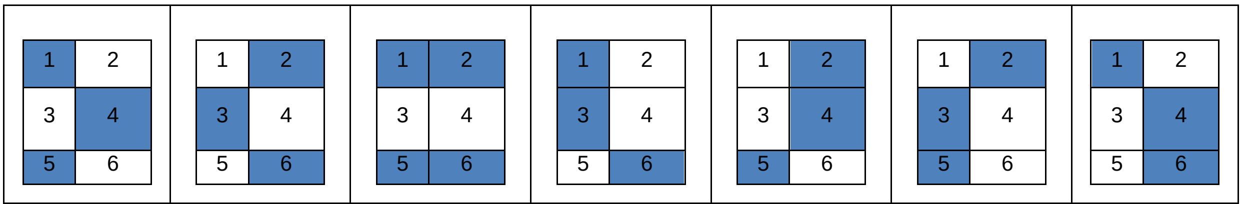
4.2.3 Unfavourable loadings and envelopes of stresses – deflections

The minimum load applied on a slab is equal to g whereas the maximum load is equal to $p=(\gamma_g-1)\cdot g_i + \gamma_q\cdot q_i$. The general problem concerns the way that the slabs should be loaded for developing maximum stresses.

This is a complicated issue since, even for a simple case of six slabs arranged in a grid seven unfavourable loadings are required, as illustrated in the following figure. The analysis of such a simple example via tables can be performed only for equally grid axes.

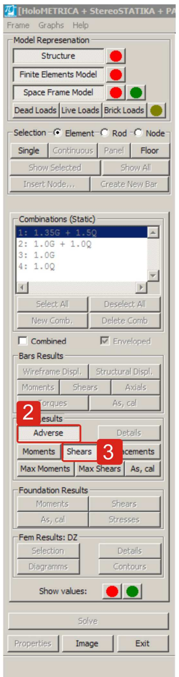


max M1, max M4, max M5, min M2, min M3, min M6	max M2, max M3, max M6, min M1, min M4, min M5	max |M1-2| max |M5-6| min |M3-4|	max |M1-3|, min |M2-4|	max |M2-4|, min |M1-3|	max |M3-5|, min |M4-6|	max |M4-6|, min |M3-5|

The problem becomes even more complicated when slabs are not arranged in a grid.

General and accurate analysis can only be achieved by means of the the finite element method. However, the resources for such an analysis require sophisticated algorithms and modern computers. The related software performs parallel processing of such algorithms on all available cores of a personal computer providing solutions to such complicated problems within seconds.

The unfavourable loadings on the three previously resolved examples will be examined next.



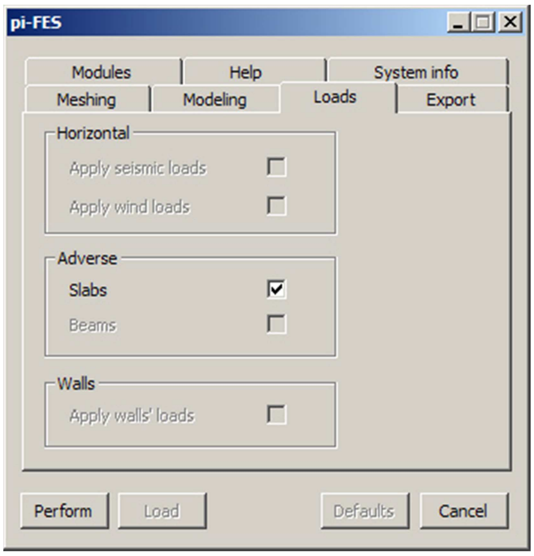


Figure 4.2.3-2

Calculations, taking into account the unfavourable loadings, are performed by selecting “Adverse\Slabs” ① in the tab ‘Loads’ of pi-FES interface.

Results are displayed by pressing, “Adverse” ② and the stress resultant required e.g. “Shears”③.

Figure 4.2.3-1

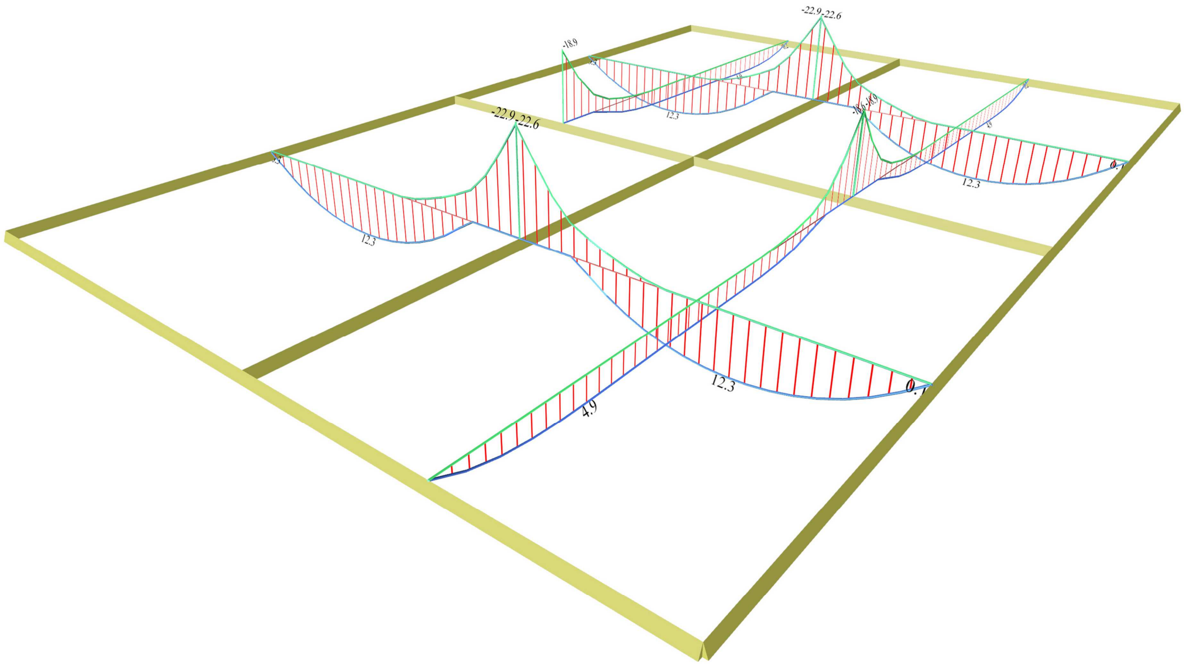


Figure 4.2.3-6: Bending moment envelopes

The most unfavourable bending moments are equal to:

- x direction: M_x=12.3 (10.8), $M_{x,erm}$=-22.8 (-22.0) [kNm]
- y direction: M_y=4.9 (4.1), $M_{y,erm}$=-18.8 (-16.3) [kNm]

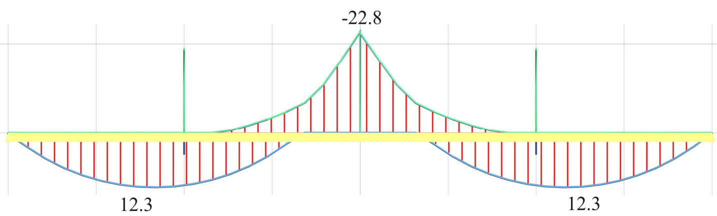


Figure 4.2.3-7: Front view of 3D bending moment diagrams, corresponding to the envelope of [M_x]

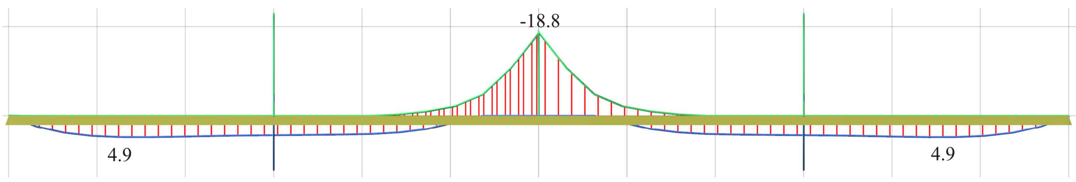


Figure 4.2.3-8: Side view of 3D bending moment diagrams, corresponding to the envelope of [M_y]

Note that although the live load has a relatively high value, the differences between the bending moments are small and less than15%.

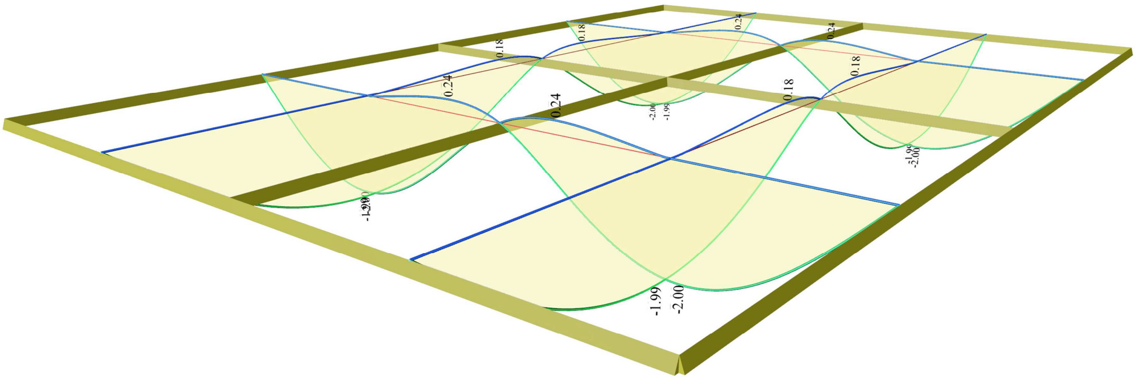


Figure 4.2.3-9: Deflection envelopes

The largest slab deflection is equal to y=-2.00 (-1.53) mm and y=+0.24 mm. It is concluded that the slab is lifted, which is in contrast with the responseof the global loading case, due to symmetry of course.

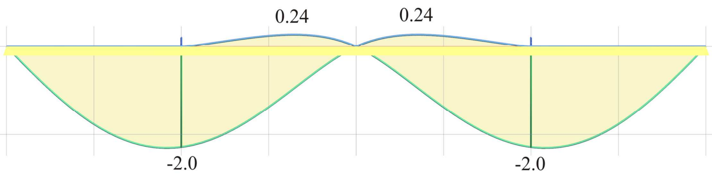


Figure 4.2.3-10: Front view of 3D deflection diagrams

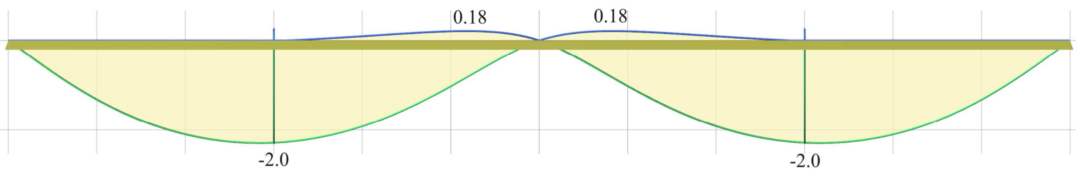


Figure 4.2.3-11: Side view of 3D deflection diagrams

Notice that the deflections are as high as 30% while opposite sign deformations also arise (blue lines).

- The “BUILDING” module

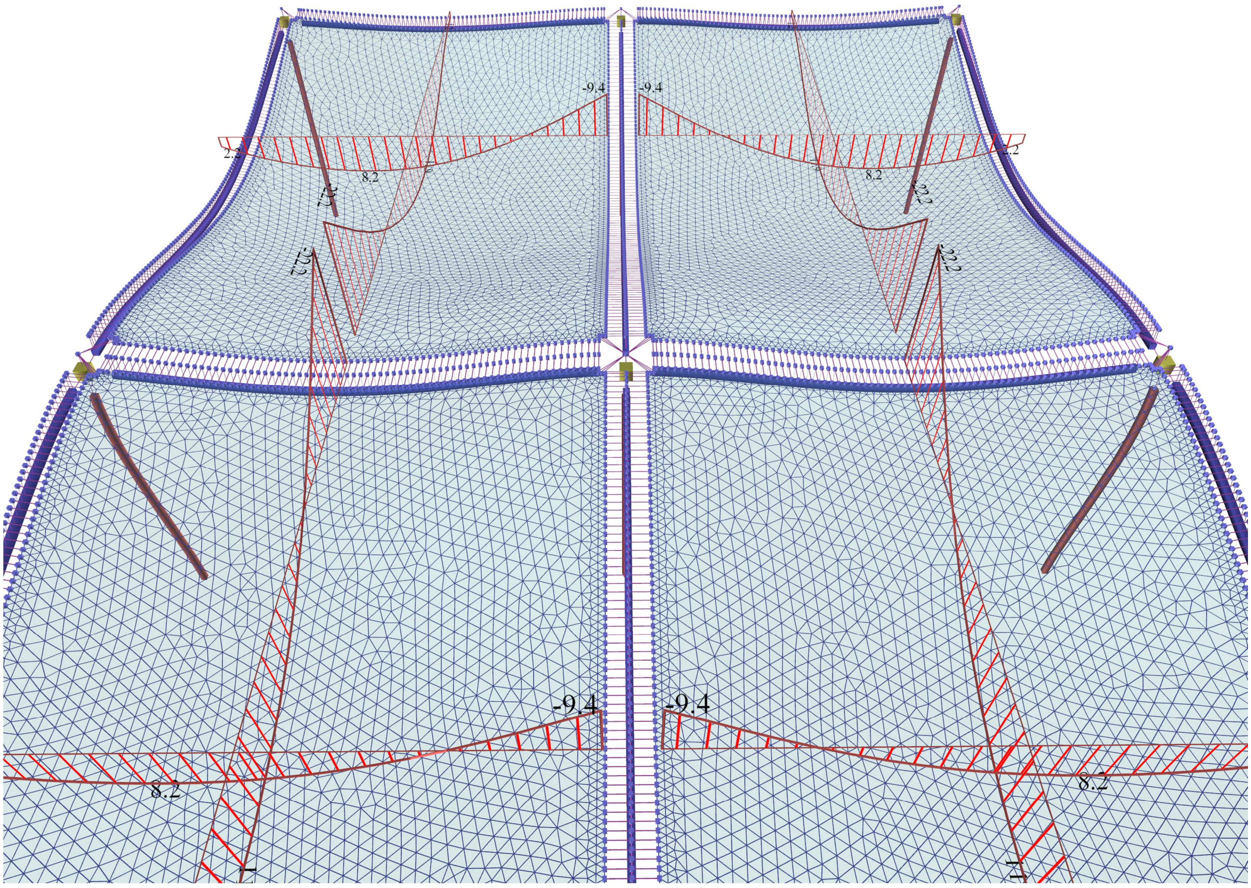


Figure 4.2.4-7: In module ‘BUILDING’, the interaction of the slabs with the structure is taken into account resulting from point to point more or less favourable stresses compared to the module ‘SLABS’.

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As explained in detail in chapter 3 and Appendix A, the influence of beams and columns on the behaviour of a building is very important. In this example, the bending moment of the slabs S_1-S_2 is significantly smaller compared to the ‘SLABS’ module. The support moment, in this module, is provided directly on the side faces of the beams, wherein the detailing takes place. However, the peak moment in the middle of the support (in the middle of the beam) is much higher.

Project <B_411-1> (Adverse\Slabs – Active module\BUILDING), dense meshing gives:
<u>26672</u> triangular elements, 16,417 nodes, 3856 linear members, system of <u>98,502</u> equations, memory 680 MB, time <u>12</u> sec, FPS=56

- Multistorey buildings and envelopes

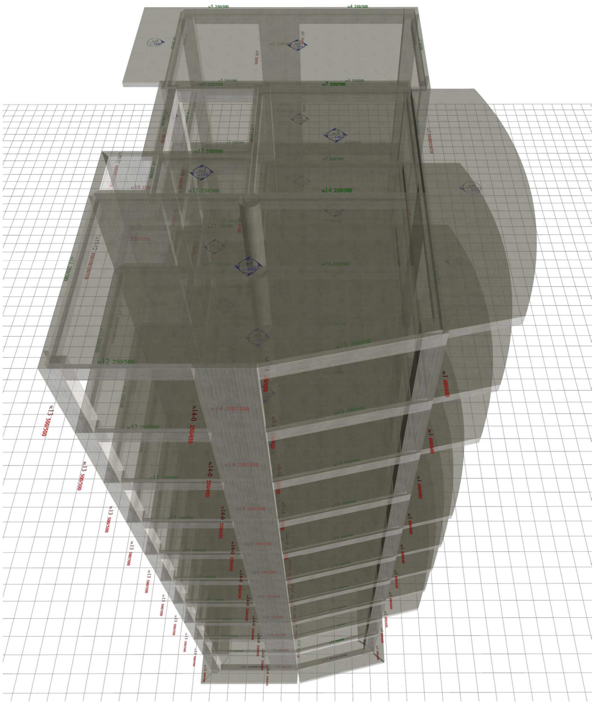

Figure 4.2.4-8: The actual structure in 3D

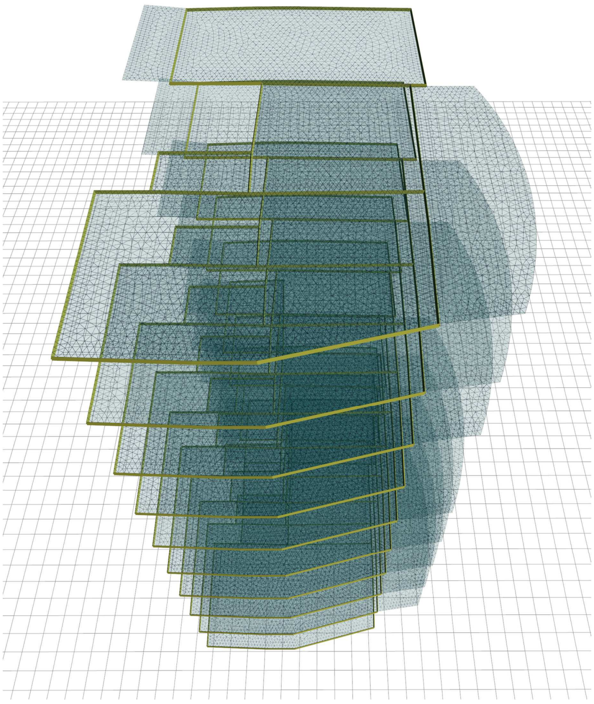

Figure 4.2.4-9: The structure's model in 3D

For the slab analysis, the unfavourable loadings are created per floor, i.e. loading of any floor slab has no effect on slabs of other floors. In "SLABS" module this effect is obvious while in "BUILDING" module is rather insignificant.

Project <Japan5>, running only in the professional version, consists of 10 floors with an area of 200 m^2. The following measurements are obtained using the following meshing parameters: "*Overall size*" = 0.20 m, *"Perimeter size"* = 0.10 m.

Adverse\Slabs – Active module\"SLABS":
134,292 triangular elements, 77,131 nodes, 6,507 linear members, 462,786 equations, memory 3.8 GB, time 125 sec, FPS=37

Adverse\Slabs – Active module\ "BUILDING":
183,217 triangular elements, 120,239 nodes, 34,727 linear members, 721,434 equations, memory 5.3 GB, time 209 sec, FPS=28