Seismic Design in Scia Engineer

Upcoming New Functionality:
Storey Results & Condensed Model Analysis

Webinar 26/02/2013

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Contents

- Introduction
- Improved Generation of Masses
- Condensed Model Analysis
- Storey Results
- Modal Superposition

Introduction

Development Strategy

- Provide EC8-compliant seismic analysis tools for buildings
- First: Code-independent basis for analysis
- Then: Design & Checks

New Features

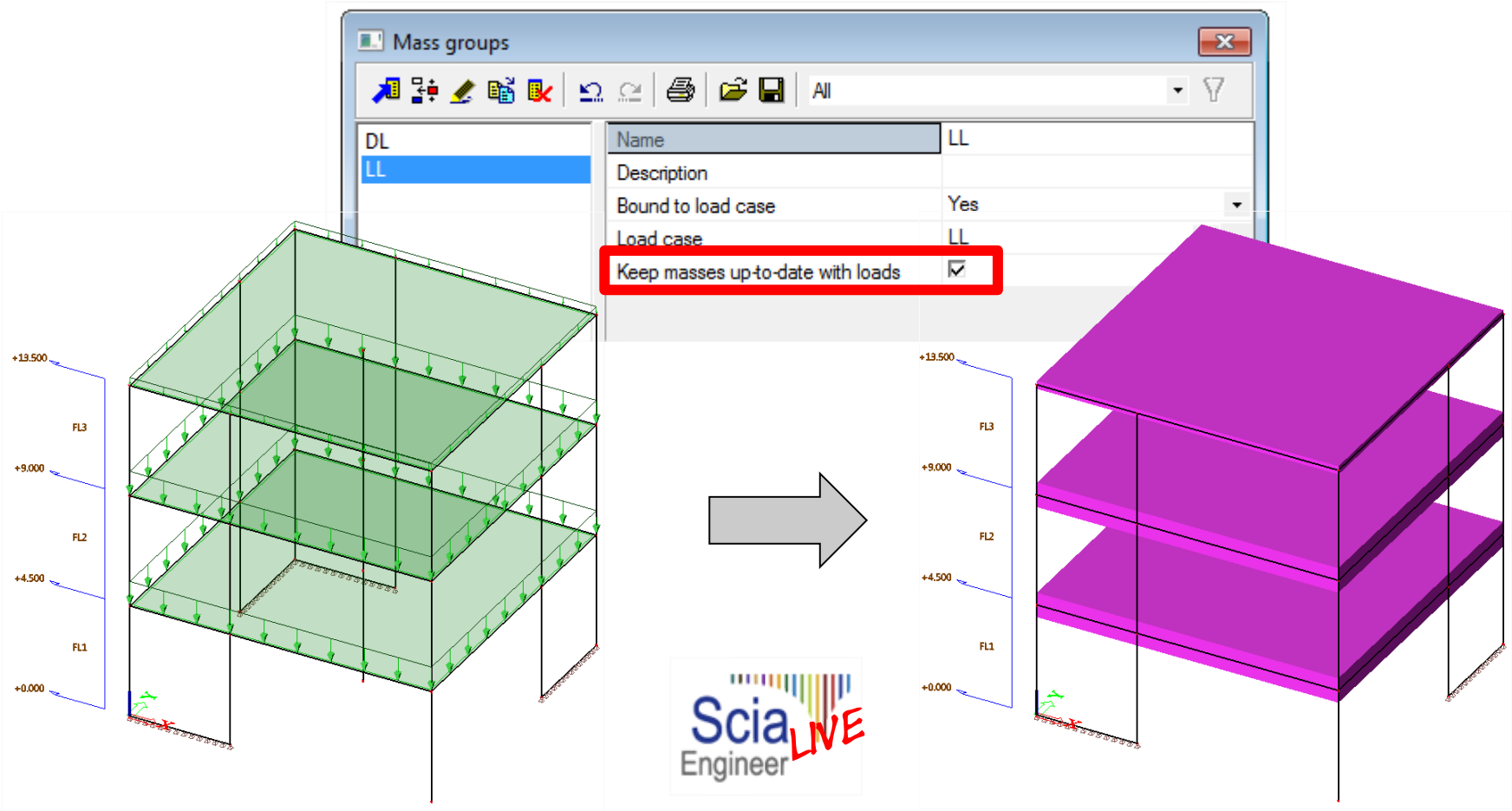
- What is coming in Scia Engineer 2013
- What is planned for further releases

New Features in Scia Engineer for Seismic Analysis & Design

IMPROVED GENERATION OF MASSES

Improved Generation of Masses

- Automatic update of masses generated from loads



New Features in Scia Engineer for Seismic Analysis & Design

CONDENSED MODEL ANALYSIS

Condensed Model Analysis

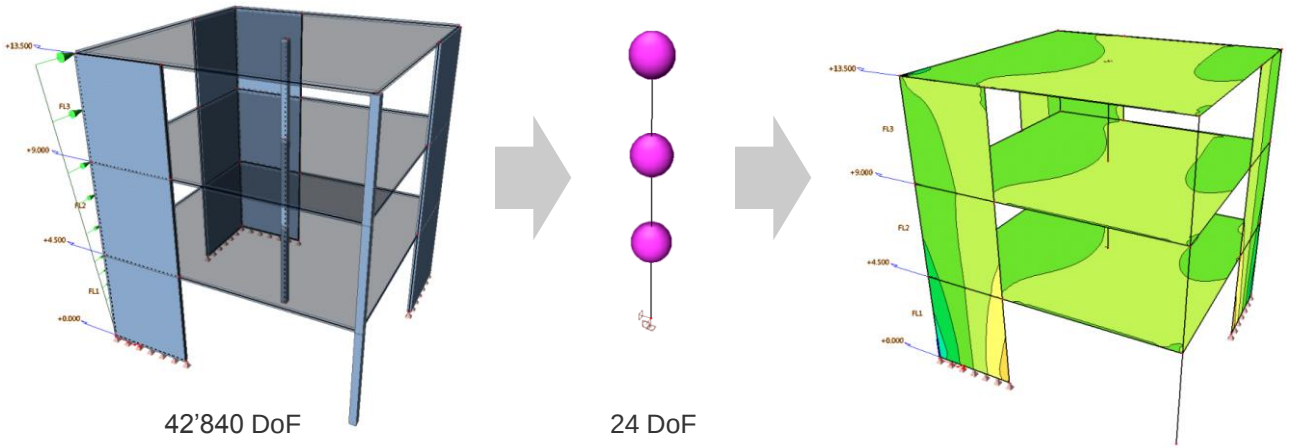
- Goal: fast modal analysis of large 3D modelization
  - ➔Matrix condensation techniques
  - ➔Improved Reduced System (IRS) for dynamic analysis

- IRS accounts for the mass matrix during condensation

Full 3D storey-based input

Condensed model & dynamic analysis

Expand back to full mesh for result output



42’840 DoF

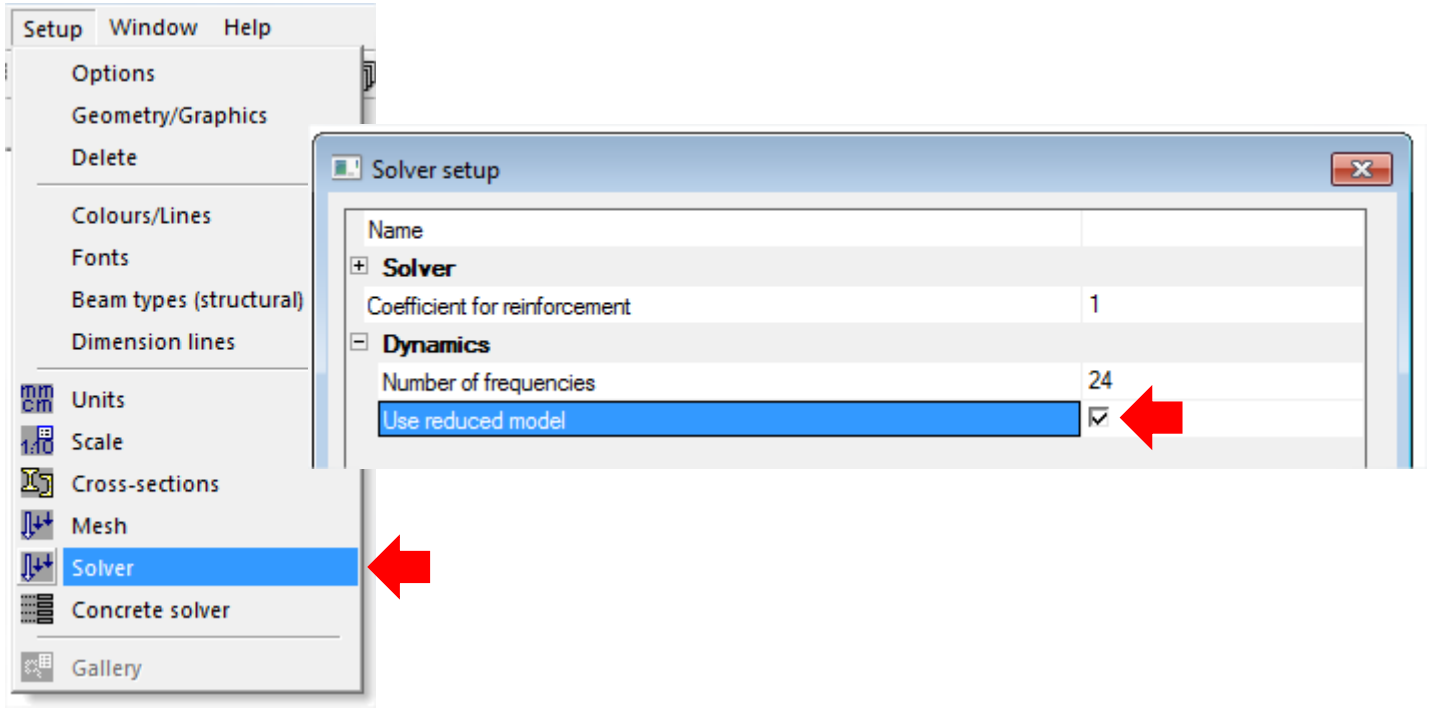
24 DoF

Advantages of the IRS Analysis vs Full Mesh Analysis

- Smaller analysis model: typically 1’000 times less DoF than original mesh
- Elimination of most local modes
- Easier achievement of required modal mass (90% criterion)
- Full mass matrix → allows for explicit mass eccentricity (further development)

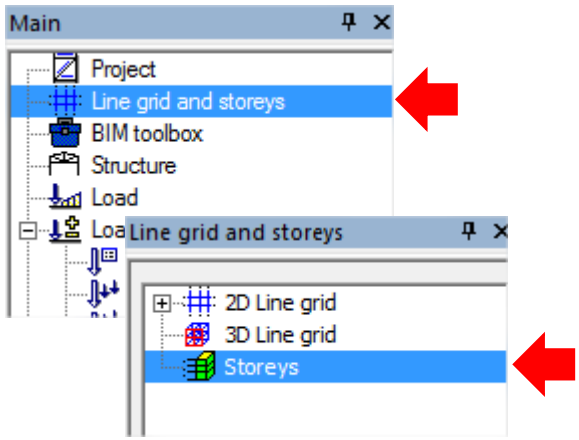
Definition of the Condensed Model in Scia Engineer

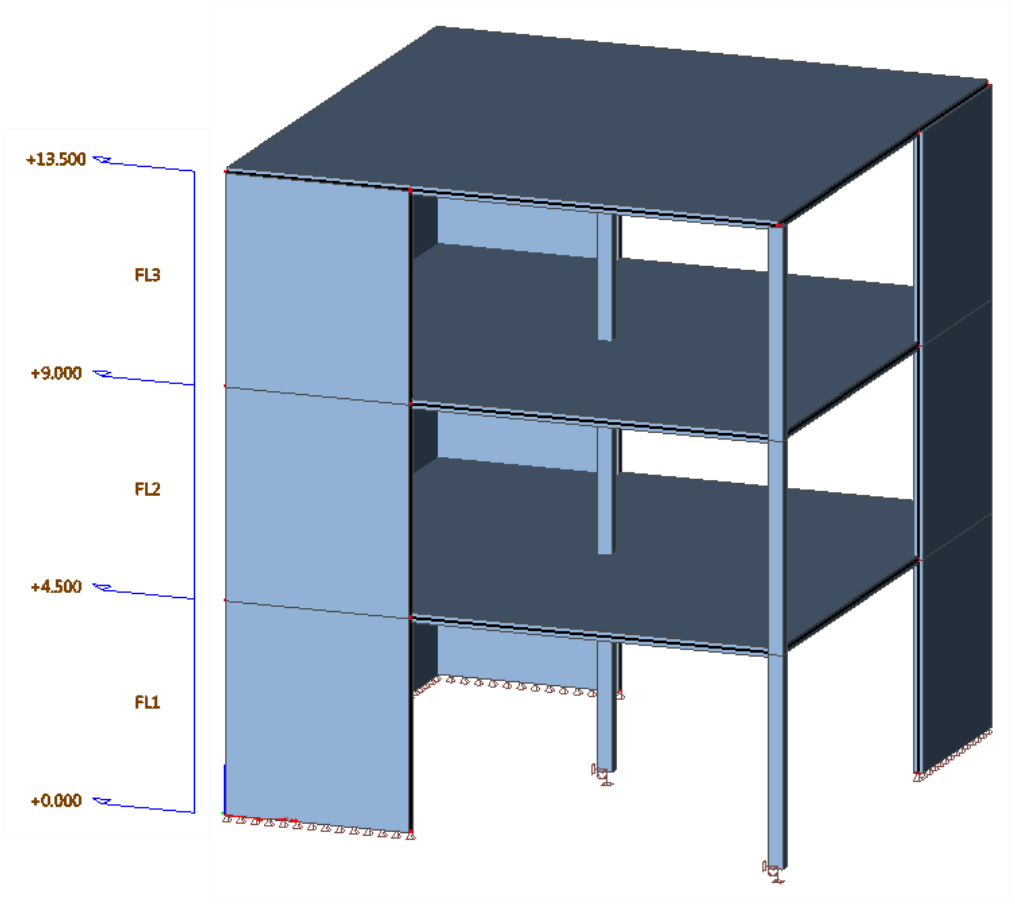
- Step 1: enable the reduced model



Definition of the Condensed Model in Scia Engineer

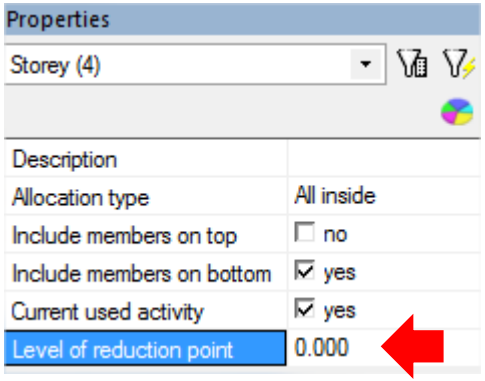
- Step 2: define storeys

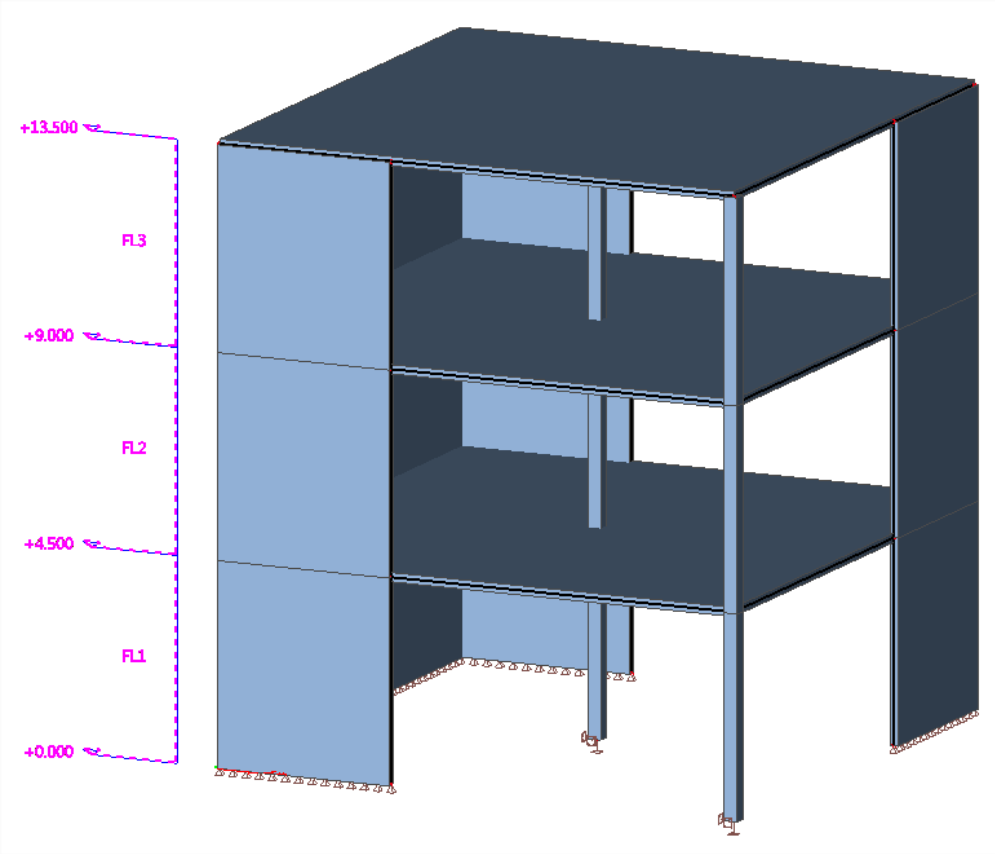




Definition of the Condensed Model in Scia Engineer

- Step 3 (optional): choose location of reduction nodes



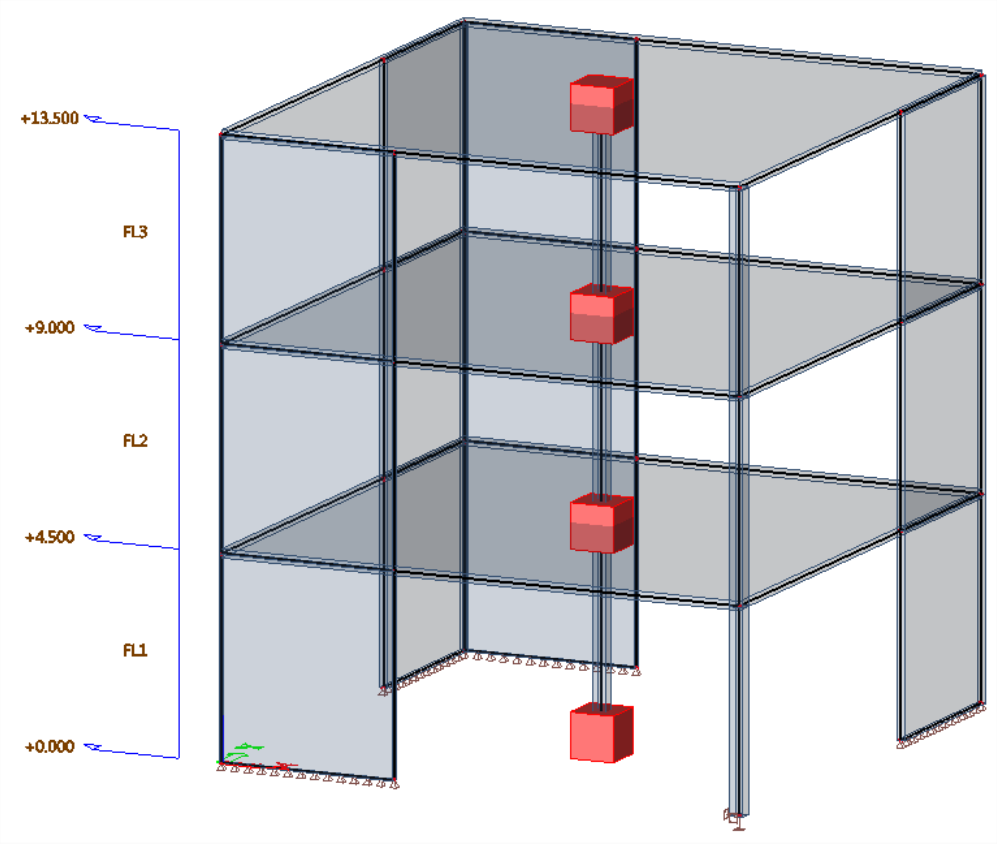


0.0 = bottom of the storey
1.0 = top of the storey

By default, the slab is located at the bottom of each storey, and so is the reduction point

Definition of the Condensed Model in Scia Engineer

- That’s it !

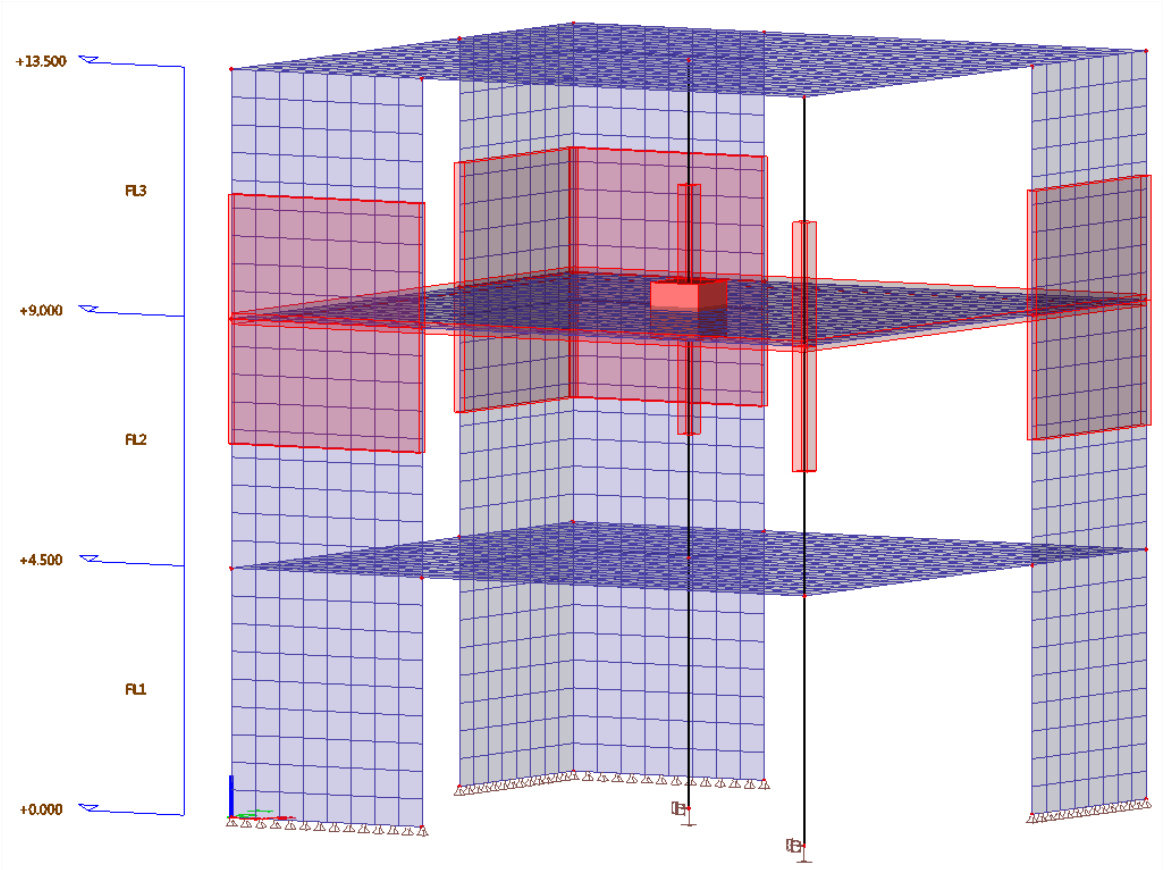


R-nodes are generated in the background during the analysis. They are not displayed as such.

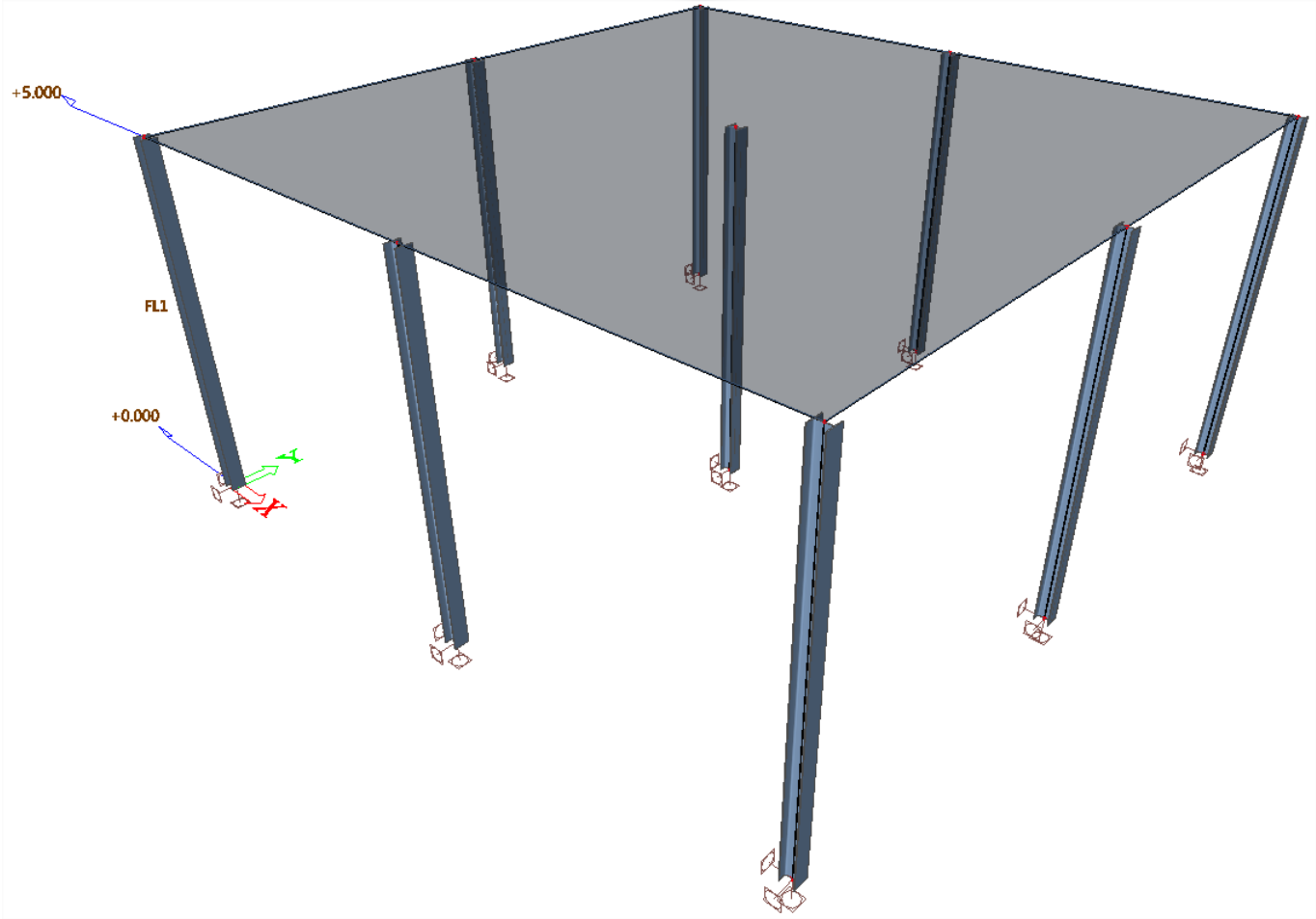
R-nodes do not have to correspond to the mass center of each storey.
They are placed in the middle of the building.

Definition of the Condensed Model in Scia Engineer

- Mapping of each FE of the mesh to the closest R-node

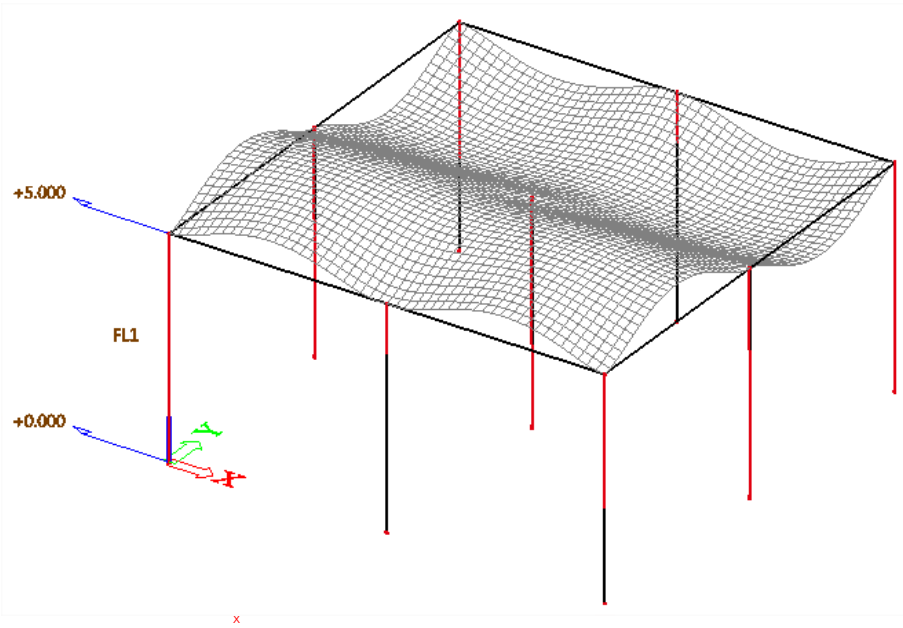


IRS vs Full Mesh Analysis – a simple example

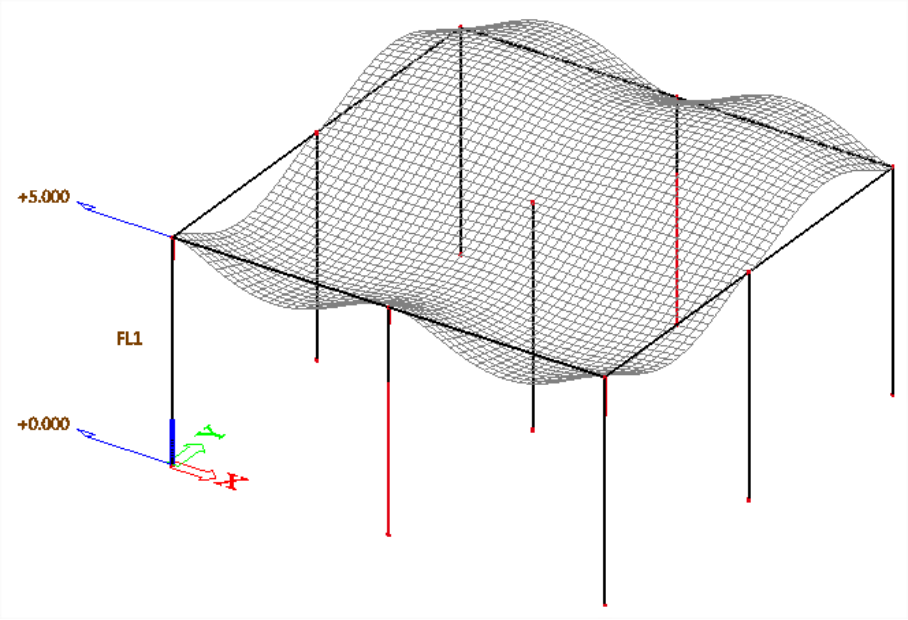


IRS vs Full Mesh Analysis – eigenmodes

Full Mesh – Mode 1 – 1.15 Hz

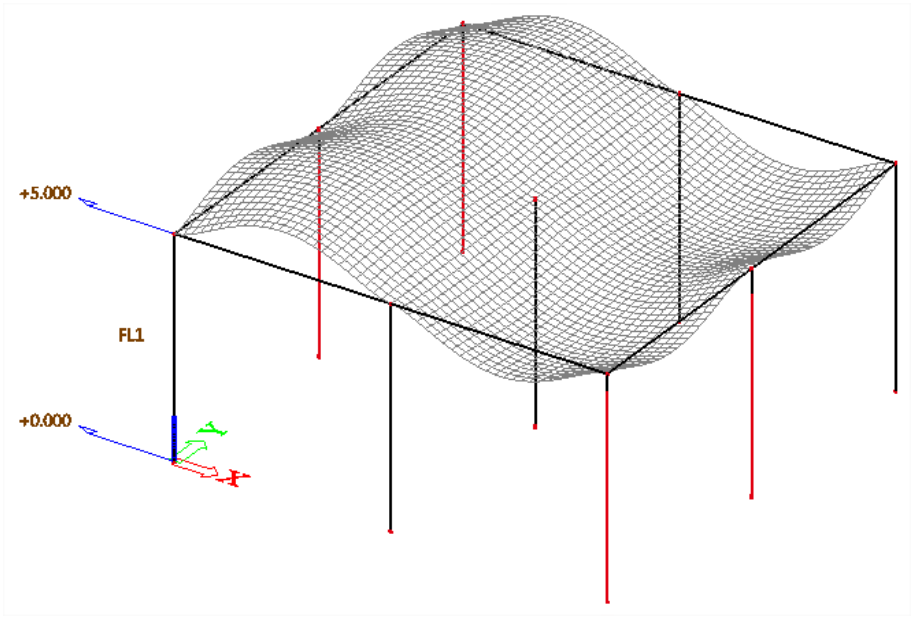


IRS – Mode 1 – 1.17 Hz

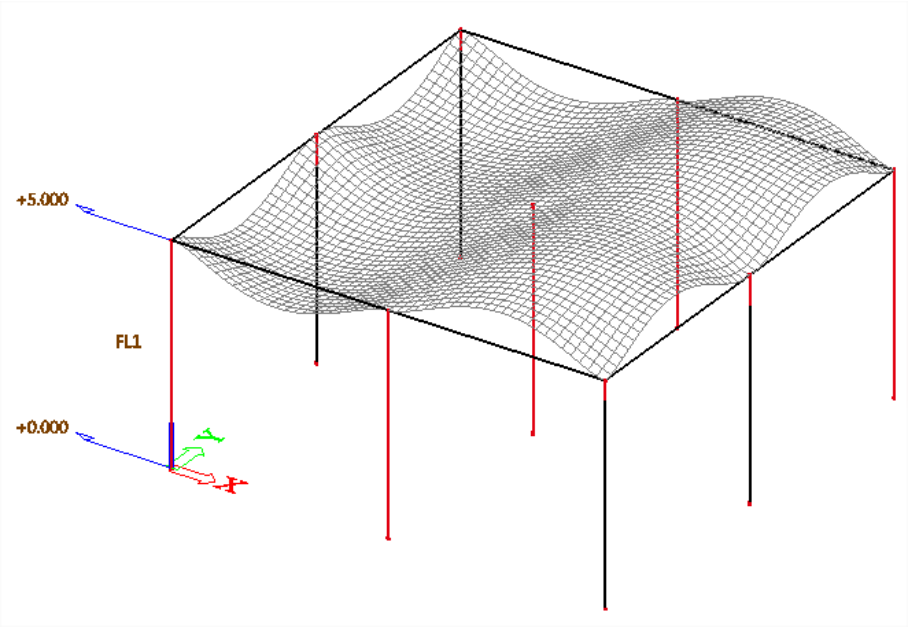


IRS vs Full Mesh Analysis – eigenmodes

Full Mesh – Mode 2 – 1.15 Hz

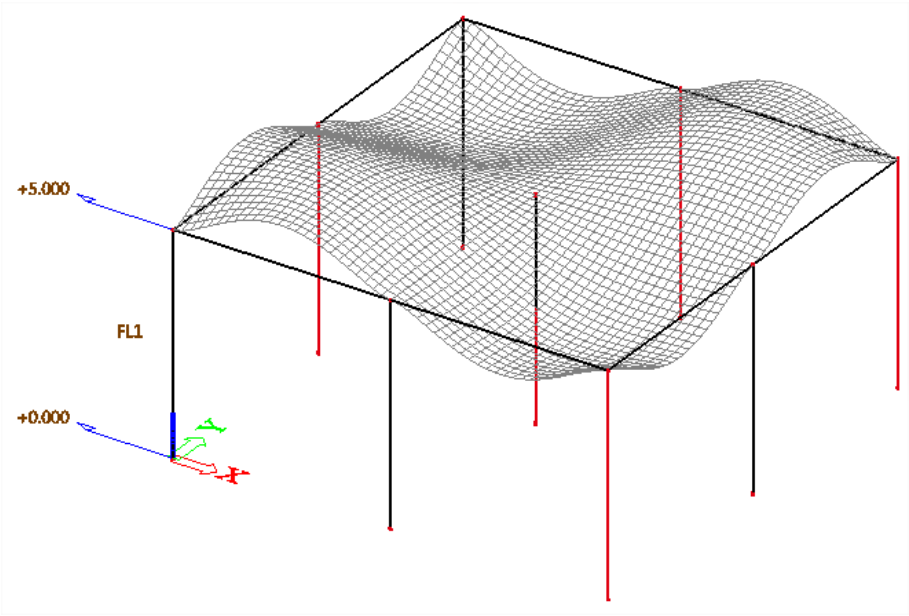


IRS – Mode 2 – 1.17 Hz



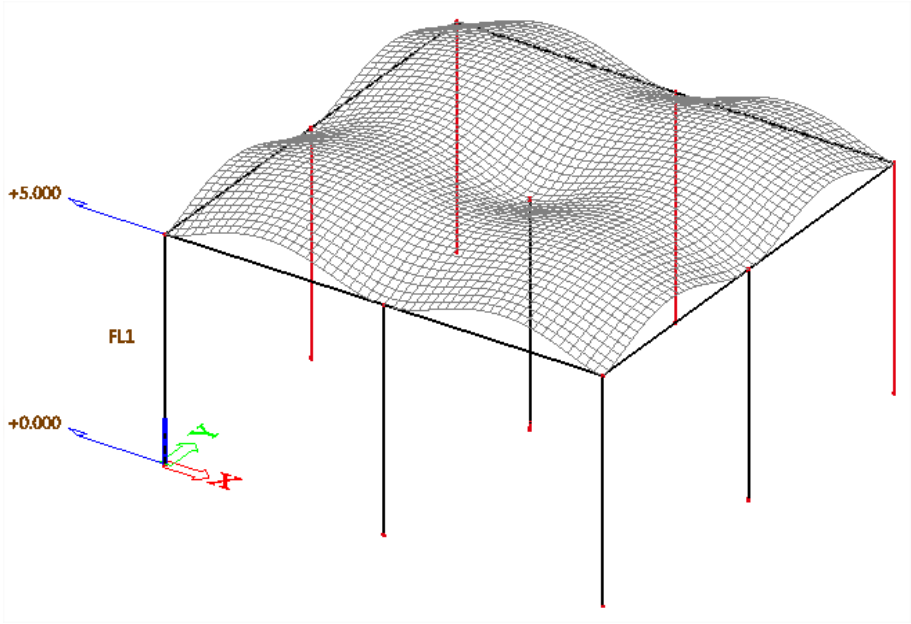
IRS vs Full Mesh Analysis – eigenmodes

Full Mesh – Mode 3 – 1.21 Hz

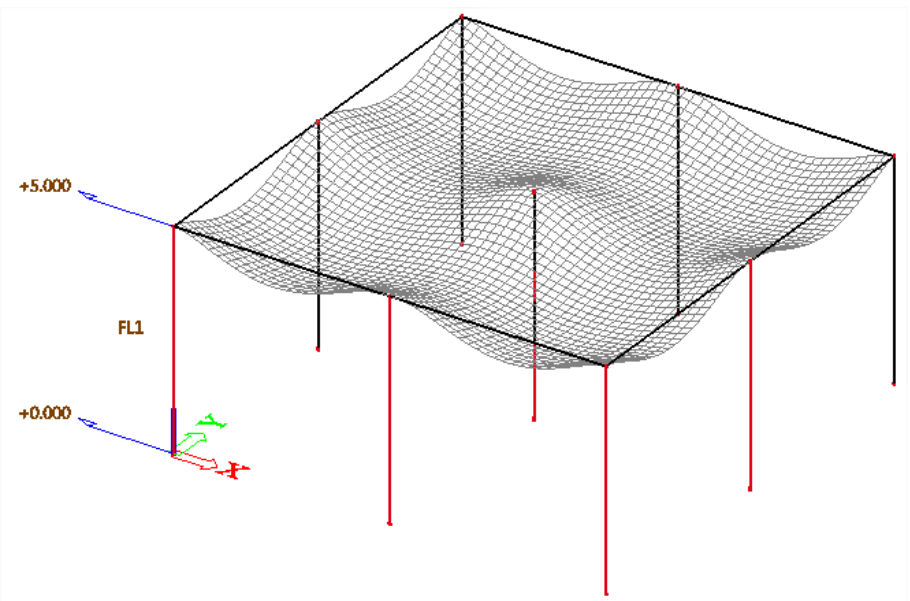


IRS vs Full Mesh Analysis – eigenmodes

Full Mesh – Mode 4 – 1.23 Hz

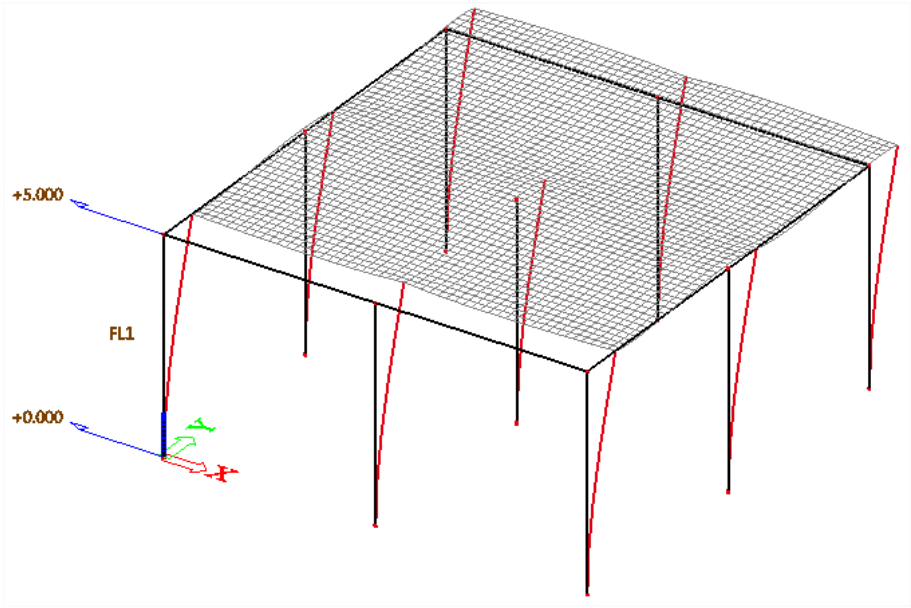


IRS – Mode 3 – 1.23 Hz

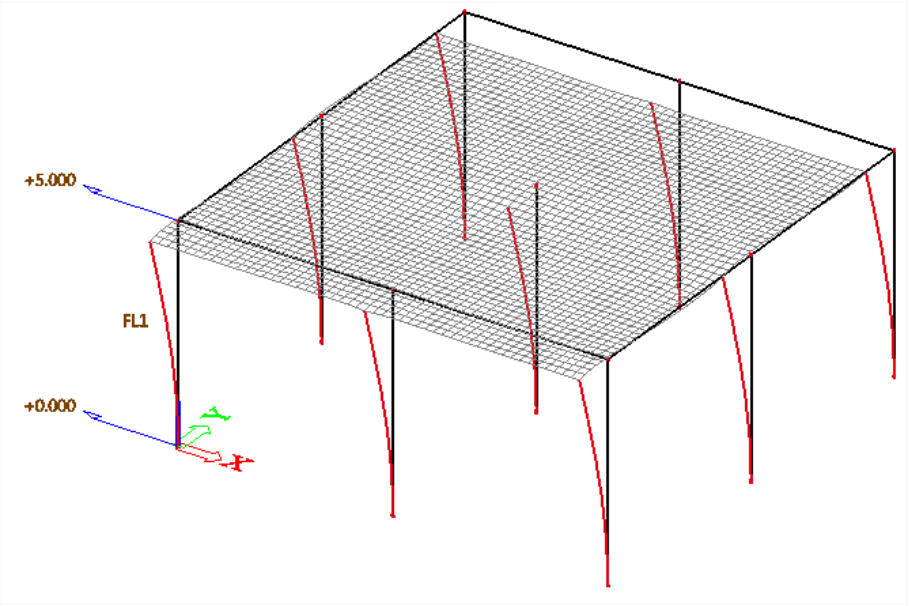


IRS vs Full Mesh Analysis – eigenmodes

Full Mesh – Mode 5 – 1.42 Hz

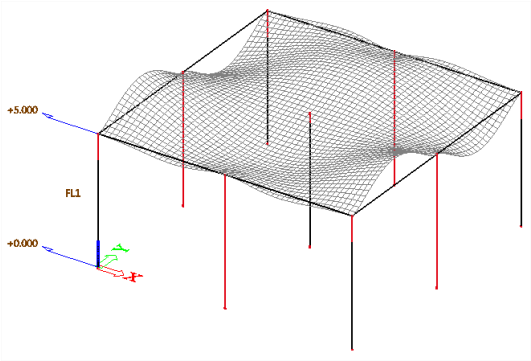


IRS – Mode 4 – 1.42 Hz

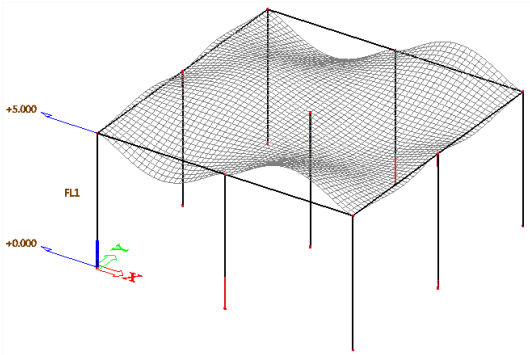


IRS vs Full Mesh Analysis – eigenmodes

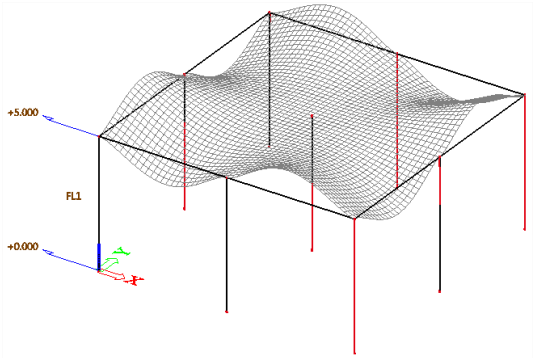
Full Mesh – Mode 6 – 2.10 Hz



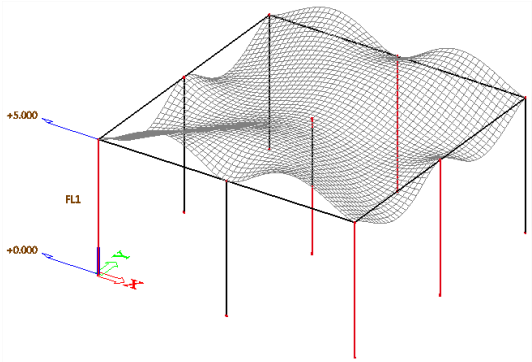
Full Mesh – Mode 7 – 2.10 Hz



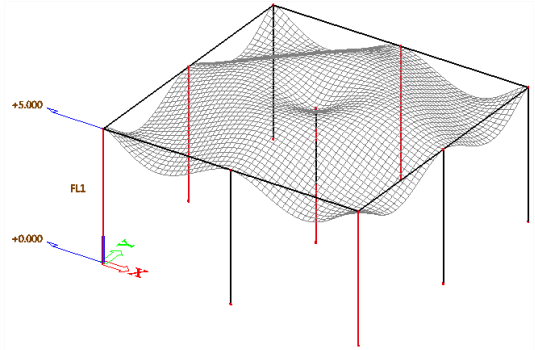
Full Mesh – Mode 8 – 2.15 Hz



Full Mesh – Mode 9 – 2.27 Hz

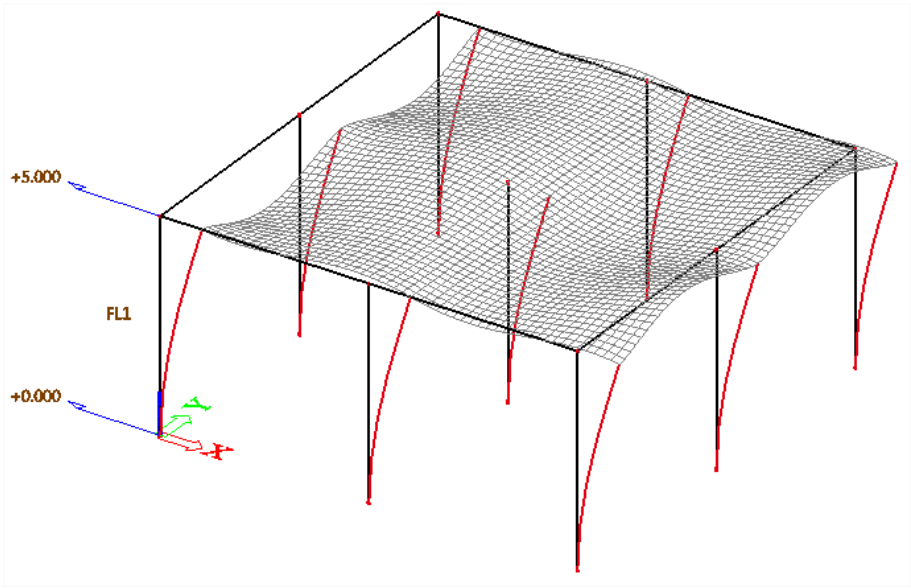


Full Mesh – Mode 10 – 2.30 Hz

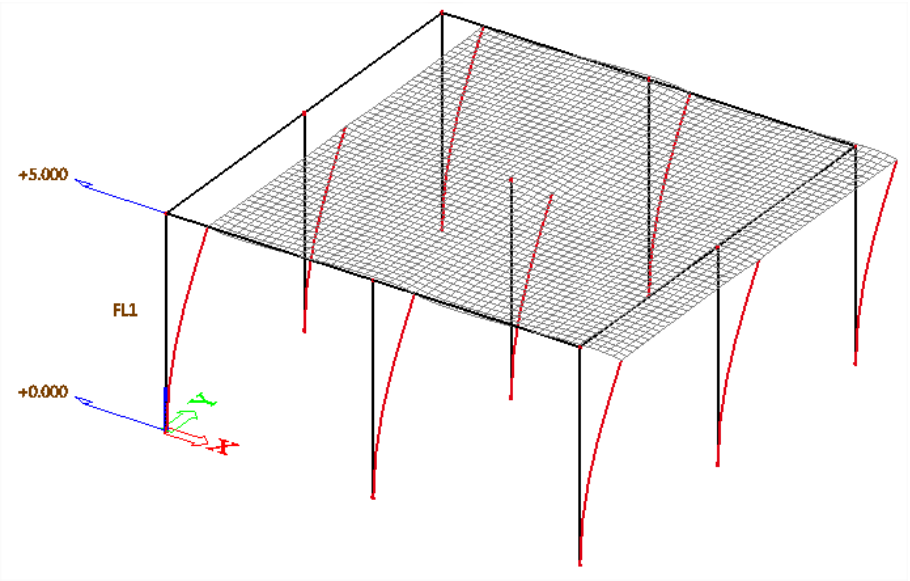


IRS vs Full Mesh Analysis – eigenmodes

Full Mesh – Mode 11 – 2.32 Hz



IRS – Mode 5 – 2.32 Hz



IRS vs Full Mesh Analysis – summary of eigenmodes

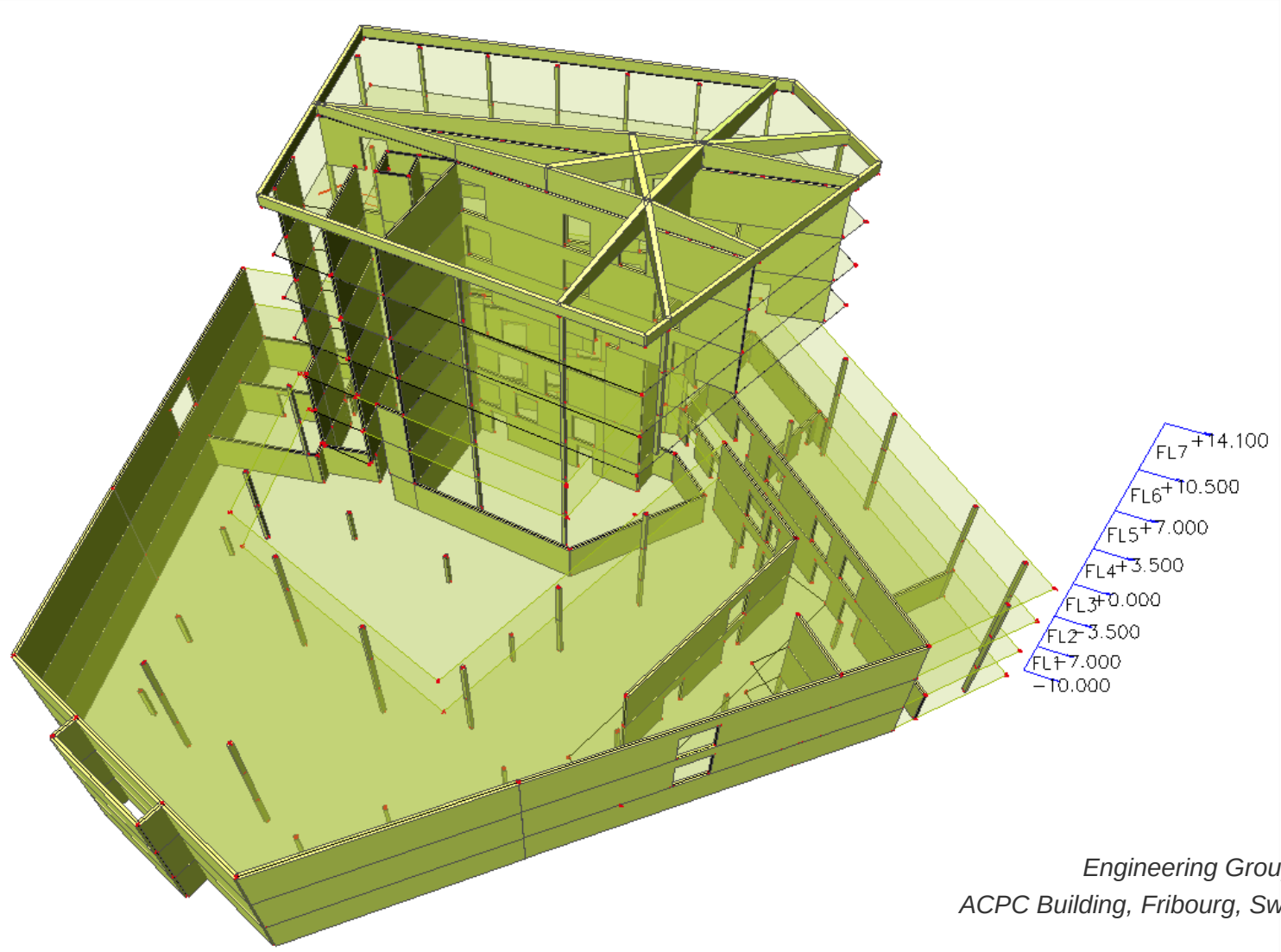
Full Mesh Analysis

Mode	Freq. [Hz]	Wxi / Wxtot	Wyi / Wytot	Wzi / Wztot
1	1.15	0	0.0001	0
2	1.15	0	0	0
3	1.21	0	0	0
4	**1.23**	0	0	**0.887**
5	**1.42**	0	**0.9981**	0
6	2.10	0	0.0001	0
7	2.10	0.0004	0	0
8	2.15	0	0	0
9	2.27	0	0	0
10	2.30	0	0	0.0001
11	**2.32**	**0.9644**	0	0
12	2.47	0	0.0011	0
		0.9648	**0.9994**	**0.8871**

IRS Analysis

Mode	Freq. [Hz]	Wxi / Wxtot	Wyi / Wytot	Wzi / Wztot
1	1.17	0	0.0003	0
2	1.17	0	0	0
3	**1.23**	0	0	**0.8934**
4	**1.42**	0	**0.9987**	0
5	**2.32**	**0.999**	0	0
6	2.71	0	0	0
7	130.72	0	0.001	0
8	205.43	0.001	0	0
9	248.14	0	0	0
10	413.53	0	0	0.1066
11	711.66	0	0	0
12	737.23	0	0	0
		1	**1**	**1**

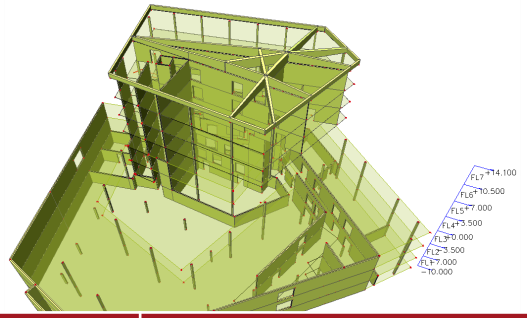
Full Mesh vs IRS Analysis – Real Building



Engineering Group GIBES

ACPC Building, Fribourg, Switzerland

Full Mesh vs IRS Analysis – Real Building



Input Data	Full Mesh	IRS
Mesh size	152’988 DoF	48 DoF
Requested modes	48	48

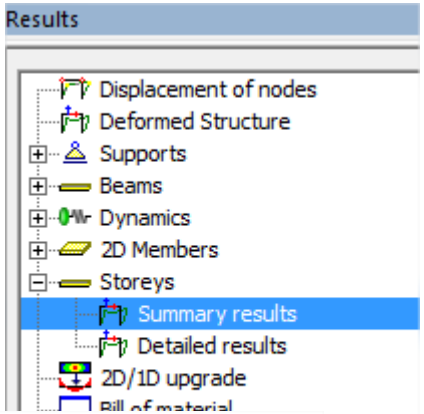
Results	Full Mesh	IRS
Data preparation	18”	16”
Modal analysis	35”	12”
Modal mass (X/Y/Z)	63% / 61% / 50%	95% / 96% / 98%

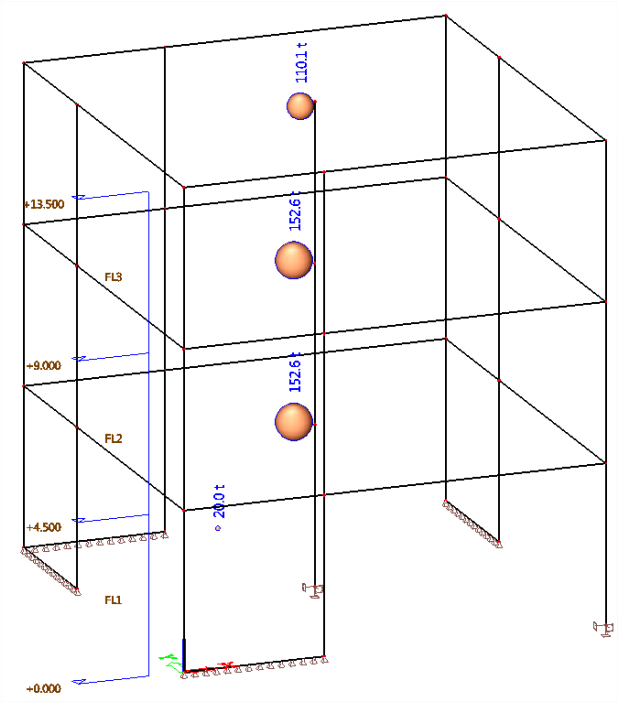
New Features in Scia Engineer for Seismic Analysis & Design

STOREY RESULTS

Summary Storey Results

- For mass combinations
  - Storey data: mass & mass center of each storey
  - Displacements of storey mass center per mode
  - Accelerations of storey mass center per mode





Summary storey result

Storey Displacements:
Eigen solution, Extreme: No, System: Principal
Selection: All
Mass combinations : CM1/1 - 2.07

Name	Ux [mm]	Uy [mm]	Uz [mm]	Phix [mrad]	Phiy [mrad]	Phiz [mrad]
FL1	-6.1e-02	6.1e-02	0.0e+00	-2.0e-03	-2.0e-03	0.0e+00
FL2	-3.3e-01	3.3e-01	7.7e-02	-8.0e-03	-8.0e-03	0.0e+00
FL3	-9.9e-01	9.9e-01	1.1e-01	-1.1e-02	-1.1e-02	0.0e+00
FL4	-1.7e+00	1.7e+00	1.3e-01	-1.0e-02	-1.0e-02	0.0e+00

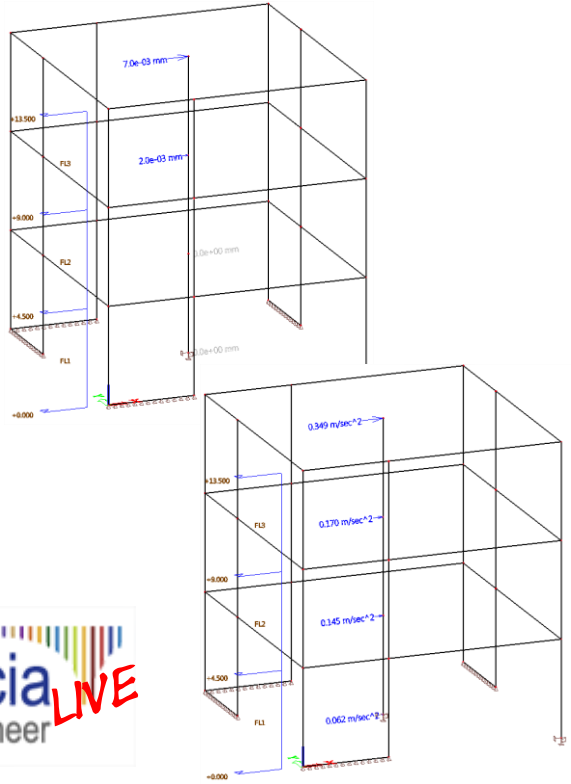
Summary storey result

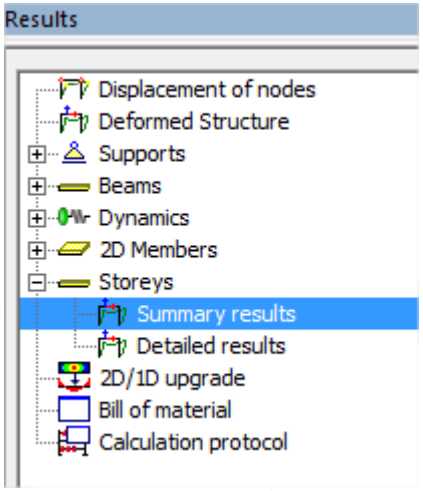
Storey Accelerations:
Eigen solution, Extreme: No, System: Principal
Selection: All
Mass combinations : CM1/1 - 2.07

Name	Ax [m/sec^2]	Ay [m/sec^2]	Az [m/sec^2]	Alpha X [mrad/sec^2]	Alpha Y [mrad/sec^2]	Alpha Z [mrad/sec^2]
FL1	-0.010	0.010	0.000	-3.38e-01	-3.38e-01	0.00e+00
FL2	-0.056	0.056	0.013	-1.35e+00	-1.35e+00	0.00e+00
FL3	-0.167	0.167	0.019	-1.86e+00	-1.86e+00	0.00e+00
FL4	-0.291	0.291	0.022	-1.69e+00	-1.69e+00	0.00e+00

Summary Storey Results

- For seismic load cases
  - Displacements of storey mass center
  - Accelerations of storey mass center





Summary storey result

Storey Displacements:
Linear calculation, Extreme: No, System: Principal
Selection: All
Load cases : EQX

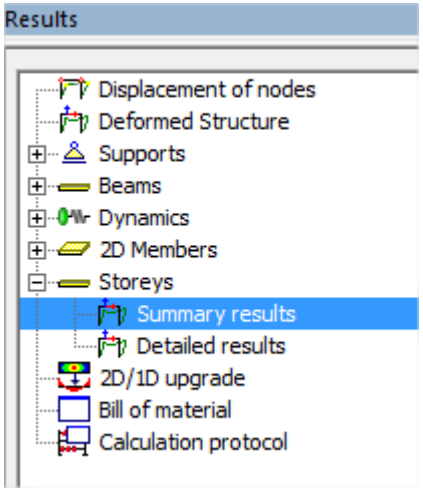
Name	Ux [mm]	Uy [mm]	Uz [mm]	Phix [mrad]	Phiy [mrad]	Phiz [mrad]
FL1	0.0e+00	0.0e+00	0.0e+00	0.0e+00	0.0e+00	0.0e+00
FL2	0.0e+00	0.0e+00	0.0e+00	0.0e+00	0.0e+00	0.0e+00
FL3	2.0e-03	2.0e-03	0.0e+00	0.0e+00	0.0e+00	0.0e+00
FL4	7.0e-03	7.0e-03	0.0e+00	0.0e+00	0.0e+00	0.0e+00

Summary storey result

Storey Accelerations:
Linear calculation, Extreme: No, System: Principal
Selection: All
Load cases : EQX

Name	Ax [m/sec^2]	Ay [m/sec^2]	Az [m/sec^2]	Alpha X [mrad/sec^2]	Alpha Y [mrad/sec^2]	Alpha Z [mrad/sec^2]
FL1	0.062	0.062	0.000	1.10e-02	1.10e-02	2.37e-01
FL2	0.145	0.145	0.001	1.55e-01	1.55e-01	8.13e-01
FL3	0.170	0.170	0.003	3.32e-01	3.32e-01	2.13e+00
FL4	0.349	0.349	0.007	4.99e-01	4.99e-01	5.27e+00

Summary Storey Results



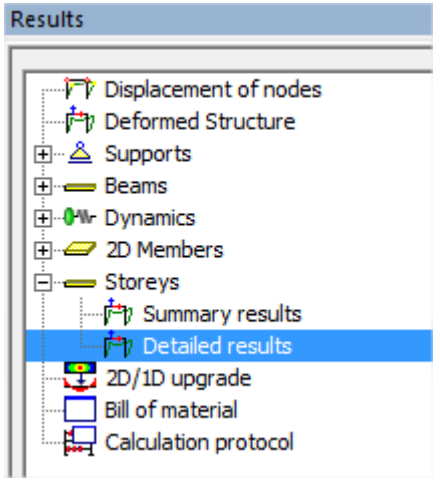
Important note

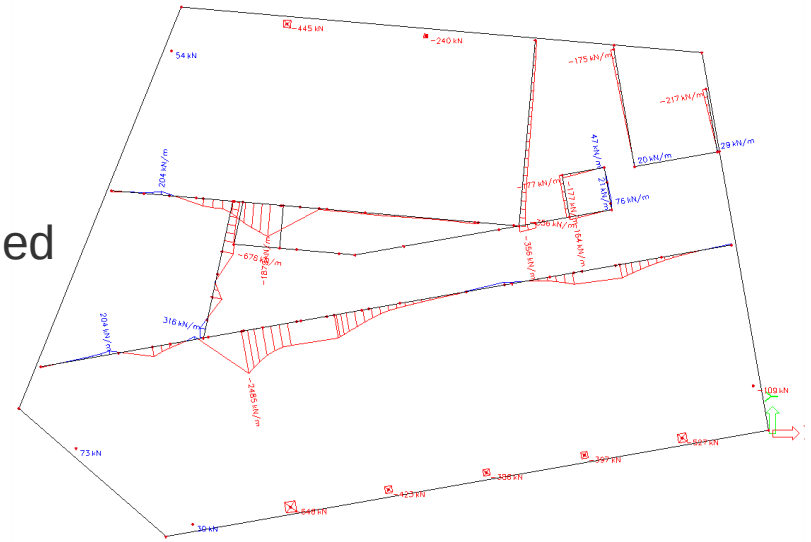
Summary Storey Results
are available only when the
reduced model analysis is enabled

Detailed Storey Results

- Internal forces in supporting members
  - Selection by storey
  - Extreme by member (also for walls !)
  - Walls & columns on the same drawing
  - Simple choice of section level
  - Display of average & total value for walls
  - Available for static & seismic results
  - Also suitable e.g. for load descending

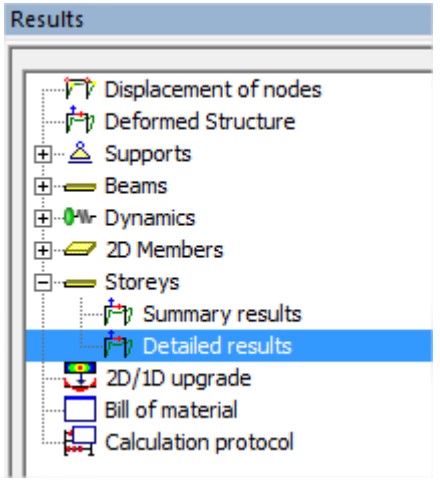
  - Only pre-requisite: storeys must be defined

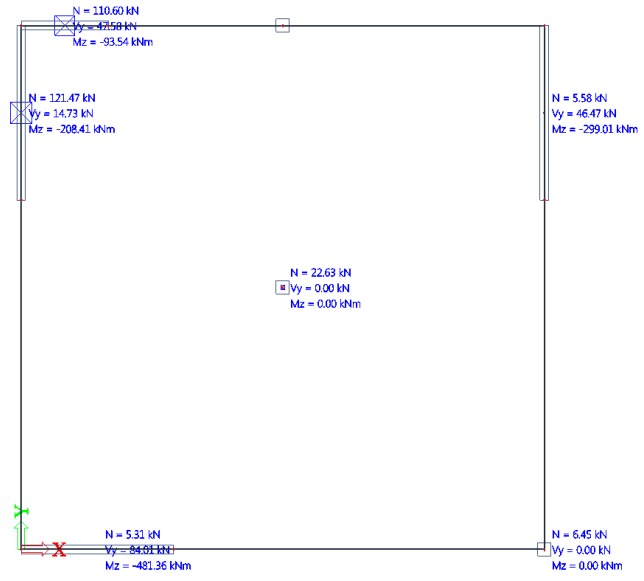




Detailed Storey Results

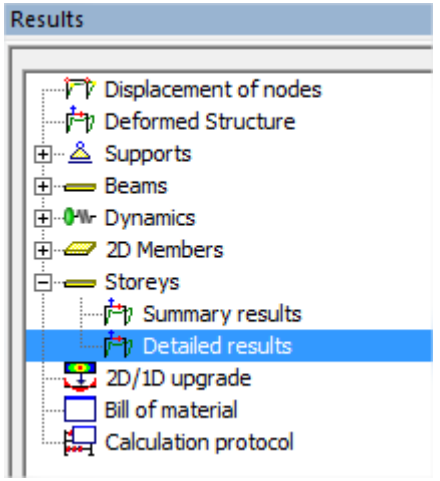
- Resultant forces in supporting members
  - Resultant for **each** wall on the same drawing
  - Clear display of more components
  - + all the key points mentioned previously
  - Only pre-requisite: storeys must be defined

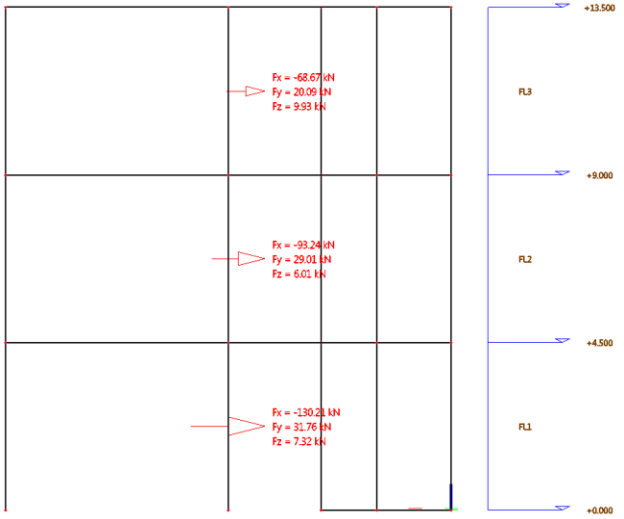




Detailed Storey Results

- Resultant forces in supporting members per storey
  - Resultant of **all** supporting members at once (walls + columns combined)
  - + all the key points mentioned previously
  - Only pre-requisite: storeys must be defined

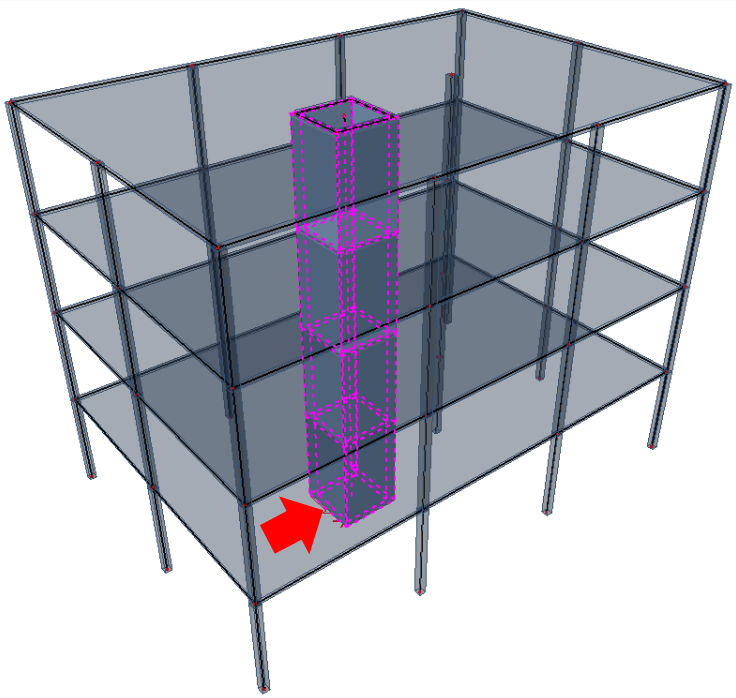


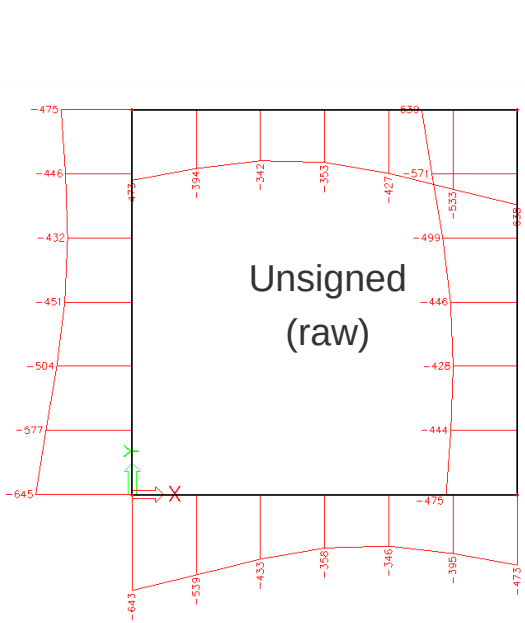


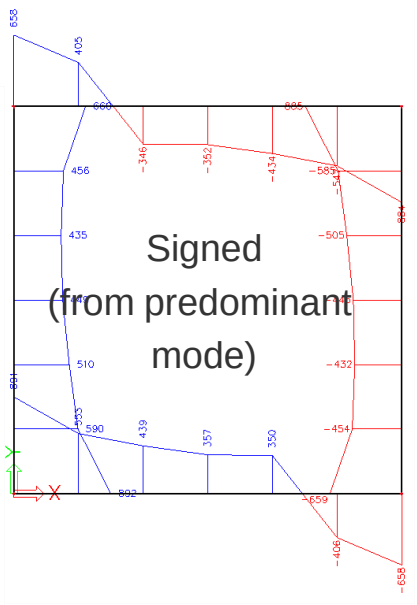
New Features in Scia Engineer for Seismic Analysis & Design

MODAL SUPERPOSITION FOR RESULTANTS

Modal Superposition for Resultants







Forces at the bottom of the core	Fx	Fy	Fz	Mx	My	Mz
Resultant from results signed after superposition	518	855	15	2509	2732	1691
New superposition of resultants	249	198	26	1900	2394	1614
Reference model (1D member)	264	209	25	1911	2429	1640