

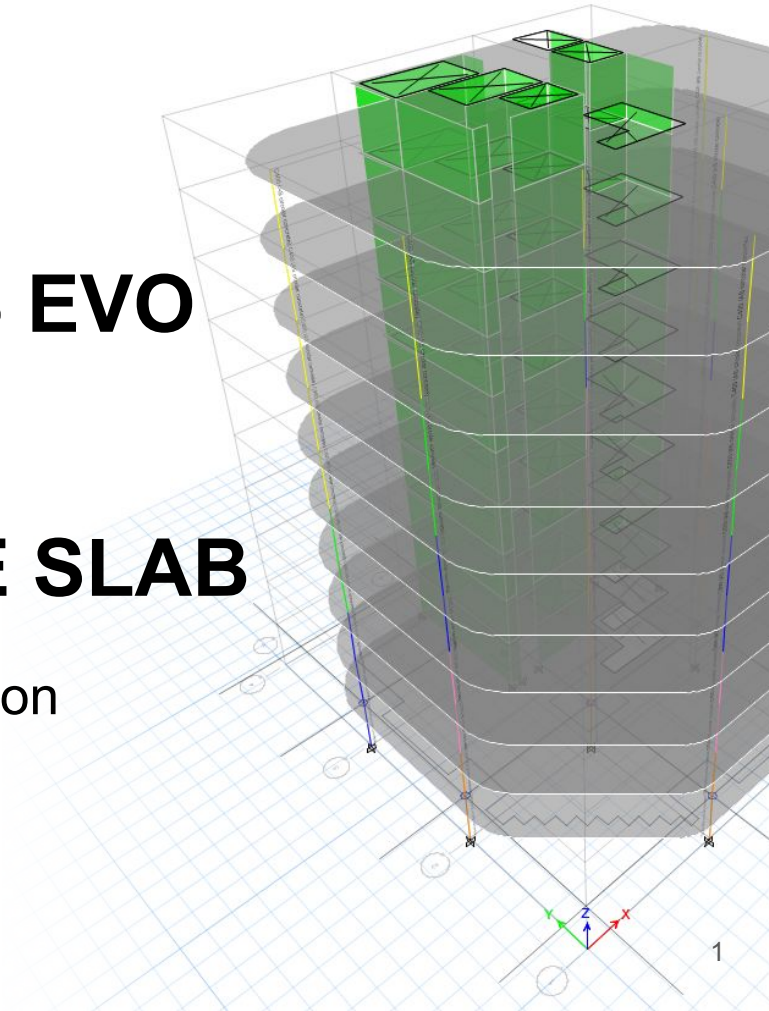


NEW NAUTILUS EVO

VS

FULL CONCRETE SLAB

Numerical comparison



CO2 EMISSION REDUCTION

-141.288 kg of CO2 EMISSIONS

The use of New Nautilus Evo in the slabs allowed for resizing the support columns and partitions, requiring a smaller quantity of both concrete and steel.

The overall comparison between a building with a solid slab and a lightened slab shows a total concrete requirement of 1.797,83 m³ for the full slab compared to 1.503,16 m³ for the lightened slab, resulting in a net saving of 294,67 m³ (-16,39%).

Regarding the steel, the amount decreased from 204,05 tonnes to 176,63 tonnes, indicating a reduction of 28 tonnes (-13,44%).

Viewing these data from a sustainability perspective, the use of the lightened slab prevented the release of 91.728 kg of CO₂ into the atmosphere for the concrete and 49.560 kg for the reduced use of steel.

Overall, the design choice made by the designer prevented the release of 141.288 kg of CO₂ into the atmosphere.

BUILDING MODEL: SUMMARY

	FULL	VOIDED	DIFF. %
Slab concrete [m ³ /m ²]	0.280	0.231	-17%
Slab steel [kg/m ²]	19.67	16.01	-19%
Earthquake forces [kN]	37143	24120	-36%

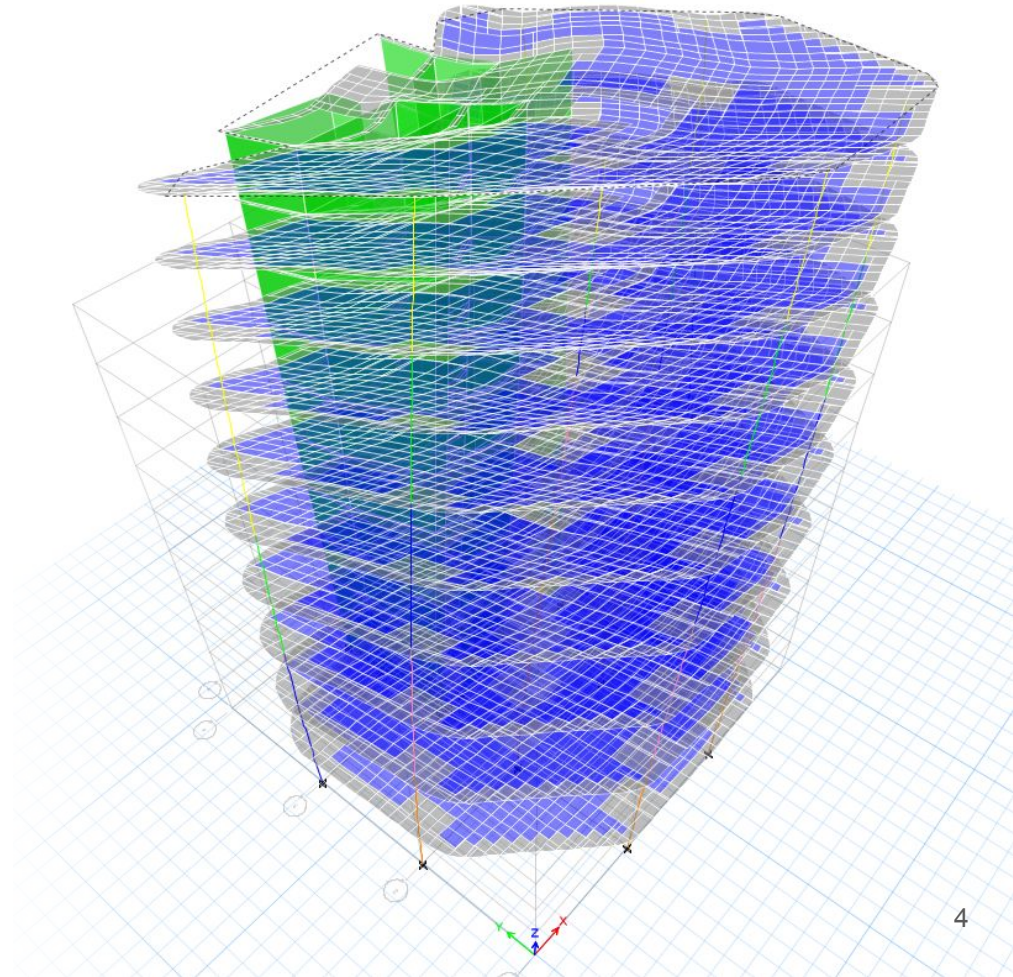
BUILDING DESCRIPTION

The comparison was conducted for two real 10-story buildings, each having:

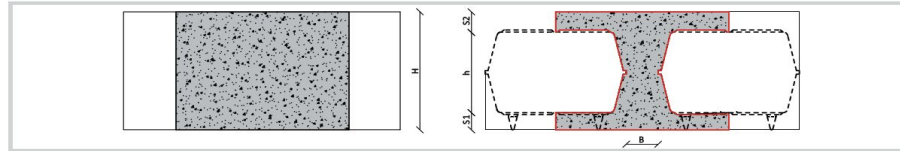
- 496 m² per story,
- 28 cm thick slabs,
- 8 x 8 m column span.

LOADS:

- Live load of 3 kN/m²,
- Permanent load of 2 kN/m².
- The columns were automatically designed by the software, which selects from a preassigned list.
- We selected one of the highest earthquake risk sites in Italy, near the city of Udine, with a ground peak acceleration of $a_g = 0.257$ g.

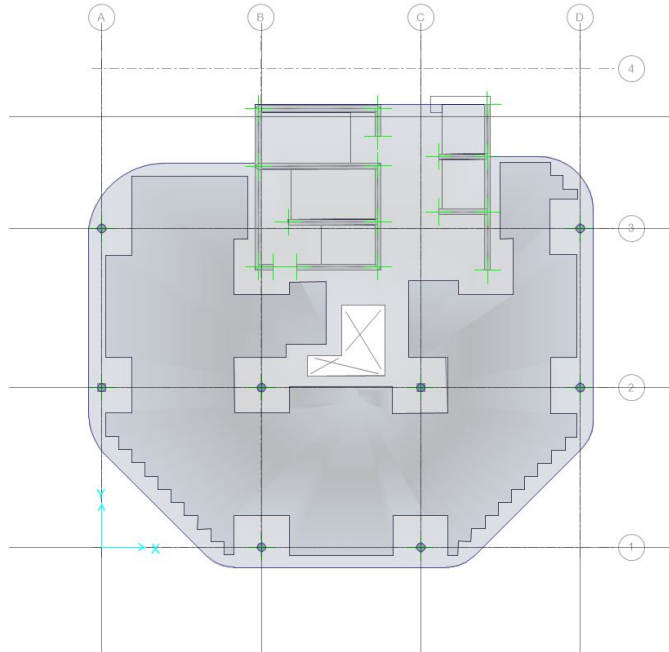


SLAB SECTION



		FULL SLAB	N. NAUTILUS EVO
Total thickness	H [mm]	280	280
Bottom slab thickness	S_1 [mm]		60
Top slab thickness	S_2 [mm]		60
Formwork used	N. Nautilus		Nautilus EVO H16
Formwork height	h [mm]		160
Rib width	B[mm]		140
Rib spacing	I [mm]		660
Full slab inertia	J [cm ⁴ /m]	182933	158844
Concrete consumption	$C_{nau,m}$ [m ³ /m ²]	0.280	0.207
Slab self-weight	$G_{k,FS}$ [kN/m ²]	7.00	5.18

F.E.M. SLAB PARAMETERS



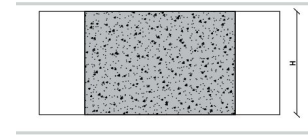
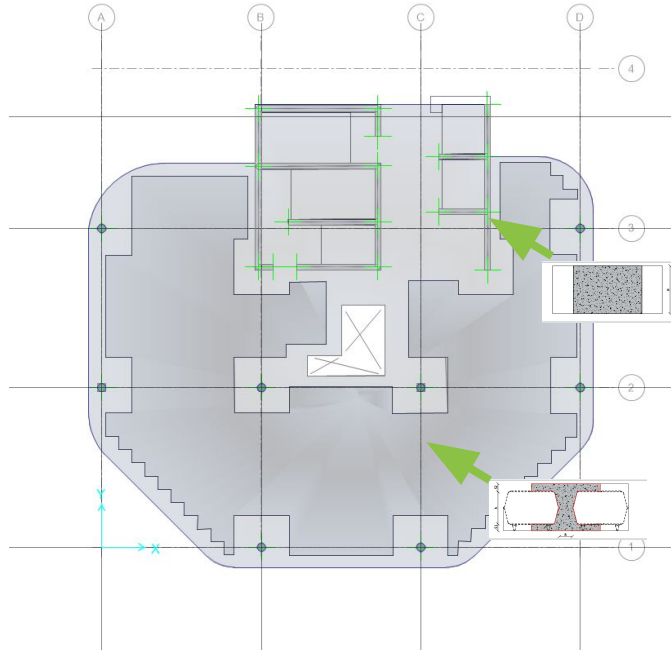
Inertia reduction
-13.17

Shear reduction
-40.23%

Weight reduction
-26.07%

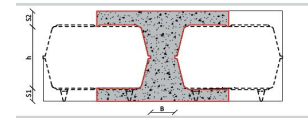
F.E.M. SLAB PARAMETERS

The F.E.M. slab can be modeled as a flat slab with different properties between voided zones and full ones:



FULL ZONE: (GREY)

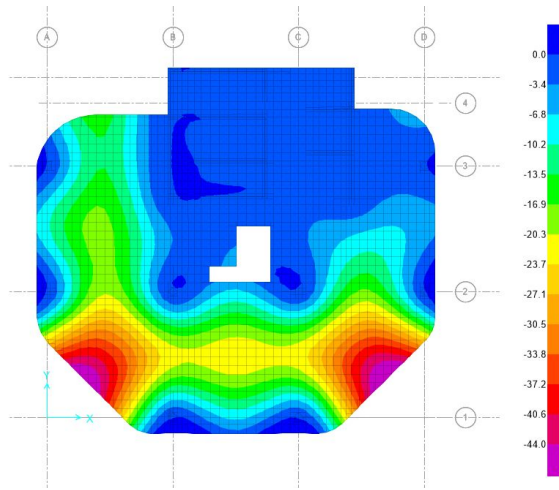
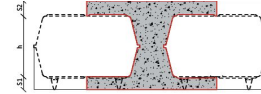
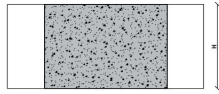
- $R_f = 1$
- $R_t = 1$
- $R_s = 1$
- $R_{sw} = 1$



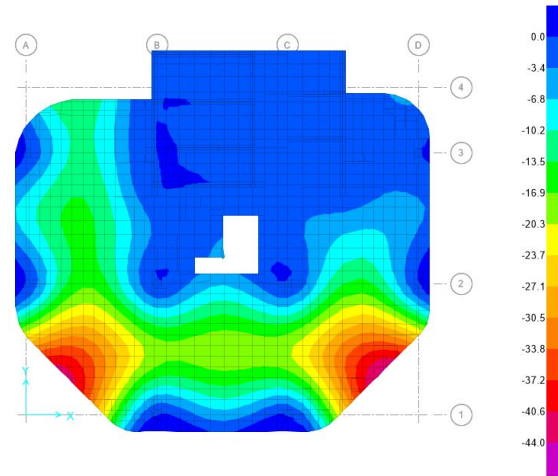
LIGHTENED ZONE (DARK GREY):

- $R_f = 0.87$
- $R_t = 0.93$
- $R_s = 0.60$
- $R_{sw} = 0.74$

ANALYSIS SLAB RESULTS: LONG TERM DEFLECTION

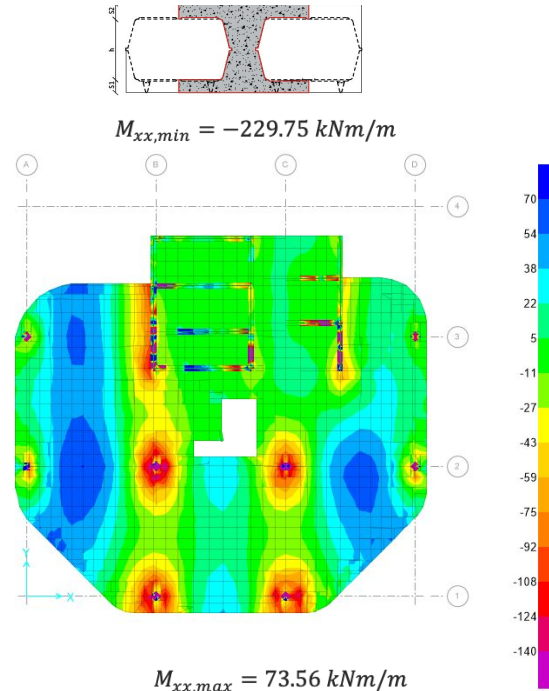
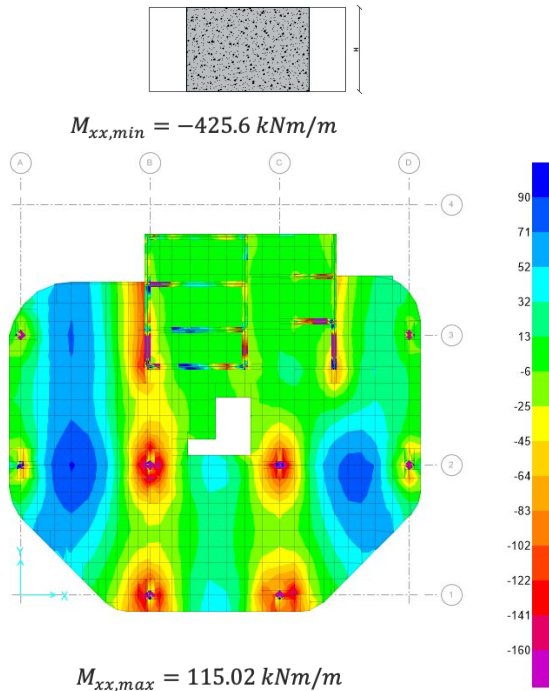


Full slab long term deflection: 49.76 mm

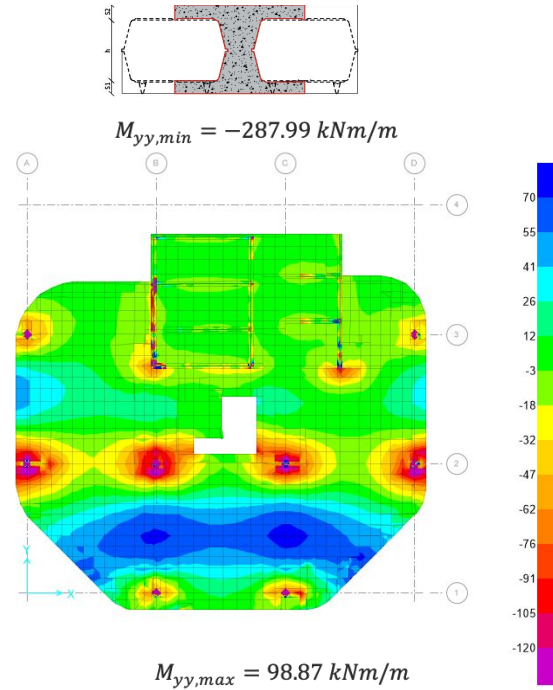
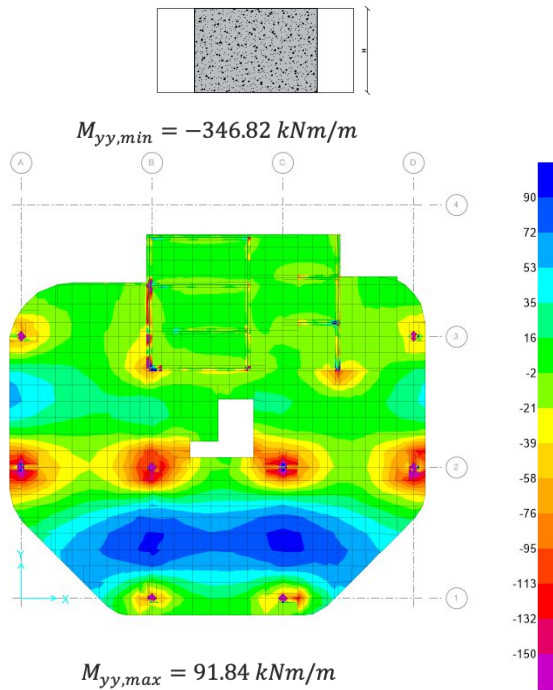


Voided slab long term deflection: 42.77 mm

ANALYSIS SLAB RESULTS: BENDING MOMENT M_{xx}



ANALYSIS SLAB RESULTS: BENDING MOMENT M_{xx}



ANALYSIS SLAB RESULTS: STRESS SUMMARY

	FULL	VOIDED	DIFF. %
Deflection [mm]	49.76	42.77	-14%

The deflection of voided slab is 14 % less than the full slab.

	FULL	VOIDED	DIFF. %
M_{xx}^+ [kNm]	115.02	73.56	-36.05%
M_{xx}^- [kNm]	-425.06	-229.75	-45.95%
M_{yy}^+ [kNm]	91.84	98.87	7.65%
M_{yy}^- [kNm]	-346.82	-287.99	-16.96%

The average bending moment of voided slab is 17% less than the full slab section.

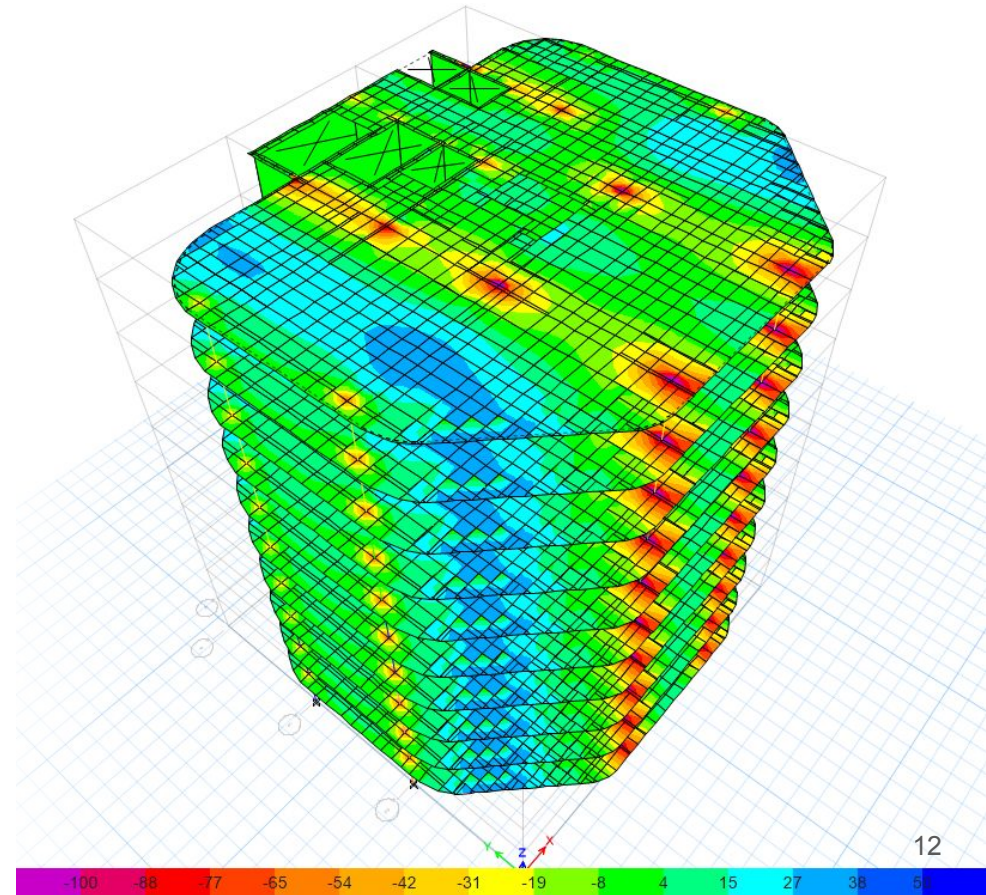
BUILDING MODEL: BASE REACTIONS

FULL		VOIDED	
Load Case/Combo	FZ kN	Load Case/Combo	FZ kN
Dead	45097	Dead	30464
Live	13627	Live	13627
Sdead	9084	Sdead	9084
USL	93586	USL	73831

-26% only slab self weight

-32% of total self weight
(shear wall+columns+slabs)

-21% of total combined loads 1.3
(self +permanent) +1.5 live



BUILDING MODEL: RESPONSE SPECTRUM

Parameters

ag, F0 and Tc* from: By Lat./Long.

Site Longitude: deg

Site Latitude: deg

Island Name:

Limit State: SLV

Usage Class: II

Nominal Life:

Peak Ground Acc., ag/g:

Magnification Factor, F0:

Reference Period, Tc*: sec

Spectrum Type: Design Horizontal

Soil Type: D

Topography: T1

h/H Ratio:

Tb; Tc; Td: sec


Damping [in %], Xi:

Behavior Factor, q:

Function Name:

Function Damping Ratio:

Function Graph



Function Points

Period	Acceleration
0	0.3784
0.2397	0.2604
0.7192	0.2604
0.8192	0.2286
0.9192	0.2037
1.0192	0.1837
1.1192	0.1673
1.2192	0.1536
1.3192	0.142
1.4192	0.1319

Plot Options

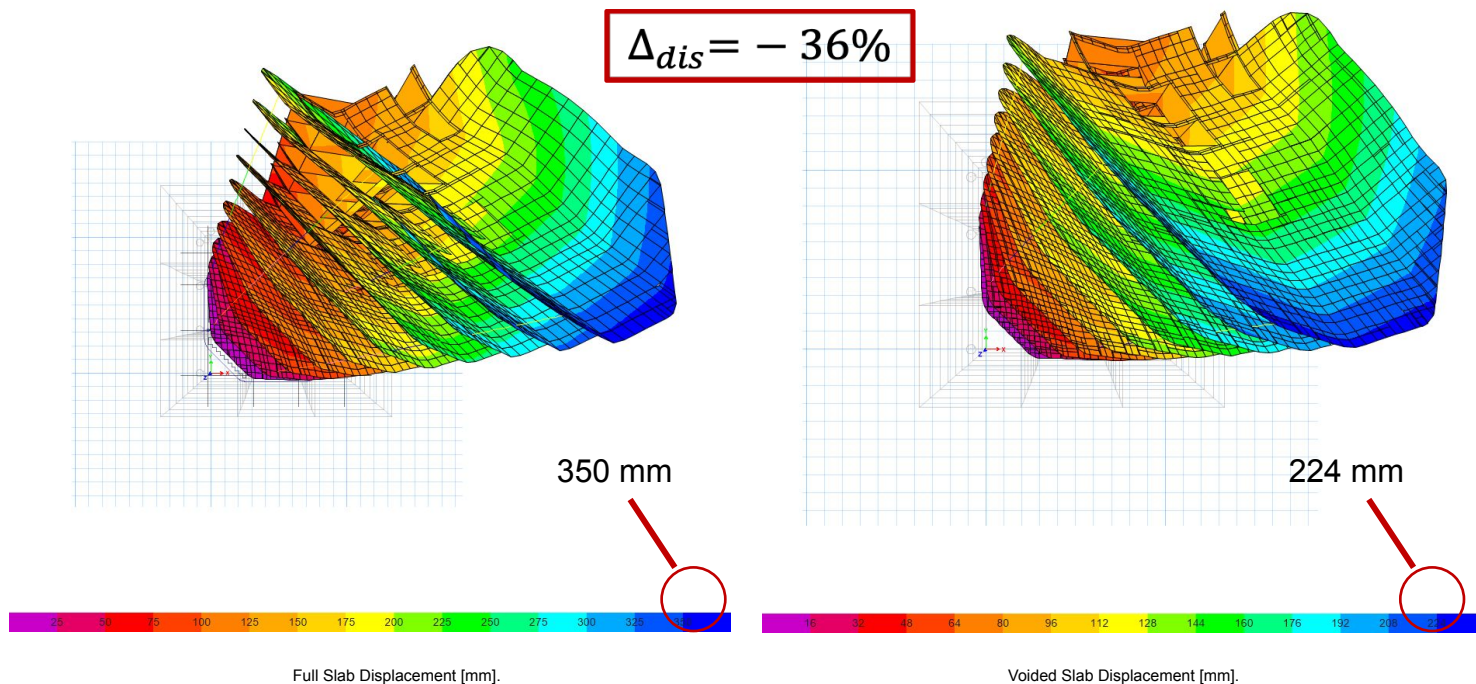
Linear X - Linear Y

Linear X - Log Y

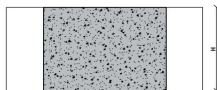
Log X - Linear Y

Log X - Log Y

BUILDING MODEL: SEISMIC DISPLACEMENT COMPARISON



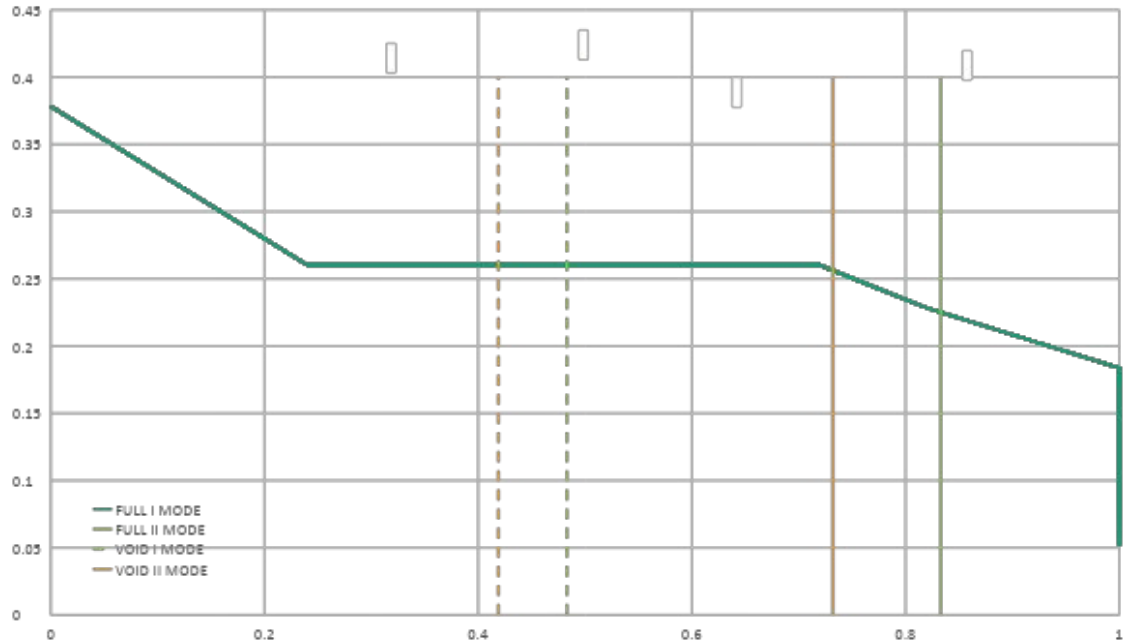
BUILDING MODEL: MODAL PARTICIPATION MASS



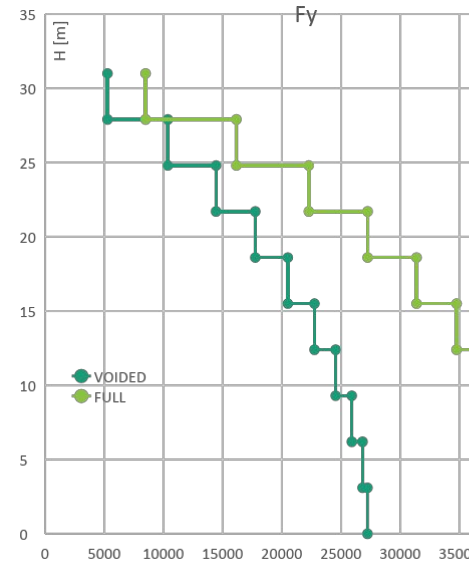
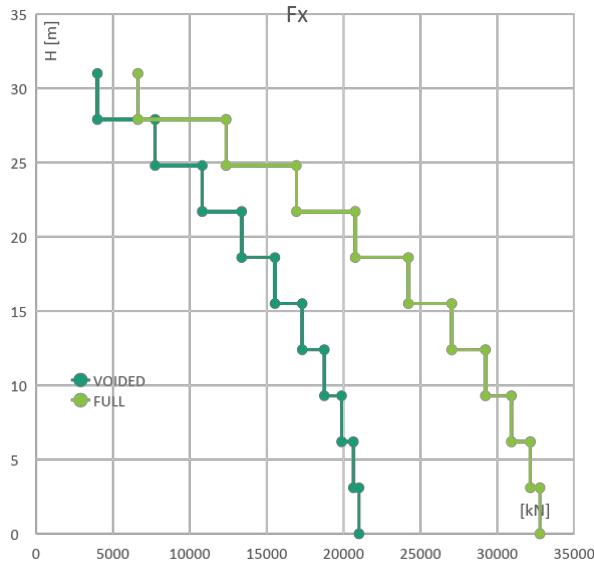
FULL							
Case	Mode	Period	UX	UY	UZ	Sum UX	Sum UY
		sec					
Modal	1	0.83	0.50	0.00	0.00	0.50	0.00
Modal	2	0.48	0.00	0.68	0.00	0.50	0.68
Modal	3	0.34	0.15	0.00	0.00	0.66	0.68
Modal	4	0.22	0.15	0.00	0.00	0.80	0.68
Modal	5	0.11	0.01	0.11	0.00	0.81	0.79

VOIDED							
Case	Mode	Period	UX	UY	UZ	Sum UX	Sum UY
		sec					
Modal	1	0.732	0.49	0.00	0.00	0.49	0.00
Modal	2	0.419	0.00	0.68	0.00	0.49	0.68
Modal	3	0.306	0.17	0.00	0.00	0.66	0.68
Modal	4	0.192	0.14	0.00	0.00	0.80	0.68
Modal	5	0.098	0.00	0.15	0.00	0.80	0.83

BUILDING MODEL: MODE COMPARISON



BUILDING MODEL: STORY SHEAR FORCES



Average of seismic forces = -36%



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