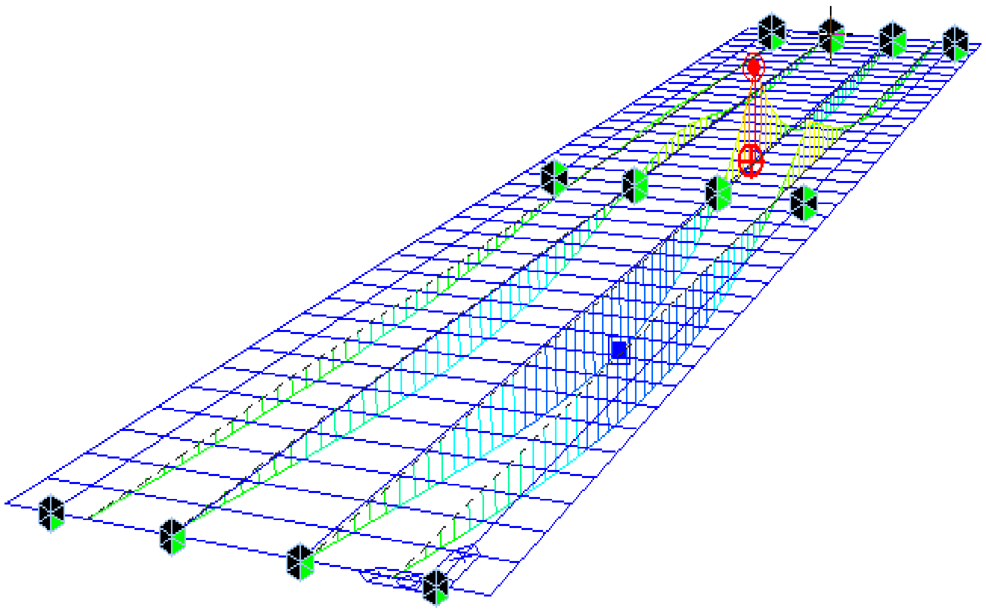
Moving load analysis

(CSA-S6-06 : 2010)



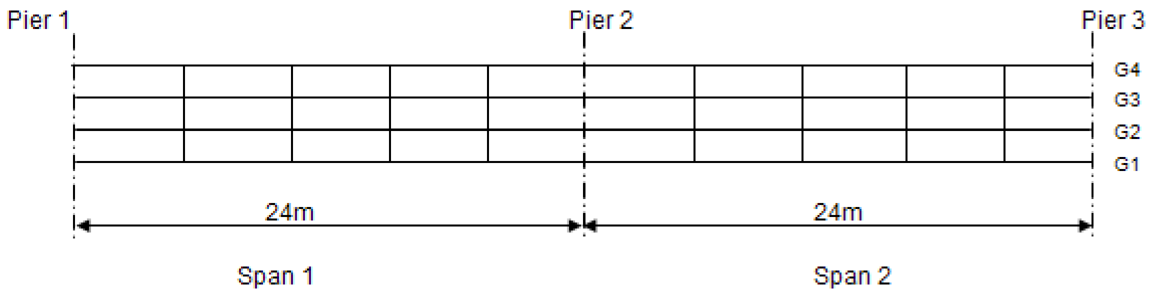
Program Version	Civil 2013 (v1.1)
Program License	Registered, Trial
Revision Date	August 31, 2012

Overview

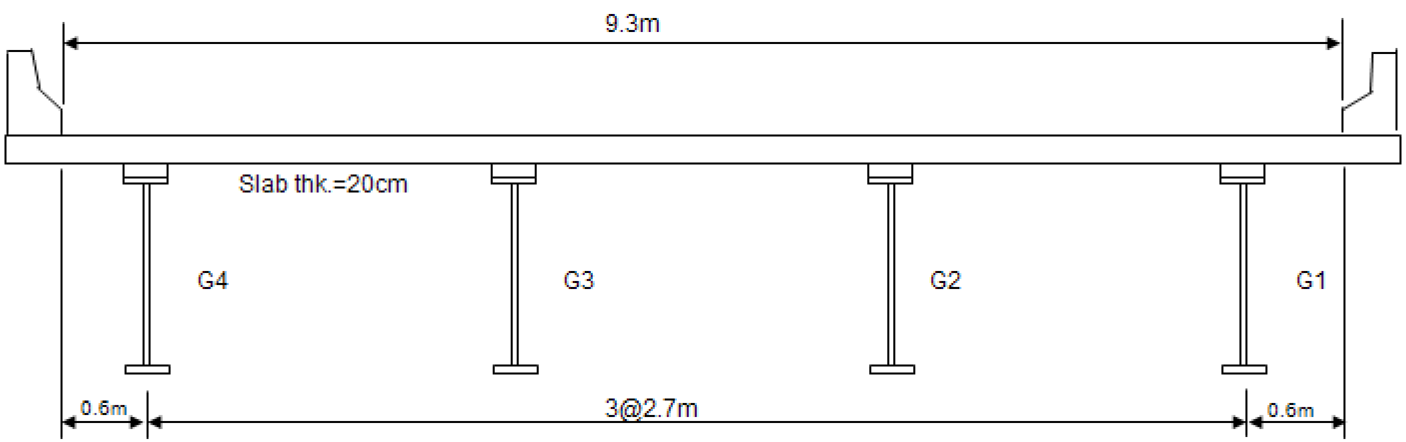
- **Bridge overview**
  - ✓ *2 span continuous composite girder bridge*
  - ✓ *Span length: 2@24 m*
  - ✓ *Carriageway width: 9.3 m*
  - ✓ *Unit system: kN, m*
- **Lane definition**
  - ✓ *As per Table 3.4 of CSA-S6-06:2010*
- **Vehicle load**
  - ✓ *CL-625 Truck Load*
  - ✓ *CL-625 Lane Load*
- **Moving load analysis option**
  - ✓ *Concurrent forces*
- **Result evaluation**
  - ✓ *Influence line*
  - ✓ *Moving load tracer*
  - ✓ *Envelope of member forces*

1. Bridge overview

- Bridge type: Straight bridge
- Span length: 2@24 m
- Carriageway width: 9.3 m
- Total Deck Width: 10.2 m
- Spacing of cross beams: 4.8 m



a) Plan view



b) Cross section

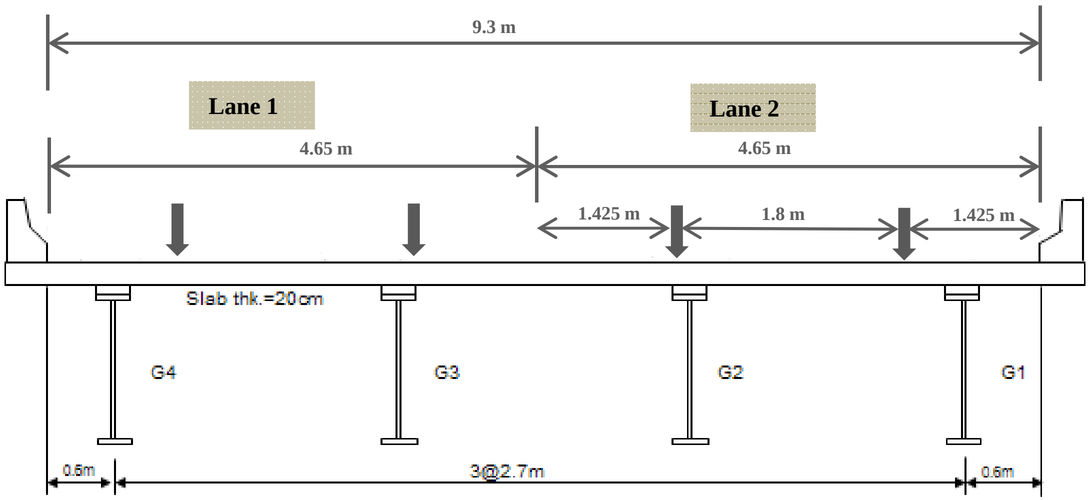
2. Number and width of notional lanes

CSA-S6-06 : 2010: *Table 3.4 Number of Design Lanes*

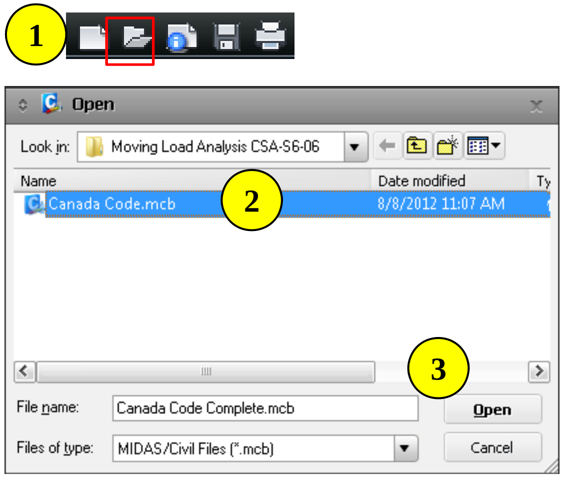
Carriageway width w	Number of lanes	Width of one lane w_e
$w = 9.3\ m$	$n = 2$	$4.65\ m$

3. Location and numbering of the lanes of the bridge

- ✓ **In midas Civil, the user directly defines the locations of lanes. For this tutorial, the lanes and axle loads are illustrated below.**



Step 1. Open the model file.



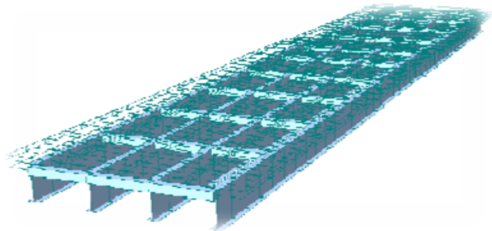
1. Click .

2. Select ***'Canada Moving Load .mcb'.***

3. Click **[Open]** *button.*

This tutorial is intended to introduce the functions of Moving load analysis. Therefore the procedures of creating elements, assigning static loads and boundary conditions are omitted here.

Please refer to the online manual for the detailed usage.



Step2. Define moving load code

1. ***Load > Moving load analysis data > Moving load code…***

2. Moving Load Code: ***Canada***

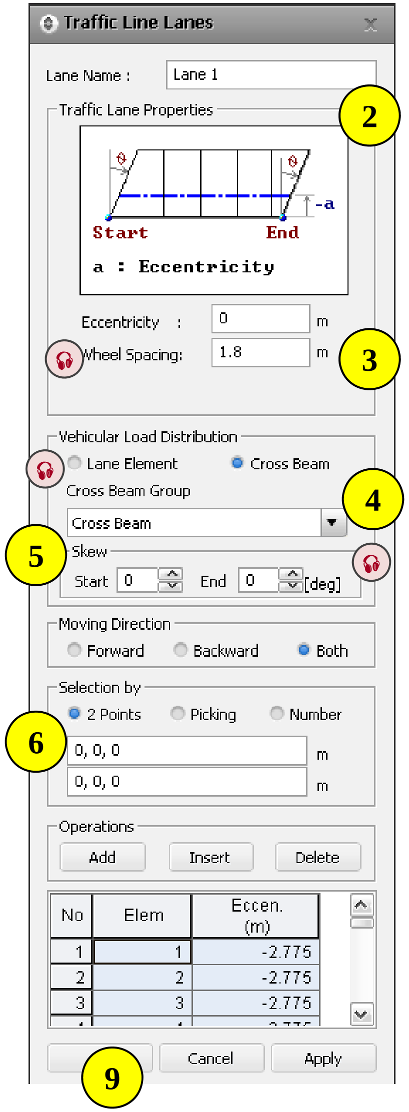
3. Click **[OK]** *button.*

Step3-1. Define traffic line lane (Lane 1)

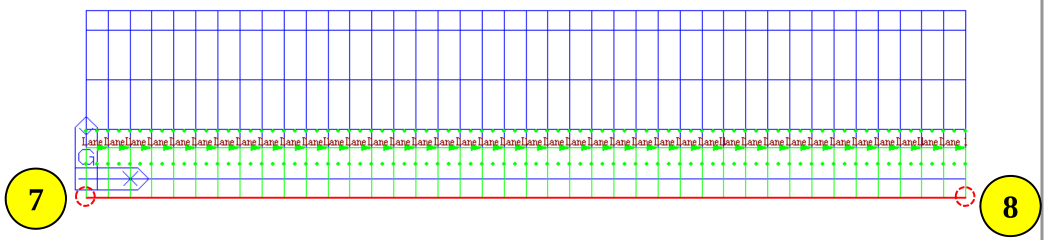
For detailed information of Vehicular Load Distribution, refer to the next page.

For the calculation of the eccentricity, refer to page 7 of this tutorial.

Cross Beam group comprises all the transverse elements.



1. *Load > Moving load analysis data > Traffic line lanes…*
2. *Lane Name: **Lane 1***
3. *Eccentricity : **-2.775 m***
4. *Vehicular Load Distribution : **Cross Beam***
5. *Cross Beam Group: **Cross Beam***
6. *Selection by : **2 Points***
7. *Click **(0,-1.05,0).***
8. *Click **(48,-1.05,0).***
9. *Click **[OK]** button.*

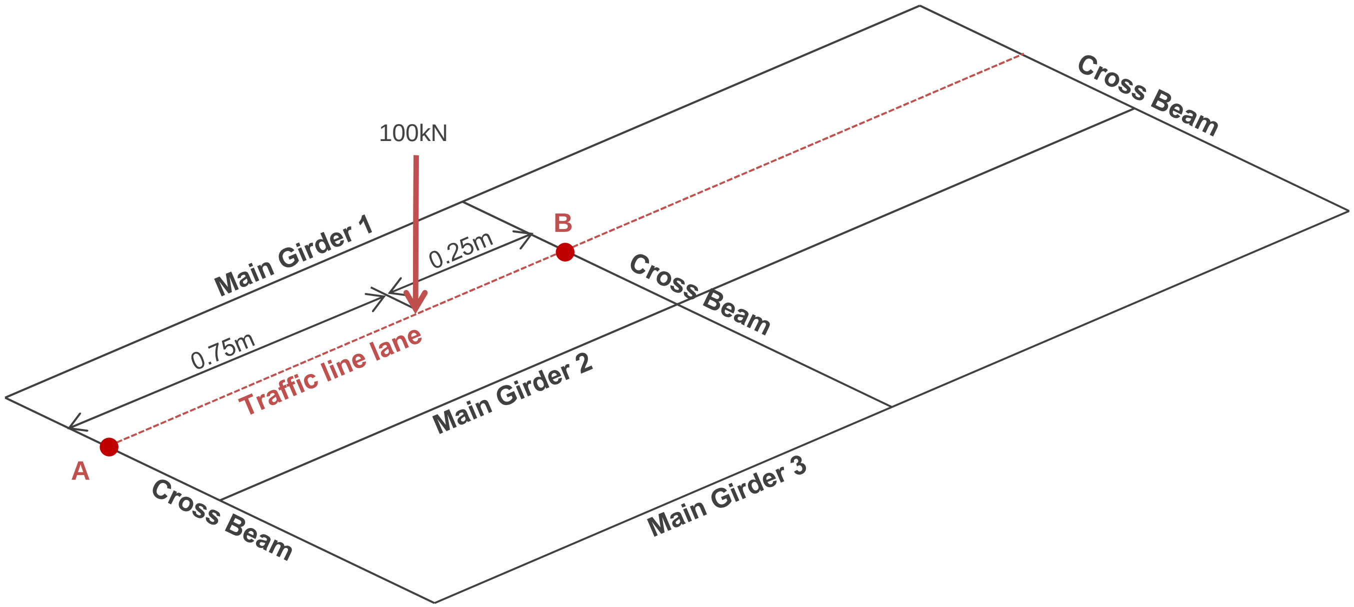


Tip 1. Vehicular load distribution

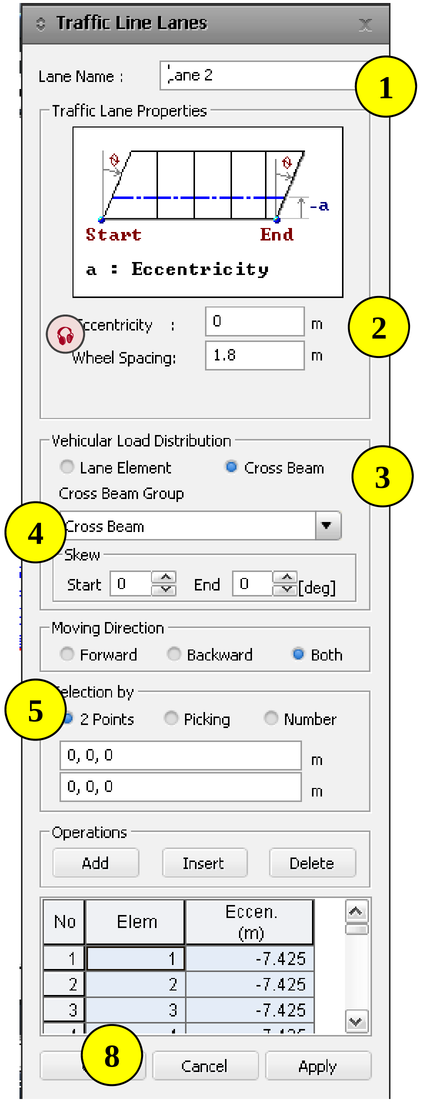
▯ **Lane element**: Apply loads to the traffic line lane elements reflecting the eccentricity.
When defining lanes by the lane element type, the vertical load components (vehicle loads) and the moments due to the eccentricity are assigned only to the line lane elements. Even though the lanes can be located on cross beam elements, if the lane element type is selected, then the distribution of the loads onto the cross beams will not be considered.

▯ **Cross beam**: Apply the traffic loads to the cross beams.
When using Cross Beam type, the eccentricity is used only for locating the lanes from the line lane elements. The vehicle loads are distributed to the girders via cross beam elements defined as a Cross Beam Group. If the user is modeling a bridge having multiple girders, the Cross Beam type is recommended for vehicular load distribution.

For example, an axle load of 100kN is located as shown below. Then, concentrated loads, 25kN and 75kN, are applied to point A and point B respectively. The cross beams themselves are loaded.

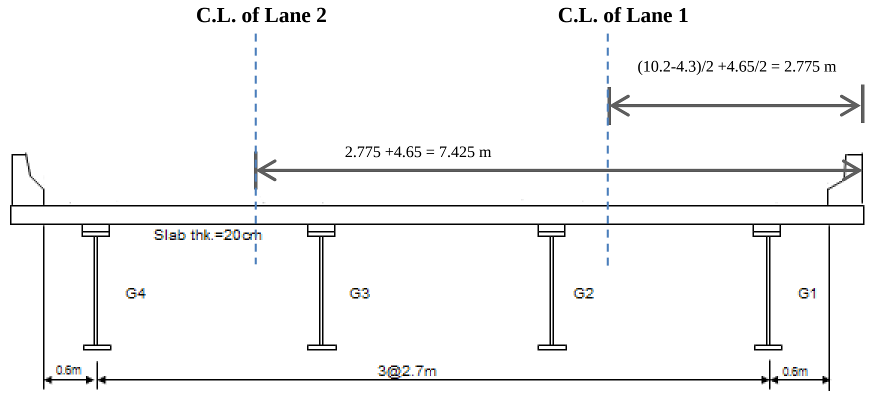


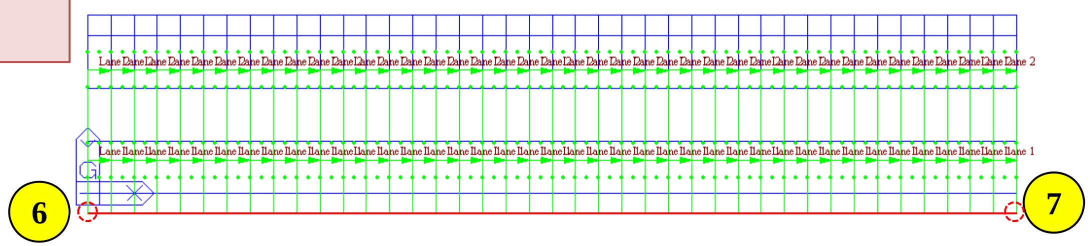
Step3-2. Define traffic line lane (Lane 2)



- Enter the eccentricity of a traffic line lane relative to a traffic line lane element. Traffic line lane elements are defined as the reference frame elements from which the eccentricity is measured.
- In this tutorial, the eccentricities are between the 2 Point Line (created in step 5) and the center-line of the lane .

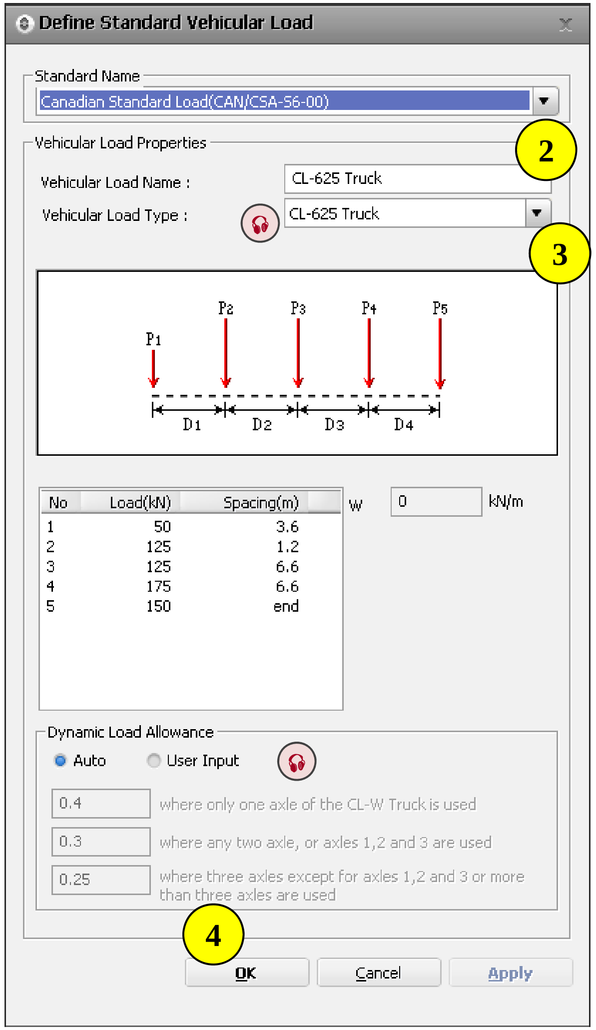
1. Lane Name: **Lane 2**
2. Eccentricity : **-7.425 m**
3. Vehicular Load Distribution : **Cross Beam**
4. Cross Beam Group: **Cross Beam**
5. Selection by : **2 Points**
6. Click **(0,-1.05,0).**
7. Click **(48,-1.05,0).**
8. Click **[OK]** button.





Step6. Define vehicular load

(Case 1. CL-625 Truck)



*1. **Load > Moving load analysis data > Vehicles…***

*2. Standard Name : **Canadian Standard Load***

*3. Vehicular Load Type : **CL-625 Truck***

*4. Click **[OK]** button.*

For Ontario , the program also provides CL-625-ONT loadings under the vehicle load type

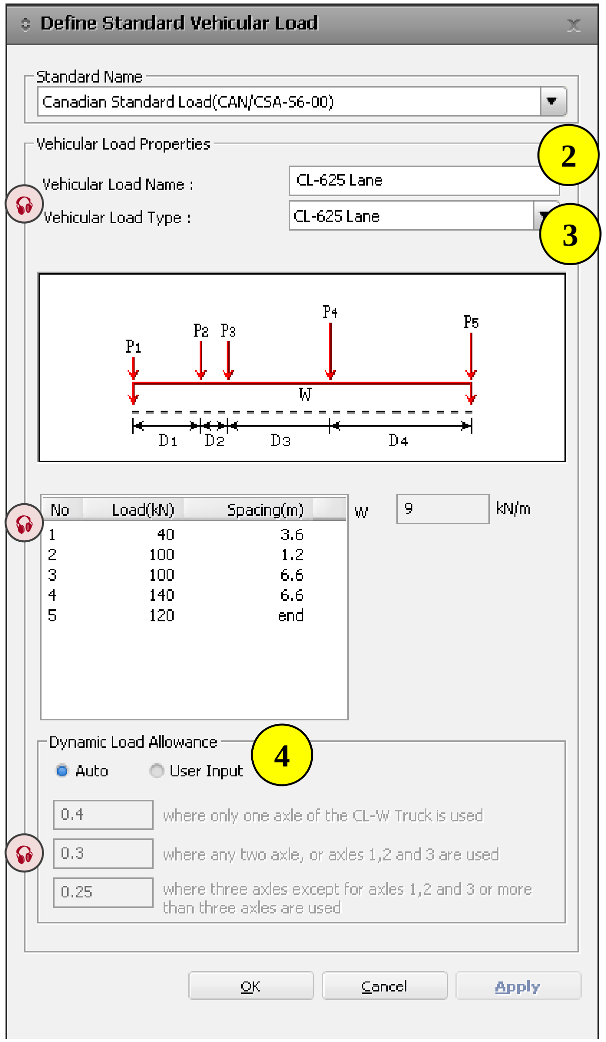
BCL-625 Truck and BCL-625 Lane are new additions to Civil 2013 (v1.1) as per BC Ministry of Transportation Supplement to the Canadian Highway Bridge Design Code

The user can directly change Dynamic Load Allowance via the user input option

The Static Effects Without Dynamic Load Allowance can be considered by entering 'zero' in the values fields after selecting user input

Step4. Define vehicular load

(Case 2. CL-625 Lane)



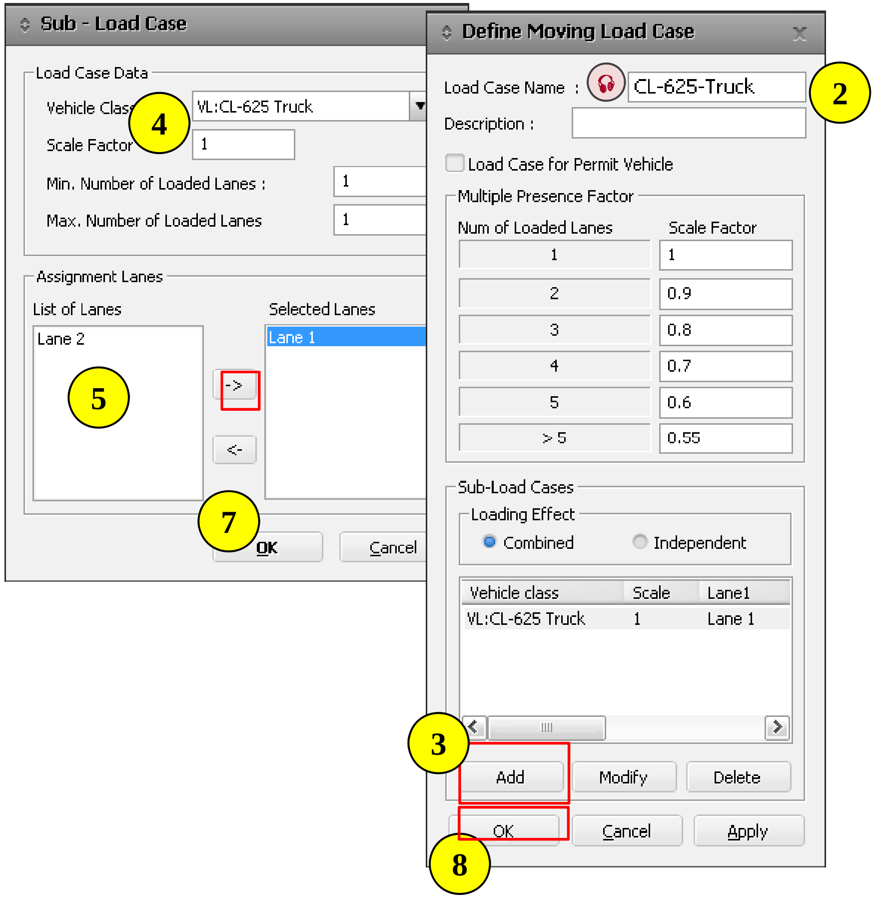
1. *Load > **Moving load analysis data > Vehicles…***
2. *Standard Name : **Canadian Standard Load***
3. *Vehicular Load Type : **CL-625 Lane***
4. *Click **[OK]** button.*

CL-625 Lane : The CL-W Lane Load consists of a CL-W Truck with each axle reduced to 80% of the value specified for CL-W Truck load ,superimposed within a uniformly distributed load of 9 kN/m, and 3.0 m wide

The user can directly change Dynamic Load Allowance via the user input option

Step5. Define moving load case

(Case 1. FLS Combination)

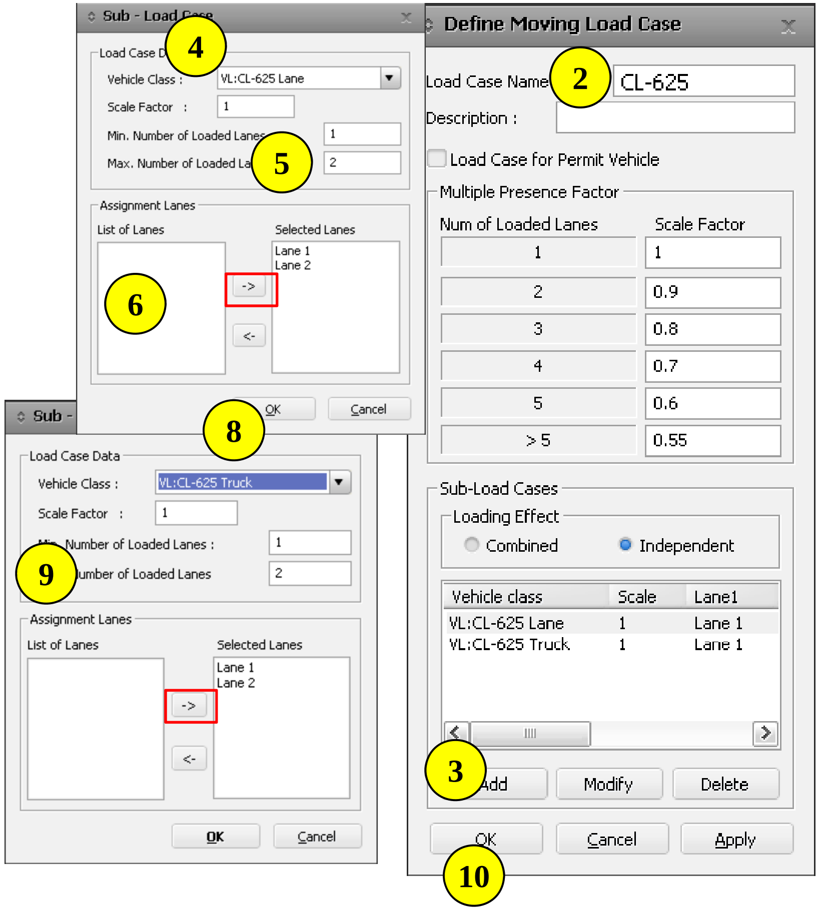


1. *Load > Moving load analysis data > Moving Load Cases…*
2. *Load Case Name :* ***CL-625 Truck***
3. *Click* **[Add]** *Button.*
4. *Vehicle : CL -625 Truck*
5. *Select* ***Lane 1***
6. *Click* ->
7. *Click* **[OK]** *button.*
8. *Click* **[OK]** *button .*

For the FLS and for SLS Combination 2, the traffic load shall be one truck only, placed at the center of one travelled lane. The lane load shall not be considered.

Step7. Define moving load case

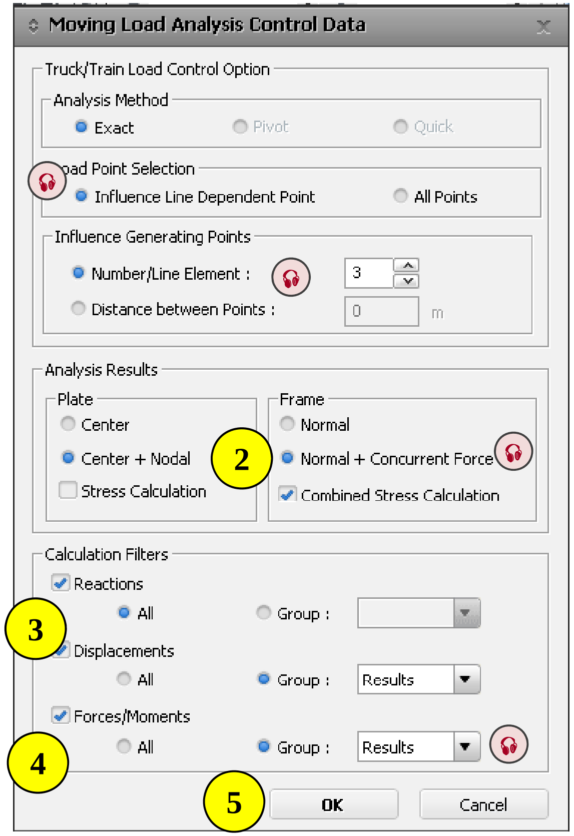
(Case 2. SLS Combination 1 / Ultimate Limit State)



1. **Load > Moving load analysis data > Moving Load Cases…**
2. Load Case Name : **CL-625**
3. Click **[Add]** button.
4. Vehicle Class : **VL-CL-625 Lane**
5. Max. Number of Loaded Lanes: **2**
6. Select **Lane 1** and **Lane 2**
7. Click ->
8. Click **[OK]** button.
9 . Repeat steps 5 to 9 with vehicle class **VL-CL-625 Truck**
10. Click **[OK]** button.

For SLS Combination 1 and for ultimate limit states, the traffic load shall be the truck load increased by the dynamic load allowance or the lane load, whichever produces the maximum load effect

Step10. Moving load analysis option



Influence Line Dependent point/All Points :
Refer next slide

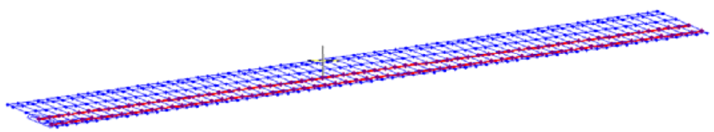
1. *Analysis Tab > Moving Load*
2. *Frame : **Normal + Concurrent Force***
3. *Displacements Group : **Results***
4. *Forces/Moments Group : **Results***
5. *Click **[OK]** button.*

***Number/Line Element :** Assign the number of reference points on a line element for moving loads and drawing influence line in an influence line analysis. The accuracy of results increases with increase in the number, but the analysis time may become excessive.*

***Normal + Concurrent Force :** If the output of concurrent forces for max and min values is required for moving load analysis, select 「Normal + Concurrent Force」.*

Select the specific group for which analysis results need to be checked in order to reduce analysis time.

[Structure Group: Results]



Tip 2. Influence Line Dependent Point / All Points (Refer fig. in last slide)

Influence Line Dependent Point

This is a method which controls the vehicular loads in a moving load analysis according to the influence values.

Maximum value(+): From the locations of the applied loads only the loads that result in positive influence values are used in the computation.
Minimum value(-): From the locations of the applied loads, only the loads that result in negative(-) influence values are used in the computation.

This method is used for general vehicular loading and yields results larger than that from the All Points method because the loads are controlled according to the influence values.

All Points

This is a method which analyzes the structure for applied vehicular loads in the moving load analysis at all locations without controlling the influence values.

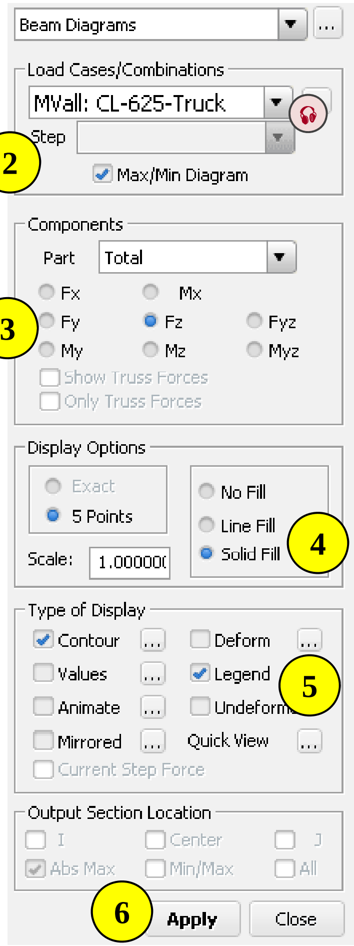
The method is used for train loading and yields results smaller than that from the Influence Dependent Point method because the loads are not controlled according to the influence values.

Step 11. Perform analysis

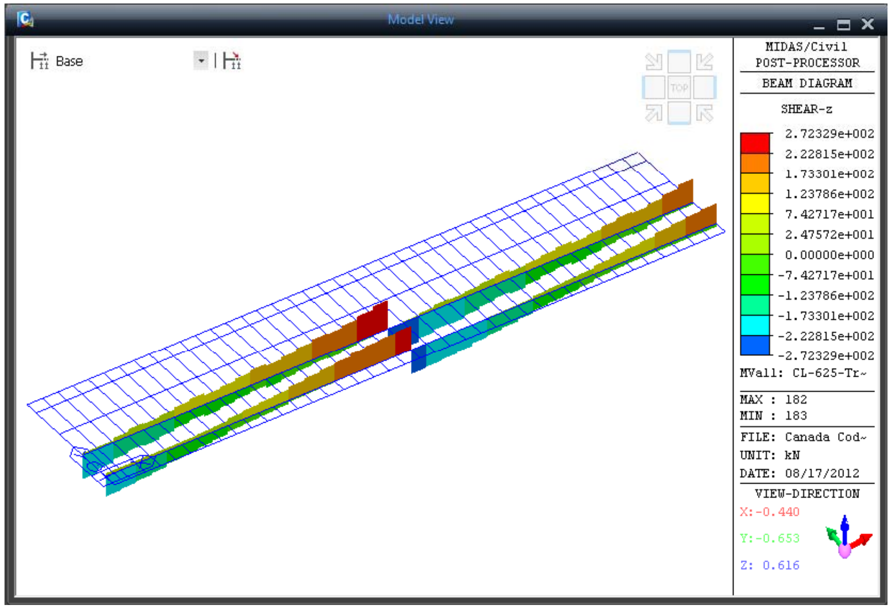
1. Click .

Step 12-1. Shear force diagrams

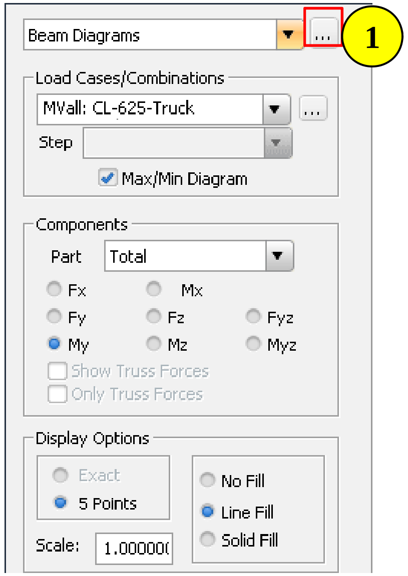
- ***MVmin** : The minimum force resulting from the vehicle load applied to the structure.*
- ***MVmax**: The maximum force resulting from the vehicle load applied to the structure.*
- ***MVall**: Both maximum and minimum force resulting from the vehicle load applied to the structure.*



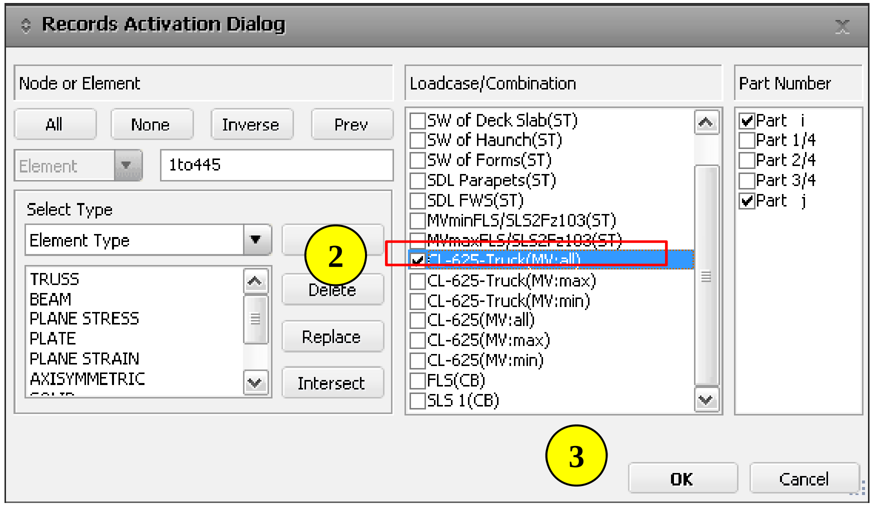
1. ***Results** > **Forces** > **Beam Diagrams…***
2. *Load Cases/Combinations : **Mvall:CL-625 Truck***
3. *Components : **Fz***
4. *Display Options : **Solid Fill***
5. *Check on **Legend**.*
6. *Click **[Apply]** button.*



Step 12-2. Shear force tables



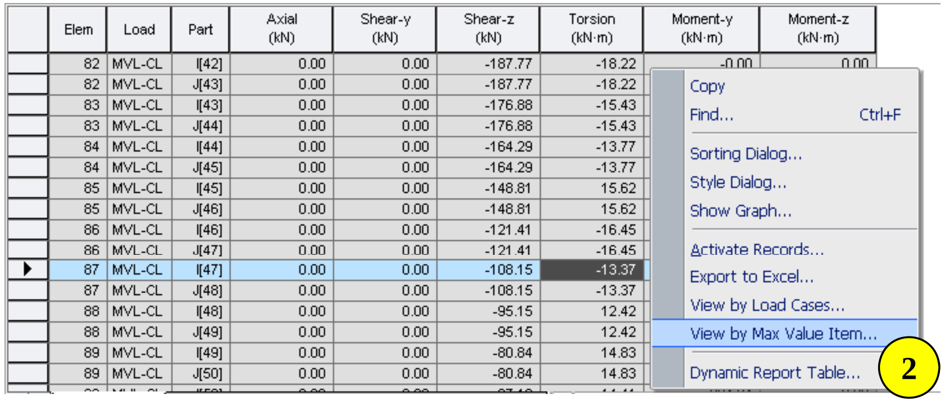
1. Click ... .
2. Check on ***CL-625-Truck (MV:all)*** .
3. Click **[OK]** button.



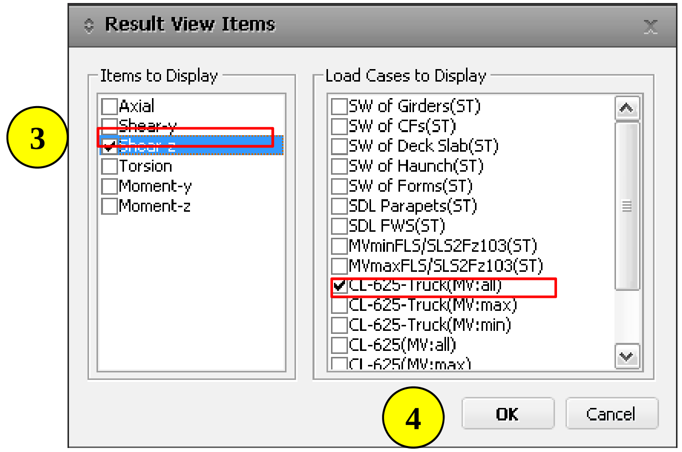
	Elem	Load	Part	Axial (kN)	Shear-y (kN)	Shear-z (kN)	Torsion (kN·m)	Moment-y (kN·m)	Moment-z (kN·m)
	82	CL-625-	I[42]	0.00	0.00	-187.77	-15.74	-0.00	0.00
	82	CL-625-	J[43]	0.00	0.00	-187.77	-15.74	225.33	0.00
	83	CL-625-	I[43]	0.00	0.00	-176.88	-12.63	222.32	0.00
	83	CL-625-	J[44]	0.00	0.00	-176.88	-12.63	419.98	0.00
	84	CL-625-	I[44]	0.00	0.00	-164.29	12.83	416.69	0.00
	84	CL-625-	J[45]	0.00	0.00	-164.29	12.83	584.54	0.00
	85	CL-625-	I[45]	0.00	0.00	-148.81	15.62	581.19	0.00
	85	CL-625-	J[46]	0.00	0.00	-148.81	15.62	736.92	0.00
	86	CL-625-	I[46]	0.00	0.00	-121.41	-14.87	736.92	0.00
	86	CL-625-	J[47]	0.00	0.00	-121.41	-14.87	838.41	0.00
	87	CL-625-	I[47]	0.00	0.00	-108.15	-12.00	835.64	0.00
	87	CL-625-	J[48]	0.00	0.00	-108.15	-12.00	909.85	0.00
	88	CL-625-	I[48]	0.00	0.00	-95.15	12.42	907.46	0.00
	88	CL-625-	J[49]	0.00	0.00	-95.15	12.42	954.47	0.00
	89	CL-625-	I[49]	0.00	0.00	-80.84	14.83	952.66	0.00
	89	CL-625-	J[50]	0.00	0.00	-80.84	14.83	964.84	0.00
	90	CL-625-	I[50]	0.00	0.00	67.16	-14.41	964.84	0.00
	90	CL-625-	J[51]	0.00	0.00	67.16	-14.41	925.18	0.00
	91	CL-625-	I[51]	0.00	0.00	80.93	-11.92	924.85	0.00

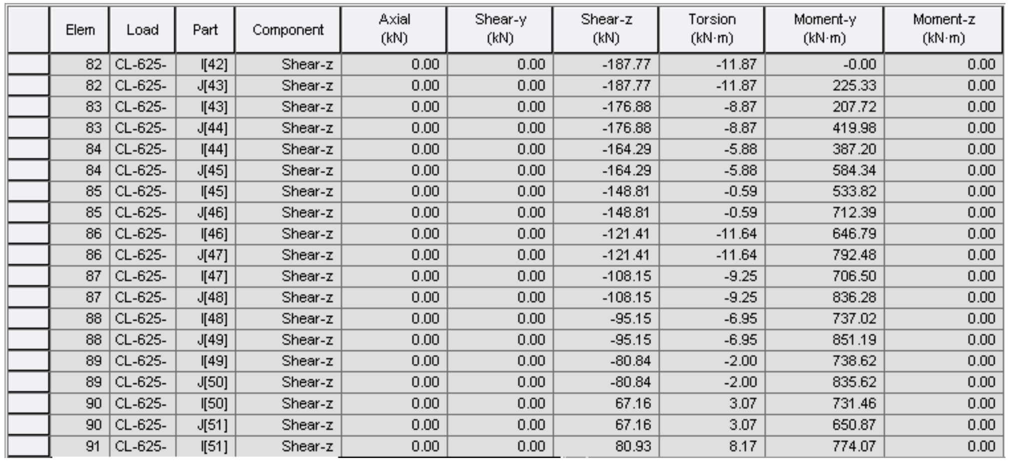
Step 12-3. Shear force tables (Concurrent forces)

1. *Right-click on the Beam Force table.*
2. *Select* ***View by Max Value Item…***
3. *Check on* ***Shear-z****.*
4. *Click* ***[OK]*** *button.*



	Elem	Load	Part	Axial (kN)	Shear-y (kN)	Shear-z (kN)	Torsion (kN·m)	Moment-y (kN·m)	Moment-z (kN·m)
	82	MVL-CL	I[42]	0.00	0.00	-187.77	-18.22	-0.00	0.00
	82	MVL-CL	J[43]	0.00	0.00	-187.77	-18.22		
	83	MVL-CL	I[43]	0.00	0.00	-176.88	-15.43		
	83	MVL-CL	J[44]	0.00	0.00	-176.88	-15.43		
	84	MVL-CL	I[44]	0.00	0.00	-164.29	-13.77		
	84	MVL-CL	J[45]	0.00	0.00	-164.29	-13.77		
	85	MVL-CL	I[45]	0.00	0.00	-148.81	15.62		
	85	MVL-CL	J[46]	0.00	0.00	-148.81	15.62		
	86	MVL-CL	I[46]	0.00	0.00	-121.41	-16.45		
	86	MVL-CL	J[47]	0.00	0.00	-121.41	-16.45		
▶	87	MVL-CL	I[47]	0.00	0.00	-108.15	-13.37		
	87	MVL-CL	J[48]	0.00	0.00	-108.15	-13.37		
	88	MVL-CL	I[48]	0.00	0.00	-95.15	12.42		
	88	MVL-CL	J[49]	0.00	0.00	-95.15	12.42		
	89	MVL-CL	I[49]	0.00	0.00	-80.84	14.83		
	89	MVL-CL	J[50]	0.00	0.00	-80.84	14.83		

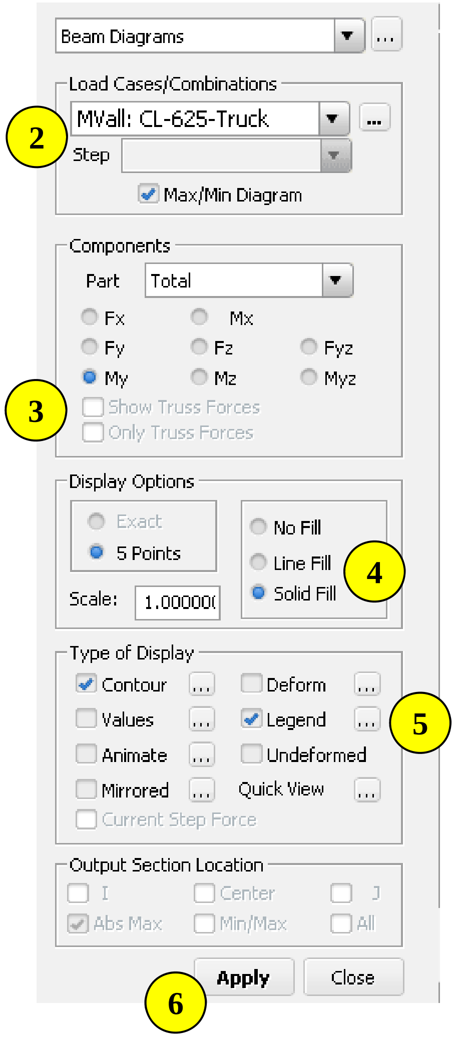




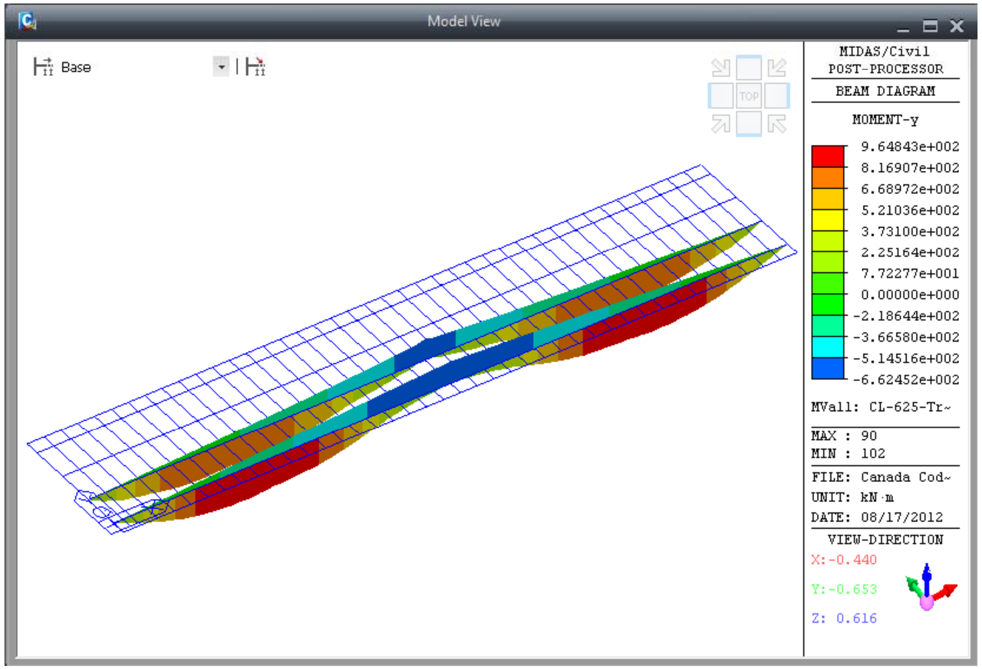
	Elem	Load	Part	Component	Axial (kN)	Shear-y (kN)	Shear-z (kN)	Torsion (kN·m)	Moment-y (kN·m)	Moment-z (kN·m)
	82	CL-625-	I[42]	Shear-z	0.00	0.00	-187.77	-11.87	-0.00	0.00
	82	CL-625-	J[43]	Shear-z	0.00	0.00	-187.77	-11.87	225.33	0.00
	83	CL-625-	I[43]	Shear-z	0.00	0.00	-176.88	-8.87	207.72	0.00
	83	CL-625-	J[44]	Shear-z	0.00	0.00	-176.88	-8.87	419.98	0.00
	84	CL-625-	I[44]	Shear-z	0.00	0.00	-164.29	-5.88	387.20	0.00
	84	CL-625-	J[45]	Shear-z	0.00	0.00	-164.29	-5.88	584.34	0.00
	85	CL-625-	I[45]	Shear-z	0.00	0.00	-148.81	-0.59	533.82	0.00
	85	CL-625-	J[46]	Shear-z	0.00	0.00	-148.81	-0.59	712.39	0.00
	86	CL-625-	I[46]	Shear-z	0.00	0.00	-121.41	-11.64	646.79	0.00
	86	CL-625-	J[47]	Shear-z	0.00	0.00	-121.41	-11.64	792.48	0.00
	87	CL-625-	I[47]	Shear-z	0.00	0.00	-108.15	-9.25	706.50	0.00
	87	CL-625-	J[48]	Shear-z	0.00	0.00	-108.15	-9.25	836.28	0.00
	88	CL-625-	I[48]	Shear-z	0.00	0.00	-95.15	-6.95	737.02	0.00
	88	CL-625-	J[49]	Shear-z	0.00	0.00	-95.15	-6.95	851.19	0.00
	89	CL-625-	I[49]	Shear-z	0.00	0.00	-80.84	-2.00	738.62	0.00
	89	CL-625-	J[50]	Shear-z	0.00	0.00	-80.84	-2.00	835.62	0.00
	90	CL-625-	I[50]	Shear-z	0.00	0.00	67.16	3.07	731.46	0.00
	90	CL-625-	J[51]	Shear-z	0.00	0.00	67.16	3.07	650.87	0.00
	91	CL-625-	I[51]	Shear-z	0.00	0.00	80.93	8.17	774.07	0.00

Calculate the corresponding member forces under the conditions where the maximum and minimum member forces occur at each position.

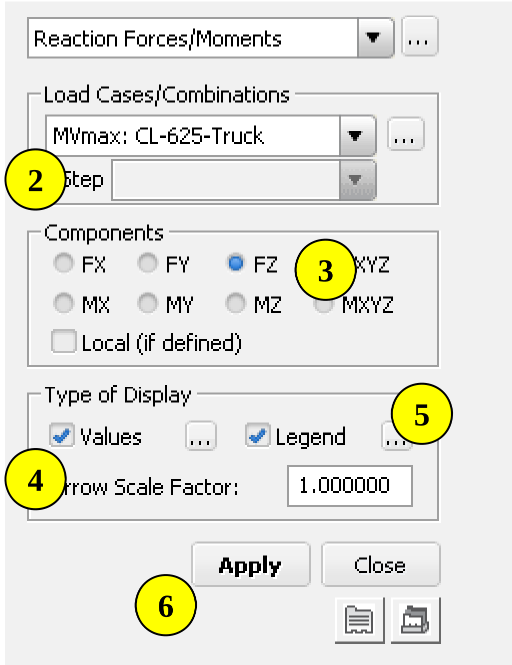
Step 13. Bending moment diagrams



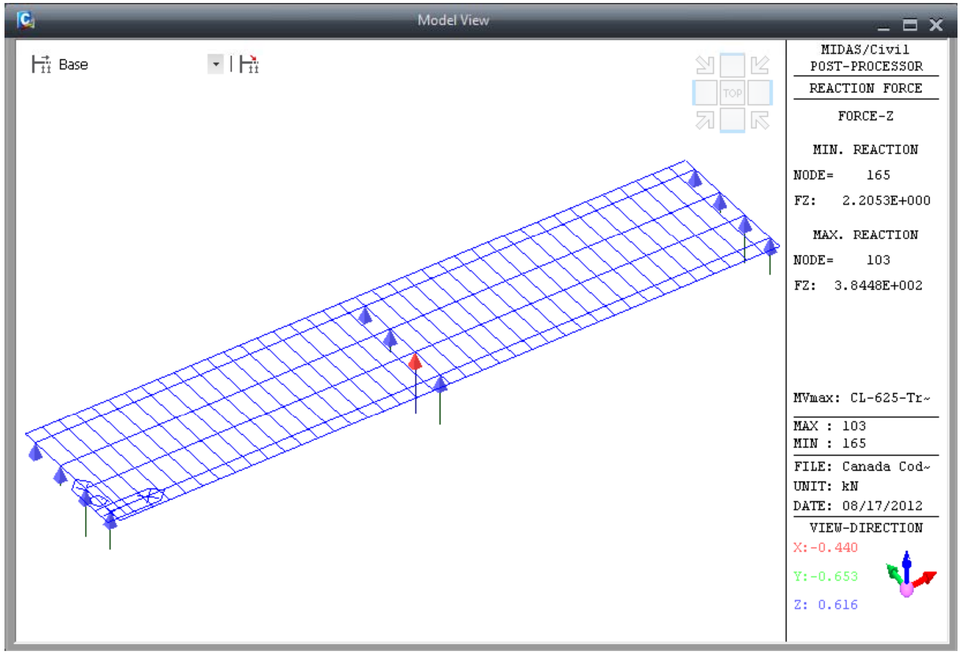
1. ***Results > Forces > Beam Diagrams…***
2. *Load Cases/Combinations :* ***MVall: CL-625-Truck***
3. *Components :* ***My***
4. *Display Options :* ***Solid Fill***
5. *Check on* ***Legend****.*
6. *Click* **[Apply]** *button.*



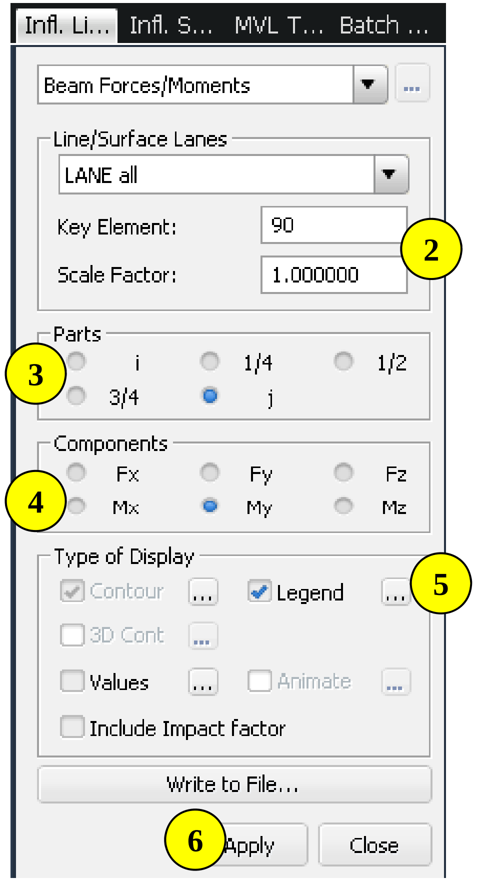
Step 14. Reactions



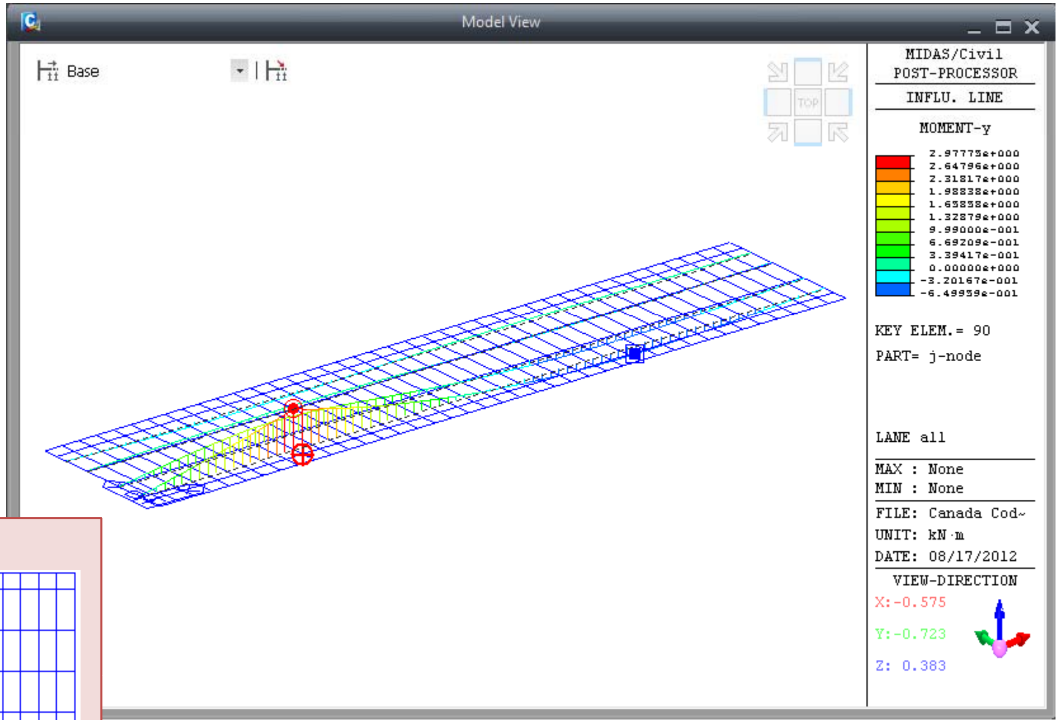
1. ***Results > Reactions > Reaction Forces /Moments…***
2. *Load Cases/Combinations :* ***MVmax: CL-625-Truck***
3. *Components :* ***Fz***
4. *Check on* ***Values****.*
5. *Check on* ***Legend****.*
6. *Click* **[Apply]** *button.*



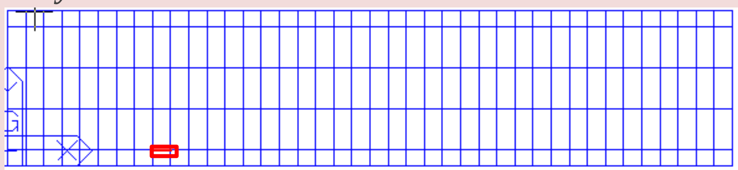
Step 15. Influence lines



1. **Results > Influence Lines > Beam Forces/Moments…**
2. Key Element: **90**
3. Parts: ***j***
4. Components: ***My***
5. Check on ***Legend***
6. Click **[Apply]** button.



Key Element: 195

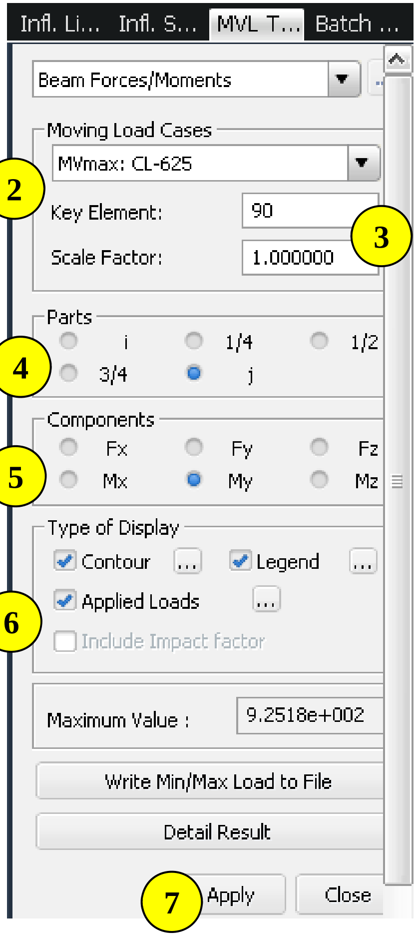


i-end *j-end*

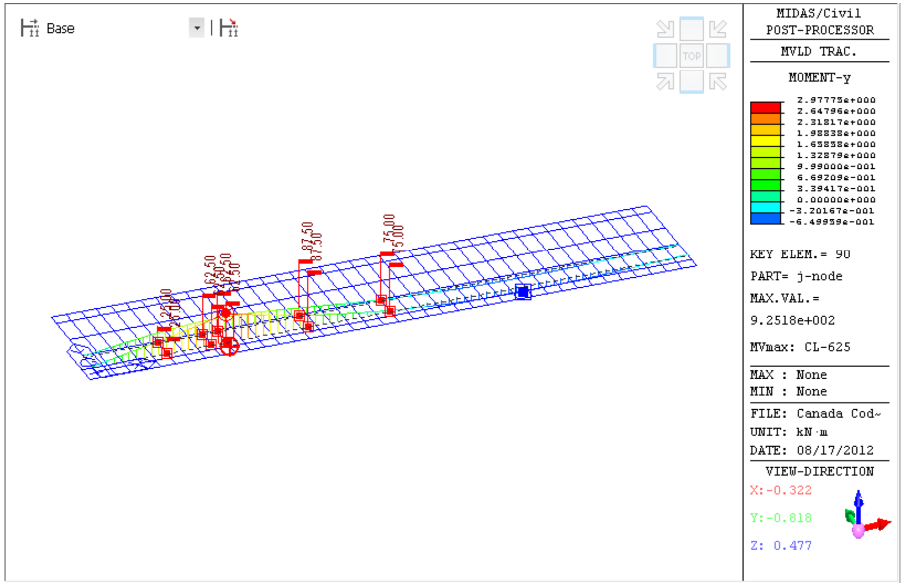
Step 16-1. Moving load tracer

Display moving load location that results in the minimum moment at the j-end of the element no. 90 due to the "CL-625" load case.

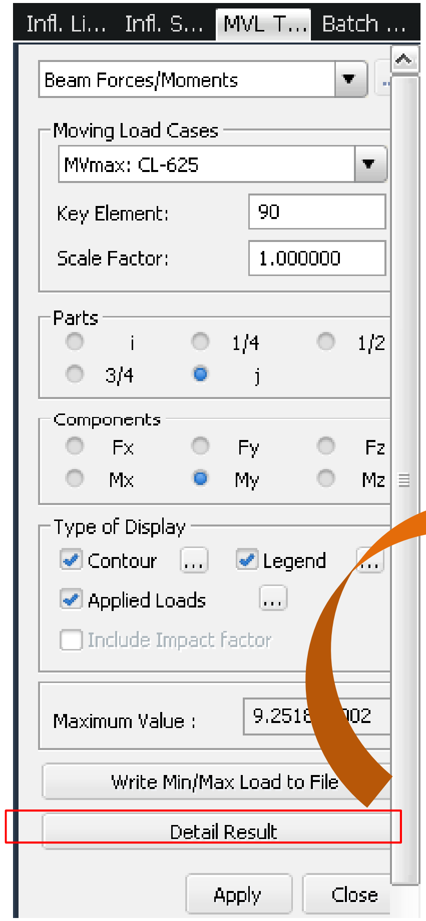
- ***Trace and graphically display the vehicle loading condition (corresponding moving load case and location) that results in the maximum/ minimum force of a beam element. The loading condition is converted into a static loading and produced as a model file of the MCT type by clicking [Write Min/Max Load to File] button.***



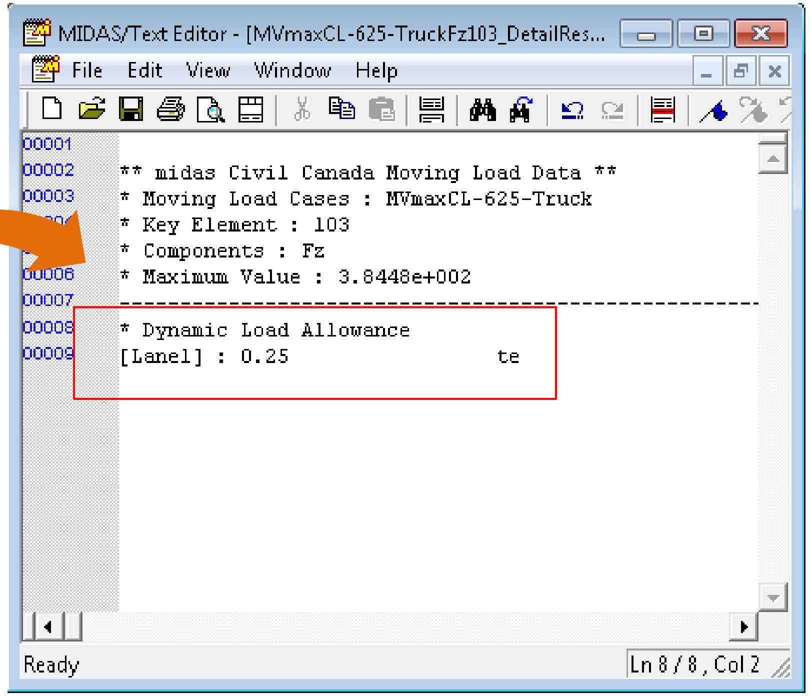
1. ***Results > Moving Load Tracer > Beam Forces/Moments…***
2. *Moving Load Cases: **MVmin: CL-625***
3. *Key Element: **90***
4. *Select **j** end*
5. *Components: **My***
6. *Check on **Contour, Legend** and **Applied Loads.***
7. *Click **[Apply]** button.*



Tip 3. Checking dynamic load allowance in post processing



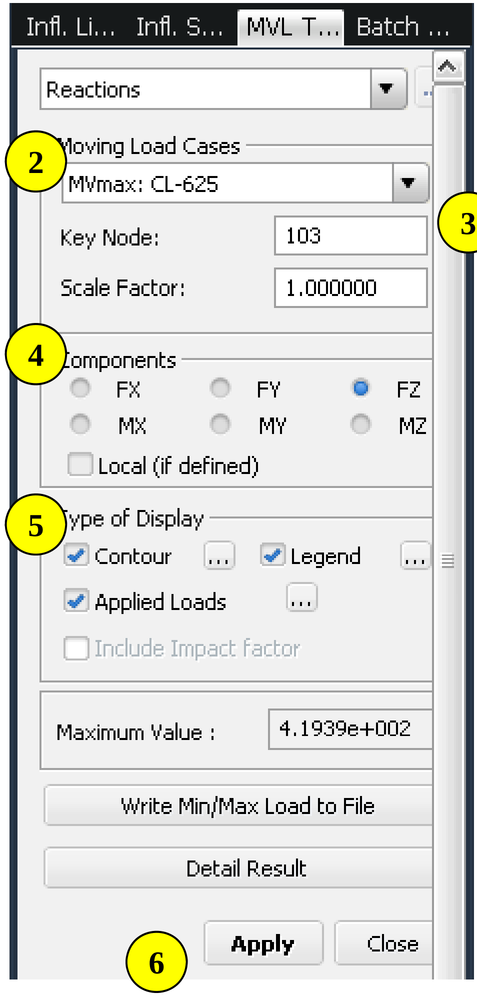
In midas Civil , one can easily confirm the value of the dynamic load allowance used by clicking on the ***Detail Result*** *button . This generates a text file as shown in the figure .*

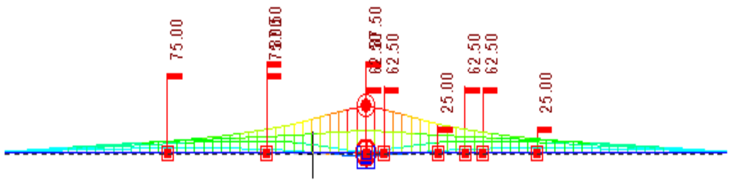


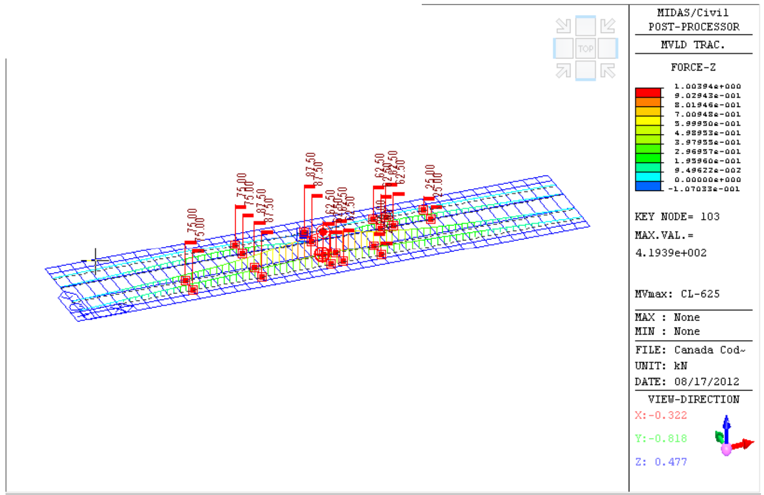
Step 16-2. Moving load tracer

Display moving load location that results in the maximum Reaction at the mid support - say at element no. 103 due to the "CL-625" load case.

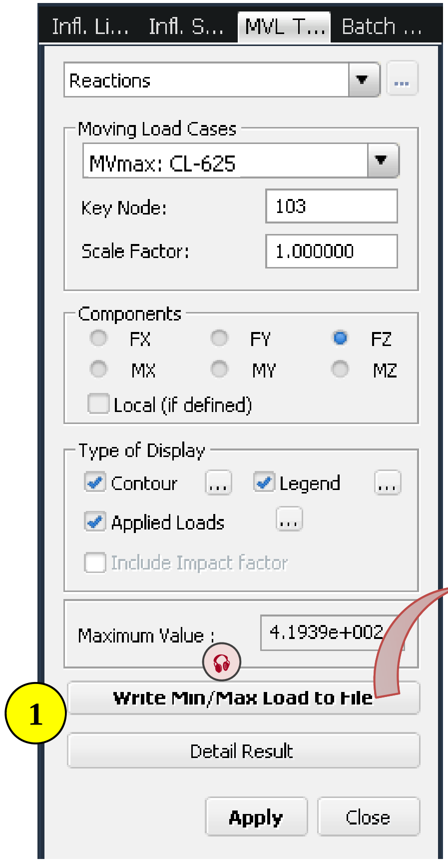
1. **Results > Moving Load Tracer > Reactions**
2. Moving Load Cases: **Mvmax : CL-625**
3. Key Element: **103**
4. Components: **Fz**
5. Check on **Contour, Legend** and **Applied Loads.**
6. Click **[Apply]** button.



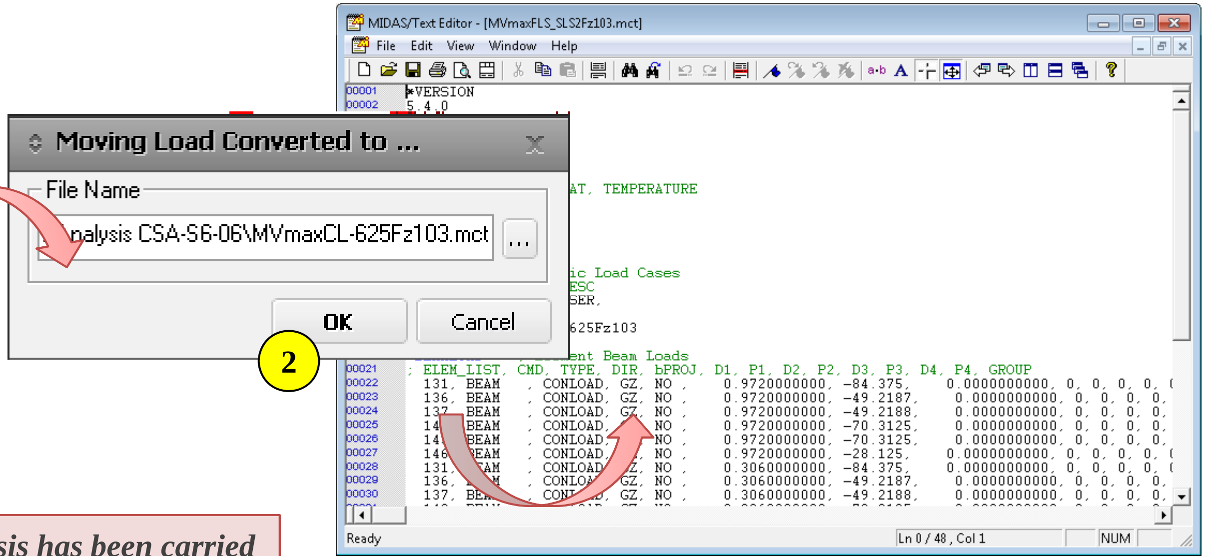




Step 17-1. Converting the moving load into a static load

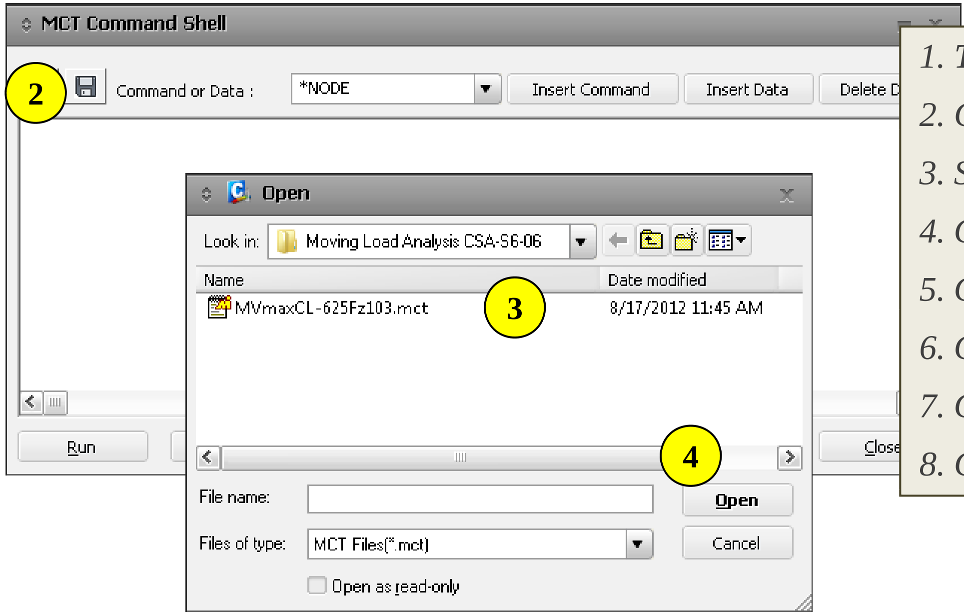


1. Click **[Write Min/Max Load to File]** button.
2. Click **[OK]** button.
3. Select ***File>Exit*** in the ***MIDAS/Text Editor***.

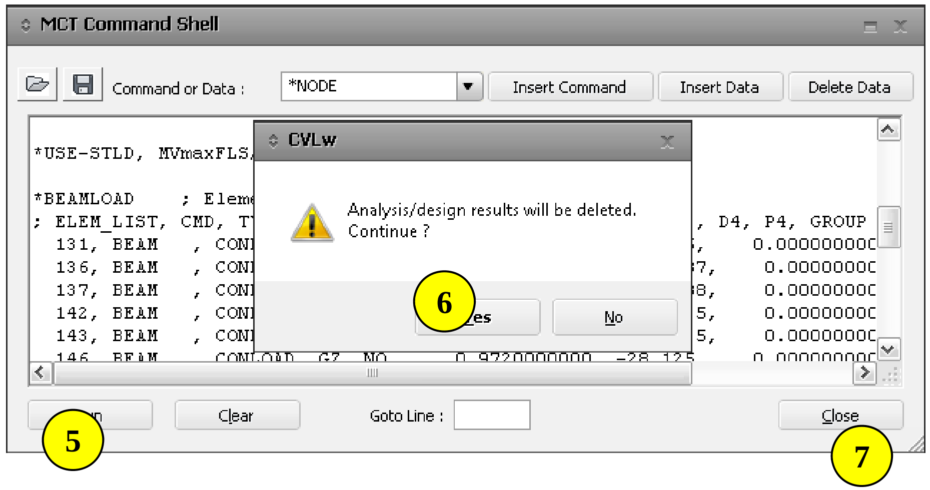


Where moving load analysis has been carried out, the moving load case, which produces the maximum or minimum results, is converted into a static loading and produced as the MCT type.

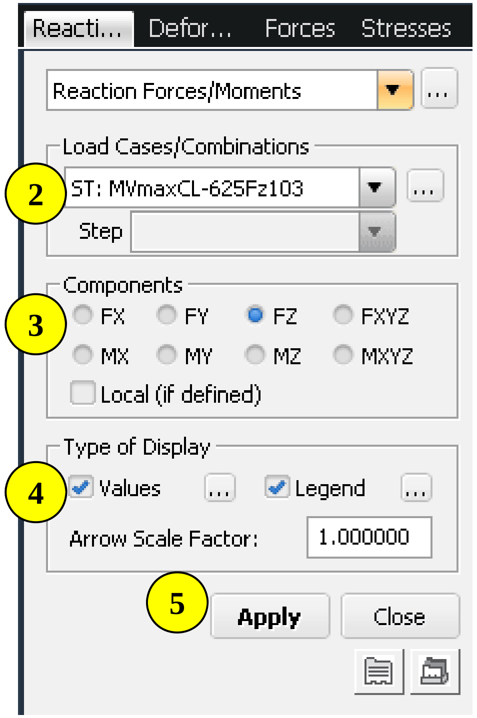
Step 17-2. Converting the moving load into a static load



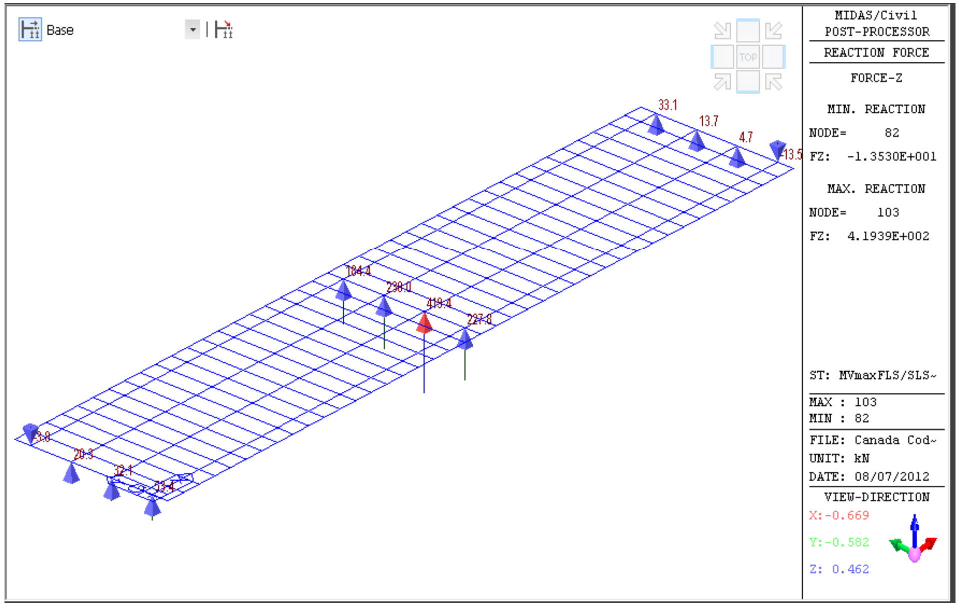
1. *Tools>MCT Command Shell*
2. *Click* .
3. *Select the file name* ***"MVmaxCL-625Fz103.mct".***
4. *Click* **[Open]** *button.*
5. *Click* **[Run]** *button.*
6. *Click* **[Yes]** *button.*
7. *Click* **[Close]** *button.*
8. *Click* .



Step 18-1. Check beam reactions due to the converted static load

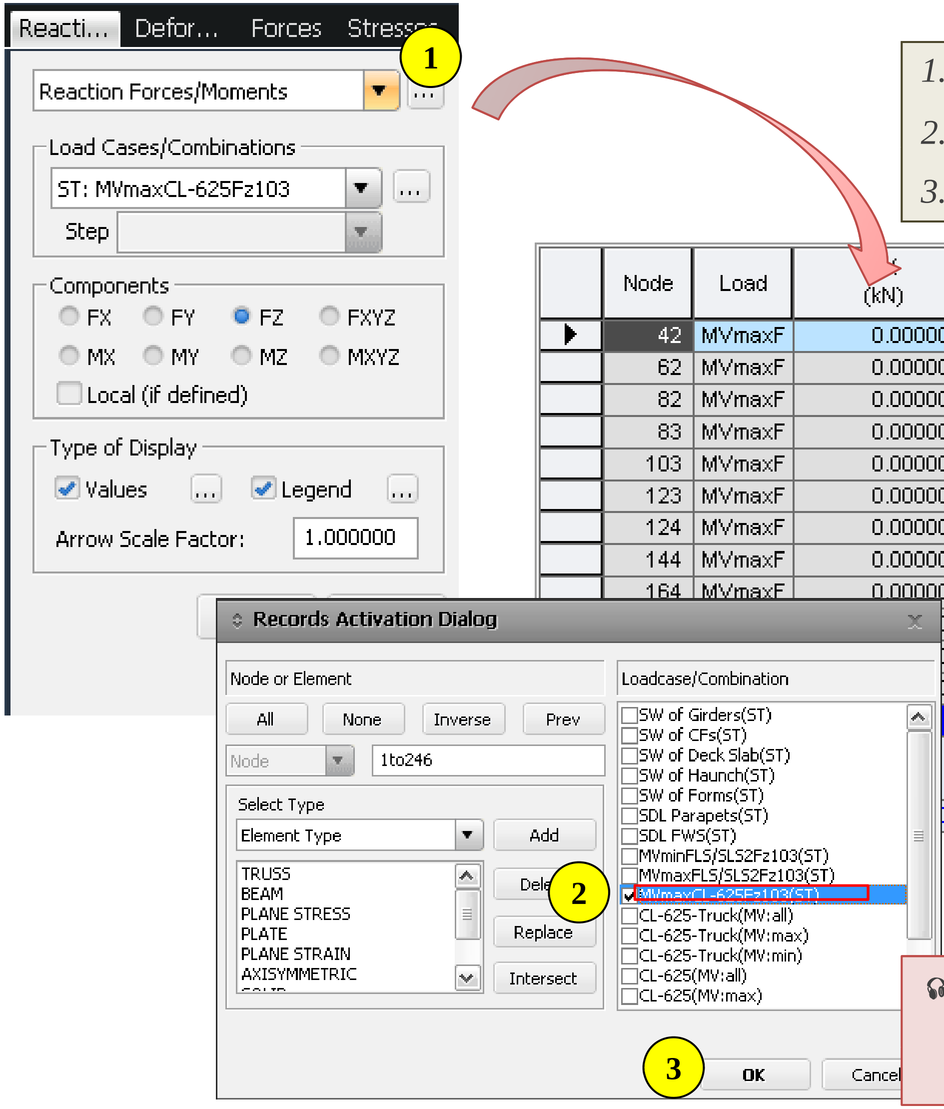


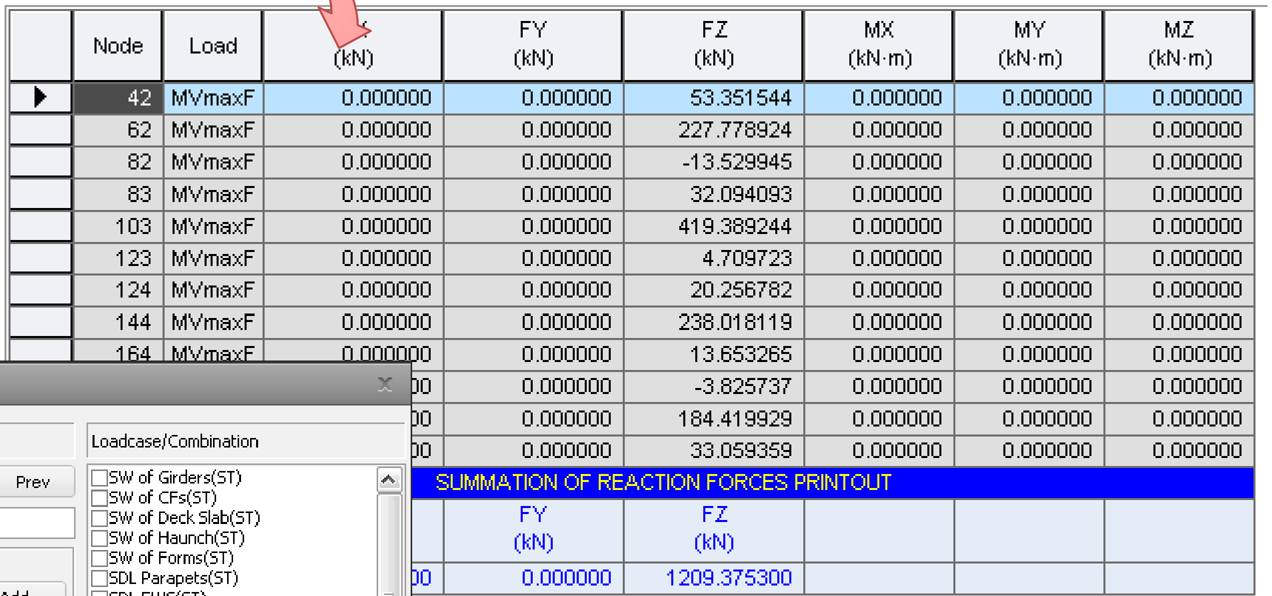
1. ***Results>Reactions>Reaction Forces/Moments…***
2. *Load Cases/Combinations:* ***ST:MVmaxCL-625Fz103***
3. *Components:* ***Fz***
4. *Check on* ***Values*** *and* ***Legend****.*
5. *Click* **[Apply]** *button.*



Step 18-2. Check reaction table due to the static load

1. Click [...] .
2. Check on MVmaxCL-625Fz103**(ST)**.
3. Click **[OK]** button.





Node	Load	FX (kN)	FY (kN)	FZ (kN)	MX (kN·m)	MY (kN·m)	MZ (kN·m)
42	MVmaxF	0.000000	0.000000	53.351544	0.000000	0.000000	0.000000
62	MVmaxF	0.000000	0.000000	227.778924	0.000000	0.000000	0.000000
82	MVmaxF	0.000000	0.000000	-13.529945	0.000000	0.000000	0.000000
83	MVmaxF	0.000000	0.000000	32.094093	0.000000	0.000000	0.000000
103	MVmaxF	0.000000	0.000000	419.389244	0.000000	0.000000	0.000000
123	MVmaxF	0.000000	0.000000	4.709723	0.000000	0.000000	0.000000
124	MVmaxF	0.000000	0.000000	20.256782	0.000000	0.000000	0.000000
144	MVmaxF	0.000000	0.000000	238.018119	0.000000	0.000000	0.000000
164	MVmaxF	0.000000	0.000000	13.653265	0.000000	0.000000	0.000000
		00	0.000000	-3.825737	0.000000	0.000000	0.000000
		00	0.000000	184.419929	0.000000	0.000000	0.000000
		00	0.000000	33.059359	0.000000	0.000000	0.000000
SUMMATION OF REACTION FORCES PRINTOUT							
			FY (kN)	FZ (kN)			
		00	0.000000	1209.375300			

Reaction table due to static load case 'MVmaxCL−625Fz103**' displays the concurrent reactions due to the moving load case 'CL-625' when the reaction of the node no. 103 is maximum.**