Modeling and Analysis of a RC Arch Bridge with MIDAS CIVIL NX

CVL API

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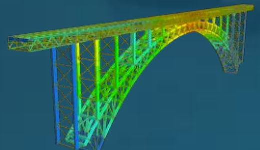

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Contents Overview

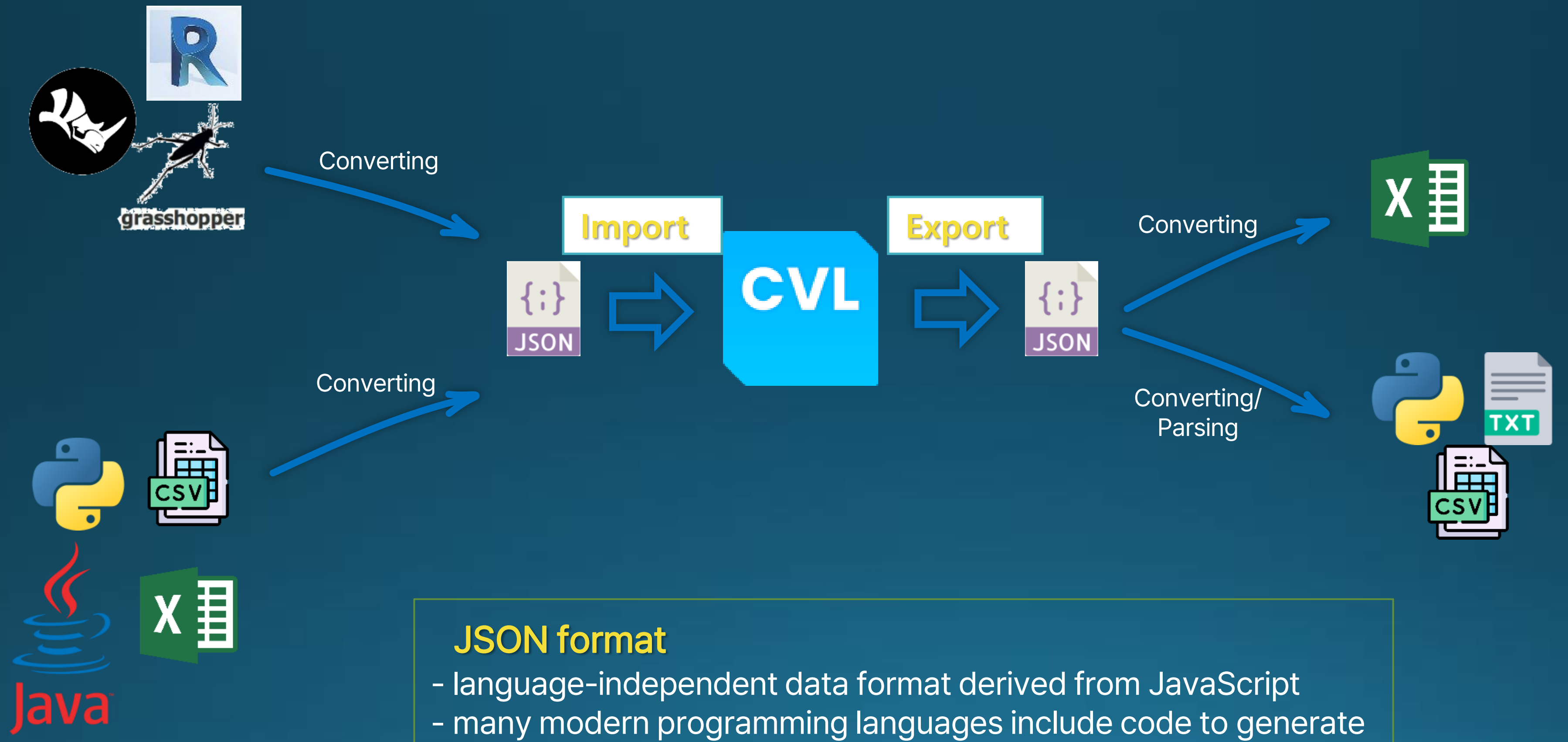
Contents

Key enhancements in Civil NX

- **API Integration** available in Civil NX leading to more advanced automation capabilities
- **Interoperability** through dedicated links between Civil NX and external software and coding platforms (MS Excel, Grasshopper, BIM, Python,…)
- Marketplace of special **Plug-ins** developed by Midas (and open source)
- **Improved UI** implementing latest graphic engine and better overall usability
- **Faster Post-processing** performance (much quicker generation of analysis results and reports)
- **Further software development** dedicated to EU users (NA progressive implementation, upgraded faster top-performing solver,…)

Key enhancements in Civil NX

The concept of Data Transferring using API

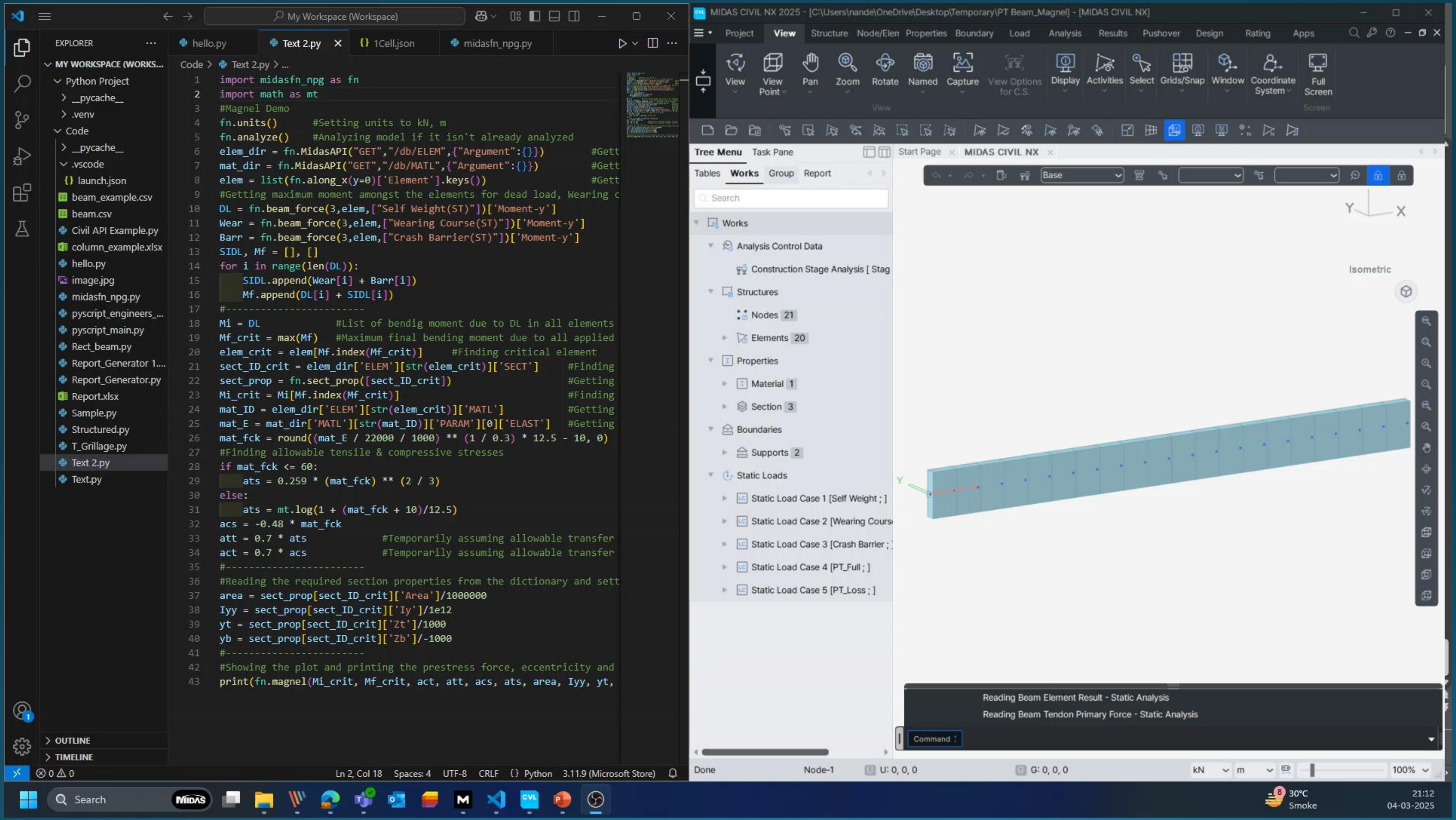


JSON format

- language-independent data format derived from JavaScript
- many modern programming languages include code to generate and parse JSON-format data

New Capabilities of Civil NX

API Integration EXAMPLE ⟶ Python Template – Magnel Diagram for Prestress Beam



RC Arch Bridges – Typologies

Primarily 3 types of existing concrete arch bridges

- ❑ **Filled (solid) spandrel wall arches**
  - **Arch rib supports the roadway on earth fill that is contained between the spandrel walls. Roadbed is placed directly on the fill.**
- ❑ **Open spandrel arches**
  - **Instead of solid spandrel walls, has columns resting on the arch ring that support floor beams, which in turn carry the roadway .**

- ❑ **Through arch (rainbow)**
  - **Consists of two arch ribs that extend well above the roadway on each side of the bridge. The roadway passes between the arch ribs. Vertical columns are attached to the underside of the arch ribs at regular spaces. The verticals hold up transverse floor beams which in turn support the deck slab.**

Source: *Ohio Department of Transportation,* Arch Bridges, https://www.transportation.ohio.gov/working/engineering/structural/bmm/arch-bridges

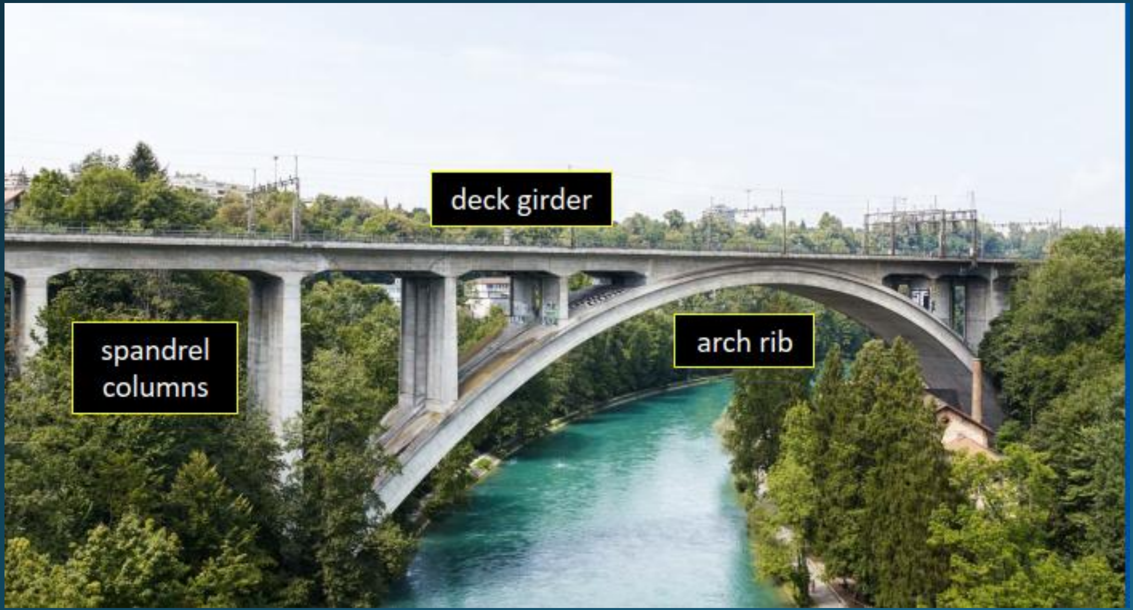
Source: *ETH Zürich,* Bridge Design Lectures , https://concrete.ethz.ch/assets/arch-bridges-2023-04-11.pdf

Source: Rainbow Bridge over Brush Creek, Kansas (USA), 1923, https://en.wikipedia.org/wiki/Rainbow_Bridge_%28Kansas%29

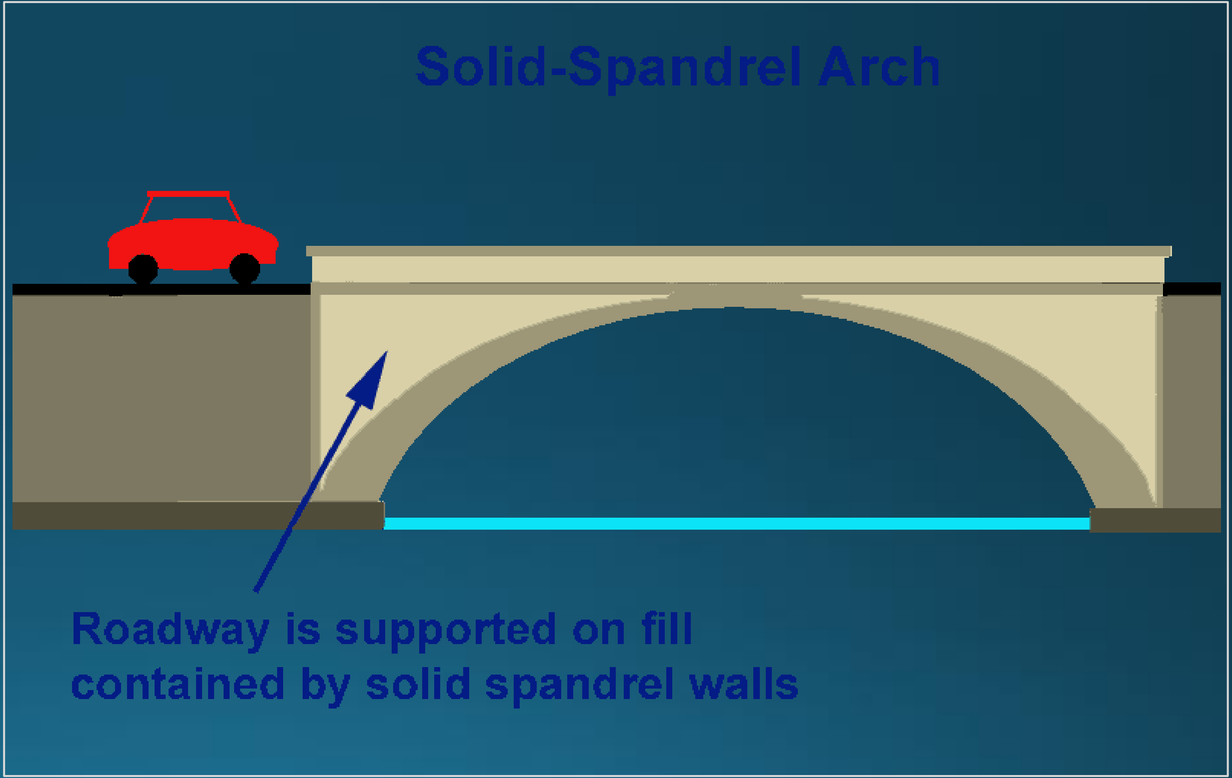
RC Deck Arch Bridges - Characteristics

Deck Arch Bridges: OPEN or SOLID-SPANDREL Arch

- **Deck arch bridge → deck above arch.**
- **The spandrel is the area between the arch ring and the roadway.**
- **Full arch thrust transferred to arch abutments and soil (most efficient arch typology if soil is stiff)**



Source: *ETH Zürich,* Bridge Design Lectures , https://concrete.ethz.ch/assets/arch-bridges-2023-04-11.pdf



Source: *Connecticut Department of Transportation,* https://legacy.ahs-inc.com/open-spandrel/comparison.html

RC Deck Arch Bridges – Characteristics

Advantages

- ✓ Very efficient structures in the final configuration
- ✓ Concrete perfectly suited for arch bridges with its high compressive strength and used to replace (and imitate) the behavior of masonry arches .
- ✓ Steel reinforcement expensive but the overall cost of a concrete arch bridge was generally less than a stone masonry bridge or a metal truss.
- ✓ Long and high arches used to bridge even the widest and steepest river valleys (in particular open-spandrel arches).
- ✓ Often the largest bridge projects of their era.
- ✓ Aesthetics: archs look spectacular.

Disadvantages

- ○ Entrapment of moisture in the fill, deterioration of concrete, walls leaning outward, high dead weight → solid spandrel arch
- ○ Open-spandrel arches save material but more complicated and expensive to design and build → high erection costs and tailor-made formwork and falsework needed

Source: *ETH Zürich*, Bridge Design Lectures , https://concrete.ethz.ch/assets/arch-bridges-2023-04-11.pdf

RC Deck Arch Bridges – Design Considerations

- Were popular since the early 1920s when RC become a standard bridge-building material around 1910.
- With progress of more economical typologies (girder, cable-stayed) RC arch bridges were basically abandoned in the 2nd half of the 20th century.
- Even for very large spans, and using normal strength concrete, concrete is by far the most economical material in the final configuration of the arch due to its low cost and high compressive strength. So why?

HOWEVER

→ Falsework and formwork for long-span arches are very expensive so **concrete arches are economical only for short spans (< 100m)** with conventional scaffold. However for short spans the **girder bridges are more economical** (cost of arch is not compensated by savings in the deck girder for open-spandrel).

→ **For medium/large spans** in absence of efficient arch construction methods, also **steel arches are thus more economical** compared with the concrete ones.

→ **For long spans (> 300m), cable-stayed bridges are more economical** due to the efficient erection method.

→ Longer spans may be **economical if an optimised erection method is used** (e.g. CFST arches).

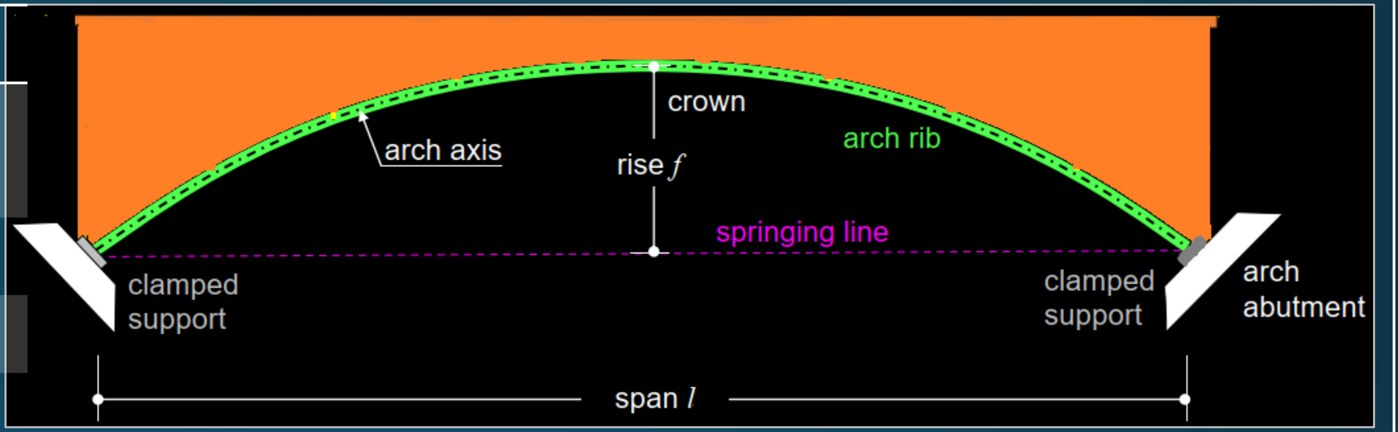
→ Sometimes higher cost of an arch bridge may be justified by the **superior aesthetics quality**.

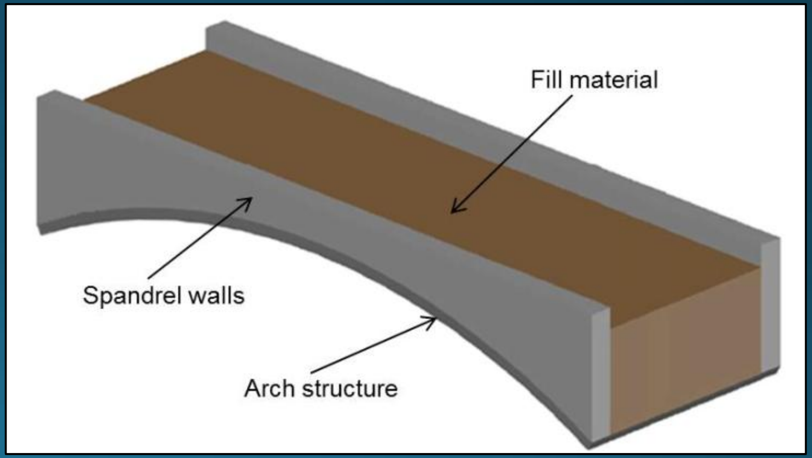
Source: *ETH Zürich,* Bridge Design Lectures , https://concrete.ethz.ch/assets/arch-bridges-2023-04-11.pdf

RC Arch Bridge – Data

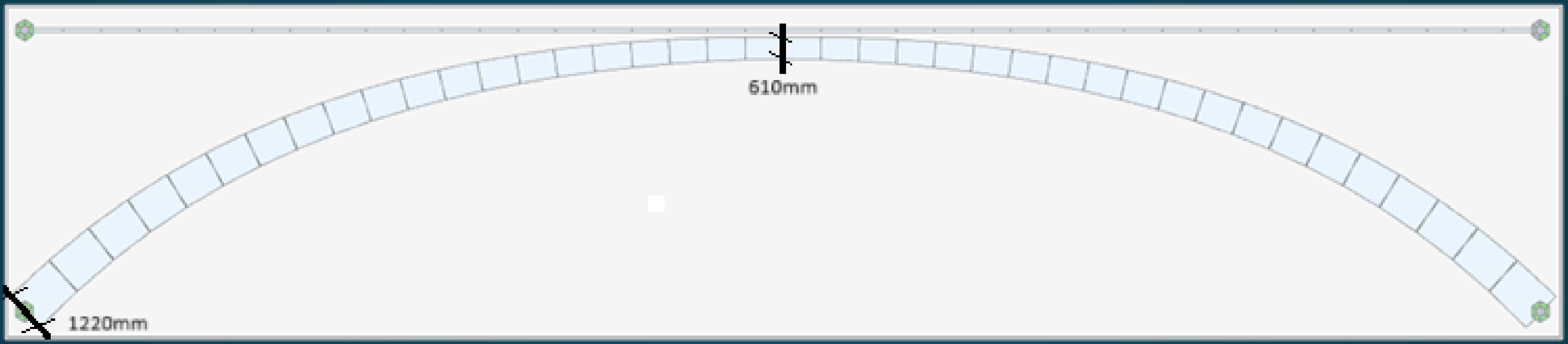
Main Data

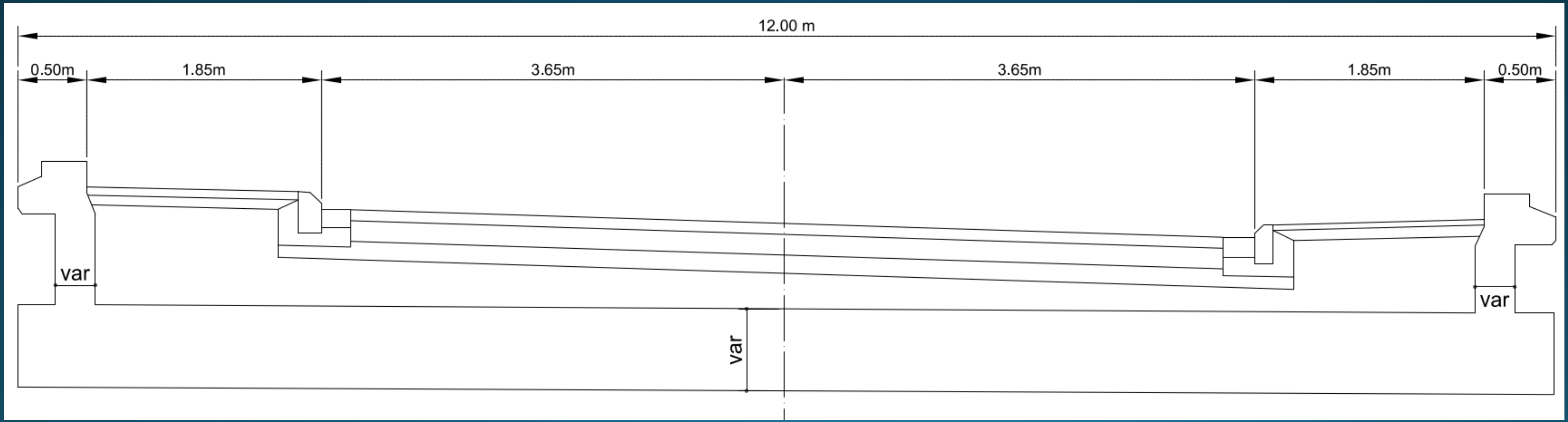
Scope	Structural Assessment of existing RC bridge
Bridge Type	Solid-Spandrel RC Arch with earth fill between Walls (+ Abutments and Wing Walls monolithic with them)
Support	Clamped to Abutments
Traffic	Roadway, Carriageway width = 7.30m
Total width	12 m (= 2 Lanes x3.65m + 2 Footways x 1.85m + 2 Edge x 0.50m)
Span L	42.672 m (between springings)
Rise f	7.468 m (f/l= 1/5.71)
Crown thk	0.61 m
Thk at supports	1.22 m
Spandrel Walls thk	Varying= 0.30 ÷ 1.22 m
H fill at crown	0.30 m
H surface pav	0.40 m





RC Arch Bridge – Data

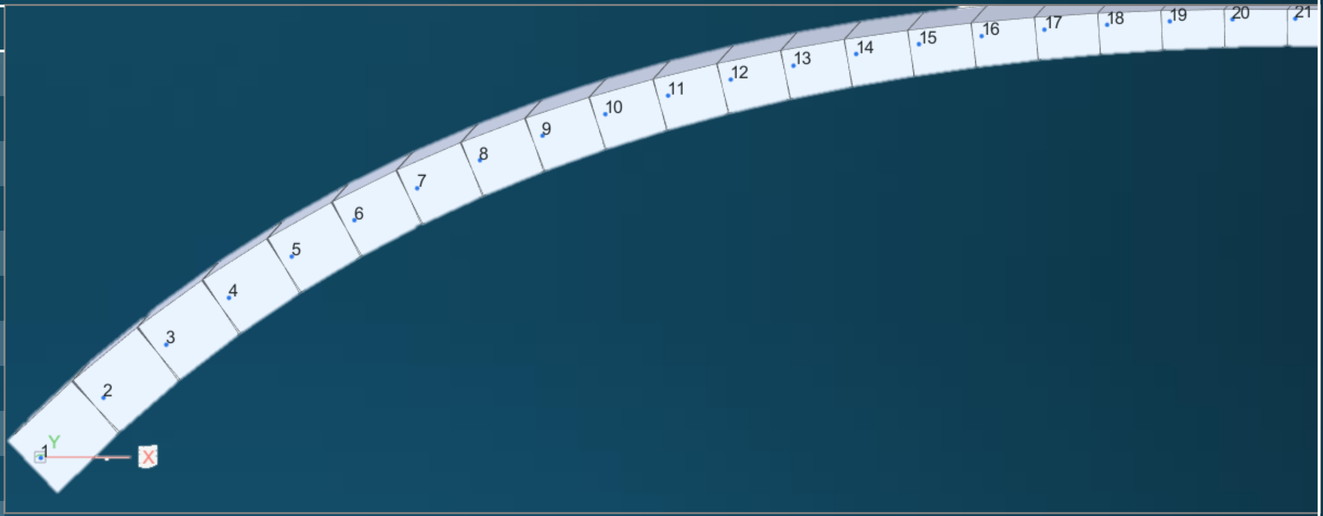




Arch Rib – Coordinates of c/l

Existing construction drawing → Table of coordinates in ft (Imperial system)

X	Y	Z	THK	
[ft]	[ft]	[ft]	[ft]	[m]
0.00	0.00	0.000	4.000	1.219
3.50	0.00	3.350	3.465	1.056
7.00	0.00	6.308	3.125	0.953
10.50	0.00	8.918	2.886	0.880
14.00	0.00	11.219	2.706	0.825
17.50	0.00	13.245	2.567	0.782
21.00	0.00	15.026	2.457	0.749
24.50	0.00	16.590	2.368	0.722
28.00	0.00	17.959	2.295	0.700
31.50	0.00	19.154	2.236	0.682
35.00	0.00	20.193	2.186	0.666
38.50	0.00	21.091	2.145	0.654
42.00	0.00	21.862	2.110	0.643
45.50	0.00	22.517	2.082	0.635
49.00	0.00	23.066	2.059	0.628
52.50	0.00	23.518	2.040	0.622
56.00	0.00	23.878	2.025	0.617
59.50	0.00	24.153	2.014	0.614
63.00	0.00	24.347	2.006	0.611
66.50	0.00	24.462	2.002	0.610
70.00	0.00	24.500	2.000	0.610

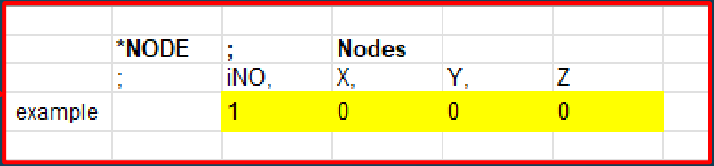


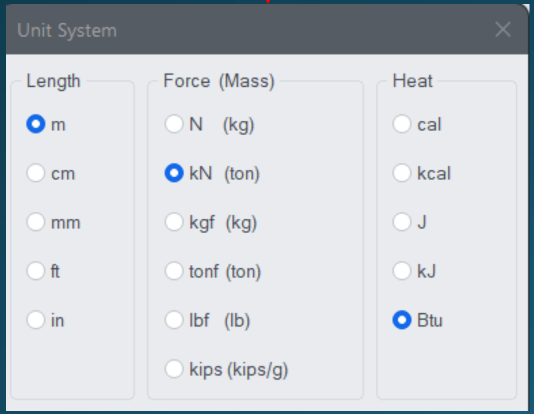
Modeling – Arch Rib Nodes

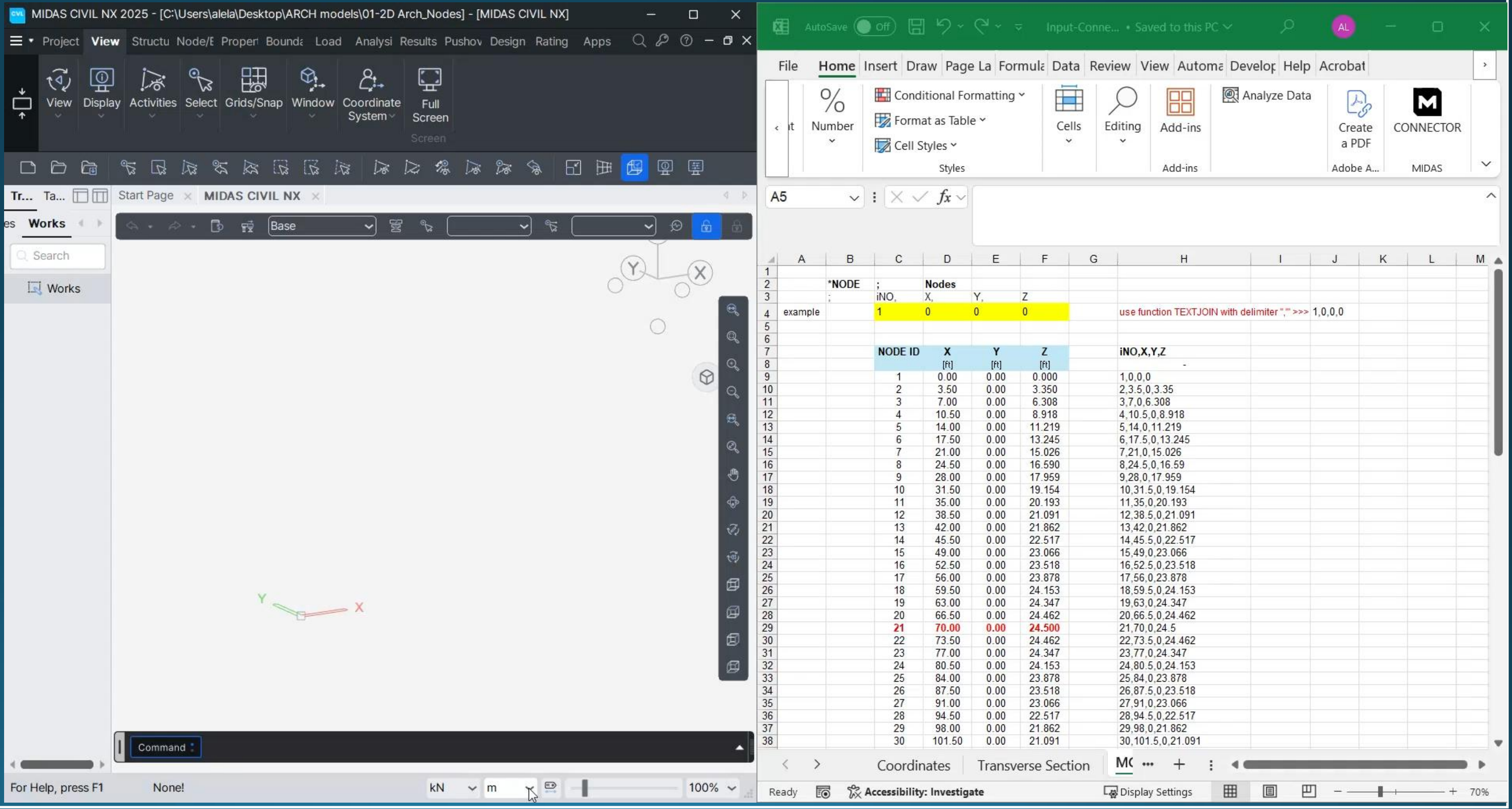
Input Nodes from Excel using Midas CONNECTOR

General Procedure:

1. **Arrange data according to MCT command.**
2. **Open Midas Connector from Excel and connect to Civil NX via API**
3. **Use MXT Command feature in the Connector to input data in the model avoiding passing by MCT Command Shell**
4. **Change units to „m"**





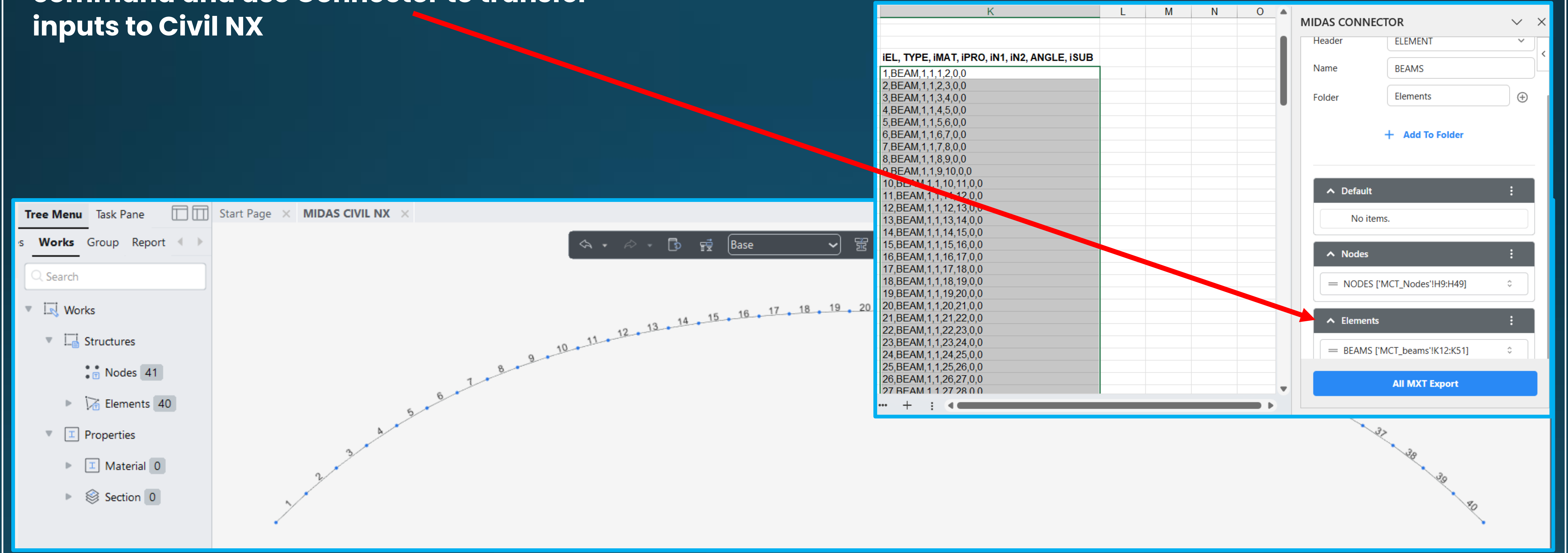


Modeling – Arch Rib Elements

Input Beams from Excel using Midas CONNECTOR

→ Similarly to previous step arrange data of beam elements according to MCT command and use Connector to transfer inputs to Civil NX

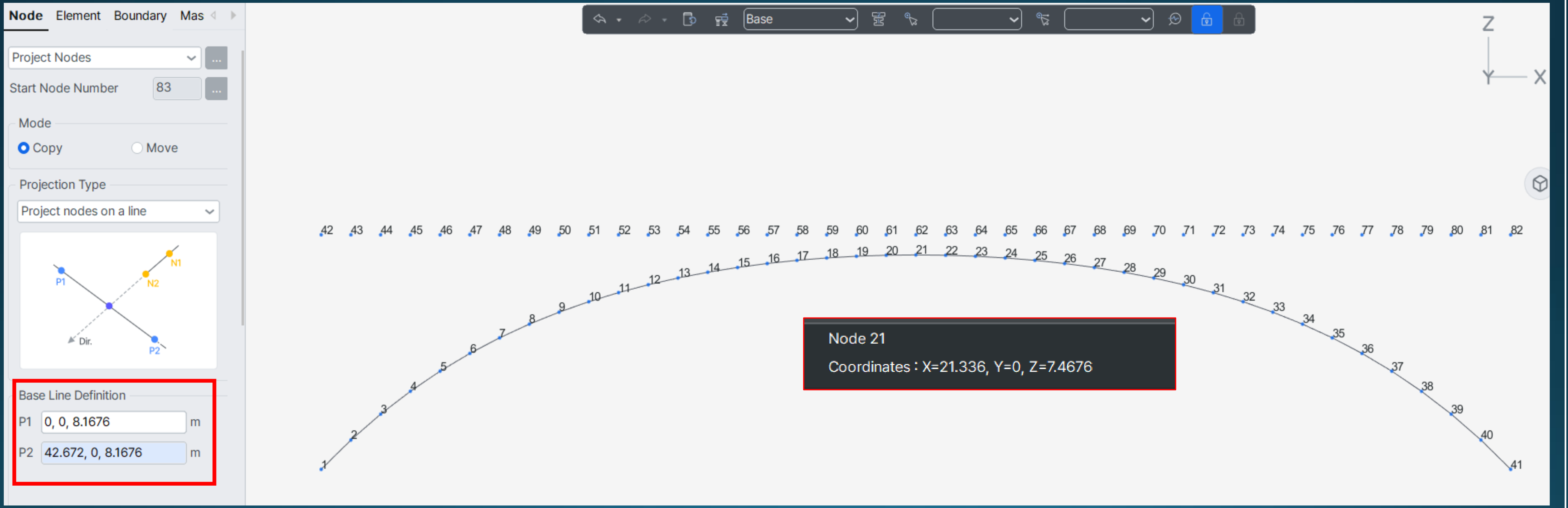
```
*ELEMENT    ; Elements
; iEL, TYPE, iMAT, iPRO, iN1, iN2, ANGLE, iSUB,                ; Frame  Element
; iEL, TYPE, iMAT, iPRO, iN1, iN2, ANGLE, iSUB, EXVAL, EXVAL2, bLMT ; Comp/Tens Truss
; iEL, TYPE, iMAT, iPRO, iN1, iN2, iN3, iN4, iSUB, iWID , LCAXIS   ; Planar Element
; iEL, TYPE, iMAT, iPRO, iN1, iN2, iN3, iN4, iN5, iN6, iN7, iN8    ; Solid  Element

   1, BEAM ,  1,   1,   1,   2,   0,   0
```



Modeling –Top level elements

Create dummy elements at road surface level to transfer traffic loads to arch rib

→ Projects nodes on horizontal line with top surface elevation (= 8.17 m)

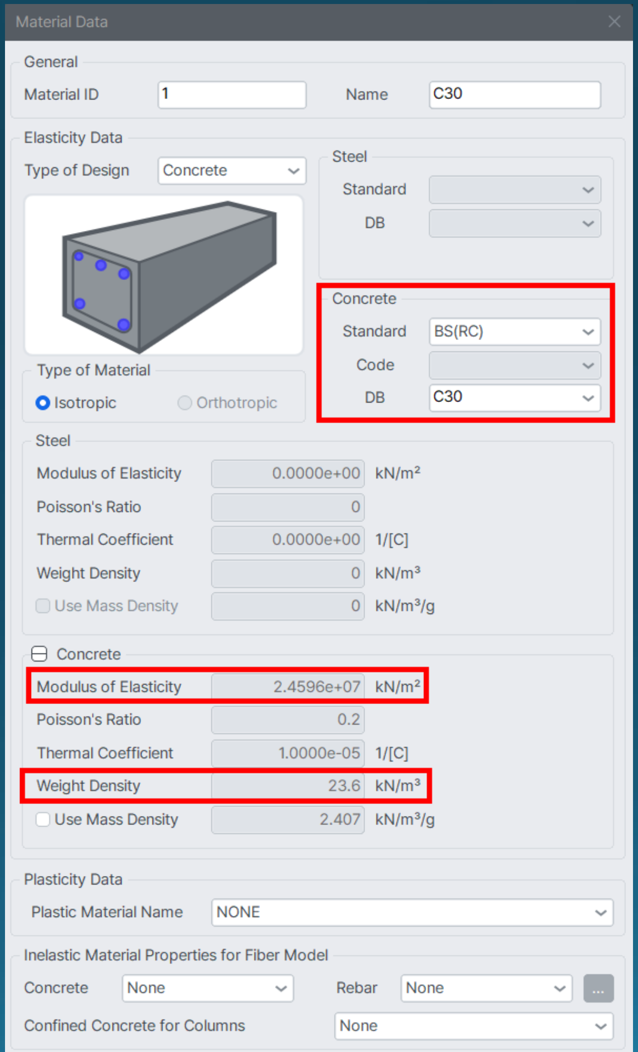


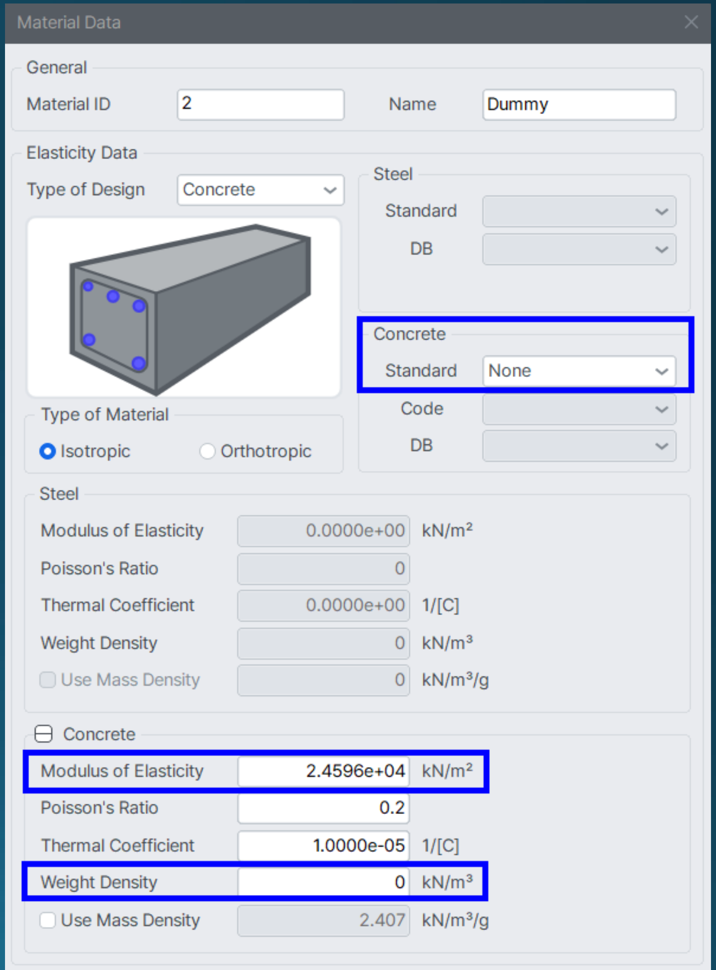
Modeling – Materials

Create materials for arch rib and top elements

→ **Bending moments supposed to be carried by the arch rib alone for this kind of arch bridge**

→ **Assign dummy material to surface elements(weight = 0, much lower stiffness compared to concrete arch rib)**

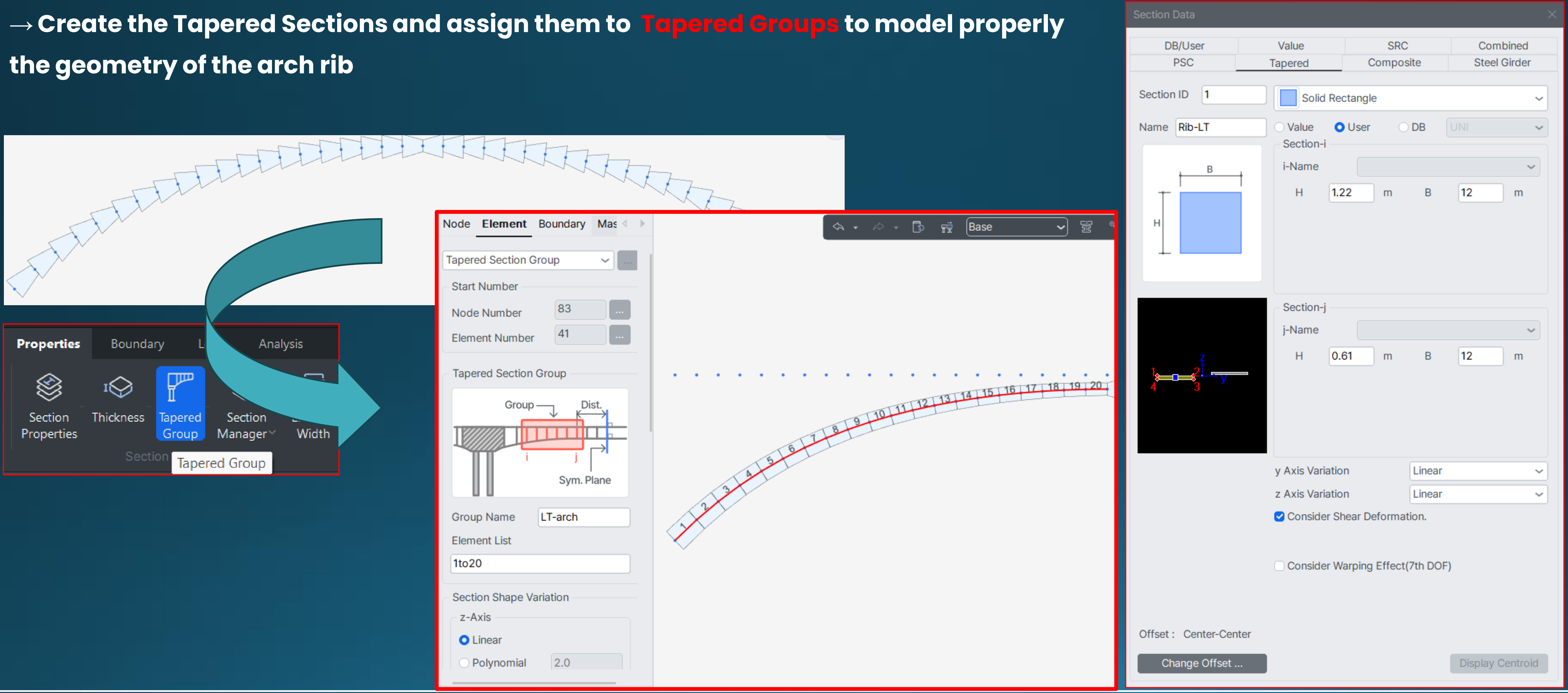




Modeling – Tapered Sections & Tapered Groups

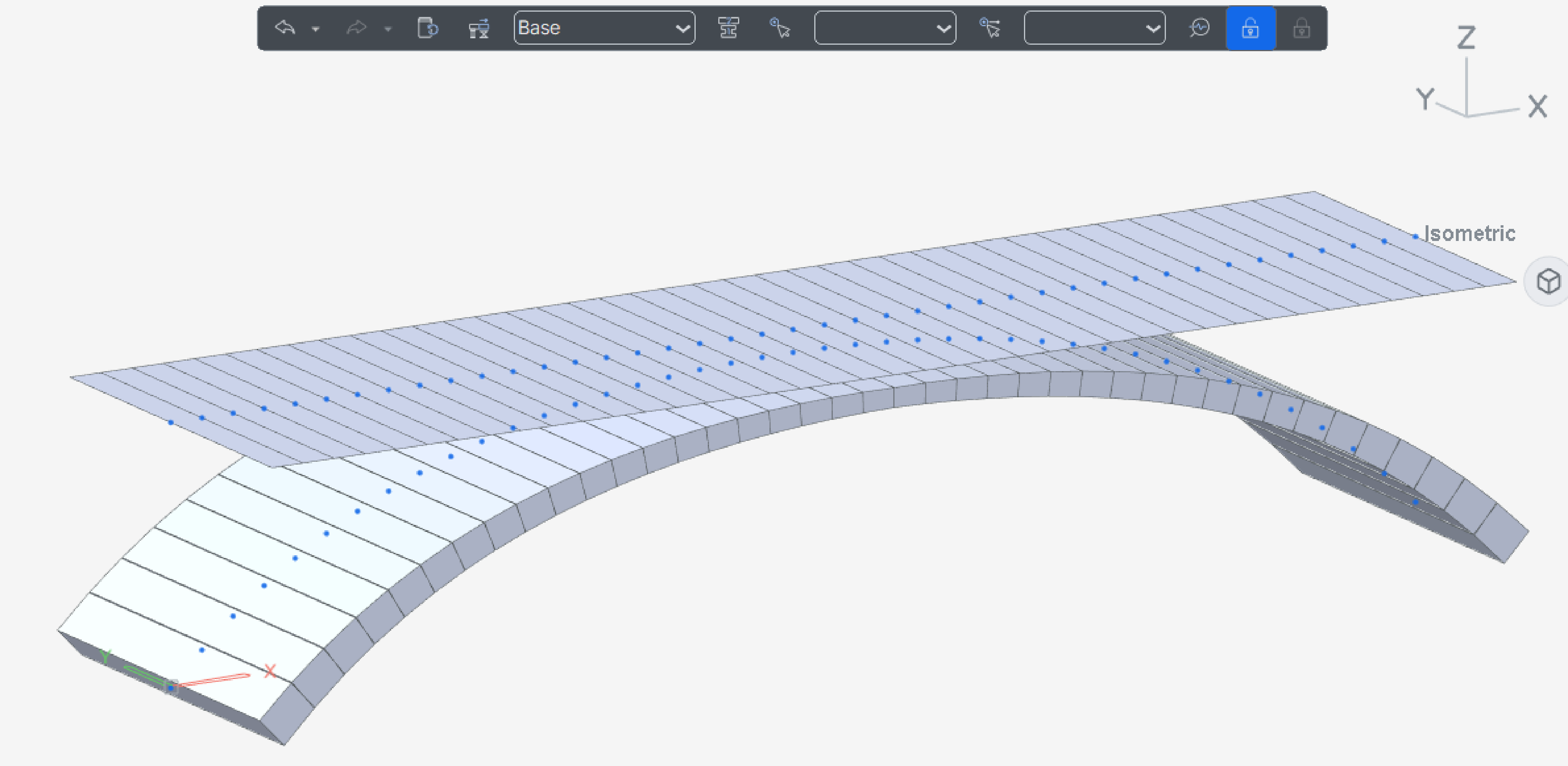
Create the tapered shape of the Left and Right side of arch rib

→ **Create the Tapered Sections and assign them to Tapered Groups to model properly the geometry of the arch rib**



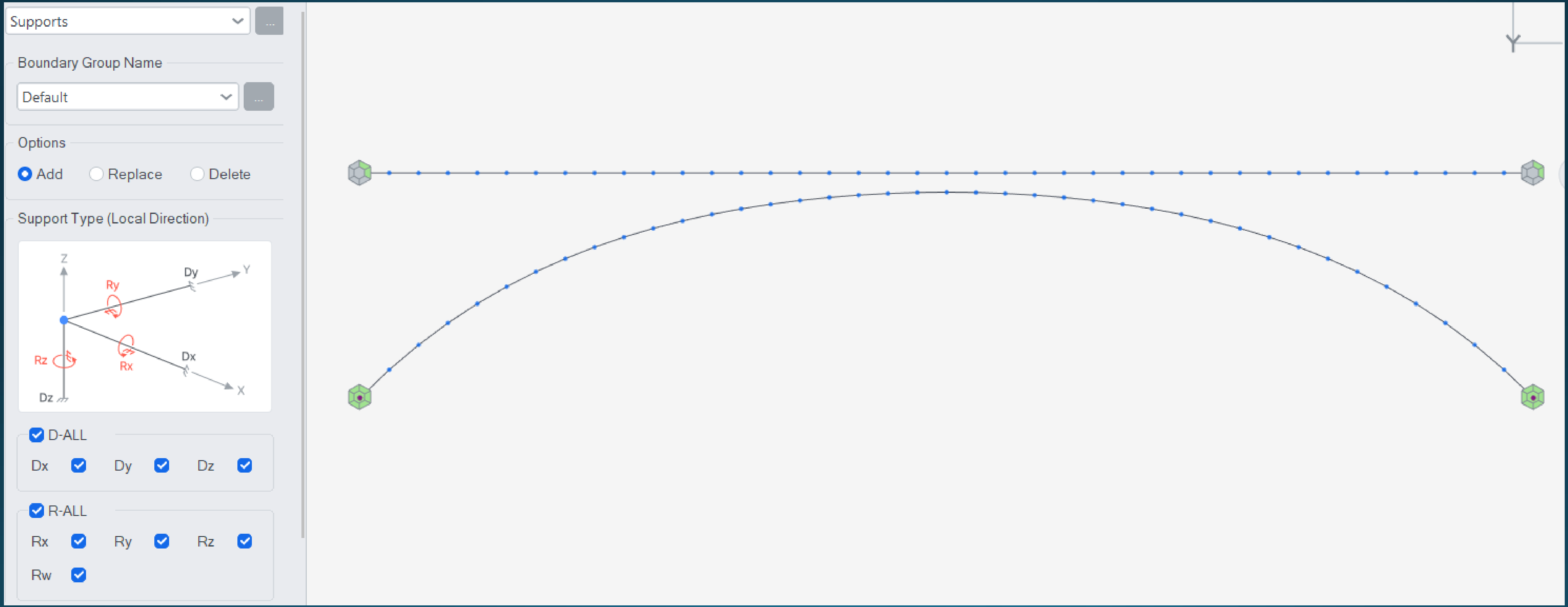
Modeling – Bridge Shape

Final Geometry



Modeling – Boundary (supports)

Support conditions→ Arch rib clamped at CL Springings



Modeling – Links between Surface-Arch Rib

Elastic Links (Compr-only) → Vertical rigidity to simulate the transfer of live loads from surface on arch rib

→ Copy and paste from Excel into Civil NX Table to insert quickly links in every node

Tree Menu | Task Pane

Node | Element | **Boundary** | Mass

Elastic Link

Boundary Group Name

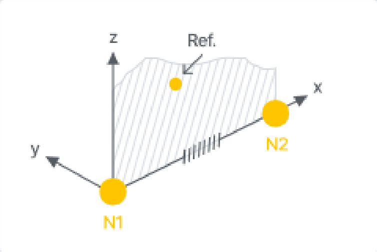
Vertical Links

Options

- Add
- Delete

Elastic Link Data

Type: Compression Only

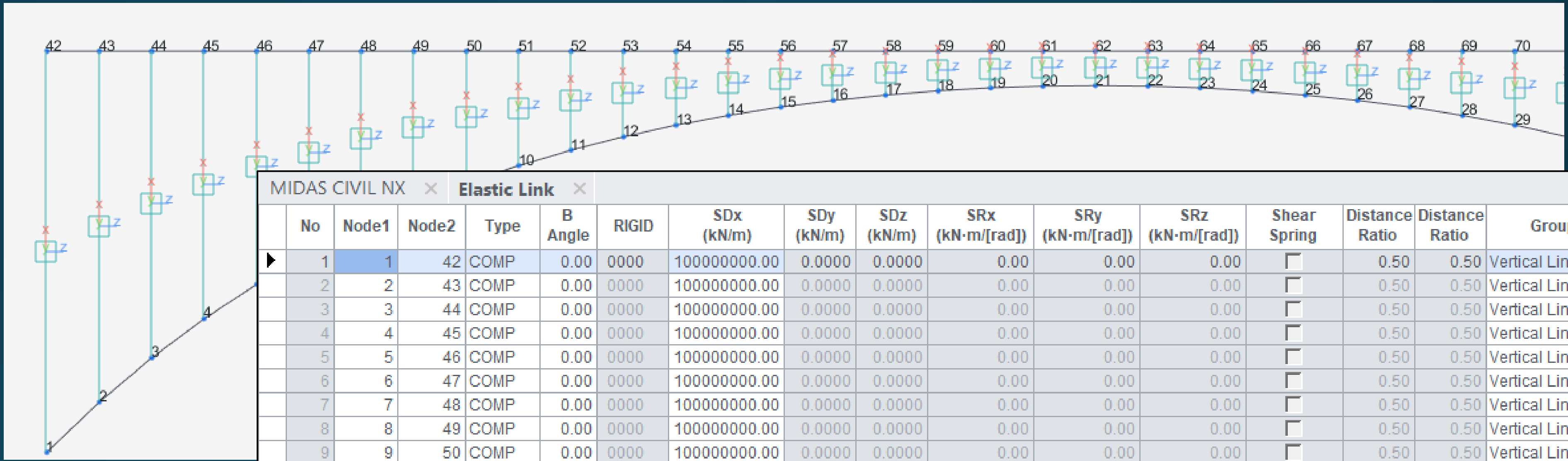


SDx: 1E08 kN/m

SDy: 0 kN/m

SDz: 0 kN/m

SRx: 0 kN·m/[rad]



MIDAS CIVIL NX | **Elastic Link**

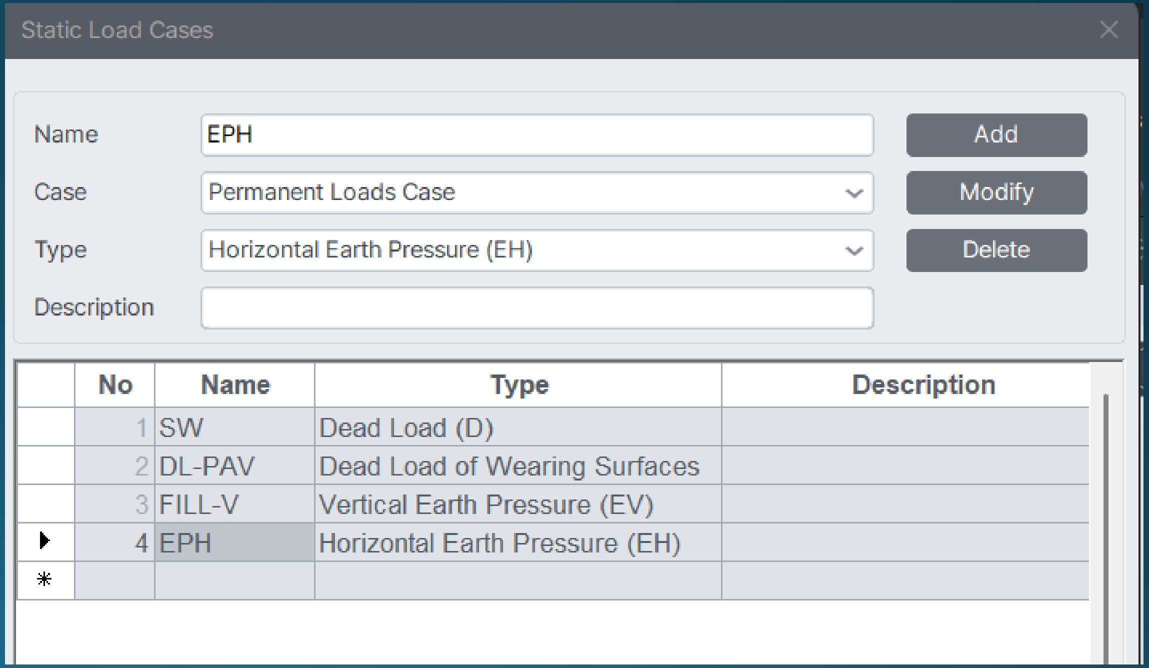
No	Node1	Node2	Type	B Angle	RIGID	SDx (kN/m)	SDy (kN/m)	SDz (kN/m)	SRx (kN·m/[rad])	SRy (kN·m/[rad])	SRz (kN·m/[rad])	Shear Spring	Distance Ratio	Distance Ratio	Group
1	1	42	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
2	2	43	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
3	3	44	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
4	4	45	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
5	5	46	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
6	6	47	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
7	7	48	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
8	8	49	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
9	9	50	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
10	10	51	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
11	11	52	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
12	12	53	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
13	13	54	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
14	14	55	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
15	15	56	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
16	16	57	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
17	17	58	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
18	18	59	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
19	19	60	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
20	20	61	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
21	21	62	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
22	22	63	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
23	23	64	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
24	24	65	COMP	0.00	0000	100000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links

Load Cases definition

Loads considered:

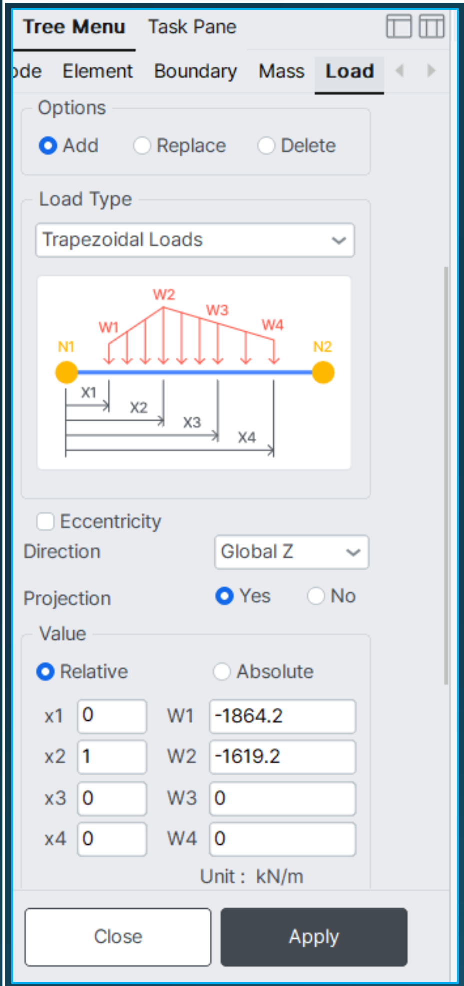
- Self-weight of arch rib (spandrel walls not considered)
- SIDL of road surface
- Soil (vertical pressure)
- Soil (horizontal pressure)
- Vehicular loads

Static Load cases need to be preliminarily defined →



No	Name	Type	Description
1	SW	Dead Load (D)	
2	DL-PAV	Dead Load of Wearing Surfaces	
3	FILL-V	Vertical Earth Pressure (EV)	
4	EPH	Horizontal Earth Pressure (EH)	

Loads Assignment – Soil (Vertical) → Trapezoidal Beam Load



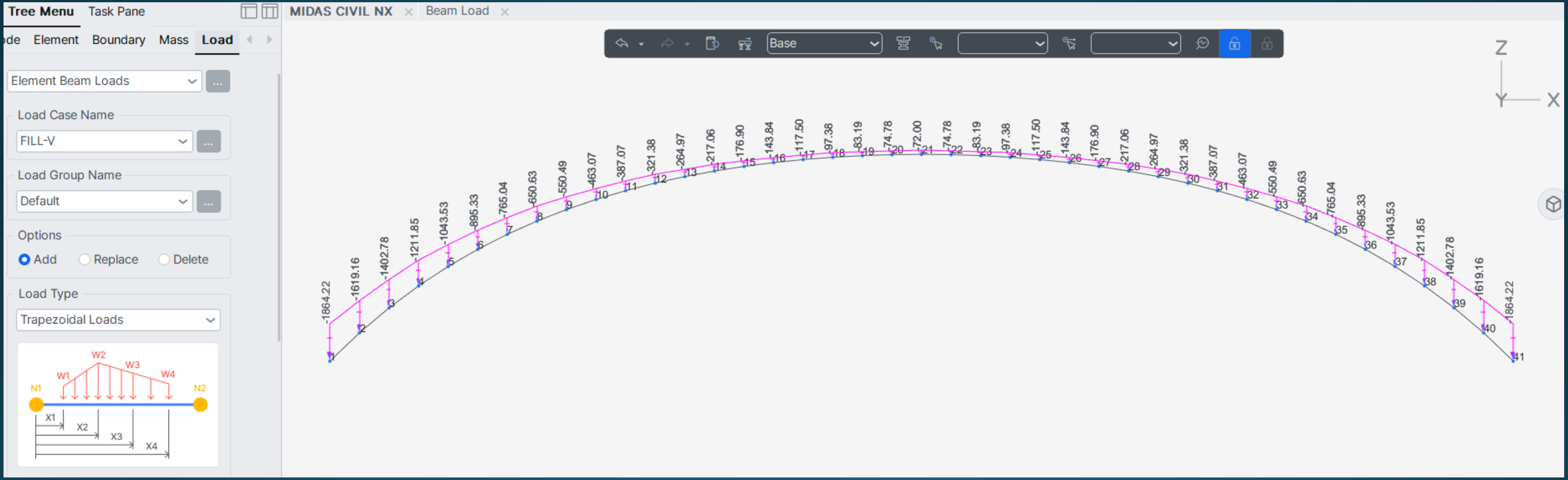
IDAS CIVIL NX × Beam Load ×

Element	BM LD Type	Load Cas	Load Type	Ecc.	Ecc. Type	Ecc. Dir.	Use J	Dist-I(m)	Dist-J(m)	Add. H	Add. Use J	Add. Dist I(m)	Add. Dist J(m)	Direction	Projectio	D1	D2	D3	D4	P1	P2	P3	P4	Unit
1	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-1864.	-1619.	0.00	0.00	kN/m
2	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-1619.	-1402.	0.00	0.00	kN/m
3	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-1402.	-1211.	0.00	0.00	kN/m
4	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-1211.	-1043.	0.00	0.00	kN/m
5	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-1043.	-895.3	0.00	0.00	kN/m
6	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-895.3	-765.0	0.00	0.00	kN/m
7	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-765.0	-650.6	0.00	0.00	kN/m
8	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-650.6	-550.4	0.00	0.00	kN/m
9	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-550.4	-463.0	0.00	0.00	kN/m
10	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-463.0	-387.0	0.00	0.00	kN/m
11	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-387.0	-321.3	0.00	0.00	kN/m
12	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-321.3	-264.9	0.00	0.00	kN/m
13	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-264.9	-217.0	0.00	0.00	kN/m
14	Beam Load	FILL-V	Distribut	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-217.0	-176.9	0.00	0.00	kN/m
15								0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-176.9	-143.8	0.00	0.00	kN/m
16								0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-143.8	-117.5	0.00	0.00	kN/m
17								0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-117.5	-97.38	0.00	0.00	kN/m
18								0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-97.38	-83.19	0.00	0.00	kN/m
19								0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-83.19	-74.78	0.00	0.00	kN/m
20								0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-74.78	-72.00	0.00	0.00	kN/m
21								0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-72.00	-74.78	0.00	0.00	kN/m
22								0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-74.78	-83.19	0.00	0.00	kN/m
23								0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-83.19	-97.38	0.00	0.00	kN/m
24								0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-97.38	-117.5	0.00	0.00	kN/m
25								0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-117.5	-143.8	0.00	0.00	kN/m
26								0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-143.8	-176.9	0.00	0.00	kN/m

					INFILL
NODE ID	H_rel	H_fill-top	γ_fill	Elem.Width	γ_{fill}*B*H
-	[m]	[m]	[kN/m3]	[m]	[kN/m]
1	7.47	0.30	20.0	12.00	-1864.2
2	6.45	0.30	20.0	12.00	-1619.2
3	5.54	0.30	20.0	12.00	-1402.8
4	4.75	0.30	20.0	12.00	-1211.9
5	4.05	0.30	20.0	12.00	-1043.5
6	3.43	0.30	20.0	12.00	-895.3
7	2.89	0.30	20.0	12.00	-765.0
8	2.41	0.30	20.0	12.00	-650.6
9	1.99	0.30	20.0	12.00	-550.5
10	1.63	0.30	20.0	12.00	-463.1
11	1.31	0.30	20.0	12.00	-387.1
12	1.04	0.30	20.0	12.00	-321.4
13	0.80	0.30	20.0	12.00	-265.0
14	0.60	0.30	20.0	12.00	-217.1
15	0.44	0.30	20.0	12.00	-176.9
16	0.30	0.30	20.0	12.00	-143.8
17	0.19	0.30	20.0	12.00	-117.5
18	0.11	0.30	20.0	12.00	-97.4
19	0.05	0.30	20.0	12.00	-83.2
20	0.01	0.30	20.0	12.00	-74.8
21	0.00	0.30	20.0	12.00	-72.0

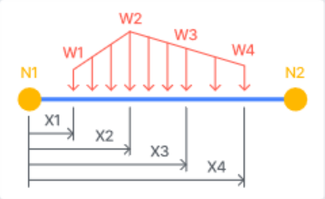
→ Copy and paste from Excel into Civil NX Table to insert quickly P1, P2 for every arch element

Loads Assignment – Soil (Vertical) → Trapezoidal Beam Load



Loads Assignment – Soil (Horizontal) → Trapezoidal Beam Load

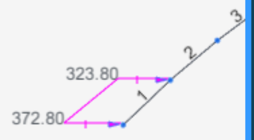
Load Type
Trapezoidal Loads



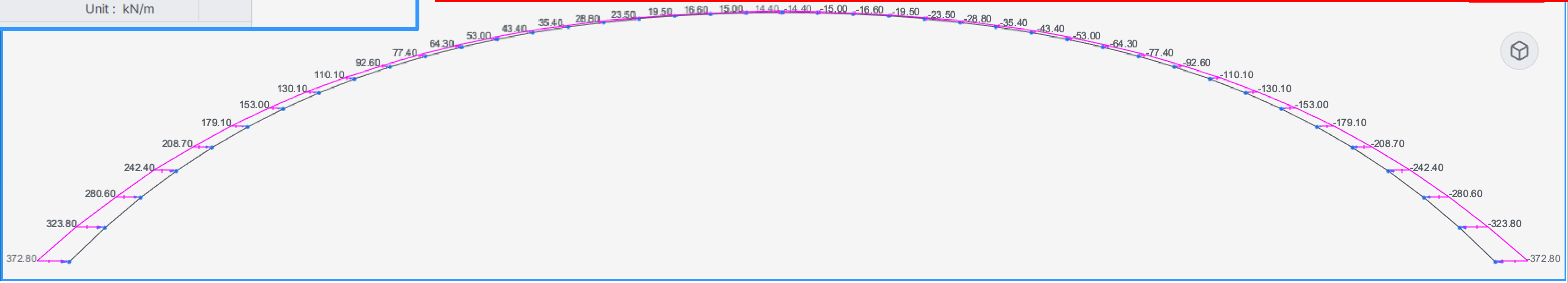
Eccentricity
Direction: Global X
Projection: (•) Yes ( ) No
Value
(•) Relative ( ) Absolute

x1	0	W1	372.8
x2	1	W2	323.8
x3	0	W3	0
x4	0	W4	0

Unit : kN/m

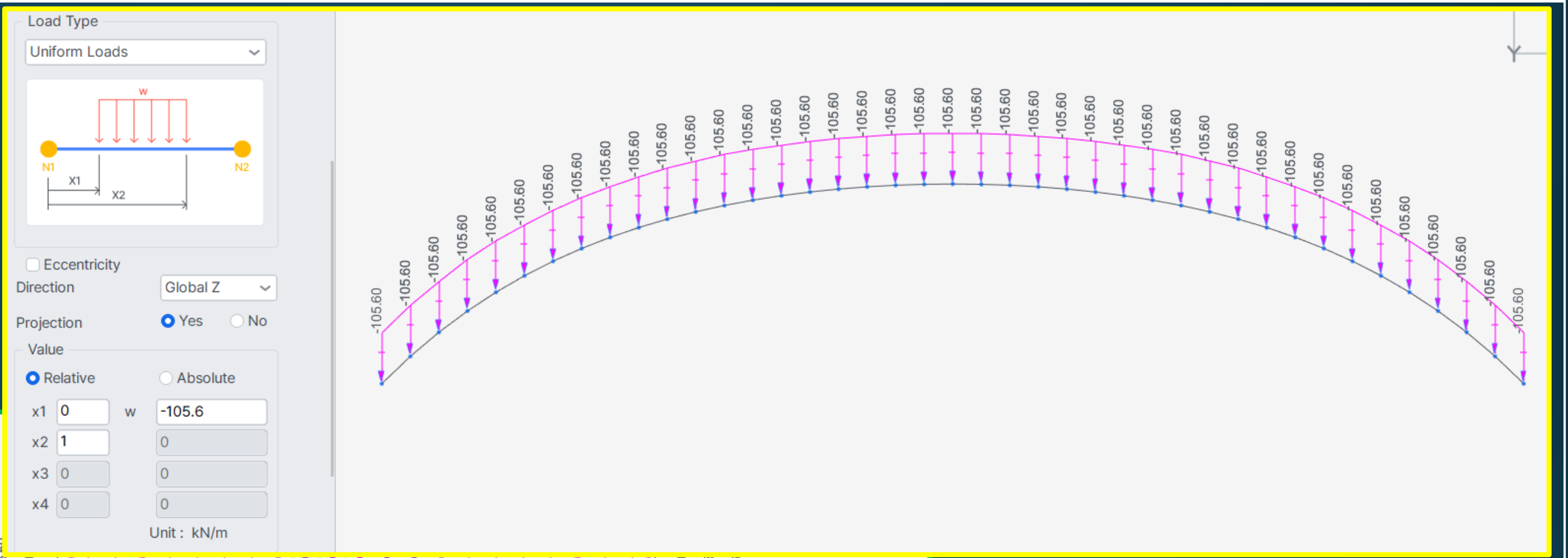


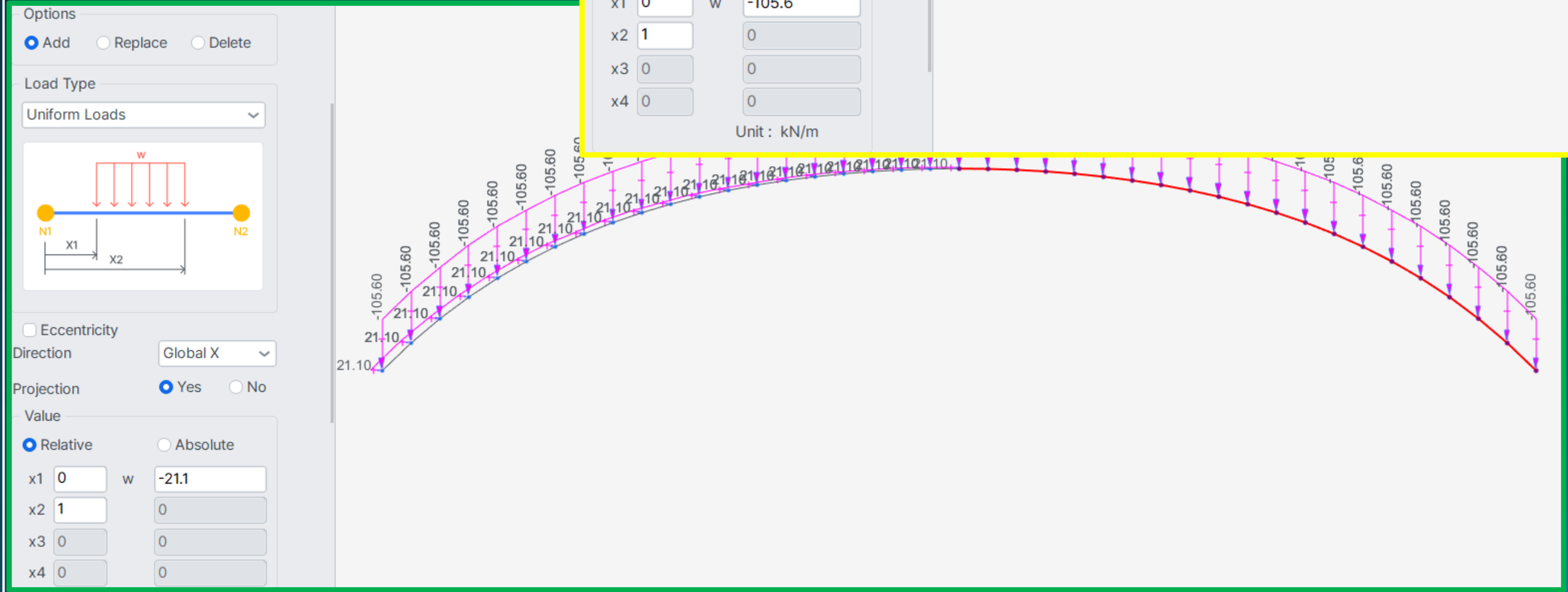
Element	BM LD Type	Load Cas	Load Type	Ecc.	Ecc. Type	Ecc. Dir.	Use J	Dist-I(m)	Dist-J(m)	Add. H	Add. Use J	Add. Dist I(m)	Add. Dist J(m)	Direction	Projectio	D1	D2	D3	D4	P1	P2	P3
1	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	372.80	323.80	0.00
2	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	323.80	280.60	0.00
3	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	280.60	242.40	0.00
4	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	242.40	208.70	0.00
5	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	208.70	179.10	0.00
6	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	179.10	153.00	0.00
7	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	153.00	130.10	0.00
8	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	130.10	110.10	0.00
9	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	110.10	92.60	0.00
10	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	92.60	77.40	0.00
11	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	77.40	64.30	0.00
12	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	64.30	53.00	0.00
13	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	53.00	43.40	0.00
14	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	43.40	35.40	0.00
15	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	35.40	28.80	0.00
16	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	28.80	23.50	0.00
17	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	23.50	19.50	0.00
18	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	19.50	16.60	0.00
19	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	16.60	15.00	0.00
20	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	15.00	14.40	0.00
21	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-14.40	-15.00	0.00
22	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-15.00	-16.60	0.00
23	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-16.60	-19.50	0.00
24	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-19.50	-23.50	0.00
25	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-23.50	-28.80	0.00
26	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-28.80	-35.40	0.00
27	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-35.40	-43.40	0.00
28	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-43.40	-53.00	0.00
29	Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00	No	No	0.00	0.00	Global	Yes	0.00	1.00	0.00	0.00	-53.00	-64.30	0.00



Loads Assignment – Wearing/Pav→ Uniform Beam Load

H_pav	γ_pav	γ_{pav}*B*H	γ_{pav}*B*H*K0
[m]	[kN/m3]	[kN/m]	[kN/m]
0.40	22	105.60	21.1





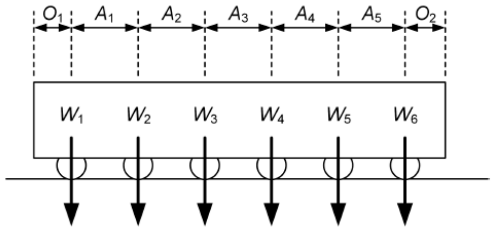
Assessment Live Load– UK case (example)

UK – CS 454 & 455

CS 454
Assessment of highway bridges and structures
(formerly BD 21/01, BA 16/97 and BD 37/01)

Either of these two models can be used (Normal traffic):

- **ALL model 1**
  - Based on real vehicles with authorized weight
  - Single vehicle or convoy of vehicles
  - Suitable for all structures



ALL model 1 - vehicle notation

- **ALL model 2** → used in this case

ALL model 2

The ALL model 2 shall consist of the following loads, applied separately:

1) a combined uniform and knife-edge load;
2) a single axle load.

Combined uniform and knife-edge load

For the purposes of applyi
be divided into a number o

single axle load not automatized in midas Civil NX.

The notional lanes should be assumed to be equally distributed across the carriageway width.

The combined uniform and knife-edge loading, applied in each lane, shall consist of a uniformly distributed load (UDL) together with a single knife-edge load (KEL), determined in accordance with Table 5.19a, modified by the following factors:

1) The lane factors in Table 5.19b;
2) The K-factors accounting for surface category and traffic flow category given in Figures 5.19a to 5.19f and Table 5.19c.

Figure 5.19a K-factor for high traffic flow, poor surface

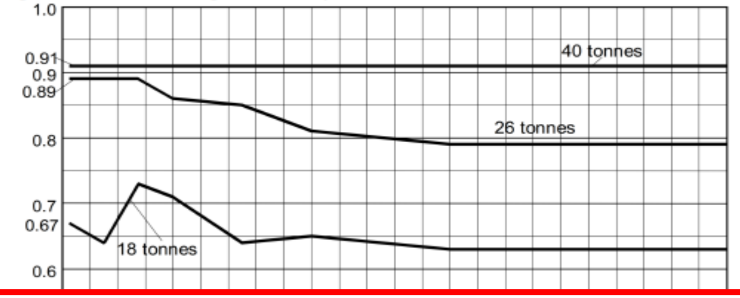


Table 5.19a Uniform and knife-edge loading

Loaded length, L (m)	UDL (kN/m)	KEL (kN)
$L \leq 20$m	$\frac{230}{L^{0.67}}$	82
$20\text{m} < L < 40$m	$\frac{336}{L^{0.67}} \cdot \frac{1}{1.92-0.023L}$	$\frac{120}{1.92-0.023L}$
$40\text{m} \leq L \leq 50$m	$\frac{336}{L^{0.67}}$	120
$L > 50$m	$\frac{36}{L^{0.1}}$	120

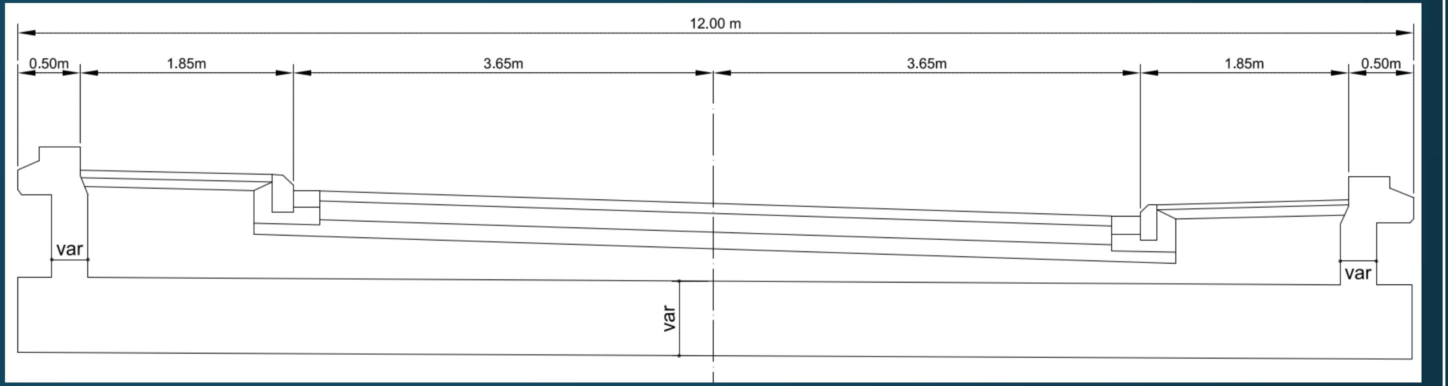
Table 5.19b Lane factors for ALL model 2

Lane	Lane factor
Lane 1	1.0
Lane 2	$\max\left(0.67, \frac{7.1}{\sqrt{L}}\right)$ when $L > 50$ m and $N < 6$
	1.0 in all other cases
Lane 3	0.5
Lane 4 and subsequent	0.4

Note 1: Where the bridge carries two-way traffic, N is taken as the total number of notional lanes on the bridge, including all notional lanes for dual carriageway roads.
Note 2: Where the bridge carries one-way traffic only, the value of N is taken as twice the number of notional lanes on the bridge.
Note 3: The lane factors are interchangeable between lanes.

Live Load– UK case

- **Carriage width = 7.30 m**
- **N° Notional lanes = 2 (x 3.65 m) = n°marked lanes for All Model 2**
- **Footway = 2x 1.85 m**



Pedestrian ALL model

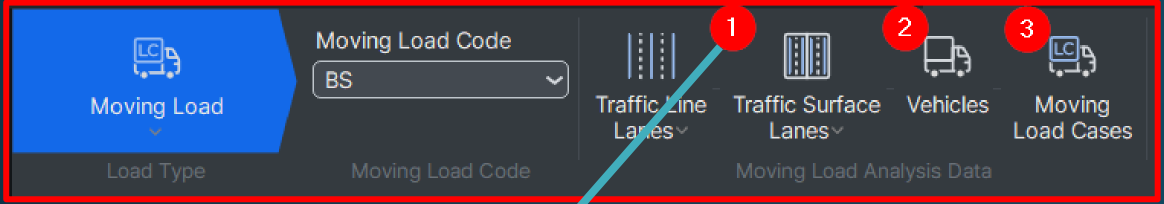
The pedestrian ALL model shall comprise a uniformly distributed load as defined in Table 5.32a, as modified by the pedestrian live load factor and width factor in Table 5.32b.

Table 5.32a UDL for pedestrian live loading model

Loaded length, L (m)	Pedestrian live load, P (kN/m^2)
$0 < L \leq 36$	5.0
$36 < L \leq 50$	$\frac{336}{L^{0.67}} \cdot \frac{10}{L+270} \cdot 5.0$
$50 < L \leq 400$	$\frac{36}{L^{0.1}} \cdot \frac{10}{L+270} \cdot 5.0$

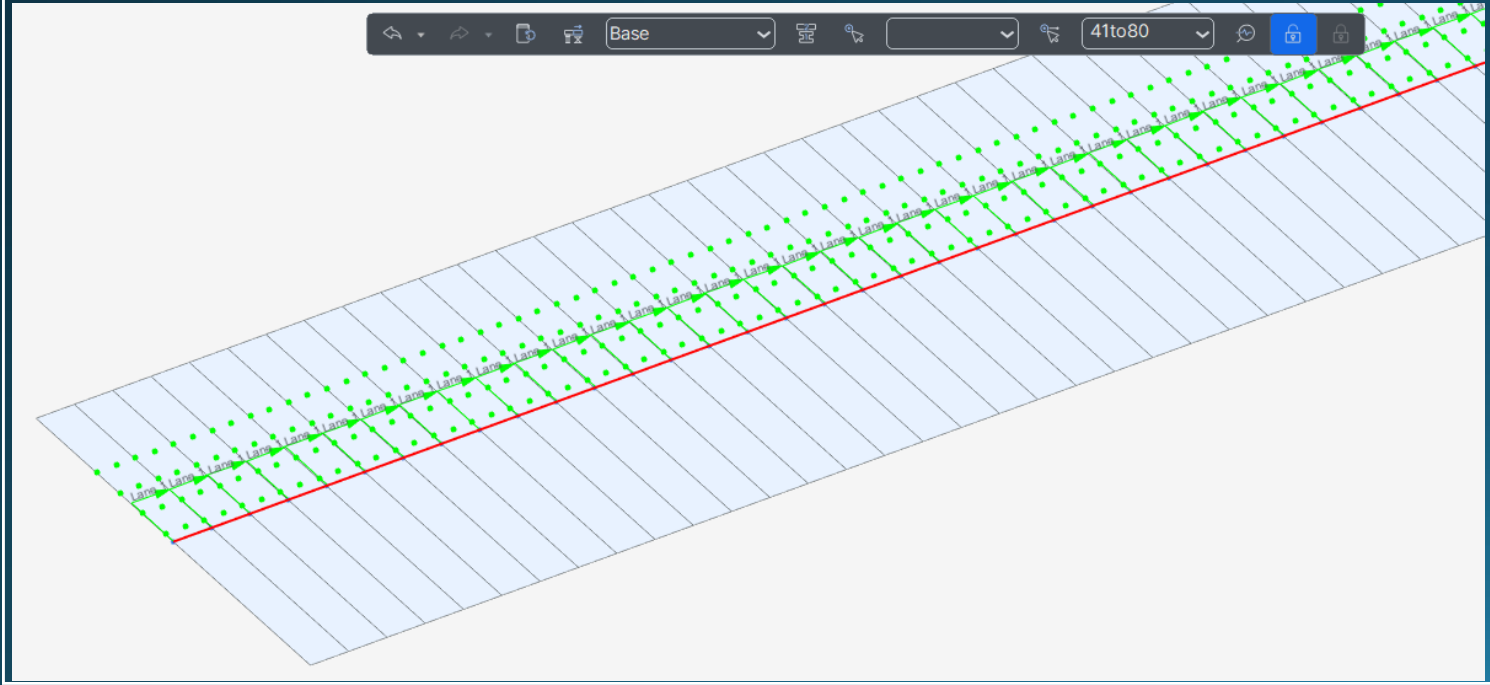
Live Load– UK case

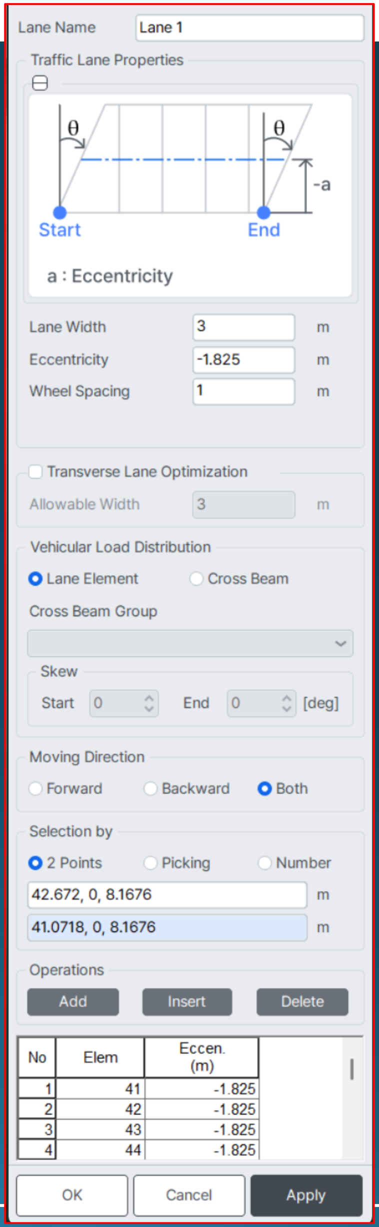
3 fundamental steps to define live load in Civil NX:

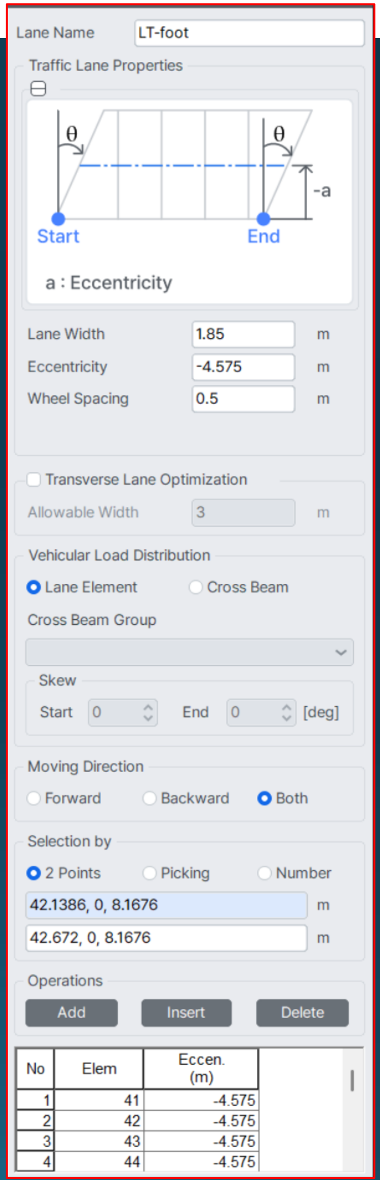


Traffic Lanes definition:

	footway	remaining	notional	notional	remaining	footway
	LT FOOT	**LT R.A.**	**LANE 1**	**LANE 2**	**RT R.A.**	**RT FOOT**
w [m]	1.85	0.00	3.65	3.65	0.00	1.85
e_ctr [m]	-4.575	-	-1.825	1.825	-	4.575

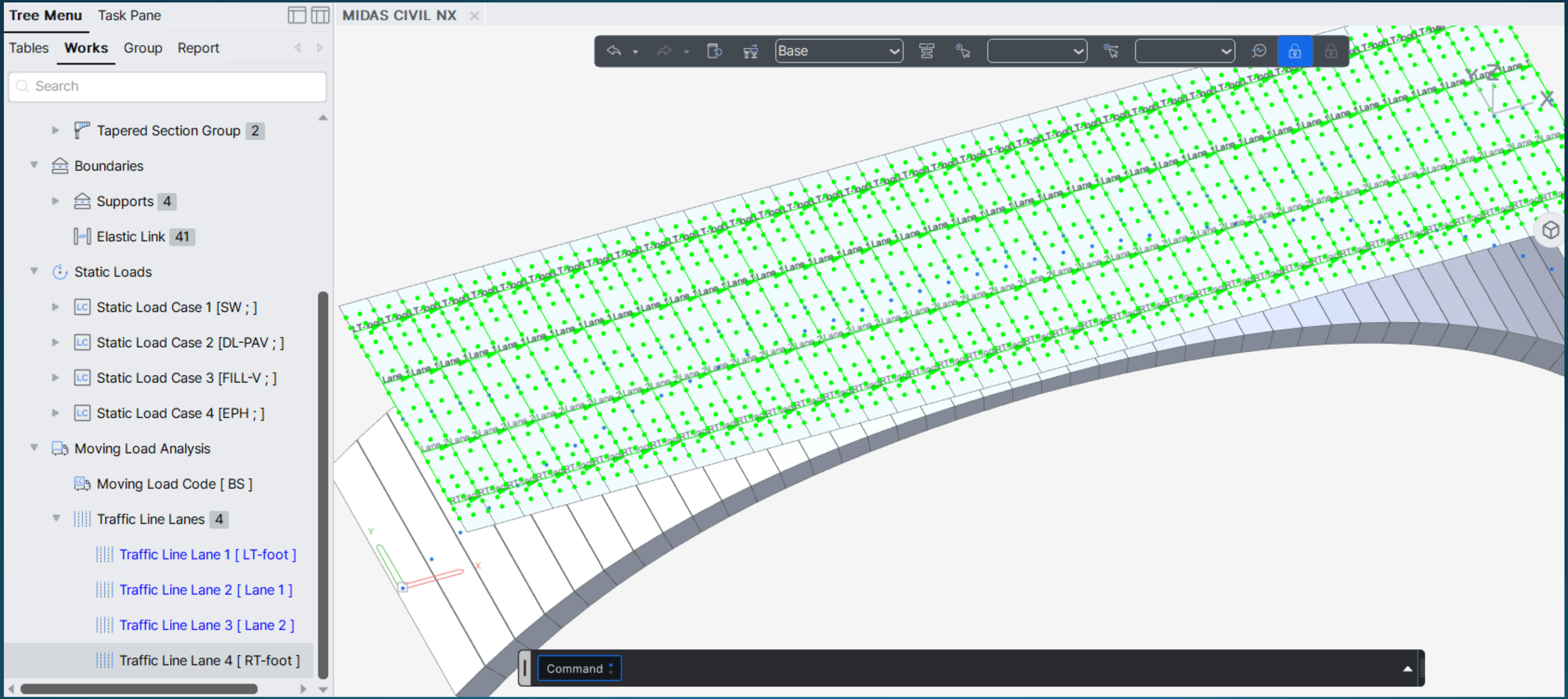






Live Load– UK case

Traffic Lanes definition:



Live Load– Vehicles for Assessment

Only KEL + UDL of All Model 2 considered

(Load dispersal is not considered in Civil NX)

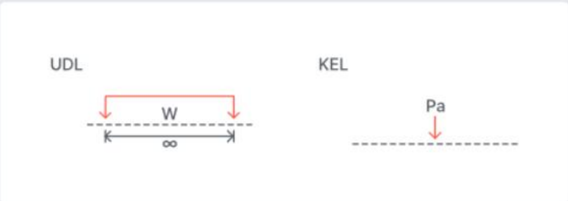
Define Standard Vehicular Load

Standard Name: CS 454 Assessment

Vehicular Load Properties

Vehicular Load Name: ALL MODEL 2(UDL+KEL)

Vehicular Load Type: ALL MODEL 2(UDL+KEL)



Lane Factor

- CS 454 (selected)
- User-defined — Lane Factor ...

Loaded length, L (m)	UDL (kN/m)	KEL (kN)
$L \leq 20$m	$\frac{230}{L^{0.67}}$	82
20m < L <40m	$\frac{336}{L^{0.67}} \cdot \frac{1}{1.92 - 0.023L}$	$\frac{120}{1.92 - 0.023L}$
40m ≤ L ≤ 50m	$\frac{336}{L^{0.67}}$	120
L > 50m	$\frac{36}{L^{0.1}}$	120

Category for K-Factor

Traffic/Surface Category : Hp

Load Level : 40t

Loaded length	The length of the structure that is loaded with traffic in the assessment of load effects, determined from the adverse areas of the influence line for the effect being evaluated.

The loaded length should be calculated from the base length of the adverse area of the influence line, aligned with the carriageway, for the effect being evaluated.
Where the influence line has more than one adverse area (for example in continuous multi-span bridge structures), the most onerous traffic loading effect should be determined from loading any combination of adverse areas, with the loaded length taken as the total sum of the base lengths of the adverse areas that are loaded with traffic.

Pedestrian Live Load

Define Standard Vehicular Load

Standard Name: BD37/01 Standard Load

Vehicular Load Properties

Vehicular Load Name: Pedestrian

Vehicular Load Type: Pedestrian

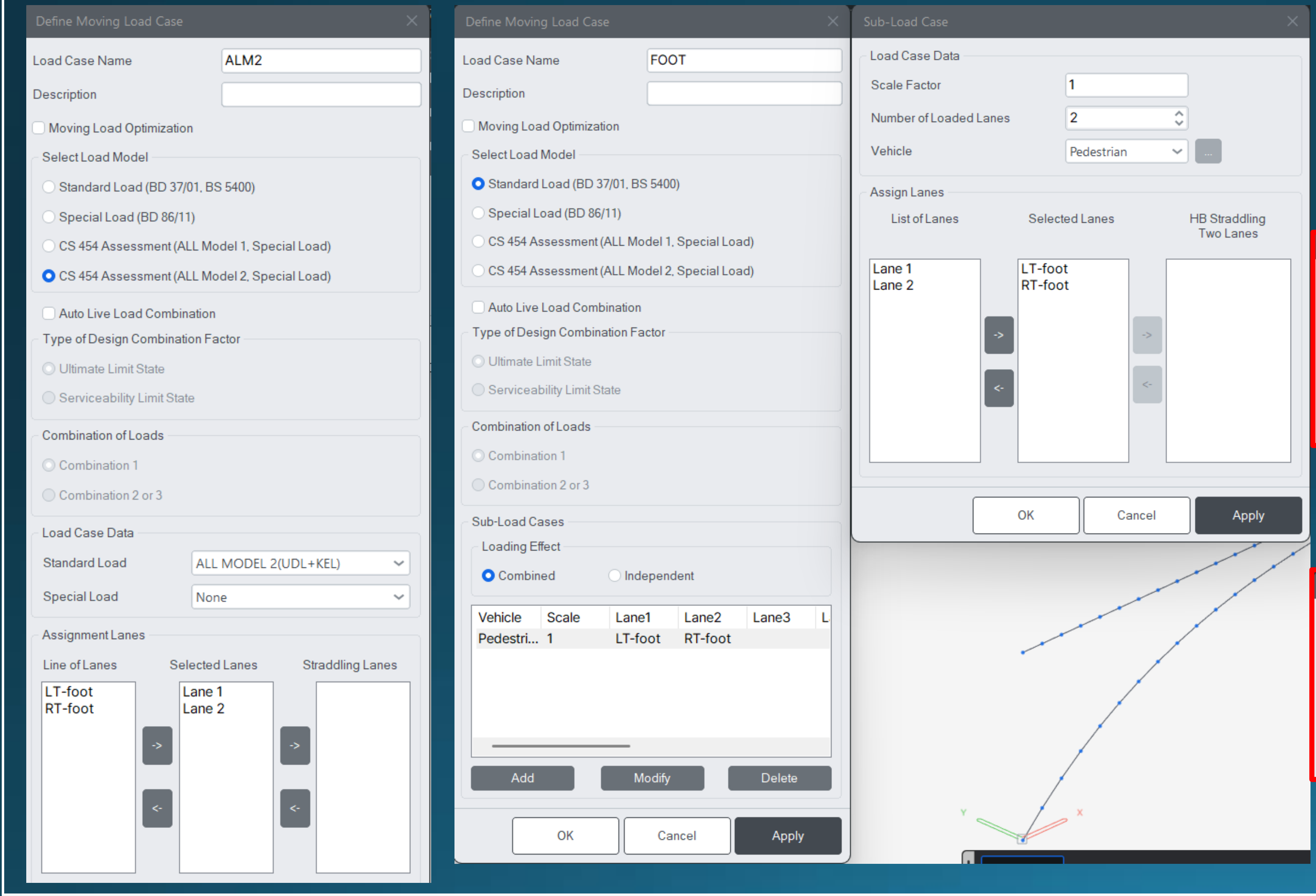
W = 5 kN/m² : L <= 36 m

W = k*5 kN/m² : 36 < L m

k = nominal HA UDL for appropriate loaded length*10 / (L+270)

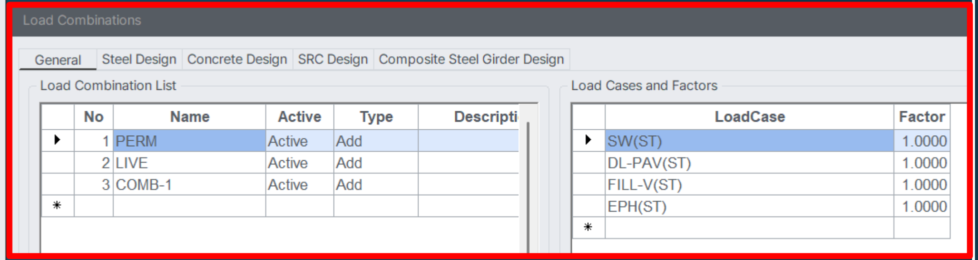
MVL Cases and Load Combinations

ALL MODEL 2 (KEL+UDL) + FOOTWAY

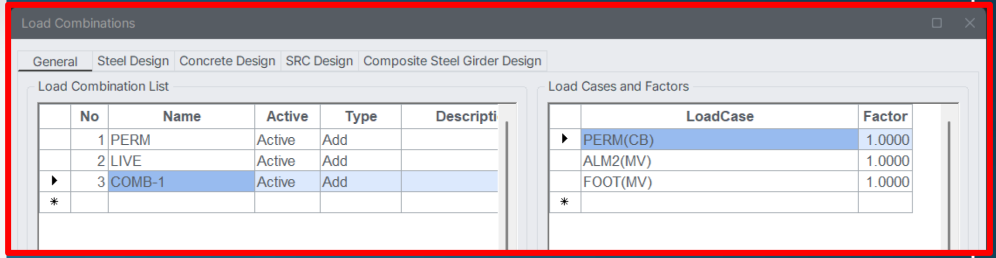


LOAD COMBINATIONS

PERM LOADS

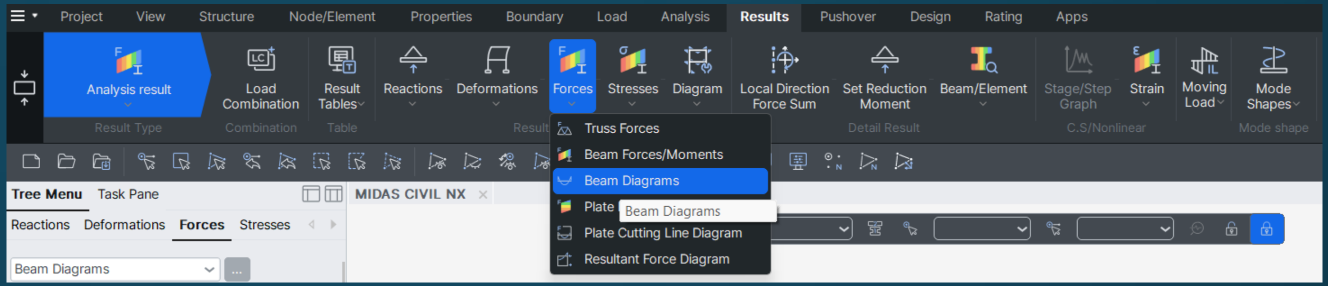


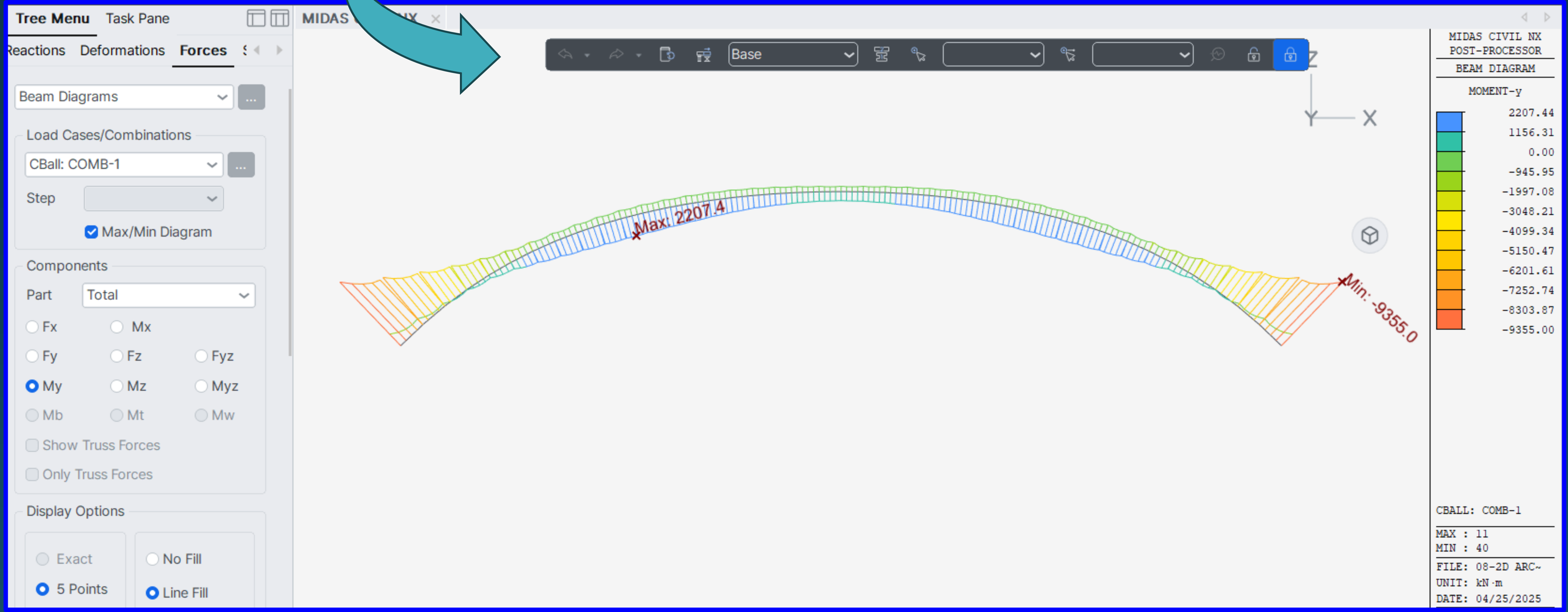
PERM + LIVE



Results Display – Conventional functions

Display BM max diagram

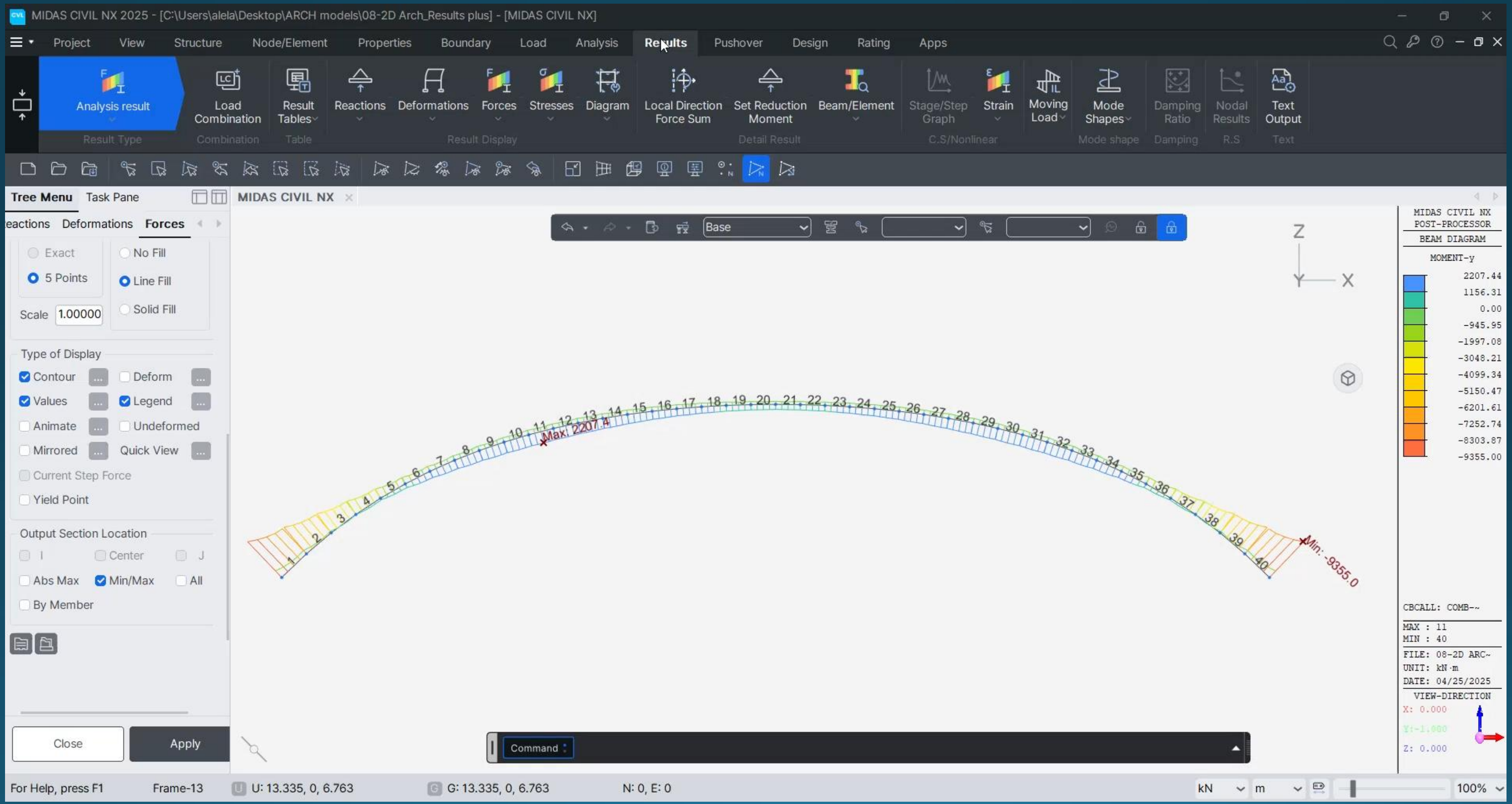




Results Display – Moving Load Tracer

Using Moving Load Tracer

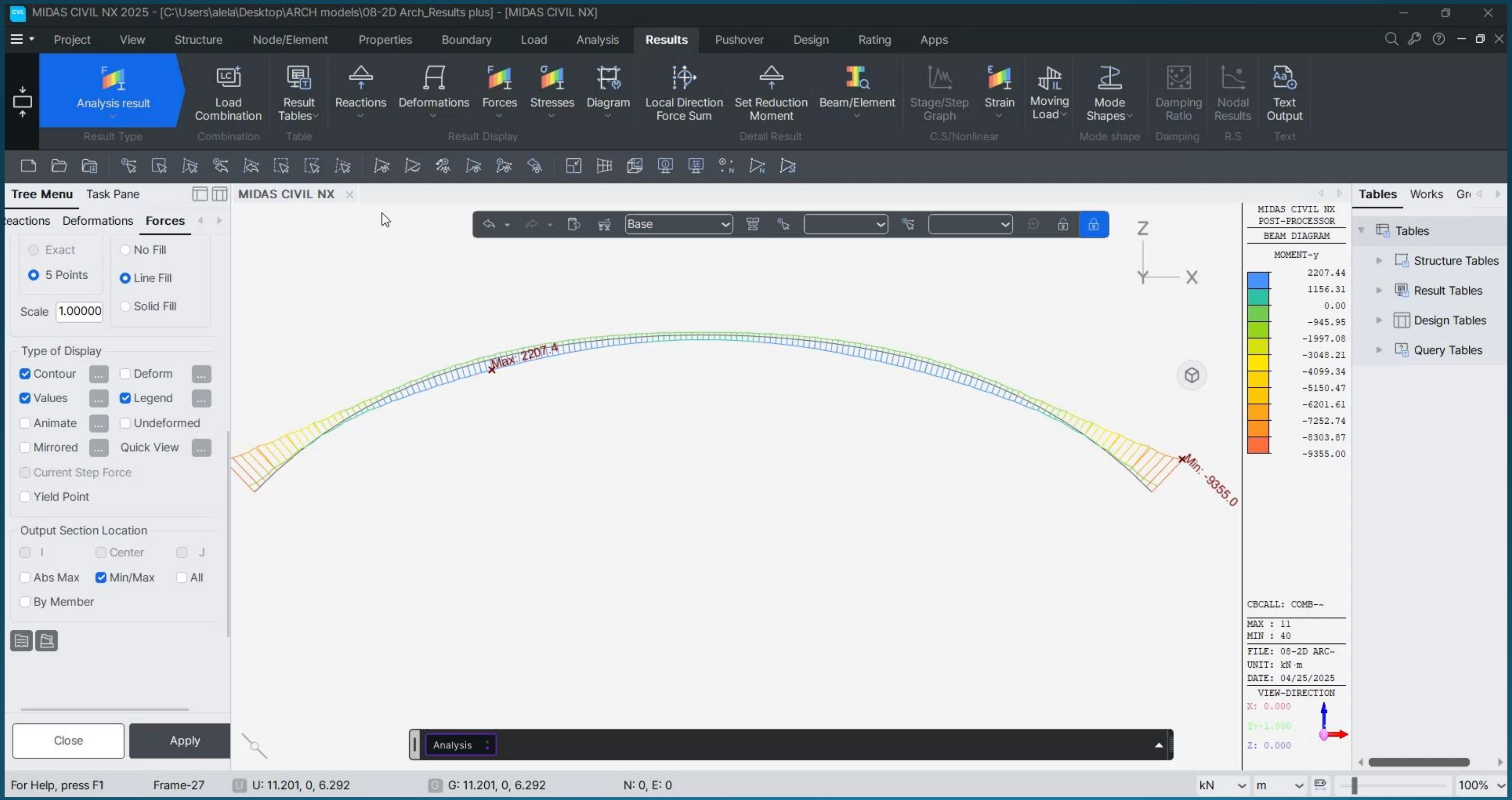
- **Trace and graphically display the vehicle loading condition (corresponding moving load case and location) that results in the maximum/minimum reaction of support, node displacement or force/moment component**



Results Extraction – Excel Connector

Use Midas CONNECTOR to automate results and image extraction to EXCEL

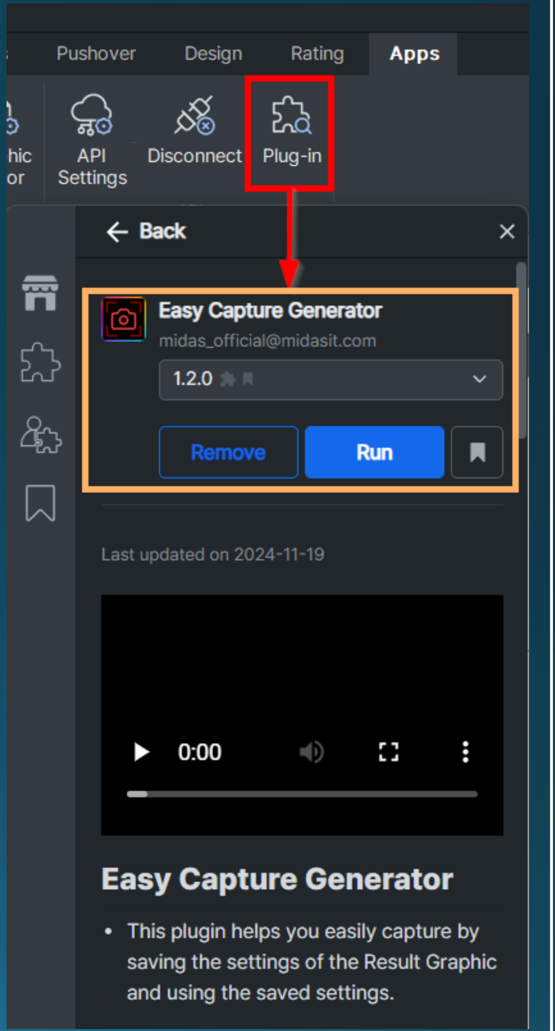
- **The extraction is dynamic: changes to the analysis model will be reflected into the previously extracted results**



Results Extraction – Plug-ins

Use integrated Plug-ins → example: automate the creation of sets of results images

- **EASY CAPTURE GENERATOR** helps you automatically generate multiple prints by saving the settings information of the Result Graphic and using the saved files (in JSON format) for other models (Fixing bugs in progress !!!)



THANK YOU

CVL

A Powerful Move Forward

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MIDAS