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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 i^{th} 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 $LLRF_i$.

The live load reduction options are:

- CNBC

  $0.3 + \sqrt{9.8/A}$ **or** $0.5 + \sqrt{20/A}$

- ASCE 7

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

- Custom (By Tributary Area)

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

- Custom (By Supported Storeys)

- No reduction

STEPS TO APPLY LIVE LOAD REDUCTION

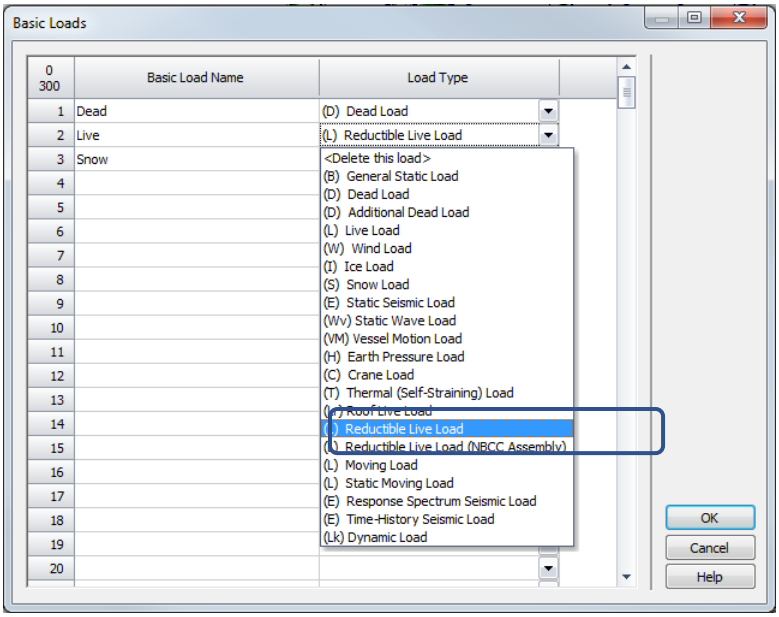
The required steps to apply the live load reduction is defined below. The steps are the same for the steel, concrete, aluminum and wood modules.

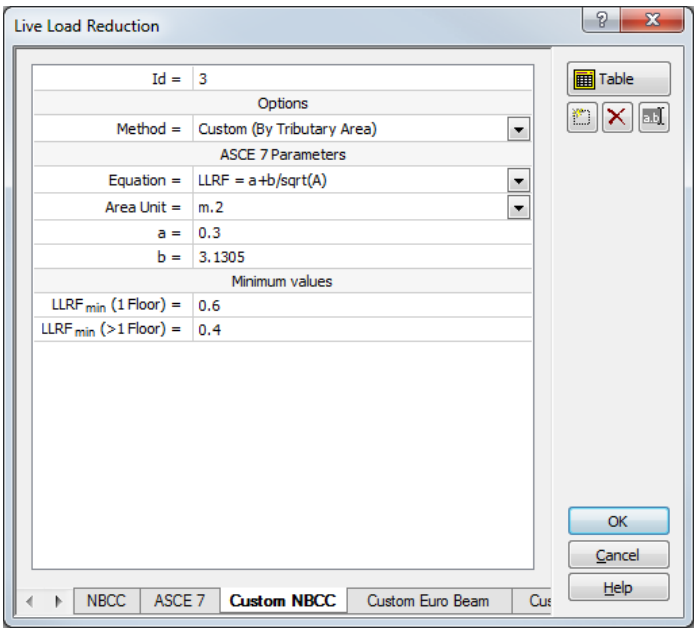
Step 1:
Basic loads

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.





Step 2:
Live load reduction definition

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

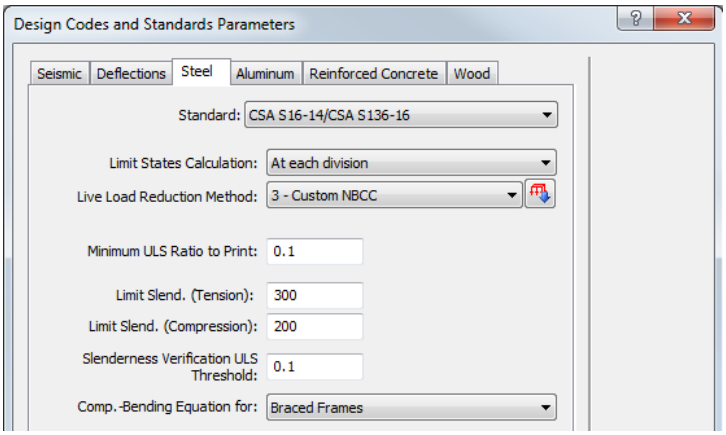
Four methods are available:

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

Step 3:
Activate the live load reduction method

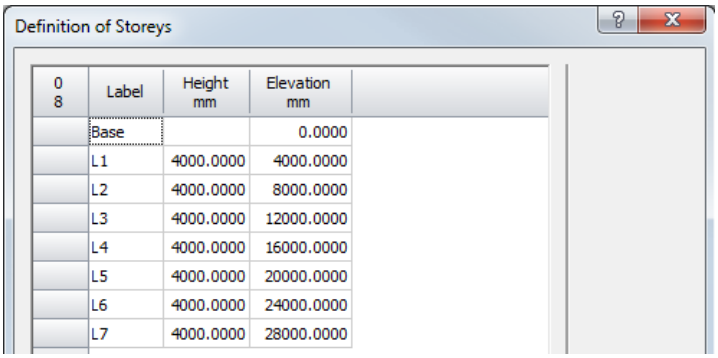
From the **Analysis** menu, select the **Codes and Standards** command. In the appropriate tab (steel, concrete, aluminum or wood) the **Live Load Reduction Method** created in the previous step can be selected.

By default, there is no live load reduction active.



Step 4:
Defining the storeys

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

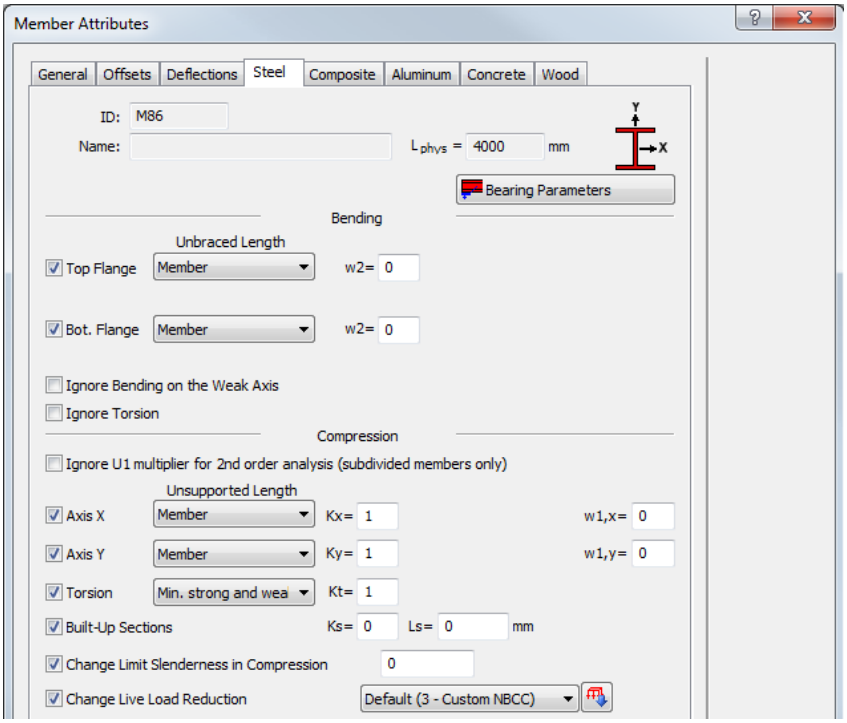


Step 5 (optional):
Override the live load reduction per member

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.

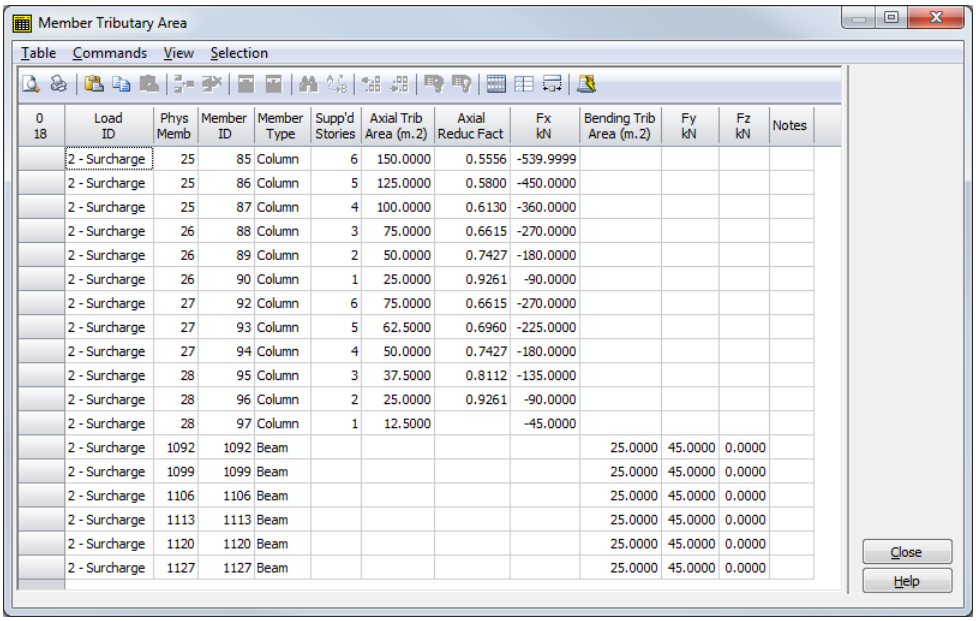
Step 6:
Run the analysis

Run the analysis with the appropriate design option.



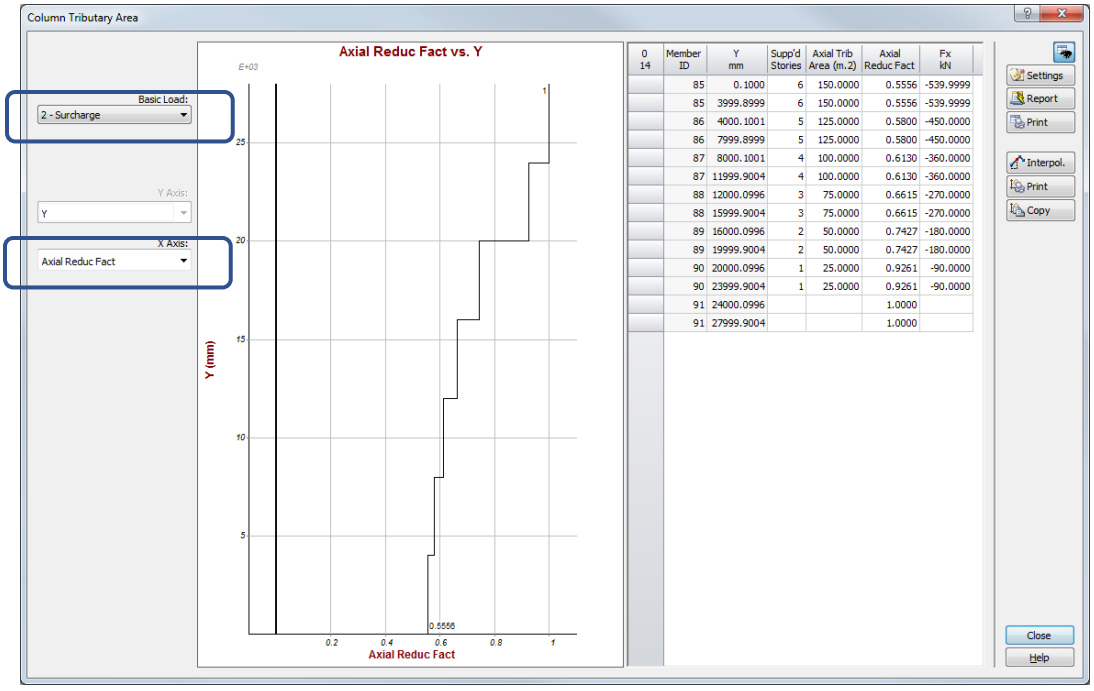
Step 7:
Validate the tributary area and the LLRF

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.



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	

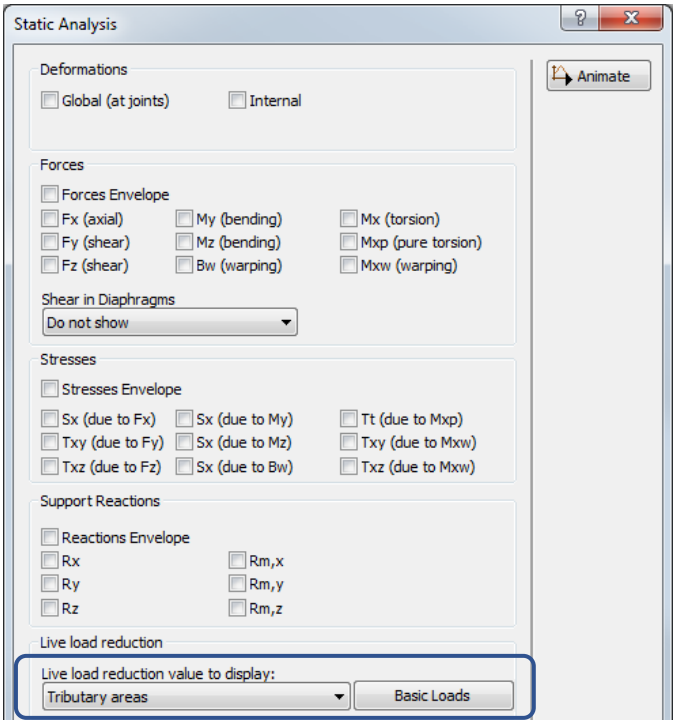
It is also possible to validate tributary area and the LLRF in a graphical way for each column by selecting the **Analysis – Charts – Analysis – Column Tributary Area** command.

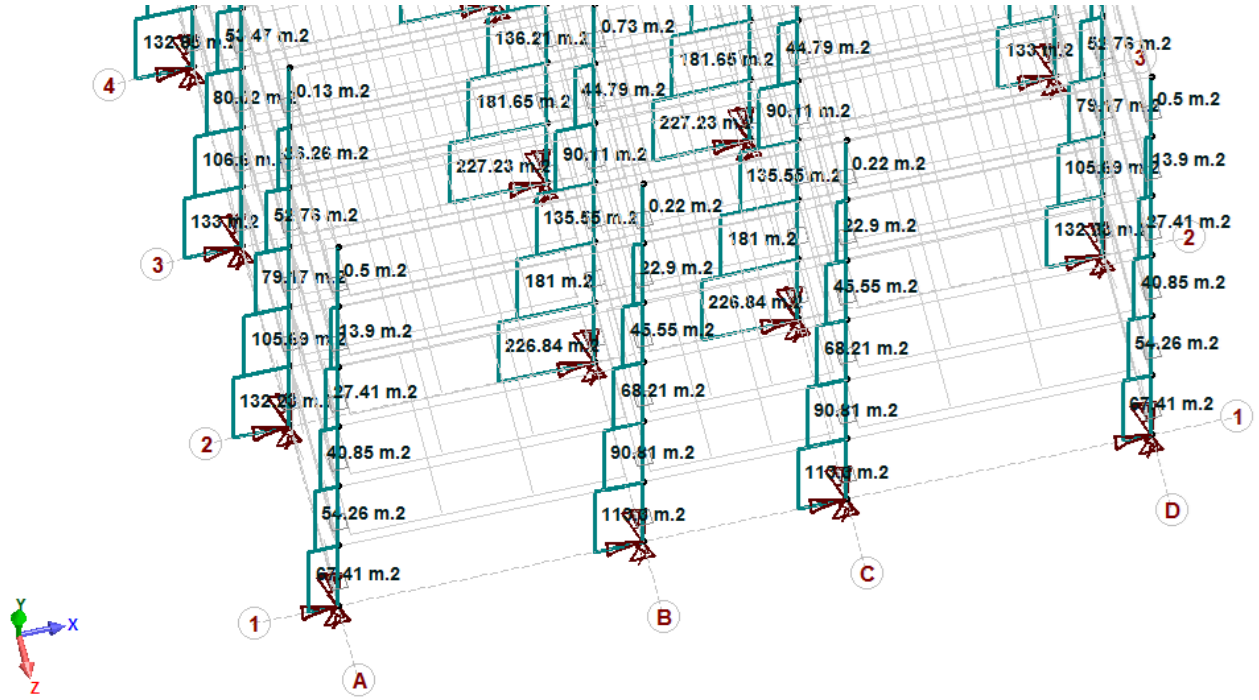


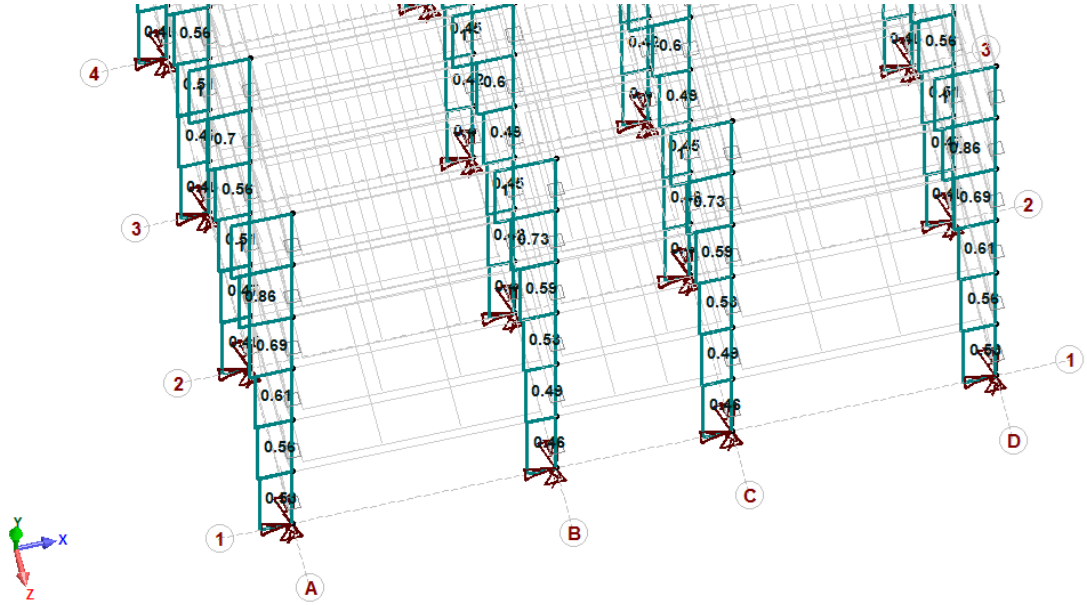
0 14	Member ID	Y mm	Supp'd Stories	Axial Trib Area (m.2)	Axial Reduc Fact	Fx kN
	85	0.1000	6	150.0000	0.5556	-539.9999
	85	3999.8999	6	150.0000	0.5556	-539.9999
	86	4000.1001	5	125.0000	0.5800	-450.0000
	86	7999.8999	5	125.0000	0.5800	-450.0000
	87	8000.1001	4	100.0000	0.6130	-360.0000
	87	11999.9004	4	100.0000	0.6130	-360.0000
	88	12000.0996	3	75.0000	0.6615	-270.0000
	88	15999.9004	3	75.0000	0.6615	-270.0000
	89	16000.0996	2	50.0000	0.7427	-180.0000
	89	19999.9004	2	50.0000	0.7427	-180.0000
	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	

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.



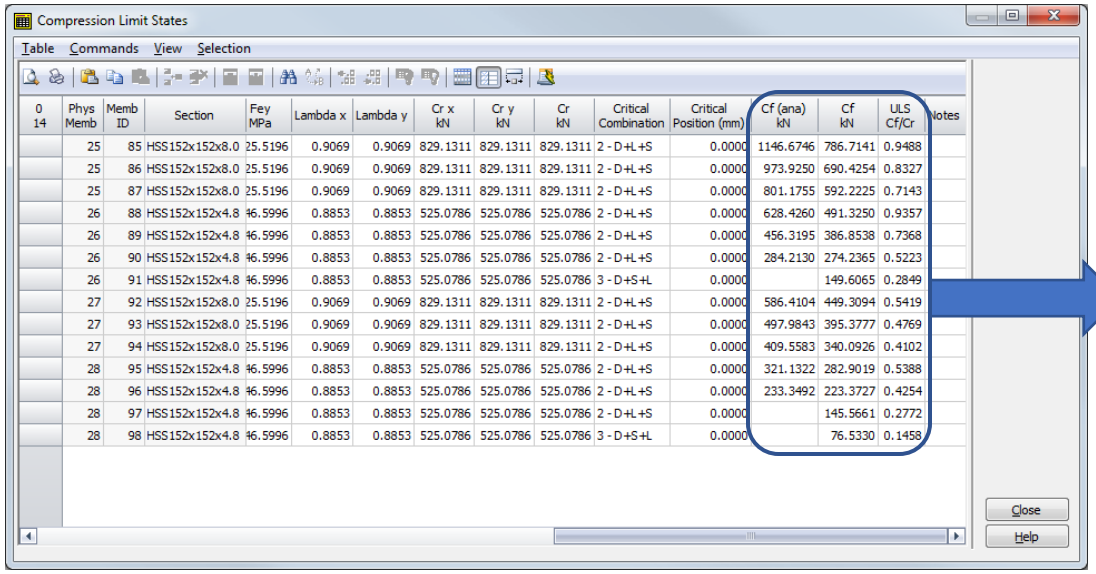




Step 8:
Look at the compression limit states results

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.



0 14	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
	25	85	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	
	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	
	25	87	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	
	26	88	HSS152x152x4.8	46.5996	0.8853	0.8853	525.0786	525.0786	525.0786	2 - D+L+S	0.0000	628.4260	491.3250	0.9357	
	26	89	HSS152x152x4.8	46.5996	0.8853	0.8853	525.0786	525.0786	525.0786	2 - D+L+S	0.0000	456.3195	386.8538	0.7368	
	26	90	HSS152x152x4.8	46.5996	0.8853	0.8853	525.0786	525.0786	525.0786	2 - D+L+S	0.0000	284.2130	274.2365	0.5223	
	26	91	HSS152x152x4.8	46.5996	0.8853	0.8853	525.0786	525.0786	525.0786	3 - D+S+L	0.0000		149.6065	0.2849	
	27	92	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	
	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	
	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	
	28	95	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	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	
	28	97	HSS152x152x4.8	46.5996	0.8853	0.8853	525.0786	525.0786	525.0786	2 - D+L+S	0.0000		145.5661	0.2772	
	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	

Cf (ana) kN	Cf kN	ULS Cf/Cr
1146.6746	786.7141	0.9488
973.9250	690.4254	0.8327
801.1755	592.2225	0.7143
628.4260	491.3250	0.9357
456.3195	386.8538	0.7368
284.2130	274.2365	0.5223
	149.6065	0.2849
586.4104	449.3094	0.5419
497.9843	395.3777	0.4769
409.5583	340.0926	0.4102
321.1322	282.9019	0.5388
233.3492	223.3727	0.4254
	145.5661	0.2772
	76.5330	0.1458