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MESH DENSITY AND ACCURACY OF DESIGN VALUES
Using ADAPT-Floor Pro[1]

The finite element formulation specifically developed by ADAPT for FLOOR-Pro is not as sensitive to the density of the mesh used, as the traditional formulations are, when the design values of a floor system are determined. The background of the formulation is given in reference [1]. In the general case, subdivision of a slab using 6 to 8 divisions per span, or a cell size of 4 ft (1.20m), leads to satisfactory design accuracy.

This Technical Note demonstrates the insignificant sensitivity of mesh fineness to the computed design values. This is illustrated through the application of ADAPT-Floor program to two complex floor slabs.

Figure 1 shows the floor plan of a multi-story building. A three dimensional view of this floor is given in **Fig. 2**. The floor slab consists of several slab regions separated by drops in the slab elevation. Rectangular columns with relatively small drop caps along with several perimeter walls support the slab. On one side of the floor system, three drop caps straddle across a drop in slab elevation adding to the complexity of the structural geometry. The tendon layout of the slab is illustrated in **Fig. 3**. For added clarity, the columns and walls are not included in this figure and the slab thickness is exaggerated.

For the purpose of comparison among the meshing options used, two typical "design sections" are selected. Design sections are cuts across the design strip used for code check as well as the calculation of the required reinforcement. References [1,2] include detailed outlines of the design strip and design section concepts used in the design of floor systems.

The design sections selected are for the design strip identified in **Fig. 4**. One of the design sections is at the face of the drop cap, and the other at mid-span. These are identified in **Figs. 1** and **4**. Three different meshing schemes are selected. The first was created using the manual meshing option of the program with typically 8 divisions per span. This resulted in 3105 Nodes for the structure (**Fig. 5**). The second used the automatic meshing option of the program with a suggested a coarse mesh. This resulted in 3104 nodes for the structure (**Fig. 6**). For the third option, a fine mesh and the automatic meshing option was used. The outcome was 15041 Nodes (**Fig. 7**). For both the automatically generated coarse and fine mesh

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the adaptive mesh option of the program was used. That is to say, the program automatically changes the mesh size to suit the details of the structure.

The deflected shape of the slab under selfweight is shown in **Fig. 8** from the manual meshing solution. The maximum calculated deflection from this solution was 0.2 inch (0.212). The design moments were obtained by integrating the moment (Mxx) obtained from the finite element solution across the automatically generated design sections along the design strip shown in **Fig. 4**. The outcome of the integrals is plotted along the design strip in **Fig. 9**. This is the bending moment distribution to be used for stress and safety checks stipulated in building codes. Obviously, moments due to other loads need to be added and combined with those shown in **Fig. 9**. The distribution of moment about each of the two design sections (**Fig. 10**) shows a sharp peak for the section next to the column and a smooth distribution for the section at midspan. However, for the purposes of design the total (integral) of each of the two sections is used. The values of the moment for the two design sections selected are entered in **Table 1** for comparison.

The results listed in **Table 1** confirm the insensitivity of the mesh fineness to the values used for the design of floor systems when using ADAPT-Floor Pro. Note that the maximum deflection in the three cases is practically the same. The difference between the total span moment among the three options is about 2%. This is well within the approximations involved in engineering design work. In the case of the coarse mesh (**Fig. 6**), the design section at midspan covered only 5 elements (shell elements). The moment value obtained (96.09) compares well with those obtained from finer divisions.

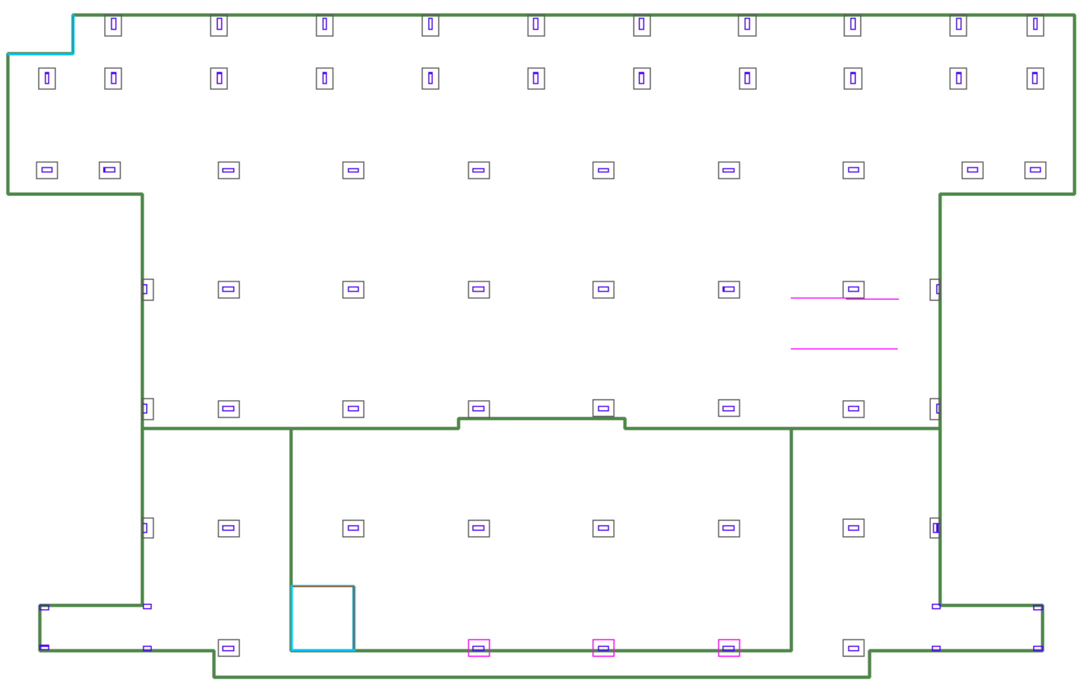

FIGURE 1 PLAN OF FLOOR SHOWING THE DESIGN SECTIONS SELECTED FOR COMPARATIVE STUDY

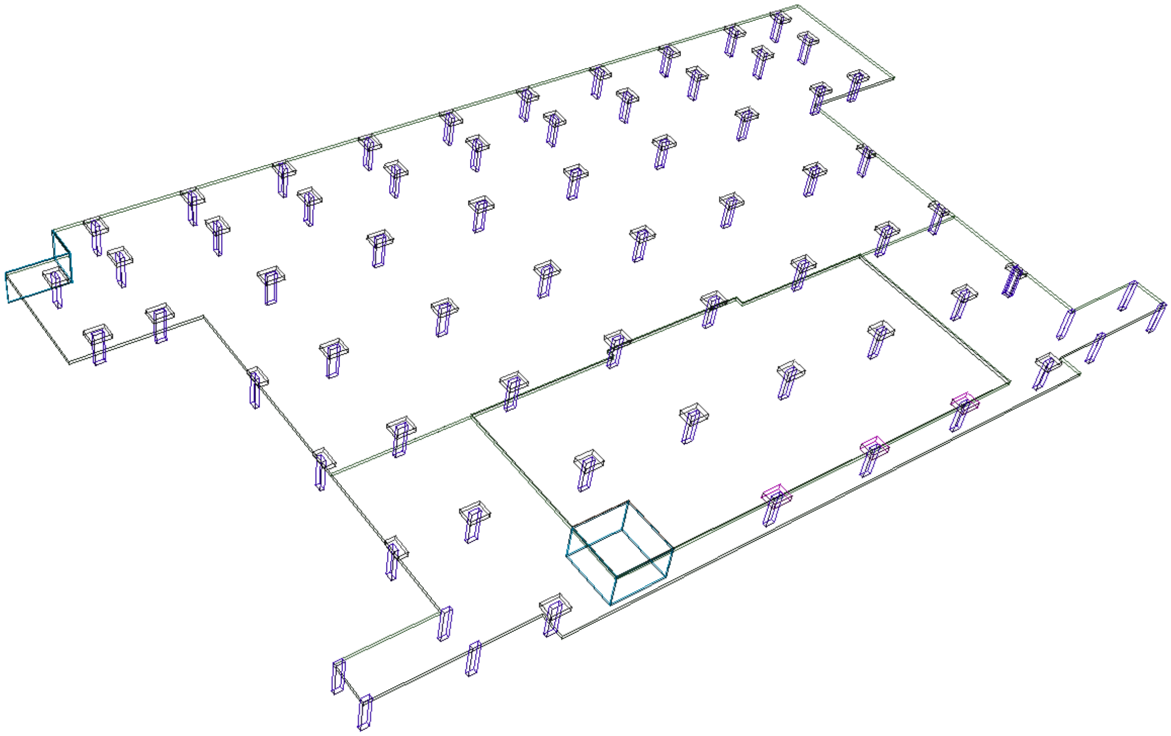

FIGURE 2 THREE DIMENSIONAL VIEW OF THE FLOOR SYSTEM

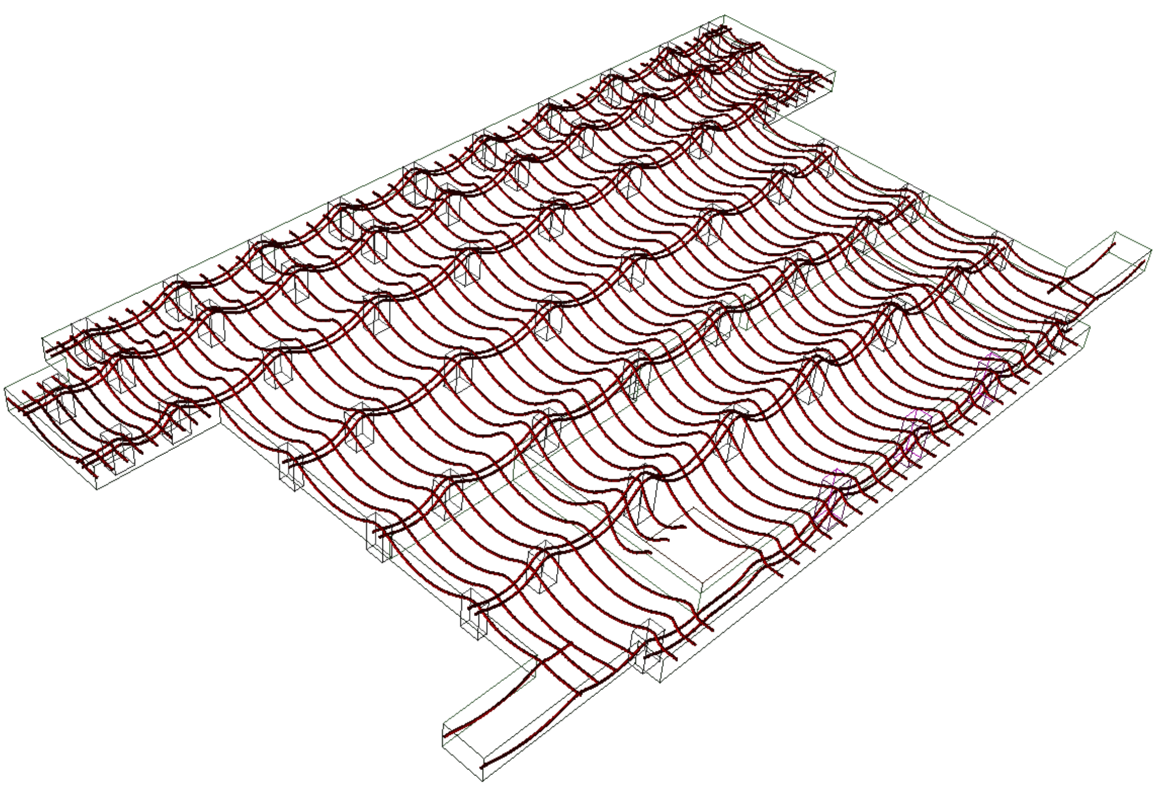

FIGURE 3 TENDON LAYOUT IN THE SLAB

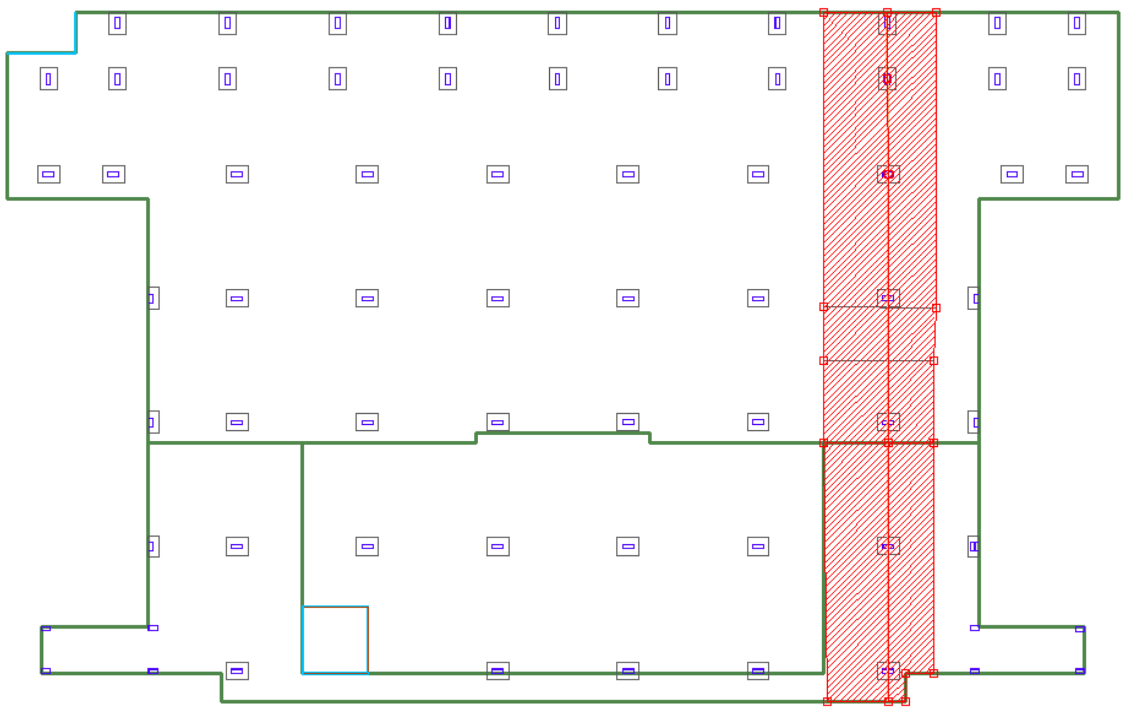

FIGURE 4 DESIGN STRIP AND DESIGN SECTIONS SELECTED FOR COMPARATIVE STUDY

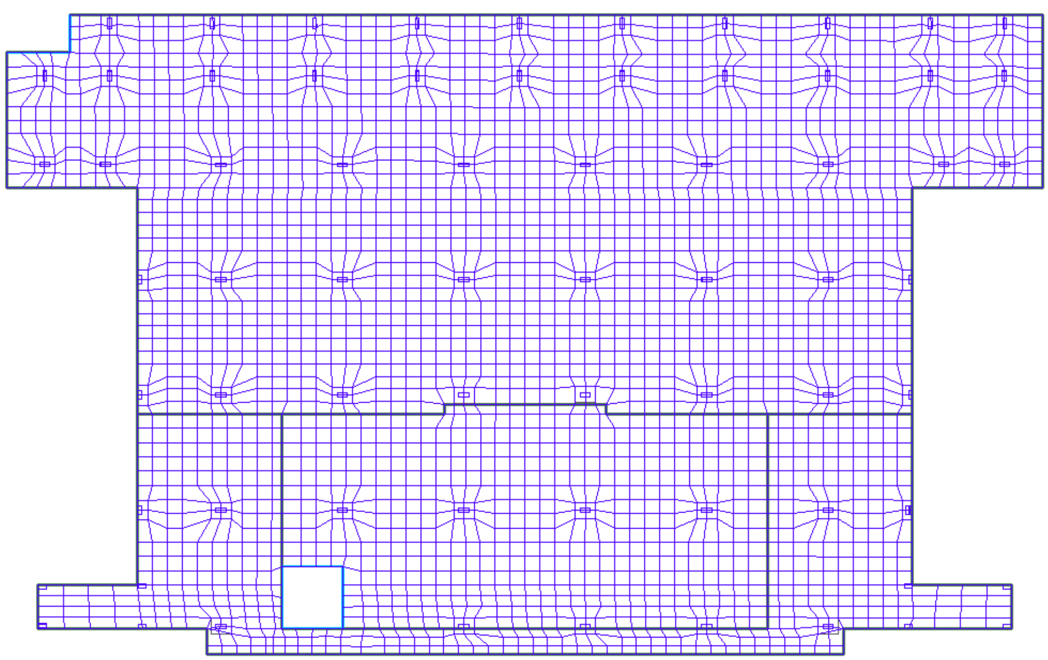

FIGURE 5 MESH OPTION 1, USING MANUAL MESHING (3105 NODES)

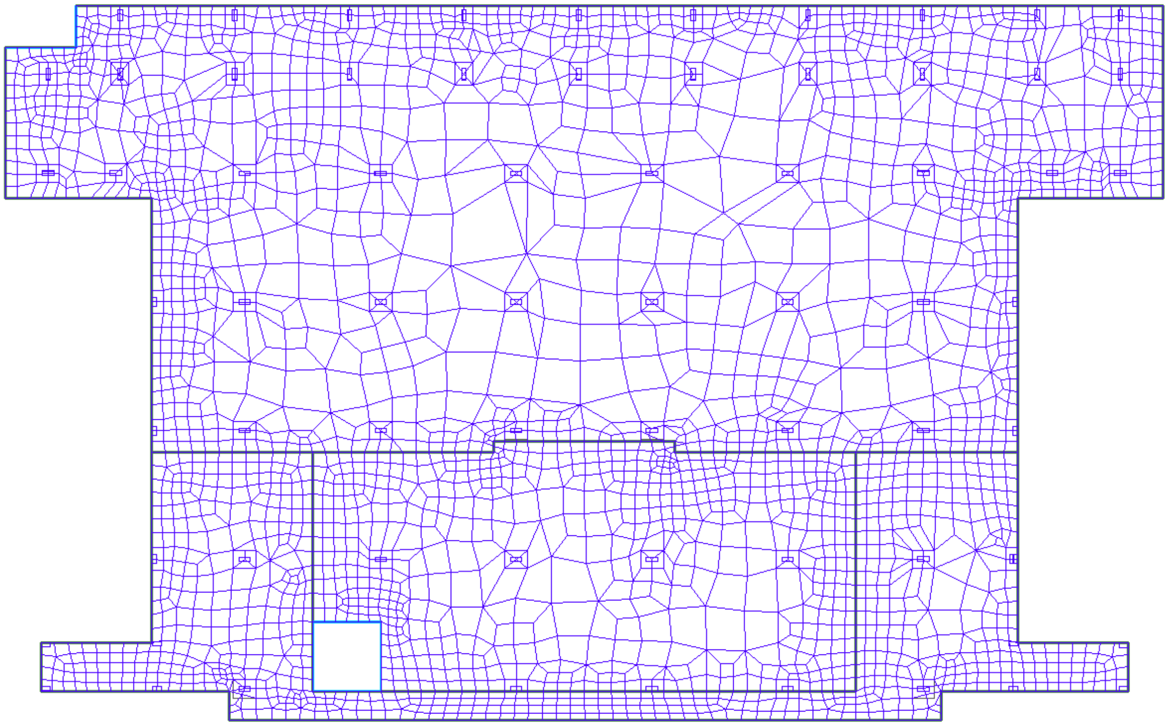

FIGURE 6 MESH OPTION 2, USING COARSE SELECTION OF AUTOMATIC MESHING (3104 NODES)

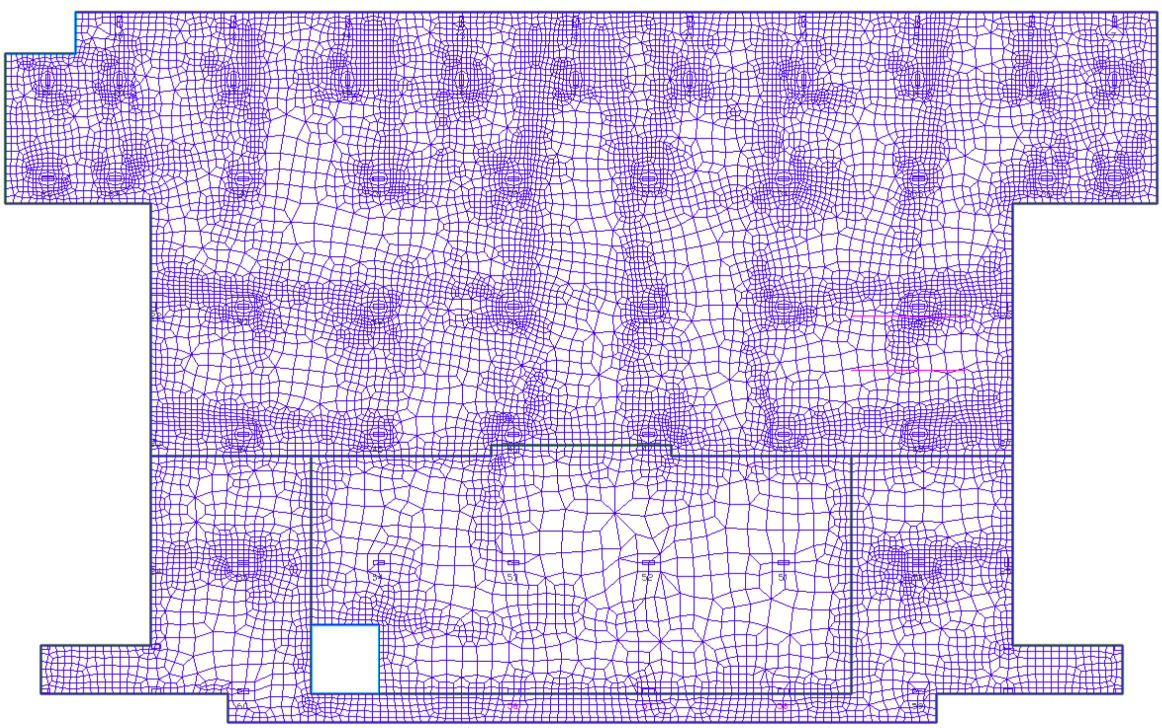

FIGURE 7 MESH OPTION 3, USING AUTOMATIC AND FINE MESH SELECTION (15041 NODES)

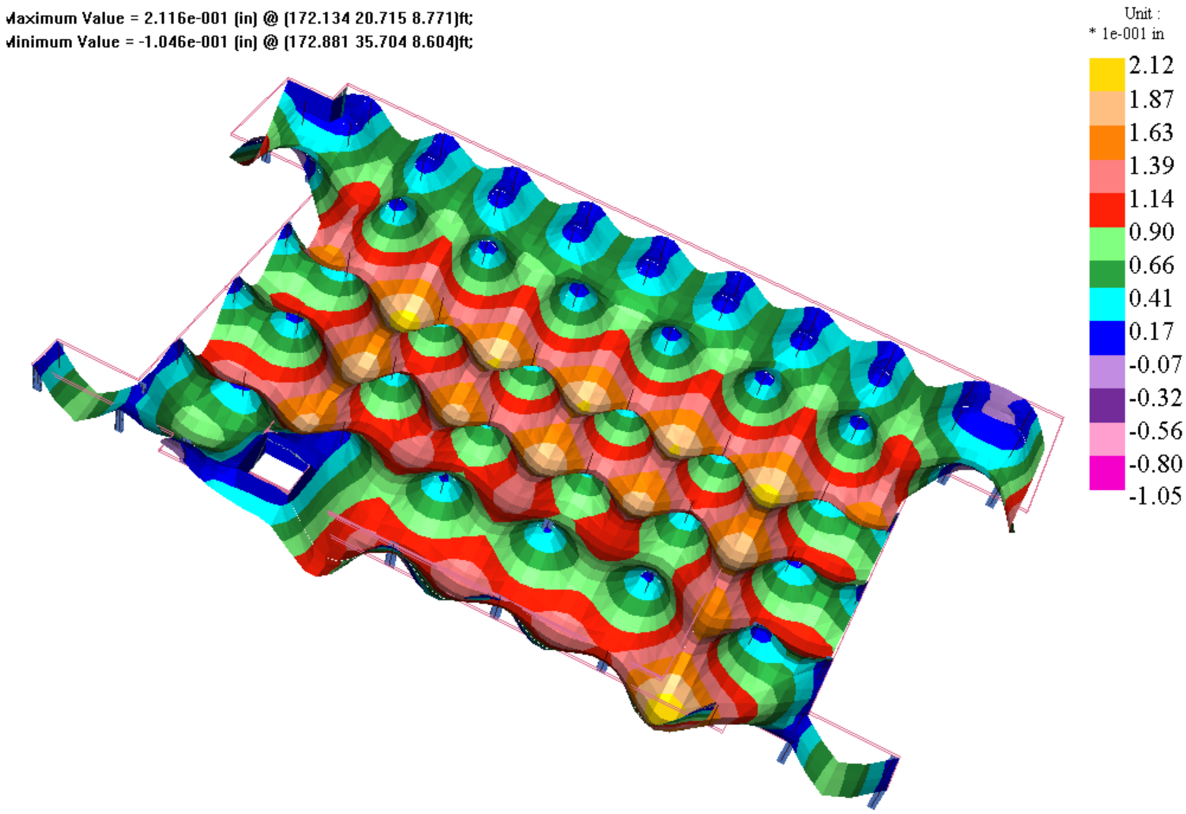

FIGURE 8 DEFLECTION PROFILE UNDER SELFWEIGHT

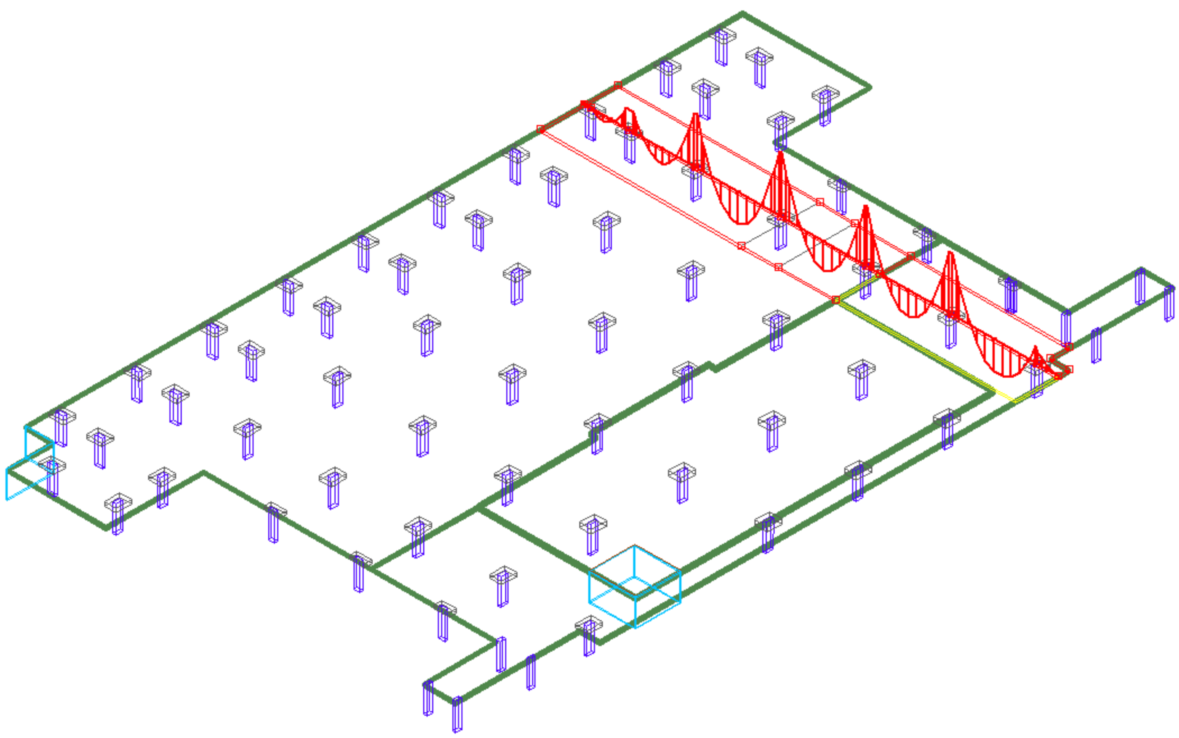

FIGURE 9 FINITE ELEMENT DISTRIBUTION OF MOMENT FOR THE DESIGN STRIP UNDER CONSIDERATION

(The selected design sections are also shown in the figure)

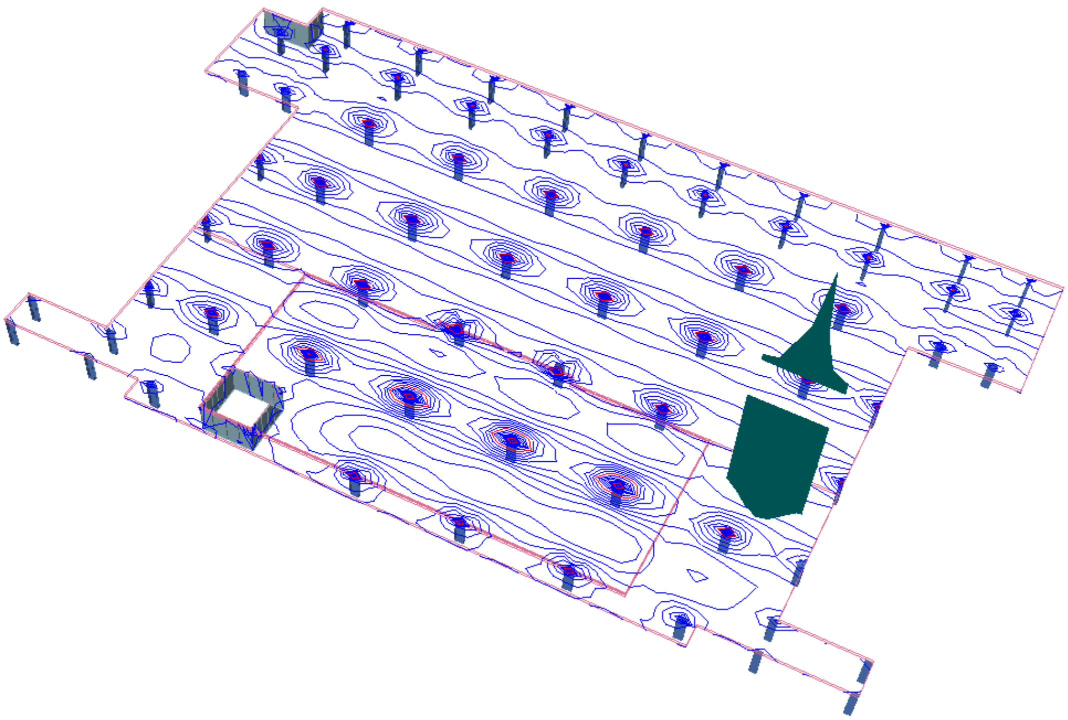

FIGURE 10 DISTRIBUTION OF MOMENT ABOUT THE DESIGN STRIPS

TABLE 1 DESIGN VALUES OBTAINED FROM THE THREE DIFFERENT MESH DENSITY OPTIONS

	Manual	**Automatic Coarse**	**Automatic Fine**
Number of nodes	3105	3104	15041
Max deflection (inch)	**0.212**	**0.211**	**0.214**
Midspan moment (k-ft)	98.83	6.09	95.70
Support moment (k-ft)	-141.7	-141.7	-147.0
Total moment (k-ft)	**240.53**	**237.79**	**242.70**

The geometry of another complex podium slab with many changes in slab elevation is illustrated in **Figs. 11** and **12**. The floor system was analyzed with two different mash divisions, namely a regular size mesh with 3602 nodes and a fine mesh with 6888 nodes (**Figs. 13** and **14**).

The values of the calculated deflection are listed in **Table 2**. It is noted that there is essentially no increase in accuracy in the fineness of the mesh achieved through the selection of smaller cell sizes

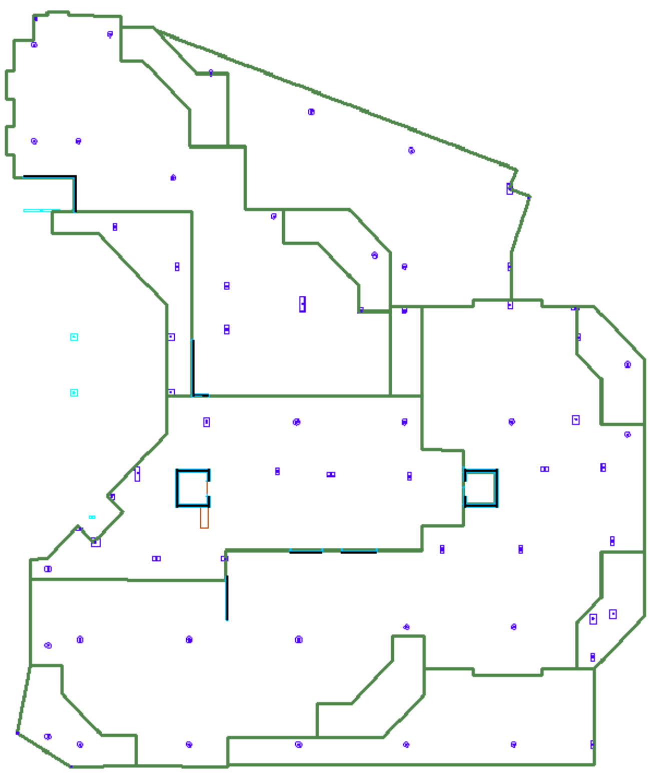

FIGURE 11 PLAN OF PODIUM SLAB

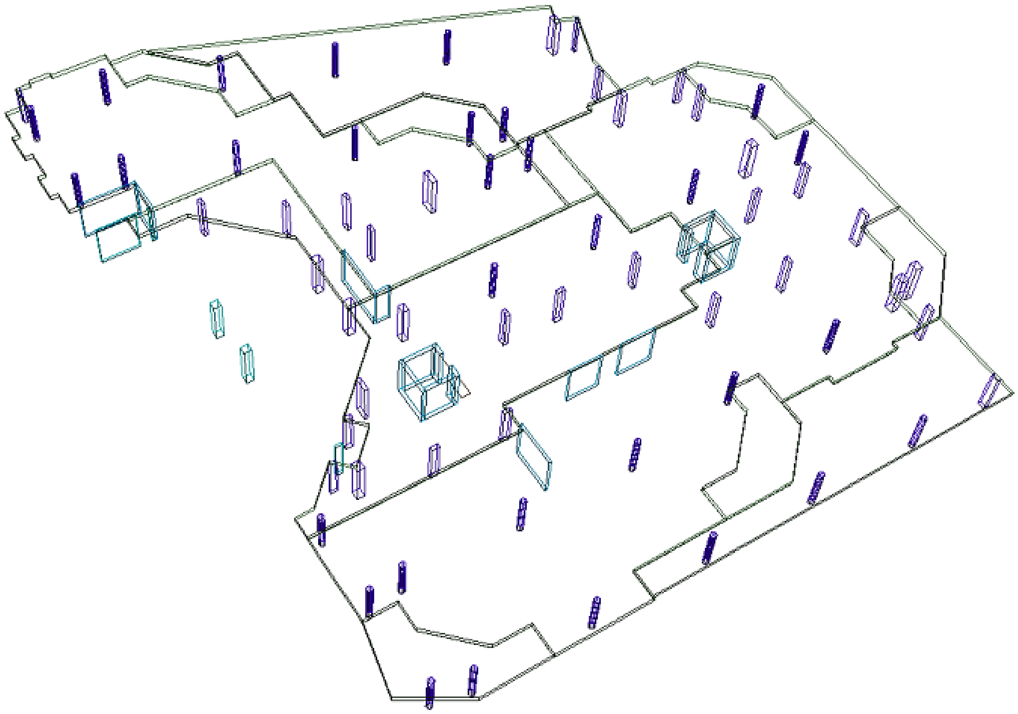

FIGURE 12 THREE DIMENSIONAL VIEW OF THE PODIUM SLAB

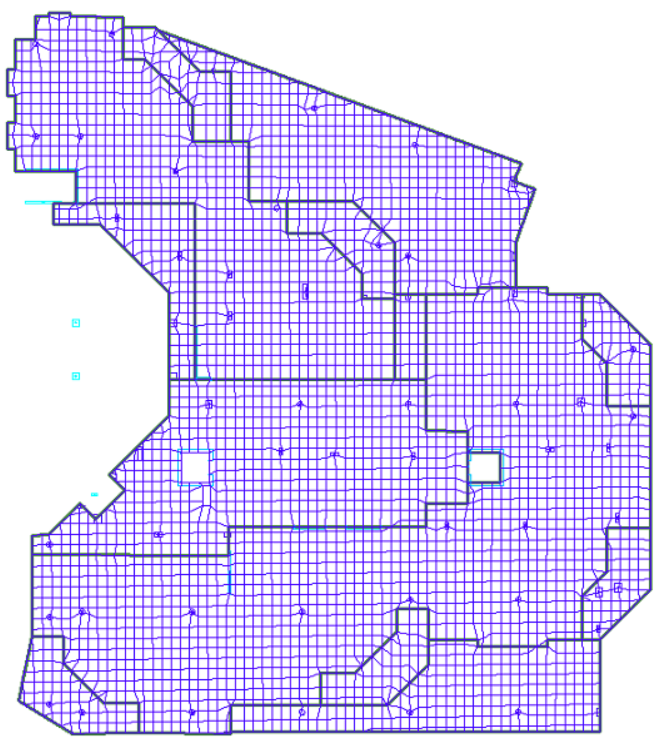

FIGURE 13 MANUAL MESHING, 3602 NODES
Maximum deflection 0.305”, Minimum deflection –0.088”

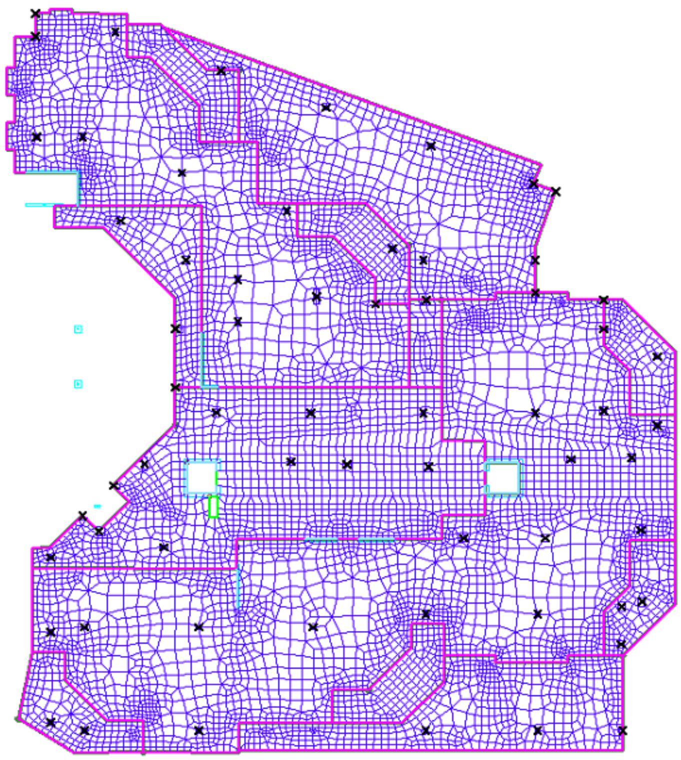

FIGURE 14 FINE MIXED MESHING, 6888 NODES
Maximum deflection 0.307", Minimum deflection –0.085"

TABLE 2 DEFLECTION VALUES OBTAINED FROM DIFFERENT MESH DENSITY

	Coarse Mesh	**Fine Mesh**
Number of nodes	3602	6888
Max deflection (inch)	0.305	0.307
Min deflection (inch)	-0.088	-0.085

REFERENCES

1 - Aalami, B. O. (2001)“Software for the Design of Concrete Buildings,” American Concrete Institute, Concrete International Journal, December 29, 2001, pp. 28-35.

2 - Aalami, Bijan, O., and Kelley, Gail, S. (2001a), “*Design of Concrete Floors with Particular Reference to Post-Tensioning,”* Post-Tensioning Institute, Phoenix, AZ, Technical Note 11, January 2001, pp 16.

AKNOWLEGEMENT

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