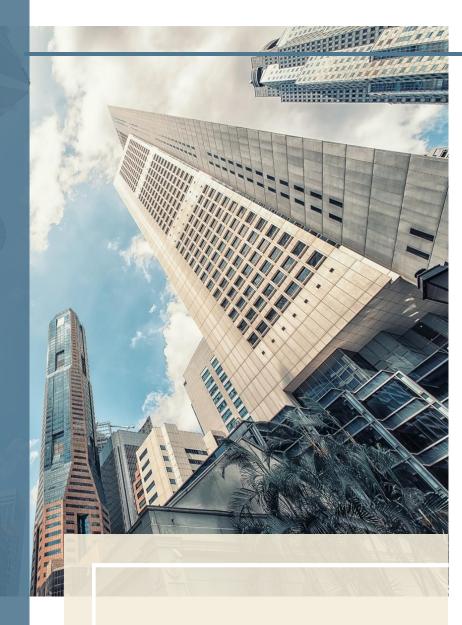
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SAFI STRUCTURAL ENGINEERING SOFTWARE

TECHNICAL PAPER





TRIBUTARY AREA AND LIVE LOAD REDUCTION



LIVE LOAD REDUCTION

The live load reduction is available for the steel, concrete, aluminum and wood modules. The live load reduction will be applied to columns of the structure.

Live loads can be automatically reduced according to the selected method. The software computes the live load reduction factor (LLRF) that will reduce the effective axial compression force in columns. The bending moments in the columns are not reduced.

When there is no live load reduction, **Cf** is equal to **Cf (ana)**.

When the live load reduction is enabled, **Cf** is the effective compression force.

For a specific combination used in the compression limit states design, the effective compression force **Cf** (positive value for **compression**) will be computed based on the following equation.

$$C_f = C_f(ana) - \sum_{i=1}^n \{-\alpha_{Li}F_{xi}(1 - LLRF_i)\}$$

The value $C_f(ana)$ is the original unreduced compression force in the column coming from the analysis.

The value F_{xi} is the unfactored axial force (positive value for **tension**) for a reductible basic load.

The value " $-\alpha_{Li}F_{xi}$ " is the factored compression force (positive value for **compression**) due to the ith reductible live load.

In a combination, the total live load reduction is function of the sum of all \boldsymbol{n} reductible basic live loads reduction factor LLRF_i.

The live load reduction options are:

- <u>CNBC</u>
 - $0.3 + \sqrt{9.8/A}$ or $0.5 + \sqrt{20/A}$
- <u>ASCE 7</u>

 $0.25 + 15/\sqrt{KLL \cdot A} \le 1$

• <u>Custom</u> (By Tributary Area)

 $a + b/\sqrt{A} \le 1$ or $a + b/A \le 1$ or $1 - a(A - b) \le 1$

- <u>Custom</u> (By Supported Storeys)
- <u>No reduction</u>



STEPS TO APPLY LIVE LOAD REDUCTION

The required steps to apply the live load reduction is defined below. The steps are the same for the steel, concrete, aluminum and wood modules.

Step 1: Basic loads

Create a basic load with a "Reductible Live Load" type.

For the NBCC, it is also possible to create a "Reductible Live Load (NBCC Assembly)" type. It is possible to define more than one reductible live load.

In this case, the tributary area is computed separately for each basic load.

0 300	Basic Load Name	Load Type		
1 Dea	ł	(D) Dead Load		
2 Live		(L) Reductible Live Load		
3 Snov	N	<delete load="" this=""></delete>		
4		(B) General Static Load		
		(D) Dead Load		
5		(D) Additional Dead Load		
6		(L) Live Load		
7		(W) Wind Load		
8		(I) Ice Load (S) Snow Load		
9		(E) Static Seismic Load		
-		(Wv) Static Wave Load		
10		(VM) Vessel Motion Load		
11		(H) Earth Pressure Load		
12		(C) Crane Load		
13		(T) Thermal (Self-Straining) Load		
		(r) Roof Live Load	_	h
14		() Reductible Live Load		
15		(Reductible Live Load (NBCC Assembly)	_	J
16		(L) Moving Load		
17		(L) Static Moving Load (E) Response Spectrum Seismic Load		
18		(E) Time-History Seismic Load		ОК
		(Lk) Dynamic Load		
19				Cancel

Live Load Reduction		? ×
Id =	3	Table
	Options	
Method =	Custom (By Tributary Area)	
	ASCE 7 Parameters	
Equation =	LLRF = a+b/sqrt(A)	
Area Unit =	m.2 💌	
a =	0.3	
b =	3.1305	
	Minimum values	
LLRF min (1 Floor) =	0.6	
LLRF _{min} (>1 Floor) =	0.4	
		OK Cancel

Step 2: Live load reduction definition

From the **Tables** menu, select the **Live Load Reduction** command to define live load reduction parameters.

Four methods are available:

- NBCC,
- ASCE 7,
- Custom (By Tributary Area)
- Custom (By Supported Storeys).



Step 3: Activate the live load reduction method

From the Analysis menu, select the Codes and Standards command. In the appropriate tab (steel, concrete, aluminum or wood) the Live Load Reduction Method created in the previous step can be selected.

By default, there is no live load reduction active.

Step 4:		
Defining	the	storeys

To define the storeys activate the **Edit – Storeys** command.

Step 5 (optional):	
Override the live load reduction	per
member	

It is possible to customize the method for each member. To do so, edit the **Live Load Reduction** method in the appropriate tab (steel, concrete, aluminum or wood) of the member attributes.

Step 6: Run the analysis

Run the analysis with the appropriate design option.

esign Codes and Standards Parame	eters	? ×
Seismic Deflections Steel Alum	inum Reinforced Concrete Wood	
Standard: CS	A S16-14/CSA S136-16 🔹	
Limit States Calculation:	At each division	
Live Load Reduction Method:	3 - Custom NBCC	
Minimum ULS Ratio to Print:	Live Load Reduction Method: 3 - Custom NBCC	
Limit Slend. (Tension):	300	
Limit Slend. (Compression):	200	
Slenderness Verification ULS Threshold:	0.1	
CompBending Equation for:	Braced Frames	

0 8	Label	Height mm	Elevation mm		
	Base		0.0000		
	L1	4000.0000	4000.0000		
	L2	4000.0000	8000.0000		
	L3	4000.0000	12000.0000		
	L4	4000.0000	16000.0000		
	L5	4000.0000	20000.0000		
	L6	4000.0000	24000.0000		
	L7	4000.0000	28000.0000		

Member Attributes	x
General Offsets Deflections Steel Composite Aluminum Concrete Wood	
ID: M86 Name: Lphys = 4000 mm → X	
Bending	
Unbraced Length	
▼ Top Flange Member ▼ w2= 0	
Ø Bot. Flange Member ▼ w2= 0	
Ignore Bending on the Weak Axis	
Ignore Torsion	
Compression	
Ignore U1 multiplier for 2nd order analysis (subdivided members only) Unsupported Length	
Axis X Member VKx= 1 w1,x= 0	
Ø Axis Y Member Ky= 1 w1,y= 0	
▼ Torsion Min. strong and weal ▼ Kt= 1	
Built-Up Sections Ks= 0 Ls= 0 mm	
Change Limit Slenderness in Compression 0	
Change Live Load Reduction Default (3 - Custom NBCC)	



Step 7: Validate the tributary area and the LLRF

After the analysis, it is possible to validate the tributary areas and the live load reduction factor (LLRF) for each reductible basic loads in the **Analysis – Numerical results – Analysis – Member Tributary Area** command.

ble	<u>C</u> ommands	View	Selection	on									
8	e 🕰 🖬 🖷		₽ 🖬		1 (j.	4.0 .00 E	9 📭 📟	11 1	3				
0 18	Load ID	Phys Memb	Member ID	Member Type	Supp'd Stories	Axial Trib Area (m.2)	Axial Reduc Fact	Fx kN	Bending Trib Area (m.2)	Fy kN	Fz kN	Notes	
	2 - Surcharge	25	85	Column	6	150.0000	0.5556	-539.9999					_
	2 - Surcharge	25	86	Column	5	125.0000	0.5800	-450.0000					
	2 - Surcharge	25	87	Column	4	100.0000	0.6130	-360.0000					
	2 - Surcharge	26	88	Column	3	75.0000	0.6615	-270.0000					
	2 - Surcharge	26	89	Column	2	50.0000	0.7427	-180.0000					
	2 - Surcharge	26	90	Column	1	25.0000	0.9261	-90.0000					
	2 - Surcharge	27	92	Column	6	75.0000	0.6615	-270.0000					
	2 - Surcharge	27	93	Column	5	62.5000	0.6960	-225.0000					
	2 - Surcharge	27	94	Column	4	50.0000	0.7427	-180.0000					
	2 - Surcharge	28	95	Column	3	37.5000	0.8112	-135.0000					
	2 - Surcharge	28	96	Column	2	25.0000	0.9261	-90.0000					
	2 - Surcharge	28	97	Column	1	12.5000		-45.0000					
	2 - Surcharge	1092	1092	Beam					25.0000	45.0000	0.0000		
	2 - Surcharge	1099	1099	Beam					25.0000	45.0000	0.0000		
	2 - Surcharge	1106	1106	Beam					25.0000	45.0000	0.0000		
	2 - Surcharge	1113	1113	Beam					25.0000	45.0000	0.0000		
	2 - Surcharge	1120	1120	Beam					25.0000	45.0000	0.0000		Clos
	2 - Surcharge	1127	1127	Beam					25.0000	45.0000	0.0000		Hel

It is also possible to validate tributary area and the LLRF in a graphical way for each column by selecting the **Analysis – Charts – Analysis – Column Tributary Area** command.

olumn Tributary Area										8
	E+03	Axial Reduc Fact vs. Y	0 14	Member ID	Y mm	Supp'd Stories	Axial Trib Area (m.2)	Axial Reduc Fact	Fx kN	Settin
		I I I I I		85	0.1000	6	150.0000	0.5556	-539.9999	
Basic Load:				85	3999.8999	6	150.0000	0.5556	-539.9999	Repor
2 - Surcharge 🔻				86	4000.1001	5	125.0000	0.5800	-450.0000	🔁 Print
	25			86	7999.8999	5	125.0000	0.5800	-450.0000	
				87	8000.1001	4	100.0000	0.6130	-360.0000	/ Inter
				87	11999.9004	4	100.0000	0.6130	-360.0000	
Y Axis;				88	12000.0996	3	75.0000	0.6615	-270.0000	12 Print
γ –				88	15999.9004	3	75.0000	0.6615	-270.0000	Copy Copy
				89	16000.0996	2	50.0000	0.7427	-180.0000	
X Axis:	20			89	19999.9004	2	50.0000	0.7427	-180.0000	
Axial Reduc Fact 🔹				90	20000.0996	1	25.0000	0.9261	-90.0000	
				90	23999.9004	1	25.0000	0.9261	-90.0000	
				91	24000.0996			1.0000		
				91	27999.9004			1.0000		
	10									
		0.5550 0.2 0.4 0.6 0.8 1 Axial Reduc Fact								Close <u>H</u> elp

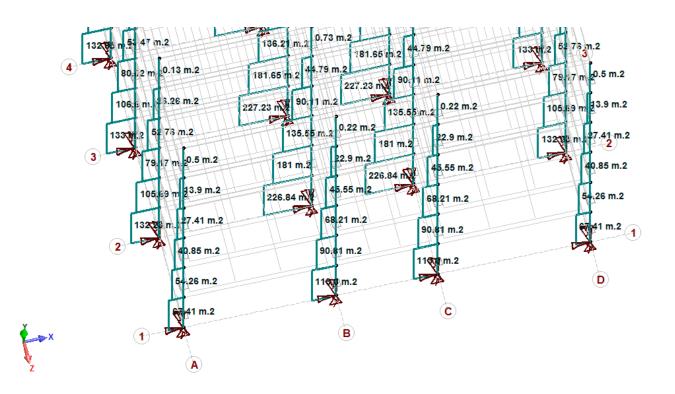
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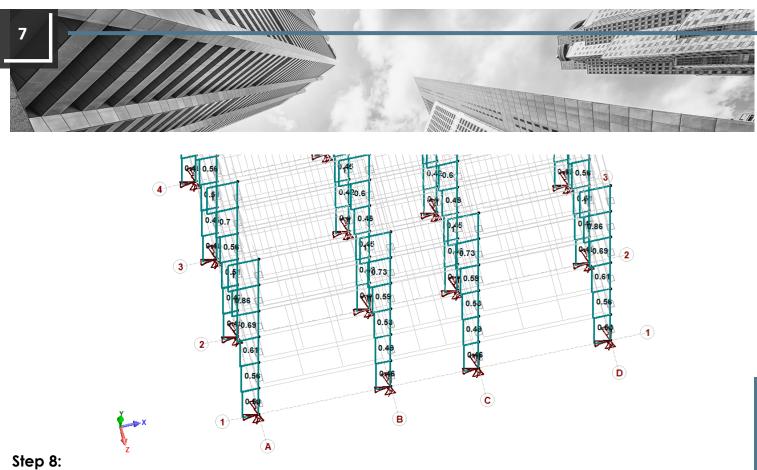


The tributary area and the LLRF can also be displayed directly on the structure. Activate the **Analysis – Global Curves– Analysis – Options**.

Select the option to display as shown below. Select a basic load by clicking on the **Basic Loads** button.

Static Analysis		? X
Deformations		Animate
Forces Forces Envelope Fx (axial) My (bending) Fy (shear) Mz (bending)	Mx (torsion)	
Fz (shear) Bw (warping) Shear in Diaphragms Do not show Stresses	Mxw (warping)	
Stresses Envelope Sx (due to Fx) Sx (due to My) Txy (due to Fy) Sx (due to Mz)	Tt (due to Mxp)	
Txz (due to Fz) Sx (due to Bw) Support Reactions	Txz (due to Mxw)	
Reactions Envelope Rx Rm,x Ry Rm,y Rz Rm,z		
Live load reduction		
Live load reduction value to display: Tributary areas	Basic Loads	





Look at the compression limit states results

It is possible to compare the original compression with the reduced force for each applicable combination. To look at these values, open the compression or the compression/bending limit states results table in the steel, concrete, aluminum or wood module.

When the live load reduction factor (LLRF) is less than 1.0, both columns the original force **Cf (ana)** and the reduced force **Cf** will be displayed.

	·		t States													<u> </u>	וו	Cf (ana) kN	Cf kN	ULS Cf/Cr
-	<u>Commands</u> <u>View</u> <u>Selection</u> ■ (20, 10, 10, 10, 10, 10, 10, 10, 10, 10, 1															1146.6746	786.7141	0.9488		
0	Phys Memb		Section	Fey	Lambda x		Cr x kN	Cr y kN	Cr	Critical	Critical Position (mm)	Cf (ana) kN	Cf kN	ULS Cf/Cr	Notes			973.9250	690.4254	0.832
	25		HSS152x152x8.0	25.5196	0.9069	0.9069	829.1311	829.1311			0.0000							801,1755	592.2225	0.714
	25	86	HSS152x152x8.0	25.5196	0.9069	0.9069	829.1311	829.1311	829.1311	2 - D +L +S	0.0000	973.9250	690.4254	0.8327				001.17.00	UVE LEEU	
	25	87	HSS152x152x8.0	25.5196	0.9069	0.9069	829.1311	829.1311	829.1311	2 - D +L +S	0.0000		592.2225					628.4260	491.3250	0.935
_	26		HSS152x152x4.8		0.8853			525.0786			0.0000		491.3250					456 2105	386.8538	0 726
_	26		HSS152x152x4.8					525.0786			0.0000		386.8538					430.3193	300.0330	0.750
-	26 26		HSS152x152x4.8 HSS152x152x4.8		0.8853			525.0786 525.0786			0.0000		274.2365					284.2130	274.2365	0.522
_	20		HSS152x152x8.0					829.1311			0.0000		449.3094		-				140 0005	0.00/
	27	93	HSS152x152x8.0	25.5196	0.9069	0.9069	829.1311	829.1311	829.1311	2 - D+L+S	0.0000	497.9843	395.3777	0.4769					149.6065	0.284
	27	94	HSS152x152x8.0	25.5196	0.9069	0.9069	829.1311	829.1311	829.1311	2 - D+L+S	0.0000	409.5583	340.0926	0.4102			1	586,4104	449.3094	0.54
	28	95	HSS152x152x4.8	16.5996	0.8853	0.8853	525.0786	525.0786	525.0786	2 - D +L +S	0.000	321.1322	282.9019	0.5388						
_	28		HSS152x152x4.8		0.8853			525.0786			0.0000		223.3727					497.9843	395.3777	0.476
_	28		HSS152x152x4.8		0.8853			525.0786			0.0000		145.5661					400 5583	340.0926	0.410
_	28	98	HSS152x152x4.8	16.5996	0.8853	0.8853	525.0786	525.0786	525.0786	3 - D + S + L	0.0000		76.5330	0.1458				105.5505	340.0920	0.410
																		321.1322	282.9019	0.538
																Close		233.3492	223.3727	0.42
L															Þ	Help			145.5661	0.27
																	1		76.5330	0.14