

# GSE SOFTWARE

General Structural Engineering

# APPLICATION

GSE Steel, Concrete, Wood and Aluminum

# FUNCTIONALITY

Calculates the live load reduction based on tributary area

# 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.





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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 i<sup>th</sup> reductible live load.

In a combination, the total live load reduction is function of the sum of all **n** reductible basic live loads reduction factor LLRFi.

The live load reduction options are:

<u>CNBC</u>	$0.3 + \sqrt{9.8/A}$ or $0.5 + \sqrt{20/A}$
ASCE 7	$0.25 + 15/\sqrt{KLL \cdot A} \le 1$
Custom (By Tributary Area)	$a + b/\sqrt{A} \le 1$ or $a + b/A \le 1$ or $1 - a(A - b) \le 1$

Custom (By Supported Storeys)

No reduction

# 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.

Basic Loads

0 300

1 Dead

2 Live

3 Snow

4

5

6 7

8

9

10

11

12

13

14

15 16

17

18

19

20

Basic Load Name

#### 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.

Id = 3       Options         Method = Custom (By Tributary Area)       Image: Cost of the second seco	e Load Reduction			? <mark>x</mark>
LLRF min (>1 Floor) = 0.6 LLRF min (>1 Floor) = 0.4	Id = Method = Equation = Area Unit = a = b =	3 Options Custom (By Tributary A ASCE 7 Parameters LLRF = a +b/sqrt(A) m.2 0.3 3.1305 Minimum values	rea)	Table
	LLRF <sub>min</sub> (>1 Floor) =	0.4		OK

# (c) Reductible Live Load (NBCC Assembly) (c) Moving Load (l.) Static Moving Load (E) Response Spectrum Seismic Load (E) Time-History Seismic Load (Lk) Dynamic Load

Step 2: Live load reduction definition

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

Load Type

(D) Dead Load

(D) Dead Load

(L) Live Load (W) Wind Load

(I) Ice Load

(S) Snow Load

(C) Crane Load

(Lr) Roof Live Load

(E) Static Seismic Load

(Wv) Static Wave Load

(VM) Vessel Motion Load

(H) Earth Pressure Load

(T) Thermal (Self-Straining) Load

(L) Reductible Live Load

(B) General Static Load

(D) Additional Dead Load

<Delete this load>

Four methods are available:

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

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OK

Cancel

Help

#### 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.

Design Codes and Standards Parameters

Seismic Deflections Steel Aluminum Reinforced Concrete Wood
Standard: CSA S16-14/CSA S136-16

Limit States Calculation: At each division
Live Load Reduction Method: 3 - Custom NBCC

Minimum ULS Ratio to Print: 0.1

Limit Slend. (Tension): 300
Limit Slend. (Compression): 200
Slenderness Verification ULS
Threshold: 0.1

Comp.-Bending 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

#### 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.

nber Attribut	es	? ×
General Offse	ets Deflections Steel Composite Aluminum Concrete Wood	
ID:	M86 ¥	
Name:	L <sub>phys</sub> = 4000 mm →x	
	Bearing Parameters	
	Bending	
	Unbraced Length	
Top Flange	e Member v2= 0	
Bot. Flange	e Member ▼ W2= 0	
Ignore Ben	nding on the Weak Axis	
Ignore Tor	sion	
	Compression	
Ignore U1	multiplier for 2nd order analysis (subdivided members only)	
🗸 Axis X	Unsupported Length Member Kx = 1 w1.x = 0	
AXIS Y	Member V Ky= 1 W1,y= 0	
Torsion	Min. strong and weal V Kt= 1	
Built-Up Se	ctions Ks= 0 Ls= 0 mm	
Change Lin	nit Slenderness in Compression 0	
Change Liv	ve 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.

able	<u>C</u> ommands	View	Selecti	on									
<u>d</u> 8	b   🕰 🗈 🖷		₽   🖬		t A⊈	*.0 .00 0	9 🗣 📰	18 <b>-</b> -   ,	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		
	2 - Surcharge	1127	1127	Beam					25.0000	45.0000	0.0000		

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.



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







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.

Co	Compression Limit States															Cf (ana) kN	Cf kN	ULS Cf/Cr		
																1146.6746	786.7141	0.9488		
0	Phys Memb	Memb ID	Section	Fey MPa	Lambda x	Lambda y	Cr x kN	Cr y kN	Cr kN	Critical Combination	Critical Position (mm)	Cf (ana) kN	Cf kN	ULS Cf/Cr	Notes			973.9250	690.4254	0.8327
	25	85	5 HSS152x152x8.0	25.5196	0.9069	0.9069	829.1311	829.1311	829.1311	2 - D+L+S	0.0000	1146.6746	786.7141	0.9488				801.1755	592.2225	0.7143
	25	86	5 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						
	25	87	7 HSS152x152x8.0	25.5196	0.9069	0.9069	829.1311	829.1311	829.1311	2 - D+L+S	0.0000	801.1755	592.2225	0.7143				628.4260	491.3250	0.9357
	26	88	8 HSS152x152x4.8	16.5996	0.8853	0.8853	525.0786	525.0786	525.0786	2 - D+L+S	0.0000	628.4260	491.3250	0.9357				456, 3195	386,8538	0.7368
	20	05	HSS152x152x4.8	10.5990	0.8853	0.8853	525.0786	525.0786	525.0786	2 - D+L+S	0.0000	284 2130	274 2365	0.7366				10010100	500.0550	0.7000
	20	91	HSS152x152x4.8	46.5996	0.8853	0.8853	525.0786	525.0786	525.0786	3 - D+S+I	0.0000	204.2130	149.6065	0.2849			284.2130	274.2365	0.5223	
	27	92	2 HSS152x152x8.0	25.5196	0.9069	0.9069	829.1311	829.1311	829.1311	2 - D+L+S	0.0000	586.4104	449.3094	0.5419					140 6065	0 2940
	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					149.0005	0.2049
	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				586.4104	449.3094	0.5419
	28	95	5 HSS152x152x4.8	46.5996	0.8853	0.8853	525.0786	525.0786	525.0786	2 - D+L+S	0.0000	321.1322	282.9019	0.5388						
	28	96	5 HSS152x152x4.8	46.5996	0.8853	0.8853	525.0786	525.0786	525.0786	2 - D+L+S	0.0000	233.3492	223.3727	0.4254				497.9843	395.3777	0.4769
	28	97	7 HSS152x152x4.8	16.5996	0.8853	0.8853	525.0786	525.0786	525.0786	2 - D+L+S	0.0000		145.5661	0.2772				400 5502	240.0005	0.4100
	28	98	HSS152x152x4.8	46.5996	0.8853	0.8853	525.0786	525.0786	525.0786	3 - D + S + L	0.0000		76.5330	0.1458	<u> </u>			409.5565	340.0926	0.4102
																		321.1322	282.9019	0.5388
																Close		233.3492	223.3727	0.4254
												111			Þ	Help			145.5661	0.2772
																			76.5330	0.1458