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

MSc Eng. Alessandro Laurenza Senior Technical Engineer MIDAS IT Europe <u>alelau@midasit.com</u>









CVL

Contents Overview

Contents

- 1. Quick Intro of Enhancements in Civil NX
- 2. Overview of RC Arch Bridges
- 3. Data of Bridge under study
- 4. Advanced Modeling with Civil NX tools
- 5. Permanent and Traffic Loads generation
- 6. Analysis of Result Forces
- 7. Output Extraction with midas Connector





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





New Capabilities of Civil NX

API Integration EXAMPLE \rightarrow **Python Template** – Magnel Diagram for Prestress Beam

×1 =		o x
Image: project Image:	A budy A	→ ●× × · · · · · · · · · · · · · · · · ·
	40 yb = sect_prop[sect_prop[sect_prop[sect_prop] 41 #	-
Q Search	🚥 🔲 📮 🖞 🧟 🥰 🚍 M 🍕 👰 🚱	21:12 04-03-2025



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 \rightarrow 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, <u>https://legacy.ahs-inc.com/open-spandrel/comparison.html</u>

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 , <u>https://concrete.ethz.ch/assets/arch-bridges-2023-04-11.pdf</u>

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)	No. of Concession, Name	arch axis	crown arch rib rise <i>f</i>		
Support	Clamped to Abutments	clamped		springing line	clamped	arch
Traffic	Roadway, Carriageway width = 7.30m	support			support	abutment
Total width	12 m (= 2 Lanes x3.65m + 2 Footways x 1.85m + 2 Edge x 0.50m)	•		span /		
Span L	42.672 m (between springings)					
Rise f	7.468 m (f/I= 1/5.71)			Fill mate	erial	
Crown thk	0.61 m					
Thk at supports	1.22 m		1	Ľ		
Spandrel Walls thk	Varying= 0.30 ÷ 1.22 m		Spandrel walls			
H fill at crown	0.30 m		A	rch structure		
H surface pav	0.40 m					



RC Arch Bridge – Data





Arch Rib – Coordinates of c/l

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

X	Y	Z	Tł	ΗK
[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



midas CIVIL NX 2025 Bridge/Structural Analysis & Design

MIDAS CIVIL NX Academy

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"

Length	Force (Mass)	Heat
O m	○ N (kg)	⊖ cal
⊖ cm	• kN (ton)	⊖ kcal
\bigcirc mm	🔿 kgf (kg)	OJ
⊖ ft	O tonf (ton)	⊖ kJ
\bigcirc in	Olbf (lb)	O Btu
	⊖ kips (kips/g)	





Modeling – Arch Rib Elements

Input Beams from Excel using Midas CONNECTOR

MIDAS

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

Start Page × MIDAS CIVIL NX ×

MIGGS CONNECTOR	*ELEMENT ; Elements							
	· IEL TYPE IMAT IPRO I'	N1 iN2	ANGL	E ISUR	1	· Frame	Element	
		NI, INC. /	ANOLE	1000	, 			
e data	; IEL, TYPE, IMAT, IPRO, IN	1, IN2, P	ANGLE,	ISUB, F	-XVAL, E	XVAL2, DLW	IT; Comp/Tens Truss	
	; iEL, TYPE, iMAT, iPRO, iN	1, iN2, if	N3, iN4	, iSUB, i	WID, LC	AXIS ; Plan	nar Element	
	· iEL TYPE IMAT IPRO IM	11 iN2 i/	N3 iN4	iN5 iN	6 iN7 iN	8 Solid F	lement	
	, IEE, III E, III I, III I, III I, III	1, 1142, 11	10, 111,	1110, 111	3, 111, 111	, 0010 E		
insfer	1, BEAM , 1, 1, 1,	2, 0), 0					
	K		М	N	0.0			_
	К	L	M	N	0	MIDAS CONF	NECTOR	\sim
						WIDAS CONT	NECTOR	
					 /	Header	ELEMENT	~
iEL	, TYPE, IMAT, IPRO, IN1, IN2, ANGLE, ISUB							
	ΕΔΜ111200	+			IV	Name	BEAMS	
28	FAM 112300				I			
38	FAM 1 1 3 4 0 0					Folder	Elements	0
4.8	EAM 1 1 4 5.0.0							
5.B	EAM.1.1.5.6.0.0	í						
6,B	EAM.1.1.6.7,0,0	(+ Add To Folder	
7,B	EAM 1.1.7.8.0.0	(
8,B	EAM.1.1,8,9,0,0	(
	EAM.1,1,9,10,0,0	(
10,7	JENU 1 1,10,11,0,0	(Defer		
11,7	3EAM,1,1,112,0,0	1				A Defaul	lt	
12,1	JEAM, 1, 1, 12, 13, 0, 0	1						
13,5	JEAM,1,1,13,14,0,0	(Noi	items.	
	JEAM,1,1,14,15,0,0	1						
🖘 🗸 🗸 🗊 🙀 Base 🛛 🖌 🔂 🚺	JEAM,1,1,15,16,0,0					A Node		
16,1	EAM,1,1,16,17,0,0					∧ Nodes	5	
17,	EAM,1,1,17,18,0,0	i						
18,1	EAM,1,1,18,19,0,0	(= NODE	ES ['MCT_Nodes'!H9:H49]	\$
19,1	EAM,1,1,19,20,0,0	(-				
	EAM,1,1,20,21,0,0	l						
13 14 19 22	EAM, 1, 1, 21, 22, 0, 0	(▲ Elemer	ents	
11 12 23	2EAM 1 1 22 24 0 0	(
10 241	PEAM 1 1 24 25 0 0	(+				= BEAM	/IS ['MCT_beams'!K12:K51]	¢
9	PEAM 1 1 25 26 0 0	(
261	REAM 1 1 26 27 0 0	(
271	REAM 1 1 27 28 0 0	(•		All MXT Export	
	+ : 0	_	_					
	T : N							_
							×	
							3.9	

Section 0

I Material 0

I Properties

Tree Menu Task Pane

Search

Works

Structures

Works Group Report 4

Nodes 41 Elements 40

Modeling -Top level elements

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

 \rightarrow 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)

					Material Data					>	<
neral					General						
terial ID 1		Name	C30		Material ID	2	Na	me	Dummy		
sticity Data					Electicity Data						
be of Design	oncrete 🗸	Steel			Elasticity Data	a	Steel				
		Standard		~	Type of Design	Concrete ~	Sta	ndard		~	
-		DB		~				DB		~	
		Concrete									
		Standard	BS(RC)	~			- Cond	rete			
ype of Material		Code		~			Sta	ndard	None	~	
Isotropic	Orthotropic	DB	C30	~	- Type of Materia		c	ode		~	
teel						O Orthotropic		DB		~	
Iodulus of Elasticity	0.0000	e+00 kN/m ²				C transfer					
oisson's Ratio		0			Steel						
hermal Coefficient	0.0000)e+00 1/[C]			Modulus of Elas	ticity 0.0	000e+00	kN/m ²			
Veight Density		0 kN/m ³			Poisson's Ratio		0				
Use Mass Density		0 kN/m ³ /	'g		Thermal Coeffic	ient 0.0	000e+00	1/[C]			
Concrete					Weight Density		0	kN/m³			
odulus of Elasticity	2,4596	6e+07 kN/m ²			Use Mass Der	nsity	0	kN/m³/	g		
oisson's Ratio		0.2									
hermal Coefficient	1.000	De-05 1/[C]			Madulus of Floo	tioitu 0.4	E06a (0.4	Ich I /ma 2	1		
Veight Density		23.6 kN/m ³	1		Modulus of Elas	2.4	5966+04	KIN/M-	1		
Use Mass Density		2.407 kN/m³/	g		Poisson's Ratio		0.2				
					Thermal Coeffic	ient 1.0	000e-05	1/[C]			
sticity Data					Weight Density		0	kN/m³			
astic Material Name	NONE			~	Use Mass De	nsity	2.407	kN/m³/	g		
lastic Material Prop	erties for Fiber Mode	el									
ncrete None	~	Rebar No	one								
nfined Concrete for	Columns	None		~							



Ge

Ma

۷

Co Co

SRC

Composite

Combined

Steel Girder

m

~

 \sim

m

DB/User

PSC

Value

Tapered

Modeling - Tapered Sections & Tapered Groups

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

 \rightarrow 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 \rightarrow 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



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

43	44	45	46 ×	47 *	48 × Y	49 * 2	50 51	52 × z	53 7 z 12	54 55 4 72 72 72 13 14	6 57 Jz 7 5 16	58	59 60 12 112 (18 19 (61 62 20 21 [20 21	63 64 22 23	65 66 22 22 24 25	67 6 26 2	8 69 Jz 1 z 7 28	70 * 29 29
	(¹ 2 ^z		M	No	Node1	X X Node2	Elastic Lii Type	nk × 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	10000000.00	0.0000	0.0000	0.00	0.00	0.00	Γ	0.50	0.50	Vertical Links
			/	2	2	43	COMP	0.00		10000000.00		0.0000			0.00	Γ	0.50	0.50	Vertical Links
		4		3	3	44	COMP	0.00	0000	10000000.00	0.0000	0.0000	0.00	0.00	0.00	Г	0.50	0.50	Vertical Links
	/			4	4	45	COMP	0.00	0000	10000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
	13			5	5	46	COMP	0.00	0000	10000000.00	0.0000	0.0000	0.00	0.00	0.00		0.50	0.50	Vertical Links
~				6	6	47	COMP	0.00	0000	10000000.00	0.0000	0.0000	0.00	0.00	0.00	<u> </u>	0.50	0.50	Vertical Links
				7	7	48	COMP	0.00	0000	10000000.00	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
			_	10	10	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	54	COMP	0.00	0000	10000000000000	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	Ē	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	Г	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	Г	0.50	0.50	Vertical Links
				19	19	60	COMP	0.00	0000	10000000.00	0.0000	0.0000	0.00	0.00	0.00	Г	0.50	0.50	Vertical Links
				20	20	61	COMP	0.00		10000000.00	0.0000	0.0000	0.00	0.00	0.00	Γ	0.50	0.50	Vertical Links
				21	21	62	COMP	0.00		10000000.00	0.0000	0.0000	0.00	0.00	0.00	Г	0.50	0.50	Vertical Links
				22	22	63	COMP	0.00	0000	10000000.00	0.0000	0.0000	0.00	0.00	0.00	Г	0.50	0.50	Vertical Links
				23	23	64	COMP	0.00	0000	10000000.00	0.0000	0.0000	0.00	0.00	0.00	Γ	0.50	0.50	Vertical Links
				24	24	65	COMP	0.00	0000	10000000.00	0.0000	0.0000	0.00	0.00	0.00	Г	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 preliminarly defined \rightarrow

Static Load Cases ×											
Nan	ne	EPH		Add							
Cas	е	Permane	~	Modify							
Тур	е	Horizonta	al Earth Pressure (EH)	~	Delete						
Des											
	No	Name	Туре	De	Description						
	1	SW	Dead Load (D)								
	2	DL-PAV									
	3	FILL-V									
	4	EPH									
*											



Loads Assignment – Soil (Vertical) – Trapezoidal Beam Load

Tree Menu Task Pane	IIDAS CIVIL NX \times	Beam Load	×															
de Element Boundary Mass Load 🔹 🕨	Element BM LD Type	Load Cas Loa	d Type Ecc.	Есс. Туре	Ecc. Dir. Us	se J Dist-I(m)	Dist-J(m)	Add. H	Add. Use J	Add. Dist I(m)	Add. Dist J(m)	irection Proje	ctio D1 D2	D3 D4	P1 P2	P3	P4	Ur
Options	1 Beam Load	FILL-V Dist	ibut 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	-18641619.	0.00	0.00	kiv)
Options	2 Beam Load	FILL-V Dist	ibut 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	-16191402.	0.00	0.00	/ kiv
Add	3 Beam Load	FILL-V Dist	ibut 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	-14021211.	0.00	0.00	kiv
	4 Beam Load	FILL-V Dist	ibut No	Centroid	Localy No	0.00	0.00	No	No	0.00	0.00	Global Yes	0.00 1.00	0.00 0.00	-12111043.	0.00	0.00	
Load Type	5 Beam Load	FILL-V Dist	ibut No	Centroid	Local y No	0.00	0.00	No	No	0.00	0.00	Slobal Yes	0.00 1.00	0.00 0.00	-1043895.3	0.00	0.00	
Trapezoidal Loads	6 Beam Load	FILL-V DIST	IDUT NO	Centrold	Local y No	0.00	0.00	NO No	N0	0.00	0.00	GIODAI Yes	0.00 1.00	0.00 0.00	-895.3 -765.0	0.00	0.00	
	7 Beam Load	FILL-V Dist	ibut No	Centroid	Local y No	0.00	0.00	No	No	0.00	0.00	Nobal Yes	0.00 1.00	0.00 0.00	-705.0 -050.0	0.00	0.00	
W2	0 Beam Load	FILL-V Dist	ibut No	Centroid	Localy No	0.00	0.00	No	No	0.00	0.00	Nobal Yes	0.00 1.00		-050.0 -550.4	0.00	0.00	
W1 W3 W4	10 Beam Load	FILL-V Dist	ibut No	Centroid	Localy No	0.00	0.00	No	No	0.00	0.00	Slobal Ves	1.00 1.00	0.00 0.00	-163.0 -387.0	0.00	0.00	
N1 N2	11 Beam Load	FILL-V Dist	ibut No	Centroid	Localy No	0.00	0.00	No	No	0.00	0.00	Slobal les	0.00 1.00	0.00 0.00	-387.0 -321.3	0.00	0.00	klu
	12 Beam Load	FILL-V Dist	ibut No	Centroid	Local v No	0.00	0.00	No	No	0.00	0.00	what Yes	0.00 1.00	0.00 0.00	-321.3 -264.9	0.00	0.00	klu
X1 X2	13 Beam Load	FILL-V Dist	ibut No	Centroid	Local v 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	klu
X3 X4	14 Beam Load	FILL-V Dist	ibut No	Centroid	Local v 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	k k
7 14	15				INFIL I	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	k
			4		4h *D*LL	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	k ki ki
O Fesentriaitu	17 NODE ID	H_rei H_fil	-тор ү_тш	Elem.wid	τη γ _{fill} Β΄Η	0.00	0.00	No	110	0.00	0.00	Global Yes	0.00 1.00	0.00 0.00	-117.5 -97.38	0.00	0.00	k ki vi
	18	[m] [n] [kN/m3]	[m]	[kN/m]	0.00	0.00	10	No	0.00	0.00	Global Yes	0.00 1.00	0.00 0.00	-97.38 -83.19	0.00	0.00	i ki J/
Direction Global Z 🗸	19 1	7.47 0.3	0 20.0	12.00	-1864.2	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	i kivi
Projection O Yes O No	20 2	6.45 0.3	0 20.0	12.00	-1619.2	5.00	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	/ kiv/
Velue	21 3	5.54 0.3	0 20.0	12.00	-1402.8	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	/ kiv/
value	22 4	4.75 0.3	0 20.0	12.00	-1211.9	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	/ kid/
Relative Absolute	23 5	4.05 0.3	0 20.0	12.00	-1043.5	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	/ kid/
	24 6	3 43 0 3	0 20.0	12 00	-895.3	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	i kivi
x1 0 W1 -1864.2	25 7	2.89 0.3	0 20.0	12.00	-765.0	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	/ kid/
x2 1 W2 -1619.2	26	2.03 0.0	0 20.0	12.00	-650.6	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	/ kiv/
x3 0 W/3 0	9	1.99 0.3	0 20.0	12.00	-550.5													
	10	1.63 0.3	0 20.0	12.00	-463.1						into Oiv			inee				
x4 0 W4 0	11	1.31 0.3	0 20.0	12.00	-387.1	\rightarrow Cob		pasi	eiron	1 EXCEI	into Civ		apie (o	inse	ru			
Unit: kN/m	12	1.04 0.3	0 20.0	12.00	-321.4													
	13	0.80 0.3	0 20.0	12.00	-265.0	quickiy	/ PI, P4	2 TOF (every	arch e	iement							
Close Apply	14	0.60 0.3	0 20.0	12.00	-217.1													
	15	0.44 0.3	0 20.0	12.00	-176.9													
	16	0.30 0.3	0 20.0	12.00	-143.8													
	17	0.19 0.3	0 20.0	12.00	-117.5													
	18	0.11 0.3	0 20.0	12.00	-97.4													
	19	0.05 0.3	0 20.0	12.00	-83.2													
	20	0.01 0.3	0 20.0	12.00	-74.8													
	21	0.00 0.3	0 20.0	12.00	-72.0													

Loads Assignment – Soil (Vertical) – Trapezoidal Beam Load



midas CIVIL NX 2025 Bridge/Structural Analysis & Design

Loads Assignment – Soil (Horizontal) -> Trapezoidal 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. Us	e J Add. Dist I(m)	Add. Dist J(m) Direction Pr	ojectio D1	D2 D3 I)4 P1 P2	P3
Load Type		1 Beam Load	EPH	Distributed F	No	Centroid	Local y	No		0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 372.80 323.8	0.00
Trapezoidal Loads		2 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 323.80 280.6/	0.00
		3 Beam Load	EPH	Distributed F	No	Centroid	Local y	No		0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 280.60 242.4	0.00
		4 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 242.40 208.7/	0.00
W2 W3		5 Beam Load	EPH	Distributed F	No	Centroid	Local y	No		0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 208.70 179.1/	0.00
W1 W4		6 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 179.10 153.0	0.00
N1 N2		7 Beam Load	EPH	Distributed F	No	Centroid	Local y	No		0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 153.00 130.1/	0.00
		8 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 130.10 110.1/	0.00
		9 Beam Load	EPH	Distributed F	No	Centroid	Local y	No		0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 110.10 92.6/	0 0.00
×2 ×3		10 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 92.60 77.4/	0 0.00
X4		11 Beam Load	EPH	Distributed F	No	Centroid	Local y	No		0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 77.40 64.3/	0.00
		12 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 64.30 53.0/	0 0.00
		13 Beam Load	EPH	Distributed F	No	Centroid	Local y	No		0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 53.00 43.4/	0 0.00
		14 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 43.40 35.4/	0 0.00
Eccentricity		15 Beam Load	EPH	Distributed F	No	Centroid	Local y	No		0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 35.40 28.8/	0 0.00
Direction Global X 🗸		16 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 28.80 23.5/	0 0.00
	3	17 Beam Load	EPH	Distributed F	No	Centroid	Local y	No		0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 23.50 19.5/	0 0.00
Projection O Yes O No		18 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 19.50 16.6/	0 0.00
	323.80	19 Beam Load	EPH	Distributed F	No	Centroid	Local y	No		0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 16.60 15.0/	0 0.00
Value	323.00	20 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 15.00 14.4/	0 0.00
Relative Absolute	372.80	21 Beam Load	EPH	Distributed F	No	Centroid	Local y	No		0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 -14.40 -15.0/	0 0.00
• Relative • Absolute	012.000	22 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 -15.00 -16.6/	0 0.00
x1 0 W1 372.8		23 Beam Load	EPH	Distributed F	No	Centroid	Local y	No		0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 -16.60 -19.5/	0 0.00
		24 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 -19.50 -23.5/	0 0.00
x2 1 W2 323.8		25 Beam Load	EPH	Distributed F	No	Centroid	Local y	No		0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 -23.50 -28.8/	0 0.00
		26 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 -28.80 -35.4/	0 0.00
x3 0 W3 0		27 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 -35.40 -43.4/	0 0.00
		28 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 -43.40 -53.0/	0 0.00
x4 0 W4 0		29 Beam Load	EPH	Distributed F	No	Centroid	Local y	No	0.00	0.00 N	o No	0.00	0.00 Global Ye	s 0.00	.00 0.00 0	.00 -53.00 -64.3/	0 0.00
Linit · kN/m				40.50	16.60 15.0	00 14.40 -1	4 40 -15 00	-16 60	40.50								
Onic. Kiyini			40 28.80	23.50 19.50	10.00		10.00	-10.00	19.50 -23.50	-28.80 -35.40							
		53.00 43.40									-43.40 -53.00						
	77.40	64.30										-64.30				\bigcirc	
	92.60											-92	.60			\checkmark	
	110.10												-110.10				
	130.10												-130.10				
15	53.00												-153.00				
179.10														-179.10			
208.70														-208.7	D		
242.40															-242.40		
200.00																00.00	
280.60																00.06	
222.90																222.00	
323.60																-323.80	
372.80																	72.80

Loads Assignment – Wearing/Pav→ Uniform Beam Load



Assessment Live Load-UK case (example)

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):

<u>ALL model 1</u>

UK – CS 454 & 455

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



MIDAS

• <u>All model 2</u> \rightarrow used in this case

ALL model 2

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

5.19f and Table 5.19c.

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

Civil NX.

Comb ned uniform and knife-edge load

For the	purposes of applyi	The notional lanes should be assumed to be equally distributed across the carriageway width.
be divi de	ed into a number o	The combined uniform and unifored as leading, applied in each land, shall consist of a uniformly
ļ		distributed load (UDL) together with a single knife-edge load (KEL), determined in accordance with Table 5.19a, modified by the following factors:
<u>single ax</u> utomatiz	<u>le load not</u> ed in midas	 The lane factors in Table 5.19b; The K-factors accounting for surface category and traffic flow category given in Figures 5.19a to



Table 5.19a Uniform and knife-edge loading

Loaded length, L (m)	UDL (kN/m)	KEL (kN)
$L \leq 20 {\sf m}$	$\frac{230}{L^{0.67}}$	82
20m < L < 40m	$\frac{336}{L^{0.67}}$, $\frac{1}{1.92 - 0.023L}$	$\frac{120}{1.92 - 0.023L}$
$40m \le L \le 50m$	$\frac{336}{L^{0.67}}$	120
L > 50m	$\frac{36}{L^{0.1}}$	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
ane 4 and	subsequent	0.4

lote 1: Where the bridge carries two-way traffic, N is taken as the total number of notional lanes on ne bridge, including all notional lanes for dual carriageway roads.

lote 2: Where the bridge carries one-way traffic only, the value of N is taken as twice the number of otional lanes on the bridge.

lote 3: The lane factors are interchangeable between lanes.

midas CIVIL NX 2025 Bridge/Structural Analysis & Design

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
$36 < L \le 50$	$\frac{336}{L^{0.67}} \cdot \frac{10}{L+270} \cdot 5.0$
$50 < L \le 400$	$\frac{36}{L^{0.1}} \cdot \frac{10}{L+270} \cdot 5.0$



Live Load – UK case

3 fundamental steps to define live load in Civil NX:

Moving Load	Moving Load Code BS ~	raffic Line Tr Lanes ∨	affic Surface Lanes~	2 Vehicles K	loving d Cases			
	Moving Load Code	М						
raffic Lane	s definition:		footway	remaining	notional	notional	remaining	footway
			LT FOOT	LT R.A.	LANE 1	LANE 2	RT R.A.	RTFOC
		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





Lane Name LT-foot
Traffic Lane Properties
θ
e Start End
a : Eccentricity
Lane Width 1.85 m
Eccentricity -4.575 m
Wheel Spacing 0.5 m
Transverse Lane Optimization
Allowable Width 3 m
Vehicular Load Distribution
Lane Element Cross Beam
Cross Beam Group
Skew
Start 0 \$\$ End 0 \$\$ [deg]
Moving Direction
○ Forward ○ Backward ○ Both
Selection by
• 2 Points • Picking • Number
42.1386, 0, 8.1676 m
42.672, 0, 8.1676 m
Operations
Add Insert Delete
No Elem Eccen. (m)
1 41 -4.575
<u>2</u> <u>42</u> <u>-4.575</u> <u>3</u> <u>43</u> <u>-4.575</u>
4 44 -4.575

Live Load- UK case

Traffic Lanes definition:





midas CIVIL NX 2025 Bridge/Structural Analysis & Design

Live Load-Vehicles for Assessment

Only KEL + UDL of All Model 2 considered

(Load dispersal is not considered in Civil NX)

Pedestrian Live Load

Define Standard Vehicular Load		
Standard Name		
BD37/01 Standard Load	~	
Vehicular Load Properties		
Vehicular Load Name	Pedestrian	
Vehicular Load Type	Pedestrian ~	
Pedestrian Live Load		
\checkmark	w	
K	K oo	
W = 5 kN/m ²	:L<= 36 m	
W = k*5 kN/m ²	: 36 < L m	
k = nominal HA UDL for appropria	ate loaded length*10 / (L+270)	

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 bas 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.

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

OCS 454

User-defined

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

Lane Factor

- Category for K-Facto

Traffic/Surface Category :	Hp	~
Load Level :	40t	~



MVL Cases and Load Combinations

ALL MODEL 2 (KEL+UDL) + FOOTWAY

Define Moving Load Case	×
Load Case Name	ALM2
Description	
Moving Load Optimization	n
Select Load Model	
Standard Load (BD 37/0	01, BS 5400)
O Special Load (BD 86/11	1)
O CS 454 Assessment (AL	LL Model 1, Special Load)
CS 454 Assessment (AL	LL Model 2, Special Load)
 Auto Live Load Combination Type of Design Combination Ultimate Limit State Serviceability Limit State Combination of Loads Combination 1 Combination 2 or 3 Load Case Data Standard Load Special Load 	ation on Factor e ALL MODEL 2(UDL+KEL)
Assignment Lanes	
Line of Lanes Sel	lected Lanes Straddling Lanes
LT-foot RT-foot	ane 1 ane 2

Define Moving Load Case		Sub-Load Case
Load Case Name Description Moving Load Optimization Select Load Model Standard Load (BD 37/01, BS Special Load (BD 86/11) CS 454 Assessment (ALL Mo CS 454 Assessment (ALL Mo Auto Live Load Combination Fa	FOOT 5 5400) del 1. Special Load) del 2. Special Load) ctor	Load Case Data Scale Factor Number of Loaded Lanes Vehicle Assign Lanes List of Lanes Select Lane 1 Lane 2
Combination of Loads Combination 1 Combination 2 or 3 Sub-Load Cases		ОК
Loading Effect Combined Inde Vehicle Scale Lane Pedestri 1 LT-fo	ependent 1 Lane2 Lane3 L toot RT-foot Image: Cancel of the second s	v J

			×
oad Case Data			
cale Factor	1		
lumber of Loaded Lanes	2	\$	
ehicle	Pedestrian	*	
ssign Lanes			
List of Lanes S	elected Lanes	HB Straddling Two Lanes	
ane 1 LT ane 2 R <	'-foot '-foot		-
ок	Cance	Apply	
*			
Y V	×		

LOAD COMBINATIONS

PERM LOADS

General Steel Design Concrete Design SRC Design Composite Steel Girder Design

No	Name	Active	Туре	Descripti
1	PERM	Active	Add	
2	LIVE	Active	Add	
3	COMB-1	Active	Add	

General Steel Design
Load Combination List
No N

•

1 PERM 2 LIVE 3 COMB-1

	LoadCase	Factor
۲	SW(ST)	1.0000
	DL-PAV(ST)	1.0000
	FILL-V(ST)	1.0000
	EPH(ST)	1.0000
*		

PERM + LIVE

In Concrete	Design SRC	Design Compo	site Steel Girder Desig	n		
st				Loa	d Cases and Factors	
Name	Active	Туре	Descripti		LoadCase	Factor
	Active	Add		•	PERM(CB)	1.0000
	Active	Add			ALM2(MV)	1.0000
1	Active	Add			FOOT(MV)	1.0000
				*		



Results Display – Conventional functions



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 \rightarrow example: automate the creation of sets of results images

MIDAS

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 !!!)



• This plugin helps you easily capture by saving the settings of the Result Graphic and using the saved settings.

THANK YOU

A Powerful Move Forward

CVL

alelau@midasit.com

