

# Release Note

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Release Date : July 2018

Product Ver. : Civil 2019 (v1.1)



DESIGN OF CIVIL STRUCTURES

Integrated Solution System for Bridge and Civil Engineering

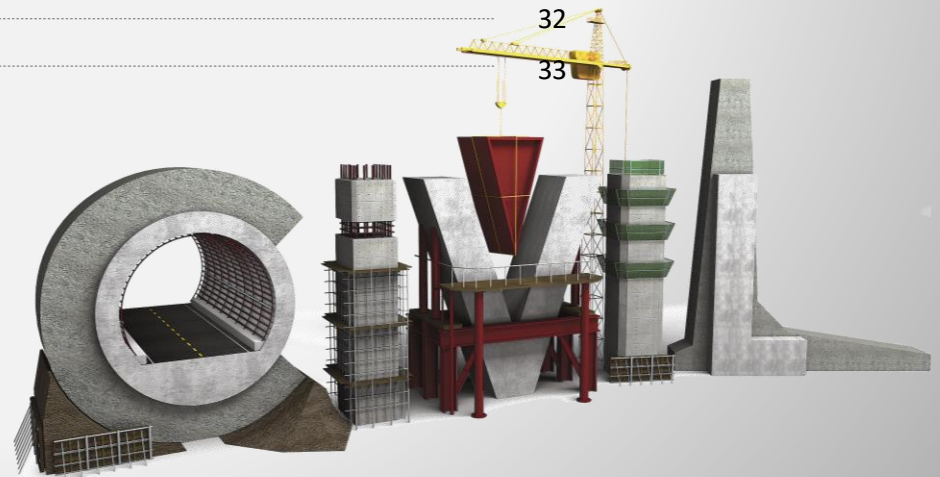
# Enhancements

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## 1. Traffic Load Models for Turkey

- Five Turkish live load models are implemented in midas Civil. KGM-45, H30-S24, H30-S24L, H20-S16, H20-S16L
- These vehicles can be found from the AASHTO LRFD / AASHTO Standard code.

### Load/Moving Load Analysis Data > Vehicles

**Define Standard Vehicular Load**

Standard Name: Turkey

Vehicular Load Properties

Vehicular Load Name: KGM-45

Vehicular Load Type: KGM-45

Dynamic Load Allowance: 0 %

(a)

(b)

Lane Support-Neg. Moment/ Reaction	Application
Not assigned	a
Assigned	a, b

No	Load(kN)	Spacing(m)	W	10	kN/m
1	50	4.25	r	90	%
2	200	4.25	Dist.	15	m
3	200	9			

OK Cancel Apply

Standard Vehicular Load, KGM-45

Standard Name

AASHTO LRFD Load

AASHTO LRFD Load

AASHTO Standard Load

AASHTO Legal/Permit Load

IADOT Load

ILDOT Load

LADOT Load

MODOT Load

OHDOT Load

RIDOT Load

VADOT Load

WIDOT Load

Caltrans Standard Load(2017\_drift)

Caltrans Standard Load

Turkey

Others

Standard Name

AASHTO Standard Load

AASHTO Standard Load

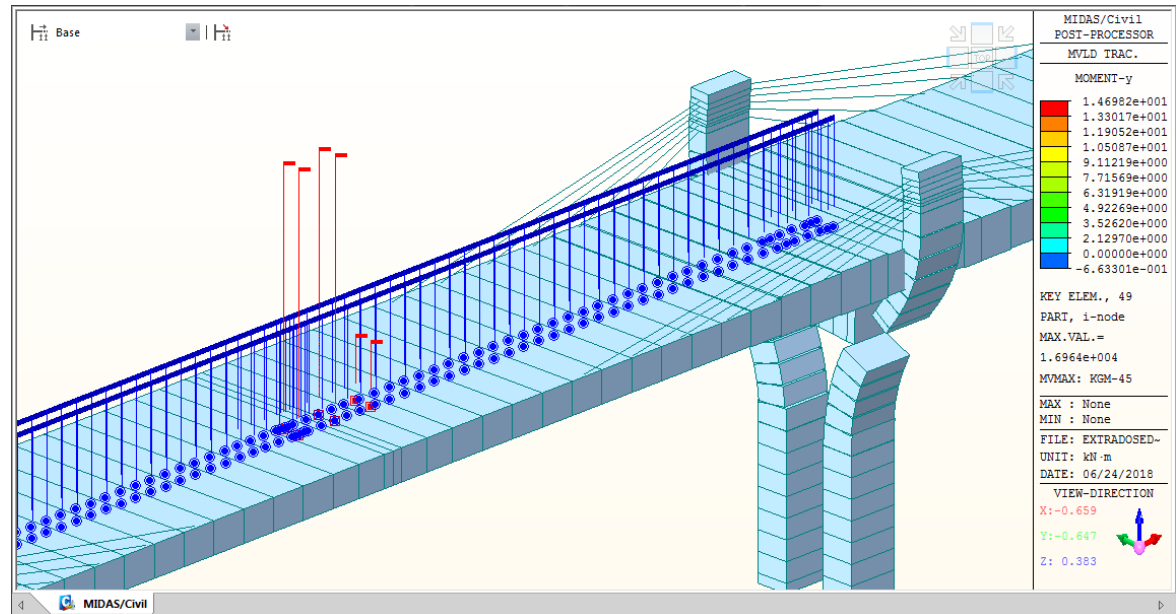
AASHTO Legal Load

Caltrans Standard Load(2017\_drift)

Caltrans Standard Load

Turkey

Others



Moving Load Tracer, KGM-45

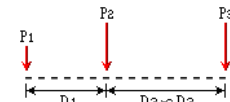
## 1. Traffic Load Models for Turkey

### ▪ Load/Moving Load Analysis Data > Vehicles

Define Standard Vehicular Load

Standard Name  
Turkey

Vehicular Load Properties  
 Vehicular Load Name : H30-S24  
 Vehicular Load Type : H30-S24



No	Load(kN)	Spacing(m)	W
1	60	4.25	Ps
2	240	4.25	Pm
3	240	9	

dW1 0  
dD1 0  
dW2 0  
dD2 0

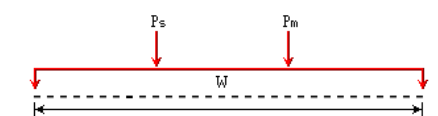
OK Cancel

Standard Vehicular Load, H30-S24

Define Standard Vehicular Load

Standard Name  
Turkey

Vehicular Load Properties  
 Vehicular Load Name : H30-S24L  
 Vehicular Load Type : H30-S24L



No	Load(kN)	Spacing(m)	W
			15 kN/m
			Ps 195 kN
			Pm 135 kN

dW1 0 kN/m  
dD1 0 m  
dW2 0 kN/m  
dD2 0 m

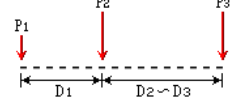
OK Cancel Apply

Standard Vehicular Load, H30-S24L

Define Standard Vehicular Load

Standard Name  
Turkey

Vehicular Load Properties  
 Vehicular Load Name : H20-S16  
 Vehicular Load Type : H20-S16



No	Load(kN)	Spacing(m)	W
1	40	4.25	Ps
2	160	4.25	Pm
3	160	9	

dW1 0  
dD1 0  
dW2 0  
dD2 0

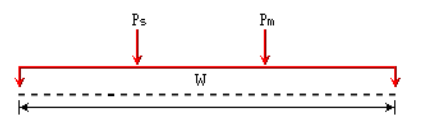
OK Cancel

Standard Vehicular Load, H20-S16

Define Standard Vehicular Load

Standard Name  
Turkey

Vehicular Load Properties  
 Vehicular Load Name : H20-S16L  
 Vehicular Load Type : H20-S16L



No	Load(kN)	Spacing(m)	W
			10 kN/m
			Ps 135 kN
			Pm 90 kN

dW1 0 kN/m  
dD1 0 m  
dW2 0 kN/m  
dD2 0 m

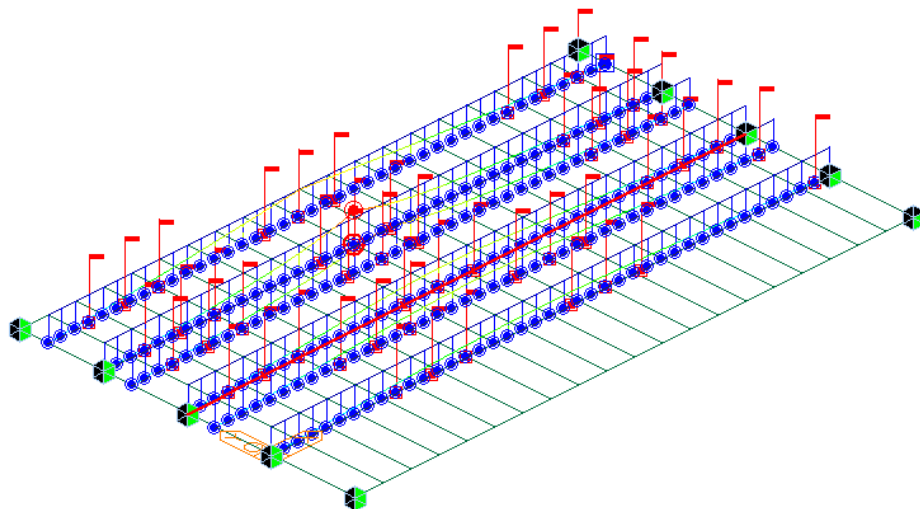
OK Cancel Apply

Standard Vehicular Load, H20-S16L

## 2. Moving Load Optimization for Australia

- Now, the moving load optimization function can be applied with the Australia code as well.
- Moving Load Optimization extends the capabilities of moving load analysis and helps to significantly simplify the evaluation of critical vehicle locations. The critical locations of vehicles can be identified in the transverse direction as well as longitudinal direction according to the code provision.

- Load > Moving Load > Traffic Line/Surface Lane > Moving Load Optimization**
- Load > Moving Load > Moving Load Cases**



Optimized Results for Exterior Girder by S1600

**Moving Load Optimization**

Lane Name : LO

Traffic Lane Optimization Properties

**Start** **End**  
**a : Eccentricity**

Optimization Lane 11 m  
Lane Width 3 m  
Anal. Lane Offset 1 m  
Wheel Spacing 2 m  
Margin 0 m  
Eccentricity 0 m

Vehicular Load Distribution  
☐ Lane Element ☒ Cross Beam  
Cross Beam Group Cross Beam  
Skew Start 0 End 0 [deg]

Moving Direction  
☐ Forward ☐ Backward ☒ Both

Selection by  
☒ 2 Points ☐ Picking ☐ Number  
0, 0, 0 m  
0, 0, 0 m

Operations  
Add Insert Delete

No	Elem	Eccen. (m)	Span Start
1	11	0	<input checked="" type="checkbox"/>
2	12	0	<input type="checkbox"/>
3	13	0	<input type="checkbox"/>

OK Cancel Apply

Traffic Line Lane Optimization

**Define Moving Load Case**

Load Case Name : MO

Description :

☐ Load Case for Permit Vehicle  
☒ **Moving Load Optimization**

☐ Accompanying Lane Factor

Num of Loaded Lanes	Scale Factor
1	1
2	0.8
3 or more	0.4

Optimization  
Min. Vehicle Distance 1 m

Load Case Data  
Loaded Lane LO

Min. Number of Vehicle 0  
Max. Number of Vehicle 4

Loading Effect  
☐ Combined ☒ Independent

Assignment Vehicle  
Selected Vehicle VL:S1600  
Scale Factor 1.0

Vehicle class	Scale
VL:S1600	1

Add Modify Delete

OK Cancel Apply

Moving Load Case



### 3. India IRS Bridge Rules: Railway Loads

- All the applicable railway loads could now directly be applied to any structure. The tractive and braking load of locomotive as well as wagon would be automatically considered.

- Loads > Moving Load > India > Vehicles > IRS Bridge Rules**
- Analysis > Moving Load Analysis Control > Railway Bridge Information**

Bridge Type for Impact/CDA Calculation

☐ Steel ☒ RC

Railway Bridge Information

Tracks Single

Longitudinal Load Dispersion

Sleeper Width Type 2 0 m

Depth of fill(d) 0.3 m

Define Standard Vehicular Load

Standard Name IRS: Bridge Rules

Vehicular Load Properties

Vehicular Load Name Heavy Mineral Loadings

Vehicular Load Type Heavy Mineral Loadings

Select Vehicle

**Gondola Wagon**

**Train Load**

Define Standard Vehicular Load

Standard Name IRS: Bridge Rules

Vehicular Load Properties

Vehicular Load Name Broad Gauge-1676mm

Vehicular Load Type Broad Gauge-1676mm

Select Vehicle

**Modified B.G. Loading 1987-1**

**Modified B.G. Loading 1987-2**

**B.G. Standard Loading 1926-M.L.**

**B.G. Standard Loading 1926-B.L.**

**Revised B.G. Loading 1975-WG1+WG1**

**Revised B.G. Loading 1975-WAM4A+WAM4A**

**Revised B.G. Loading 1975-Bo-Bo+Bo-Bo**

**Revised B.G. Loading 1975-WAM4A**

**Revised B.G. Loading 1975-WAM4A+WAM4**

**Revised B.G. Loading 1975-WAM4A+WDM2**

**25t Loading-2008 Combination 1**

**25t Loading-2008 Combination 2**

**25t Loading-2008 Combination 3**

**25t Loading-2008 Combination 4**

**25t Loading-2008 Combination 5**

**DFC Loading Combination 1**

**DFC Loading Combination 2**

**DFC Loading Combination 3**

**DFC Loading Combination 4**

**DFC Loading Combination 5**

2 LOCO

No	P(tonf)	D(m)
1	25	2.05
2	25	1.95
3	25	5.56
4	25	1.95
5	25	2.05
9	25	1.95
10	25	5.56
11	25	1.95
12	25	2.05

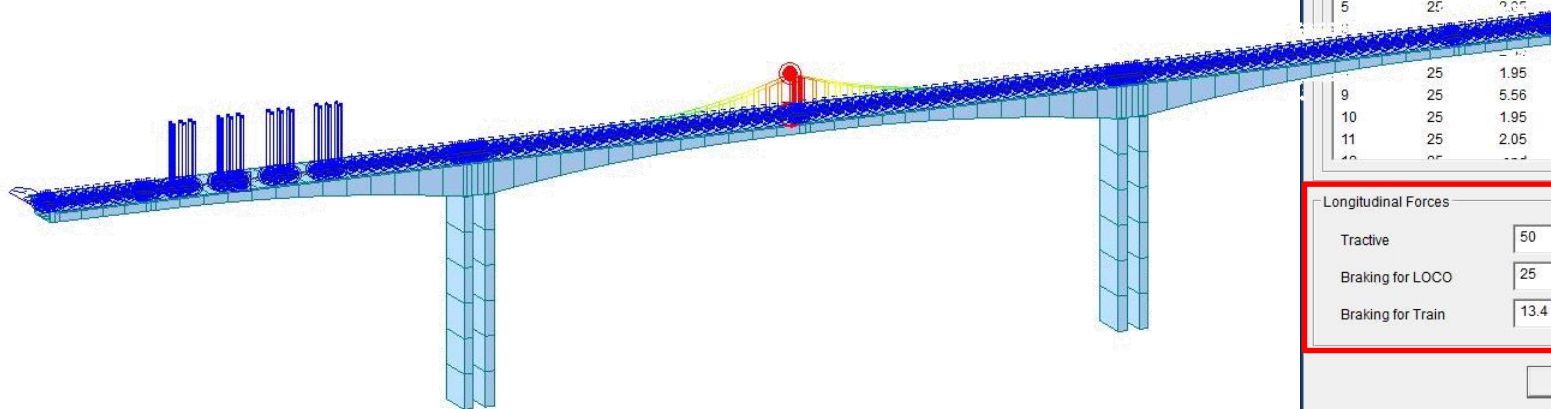
Longitudinal Forces

Tractive 50 tonf

Braking for LOCO 25 % of P

Braking for Train 13.4 % of W

OK Cancel Apply



## 4. Nonlinear Elastic Links for Pushover Analysis

- Nonlinear behavior of the elastic links, i.e. comp.-only, tens.-only, multi-linear can be taken into account in the pushover analysis.
- Link forces imported from static analysis or construction stage analysis cannot be specified as initial loads for pushover analysis.

### Pushover > Control > Global Control

**Pushover Global Control**

Geometric Nonlinearity Type  
☒ None ☐ Large Displacements

Initial Load  
☒ Perform Nonlinear Static Analysis for Initial Load  
☐ Import Static Analysis / Construction Stage Analysis Results  
 - When the boundary conditions are different between initial load and pushover load  
 - When the element forces in the last construction stage are used as an initial load

Load Case: LDC2 Scale Factor: 1

Static Load Case: Scale

Buttons: Add, Modify, Delete

Nonlinear Analysis Option  
☒ Permit Convergence Failure  
 Max. Number of Substeps: 10  
 Maximum Iteration: 10

Convergence Criteria  
☒ Displacement Norm: 0.001  
☐ Force Norm: 0.001  
☐ Energy Norm: 0.001

Analysis Stop  
☐ Shear Component Yield  
☒ Beam/Column  
☐ Axial Component Collapse/Buckling  
☒ Beam/Column  
☐ Support Uplifting/Collapse  
☐ Uplifting  
☐ Collapse

Pushover Hinge Data Option  
☒ Assign Hinge Properties to Member only for Moment-Rotation Beam/Column

Default Stiffness Reduction Ratio of Skeleton Curve  
 Trilinear / Slip Trilinear Type  
☒ Symmetric  

	(+)	(-)
$\alpha_1$	0.1	0.1
$\alpha_2$	0.05	0.05

 Bilinear / Slip Bilinear Type  
☒ Symmetric  

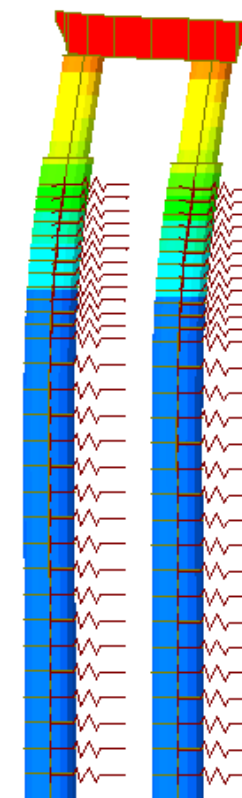
	(+)	(-)
$\alpha_1$	0.05	0.05

Buttons: Remove Pushover Global Control, Misc..., OK, Cancel

Point Spring Support : Comp.-Only, Tens.-Only, Multilinear Type  
☒ Apply the nonlinear properties defined in Point Spring Support for pushover analysis  
☐ Assumed as linear spring support for pushover analysis

Note. In case when pushover hinges are assigned to Point Spring Support, the pushover hinge properties will be used for pushover analysis.

Elastic Link : Comp.-Only, Tens.-Only, Multilinear Type  
☒ Apply the nonlinear properties defined in Elastic Link for pushover analysis  
☐ Assumed as linear Elastic Link for pushover analysis



Bi-linear Elastic Links representing soil resistance

Pushover Global Control

Pushover Analysis for the Pier and Shaft

## 5. GSD > Crack Width Calculation as per IRC 112: 2011

- For any irregular section, both elastic and cracked-elastic crack width can be computed as per IRC 112: 2011 code.
- Excel report of the stress and crack width calculation can be obtained.

### GSD > Design Section > Crack width > Report

**Crack Status**

☐ Elastic ☒ Cracked elastic ☐ Ultimate State

☐ User-defined Ratio of Modulus of Elasticity

Rebar/Conc. : 6 Steel/Conc. : 6

Force and Stress in bars :

**Stress Contour**

Concrete ☒ Stress ☐ Mesh ☒ Max/Min

Steel ☐ Stress ☐ Mesh

Rebar ☒ Stress ☐ ID

Coordinate ☒ Section ☐ Neutral Axis ☐ Contour

Display ☒ Contour

**Table**

Siq_max	at Y =	at Z =	Unit
104.152	934	534	N/mm²
-72.7997	-934	-534	
CW = 0.0678345	CW Lim= 0.3	CW OK	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R		
1	Crack Width																			
2																				
3	1. Material																			
4	Name												M40							
5	fck												40.00 N/mm²							
6	fcm = fck+10(MPa)												50.00 N/mm²							
7	fctm = 0.259*fck^(2/3)												3.029282377 N/mm²							
8																				
9																				
10	2. Calculation of Effective Area																			
11																				
12	Overall Depth												h	2032.72 mm						
13	Steel Centroid Depth												d	1572.70 mm						
14	Neutral Axis Depth												x	1204.28 mm						
15																				
16	Height of effective area												hc,eff = min( 2.5 * (h - d) , (h - x) / 3, h/2)	276.15 mm						
17																				
18	Effective area												Ac,eff	83144.34 mm²						
19																				
20																				
21	3. Calculation of Crack Width																			
22																				
23	Stress in the bars $\sigma_s$												72.80 N/mm²							
24	Area of Tension steel within As												3216.99 mm²							
25	Rho_p,eff = As/ Ac,eff												0.04							
26	Ecm = 22000 * [ fcm / 12.5 ] ^ 0.3												20575.47 N/mm²							
27	Alpha_e = Es / Ecm												5.9977632							
28																				
29	(Eps_sm-Eps_cm)												= (sigma_kt*fct,eff/Rho_p,eff*(1+Alpha_e*Rho_p,eff))/Es						0.000128	
30													< 0.6 * sigma_s / Es						0.0002184	
31																				
32	(Eps_sm-Eps_cm)																		0.0002184	
33																				
34	Bond coefficient(k1)																		0.80	
35	Strain distribution coefficient(k2)																		0.50	
36	NAD Value (k3)																		3.40	
37	NAD Value (k4)																		0.43	
38	Cover to the bar c																		50.00 mm	
39	Equivalent Diameter phi																		32.00 mm	
40																				
41	S_r,max												= k3*c + k1*k2*k4*g/Rho_p,eff						310.5988471 mm	
42																				
43	wk												= S_r,max * ( Eps_sm-Eps_cm)						0.0678345 mm	
44																				
45	CW limit (taking from the input given in serviceability parameters)																		0.30 mm	
46																				
47	Crack Width Check																		OK	
48																				
49																				
50																				

Page 1

<

Depth = 1204.28 mm

Report Close



## 6. AASHTO LRFD 2016 update

## ▪ Load Combination

Load Combination Limit State	DC DD DW EH EV ES EL PS CR SH	LL IM CE BR PL LS	WA	WS	WL	FR	TU	TG	SE	Use One of These at a Time				
										EQ	BL	IC	CT	CV
Strength I (unless noted)	$\gamma_p$	1.75	1.00	—	—	1.00	0.50/1.20	$\gamma_{TG}$	$\gamma_{SE}$	—	—	—	—	—
Strength II	$\gamma_p$	1.35	1.00	—	—	1.00	0.50/1.20	$\gamma_{TG}$	$\gamma_{SE}$	—	—	—	—	—
Strength III	$\gamma_p$	—	1.00	1.0	—	1.00	0.50/1.20	$\gamma_{TG}$	$\gamma_{SE}$	—	—	—	—	—
Strength IV	$\gamma_p$	—	1.00	—	—	1.00	0.50/1.20	—	—	—	—	—	—	—
Strength V	$\gamma_p$	1.35	1.00	1.0	1.00	1.00	0.50/1.20	$\gamma_{TG}$	$\gamma_{SE}$	—	—	—	—	—
Extreme Event I	1.0	$\gamma_{EQ}$	1.00	—	—	1.00	—	—	—	1.00	—	—	—	—
Extreme Event II	$\gamma_p$	0.50	1.00	—	—	1.00	—	—	—	—	1.00	1.00	1.00	1.00
Service I	1.00	1.00	1.00	1.0	1.00	1.00	1.00/1.20	$\gamma_{TG}$	$\gamma_{SE}$	—	—	—	—	—
Service II	1.00	1.30	1.00	—	—	1.00	1.00/1.20	—	—	—	—	—	—	—
Service III	1.00	$\gamma_{LL}$	1.00	—	—	1.00	1.00/1.20	$\gamma_{TG}$	$\gamma_{SE}$	—	—	—	—	—
Service IV	1.00	—	1.00	1.0	—	1.00	1.00/1.20	—	1.00	—	—	—	—	—
Fatigue I— LL, IM & CE only	—	1.50	—	—	—	—	—	—	—	—	—	—	—	—
Fatigue II— LL, IM & CE only	—	0.75	—	—	—	—	—	—	—	—	—	—	—	—

Automatic Generation of Load Combinations

Option

☒ Add
 ☐ Replace
 ☒ Add Envelope

Code Selection

☒ Steel
 ☐ Concrete
 ☐ SRC
 ☐ Steel Composite

Design Code : AASHTO-LRFD 16

Manipulation of Construction Stage Load Case

☒ ST Only
 ☐ CS Only
 ☐ ST+CS

ST : Static Load Case CS : Construction Stage

Load Modifier :

1

☒ Load Factors for Permanent Loads ( $\gamma_p$ )

Load Factor for Settlement :

1

☐ Structural Plate Box Structures(Metal Box Culverts)

Live Load Factor for Service III :

0.8

Condition for Temperature

☐ Deformation Check
 ☒ All Other Effects

OK

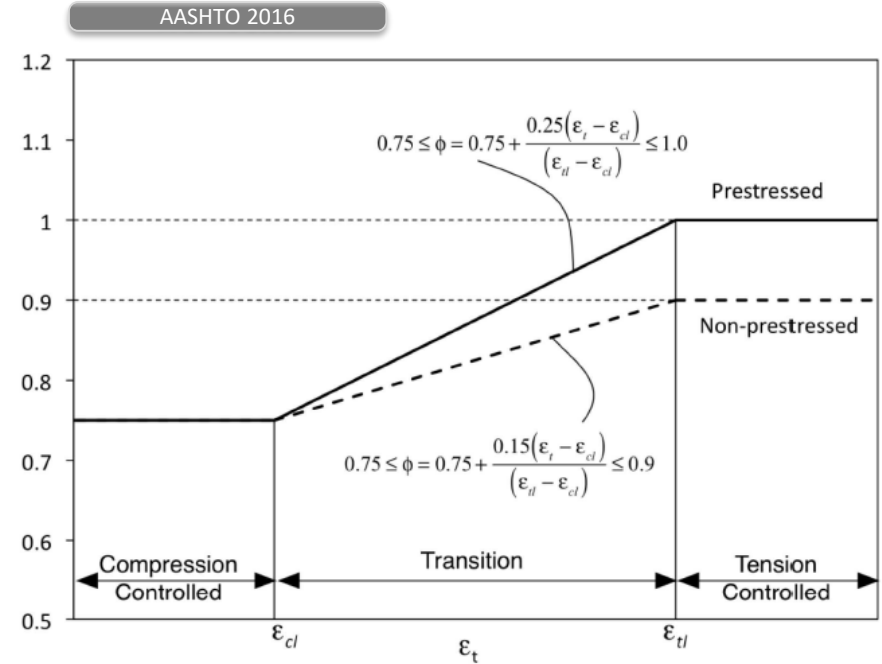
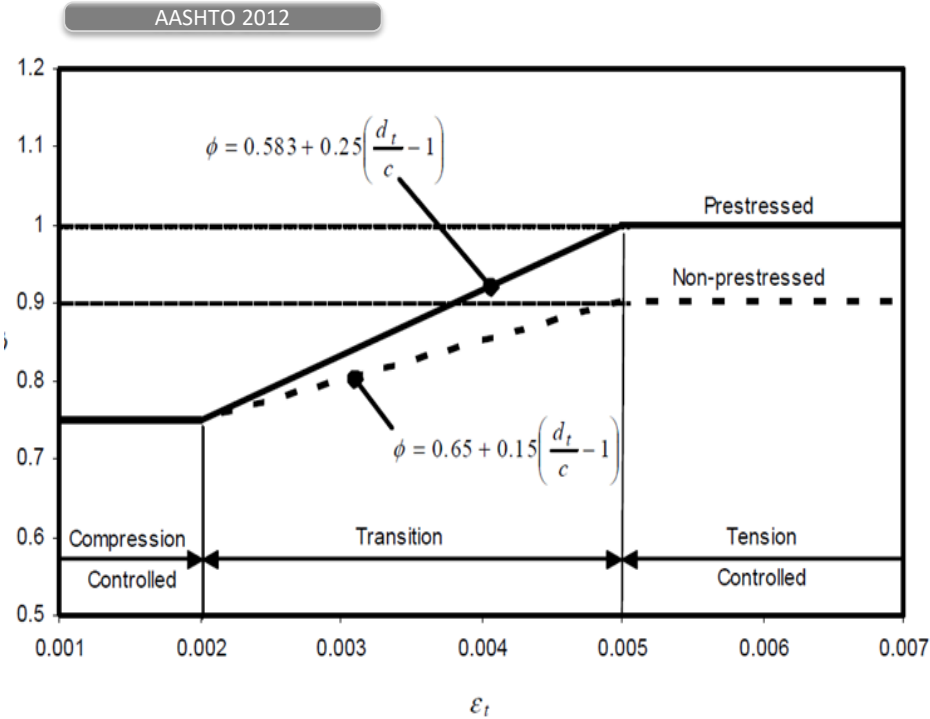
Cancel

Load Combinations Dialog

- Load factors of WS for Strength III, Strength V, Service I, Service IV are changed from 1.4 to 1.0, 0.4 to 1.0, 0.3 to 1.0, 0.7 to 1.0, respectively.
- Load factor of permanent effects for Extreme Event I is changed from  $\gamma_p$  to 1.0. AASHTO-LRFD 2012 used a value for  $\gamma_p$  greater than 1.0.

## 6. AASHTO LRFD 2016 update

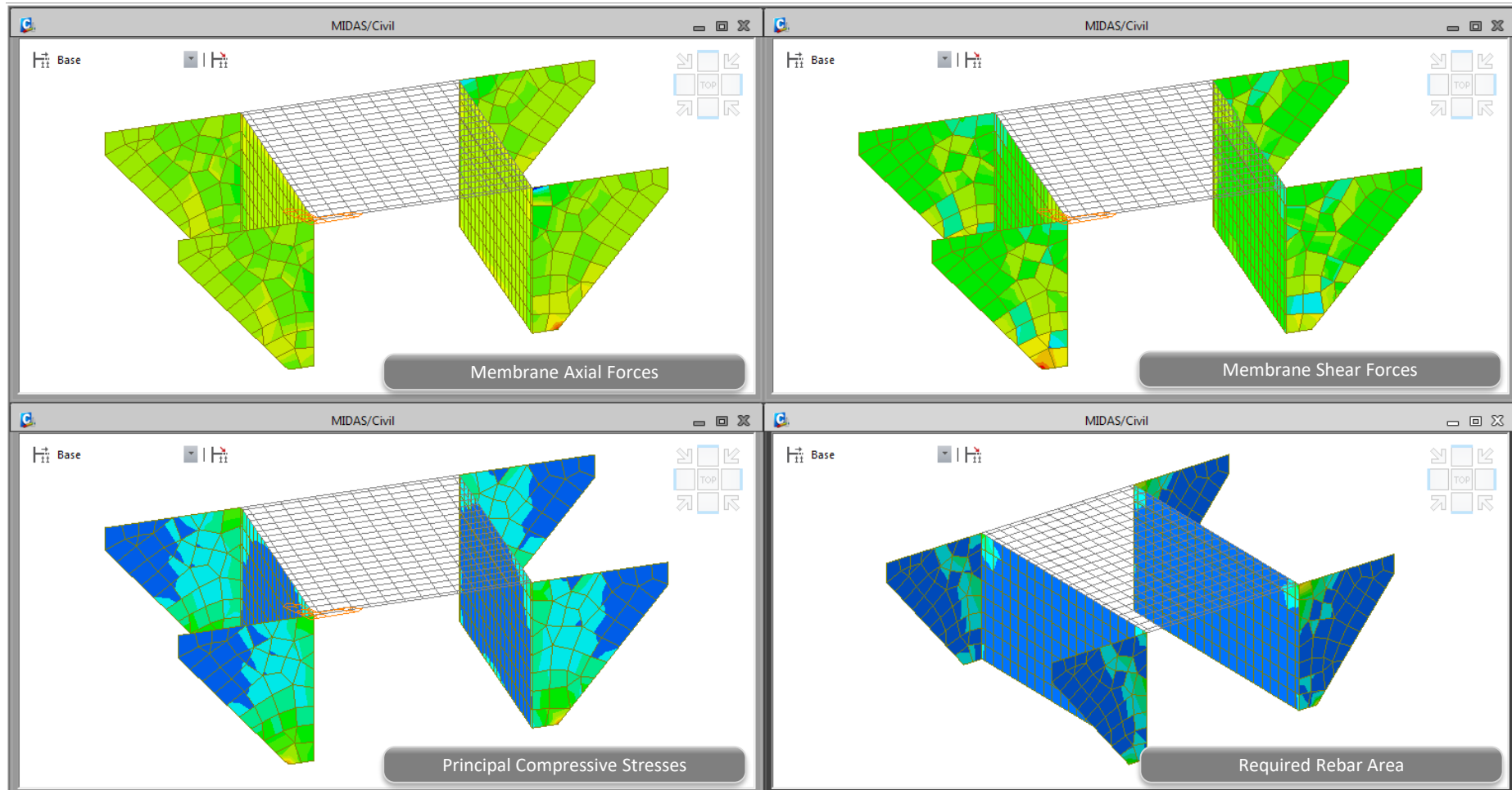
## ■ Resistance Factor



- $\epsilon_{cl}$ : compression-controlled strain limit in the extreme tension steel
- $\epsilon_{tl}$ : tension-controlled strain limit in the extreme tension steel

## 7. Shell Design

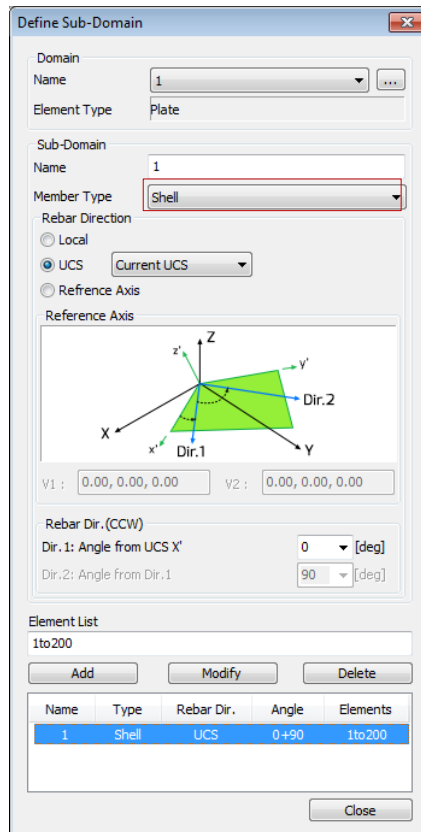
- The design of reinforcement concrete shells as per Annex LL of EN 1992-2 is implemented.
- Shell design considers three membrane forces, two flexural moments, twisting moment and two transverse shear forces.
- This design feature can be applied to concrete shell structure, abutment walls / wing walls, under ground structures.



## 7. Shell Design

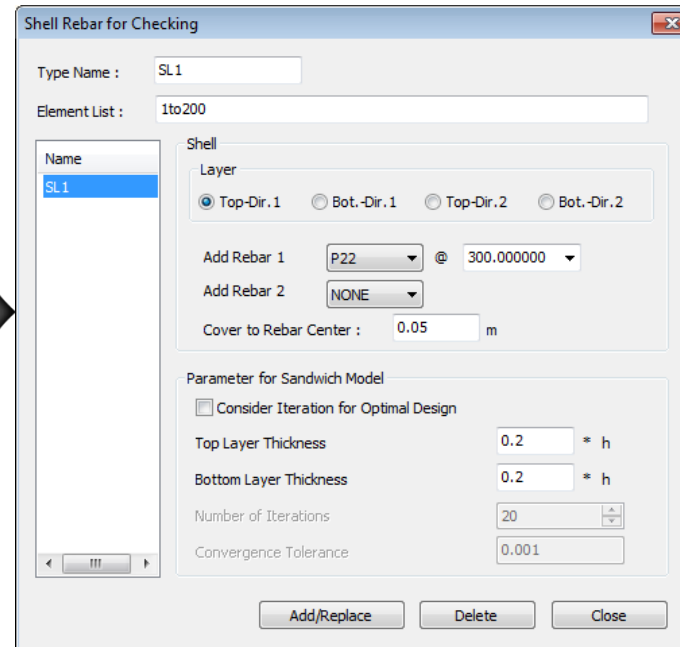
### Shell Design

Step 1. Define as a shell member



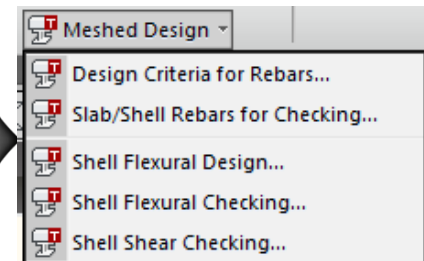
Define Sub-Domain dialog box. Domain Name: 1. Element Type: Plate. Sub-Domain Name: 1. Member Type: Shell. Rebar Direction: UCS (Current UCS). Reference Axis: V1: 0.00, 0.00, 0.00; V2: 0.00, 0.00, 0.00. Rebar Dir. (CCW): Dir.1: Angle from UCS X': 0 [deg]; Dir.2: Angle from Dir.1: 90 [deg]. Element List: 1to200. Buttons: Add, Modify, Delete, Close.

Step 2. Define Rebar Data and Layer Thickness



Shell Rebar for Checking dialog box. Type Name: SL1. Element List: 1to200. Shell Layer: Top-Dir.1 (selected). Add Rebar 1: P22 @ 300.000000. Add Rebar 2: NONE. Cover to Rebar Center: 0.05 m. Parameter for Sandwich Model: Consider Iteration for Optimal Design (checked). Top Layer Thickness: 0.2 \* h. Bottom Layer Thickness: 0.2 \* h. Number of Iterations: 20. Convergence Tolerance: 0.001. Buttons: Add/Replace, Delete, Close.

Step 3. Run Shell Design and Checking



Meshed Design menu. Options: Design Criteria for Rebars..., Slab/Shell Rebars for Checking..., Shell Flexural Design..., Shell Flexural Checking..., Shell Shear Checking...

## 7. Shell Design

### Shell Flexural Design/Checking

**Result for Rebar**

Shell Flexural Design

Load Cases/Combinations  
ALL COMBINATION

Design Force  
☒ Element ☐ Avg. Nodal

☒ Element ☐ Width 1 m

Display Option  
☐ Top ☐ Bottom ☒ Both

☒ Rebar (Dir. 1) ☐ Rebar (Dir. 2)

☐ Concrete

Type of Display  
☒ Contour ☒ Legend ☐ Values

The followings can be displayed.

1. Membrane Axial Force
2. Membrane Shear Force
3. Rebar Stress
4. As\_req  
(Required reinforcement area)
5. Rho\_req  
(Required reinforcement ratio)
6. Rebar Arrangement

**Result for Concrete**

Shell Flexural Design

Load Cases/Combinations  
ALL COMBINATION

Design Force  
☒ Element ☐ Avg. Nodal

☒ Element ☐ Width 1 m

Display Option  
☐ Top ☐ Bottom ☒ Both

☐ Rebar (Dir. 1) ☐ Rebar (Dir. 2)

☒ Concrete

Type of Display  
☒ Contour ☒ Legend ☐ Values

The followings can be displayed.

1. Membrane Axial Force
2. Membrane Shear Force
3. Principal Compressive Stress of Concrete

Results Table

	Elem	Node	POS	CHK	Dir-1				Dir-2				Conc			
					Lcom	ftd (kN/m <sup>2</sup> )	ftd (kN/m <sup>2</sup> )	Ratio	Lcom	ftd (kN/m <sup>2</sup> )	ftd (kN/m <sup>2</sup> )	Ratio	Lcom	Sig_cd (kN/m <sup>2</sup> )	sigcdlim (kN/m <sup>2</sup> )	Ratio
▶	2	2	TOP	NG	LC3-st	5720.27	808.63	7.07	LC3-st	1155.22	743.06	1.55	LC3-st	28.70	4000.00	0.01
	2	2	BOT	NG	LC3-st	139.52	771.16	0.18	LC3-st	28.18	721.21	0.04	LC3-st	5855.31	4000.00	1.46
	2	3	TOP	NG	LC3-st	5714.92	808.63	7.07	LC3-st	1148.37	743.06	1.55	LC3-st	13.97	4000.00	0.00
	2	3	BOT	NG	LC3-st	139.39	771.16	0.18	LC3-st	28.01	721.21	0.04	LC3-st	5856.79	4000.00	1.46
	2	7	TOP	NG	LC3-st	2992.12	808.63	3.70	LC3-st	524.62	743.06	0.71	LC3-st	69.89	4000.00	0.02
	2	7	BOT	OK	LC3-st	72.98	771.16	0.09	LC3-st	12.80	721.21	0.02	LC3-st	3040.47	4000.00	0.76
	2	8	TOP	NG	LC3-st	3092.07	808.63	3.82	LC3-st	630.71	743.06	0.85	LC3-st	27.22	4000.00	0.01
	2	8	BOT	OK	LC3-st	75.42	771.16	0.10	LC3-st	15.38	721.21	0.02	LC3-st	3163.41	4000.00	0.79



## 7. Shell Design

### Shell Shear Checking

#### Result for Shear

Shell Shear Checking

Load Cases/Combinations  
ALL COMBINATION

Design Force  
☒ Element ☐ Avg. Nodal  
☒ Element ☐ Width 1 m

Display Option  
 Type of Display  
☒ Contour ☒ Legend  
☐ Values

☒ V\_Edo  
☐ Shear Resistance  
☐ Resistance Ratio

The followings can be displayed.

1. V\_Edo
2. Shear Resistance for Concrete
3. Resistance Ratio

#### Results Table

	Elem	Sub-Domain	Lcom	Node	CHK	Shear Force				Resistance		
						V_Edx (kN/m)	V_Edy (kN/m)	V_Edo (kN/m)	phi_o	V_Rdc (kN/m)	V_Rds (kN/m)	Asw/s (m <sup>2</sup> /m)
▶	2	L-B	LC2-ser	7	OK	-44.70	1.76	44.73	-0.04	117.78	0.00	0.00
	2	L-B	LC2-ser	8	OK	-43.10	1.76	43.14	-0.04	117.78	0.00	0.00
	2	L-B	LC2-ser	3	OK	-43.10	0.00	43.10	-0.00	126.37	0.00	0.00
	2	L-B	LC2-ser	2	OK	-44.70	0.00	44.70	-0.00	126.37	0.00	0.00

## 7. Shell Design

### Design Concept of Shell Design

- Shell or plate element subjected to membrane forces  $N_x, N_y, N_{xy}$  + flexural forces  $M_x, M_y, M_{xy}$
- Resisted by resultant tensile forces of reinforcement + resultant compressive forces of concrete

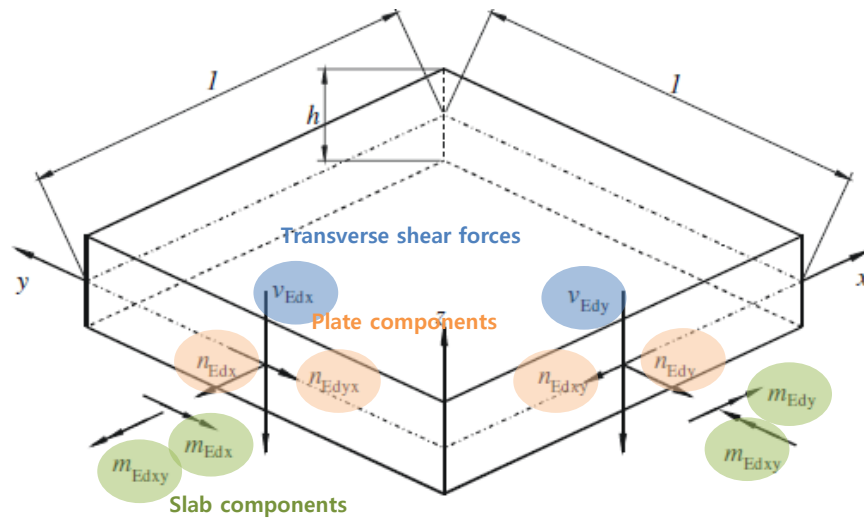


Figure LL.1 — Shell element

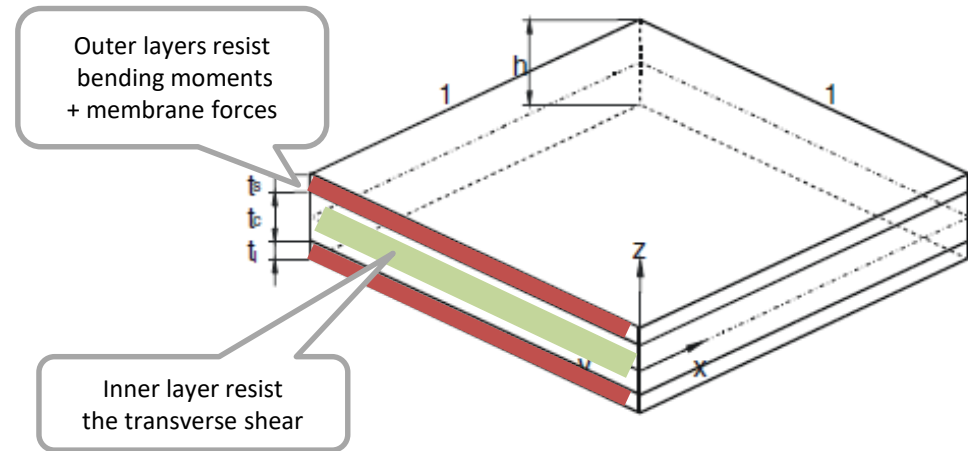
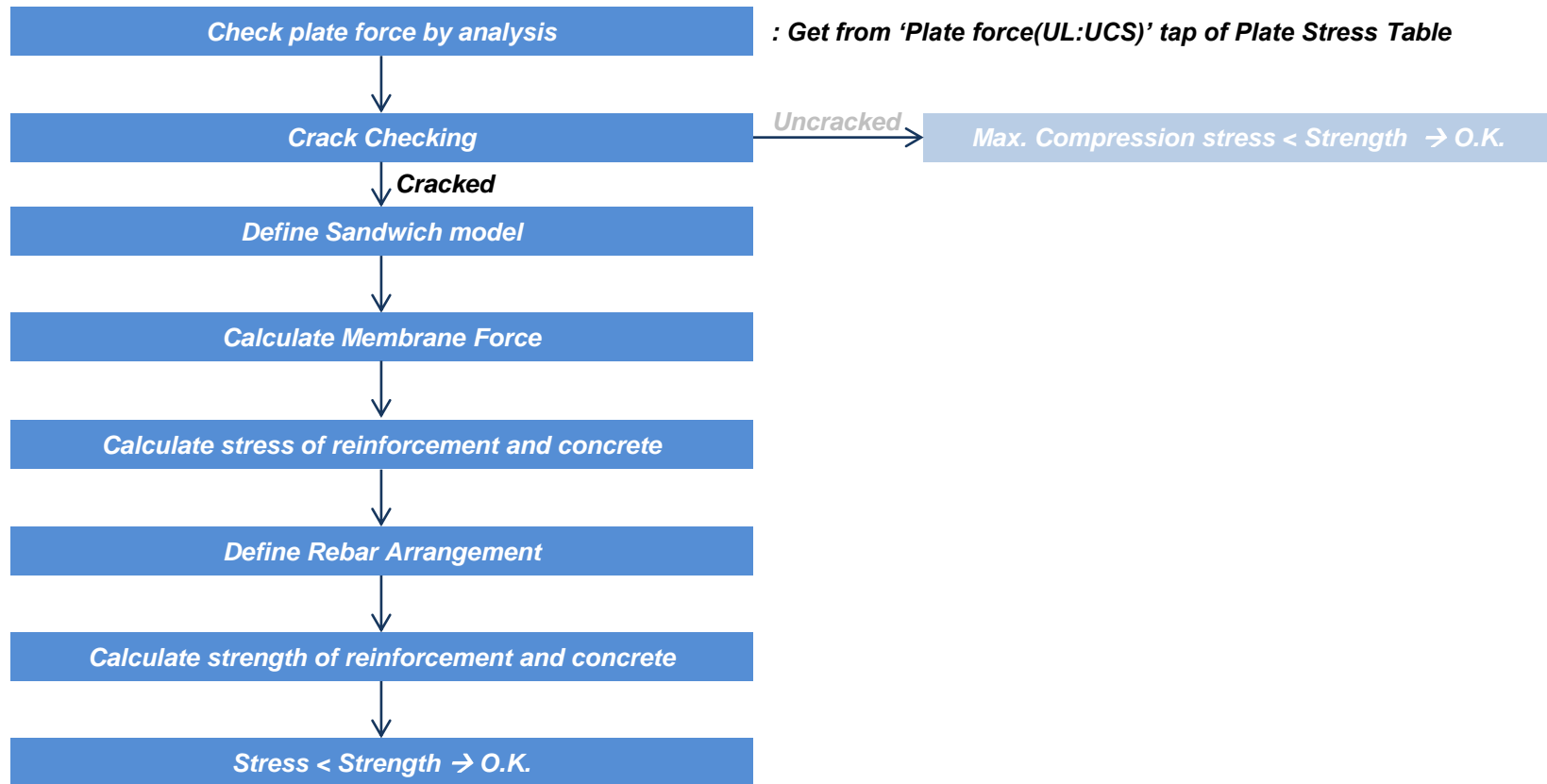


Figure LL.2 — The sandwich model

## 7. Shell Design

### Procedure of Shell Design



## 7. Shell Design

### Procedure of Shell Design

#### Crack Checking

$$\Phi = \alpha \frac{J_2}{f_{cm}^2} + \lambda \frac{\sqrt{J_2}}{f_{cm}} + \beta \frac{I_1}{f_{cm}} - 1 \leq 0 \quad \rightarrow \text{Uncracked, If } \Phi > 0.0, \text{ Cracked}$$

where:

$$J_2 = \frac{1}{6} [(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2]$$

$$J_3 = (\sigma_1 - \sigma_m)(\sigma_2 - \sigma_m)(\sigma_3 - \sigma_m)$$

$$I_1 = \sigma_1 + \sigma_2 + \sigma_3$$

$$\sigma_m = (\sigma_1 + \sigma_2 + \sigma_3)/3$$

$$\alpha = \frac{1}{9k^{1.4}}$$

$$\sigma_1 = \text{Max. } [\sigma_x, \sigma_y] = \text{Max. } [F_{xx}, F_{yy}]$$

$$\sigma_2 = \text{Min. } [\sigma_x, \sigma_y] = \text{Min. } [F_{xx}, F_{yy}]$$

$$\sigma_3 = 0$$

$$\lambda = c_1 \cos \left[ \frac{1}{3} \arccos(C_2 \cos 3\theta) \right] \quad \text{for } \cos 3\theta \geq 0$$

$$\lambda = c_1 \cos \left[ \frac{\pi}{3} - \frac{1}{3} \arccos(-C_2 \cos 3\theta) \right] \quad \text{for } \cos 3\theta < 0$$

$$\beta = \frac{1}{3.7k^{1.1}}$$

$$\cos 3\theta = \frac{3\sqrt{3}}{2} \frac{J_3}{J_2^{3/2}}$$

$$c_1 = \frac{1}{0.7k^{0.9}}$$

$$c_2 = 1 - 6.8(k - 0.07)^2$$

$$k = \frac{f_{ctm}}{f_{cm}}$$

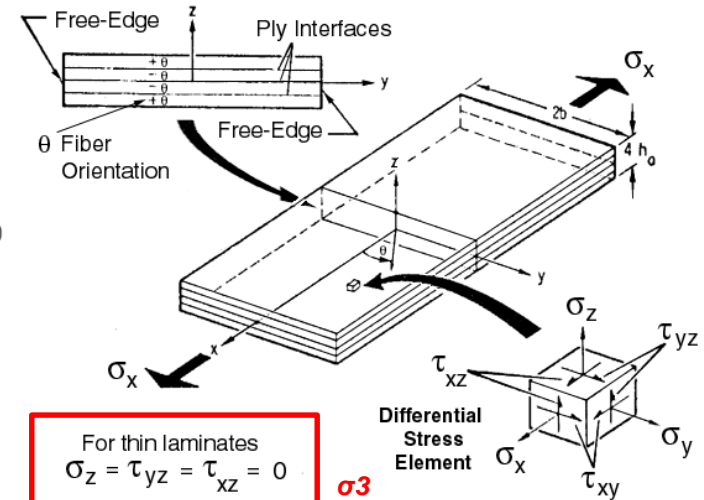


Plate Stress (UL : UCS) Table

	Elem	Load	Node	Fxx (kN/m)	Fyy (kN/m)	Fxy (kN/m)	Fmax (kN/m)	Fmin (kN/m)
▶	218	cLCB1	Cent	-17.633	-1.408	-0.083	-1.408	-17.634
	218	cLCB1	186	-18.198	-0.873	-0.319	-0.867	-18.203
	218	cLCB1	238	-17.152	-0.873	-0.275	-0.869	-17.157
	218	cLCB1	185	-17.152	-1.860	0.152	-1.859	-17.154
	218	cLCB1	150	-18.198	-1.860	0.108	-1.859	-18.198

Plate Force(L) Plate Force(G) Plate Force(UL:Local) Plate Force(UL:UCS)

## 7. Shell Design

### Procedure of Shell Design

#### Define Sandwich model

- Use '0.2\*h' as default value.
- If check on "Consider Iteration for optimal design", layer thickness will be calculated automatically.

☐ Consider Iteration for Optimal Design

Top Layer Thickness : 0.2 \* h

Bottom Layer Thickness : 0.2 \* h

Number of Iterations : 20

Convergence Tolerance : 0.001

OK Close

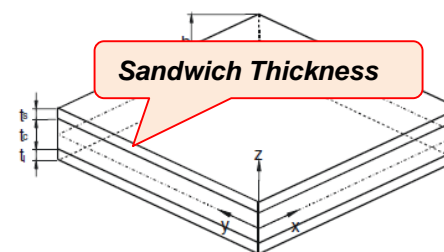
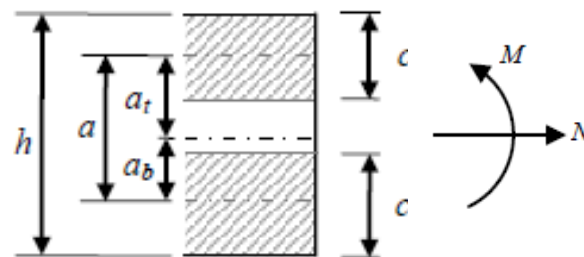


Figure LL.2 — The sandwich model

#### Calculate Membrane Force

- The geometry of sandwich element has to be known to compute the membrane forces ( $N_{xk}$ ,  $N_{yk}$ ,  $N_{xyk}$ ).

$$\begin{aligned} N_{xt} &= N_x \frac{a_b}{a} - \frac{M_x}{a} & N_{xb} &= N_x \frac{a_t}{a} + \frac{M_x}{a} \\ N_{yt} &= N_y \frac{a_b}{a} - \frac{M_y}{a} & N_{yb} &= N_y \frac{a_t}{a} + \frac{M_y}{a} \\ N_{xyt} &= N_{xy} \frac{a_b}{a} - \frac{M_{xy}}{a} & N_{xyb} &= N_{xy} \frac{a_t}{a} + \frac{M_{xy}}{a} \end{aligned}$$

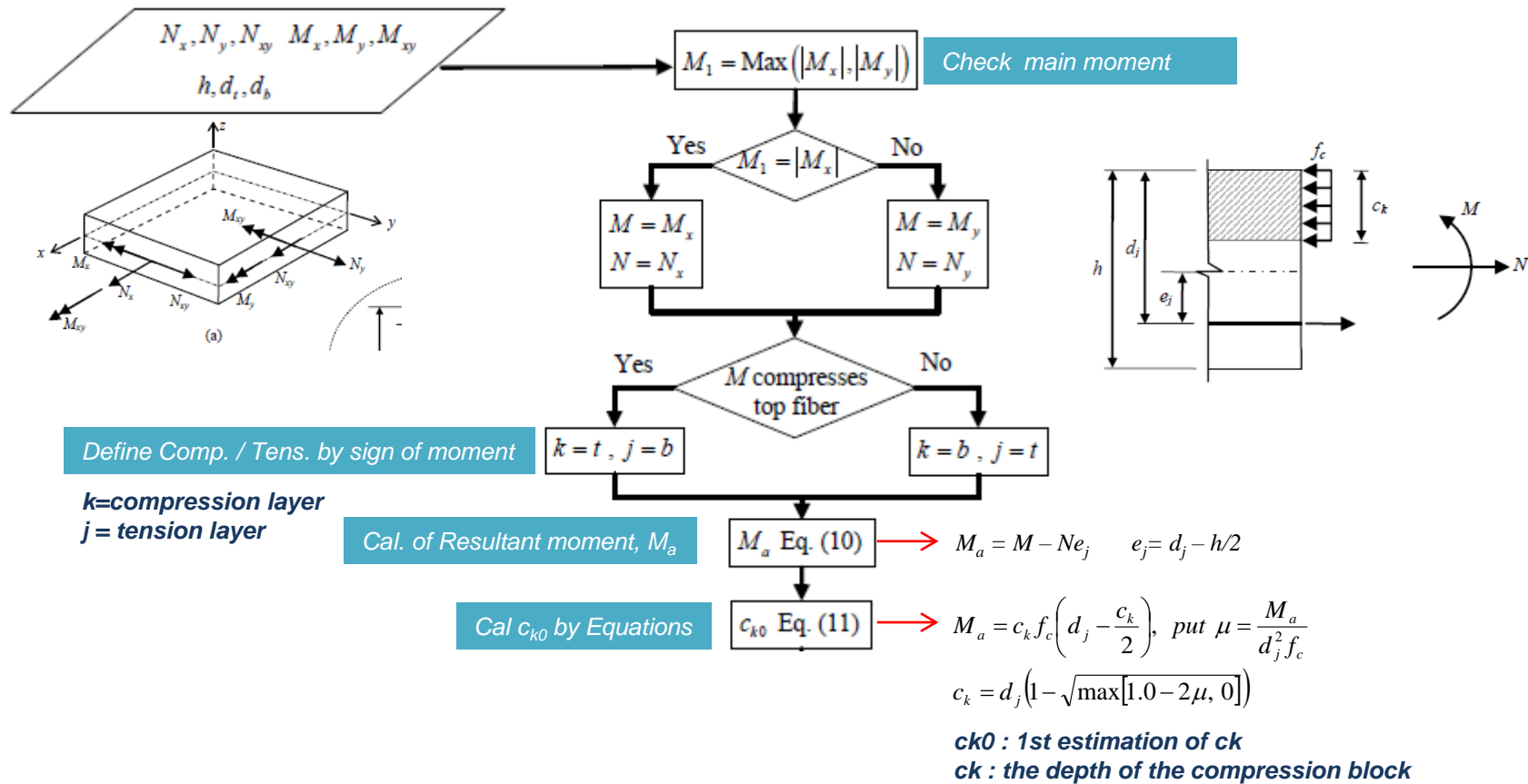




## 7. Shell Design

### Procedure of Shell Design

#### Calculation of Sandwich Thickness for Optimal Design - 1



## 7. Shell Design

### Procedure of Shell Design

#### Calculation of Sandwich Thickness for Optimal Design - 2

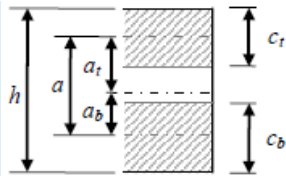
Membrane force in compression layer.

$$a = d_j - \frac{c_k}{2}, \quad a_k = \frac{h - c_k}{2}, \quad a_j = a - a_k$$

$$N_{xk} = N_x \frac{a_j}{a} - \frac{M_x}{a}$$

$$N_{yk} = N_y \frac{a_j}{a} - \frac{M_y}{a}$$

$$N_{xyk} = N_{xy} \frac{a_j}{a} - \frac{M_{xy}}{a}$$



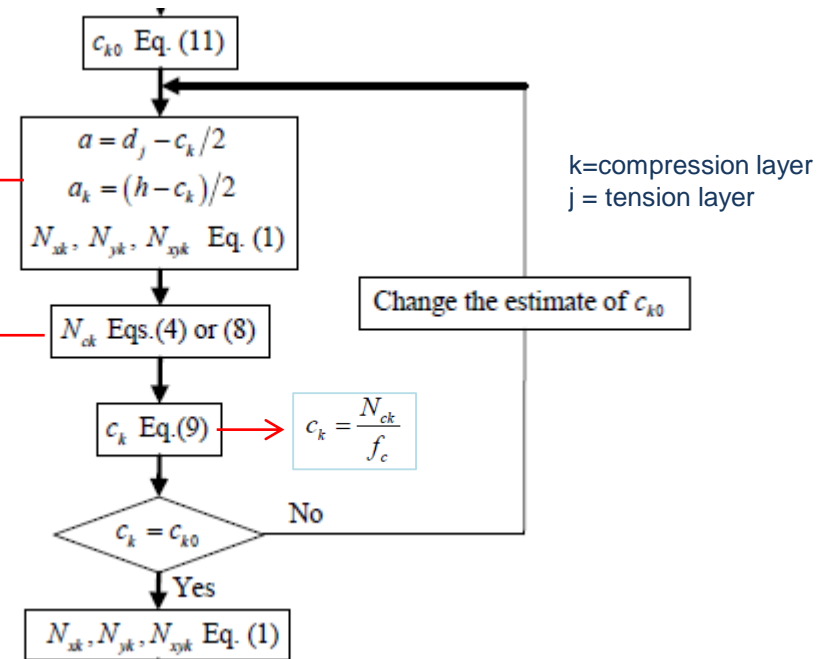
Compression Force of Concrete .

**When**  $N_{xk} < -|N_{xyk}|, N_{yk} < -|N_{xyk}|$

$$N_{ck} = \frac{1}{2}(N_{xk} + N_{yk}) - \frac{1}{2}\sqrt{(N_{xk} - N_{yk})^2 + 4N_{xyk}^2}$$

**When excluding**  $N_{xk} < -|N_{xyk}|, N_{yk} < -|N_{xyk}|$

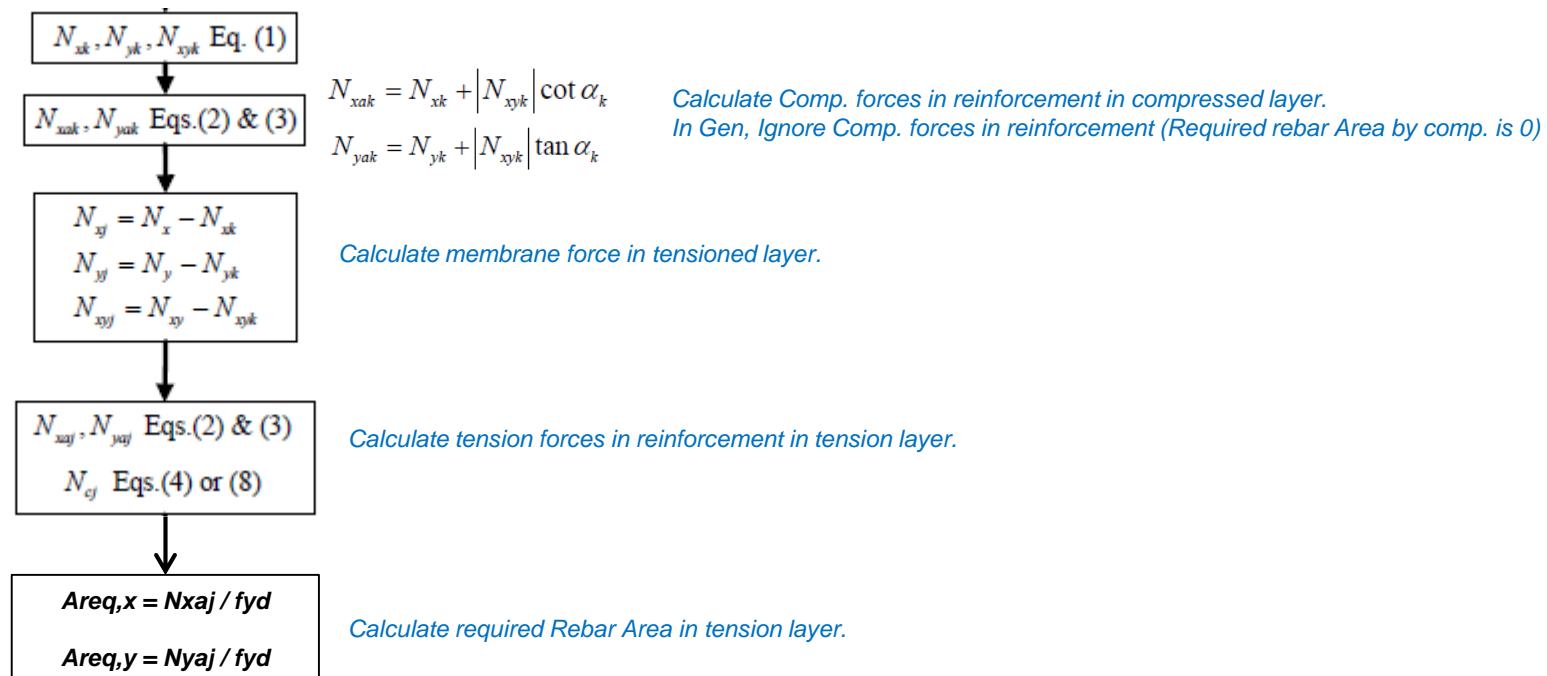
$$N_{ck} = |N_{xyk}|(\tan \alpha_k + \cot \alpha_k)$$



## 7. Shell Design

### Procedure of Shell Design

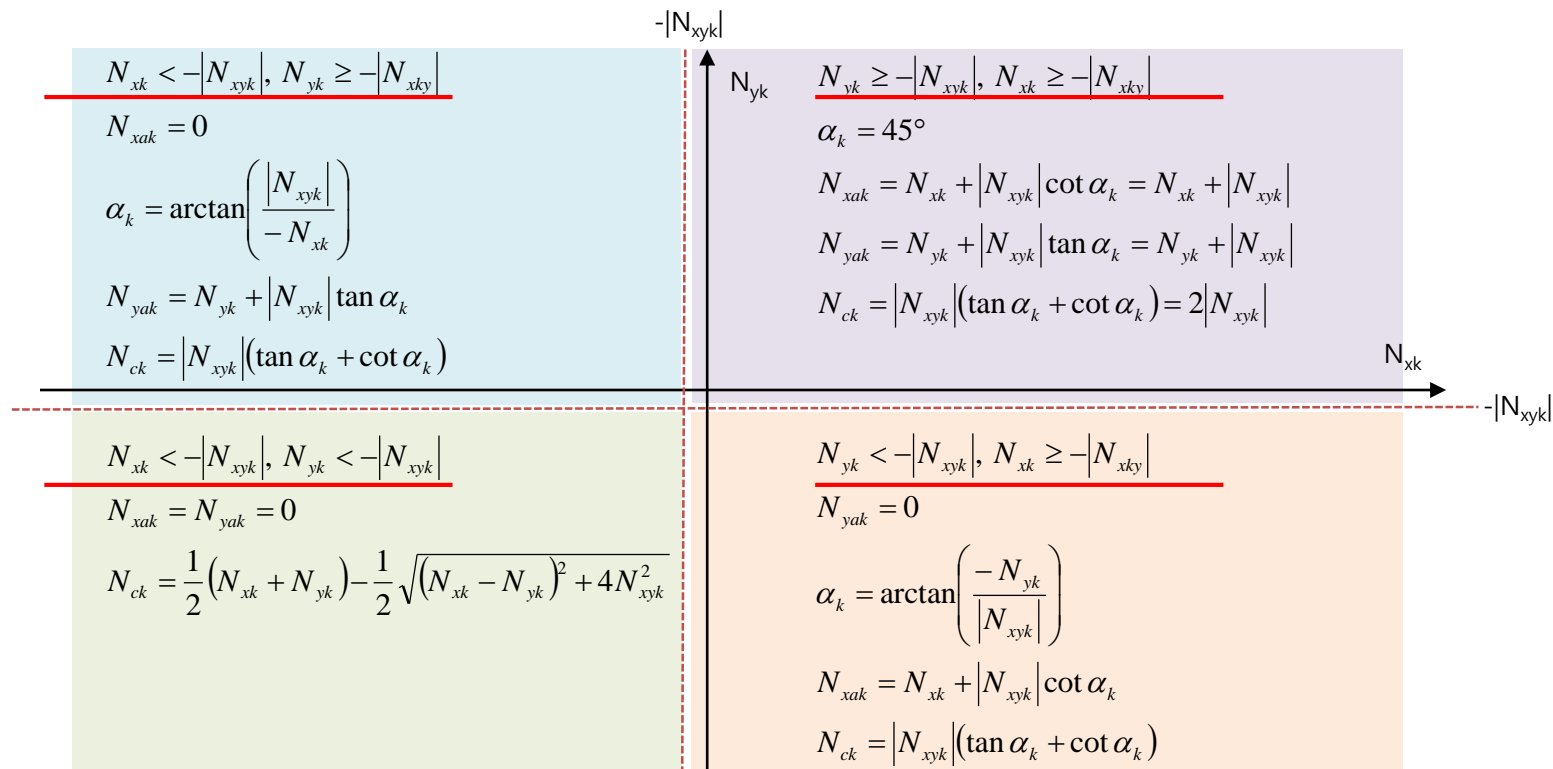
#### Calculation of Membrane Force in tension layer and Required Rebar Area



## 7. Shell Design

## Procedure of Shell Design

Calculate Force of reinforcement(Tension Layer) and concrete(Compression Layer)



$N_{xak}, N_{yak}$  : tension forces in reinforcement placed in x and y direction in layer k

$N_{ck}$  : Concrete compression force in layer k

## 7. Shell Design

### Procedure of Shell Design

#### Modification of Tension force by considering the location of rebar

Distance from center section to center of outer Rebar

Distance from center section to center of sandwich thickness

$$z_{ya} = \frac{N_{yat} z_{yat} + N_{yab} z_{yab}}{\sum N_{ya}} = \frac{168.71 \cdot 67 + 229.47(-80)}{398.18} = -17.72 \text{ mm}$$

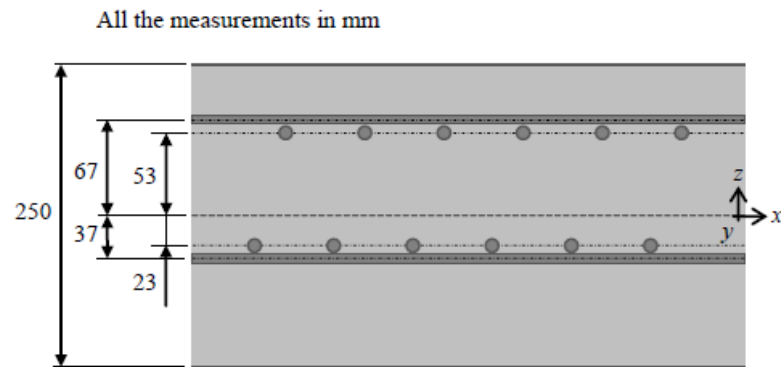
The actual positions of  $y$  reinforcement in top and bottom layer are  $z_{yat}^* = 53 \text{ mm}$  and

$z_{yab}^* = -23 \text{ mm}$ , the corresponding tension forces at those levels,  $N_{yat}^*$  and  $N_{yab}^*$ , can be

obtained from:

$$N_{yat}^* = \sum N_{ya} \frac{z_{ya} - z_{yab}^*}{z_{yat}^* - z_{yab}^*} = 398.18 \frac{-17.72 + 23}{53 + 23} = 27.68 \text{ N/mm}$$

$$N_{yab}^* = \sum N_{ya} \frac{z_{yat}^* - z_{ya}}{z_{yat}^* - z_{yab}^*} = 398.18 \frac{53 + 17.72}{53 + 23} = 370.50 \text{ N/mm}$$

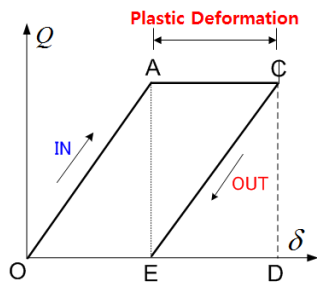
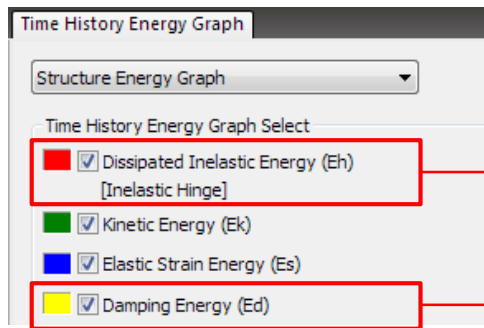




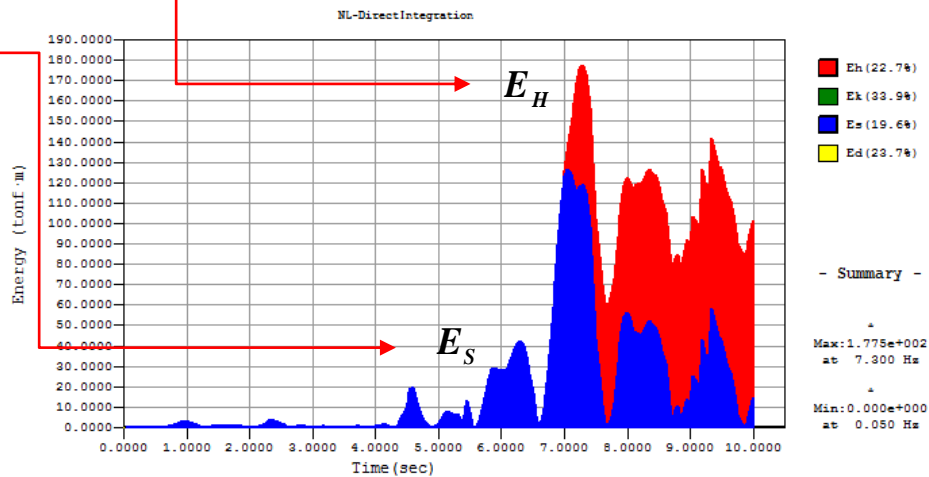
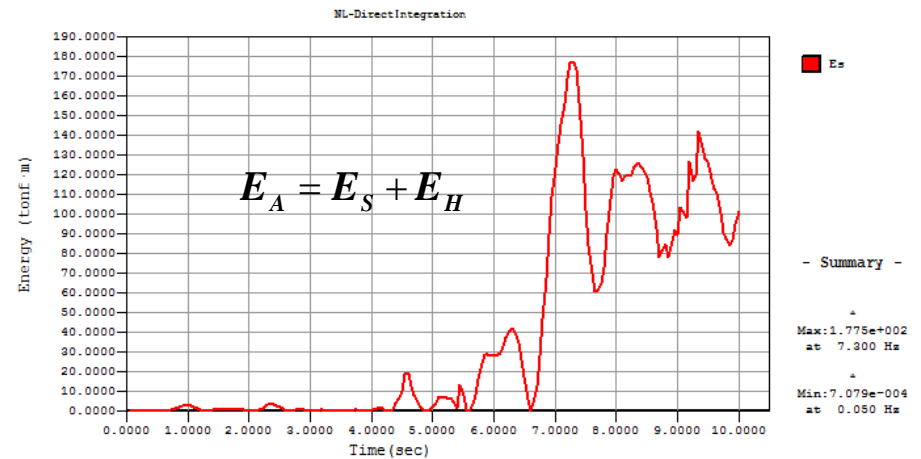
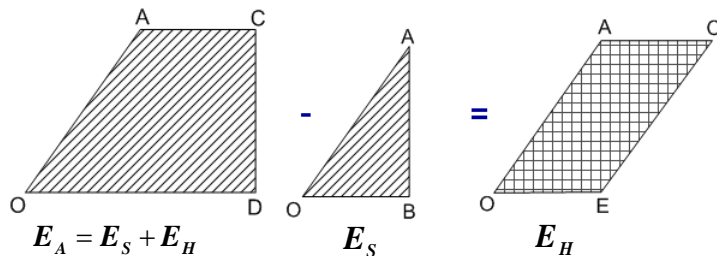
## 1. Energy Result Graph for Time History Analysis

- Print out energy results graph for isolator and vibration control devices in the nonlinear time history analysis.

### Result > T.H. Graph/Text > Time History Energy Graph

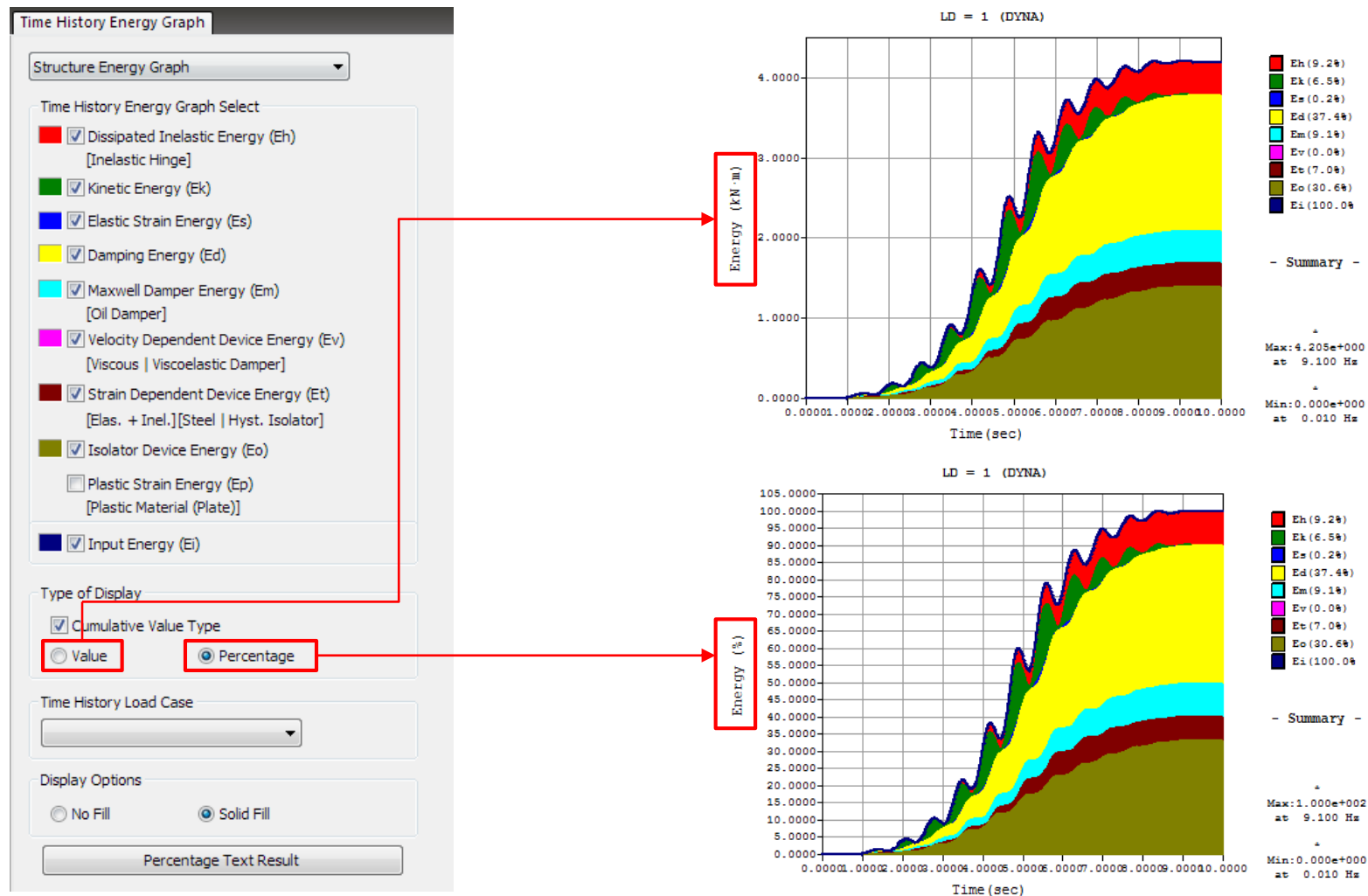


■ Input Energy   ■ Elastic Energy   ■ Dissipated Energy



## 1. Energy Result Graph for Time History Analysis

### ▪ Result > T.H. Graph/Text > Time History Energy Graph



## 1. Energy Result Graph for Time History Analysis

### ▪ Result > T.H. Graph/Text > Time History Energy Graph

Time History Energy Graph

Structure Energy Graph

Time History Energy Graph Select

☒ Dissipated Inelastic Energy (Eh)  
[Inelastic Hinge]

☒ Kinetic Energy (Ek)

☒ Elastic Strain Energy (Es)

☒ Damping Energy (Ed)

☒ Maxwell Damper Energy (Em)  
[Oil Damper]

☒ Velocity Dependent Device Energy (Ev)  
[Viscous | Viscoelastic Damper]

☒ Strain Dependent Device Energy (Et)  
[Elas. + Inel.] [Steel | Hyst. Isolator]

☒ Isolator Device Energy (Eo)

☐ Plastic Strain Energy (Ep)  
[Plastic Material (Plate)]

☒ Input Energy (Ei)

Type of Display

☒ Cumulative Value Type

☐ Value ☒ Percentage

Time History Load Case

Display Options

☐ No Fill ☒ Solid Fill

Percentage Text Result

< Text result of the each energy ratio >

MIDAS/Text Editor - [App4\_Time history analysis.spf]

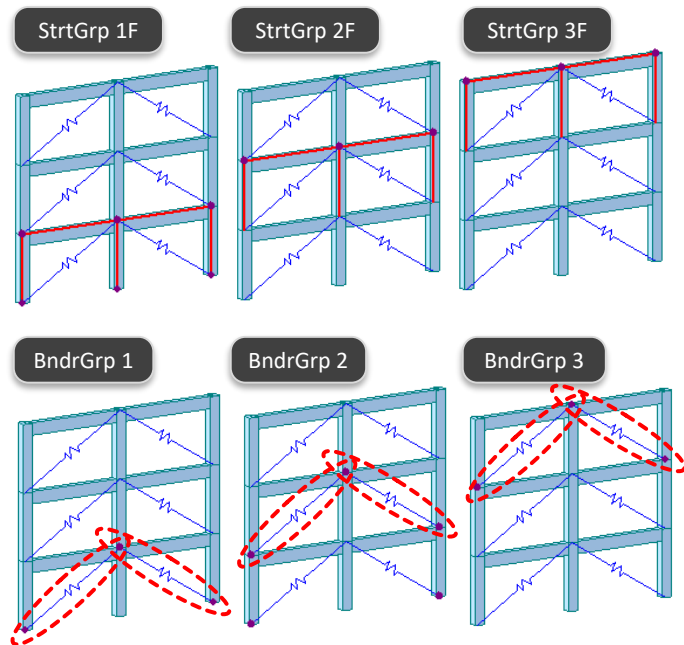
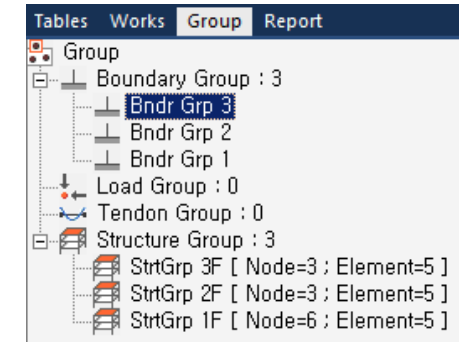
File Edit View Window Help

TIME HISTORY ANALYSIS | ENERGY RESULT PERCENTATE ; TIME HISTORY LOADCASE NO. = 1

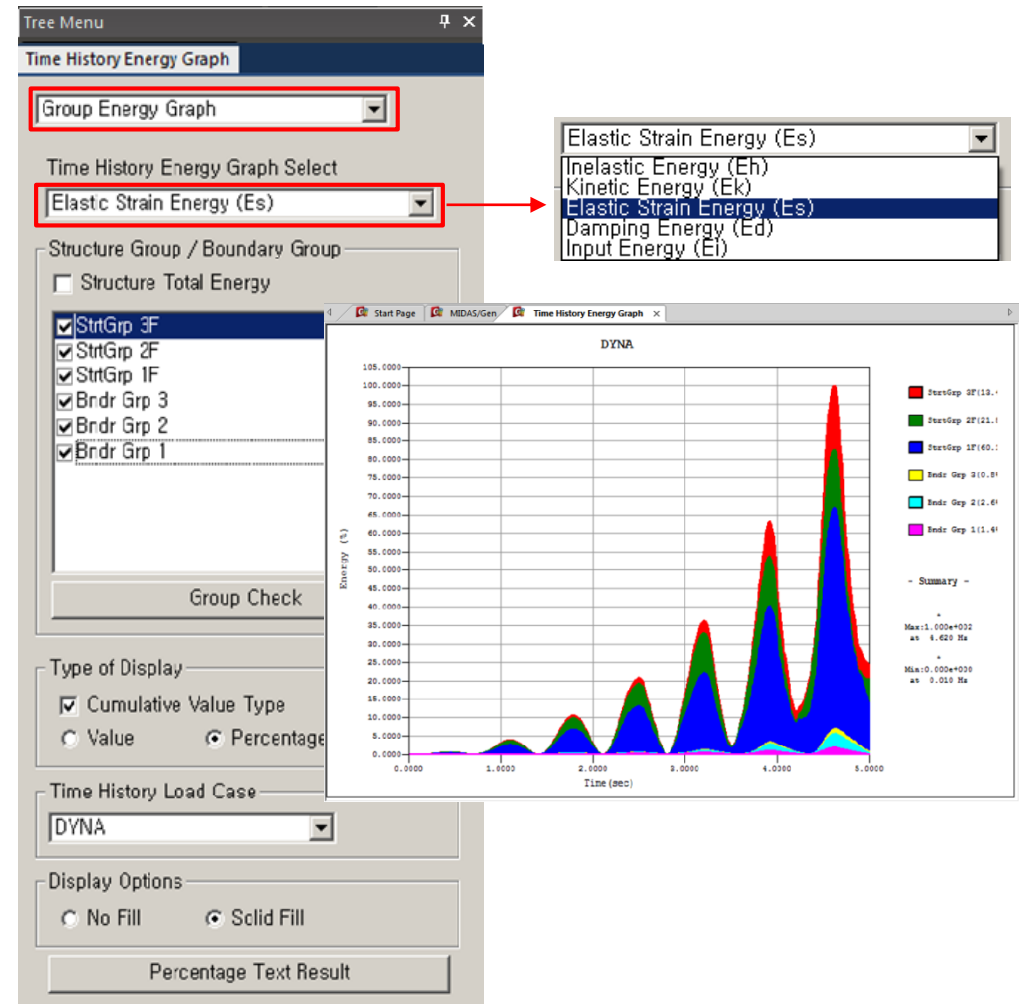
Energy Graph		Percentage (%)
(1) Dissipated Inelastic Energy [Inelastic Hinge]	Eh	9.196
(2) Kinetic Energy	Ek	6.503
(3) Elastic Strain Energy	Es	0.237
(4) Damping Energy	Ed	37.396
(5) Maxwell Damper Energy [Oil Damper]	Em	9.149
(6) Velocity Dependent Device Energy	Ev	0.000
(7) Strain Dependent Device [Steel   Hyst. Isolator]	Et	6.959
(8) Isolator Device Energy	Eo	30.559
(9) Plastic Strain Energy [Plastic Material (Plate)]	Ep	0.000
(10) Input Energy	Ei	100.000
Error (Input Energy[Ei] - Energy Sum[(1)~(9)])		0.000

## 1. Energy Result Graph for Time History Analysis

### ▪ Result > T.H. Graph/Text > Time History Energy Graph



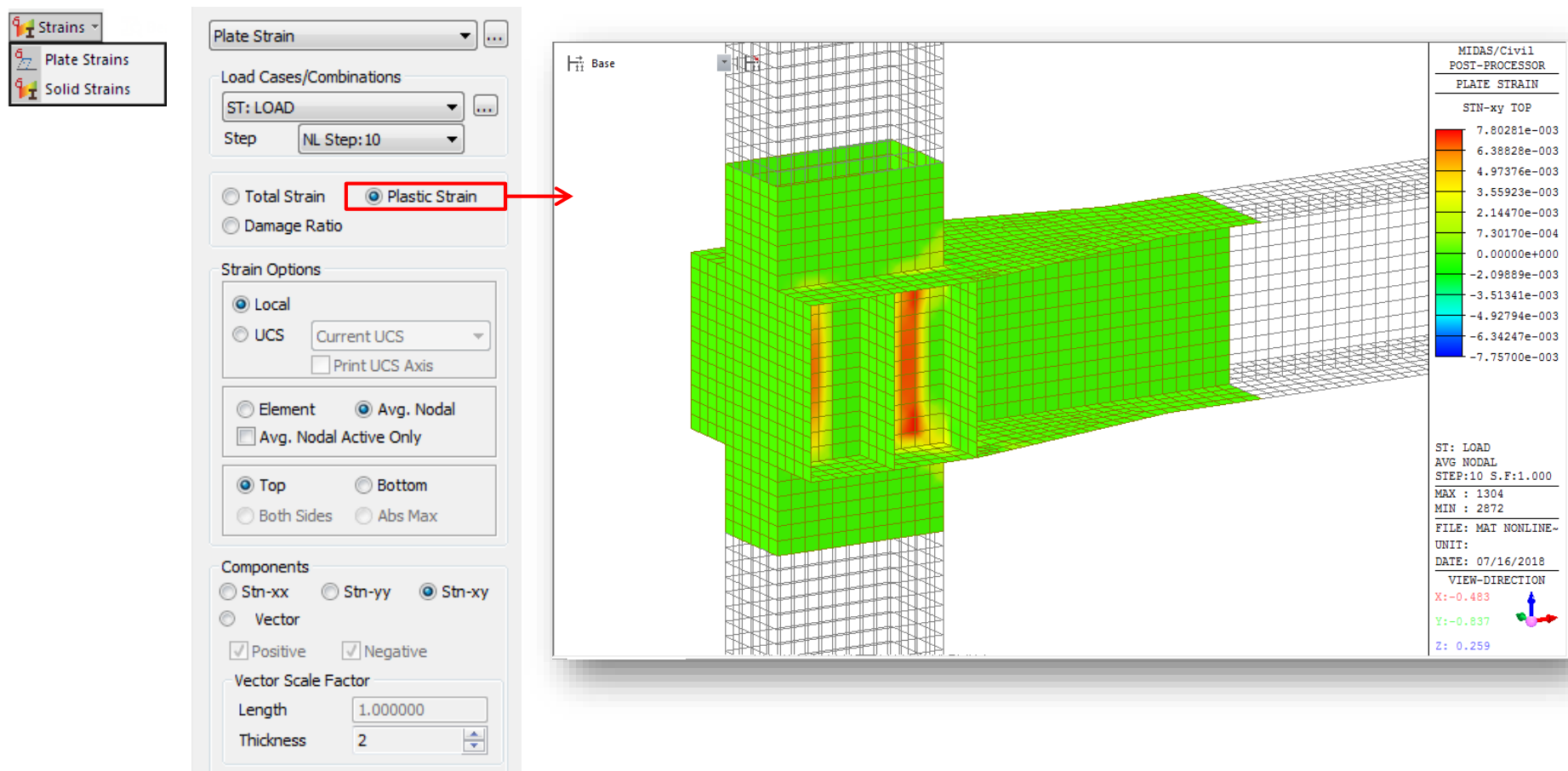
< Result output of group distribution for each energy item >



## 2. Strain Output for Material Nonlinear Analysis

- Strain results are provided for plastic materials, i.e. Tresca, Von Mises, Mohr-Coulomb, Drucker-Prager, and Concrete Damage.
- Damage ratios for compression and tension are provided for the 'Concrete Damage' model.

### Results > Results > Strains > Plate Strains/Solid Strains





## 2. Strain Output for Material Nonlinear Analysis

- Results > Tables > Results Tables > Plate/ Solid > Strain(local)/ Strain(Global)

The screenshot displays the MIDAS Gen Results Tables menu. The 'Plate' and 'Solid' options are highlighted in red. The 'Strain (Local)' and 'Strain (Global)' options are also highlighted in red. A table of results is shown on the right, with columns for Strain-xx, Strain-yy, Strain-xy, Strain-Max, Strain-Min, Angle, Max-Shear, Comp. Damage, Tens. Damage, and Damage.

Elem	Load	Step	Node	Part	Strain-xx	Strain-yy	Strain-xy	Strain-Max	Strain-Min	Angle (deg)	Max-Shear	Comp. Damage	Tens. Damage	Damage
1	LDC1	nl_001	Cent	Top	-9.802e-005	5.819e-005	0.000e+000	5.819e-005	-9.802e-005	90.0000	7.811e-005	6.720e-002	0.000e+000	6.720e-002
1	LDC1	nl_002	Cent	Top	-9.802e-005	5.819e-005	0.000e+000	5.819e-005	-9.802e-005	90.0000	7.811e-005	6.720e-002	0.000e+000	6.720e-002
1	LDC1	nl_003	Cent	Top	-2.612e-004	1.551e-004	0.000e+000	1.551e-004	-2.612e-004	90.0000	2.082e-004	1.791e-001	1.197e-007	1.791e-001
1	LDC1	nl_004	Cent	Top	-2.612e-004	1.551e-004	0.000e+000	1.551e-004	-2.612e-004	90.0000	2.082e-004	1.791e-001	1.197e-007	1.791e-001
1	LDC1	nl_005	Cent	Top	-4.181e-004	2.482e-004	0.000e+000	2.482e-004	-4.181e-004	90.0000	3.332e-004	2.768e-001	1.197e-007	2.768e-001
1	LDC1	nl_006	Cent	Top	-4.181e-004	2.482e-004	0.000e+000	2.482e-004	-4.181e-004	90.0000	3.332e-004	2.768e-001	1.197e-007	2.768e-001
1	LDC1	nl_007	Cent	Top	-7.988e-004	4.742e-004	0.000e+000	4.742e-004	-7.988e-004	90.0000	6.365e-004	3.963e-001	1.197e-007	3.963e-001
1	LDC1	nl_008	Cent	Top	-7.988e-004	4.742e-004	0.000e+000	4.742e-004	-7.988e-004	90.0000	6.365e-004	3.963e-001	1.197e-007	3.963e-001
1	LDC1	nl_009	Cent	Top	-1.237e-003	7.343e-004	0.000e+000	7.343e-004	-1.237e-003	90.0000	9.856e-004	4.946e-001	1.197e-007	4.946e-001
1	LDC1	nl_010	Cent	Top	-1.237e-003	7.343e-004	0.000e+000	7.343e-004	-1.237e-003	90.0000	9.856e-004	4.946e-001	1.197e-007	4.946e-001
1	LDC1	nl_011	Cent	Top	-1.708e-003	1.014e-003	0.000e+000	1.014e-003	-1.708e-003	90.0000	1.361e-003	5.690e-001	1.197e-007	5.690e-001
1	LDC1	nl_012	Cent	Top	-1.708e-003	1.014e-003	0.000e+000	1.014e-003	-1.708e-003	90.0000	1.361e-003	5.690e-001	1.197e-007	5.690e-001
1	LDC1	nl_013	Cent	Top	-2.197e-003	1.305e-003	0.000e+000	1.305e-003	-2.197e-003	90.0000	1.751e-003	6.247e-001	1.197e-007	6.247e-001
1	LDC1	nl_014	Cent	Top	-2.197e-003	1.305e-003	0.000e+000	1.305e-003	-2.197e-003	90.0000	1.751e-003	6.247e-001	1.197e-007	6.247e-001
1	LDC1	nl_015	Cent	Top	-2.693e-003	1.599e-003	0.000e+000	1.599e-003	-2.693e-003	90.0000	2.146e-003	6.692e-001	1.197e-007	6.692e-001
1	LDC1	nl_016	Cent	Top	-2.693e-003	1.599e-003	0.000e+000	1.599e-003	-2.693e-003	90.0000	2.146e-003	6.692e-001	1.197e-007	6.692e-001
1	LDC1	nl_017	Cent	Top	-3.193e-003	1.896e-003	0.000e+000	1.896e-003	-3.193e-003	90.0000	2.545e-003	7.069e-001	1.197e-007	7.069e-001
1	LDC1	nl_018	Cent	Top	-3.193e-003	1.896e-003	0.000e+000	1.896e-003	-3.193e-003	90.0000	2.545e-003	7.069e-001	1.197e-007	7.069e-001
1	LDC1	nl_019	Cent	Top	-3.695e-003	2.193e-003	0.000e+000	2.193e-003	-3.695e-003	90.0000	2.944e-003	7.352e-001	1.197e-007	7.352e-001
1	LDC1	nl_020	Cent	Top	-3.695e-003	2.193e-003	0.000e+000	2.193e-003	-3.695e-003	90.0000	2.944e-003	7.352e-001	1.197e-007	7.352e-001
1	LDC1	nl_021	Cent	Top	-4.197e-003	2.492e-003	0.000e+000	2.492e-003	-4.197e-003	90.0000	3.344e-003	7.573e-001	1.197e-007	7.573e-001
1	LDC1	nl_022	Cent	Top	-4.197e-003	2.492e-003	0.000e+000	2.492e-003	-4.197e-003	90.0000	3.344e-003	7.573e-001	1.197e-007	7.573e-001
1	LDC1	nl_023	Cent	Top	-4.700e-003	2.790e-003	0.000e+000	2.790e-003	-4.700e-003	90.0000	3.745e-003	7.793e-001	1.197e-007	7.793e-001
1	LDC1	nl_024	Cent	Top	-4.700e-003	2.790e-003	0.000e+000	2.790e-003	-4.700e-003	90.0000	3.745e-003	7.793e-001	1.197e-007	7.793e-001
1	LDC1	nl_025	Cent	Top	-5.203e-003	3.089e-003	0.000e+000	3.089e-003	-5.203e-003	90.0000	4.146e-003	7.990e-001	1.197e-007	7.990e-001
1	LDC1	nl_026	Cent	Top	-5.203e-003	3.089e-003	0.000e+000	3.089e-003	-5.203e-003	90.0000	4.146e-003	7.990e-001	1.197e-007	7.990e-001
1	LDC1	nl_027	Cent	Top	-5.706e-003	3.388e-003	0.000e+000	3.388e-003	-5.706e-003	90.0000	4.547e-003	8.101e-001	1.197e-007	8.101e-001
1	LDC1	nl_028	Cent	Top	-5.706e-003	3.388e-003	0.000e+000	3.388e-003	-5.706e-003	90.0000	4.547e-003	8.101e-001	1.197e-007	8.101e-001
1	LDC1	nl_029	Cent	Top	-6.209e-003	3.686e-003	0.000e+000	3.686e-003	-6.209e-003	90.0000	4.949e-003	8.206e-001	1.197e-007	8.206e-001
1	LDC1	nl_030	Cent	Top	-6.209e-003	3.686e-003	0.000e+000	3.686e-003	-6.209e-003	90.0000	4.949e-003	8.206e-001	1.197e-007	8.206e-001
1	LDC1	nl_031	Cent	Top	-6.713e-003	3.985e-003	0.000e+000	3.985e-003	-6.713e-003	90.0000	5.349e-003	8.311e-001	1.197e-007	8.311e-001
1	LDC1	nl_032	Cent	Top	-6.713e-003	3.985e-003	0.000e+000	3.985e-003	-6.713e-003	90.0000	5.349e-003	8.311e-001	1.197e-007	8.311e-001
1	LDC1	nl_033	Cent	Top	-7.217e-003	4.285e-003	0.000e+000	4.285e-003	-7.217e-003	90.0000	5.751e-003	8.416e-001	1.197e-007	8.416e-001
1	LDC1	nl_034	Cent	Top	-7.217e-003	4.285e-003	0.000e+000	4.285e-003	-7.217e-003	90.0000	5.751e-003	8.416e-001	1.197e-007	8.416e-001
1	LDC1	nl_035	Cent	Top	-7.722e-003	4.584e-003	0.000e+000	4.584e-003	-7.722e-003	90.0000	6.153e-003	8.521e-001	1.197e-007	8.521e-001
1	LDC1	nl_036	Cent	Top	-7.722e-003	4.584e-003	0.000e+000	4.584e-003	-7.722e-003	90.0000	6.153e-003	8.521e-001	1.197e-007	8.521e-001

&lt;Plate Strain (local) menu&gt;

&lt;Solid Strain (local) menu&gt;

Plate Strain Table

### 3. Multi-linear force-deformation function for Point Spring Support and Elastic Link

- Multi-linear curve for Point Spring Support and Elastic Link can be defined as a function without limitation in terms of number of data.

< Previous version >

Point Spring

Boundary Group Name: Default

Options: ☒ Add ☐ Replace ☐ Delete

Point Spring (Local Direction):

Type: Multi-Linear

Multi-Linear Type: Unsymmetric

	x: m	y: kN
a	0	0
b	0	0
c	0	0
d	0	0
e	0	0
f	0	0

Direction: Dx(+)

Multi-linear is defined as 6 points in the previous version.

< Civil 2019 (v1.1) >

Point Spring

Boundary Group Name: Default

Options: ☐ Add ☒ Replace ☐ Delete

Point Spring (Local Direction):

Type: Multi-Linear

Deformation-Forces Function: 02

Direction: Dz(-)

Elastic Link

Boundary Group Name: Default

Options: ☒ Add ☐ Delete

Elastic Link Data:

Type: Multi-Linear

Direction: Dx

Deformation-Forces Function: 01

☐ Shear Spring Location

Dist. Ratio From End I: 0.5

Beta Angle: 0 [deg]

2 Nodes:

☐ Copy Elastic Link

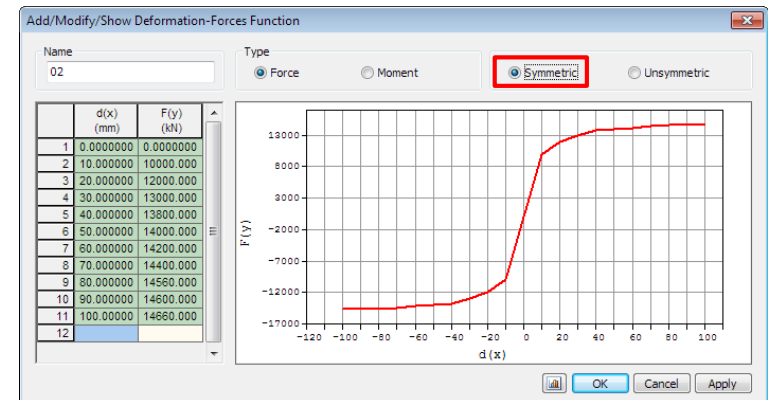
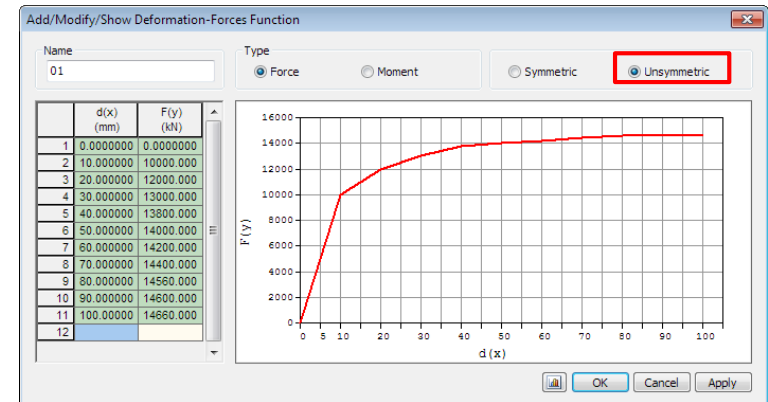
☐ Node Inc. ☒ Distance

Axis: ☒ x ☐ y ☐ z

Distances: mm

(Example: 5, 3, 4.5, 3@5.0)

Apply Close



## 4. Rail Track Analysis Report with the US Unit Setting

- Rail Track Analysis report supports the US unit system as well as SI unit system.

- Structure > Wizard > Rail Track Analysis Model > Rail Track Analysis Report**

**Rail Track Analysis Report**

Working Directory: E:\W0622\Sample\Sample Model File\W

Sample Model File\_Add1\_RelativeDisp.mcb  
Sample Model File\_Add1\_RelativeDisp\_Mov1.mcb  
Sample Model File\_Add1\_RelativeDisp\_Mov2.mcb  
Sample Model File\_Add1\_RelativeDisp\_Mov3.mcb  
Sample Model File\_Add1\_RelativeDisp\_Mov4.mcb  
Sample Model File\_Add1\_RelativeDisp\_Mov5.mcb  
Sample Model File\_Add1\_RelativeDisp\_Mov6.mcb  
Sample Model File\_Add1\_RelativeDisp\_Mov7.mcb  
Sample Model File\_Add1\_RelativeDisp\_Mov8.mcb  
Sample Model File\_Add1\_RelativeDisp\_Mov9.mcb  
Sample Model File\_Add2\_RotationAngle.mcb

Unit Setting  
☐ N-mm ☒ kips-in

Checking Criteria

Maximum permissible additional rail stresses

Compressive stress: 12 ksi  
Tensile stress: 14 ksi

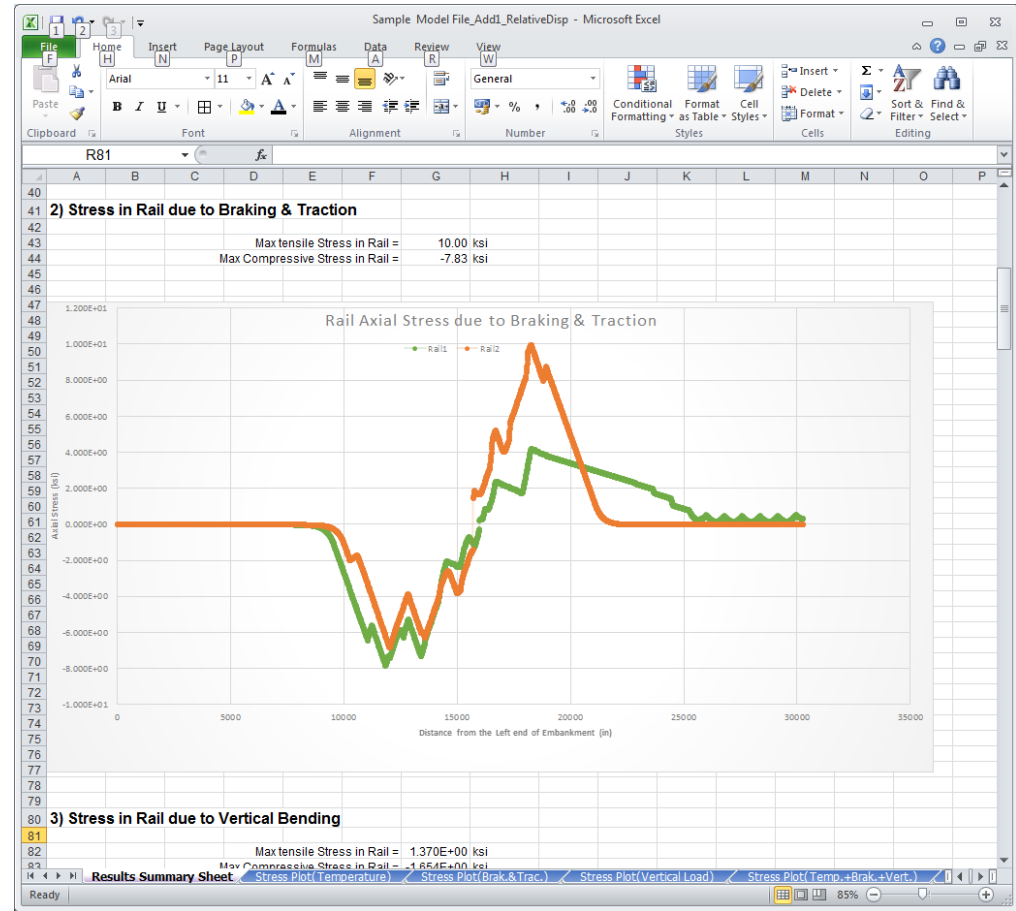
Permissible horizontal displacements due to Braking/Traction

Relative displacement between Deck and Rail: 0.5 in  
Absolute displacement of the Deck: 0.5 in

Permissible displacement between Top of Deck end and Embankment or between Top of two consecutive Deck ends: 0.5 in

OK Cancel

Report Setting to the US unit



Rail Track Analysis Report

## 5. Data Interface with GTS NX

- Reactions from Point Spring Support can be exported to GTS NX.
- Force-displacement results of soil can be imported from GTS NX into midas Civil, and the input data of the multi-linear Point Spring Supports are updated.

- File > Export > Nodal Results for GTS**
- File > Import > Nodal Results for GTS**



**Export Nodal Results**

Target Nodes

☒ All (By Supports, Point Spring, Spec. Disp.)

☐ Selected Nodes

Select Load Case & Direction

Stage: Base

Load Cases/Combination: ST: SW

Step:

Result Type: Reactions

Result Components: All

OK Cancel



**Export Nodal Results**

Target Nodes

☐ All (By Supports, Spec. Disp.)

☐ Selected Nodes

☒ Load Sets (By Force)

User Defined

Output Data

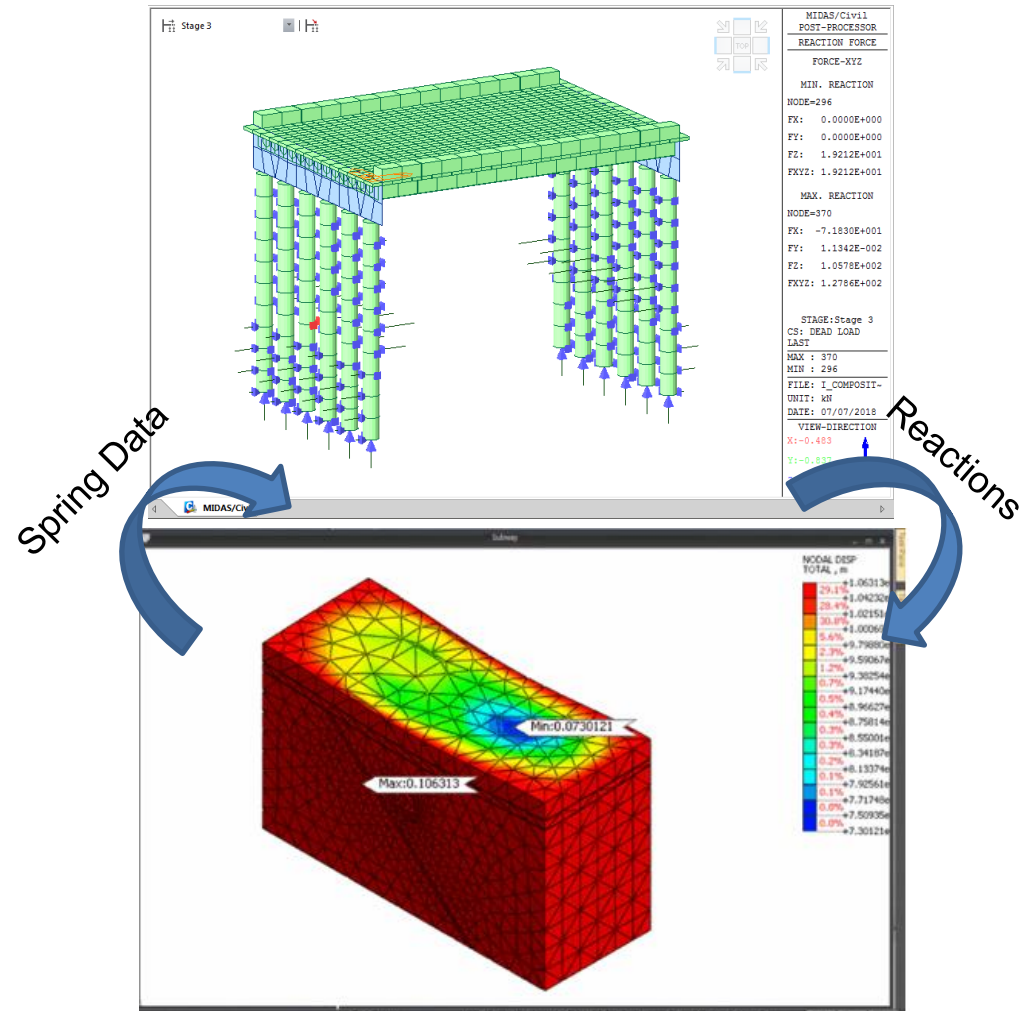
Analysis Set: NS\_every step3

Step: Nonlinear Static(In-situ)

Result Type: Reactions

Result Components: All

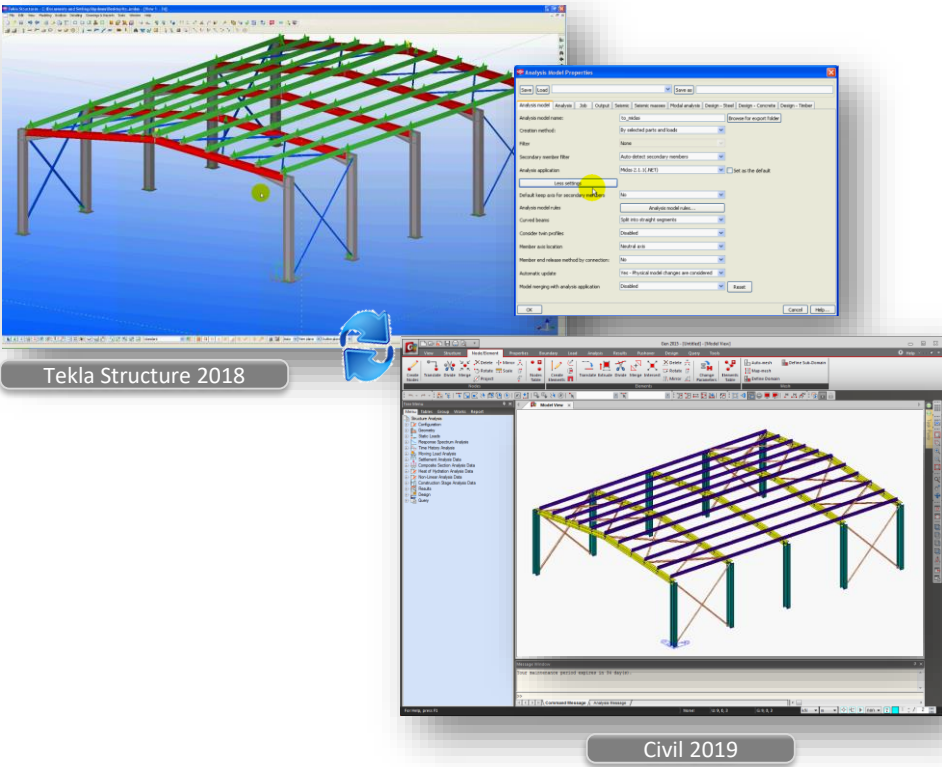
OK Cancel Apply



6. Tekla Structure 2018 Interface

- Tekla Structures interface is a tool provided to speed up the entire modeling, analysis, and design procedure of a structure by direct data transfer with midas Civil.
- Data transfer is limited to structural elements.
- Tekla Structure interface enables us to directly transfer a Tekla model data to midas Civil, and delivery back to the Tekla model file. midas Civil text file (\*.mct) is used for the roundtrip.

- **File > Import > midas Civil MCT File**
- **File > Export > midas Civil MCT File**



Category	Features	Tekla <> Gen
MATERIAL	concrete	<>
	steel	<>
	pre cast - wood and other types	<>
	Material user defined	<>
ELEMENT TYPE/ ROTATIONS	vertical column	<>
	inclined column	<>
	straight beam	<>
	curved beam	>
	Slab	<>
	vertical panel	>
2D ELEMENTS	Concrete panels and slab	<>
BOUNDARY CONDITIONS	support	>
	beam end release	<>
	section offset	>
STATIC LOAD	self weigth	>
	linear load (uniform or trapezoidal)	<>
MERGE OPTION	new element	<>
	new element that divide other elements	<>
	topology changes	<>