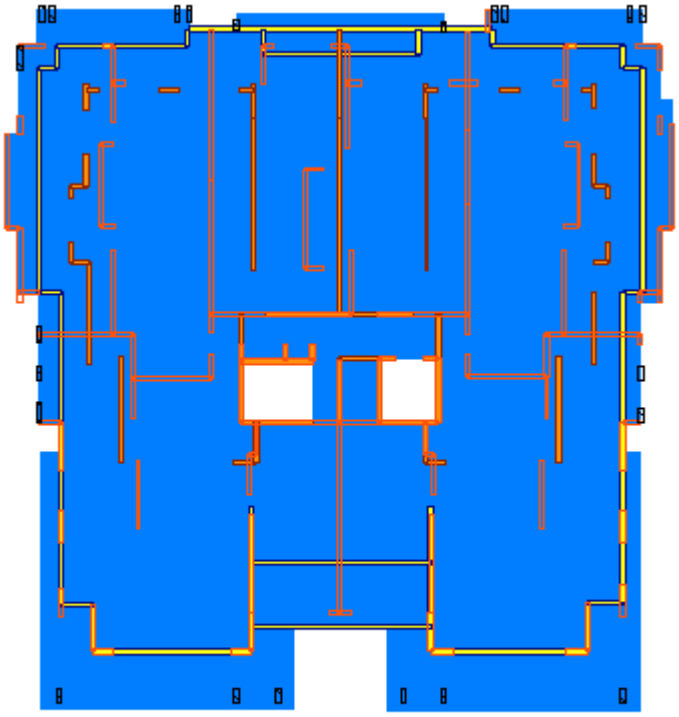
A 3D view of the model is shown below with a plan view of each floor in the model on the subsequent pages.



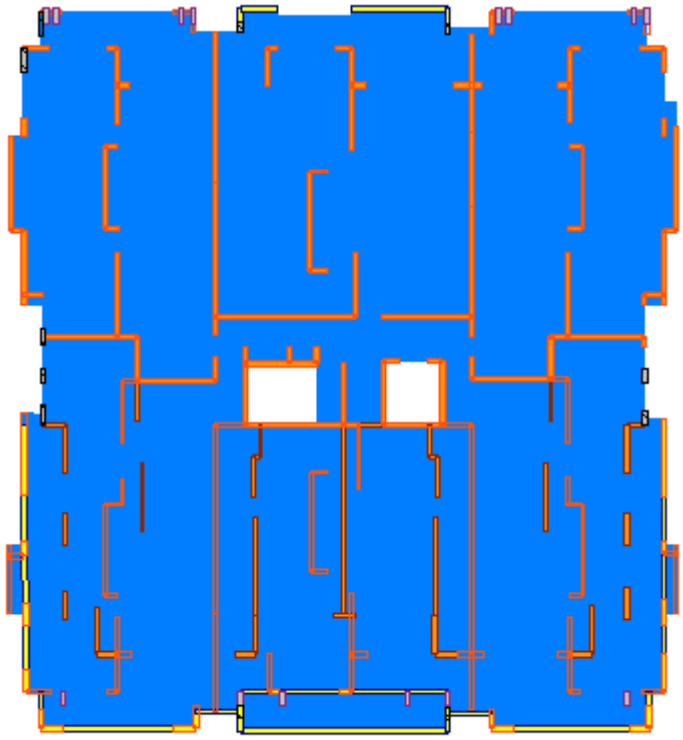
Model courtesy of BG Group - QLD



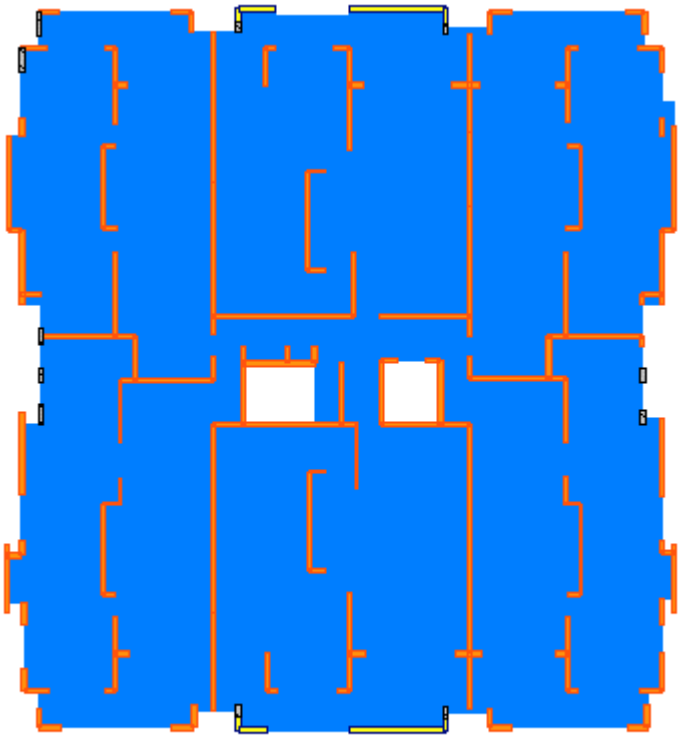
Roof



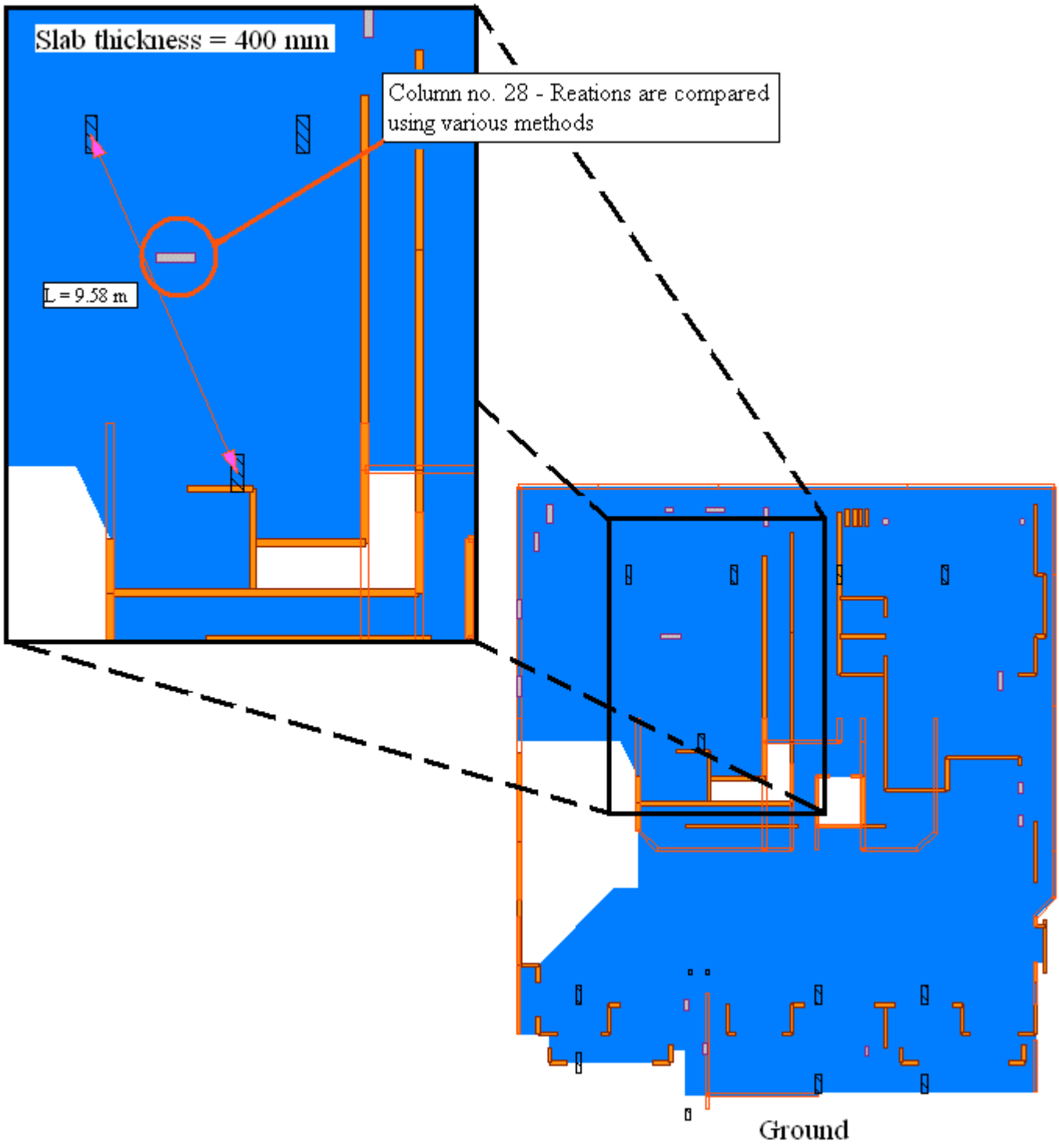
Level 5

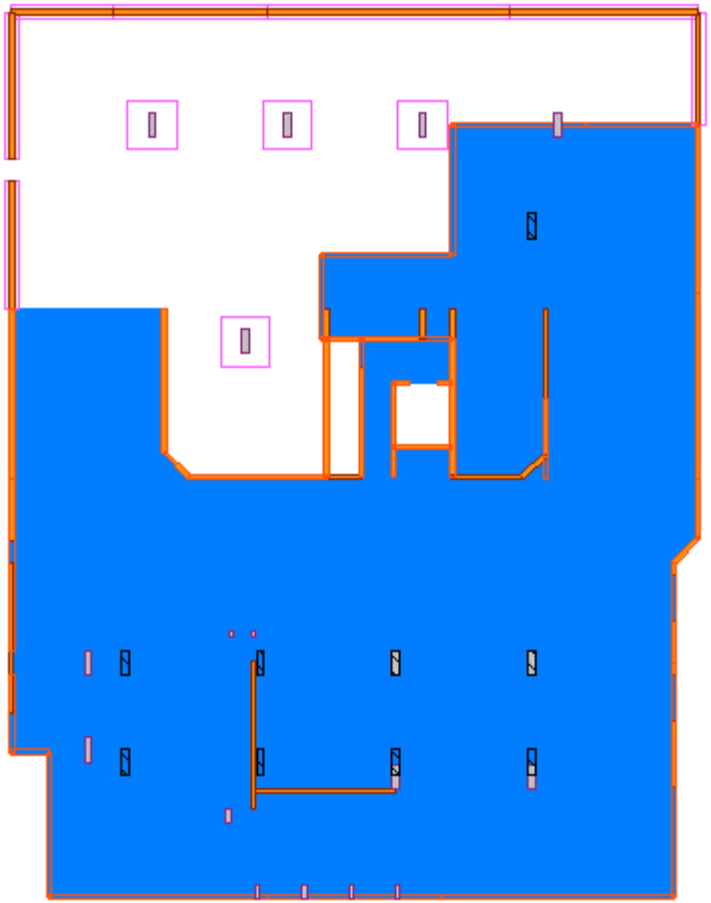


Level 4

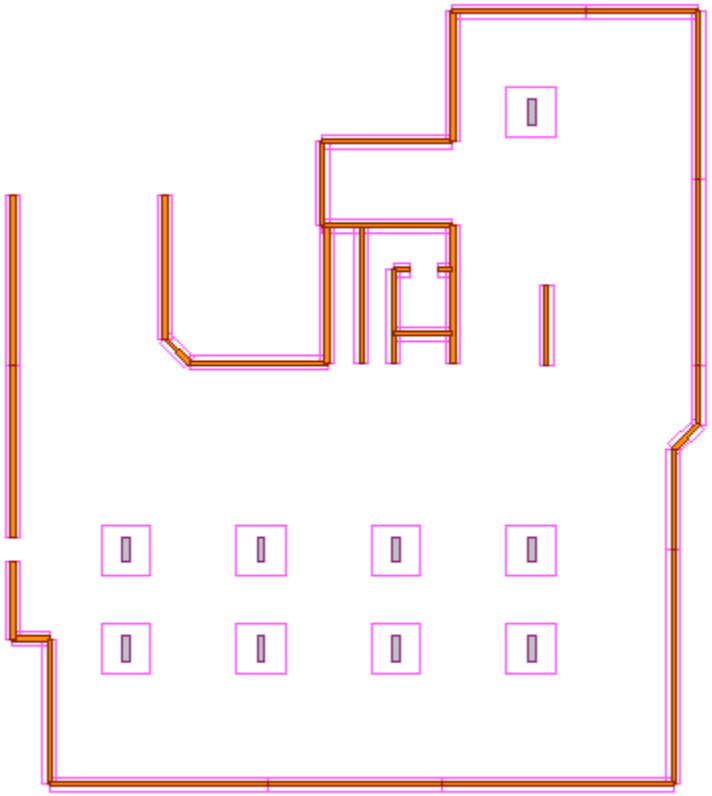


Level 3, 2, 1


Slab thickness = 400 mm
Column no. 28 - Reations are compared using various methods
L = 9.58 m
Ground



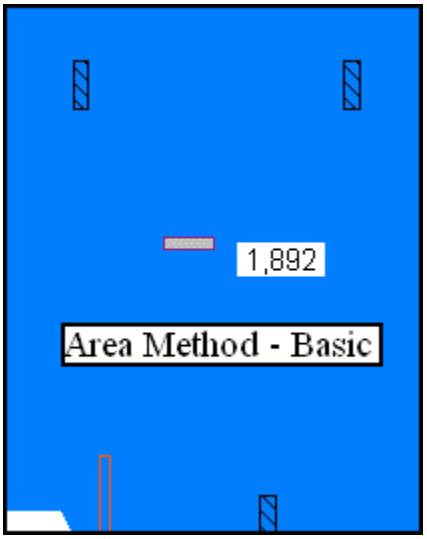
Basement



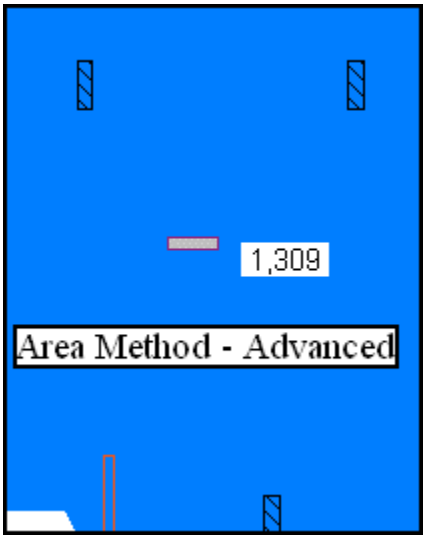
Lower Basement

When calculating reactions for a building by hand, the traditional method has been to generate contributory areas for each supporting element. This approach assumes all the supporting elements have infinitely stiff supports, and each floor in the building is treated as isolated. Using this method will always generate positive reactions in the columns and walls.
In figure (A) below, the reaction for Col. 28 is based on adding the loads that fall inside the contributory area for this column for each floor. This approach is suitable for pressure loads as the distribution of the load will be proportional to the contributory area.
When calculating the reactions by the Area Method for a transfer slab, 100% of each point and line load above the transfer will be added to the reaction of one single supporting element below. For figure (A) below, if the reactions of the floor below Col. 28 where to be shown, the 1892 kN will be "lumped" into only one of the elements, despite the relative central position of Col. 28.

The Area Method – Advanced shown in figure (B) uses the same approach for the pressure and self weight of the slab as Area Method – Basic. However for point and line loads, R/C Building will distribute the load by a ratio that is calculated by the distance and angle between each load to the supporting elements. This approach will proportion the load on a transfer slab much more logically as the elements closer to the load will take a larger proportion, but not necessarily 100% of the load.

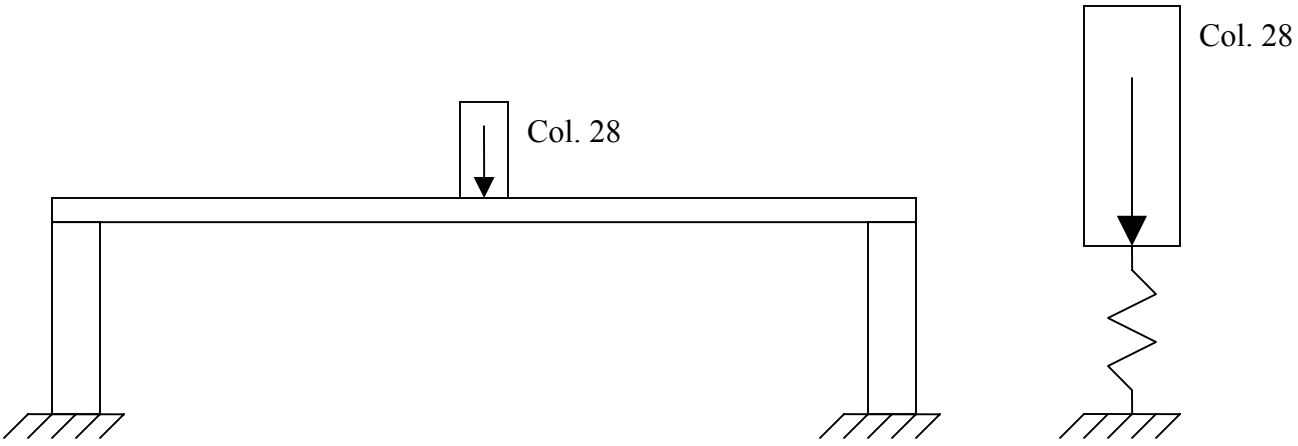


(A) – Area Method



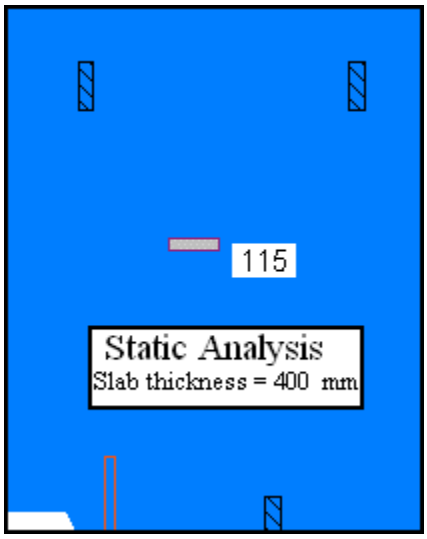
(B) – Area Method

A cross section of the area near Col. 28 is shown in the diagram below - left. As the support for Col. 28 is a 400mm thick slab, this type of support can be simulated as a spring as shown in the diagram on the right.

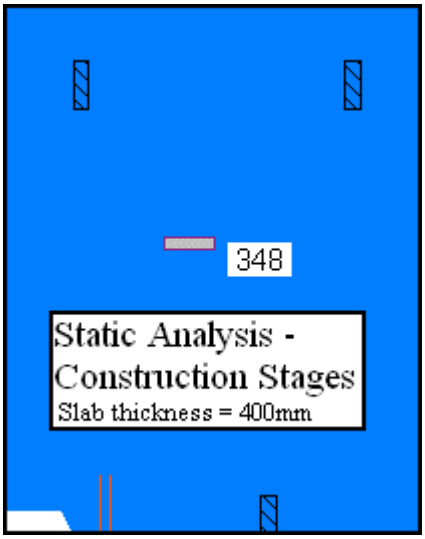


The Static Analysis in R/C Building considers frame action and the stiffness of all elements in the model. A complete 3D model will reveal global affects as the structural elements are working together, and tension in some columns/walls can be expected with certain geometry arrangements. When extracting the reactions for columns in this type of scenario, the stiffness of the support will greatly affect the final results.

The results in figure (C) below are generated by Static Analysis where the load throughout the structure is applied in one step, where in reality the load will be applied gradually or is stages as shown in figure (D).



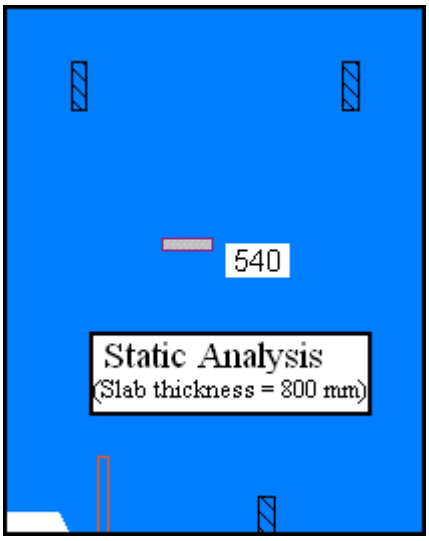
(C) – Static Analysis



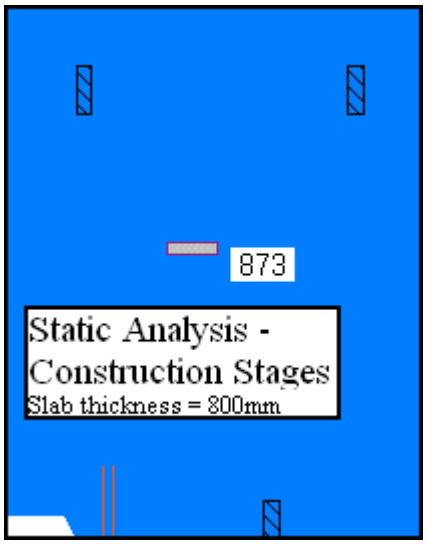
(D) – Static Analysis

The Static Analysis results shown in (C) are considerably smaller than the reactions by both Area Methods. When the same model is analysed with the Construction Stages (as shown in (D)), the load is applied gradually, simulating the way the floors will be propped during construction. As each stage is analysed, the deflections are calculated, and the loads from the next stage are applied on the already realized deflections. The reactions generated by the Construction Stage method are larger than the simple Static Analysis as expected.

For comparison, the same model was re-analysed with the slab thickness supporting Col. 28 increased to 800mm (this was the only variable that was changed). The results below show that increasing the stiffness of the support will attract more load, and the reactions in Col. 28 are larger in (E) compared to (C) and (F) compared to (D).



(E) – Static Analysis



(F) – Static Analysis