

MODELLING PHILOSOPHY: WHY MIDAS

Agenda

- **Modeling Philosophy**
- **Similarities in workflow in midas Civil & MDX**
- **MDX result verification using midas Civil**
- **Using midas Civil for more complex problems**

MODELING PHILOSOPHY

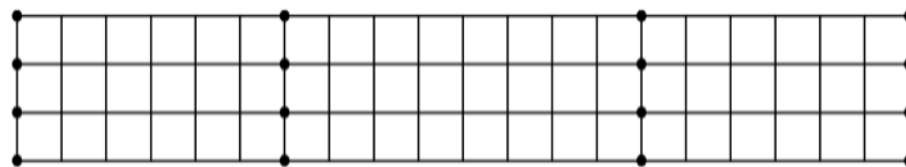
MODELING

Three main modeling methods

- 2D Grillage models
- 3D Grillage models
- Meshed Finite Element model

2D MODELING

- Most common modeling method
- Modeled as orthogonal or skewed grillage depending on site requirements

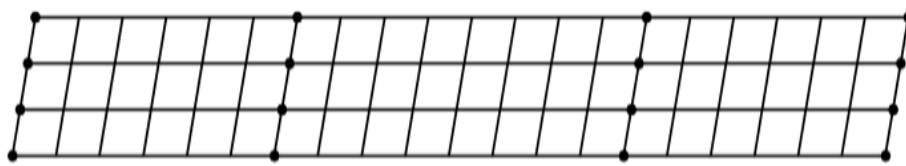


(a) Orthogonal grillage

MDX



midas Civil



(b) Grillage for spans with small skew $< 20^\circ$

MDX



midas Civil



(c) Grillage for spans with large skew ($> 20^\circ$)

MDX

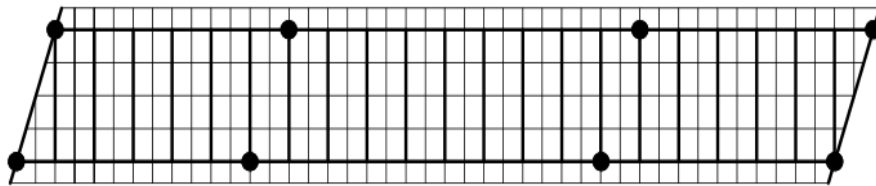


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3D MODELING

- 3D Grillages are quite useful when dealing with ladder deck bridges



Elements representing main girders, cross girders and trimmer girders
 Elements representing deck slab

MDX

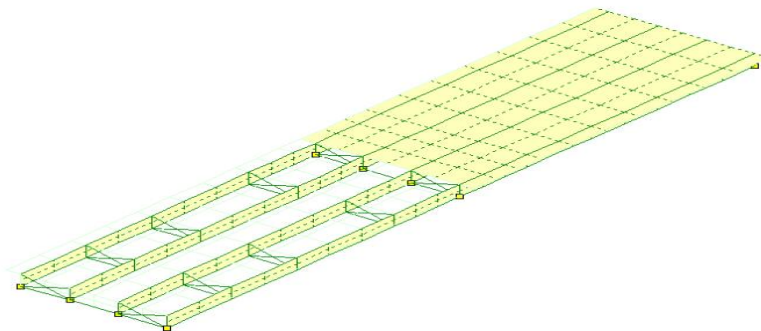


midas Civil



FINITE ELEMENT MODELING

- More realistic structural response. Accurate representation of local and global responses.
- Models can be built using combination of plate and beam elements .



(Slab on near span not shown)

MDX



midas Civil



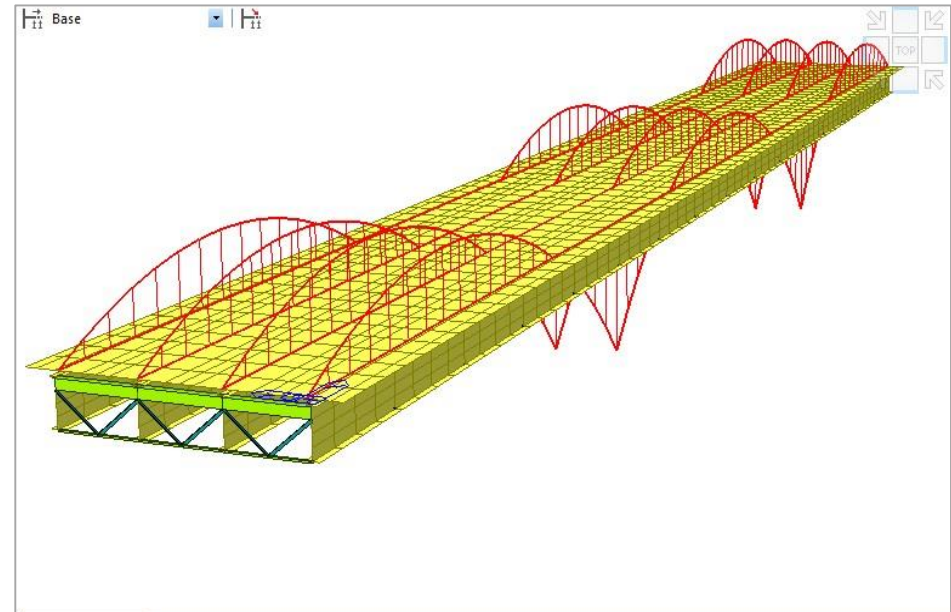
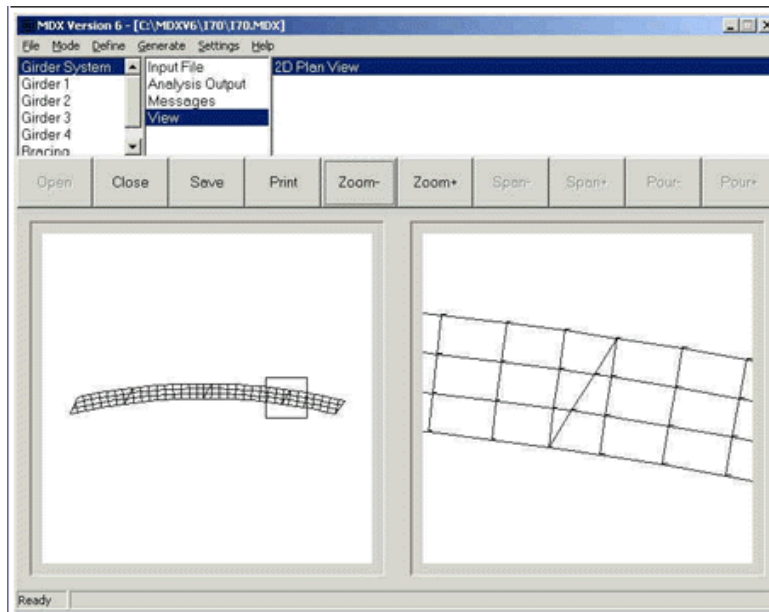
Conclusion

- For simple projects including 2D grillage with skew $< 20^\circ$, either MDX or midas Civil can be used for the preliminary design
 - Owing to similarity of input/output, midas Civil/MDX can be used to verify the results
- For bridges with skew $> 20^\circ$, MDX can be used with some spreadsheet calculations to support large skew, or midas Civil can be used directly
- For bridges requiring Finite Element Modeling, midas Civil can be used

Similarities in workflow midas Civil & MDX

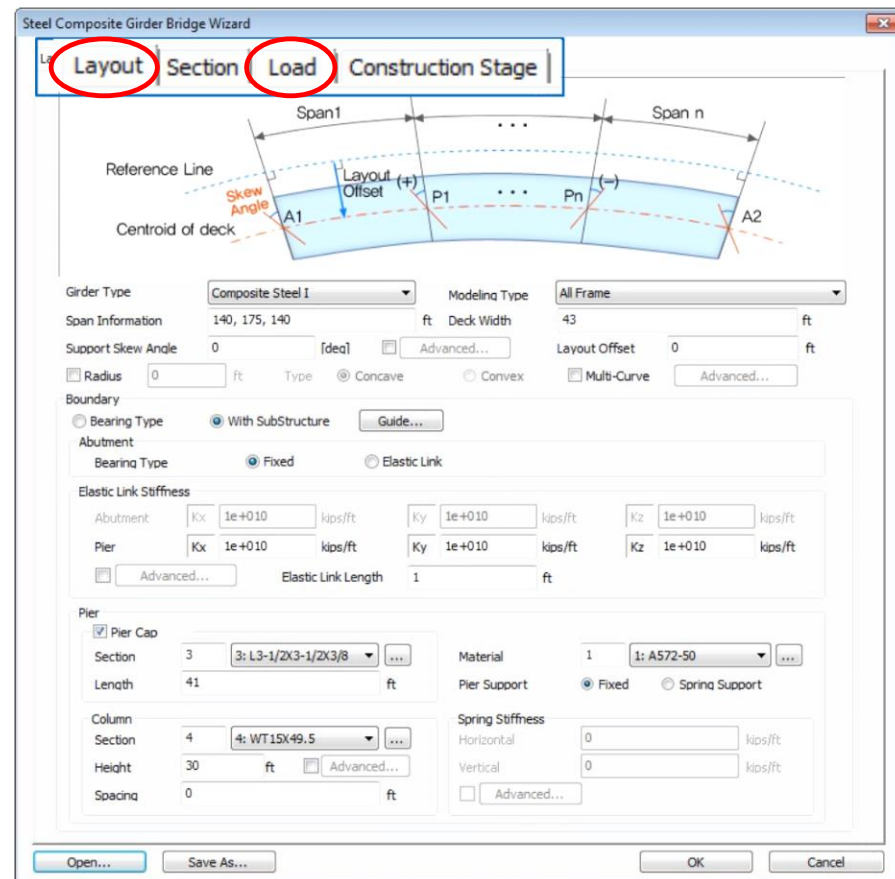
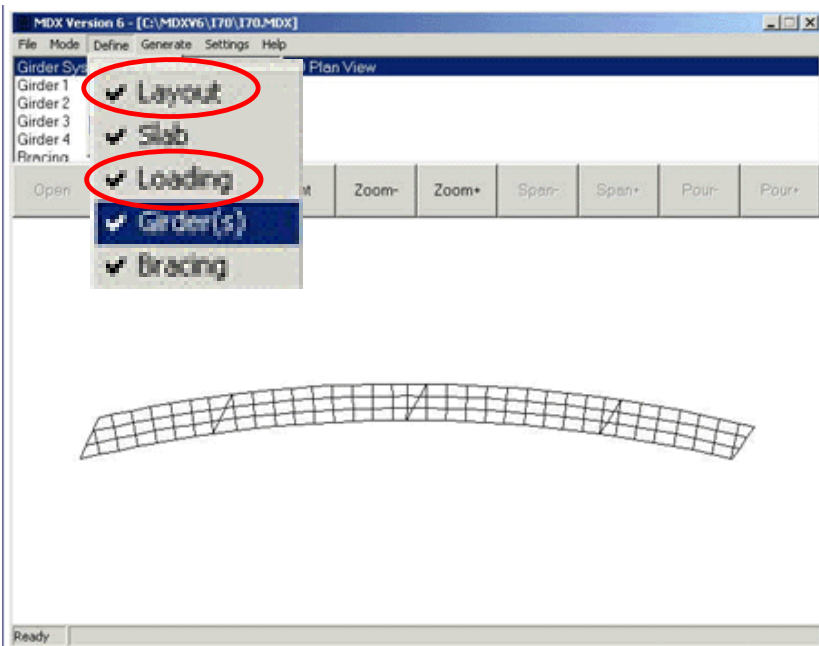
Similarity in workflow

Model View



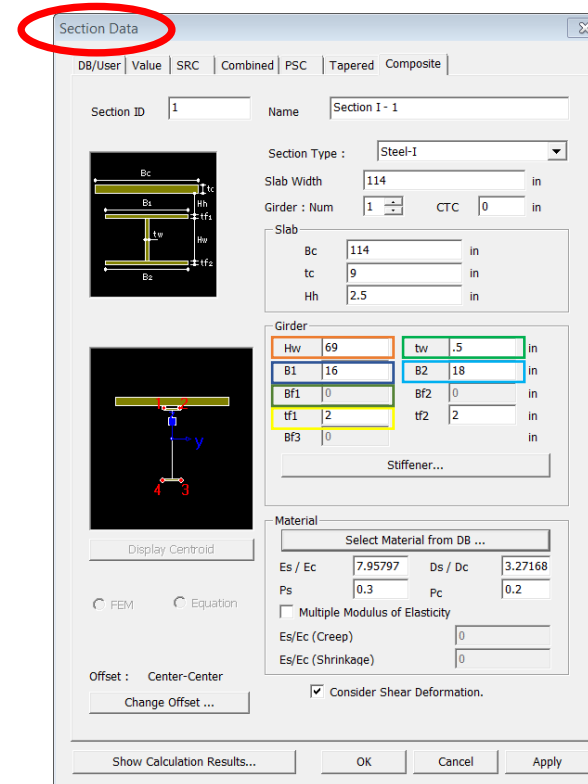
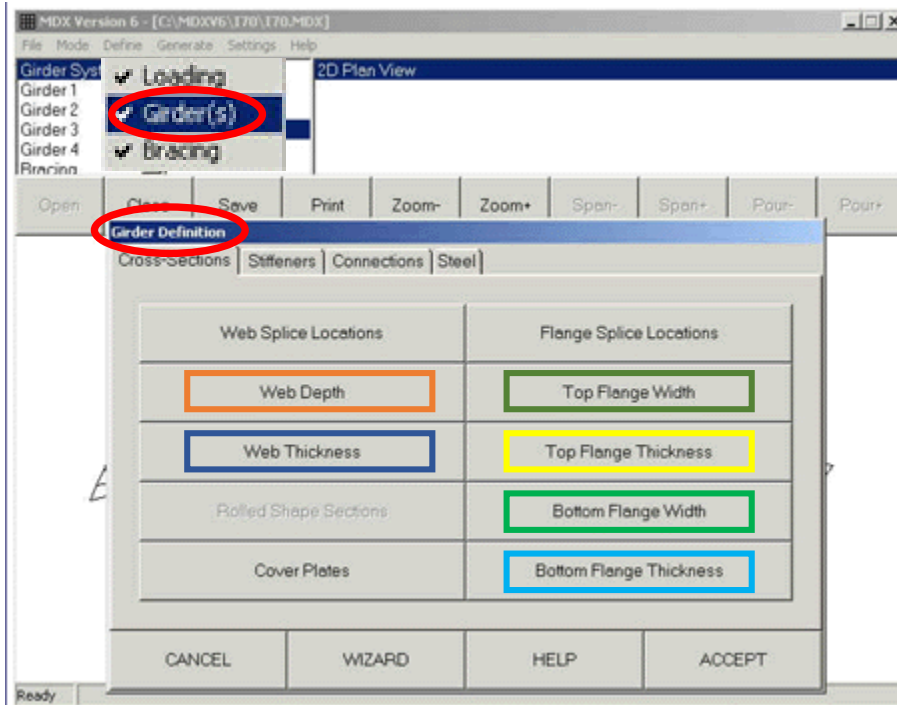
Similarity in workflow

Wizard Tabs



Similarity in workflow

Steel Composite Girder Bridge Wizard



Similarity in workflow

Temperature Load

Type of Construction	Temperature Difference (ΔT)	
	(a) Heating	(b) Cooling
<p>3a. Concrete slab</p>	<p> $h_1 = 0.3h$ but $\leq 0.15m$ $h_2 = 0.3h$ but $\geq 0.10m$ but $\leq 0.25m$ $h_3 = 0.3h$ but $\leq (0.10m + \text{surfacing depth in metres})$ (for thin slabs, h_3 is limited by $h - h_1 - h_2$) </p>	<p> $h_1 = h_2 = 0.20h$ but $\leq 0.25m$ $h_3 = h_3 = 0.25h$ but $\leq 0.20m$ </p>
<p>3b. Concrete beams</p>		

h	ΔT_1	ΔT_2	ΔT_3	ΔT_4
m	°C	°C	°C	°C
≤ 0.2	-2.0	-0.5	-0.5	-1.5
0.4	-4.5	-1.4	-1.0	-3.5
0.6	-6.5	-1.8	-1.5	-5.0
0.8	-7.6	-1.7	-1.5	-6.0
1.0	-8.0	-1.5	-1.5	-6.3
≥ 1.5	-8.4	-0.5	-1.0	-6.5

Element Temp.

Temp. Gradient

Beam Section Temp.

System Temp.

Nodal Temp.

Temperature Loads

THERMAL EFFECTS FOR STEEL BUILDING OR STRUCTURE			
Determine Max. Design Temperature Change, Change of Length or Stress as Applicable, and Max. Length either without or between Expansion Joints			
Job Name:		Subject:	
Job Number:		Originator:	Checker:
Input Data:			
Summer Temp. $T_w =$	130.0	°F	$T_w =$ Temp. exceeded only 1% of time during summer months
Mean Temp. $T_m =$	80.0	°F	$T_m =$ Mean temp. during normal construction season
Winter Temp. $T_c =$	46.0	°F	$T_c =$ Temp. exceeded 99% of time during winter months
Length, L =	500.00	ft.	L = Length of building or structure to be considered
Heated Building?	Yes		
Air Conditioned Building?	Yes		
Fixed Base Columns?	No		
Vastly Uneq. End Stiff?	No		
Results:			
Determine Max. Design Temperature Change, ΔT , per Ref. #1:			
Temp. Change, $\Delta T_1 =$	50.0	°F	$\Delta T_1 = T_w - T_m$
Temp. Change, $\Delta T_2 =$	34.0	°F	$\Delta T_2 = T_m - T_c$
Maximum Design $\Delta T =$	50.0	°F	$\Delta T =$ Maximum of ΔT_1 or ΔT_2
For Unrestrained Condition, Calculate Change of Length Due to Temperature Change:			
Thermal Exp. Coef., $\alpha =$	0	$\text{in./in./}^\circ\text{F}$	$\alpha =$ Coefficient of thermal expansion for steel (from Ref. #2)
$\Delta L =$	1.950	in.	$\Delta L = \alpha \Delta T (L \cdot 12) = \sigma (L \cdot 12) / E = F \cdot (L \cdot 12) / (A \cdot E)$ where: $\sigma = F/A$
For Restrained Ends, Calculate Change in the Unit Stress Due to Temperature Change:			
Mod. of Elasticity, E =	29000	ksi	E = 29000 (assumed modulus of elasticity for steel)
Thermal Exp. Coef., $\alpha =$	0	$\text{in./in./}^\circ\text{F}$	$\alpha =$ Coefficient of thermal expansion for steel (from Ref. #2)
Stress Change, $\Delta \sigma =$	9.43	ksi	$\Delta \sigma = \alpha \cdot E \cdot \Delta T$
Determine Max. Building or Structure Length either without or between Expansion Joints:			
(from Ref. #1, Figure 1)			for: $\Delta T \leq 25$, $L_{(allow)} = 600$ ft.
Length, $L_{(allow)} =$	488.89	ft.	for: $25 < \Delta T > 70$, $L_{(allow)} = (-200/45) \cdot \Delta T + (600 + 25 \cdot (200/45))$ ft.
			for: $\Delta T > 70$, $L_{(allow)} = 400$ ft.
$R_1 =$	0.15		$R_1 = +0.15$ if building is heated and air-conditioned, else 0
$R_2 =$	0		$R_2 = -0.33$ if building is unheated, else 0
$R_3 =$	0		$R_3 = -0.15$ if columns are fixed base in length direction, else 0
$R_4 =$	0		$R_4 = -0.25$ if bldg. has vastly greater stiffness at one end, else 0

Section Type

General PSC/Composite

Section Temperatures

Initial: [C] ...

Material: Element Input

Elast.: kN/mm²

Therm.: 1/[C]

Ref.: Top Bottom

B: Section 0 mm

H1: Z1 0 mm

H2: Z2 0 mm

T1: [C] T2: [C]

No.	Ref.	B	H1	H2

Modeling Features for Practical Analysis

Vehicle Load

EUROCODE

- Canada
- BS
- EUROCODE**
- Australia
- Russia
- Korea
- KSCE-LSD12
- China
- India
- Taiwan
- Transverse

Moving Load Analysis Control Data

Truck/Train Load Control Option

Analysis Method
 Exact Pivot Quick

Load Point Selection
 Influence Line Dependent Point All Points

Influence Generating Points
 Number/Line Element : 3
 Distance between Points : 0.3 m

Analysis Results

Plate
 Center Normal
 Center + Nodal

Frame
 Normal
 Normal + Concurrent Force

Stress Calculation Combined Stress Calculation

Calculation Filters

Reactions
 All Group : []

Displacements
 All Group : []

Forces/Moments
 All Group : []

Define Standard Vehicular Load

Standard Name
AS 5100.2 - Road Traffic

Vehicular Load Properties

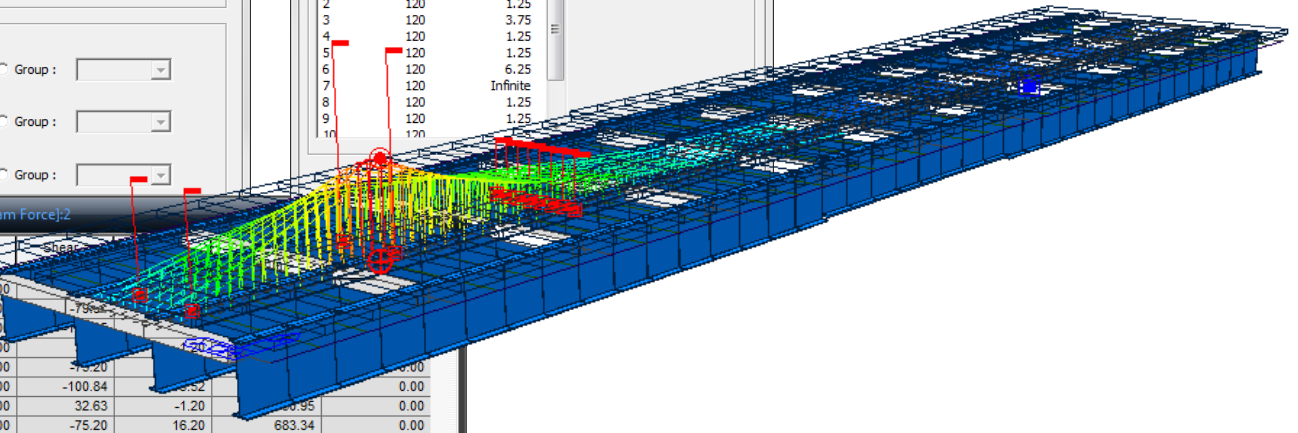
Vehicular Load Name : M1600
Vehicular Load Type : M1600
Dynamic Load Allowance : 0.4

Design Lane : 3.2 m

No	Load(kN)	Spacing(m)	W
1	120	1.25	6 kN/m
2	120	1.25	
3	120	3.75	
4	120	1.25	
5	120	1.25	
6	120	6.25	
7	120	Infinite	
8	120	1.25	
9	120	1.25	
10	120	1.25	

Result By Max Value-[Beam Force]:2

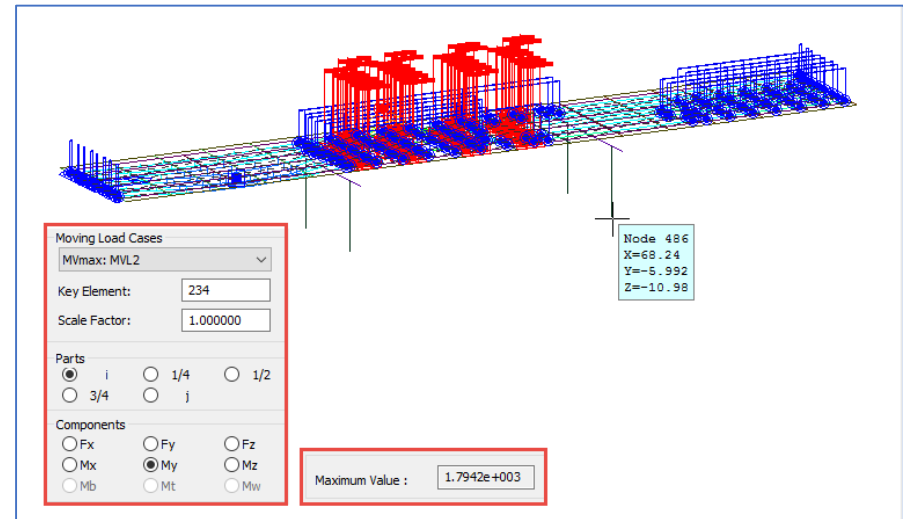
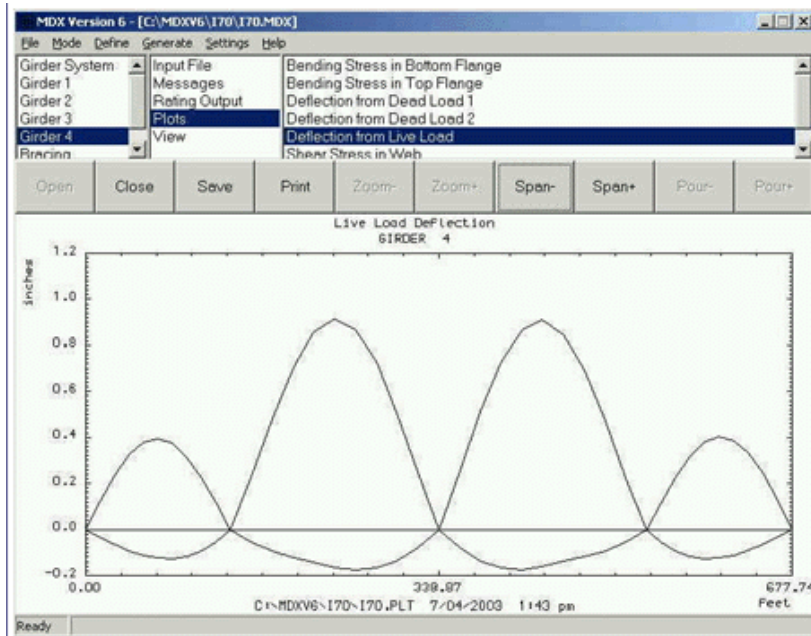
Elem	Load	Part	Component	Axial (kN)	Shear-y (kN)	Shear-z (kN)	Moment-x (kN-m)	Moment-y (kN-m)	Moment-z (kN-m)
84	mm(max)	J[45]	Shear-z	0.00	0.00				
84	mm(max)	J[45]	Torsion	0.00	0.00				
84	mm(max)	J[45]	Moment-y	0.00	0.00				
85	mm(max)	[45]	Shear-z	0.00	0.00	-93.20			0.00
85	mm(max)	[45]	Torsion	0.00	0.00	-100.84			0.00
85	mm(max)	[45]	Moment-y	0.00	0.00		-32.52		0.00
85	mm(max)	J[46]	Shear-z	0.00	0.00	32.63	-1.20		680.95
85	mm(max)	J[46]	Torsion	0.00	0.00	-75.20	16.20		683.34
85	mm(max)	J[46]	Moment-y	0.00	0.00	-158.51	0.23		787.65
86	mm(max)	[46]	Shear-z	0.00	0.00	33.63	-0.76		-111.57
86	mm(max)	[46]	Torsion	0.00	0.00	-53.63	4.75		652.28
86	mm(max)	[46]	Moment-y	0.00	0.00	-74.56	3.47		787.65
86	mm(max)	J[47]	Shear-z	0.00	0.00	33.63	-0.76		-151.93
86	mm(max)	J[47]	Torsion	0.00	0.00	-53.63	4.75		782.13
86	mm(max)	J[47]	Moment-y	0.00	0.00	-132.87	-11.97		911.15



MDX result verification in midas Civil

MDX result verification in midas Civil

Effects of Live Load



MDX result verification in midas Civil

CONCRETE SLAB ON GRADE ANALYSIS
 For Slab Subjected to Interior Concentrated Post or Wheel Loading
 Assuming Slab is Reinforced for Shrinkage and Temperature Only

Job Name: _____ Subject: _____
 Job Number: _____ Originator: _____ Checker: _____

Input Data:

Slab Thickness, t =	8.000	in.
Concrete Strength, f'c =	4000	psi
Conc. Unit Weight, wc =	150	pcf
Reinforcing Yield, fy =	60000	psi
Subgrade Modulus, k =	100	pci
Concentrated Load, P =	6000.00	lb.
Contact Area, Ac =	144.00	in ²
Factor of Safety, FS =	3.00	
Dowel Bar Dia., db =	0.750	in.
Dowel Bar Spacing, s =	12.000	in.
Const. Joint Width, z =	0.2500	in.
Joint Spacing, L =	20.000	in.
Temperature Range, ΔT =	50.00	deg
Increase for 2nd Load, I =	0.00	%

Results:

Check Slab Flexural Stress: (assuming unreinforced slab with interior load condition)

Effective Load Radius, a =	6.770	in.	$a = \sqrt{QR(Ac)}$
Modulus of Elasticity, Ec =	3834254	psi	$Ec = 30 \times 10^6 \sqrt{f'c}$
Modulus of Rupture, MR =	569.21	psi	$MR = 9 \sqrt{f'c}$
Cracking Moment, Mc =	6.07	in.-k	$Mc = MR(12 \times 10^6 / 6) / 12000$
Poisson's Ratio, μ =	0.15		$\mu = 0.15$
Radius of Stiffness, Lr =	35.968	in.	$Lr = (Ec \times 12 \times 10^6 / (1 - \mu^2) \times k) \times 0.25$
Equivalent Radius, b =	6.315	in.	$b = \sqrt{QR(1.67a^2 + Lr^2) - 0.675^2 Lr}$
For 1 Load, Rb(actual) =	121.22	psi	$Rb(actual) = 3P(1 + \mu)(2^2 + \mu^2) / (Lr(Lr + b) + 0.615R)$
For 2 Loads, Rb(actual) =	N/A	psi	$Rb(actual) = N/A$
Fb(actual) =	189.74	psi	$Fb(actual) = MR/Fs$

Note: Effect of a 2nd load was not considered.

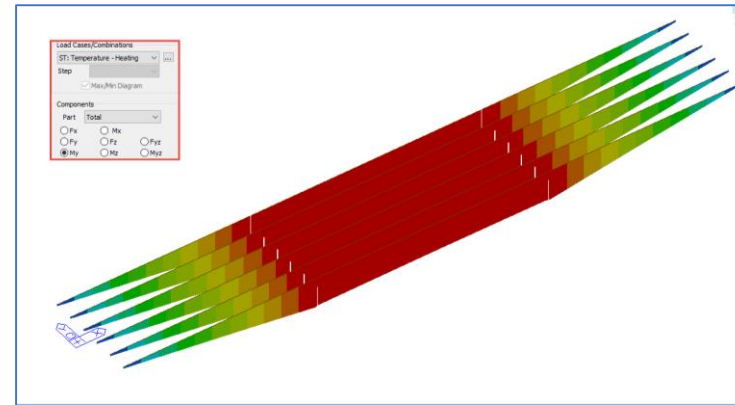
Check Slab Bearing Stress: (assuming working stress and interior load)

f(actual) =	41.67	psi	$f(actual) = P/Ac$
f(actual) =	2350.68	psi	$f(actual) = 4.2 \times MR$

Check Slab Punching Shear Stress: (assuming working stress and interior load)

db =	48.000	in.	$db = 4 \sqrt{QR(Ac)}$
f(actual) =	9.38	psi	$f(actual) = P / (db^2 \times L)$
F(actual) =	153.69	psi	$F(actual) = 0.27 \times MR$

Heating Condition – Bending Moment Diagram

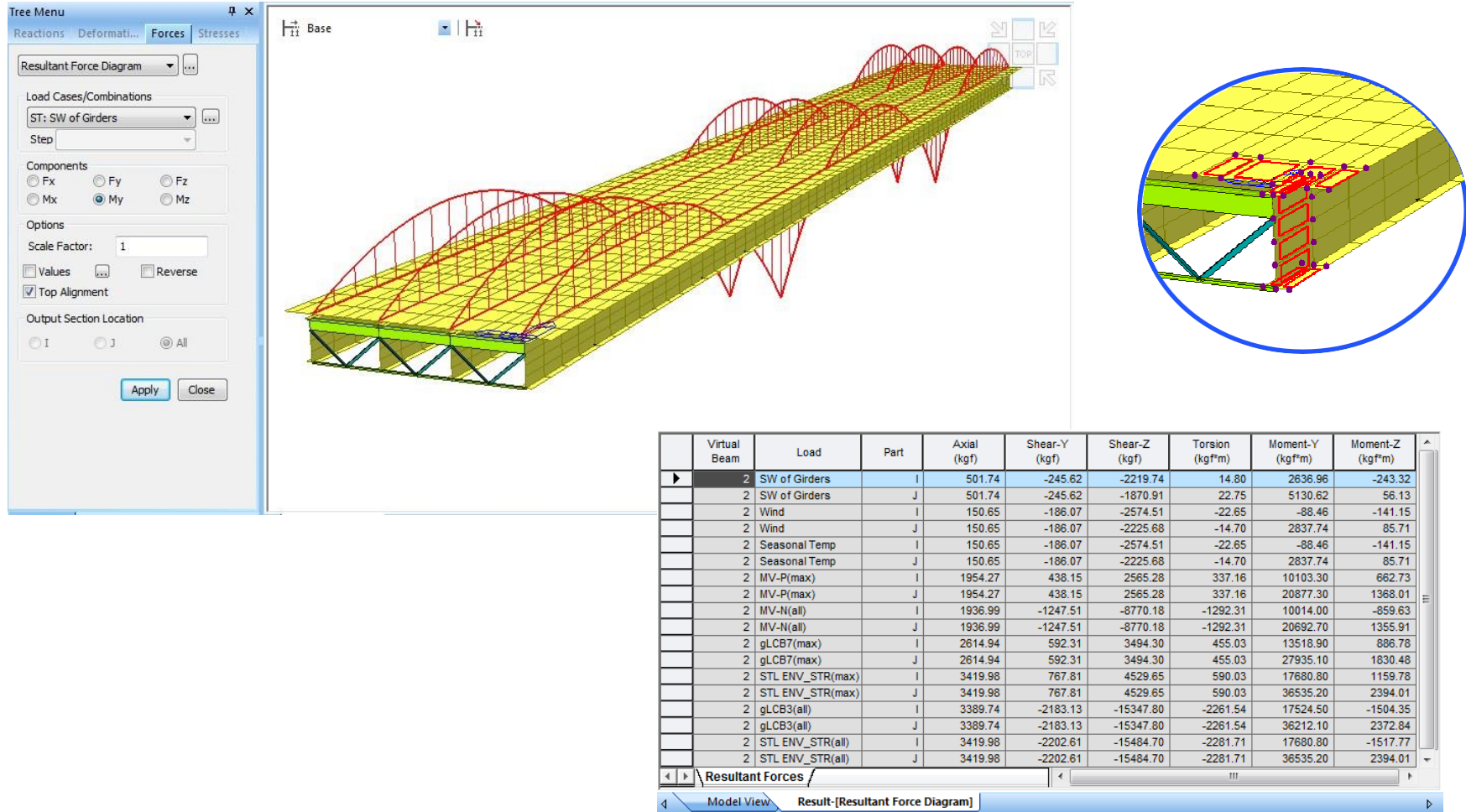


Heating Condition – Deflection Shape



MDX result verification in midas Civil

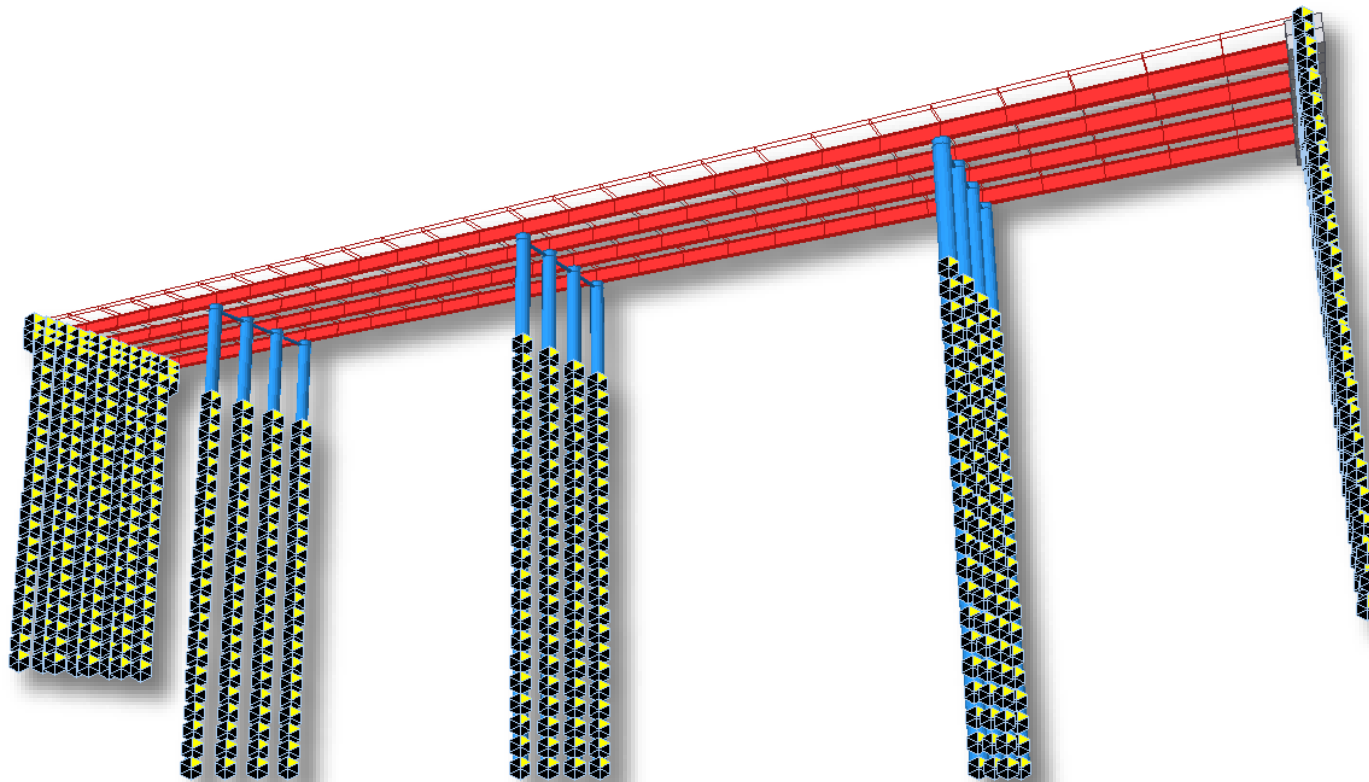
Resultant Force Diagram



Using midas Civil For more complex problems

Advanced Features in midas Civil

Sub-structure Analysis



Advanced Features in midas Civil

Sub-structure Analysis

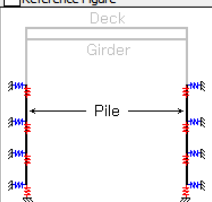
Non-linear springs

Integral Bridge Spring Supports

Boundary Group Name
Default

Soil Spring Type
 Abutment Spring
 Pile Spring

Reference Figure



Pile Spring Data

Soil Type: Sand

Ground Level: 2.3 m

Pile Diameter (D): 0.1 m

Unit Weight of Soil (γ): 19 kN/m³

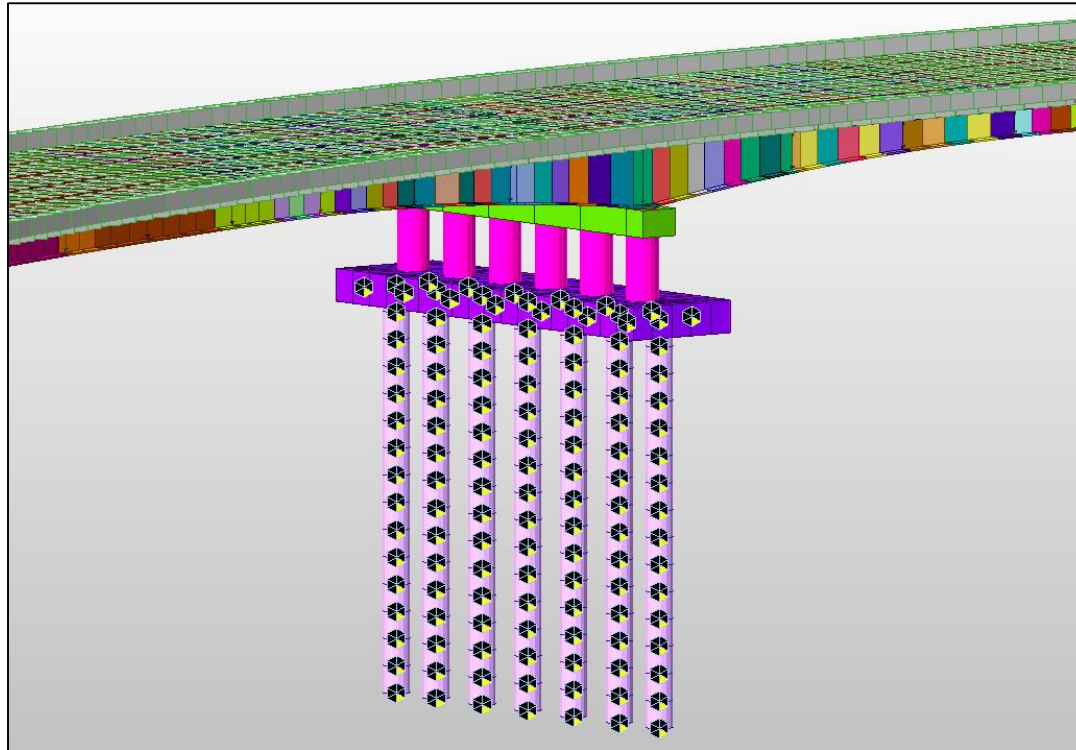
Earth Pressure Coeff. at rest (K_0): 0.4

Coeff. of Subgrade Reaction (k_h): 25000 kN/m³

Internal Friction Angle (ϕ): 30 [deg]

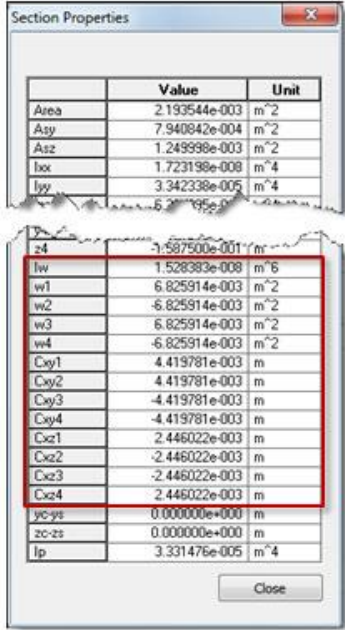
Initial Soil Modulus (k_1): Dense

33930 kN/m³

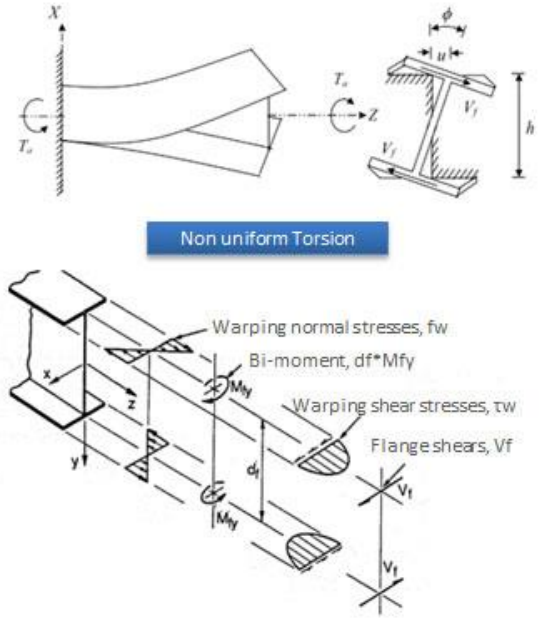


Advanced Features in midas Civil

Torsion Calculation



	Value	Unit
Area	2.193544e-003	m ²
Asy	7.940842e-004	m ²
Asz	1.249998e-003	m ²
Ixx	1.723198e-008	m ⁴
Iyy	3.342338e-005	m ⁴
Izz	6.277957e-005	m ⁴
Ixy	-1.587500e-001	m ⁴
Iyz	1.528383e-008	m ⁶
w1	6.825914e-003	m ²
w2	-6.825914e-003	m ²
w3	6.825914e-003	m ²
w4	-6.825914e-003	m ²
Cxy1	4.419781e-003	m
Cxy2	4.419781e-003	m
Cxy3	-4.419781e-003	m
Cxy4	-4.419781e-003	m
Cxz1	2.446022e-003	m
Cxz2	-2.446022e-003	m
Cxz3	-2.446022e-003	m
Cxz4	2.446022e-003	m
yc-ys	0.000000e+000	m
zc-zt	0.000000e+000	m
Ip	3.331476e-005	m ⁴



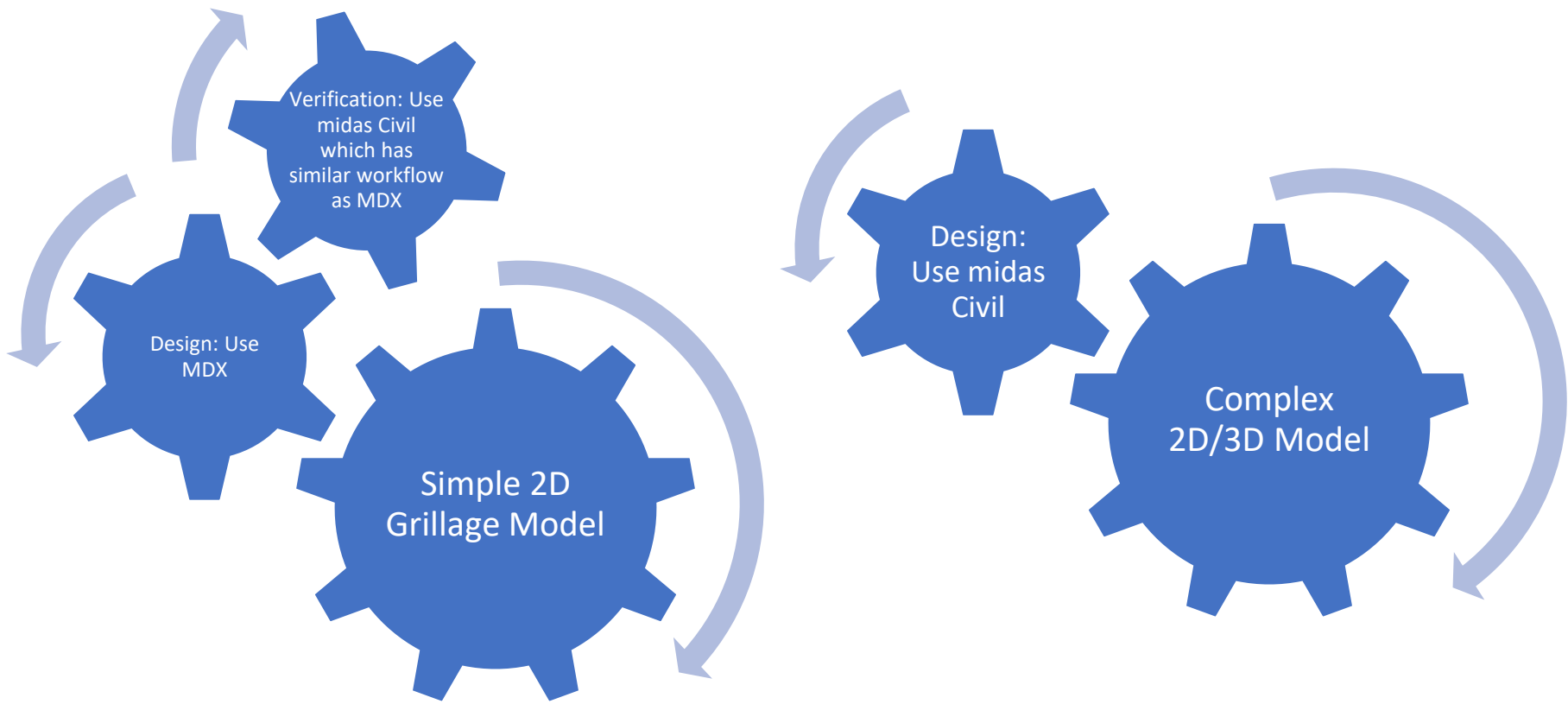
Non uniform Torsion

Bi-moment and Warping Stress

Advanced Features in midas Civil

Construction Stage Analysis

Conclusion



Thank you