

Release Note

Release Date : March 2020

Product Ver. : Civil 2020 (v2.1)



DESIGN OF CIVIL STRUCTURES

Integrated Solution System for Bridge and Civil Engineering

Enhancements

1. Multiple stage post-tensioning in tendon
2. Auto division of the fiber section (Core and cover)
3. New option for Moving load optimization
4. Application rule change of Military Load Class
5. Improvement in calculation of torsional constant for closed composite section
6. Improvement of the element temperature calculation method for the composite section for C.S.
7. Improvement of the analysis speed for the inelastic time-history analysis
8. Improvement in GSD - Civil pushover hinge export
9. Bridge Assessment to the UK standard: CS 454/19
10. RC Design to IS 456:2000 & Crack calculations by IS 3370(Part 2):2009



1. Multiple stage post-tensioning in tendon

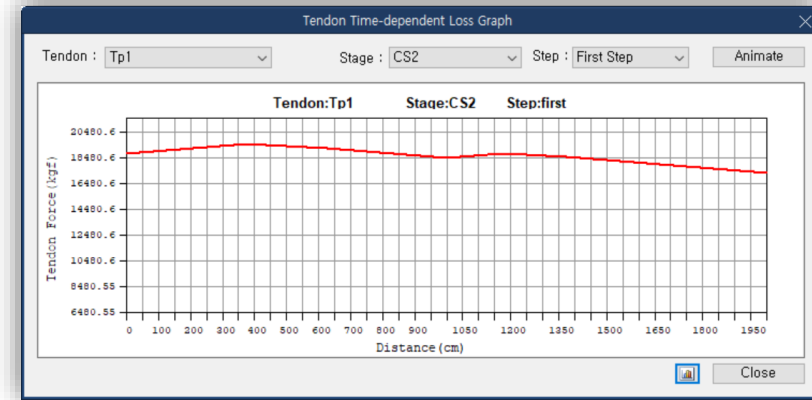
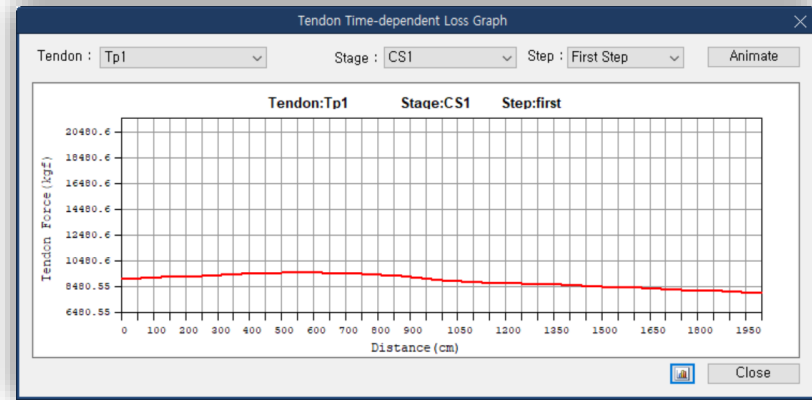
- Re-tensioning of tendon is now supported. Immediate losses and time-dependent losses which occurred before re-tensioning are removed and recalculated based on the summation of multiple stage stressing applied to the tendon starting from the time of re-tensioning.
- Re-tensioning of coupled tendon is not supported

▪ **Load > Temp./Prestress > Tendon Prestress**

Tensioning at stage 1



Re-tensioning at stage 2

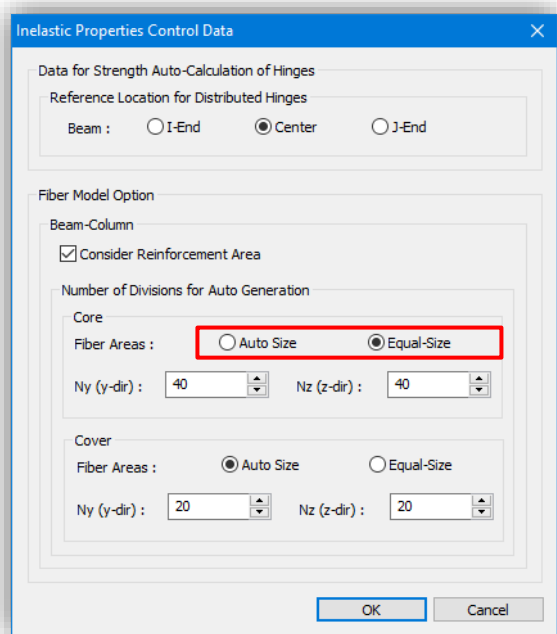


Civil 2020 v2.1

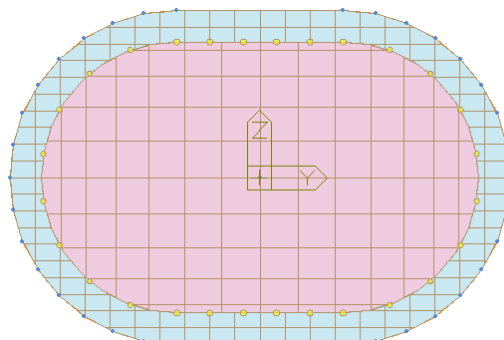
2. Auto division of the fiber section (core and cover)

- In earlier versions, the fiber section was to be manually divided into the core & cover regions and this was to be done for all such sections.
- Now, just the fiber hinge needs to be defined and the fiber division of the section can be done automatically, including differentiation for confined and un-confined concrete. Also, the fiber division can be equal size or auto size.

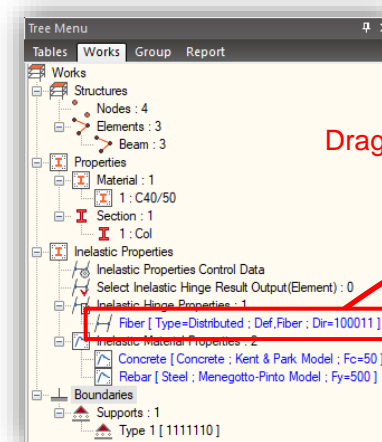
▪ Properties > Inelastic Material > Fiber Division of Section



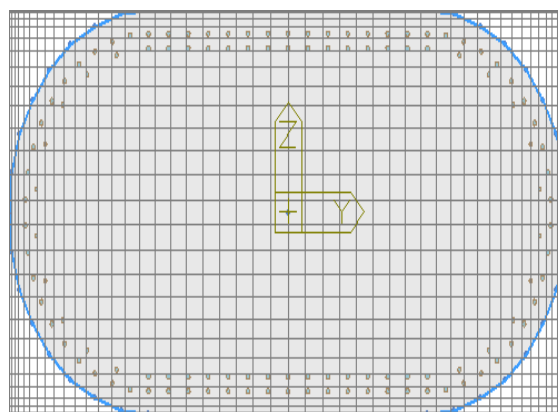
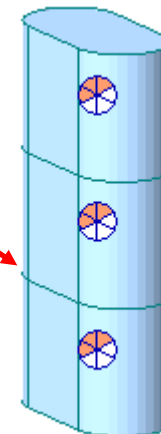
Inelastic Properties Control Data



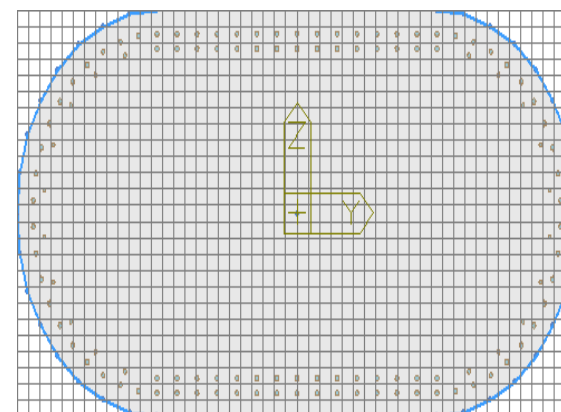
Fiber definition



Drag & Drop



Auto Size option



Equal Size option

3. New option for moving load optimization

- In earlier versions of midas, there was auto calculation to control the critical position of the analysis lanes in moving load optimization. Lane offset had to be provided manually.
- In this version, the limitation is removed as the number of analysis lanes can be specified by the user and this ensures that vehicle is placed at the extreme ends of the optimization lane.

- **Load > Moving Load > Traffic Line Lanes > Moving Load Optimization**
- **Load > Moving Load > Traffic Surface Lanes > Moving Load Optimization**

Moving Load Optimization

Lane Name : optimization lane

Traffic Lane Optimization Properties

Start End
a : Eccentricity

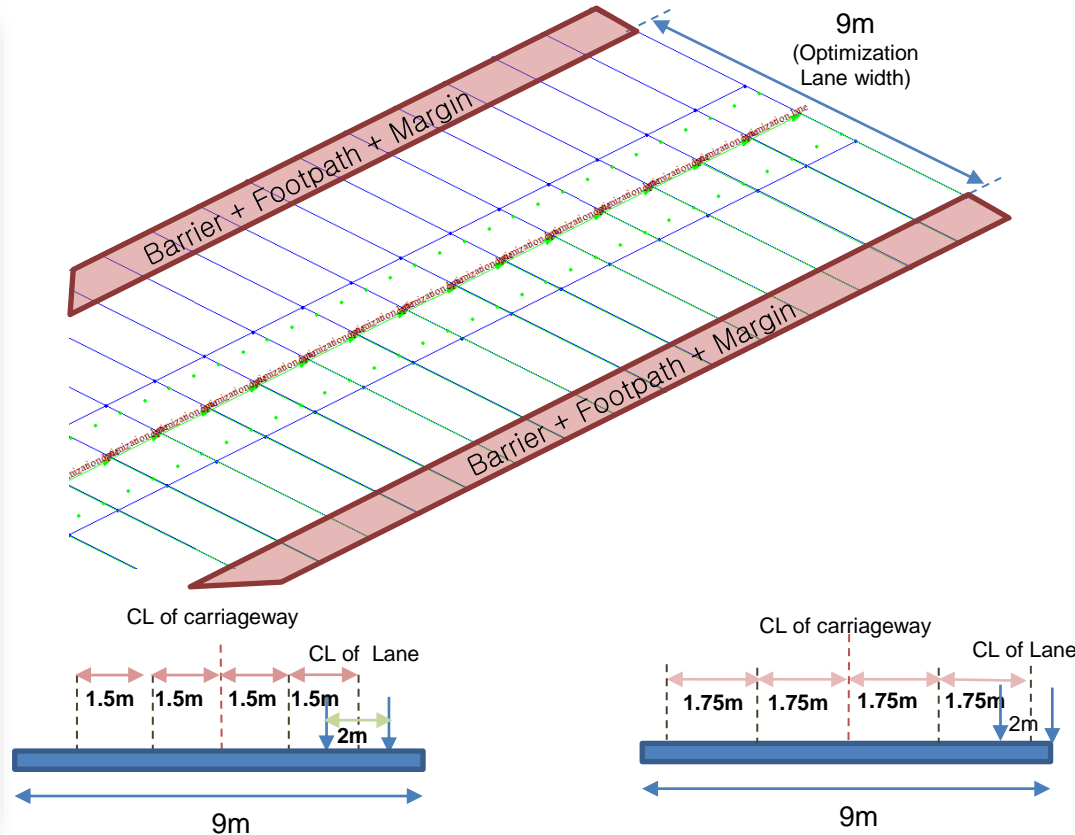
Optimization Lane 9 m
Lane Width 3 m
Anal. Lane Offset 1.5 m
Wheel Spacing 2 m
Margin 0 m
Eccentricity 0 m

Straddling Lane Type

Vehicular Load Distribution
 Lane Element Cross Beam
Cross Beam Group

Skew
Start 0 End 0 [deg]

Moving Direction
 Forward Backward Both



Define Moving Load Optimization

Lane Name : optimization lane

Traffic Lane Optimization Properties

Start End
a : Eccentricity

Optimization Lane 9 m
Lane Width 3 m

Generate Analysis Lanes

Number of Lanes(2~N+1) N: 2
 Offset from Centerline 1 m

Wheel Spacing 2 m
Margin 0 m
Eccentricity -5.1 m

Straddling Lane Type

Vehicular Load Distribution
 Lane Element Cross Beam
Cross Beam Group

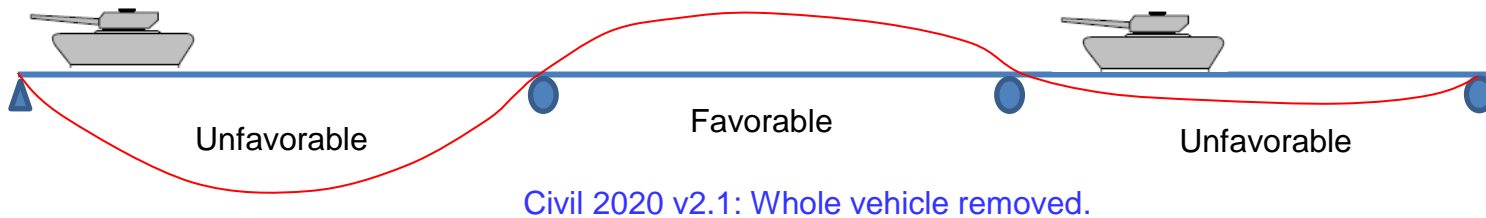
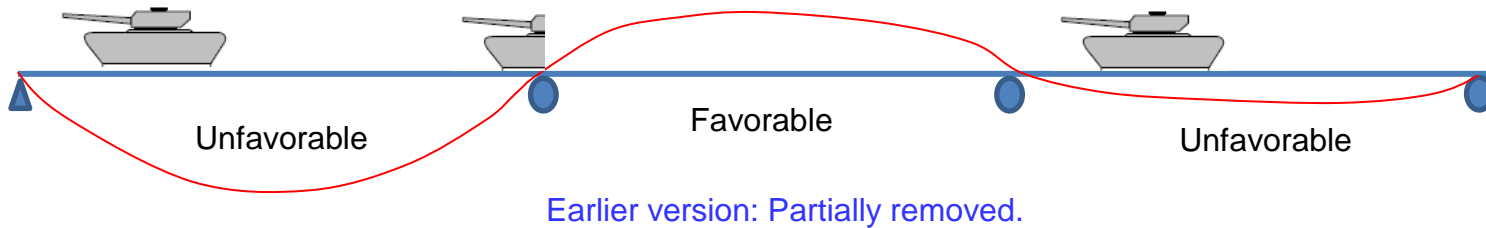
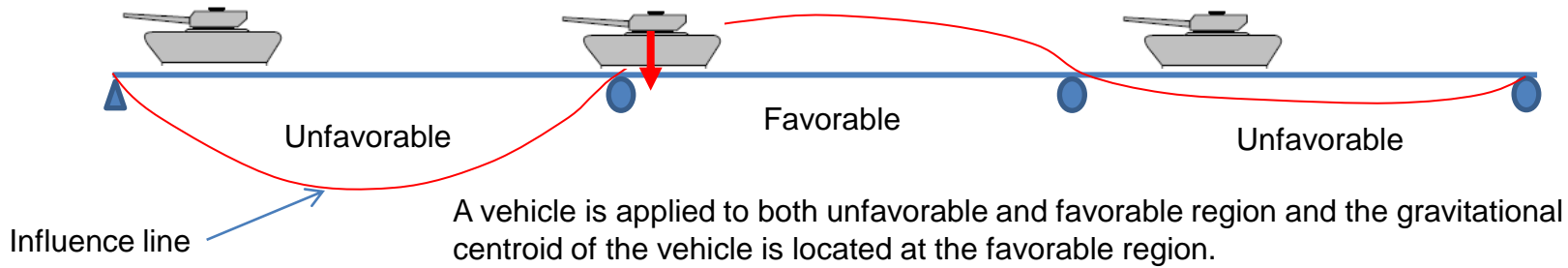
Skew
Start 0 End 0 [deg]

Moving Direction
 Forward Backward Both

4. Application rule change of Military Load Class

- In earlier version, to obtain the most unfavorable condition for the structure, even the partial vehicle load was considered.
- Now, only complete vehicle would be considered to obtain the worst effect on the structure.

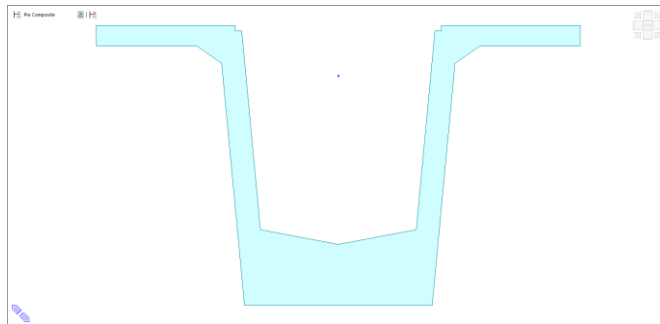
▪ **Load > Moving Load > Moving Load Code > POLAND > Vehicle Add Standard > Military Load Class**



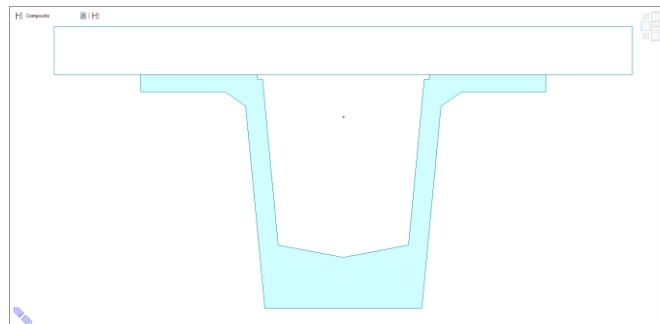
5. Improvement in calculation of torsional constant for closed composite section

- The torsional constant calculation has been improved for composite section which has open cross-section before composite and closed cross-section after composite, e.g. Super T girder.
- Now, the torsional constant is calculated according to finite element based analysis thus calculating for both before composite and after composite separately.

▪ Properties > Section Properties > Composite



Part I



Part I + Part II

	Value(Before)	Value(After)	Unit
Area	5.361715e-001	1.230545e+000	m ²
Asy	4.831434e-001	4.645265e-001	m ²
Asz	6.130852e-001	5.972085e-001	m ²
Ixx	7.834168e-003	1.506723e-002	m ⁴
Iyy	1.011163e-001	2.928666e-001	m ⁴
Izz	1.123795e-001	6.331598e-001	m ⁴
Cyp	1.050000e+000	1.050000e+000	m
Cym	1.050000e+000	1.050000e+000	m
Czp	6.635581e-001	2.185895e-001	m
Czm	5.514419e-001	9.964105e-001	m
Qyb	0.000000e+000	0.000000e+000	m ²
Qzb	0.000000e+000	0.000000e+000	m ²
Peri:O	7.967478e+000	1.446748e+001	m
Peri:I	0.000000e+000	0.000000e+000	m
Center:y	1.050000e+000	1.500000e+000	m
Center:z	5.514419e-001	9.964105e-001	m
y1	-1.050000e+000	-1.050000e+000	m
z1	6.635581e-001	2.185895e-001	m
y2	1.050000e+000	1.050000e+000	m
z2	6.635581e-001	2.185895e-001	m
y3	4.070000e-001	4.070000e-001	m
z3	-5.514419e-001	-9.964105e-001	m
y4	-4.070000e-001	-4.070000e-001	m
z4	-5.514419e-001	-9.964105e-001	m

Close

Previous version

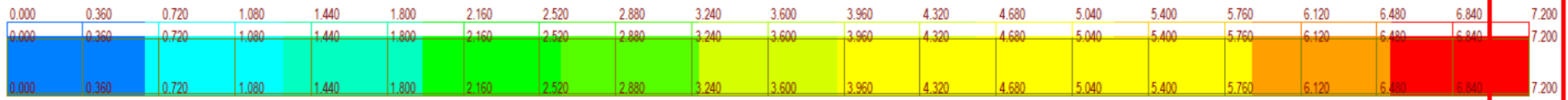
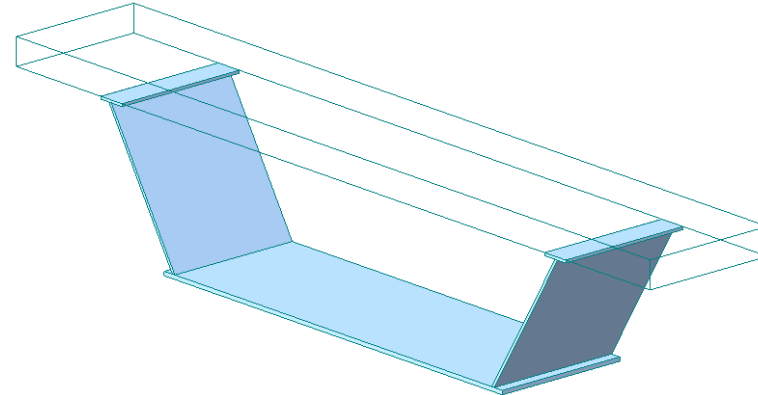
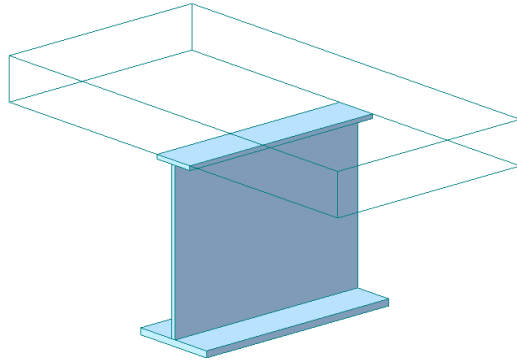
	Value(Before)	Value(After)	Unit
Area	5.361715e-001	1.230545e+000	m ²
Asy	1.237778e-001	7.374340e-001	m ²
Asz	2.125628e-001	2.803497e-001	m ²
Ixx	6.700396e-003	1.916471e-001	m ⁴
Iyy	1.011163e-001	2.928666e-001	m ⁴
Izz	1.123795e-001	6.331598e-001	m ⁴
Cyp	1.050000e+000	1.050000e+000	m
Cym	1.050000e+000	1.050000e+000	m
Czp	6.635581e-001	2.185895e-001	m
Czm	5.514419e-001	9.964105e-001	m
Qyb	0.000000e+000	0.000000e+000	m ²
Qzb	0.000000e+000	0.000000e+000	m ²
Peri:O	7.967478e+000	1.446748e+001	m
Peri:I	0.000000e+000	0.000000e+000	m
Center:y	1.050000e+000	1.500000e+000	m
Center:z	5.514419e-001	9.964105e-001	m
y1	-1.050000e+000	-1.050000e+000	m
z1	6.635581e-001	2.185895e-001	m
y2	1.050000e+000	1.050000e+000	m
z2	6.635581e-001	2.185895e-001	m
y3	4.070000e-001	4.070000e-001	m
z3	-5.514419e-001	-9.964105e-001	m
y4	-4.070000e-001	-4.070000e-001	m
z4	-5.514419e-001	-9.964105e-001	m

Close

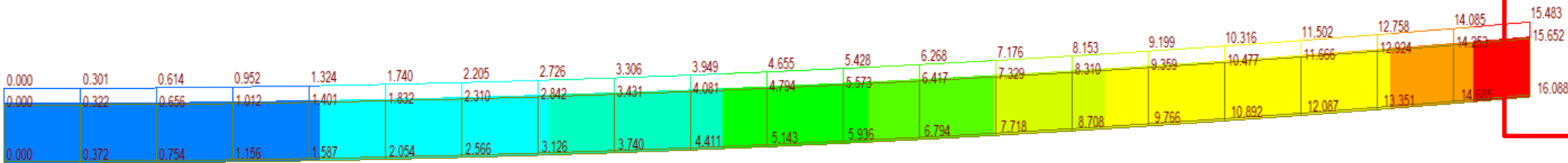
Civil 2020 v2.1

6. Improvement of the element temperature calculation method for the composite section for C.S.

- In earlier version, uniform temperature loads like system temperature, nodal temperature and element temperature were applied to transformed properties of composite beam elements.
- In new version, these loads are applied individually to each part based on temperature coefficient to predict more realistic behavior of structure, when composite section for construction stage are defined.



Previous version – Axial deformation & no bending



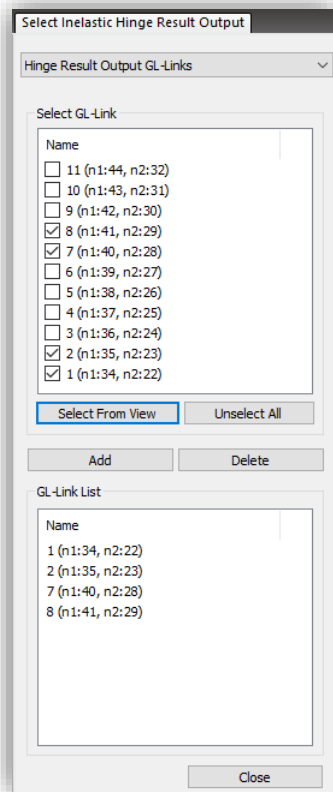
Civil 2020 v2.1 – Axial deformation & bending

7. Improvement in analysis speed for inelastic time history analysis

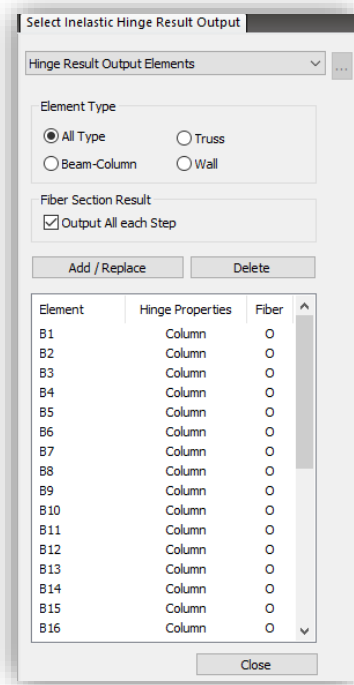
- The output for non-linear elastic time history analysis with fiber modelling could now be restricted to required elements or links. This drastically reduces the overall analysis time of the model.

▪ **Properties > Inelastic Properties Control Data > Select Inelastic Hinge Result Output (Element)**

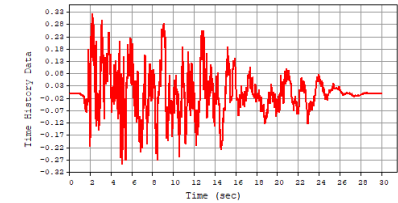
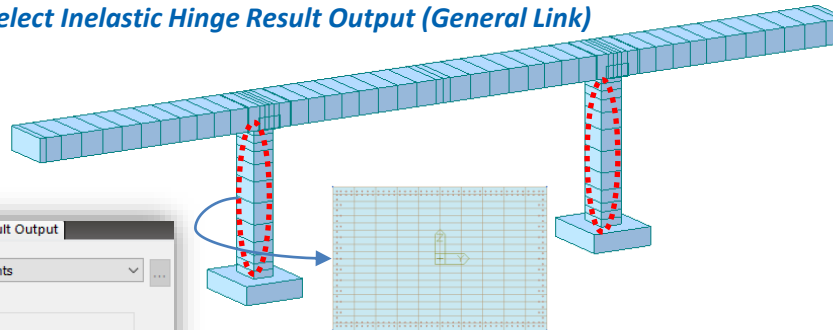
▪ **Properties > Inelastic Properties Control Data > Select Inelastic Hinge Result Output (General Link)**



Hinge Result Output (General Link)

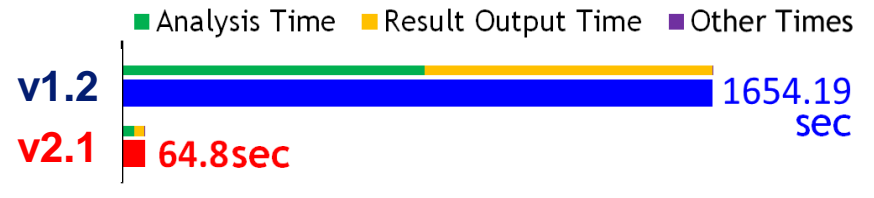


Hinge Result Output (Element)



- Duration : 30 Second (3000Step)
- Model scale : 86 Beam elements
- Fiber cell : 28,248Pieces

```
< TIME HISTORY LOADCASE NO. 2 / 2 >
* ANALYSIS TYPE : NONLINEAR
* ANALYSIS METHOD : DIRECT INTEGRATION
* TIME HISTORY TYPE : TRANSIENT
* MASS TYPE : LUMPED MASS
* DAMPING METHOD : MASS & STIFFNESS PROPORTIONAL (RAYLEIGH DAMPING)
* INCORE MULTI-FRONTAL SOLVER
-----TIME STEPS-----SUBSTEPS-- --ITERATIONS-- --ELAPSED / TOTAL TIME-----
3000 / 3000 3000 6031 845.480 / 845.480 [sec]
```



```
-----SOLUTION TERMINATED-----
YOUR MIDAS JOB IS SUCCESSFULLY COMPLETED
TOTAL SOLUTION TIME... 1654.19 [SEC] ■ 2020 v1.2
```

```
-----SOLUTION TERMINATED-----
YOUR MIDAS JOB IS SUCCESSFULLY COMPLETED.
TOTAL SOLUTION TIME... 64.80 [SEC] ■ 2020 v2.1
```

8. Improvement in GSD Pushover Hinge Export

- In earlier version, the yield moment was taken from the PMM interaction curve generated for the design instead of idealized curve in the Moment-Curvature curve.
- In this version, the yield moments depending on axial forces are taken from the idealized curve in the moment-curvature curve when exporting hinge data for pushover analysis.

▪ **Pushover > Hinge Properties > Define Pushover Hinge Type/Properties**

Section View : Cvl_Column | Interaction Curve | Moment-Curvature Curve | Stress Contour

P-M My-Mz 3D

Mode
 Angle : 0 Dec. P-My P-Mz Load Combination : LC

Code : Eurocode2:04
 Hoop Type
 Tie

Checking Ratio
 Keep M/P constant Keep M constant Keep P constant

	P (kN)
1	24908.970
2	18768.158
3	17834.453
4	16838.642
5	15794.918
6	14720.885
7	13621.335
8	12492.856
9	11357.819
10	10227.107
11	9117.409
12	8081.230
13	7329.061
14	6593.286
15	5639.075
16	4577.785
17	3493.591
18	2354.494
19	1170.870
20	7.722
21	-1225.595
22	-2540.708
23	-3900.146
24	-5438.150
25	-6146.546

Moment Curvature Curve
 Axial load = 9117.41
 Neutral Axis Angle = 0

Cracked Moment of Inertia (Icrack) = 0.0373679 m⁴

State	Curvature *10 ⁻³ (1/m)	Moment (kNxm)
a.Crack	1.046420	2540.213
b.Yield(Init.)	4.991872	5108.490
c.Yield	7.474051	5658.068
d.Ultimate(conc)	43.595	4855.292
e.Ultimate(rebar)	-	-
f.Yield(ideal)	5.485665	5613.820

Strain
 Strain Diagram
 C : 0
 R : 0

Point Number : 0
 Concrete Strain : 0
 Rebar Strain : 0
 Neutral Axis Depth : 0 m

a : Crack starts
 b : Concrete or tensile steel yields
 c : Both concrete and tensile steel yield
 d : Concrete Strain reaches the ultimate strain
 e : Tensile steel Strain reaches the ultimate strain
 f : Yield in Idealized Model

Export Report Close

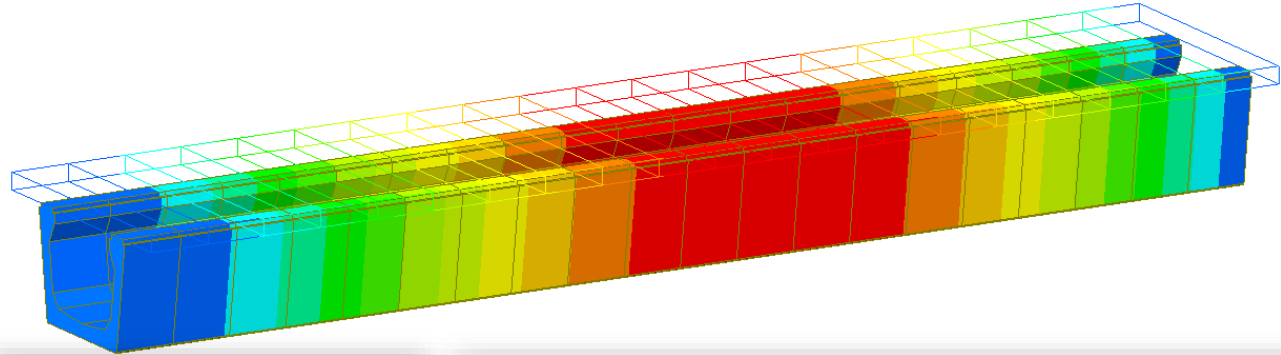
Previous version

Civil 2020 v2.1

9. Bridge Assessment to the UK standard: CS 454/19

- Level 1 assessment can be performed now for **PSC Box & PSC Composite sections** in midas Civil. All model 2 vehicle is also introduced in accordance to CS 454 Assessment code.
- Assessment load combinations can be defined to obtain output for strength & service limit states.

- **Load > Moving Load > Moving Load Code> BS> Vehicle > CS 454 Assessment**
- **Rating> PSC Bridge > CS 454/19**



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)

UDL

KEL

Lane Factor

CS 454

User-defined

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

Category for K-Factor

Traffic/Surface Category: Hp

Load Level: 40t

OK Cancel Apply

Assessment Parameter

Condition Factor (Fc): 1

Value of Gamma_m(Ultimate limit States)

Characteristic Strength

Worst Credible Strength

User Input

Modify Design Parameters

Strength Limit State

Flexure

Shear

Torsion

Serviceability Limit State

Stress/Crack

Detail Report

Ultimate Limit State

Serviceability Limit State

OK Cancel

Define Assessment Case

Name	Limit State	Comb. Type	Gamma_f3
SLS-1	SLS	Comb1	1
SLS-2	SLS	Comb2	1
SLS-3	SLS	Comb3	1
SLS-4	SLS	Comb4	1
ULS-1	ULS	Comb1	1.1
ULS-2	ULS	Comb2	1.1
ULS-3	ULS	Comb3	1.1
ULS-4	ULS	Comb4	1.1

Static Load Cases and Factors(Gamma_ff)

Static Load Cases	Factor
D(ST)	1.0000
SDL(ST)	1.2000
L(ST)	1.0000

Moving Load Cases and Factors(Gamma_ff)

Standard Vehicle HA(MV) 1.2

Special Vehicle 0

Copy Assessment Load Combination

Copy into General Load Combination

Close

All Model 2 vehicle

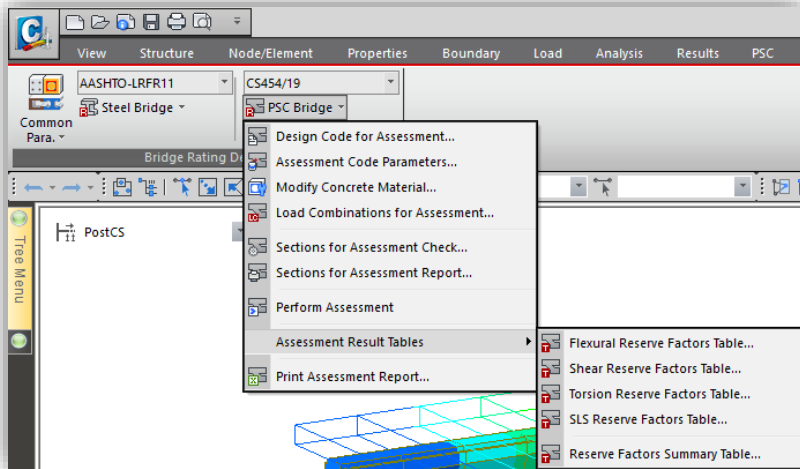
Assessment Parameters

Load combination for assessment

9. Bridge Assessment to the UK standard: CS 454/19

- Assessment results could be viewed in tabular format in midas Civil itself and these can be exported to excel file as well.
- Summary as well as detailed report is provided for Flexural, Shear, Torsion & Service limit state for Class 1 and 2 category.

Rating > PSC Bridge > CS 454/19



Assessment Result Tables

Element	Part	Rating Case	v	vt	vtu	y1	vtu(y1/550)	A	Check
10	I[11]	ULS-1_Fxx(Max)	-825.1060	0.000	6000.0	3.0	32727.2727	7.2718	OK
10	I[11]	ULS-1_Fxx(Min)	-1473.094	0.000	6000.0	3.0	32727.2727	4.0731	OK
10	I[11]	ULS-1_Fyy(Max)	-825.1060	0.000	6000.0	3.0	32727.2727	7.2718	OK
10	I[11]	ULS-1_Fyy(Min)	-1473.094	0.000	6000.0	3.0	32727.2727	4.0731	OK
10	I[11]	ULS-1_Fzz(Max)	-825.1060	0.000	6000.0	3.0	32727.2727	7.2718	OK
10	I[11]	ULS-1_Fzz(Min)	-1473.094	0.000	6000.0	3.0	32727.2727	4.0731	OK
10	I[11]	ULS-1_Mxx(Max)	-825.1060	0.000	6000.0	3.0	32727.2727	7.2718	OK
10	I[11]	ULS-1_Mxx(Min)	-1473.094	0.000	6000.0	3.0	32727.2727	4.0731	OK
10	I[11]	ULS-1_Myy(Max)	-825.1060	0.000	6000.0	3.0	32727.2727	7.2718	OK
10	I[11]	ULS-1_Myy(Min)	-1473.094	0.000	6000.0	3.0	32727.2727	4.0731	OK
10	I[11]	ULS-1_Mzz(Max)	-825.1060	0.000	6000.0	3.0	32727.2727	7.2718	OK
10	I[11]	ULS-1_Mzz(Min)	-1473.094	0.000	6000.0	3.0	32727.2727	4.0731	OK

Tabular output in midas Civil

1. Design Condition

Design code	Element	Part(Node)
CS454/19	10	I(11)

2. Assessment factors

The following factors, as in BD 86/11, have been used to compare results of different configurations and combinations.

- Adequacy factor:

$$A = \frac{R_a^*}{S_a^*}$$
- Special Vehicle reserve factor with standard vehicle:

$$\psi = \frac{R_a^* - (S_D^* + S_{ST}^*)}{S^*}$$
- Special Vehicle reserve factor without standard vehicle:

$$\psi^* = \frac{R_a^* - S_D^*}{S^*}$$

Where:

- R_a^* : the assessment resistance
- S_D^* : the assessment load effect due to combined dead and superimposed dead loads
- S_{ST}^* : the assessment load effect due to standard vehicle
- S^* : the assessment load effect due to standard vehicle
- S_a^* : the assessment load effect due to standard vehicle

3. Flexural Reserve Factors

Assessment Case	Load Effect	R_a^* (kN.m)	S^* (kN.m)	S_D^* (kN.m)	S_{ST}^* (kN.m)	S_a^* (kN.m)	A	ψ	ψ^*	Check
ULS-1_Fxx(Max)	Positive	3208.885	-	6717.530	1186.514	7904.044	0.406	-	-	NG
ULS-1_Fxx(Min)	Positive	3208.885	-	6717.530	0.000	6717.530	0.478	-	-	NG
ULS-1_Fyy(Max)										
ULS-1_Fyy(Min)										

4. Shear Reserve Factors

Assessment Case	R_a^* (kN)	S^* (kN)	S_D^* (kN)	S_{ST}^* (kN)	S_a^* (kN)	A	ψ	ψ^*	Check
ULS-2_Fxx(Max)	429.055	-	-1245.888	99.981	-158.499	2.707	-	-	OK
ULS-2_Fxx(Min)	605.191	-	-1245.888	-390.229	-158.499	3.818	-	-	OK
ULS-2_Fyy(Max)	429.055	-	-1245.888	99.981	-158.499	2.707	-	-	OK
ULS-2_Fyy(Min)	605.191	-	-1245.888	-390.229	-158.499	3.818	-	-	OK
ULS-2_Fzz(Max)	429.055	-	-1245.888	99.981	-158.499	2.707	-	-	OK
ULS-2_Fzz(Min)	605.191	-	-1245.888	-390.229	-158.499	3.818	-	-	OK
ULS-2_Mxx(Max)	429.055	-	-1245.888	99.981	-158.499	2.707	-	-	OK

Excel report output

10. RC Design to IS 456:2000 & Crack calculations by IS 3370(Part 2):2009

- Reinforced Concrete Design as per IS 456: 2000 is now available in midas civil, where we can perform Beam Design, Beam Checking, Column Design, Column Checking
- We can generate Graphic/Detailed reports which include both Ultimate Limit State and Serviceability Limit State checks as per IS 456:2000. Also, Crack Width Checks as per IS 3370 (Part-2):2009 can be obtained for Beams.

Design > RC Design > IS456:2000

Concrete Design Code

Design Code : IS456:2000

Apply Special Provisions for Seismic Design

Moment Redistribution Factor for Beam : 1

Torsion Design

IS 3370(Part 2):2009 Crack Width Check

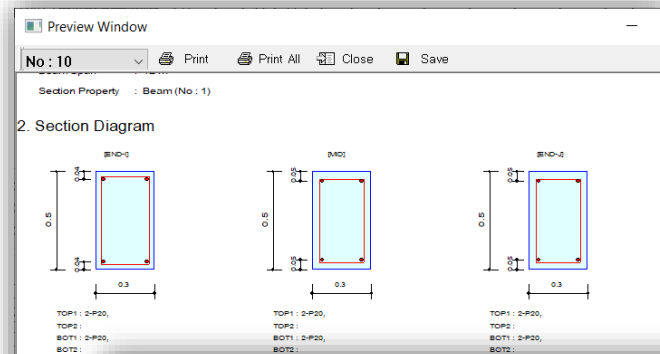
Crack Width due to Temperature & Moisture - Annex A

- Estimated Shrinkage Strain: 0.0025
- Estimated Total Thermal Contraction after Peak Temperature due to Heat of Hydration: 0.0025
- T1 (C) Fall in Temperature between the hydration peak and ambient: 30

Crack Width in Mature Concrete - Annex B

- Limiting Design Surface Crack Width(mm): 0.2

OK Close



Preview Window

No: 4

1. Design Condition

Design Code IS456:2000

Unit System kN, m

Member Number 4

Material Data fck = 40000, fy = 415000, fyw = 415000 KPa

Column Height 4 m

Section Property Column (No: 2)

Rebar Pattern

	Pos 1	Pos 2	Pos 3
Layer 1	6-P32	10-P32	--
Layer 2	6-P32	10-P32	--

Total Rebar Area Ast = 0.0514688 m² (RhoSt = 0.2145)

2. Applied Loads

Load Combination 3 AT (t) Point

N_{Ed} = 341.642 kN, M_{Edy} = 126.847, M_{Edz} = 9.56598, M_{Ed} = 127.207 kN-m

3. Axial Forces and Moments Capacity Check

Concentric Max. Axial Load N_{Rdmax} = 17327.4 kN

Axial Load Ratio N_{Ed}/N_{Rd} = 341.642 / 1074.14 = 0.318 < 1.000 OK

Moment Ratio M_{Edy}/M_{Rdy} = 126.847 / 398.879 = 0.318 < 1.000 OK

M_{Edz}/M_{Rdz} = 9.56598 / 29.1810 = 0.328 < 1.000 OK

M_{Ed}/M_{Rd} = 127.207 / 399.945 = 0.318 < 1.000 OK

Graphic report for beam & column design & checking

MIDAS/Text Editor - [1_Model_IS456_RCDesign.rc]

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( ). Compute moment magnification factors for major axis(DBy,DSy).
-. Cmy = 0.85 (Default or User defined value)
-. DBy < 1.0 --> DBy = 1.00
-. DSy = 1.00 (Default value)

( ). Compute minimum eccentric moments(Emin).
-. Emin = MAX[ MAX[LyLz]/500 + Dmax/30, 20] = 0.028 m.
-. Mmin_y = Pu * Emin = 9.57 kN-m.

( ). Compute magnified moments.
* .DESIGN CODE : IS456:2000, * .UNIT SYSTEM : kN, m
* .MEMBER : Member Type = BEAM, MEMB = 10
* .DESCRIPTION OF BEAM DATA (ISEC = 1) : Beam
  Section Type : Rectangle (RECT)
  Beam Length (Span) = 6.000 m.
  Section Depth (Hc) = 0.500 m.
  Section Width (Bc) = 0.300 m.
  Concrete Strength (fck) = 30000.000 KPa.
  Main Rebar Strength (fy) = 415000.000 KPa.
  Stirrups Strength (fyw) = 415000.000 KPa.
  Modulus of Elasticity (Es) = 200000000.000 KPa.

* .FORCES AND MOMENTS AT CHECK POINT <I> :
  Positive Bending Moment P-M_Ed = 30.82 kN-m., LCB = 2
  Negative Bending Moment N-M_Ed = 164.95 kN-m., LCB = 1
  Shear Force V_Ed = 85.03 kN., LCB = 1
  Torsion T = 2.84 kN-m., LCB = 11

* .REINFORCEMENT PATTERN :
  Location i di (m.) Rebar Asi (m^2.)
  Top 1 0.040 2-P20 0.0063
  Bottom 1 0.040 2-P20 0.0063
  Stirrups : 2.0-P12 @300

[[[*]]] ANALYZE SHEAR AND TORSION CAPACITY.

( ). Compute design parameters.
-. alpha = 0.642857
-. beta1 = 0.8400
-. Gamma_m = 1.50 (for concrete).
-. fcd = fck / Gamma_m = 20000.000 KPa.
-. Gamma_s = 1.15 (for Fundamental).
-. fyd = fyk / Gamma_s = 360869.565 KPa.

( ). Check area of tensile reinforcement (Rectangular-beam).
-. fyk = 415000.000 KPa.
-. ecu = 0.0035
-. est = fy/1.15Es + 0.002 = 0.0038
-. As_max1 = (fck*Bc/fy)*(beta1*ecu*d/(est*ecu)) = 0.0040 m^2.
-. As_max2 = 0.04 * (Bc*Hc) = 0.0060 m^2.
-. As_max = min[ As_max1, As_max2 ] = 0.0040 m^2.
-. As_min = 0.85*bd*d/fy = 0.0033 m^2.
-. As_prov = 0.006 m^2.
-. As_min < As_prov < As_max ----> O.K !
    
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Ln 208 / 392, Col 57

Detailed text output with crack calculations