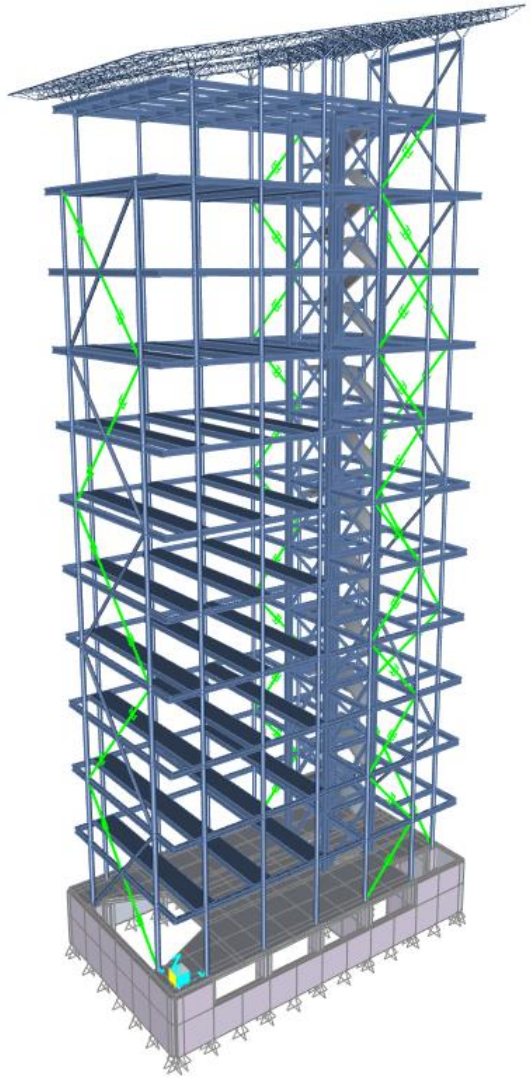
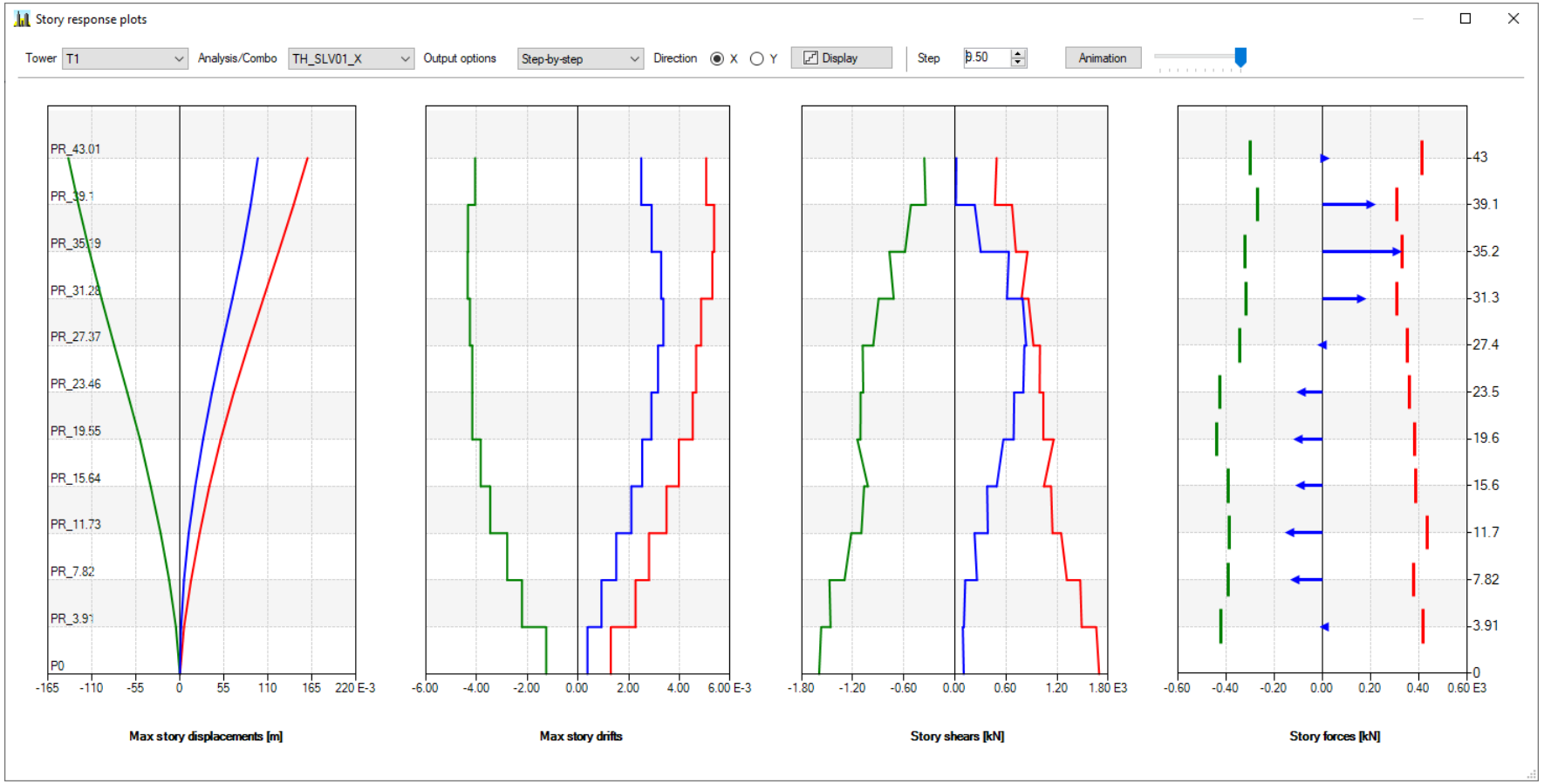
TOWERS – CARACTERIZACIÓN SÍSMICA DE EDIFICIOS



TOWERS

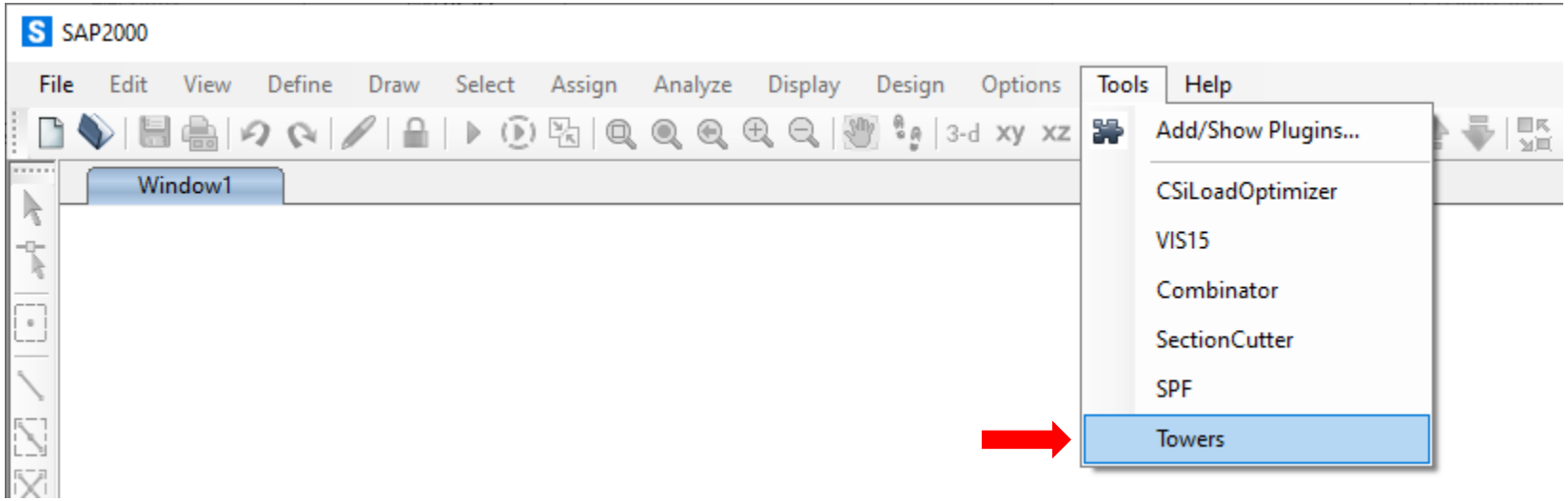


WHAT IS TOWERS?

SEISMIC ANALYSIS OF MULTISTORY BUILDINGS

TOWERS in a plugin for SAP2000 that includes specific functionalities for the analysis of multistory buildings.

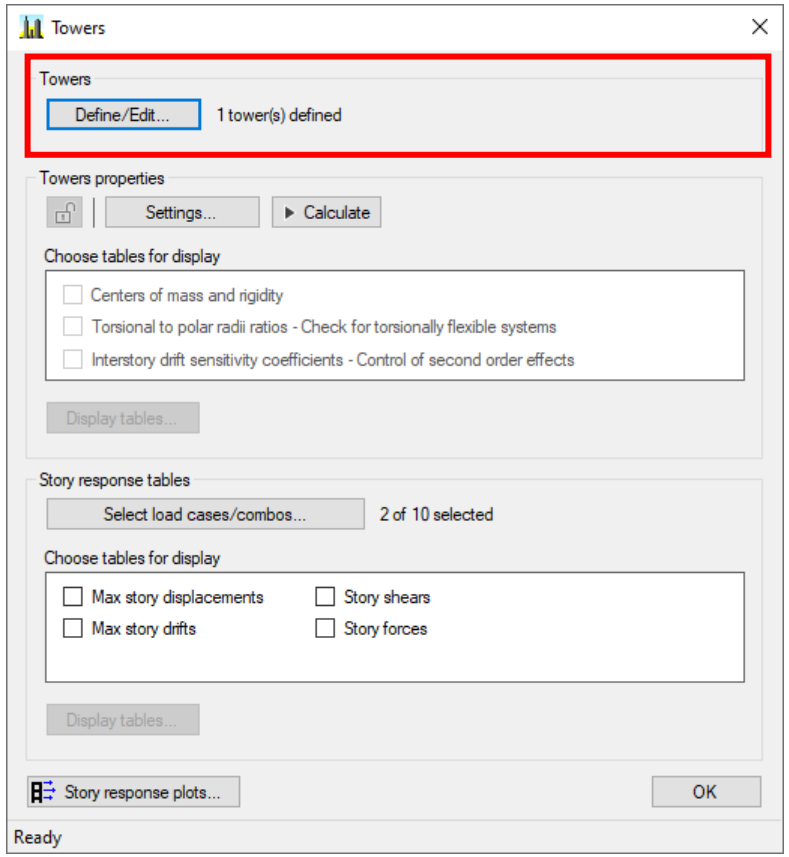
After the installation has been completed, the plugin can be executed directly from the SAP2000 "Tools" menu.

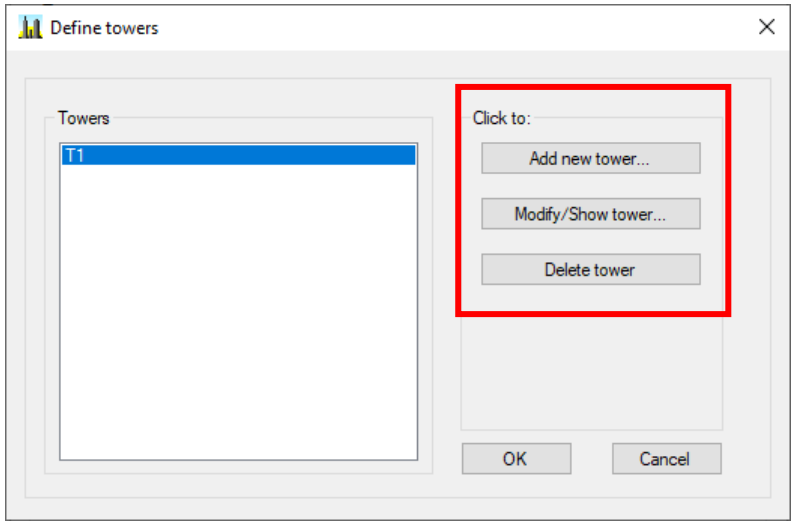


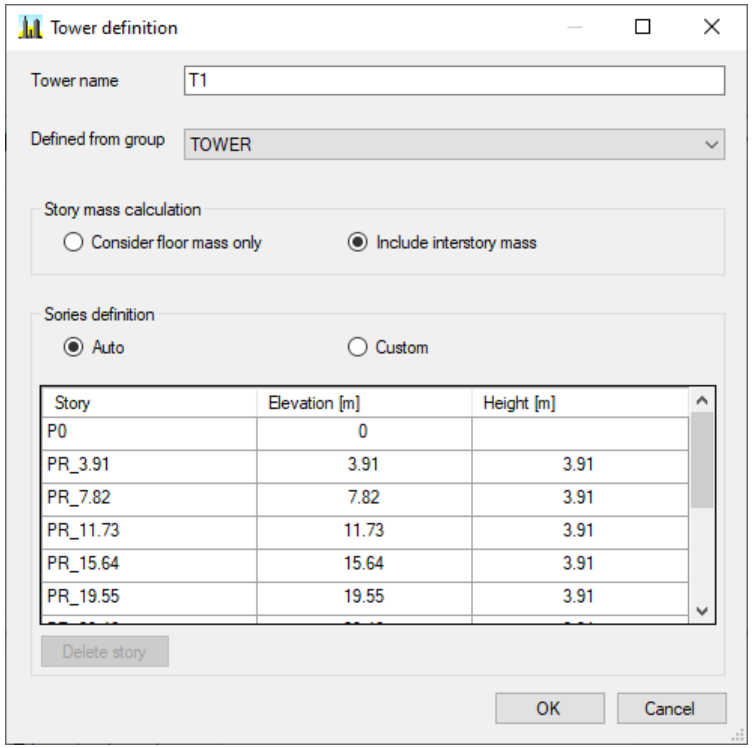
WHAT IS TOWERS?

SEISMIC ANALYSIS OF MULTISTORY BUILDINGS

One or multiple "tower" objects can readily be defined from the main window. All the towers will be saved inside .sdb file of the model and, therefore, it will not be necessary to re-define them in any subsequent session.







WHAT TOWERS DOES?

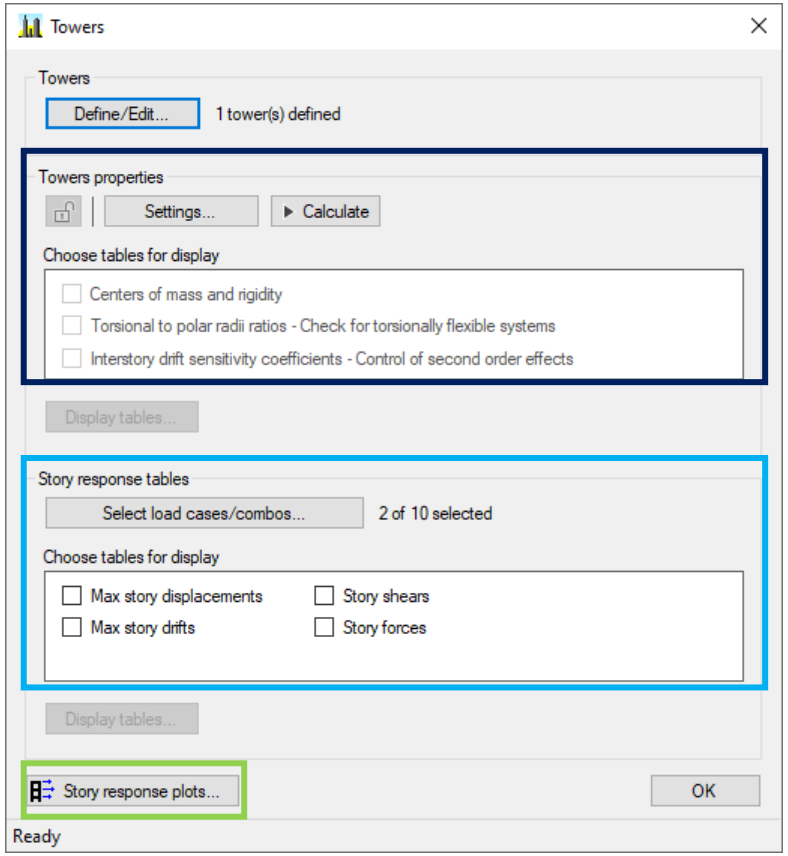
SEISMIC ANALYSIS OF MULTISTORY BUILDINGS

Once that one or more towers have been defined, the following operations will be made available:

- **TOWERS PROPERTIES CALCULATION** – Calculate the floors centers of mass, floors centers of rigidity, floors torsional radii, floors polar radii and drift sensitivity coefficients (used to measure the sensitivity to second order effects).

- **STORY RESPONSE TABLES** – Display the response tables in terms of maximum story displacements, maximum story drifts, story shears and story forces.

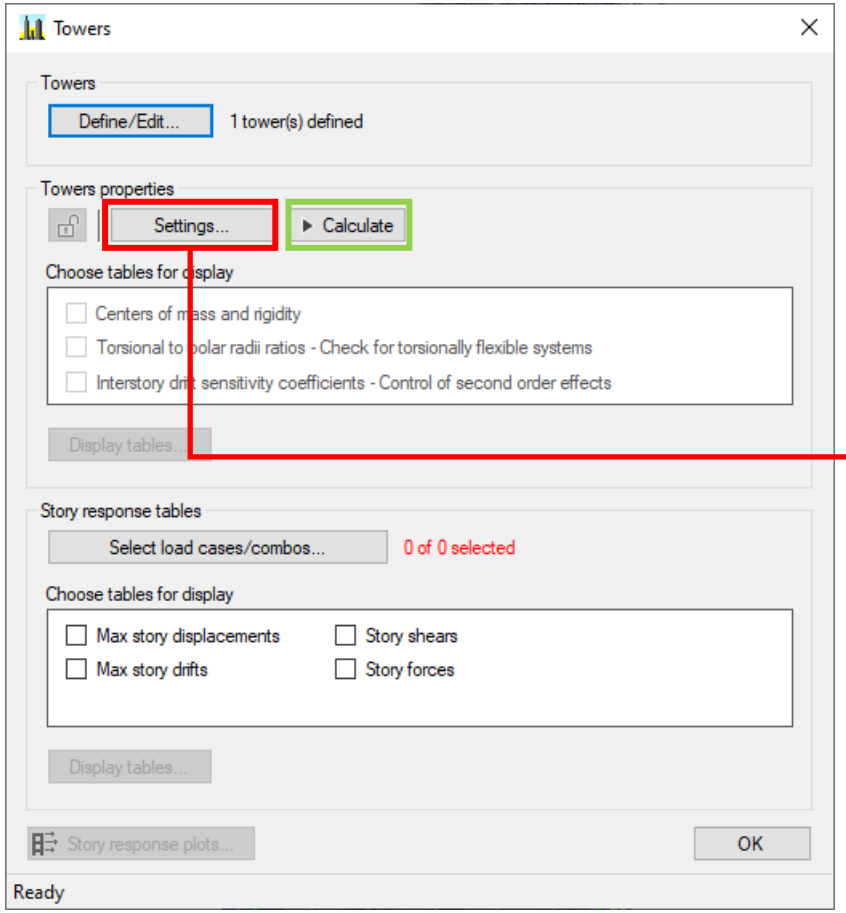
- **STORY RESPONSE PLOTS** – Display interactive diagrams of story displacements, story drifts, story shears and story forces over the height of the building.

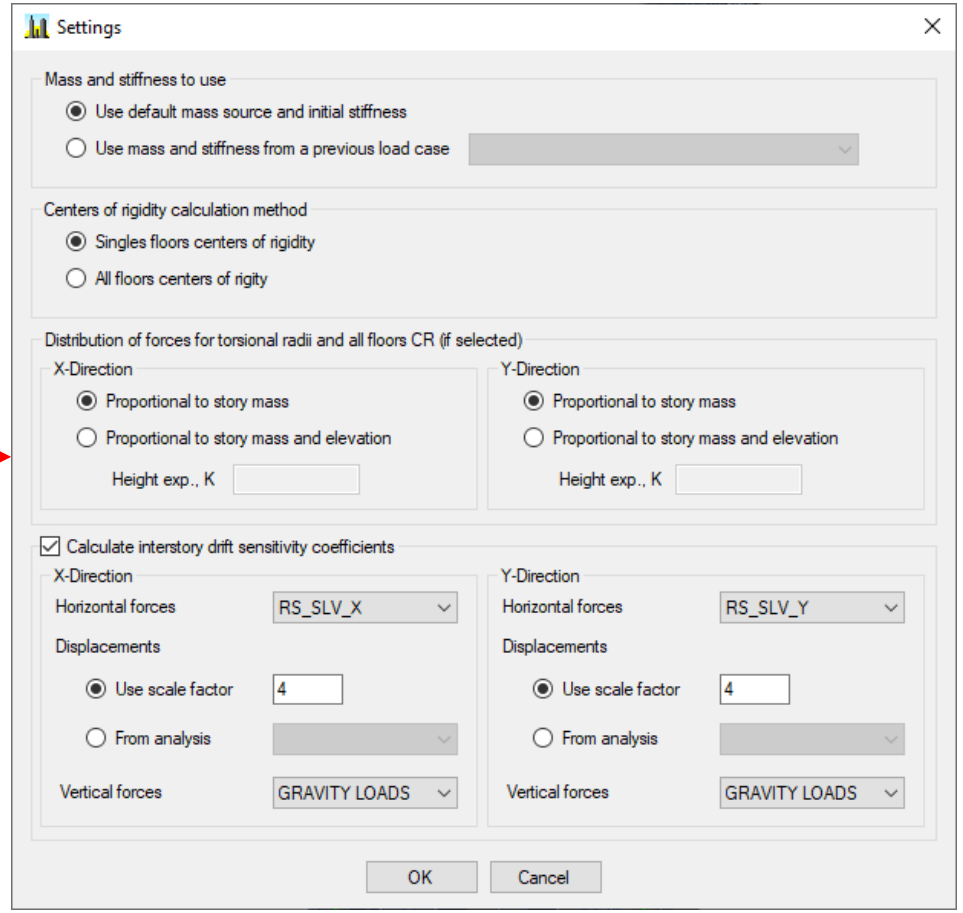


WHAT TOWERS DOES?

TOWERS PROPERTIES CALCULATION

Once that one or more towers have been defined, the following operations will be made available:





Customize the **analysis settings** and **run the calculation**.

WHAT TOWERS DOES?

TOWERS PROPERTIES CALCULATION

Output – Centers of Mass and Rigidity

Results

Export to Excel

Centers of mass and rigidity | Torsional to polar radii ratios | Drift sensitivity coefficients

Tower	Story	Elevation	Bx	By	Mx	My	Mz	Iz	Xcm	Ycm	Xcr	Ycr	ex	ey	ex/Bx	ey/By
		[m]	[m]	[m]	[kNs²/m]	[kNs²/m]	[kNs²/m]	[kNms²]	[m]	[m]	[m]	[m]	[m]	[m]		
T1	PR_3.91	3.91	19.8	10.8	183.3	183.3	183.3	1.094e+04	8.584	5.323	10.43	5.439	1.845	0.1157	0.09319	0.01072
T1	PR_7.82	7.82	19.8	10.8	184.7	184.7	184.7	1.113e+04	8.641	5.324	9.932	5.345	1.292	0.02081	0.06523	0.001927
T1	PR_11.73	11.73	19.8	10.8	184.2	184.2	184.2	1.105e+04	8.657	5.333	10.14	5.445	1.479	0.1117	0.07467	0.01035
T1	PR_15.64	15.64	19.8	10.8	183.6	183.6	183.6	1.111e+04	8.643	5.341	9.838	5.6	1.195	0.2586	0.06037	0.02394
T1	PR_19.55	19.55	19.8	10.8	184.9	184.9	184.9	1.11e+04	8.716	5.343	10.05	5.551	1.329	0.2078	0.06714	0.01924
T1	PR_23.46	23.46	19.8	10.8	182.8	182.8	182.8	1.101e+04	8.623	5.327	9.74	5.785	1.118	0.4585	0.05645	0.04245
T1	PR_27.37	27.37	19.8	10.8	182.9	182.9	182.9	1.093e+04	8.664	5.339	9.882	5.868	1.218	0.5291	0.06152	0.04899
T1	PR_31.28	31.28	19.8	10.8	180.4	180.4	180.4	1.082e+04	8.547	5.327	9.677	5.995	1.13	0.6672	0.05709	0.06178
T1	PR_35.19	35.19	19.8	10.8	182.8	182.8	182.8	1.095e+04	8.701	5.343	9.811	5.923	1.11	0.5798	0.05606	0.05368
T1	PR_39.1	39.1	19.8	10.8	179	179	179	1.071e+04	8.563	5.323	9.647	6.04	1.084	0.7171	0.05477	0.0664
T1	PR_43.01	43.01	19.16	10.8	125.5	125.5	125.5	5811	9.711	5.304	11	5.973	1.288	0.6692	0.06721	0.06197

Story inertial properties

Story centers of mass (CM)

Story centers of rigidity (CR)

Static eccentricities

WHAT TOWERS DOES?

TOWERS PROPERTIES CALCULATION

Output – Torsional to polar radii ratios

Results

Export to Excel

Centers of mass and rigidity | Torsional to polar radii ratios | Drift sensitivity coefficients

Tower	Story	Elevation	X-Direction					Y-Direction				
			K	Kθ	r	ls	(r/ls)²	K	Kθ	r	ls	(r/ls)²
		[m]	[kN/m]	[kNm/Rad]	[m]	[m]		[kN/m]	[kNm/Rad]	[m]	[m]	
T1	PR_3.91	3.91	2.808e+05	2.865e+07	10.1	7.724	1.71	2.964e+05	2.865e+07	9.833	7.724	1.62
T1	PR_7.82	7.82	1.42e+05	2.31e+07	12.75	7.762	2.7	2.273e+05	2.31e+07	10.08	7.762	1.687
T1	PR_11.73	11.73	9.576e+04	1.632e+07	13.05	7.744	2.842	1.63e+05	1.632e+07	10.01	7.744	1.669
T1	PR_15.64	15.64	6.989e+04	1.54e+07	14.84	7.779	3.641	1.543e+05	1.54e+07	9.99	7.779	1.649
T1	PR_19.55	19.55	6.532e+04	1.03e+07	12.56	7.747	2.627	1.062e+05	1.03e+07	9.849	7.747	1.616
T1	PR_23.46	23.46	5.45e+04	1.126e+07	14.37	7.759	3.433	1.088e+05	1.126e+07	10.17	7.759	1.72
T1	PR_27.37	27.37	4.48e+04	7.327e+06	12.79	7.732	2.736	7.333e+04	7.327e+06	9.996	7.732	1.671
T1	PR_31.28	31.28	3.199e+04	7.678e+06	15.49	7.746	4.001	7.494e+04	7.678e+06	10.12	7.746	1.708
T1	PR_35.19	35.19	2.756e+04	4.247e+06	12.41	7.74	2.573	4.419e+04	4.247e+06	9.804	7.74	1.604
T1	PR_39.1	39.1	1.472e+04	4.019e+06	16.52	7.737	4.561	3.755e+04	4.019e+06	10.35	7.737	1.788
T1	PR_43.01	43.01	6623	1.337e+06	14.21	6.805	4.358	1.758e+04	1.337e+06	8.721	6.805	1.642

Equivalent story translational and torsional stiffness

Story torsional radius

Story polar radius

Torsional to polar radii ratio

WHAT TOWERS DOES?

TOWERS PROPERTIES CALCULATION

Output – Drift sensitivity coefficients

Results

Export to Excel

Centers of mass and rigidity | Torsional to polar radii ratios | Drift sensitivity coefficients

Tower	Story	Elevation	X-Direction					Y-Direction				
			P	V	d	h	θ	P	V	d	h	θ
		[m]	[kN]	[kN]	[m]	[m]		[kN]	[kN]	[m]	[m]	
T1	PR_3.91	3.91	2.093e+04	638.1	0.008869	3.91	0.0744	2.093e+04	707	0.01026	3.91	0.07767
T1	PR_7.82	7.82	1.894e+04	612	0.0165	3.91	0.1306	1.894e+04	659.9	0.01298	3.91	0.09529
T1	PR_11.73	11.73	1.699e+04	522.7	0.02071	3.91	0.1722	1.699e+04	615.6	0.01521	3.91	0.1074
T1	PR_15.64	15.64	1.504e+04	455.6	0.02474	3.91	0.2088	1.504e+04	556.3	0.01577	3.91	0.109
T1	PR_19.55	19.55	1.306e+04	454.8	0.02662	3.91	0.1954	1.306e+04	505.2	0.01877	3.91	0.124
T1	PR_23.46	23.46	1.11e+04	414.8	0.02824	3.91	0.1933	1.11e+04	456	0.01795	3.91	0.1118
T1	PR_27.37	27.37	9160	380.5	0.02969	3.91	0.1828	9160	418.6	0.02066	3.91	0.1156
T1	PR_31.28	31.28	7252	324.5	0.03097	3.91	0.177	7252	387.9	0.0189	3.91	0.09035
T1	PR_35.19	35.19	5287	319	0.03087	3.91	0.1309	5287	339	0.02246	3.91	0.0896
T1	PR_39.1	39.1	3386	242.5	0.03008	3.91	0.1074	3386	262.2	0.0179	3.91	0.05913
T1	PR_43.01	43.01	1465	153.8	0.02829	3.91	0.0689	1465	168.9	0.03271	3.91	0.07256

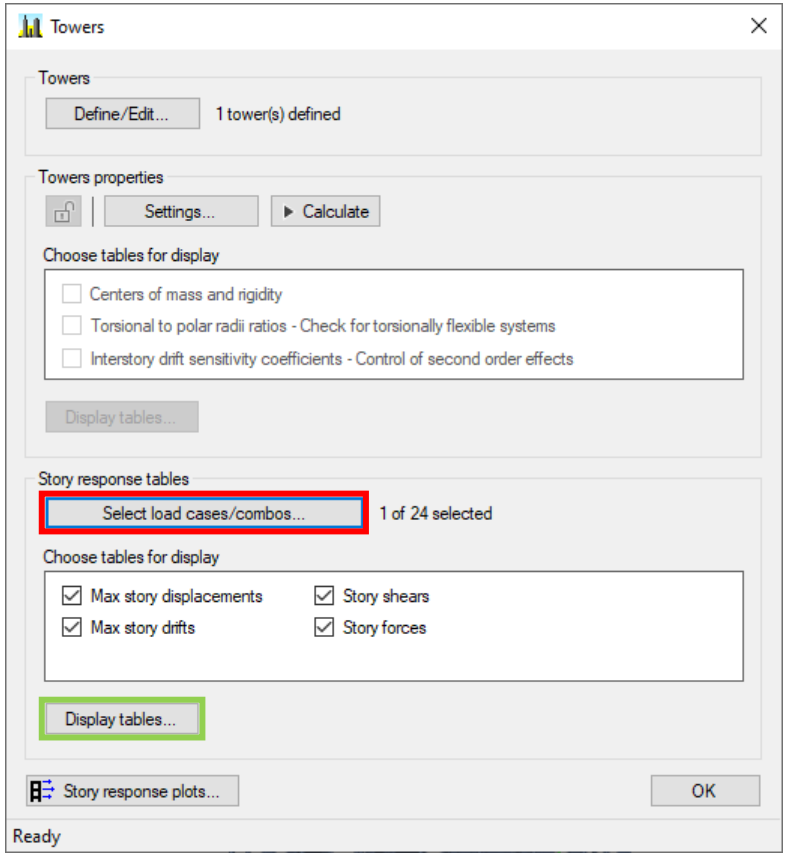
Resultant story vertical and shear forces | **Story drift** | **Story height** | **P*d/V*h**

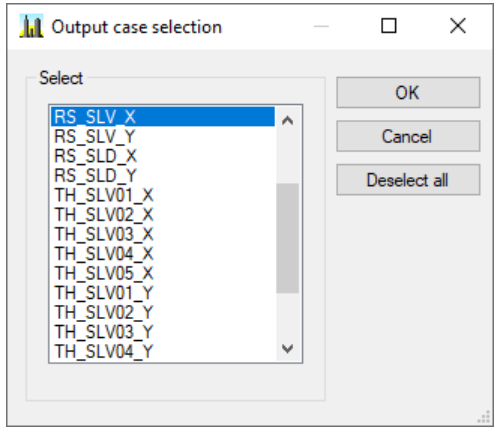
WHAT TOWERS DOES?

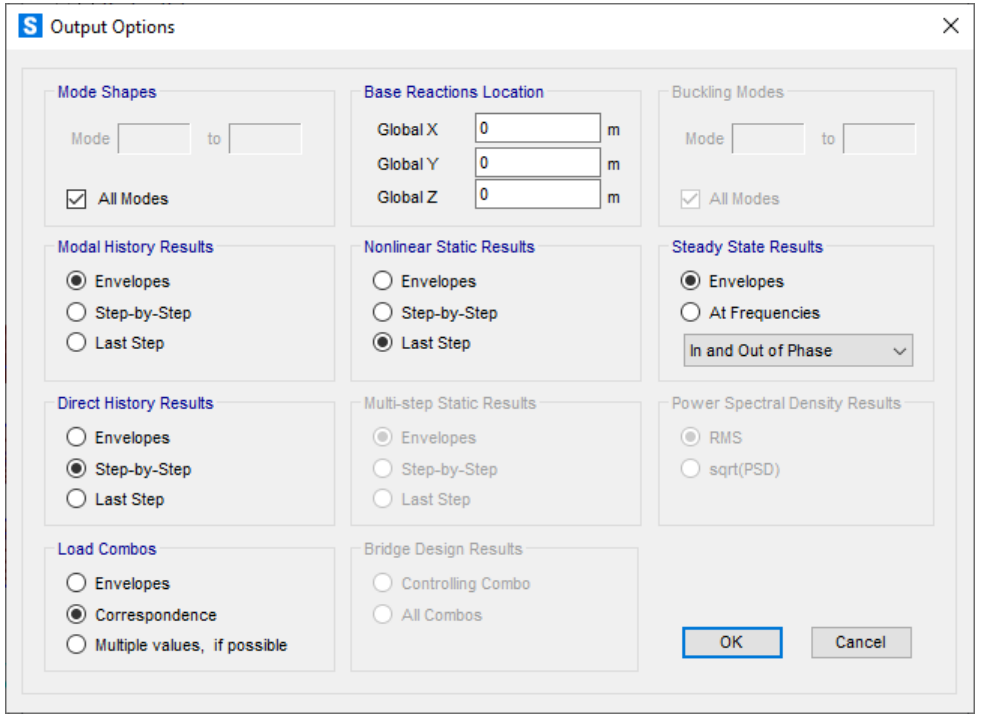
STORY RESPONSE TABLES

Select the load cases/load combinations of interest and display the corresponding output tables.

Appropriate output options can be set for the different analysis types directly from the SAP2000 interface.







WHAT TOWERS DOES?

STORY RESPONSE TABLES

Story results

Export to Excel

Max story displacements | Max story drifts | Story shears | Story forces

Tower	Story	Elevation	Analysis/Comb.	Type	Output type	X-Direction		Y-Direction	
						Ux	Joint ID	Uy	Joint ID
		[m]				[m]		[m]	
T1	P0	0	RS_SLV_X	LinRespSpec	Max	3.7e-05	73	1.2e-05	13
T1	PR_3.91	3.91	RS_SLV_X	LinRespSpec	Max	0.002412	62	0.000506	434
T1	PR_7.82	7.82	RS_SLV_X	LinRespSpec	Max	0.00668	63	0.000913	435
T1	PR_11.73	11.73	RS_SLV_X	LinRespSpec	Max	0.01212	4	0.001526	436
T1	PR_15.64	15.64	RS_SLV_X	LinRespSpec	Max	0.01858	5	0.002309	437
T1	PR_19.55	19.55	RS_SLV_X	LinRespSpec	Max	0.02529	6	0.002712	438
T1	PR_23.46	23.46	RS_SLV_X	LinRespSpec	Max	0.03249	7	0.003762	439
T1	PR_27.37	27.37	RS_SLV_X	LinRespSpec	Max	0.04006	8	0.005192	440
T1	PR_31.28	31.28	RS_SLV_X	LinRespSpec	Max	0.04756	9	0.005893	441
T1	PR_35.19	35.19	RS_SLV_X	LinRespSpec	Max	0.05504	10	0.006754	442
T1	PR_39.1	39.1	RS_SLV_X	LinRespSpec	Max	0.06236	11	0.007747	443
T1	PR_43.01	43.01	RS_SLV_X	LinRespSpec	Max	0.06939	84	0.0087	444

Maximum story displacements table available for user defined analysis/combos. For each story and each analysis, the ID of the corresponding joint is reported.

Maximum story drift table available for user defined analysis. For each story and each analysis/combos, the ID of the corresponding object is reported.

Story results

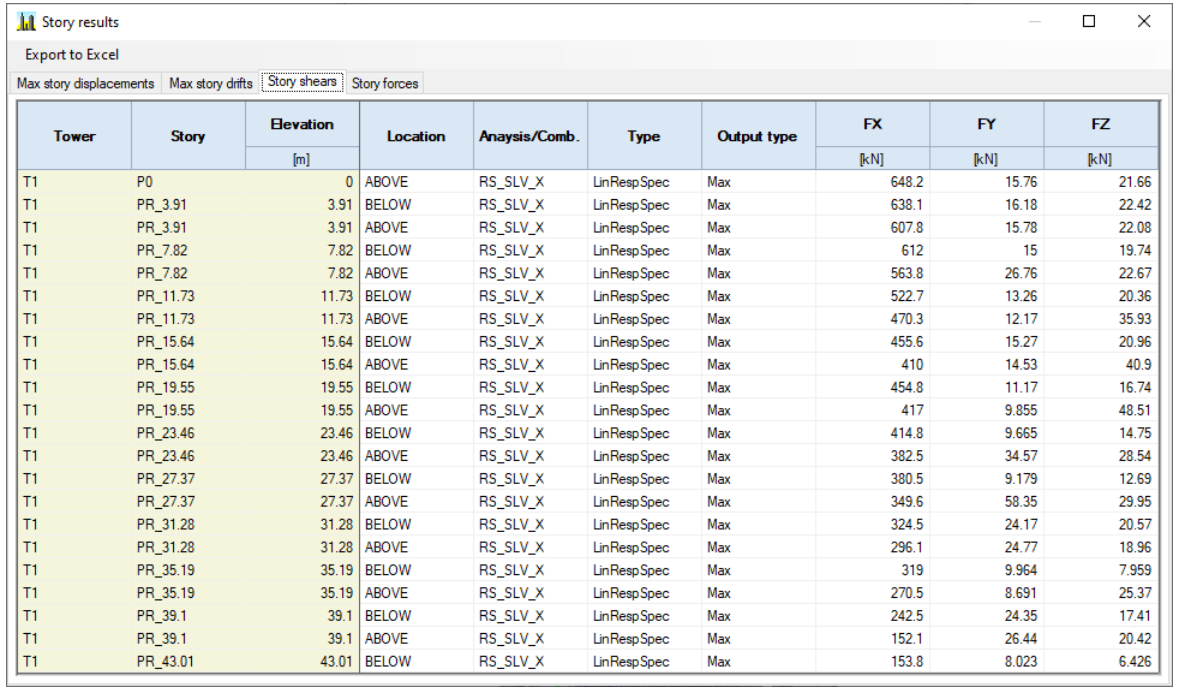
Export to Excel

Max story displacements | Max story drifts | Story shears | Story forces

Tower	Story	Elevation	Anaysis/Comb.	Type	Output type	X-Direction		Y-Direction	
						dUx	Object ID	dUy	Object ID
		[m]							
T1	PR_3.91	3.91	RS_SLV_X	LinRespSpec	Max	0.000611	122	0.00013	408
T1	PR_7.82	7.82	RS_SLV_X	LinRespSpec	Max	0.001095	123	0.000118	409
T1	PR_11.73	11.73	RS_SLV_X	LinRespSpec	Max	0.001431	135	0.000289	410
T1	PR_15.64	15.64	RS_SLV_X	LinRespSpec	Max	0.001681	136	0.000211	411
T1	PR_19.55	19.55	RS_SLV_X	LinRespSpec	Max	0.00188	546	0.000208	412
T1	PR_23.46	23.46	RS_SLV_X	LinRespSpec	Max	0.002097	547	0.000294	413
T1	PR_27.37	27.37	RS_SLV_X	LinRespSpec	Max	0.00205	139	0.000383	414
T1	PR_31.28	31.28	RS_SLV_X	LinRespSpec	Max	0.002061	140	0.000187	415
T1	PR_35.19	35.19	RS_SLV_X	LinRespSpec	Max	0.002415	554	0.000231	416
T1	PR_39.1	39.1	RS_SLV_X	LinRespSpec	Max	0.002488	555	0.000262	147
T1	PR_43.01	43.01	RS_SLV_X	LinRespSpec	Max	0.002371	383	0.000246	383

WHAT TOWERS DOES?

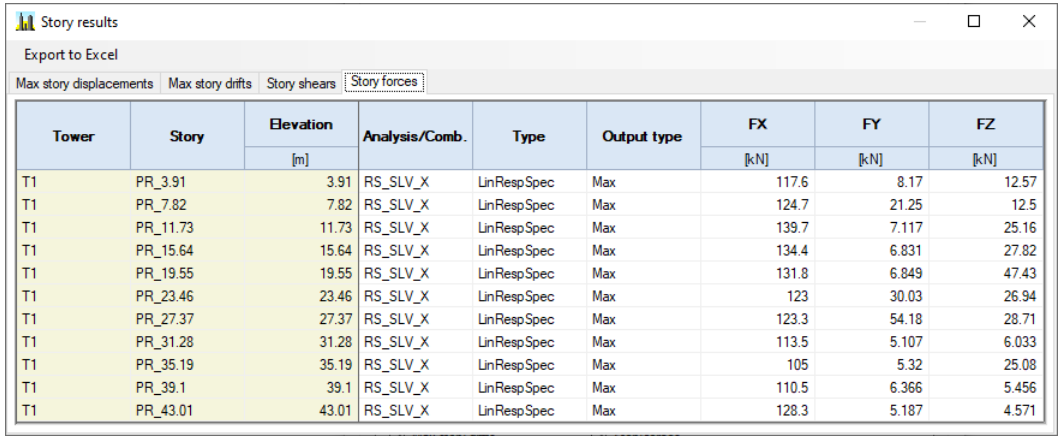
STORY RESPONSE TABLES



Tower	Story	Elevation [m]	Location	Anaysis/Comb.	Type	Output type	FX [kN]	FY [kN]	FZ [kN]
T1	P0	0	ABOVE	RS_SLV_X	LinRespSpec	Max	648.2	15.76	21.66
T1	PR_3.91	3.91	BELOW	RS_SLV_X	LinRespSpec	Max	638.1	16.18	22.42
T1	PR_3.91	3.91	ABOVE	RS_SLV_X	LinRespSpec	Max	607.8	15.78	22.08
T1	PR_7.82	7.82	BELOW	RS_SLV_X	LinRespSpec	Max	612	15	19.74
T1	PR_7.82	7.82	ABOVE	RS_SLV_X	LinRespSpec	Max	563.8	26.76	22.67
T1	PR_11.73	11.73	BELOW	RS_SLV_X	LinRespSpec	Max	522.7	13.26	20.36
T1	PR_11.73	11.73	ABOVE	RS_SLV_X	LinRespSpec	Max	470.3	12.17	35.93
T1	PR_15.64	15.64	BELOW	RS_SLV_X	LinRespSpec	Max	455.6	15.27	20.96
T1	PR_15.64	15.64	ABOVE	RS_SLV_X	LinRespSpec	Max	410	14.53	40.9
T1	PR_19.55	19.55	BELOW	RS_SLV_X	LinRespSpec	Max	454.8	11.17	16.74
T1	PR_19.55	19.55	ABOVE	RS_SLV_X	LinRespSpec	Max	417	9.855	48.51
T1	PR_23.46	23.46	BELOW	RS_SLV_X	LinRespSpec	Max	414.8	9.665	14.75
T1	PR_23.46	23.46	ABOVE	RS_SLV_X	LinRespSpec	Max	382.5	34.57	28.54
T1	PR_27.37	27.37	BELOW	RS_SLV_X	LinRespSpec	Max	380.5	9.179	12.69
T1	PR_27.37	27.37	ABOVE	RS_SLV_X	LinRespSpec	Max	349.6	58.35	29.95
T1	PR_31.28	31.28	BELOW	RS_SLV_X	LinRespSpec	Max	324.5	24.17	20.57
T1	PR_31.28	31.28	ABOVE	RS_SLV_X	LinRespSpec	Max	296.1	24.77	18.96
T1	PR_35.19	35.19	BELOW	RS_SLV_X	LinRespSpec	Max	319	9.964	7.959
T1	PR_35.19	35.19	ABOVE	RS_SLV_X	LinRespSpec	Max	270.5	8.691	25.37
T1	PR_39.1	39.1	BELOW	RS_SLV_X	LinRespSpec	Max	242.5	24.35	17.41
T1	PR_39.1	39.1	ABOVE	RS_SLV_X	LinRespSpec	Max	152.1	26.44	20.42
T1	PR_43.01	43.01	BELOW	RS_SLV_X	LinRespSpec	Max	153.8	8.023	6.426

Resultant story shears (FX, FY, FZ) are available for user defined analysis/combos.

Resultant story forces (FX, FY, FZ) are available for user defined analysis/combos.

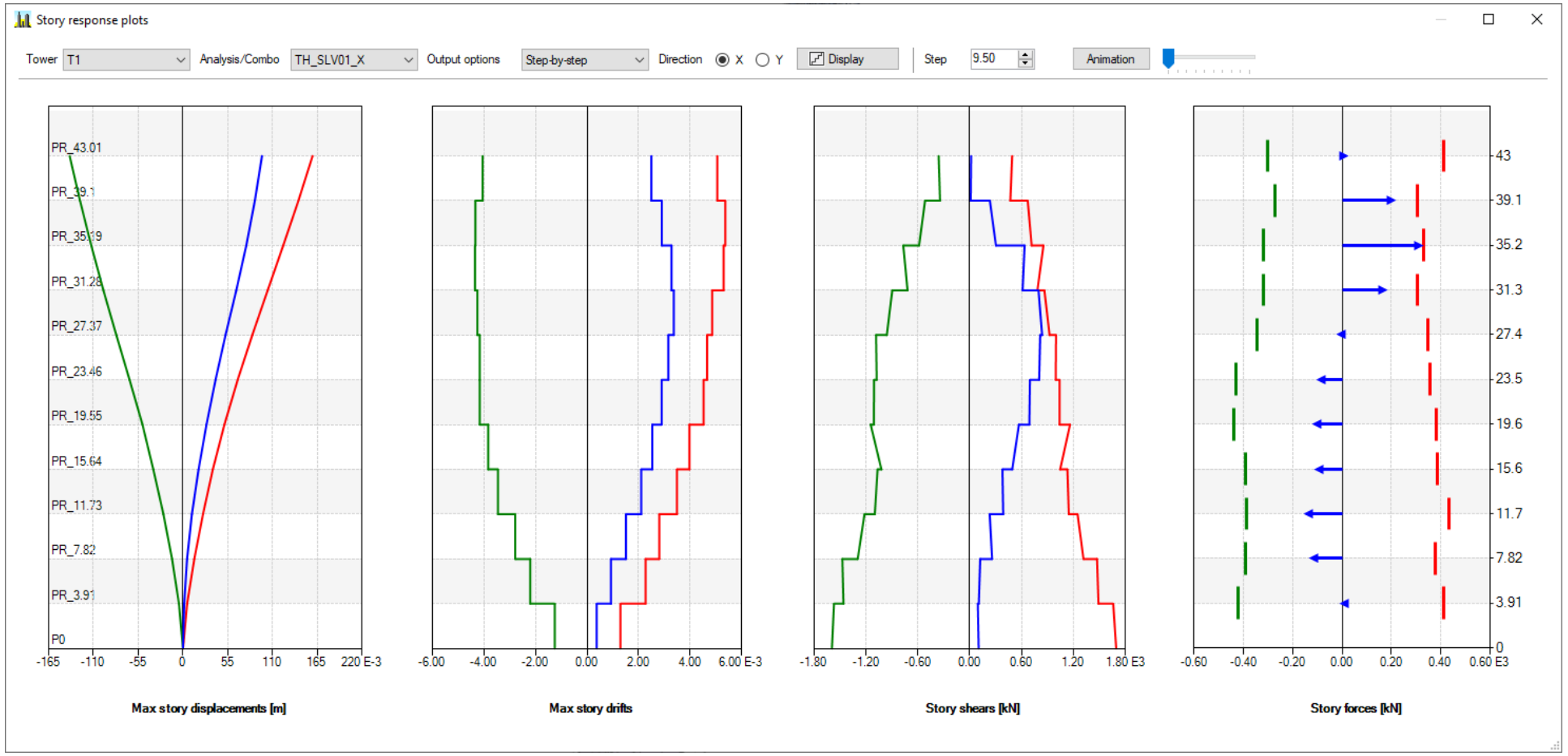


Tower	Story	Elevation [m]	Analysis/Comb.	Type	Output type	FX [kN]	FY [kN]	FZ [kN]
T1	PR_3.91	3.91	RS_SLV_X	LinRespSpec	Max	117.6	8.17	12.57
T1	PR_7.82	7.82	RS_SLV_X	LinRespSpec	Max	124.7	21.25	12.5
T1	PR_11.73	11.73	RS_SLV_X	LinRespSpec	Max	139.7	7.117	25.16
T1	PR_15.64	15.64	RS_SLV_X	LinRespSpec	Max	134.4	6.831	27.82
T1	PR_19.55	19.55	RS_SLV_X	LinRespSpec	Max	131.8	6.849	47.43
T1	PR_23.46	23.46	RS_SLV_X	LinRespSpec	Max	123	30.03	26.94
T1	PR_27.37	27.37	RS_SLV_X	LinRespSpec	Max	123.3	54.18	28.71
T1	PR_31.28	31.28	RS_SLV_X	LinRespSpec	Max	113.5	5.107	6.033
T1	PR_35.19	35.19	RS_SLV_X	LinRespSpec	Max	105	5.32	25.08
T1	PR_39.1	39.1	RS_SLV_X	LinRespSpec	Max	110.5	6.366	5.456
T1	PR_43.01	43.01	RS_SLV_X	LinRespSpec	Max	128.3	5.187	4.571

WHAT TOWERS DOES?

STORY RESPONSE PLOTS

Multi-step animated response plots are available for each analysis/load combination to provide an immediate feedback of the structural response.



WHAT TOWERS DOES?

EUROCODE 8 - BEHAVIOUR FACTOR - TORSIONALLY FLEXIBLE SYSTEM?

Results

Export to Excel

Centers of mass and rigidity | Torsional to polar radii ratios | Drift sensitivity coefficients

Tower	Story	Elevation	X-Direction					Y-Direction				
			K	Kθ	r	ls	(r/ls)²	K	Kθ	r	ls	(r/ls)²
		[m]	[kN/m]	[kNm/Rad]	[m]	[m]		[kN/m]	[kNm/Rad]	[m]	[m]	
T1	PR_3.91	3.91	2.808e+05	2.865e+07	10.1	7.724	1.71	2.964e+05	2.865e+07	9.833	7.724	1.62
T1	PR_7.82	7.82	1.42e+05	2.31e+07	12.75	7.762	2.7	2.273e+05	2.31e+07	10.08	7.762	1.687
T1	PR_11.73	11.73	9.576e+04	1.632e+07	13.05	7.744	2.842	1.63e+05	1.632e+07	10.01	7.744	1.669
T1	PR_15.64	15.64	6.989e+04	1.54e+07	14.84	7.779	3.641	1.543e+05	1.54e+07	9.99	7.779	1.649
T1	PR_19.55	19.55	6.532e+04	1.03e+07	12.56	7.747	2.627	1.062e+05	1.03e+07	9.849	7.747	1.616
T1	PR_23.46	23.46	5.45e+04	1.126e+07	14.37	7.759	3.433	1.088e+05	1.126e+07	10.17	7.759	1.72
T1	PR_27.37	27.37	4.48e+04	7.327e+06	12.79	7.732	2.736	7.333e+04	7.327e+06	9.996	7.732	1.671
T1	PR_31.28	31.28	3.199e+04	7.678e+06	15.49	7.746	4.001	7.494e+04	7.678e+06	10.12	7.746	1.708
T1	PR_35.19	35.19	2.756e+04	4.247e+06	12.41	7.74	2.573	4.419e+04	4.247e+06	9.804	7.74	1.604
T1	PR_39.1	39.1	1.472e+04	4.019e+06	16.52	7.737	4.561	3.755e+04	4.019e+06	10.35	7.737	1.788
T1	PR_43.01	43.01	6623	1.337e+06	14.21	6.805	4.358	1.758e+04	1.337e+06	8.721	6.805	1.642

(4)P Los cuatro primeros tipos de sistemas (es decir, sistemas de pórticos, duales y de muros de ambos tipos) deben tener una mínima rigidez de torsión que satisfaga la ecuación (4.1b) en ambas direcciones horizontales.

$$r_x \geq l_s \qquad (4.1b)$$

donde

r_x es la raíz cuadrada del cociente entre la rigidez a torsión y la rigidez lateral en la dirección *y* ("radio de torsión"); y

l_s es el radio de giro de la masa del forjado en planta (raíz cuadrada del cociente entre: (a) el momento polar de inercia en planta de la masa del forjado con respecto al centro de gravedad de éste, y (b) la masa del forjado).

WHAT TOWERS DOES?

EUROCODE 8 - BEHAVIOUR FACTOR – REGULAR IN PLAN BUILDING?

Results

Export to Excel

Centers of mass and rigidity | Torsional to polar radii ratios | Drift sensitivity coefficients

Tower	Story	Elevation	X-Direction					Y-Direction				
			K	Kθ	r	ls	(r/ls)²	K	Kθ	r	ls	(r/ls)²
		[m]	[kN/m]	[kNm/Rad]	[m]	[m]		[kN/m]	[kNm/Rad]	[m]	[m]	
T1	PR_3.91	3.91	2.808e+05	2.865e+07	10.1	7.724	1.71	2.964e+05	2.865e+07	9.833	7.724	1.62
T1	PR_7.82	7.82	1.42e+05	2.31e+07	12.75	7.762	2.7	2.273e+05	2.31e+07	10.08	7.762	1.687
T1	PR_11.73	11.73	9.576e+04	1.632e+07	13.05	7.744	2.842	1.63e+05	1.632e+07	10.01	7.744	1.669
T1	PR_15.64	15.64	6.989e+04	1.54e+07	14.84	7.779	3.641	1.543e+05	1.54e+07	9.99	7.779	1.649
T1	PR_19.55	19.55	6.532e+04	1.03e+07	12.56	7.747	2.627	1.062e+05	1.03e+07	9.849	7.747	1.616
T1	PR_23.46	23.46	5.45e+04	1.126e+07	14.37	7.759	3.433	1.088e+05	1.126e+07	10.17	7.759	1.72
T1	PR_27.37	27.37	4.48e+04	7.327e+06	12.79	7.732	2.736	7.333e+04	7.327e+06	9.996	7.732	1.671
T1	PR_31.28	31.28	3.199e+04	7.678e+06	15.49	7.746	4.001	7.494e+04	7.678e+06	10.12	7.746	1.708
T1	PR_35.19	35.19	2.756e+04	4.247e+06	12.41	7.74	2.573	4.419e+04	4.247e+06	9.804	7.74	1.604
T1	PR_39.1	39.1	1.472e+04	4.019e+06	16.52	7.737	4.561	3.755e+04	4.019e+06	10.35	7.737	1.788
T1	PR_43.01	43.01	6623	1.337e+06	14.21	6.805	4.358	1.758e+04	1.337e+06	8.721	6.805	1.642

Results

Ycm	Xcr	Ycr	ex	ey	ex/Bx	ey/By
[m]	[m]	[m]	[m]	[m]		
5.323	10.43	5.439	1.845	0.1157	0.09319	0.01072
5.324	9.932	5.345	1.292	0.02081	0.06523	0.001927
5.333	10.14	5.445	1.479	0.1117	0.07467	0.01035
5.341	9.838	5.6	1.195	0.2586	0.06037	0.02394
5.343	10.05	5.551	1.329	0.2078	0.06714	0.01924
5.327	9.74	5.785	1.118	0.4585	0.05645	0.04245
5.339	9.882	5.868	1.218	0.5291	0.06152	0.04899
5.327	9.677	5.995	1.13	0.6672	0.05709	0.06178
5.343	9.811	5.923	1.11	0.5798	0.05606	0.05368
5.323	9.647	6.04	1.084	0.7171	0.05477	0.0664
5.304	11	5.973	1.288	0.6692	0.06721	0.06197

(6) Para cada nivel y para cada dirección, *x* e *y*, del análisis la excentricidad estructural e_0 y el radio de torsión *r* deben ser conformes con las dos condiciones siguientes, que para la dirección de análisis *y* se expresan como:

$$e_{ox} \leq 0{,}30 \cdot r_x \qquad (4.1a)$$

$$r_x \geq l_s \qquad (4.1b)$$

donde

e_{ox} es la distancia entre el centro de rigidez y el centro de gravedad, medida a lo largo de la dirección *x*, la cual es normal a la dirección de análisis considerada;

r_x es la raíz cuadrada del cociente entre la rigidez a torsión y la rigidez lateral en la dirección *y* ("radio de torsión"); y

l_s es el radio de giro de la masa del forjado en planta (raíz cuadrada del cociente entre: (a) el momento polar de inercia en planta de la masa del forjado con respecto al centro de gravedad de éste, y (b) la masa del forjado).

WHAT TOWERS DOES?

EUROCODE 8 - BEHAVIOUR FACTOR – REGULAR IN ELEVATION BUILDING?

Results

Export to Excel

Centers of mass and rigidity | Torsional to polar radii ratios | Drift sensitivity coefficients

Tower	Story	Elevation	Bx	By	Mx	My	Mz	Iz	Xcm	Ycm	Xcr	Ycr	ex	ey	ex/Bx	ey/By
		[m]	[m]	[m]	[kNs²/m]	[kNs²/m]	[kNs²/m]	[kNms²]	[m]	[m]	[m]	[m]	[m]	[m]		
T1	PR_3.91	3.91	19.8	10.8	183.3	183.3	183.3	1.094e+04	8.584	5.323	10.43	5.439	1.845	0.1157	0.09319	0.01072
T1	PR_7.82	7.82	19.8	10.8	184.7	184.7	184.7	1.113e+04	8.641	5.324	9.932	5.345	1.292	0.02081	0.06523	0.001927
T1	PR_11.73	11.73	19.8	10.8	184.2	184.2	184.2	1.105e+04	8.657	5.333	10.14	5.445	1.479	0.1117	0.07467	0.01035
T1	PR_15.64	15.64	19.8	10.8	183.6	183.6	183.6	1.111e+04	8.643	5.341	9.838	5.6	1.195	0.2586	0.06037	0.02394
T1	PR_19.55	19.55	19.8	10.8	184.9	184.9	184.9	1.11e+04	8.716	5.343	10.05	5.551	1.329	0.2078	0.06714	0.01924
T1	PR_23.46	23.46	19.8	10.8	182.8	182.8	182.8	1.101e+04	8.623	5.327	9.74	5.785	1.118	0.4585	0.05645	0.04245
T1	PR_27.37	27.37	19.8	10.8	182.9	182.9	182.9	1.093e+04	8.664	5.339	9.882	5.868	1.218	0.5291	0.06152	0.04899
T1	PR_31.28	31.28	19.8	10.8	180.4	180.4	180.4	1.082e+04	8.547	5.327	9.677	5.995	1.13	0.6672	0.05709	0.06178
T1	PR_35.19	35.19	19.8	10.8	182.8	182.8	182.8	1.095e+04	8.701	5.343	9.811	5.923	1.11	0.5798	0.05606	0.05368
T1	PR_39.1	39.1	19.8	10.8	179	179	179	1.071e+04	8.563	5.323	9.647	6.04	1.084	0.7171	0.05477	0.0664
T1	PR_43.01	43.01	19.16	10.8	125.5	125.5	125.5	5811	9.711	5.304	11	5.973	1.288	0.6692	0.06721	0.06197

Results

Export to Excel

Centers of mass and rigidity | Torsional to polar radii ratios | Drift sensitivity coefficients

Tower	Story	Elevation	X-Direction					Y-Direction				
			K	Kθ	r	ls	(r/ls)²	K	Kθ	r	ls	(r/ls)²
		[m]	[kN/m]	[kNm/Rad]	[m]	[m]		[kN/m]	[kNm/Rad]	[m]	[m]	
T1	PR_3.91	3.91	2.808e+05	2.865e+07	10.1	7.724	1.71	2.964e+05	2.865e+07	9.833	7.724	1.62
T1	PR_7.82	7.82	1.42e+05	2.31e+07	12.75	7.762	2.7	2.273e+05	2.31e+07	10.08	7.762	1.687
T1	PR_11.73	11.73	9.576e+04	1.632e+07	13.05	7.744	2.842	1.63e+05	1.632e+07	10.01	7.744	1.669
T1	PR_15.64	15.64	6.989e+04	1.54e+07	14.84	7.779	3.641	1.543e+05	1.54e+07	9.99	7.779	1.649
T1	PR_19.55	19.55	6.532e+04	1.03e+07	12.56	7.747	2.627	1.062e+05	1.03e+07	9.849	7.747	1.616
T1	PR_23.46	23.46	5.45e+04	1.126e+07	14.37	7.759	3.433	1.088e+05	1.126e+07	10.17	7.759	1.72
T1	PR_27.37	27.37	4.48e+04	7.327e+06	12.79	7.732	2.736	7.333e+04	7.327e+06	9.996	7.732	1.671
T1	PR_31.28	31.28	3.199e+04	7.678e+06	15.49	7.746	4.001	7.494e+04	7.678e+06	10.12	7.746	1.708
T1	PR_35.19	35.19	2.756e+04	4.247e+06	12.41	7.74	2.573	4.419e+04	4.247e+06	9.804	7.74	1.604
T1	PR_39.1	39.1	1.472e+04	4.019e+06	16.52	7.737	4.561	3.755e+04	4.019e+06	10.35	7.737	1.788
T1	PR_43.01	43.01	6623	1.337e+06	14.21	6.805	4.358	1.758e+04	1.337e+06	8.721	6.805	1.642

(3) Tanto la rigidez lateral como la masa de cada planta deben mantenerse constantes o reducirse gradualmente, sin cambios bruscos, desde la base hasta la parte superior de cada edificio particular.

WHAT TOWERS DOES?

EUROCODE 8 - BEHAVIOUR FACTOR – INVERTED PENDULUM SYSTEM?

Results

Export to Excel

Centers of mass and rigidity | Torsional to polar radii ratios | Drift sensitivity coefficients

Tower	Story	Elevation	Bx	By	Mx	My	Mz	Iz	Xcm	Ycm	Xcr	Ycr	ex	ey	ex/Bx	ey/By
		[m]	[m]	[m]	[kNs²/m]	[kNs²/m]	[kNs²/m]	[kNms²]	[m]	[m]	[m]	[m]	[m]	[m]		
T1	PR_3.91	3.91	19.8	10.8	183.3	183.3	183.3	1.094e+04	8.584	5.323	10.43	5.439	1.845	0.1157	0.09319	0.01072
T1	PR_7.82	7.82	19.8	10.8	184.7	184.7	184.7	1.113e+04	8.641	5.324	9.932	5.345	1.292	0.02081	0.06523	0.001927
T1	PR_11.73	11.73	19.8	10.8	184.2	184.2	184.2	1.105e+04	8.657	5.333	10.14	5.445	1.479	0.1117	0.07467	0.01035
T1	PR_15.64	15.64	19.8	10.8	183.6	183.6	183.6	1.111e+04	8.643	5.341	9.838	5.6	1.195	0.2586	0.06037	0.02394
T1	PR_19.55	19.55	19.8	10.8	184.9	184.9	184.9	1.11e+04	8.716	5.343	10.05	5.551	1.329	0.2078	0.06714	0.01924
T1	PR_23.46	23.46	19.8	10.8	182.8	182.8	182.8	1.101e+04	8.623	5.327	9.74	5.785	1.118	0.4585	0.05645	0.04245
T1	PR_27.37	27.37	19.8	10.8	182.9	182.9	182.9	1.093e+04	8.664	5.339	9.882	5.868	1.218	0.5291	0.06152	0.04899
T1	PR_31.28	31.28	19.8	10.8	180.4	180.4	180.4	1.082e+04	8.547	5.327	9.677	5.995	1.13	0.6672	0.05709	0.06178
T1	PR_35.19	35.19	19.8	10.8	182.8	182.8	182.8	1.095e+04	8.701	5.343	9.811	5.923	1.11	0.5798	0.05606	0.05368
T1	PR_39.1	39.1	19.8	10.8	179	179	179	1.071e+04	8.563	5.323	9.647	6.04	1.084	0.7171	0.05477	0.0664
T1	PR_43.01	43.01	19.16	10.8	125.5	125.5	125.5	5811	9.711	5.304	11	5.973	1.288	0.6692	0.06721	0.06197

sistemas de péndulo invertido:
Sistema en el que el 50% o más de su masa se localiza en el tercio superior de la altura de la estructura, o en el que la disipación de energía tiene lugar principalmente en la base de un elemento aislado del edificio.

WHAT TOWERS DOES?

EUROCODE 8 - INTERSTOREY DRIFT SENSITIVITY COEFFICIENT

Results

Export to Excel

Centers of mass and rigidity | Torsional to polar radii ratios | Drift sensitivity coefficients

Tower	Story	Elevation	X-Direction					Y-Direction				
			P	V	d	h	θ	P	V	d	h	θ
		[m]	[kN]	[kN]	[m]	[m]		[kN]	[kN]	[m]	[m]	
T1	PR_3.91	3.91	2.093e+04	638.1	0.008869	3.91	0.0744	2.093e+04	707	0.01026	3.91	0.07767
T1	PR_7.82	7.82	1.894e+04	612	0.0165	3.91	0.1306	1.894e+04	659.9	0.01298	3.91	0.09529
							0.1722	1.699e+04	615.6	0.01521	3.91	0.1074
							0.2088	1.504e+04	556.3	0.01577	3.91	0.109
							0.1954	1.306e+04	505.2	0.01877	3.91	0.124
							0.1933	1.11e+04	456	0.01795	3.91	0.1118
							0.1828	9160	418.6	0.02066	3.91	0.1156
							0.177	7252	387.9	0.0189	3.91	0.09035
							0.1309	5287	339	0.02246	3.91	0.0896
							0.1074	3386	262.2	0.0179	3.91	0.05913
							0.0689	1465	168.9	0.03271	3.91	0.07256

(2) Los efectos del segundo orden (efectos P-Δ) no necesitan tenerse en cuenta si se cumple la siguiente condición en todas las plantas:

$$\theta = \frac{P_{tot} \cdot d_r}{V_{tot} \cdot h} \leq 0{,}10 \qquad (4.28)$$

donde

θ es el coeficiente de sensibilidad del desplome entre plantas;

P_{tot} es la carga total gravitatoria desde la planta considerada hacia arriba, para la situación sísmica de cálculo;

d_r es el valor de cálculo del desplome entre plantas, evaluado como la diferencia entre el desplazamiento lateral medio, d_s, de la parte superior e inferior de la planta considerada, y calculado conforme al apartado **4.3.4**;

V_{tot} es el esfuerzo cortante sísmico total de la planta; y

h es la altura entre plantas.

(3) Si $0{,}1 < \theta \leq 0{,}2$, los efectos de segundo orden pueden tenerse en cuenta, aproximadamente, mayorando los correspondientes efectos de la acción sísmica mediante un coeficiente igual a $1/(1-\theta)$.

(4)P El valor del coeficiente θ no debe superar 0,3.

WHAT TOWERS DOES?

EUROCODE 8 - DAMAGE LIMITATION – LIMITATION OF INTERSTOREY DRIFT

Story results

Export to Excel

Max story displacements | Max story drifts | Story shears | Story forces

Tower	Story	Elevation [m]	Anaysis/Comb.	Type	Output type	X-Direction		Y-Direction	
						dUx	Object ID	dUy	Object ID
T1	PR_3.91	3.91	RS_SLV_X	LinRespSpec	Max	0.000611	122	0.00013	408
T1	PR_7.82	7.82	RS_SLV_X	LinRespSpec	Max	0.001095	123	0.000118	409
T1	PR_11.73	11.73	RS_SLV_X	LinRespSpec	Max	0.001431	135	0.000289	410
T1	PR_15.64	15.64	RS_SLV_X	LinRespSpec	Max	0.001681	136	0.000211	411
T1	PR_19.55	19.55	RS_SLV_X	LinRespSpec	Max	0.00188	546	0.000208	412
						0.002097	547	0.000294	413
						0.00205	139	0.000383	414
						0.002061	140	0.000187	415
						0.002415	554	0.000231	416
						0.002488	555	0.000262	147
						0.002371	383	0.000246	383

a) para edificios que tengan elementos no estructurales de materiales frágiles unidos a la estructura:

$$d_r \nu \leq 0,005\, h \qquad (4.31)$$

b) para edificios que tengan elementos no estructurales dúctiles

$$d_r \nu \leq 0,0075\, h \qquad (4.32)$$

c) para edificios que tengan elementos no estructurales unidos de forma que no interfieran con las deformaciones estructurales o que carezcan de elementos no estructurales:

$$d_r \nu \leq 0,010\, h \qquad (4.33)$$

donde

d_r es el valor de cálculo del desplome entre plantas, tal como se define en el punto **(2)** del apartado **4.4.2.2**;

h es la altura de la planta;

ν es el coeficiente de reducción que considera el menor periodo de retorno de la acción sísmica asociada con el requisito de limitación de daño.