

# Release Note

---

Release Date : July 2018

Product Ver. : Civil 2019 (v1.1)



DESIGN OF CIVIL STRUCTURES

Integrated Solution System for Bridge and Civil Engineering

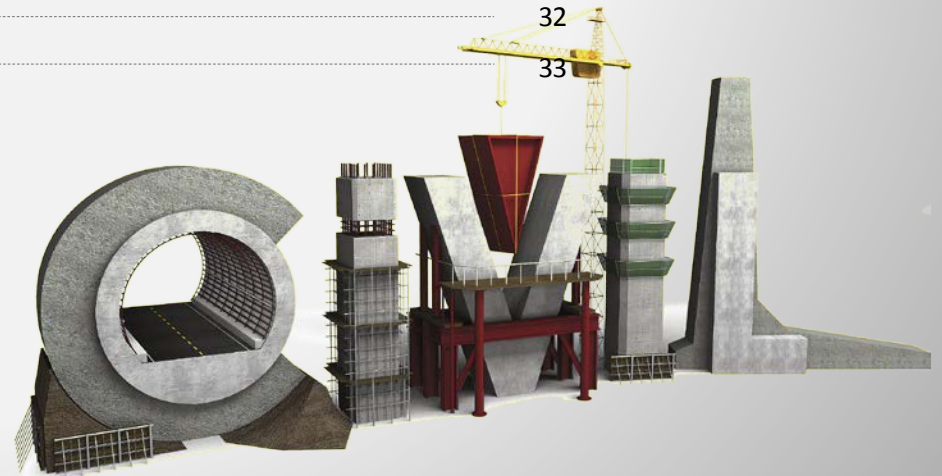
# Enhancements

## ■ Analysis & Design

1. Traffic Load Models for Turkey	3
2. Moving Load Optimization for Australia	5
3. India IRS Bridge Rules: Railway Loads	6
4. Nonlinear Elastic Links for Pushover Analysis	7
5. GSD - Crack Width Calculation as per IRC 112: 2011	8
6. AASHTO LRFD 2016 update	9
7. Shell Design	11

## ■ Pre & Post-Processing

1. Energy Result Graph for Time History Analysis	24
2. Strain Output for Material Nonlinear Analysis	28
3. Multi-linear force-deformation function for Point Spring Support and Elastic Link	30
4. Rail Track Analysis Report with the US Unit Setting	31
5. Data Interface with GTS NX	32
6. Tekla Structure 2018 Interface	33



### 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 %

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

MIDAS/Civil1  
POST-PROCESSOR  
MVLD TRAC.

MOMENT-y

- 1.46982e+001
- 1.33017e+001
- 1.19052e+001
- 1.05087e+001
- 9.11219e+000
- 7.71569e+000
- 6.31919e+000
- 4.92269e+000
- 3.52620e+000
- 2.12970e+000
- 0.00000e+000
- 6.63301e-001

KEY ELEM., 49  
PART, 1-node  
MAX.VAL.=  
1.6964e+004  
MVMAX: KGM-45

MAX : None  
MIN : None

FILE: EXTRADOSED-  
UNIT: kN.m  
DATE: 06/24/2018

VIEW-DIRECTION  
X: -0.659  
Y: -0.647  
Z: 0.383

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	

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

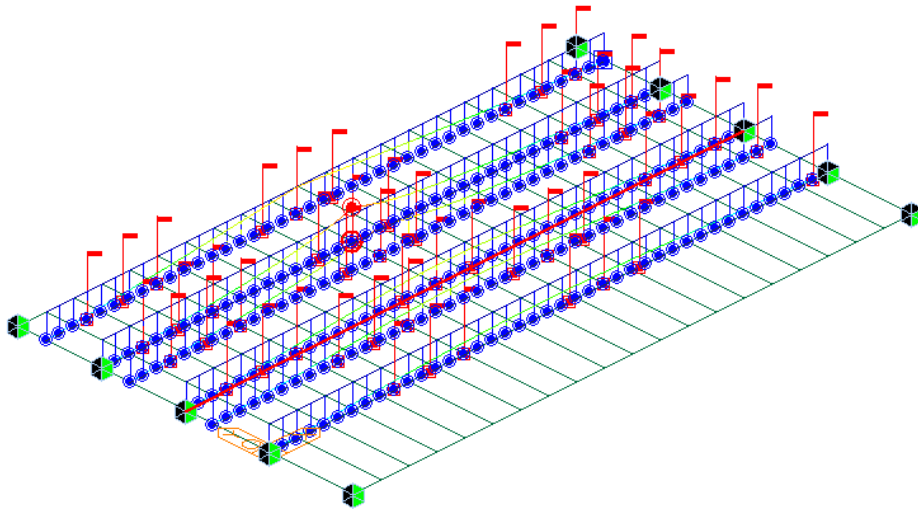
OK Cancel Apply

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

**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

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"/>

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

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  m

Depth of fill(d)  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 Heavy Mineral Loadings

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

---

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

---

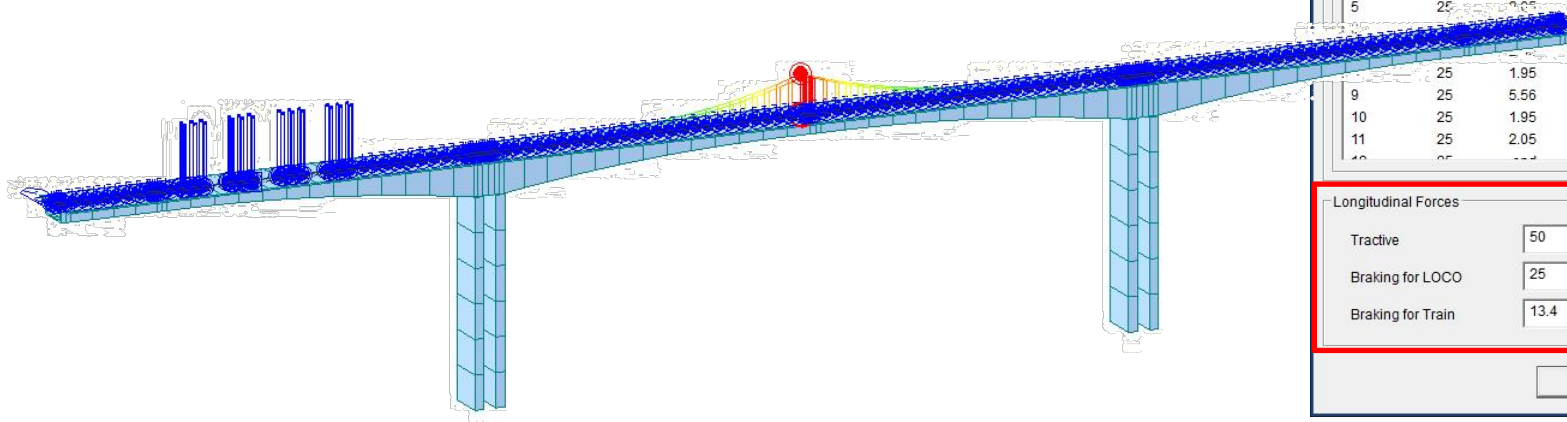
Longitudinal Forces

Tractive  tonf

Braking for LOCO  % of P

Braking for Train  % of W

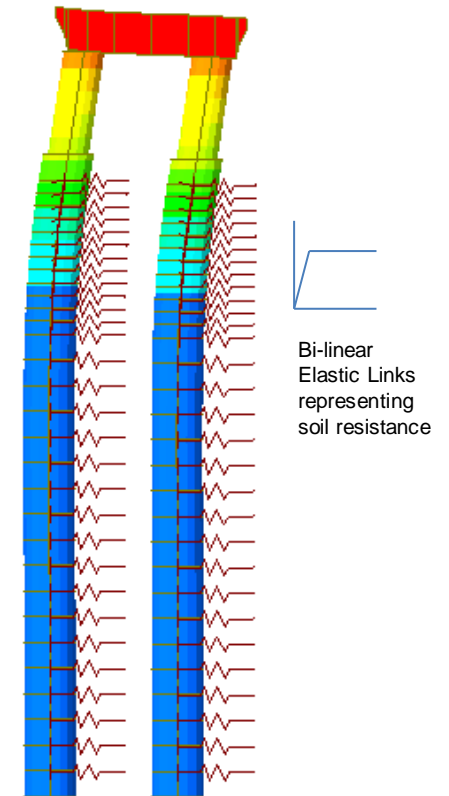
OK Cancel Apply



### 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

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.

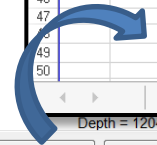
▪ **GSD > Design Section > Crack width > Report**

The screenshot displays the MIDAS Civil software interface for crack width calculation. On the left, the 'Stress Contour' dialog box is open, with 'Crack Status' set to 'Cracked elastic'. The 'Force and Stress in bars' section shows a 'Table' button. The main window shows a stress contour plot of a section with a maximum stress of 104.152 and a minimum stress of -72.800. At the bottom, a summary table shows the crack width (CW) as 0.0678345, which is less than the CW limit of 0.3, resulting in a 'CW OK' status.

On the right, an Excel report titled 'Crack Width' provides the following data:

1. Material		
Name		M40
fck		40.00 N/mm <sup>2</sup>
fcm = fck+10(MPa)		50.00 N/mm <sup>2</sup>
fc <sub>tm</sub> = 0.259*fck^(2/3)		3.029282377 N/mm <sup>2</sup>
2. Calculation of Effective Area		
Overall Depth	h	2032.72 mm
Steel Centroid Depth	d	1572.70 mm
Neutral Axis Depth	x	1204.28 mm
Height of effective area	h <sub>c,eff</sub> = min( 2.5 * (h - d) , (h - x) / 3, h/2)	276.15 mm
Effective area	A <sub>c,eff</sub>	83144.34 mm <sup>2</sup>
3. Calculation of Crack Width		
Stress in the bars σ <sub>s</sub>		72.80 N/mm <sup>2</sup>
Area of Tension steel within A <sub>s</sub>		3216.99 mm <sup>2</sup>
Rho <sub>p,eff</sub>	= A <sub>s</sub> / A <sub>c,eff</sub>	0.04
E <sub>cm</sub>	= 22000 * [ fcm / 12.5 ] ^ 0.3	20575.47 N/mm <sup>2</sup>
Alpha <sub>e</sub>	= E <sub>s</sub> / E <sub>cm</sub>	5.9977632
(Eps <sub>sm</sub> -Eps <sub>cm</sub> )	= (σ <sub>s</sub> -k <sub>t</sub> *fct,eff/Rho <sub>p,eff</sub> *(1+Alpha <sub>e</sub> *Rho <sub>p,eff</sub> ))/E <sub>s</sub>	0.0001228
	< 0.6 * σ <sub>s</sub> / E <sub>s</sub>	0.0002184
(Eps <sub>sm</sub> -Eps <sub>cm</sub> )		0.0002184
Bond coefficient(k <sub>1</sub> )		0.80
Strain distribution coefficient(k <sub>2</sub> )		0.50
NAD Value (k <sub>3</sub> )		3.40
NAD Value (k <sub>4</sub> )		0.43
Cover to the bar c		50.00 mm
Equivalent Diameter ϕ		32.00 mm
S <sub>r,max</sub>	= k <sub>3</sub> *c + k <sub>1</sub> *k <sub>2</sub> *k <sub>4</sub> *ϕ/Rho <sub>p,eff</sub>	310.5988471 mm
w <sub>k</sub>	= S <sub>r,max</sub> * ( Eps <sub>sm</sub> -Eps <sub>cm</sub> )	0.0678345 mm
CW limit (taking from the input given in serviceability parameters)		0.30 mm
Crack Width Check		OK

Page 1



Unit : N/mm<sup>2</sup>  
 Sig<sub>q</sub> max = 104.152 at Y = 934 at Z = 534  
 Sig<sub>q</sub> min = -72.7997 at Y = -934 at Z = -534  
**CW = 0.0678345 CW Lim= 0.3 CW OK**



## 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-LRFD16 ...

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

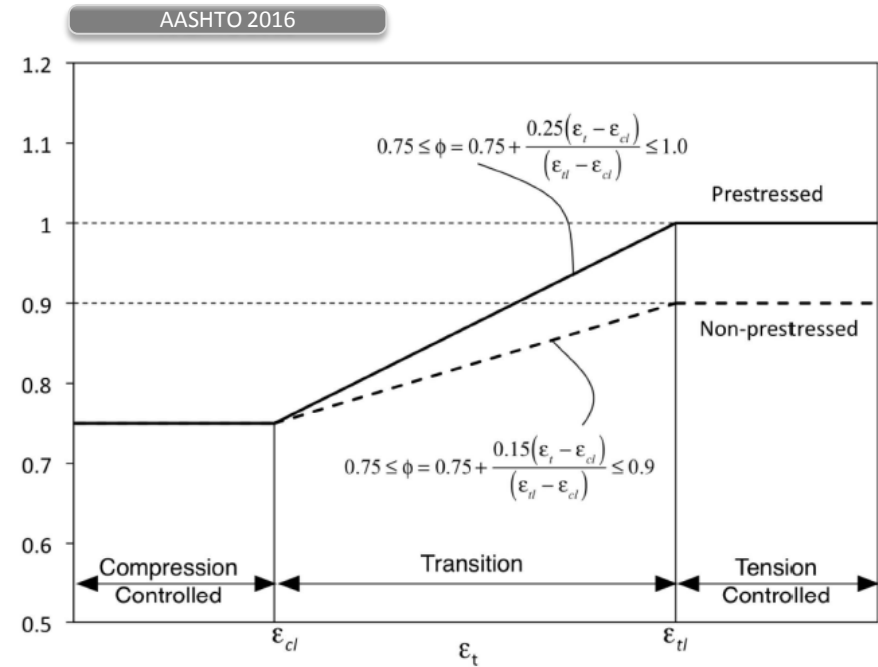
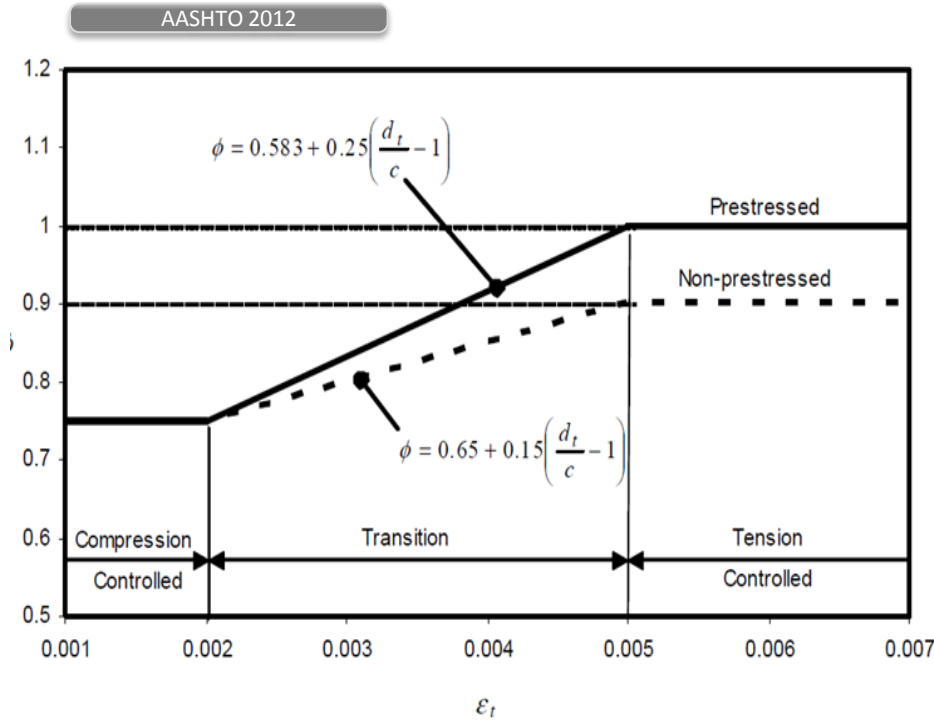
OK
Cancel

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

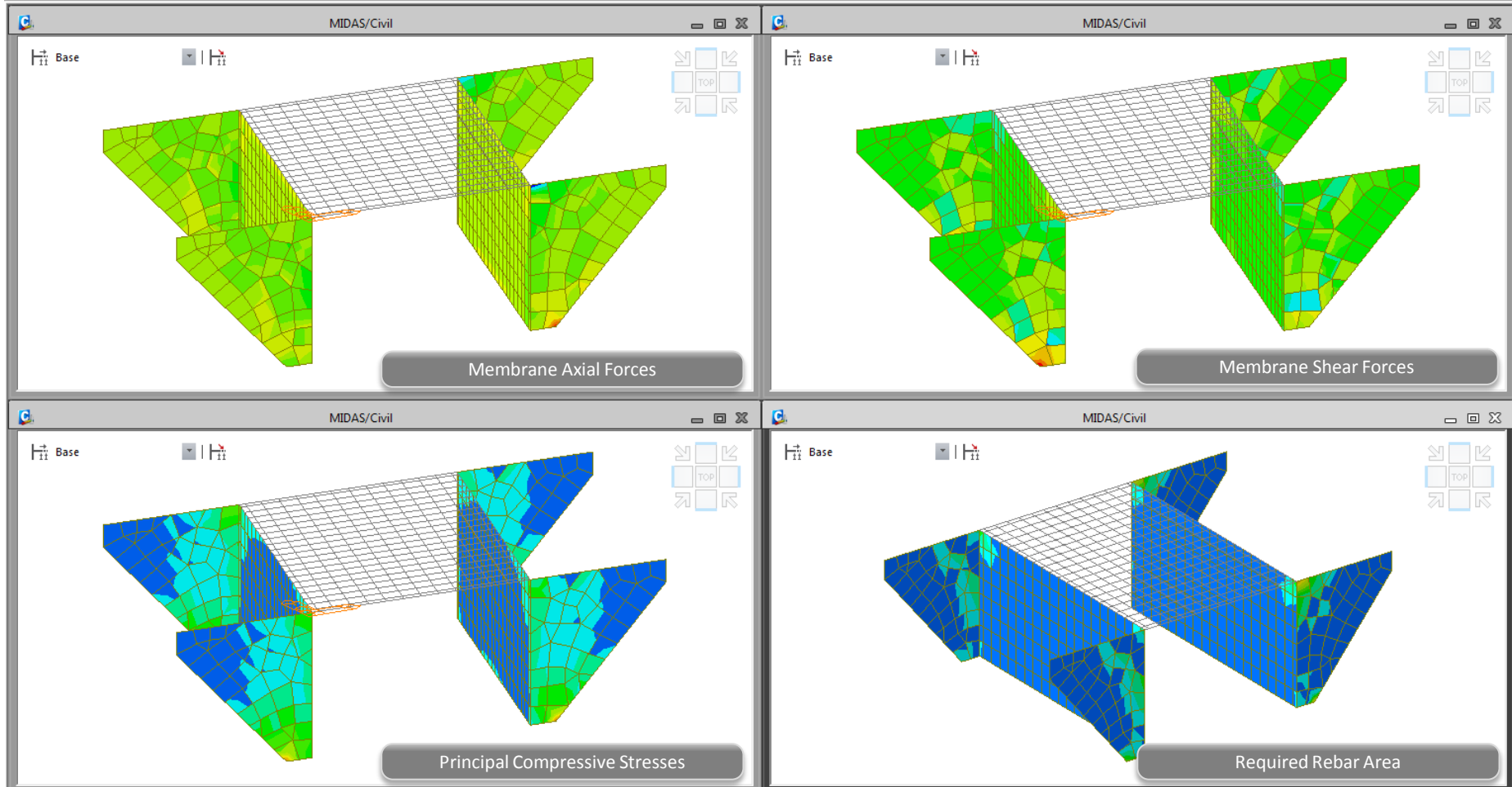
### Resistance Factor



- $\epsilon_{cl}$ : 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.



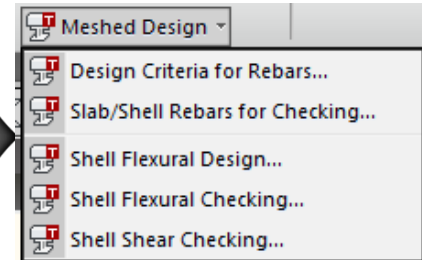
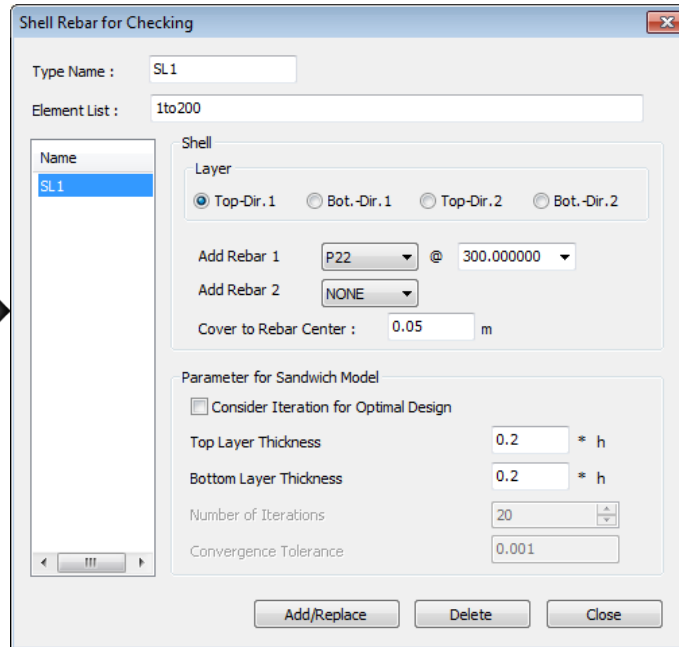
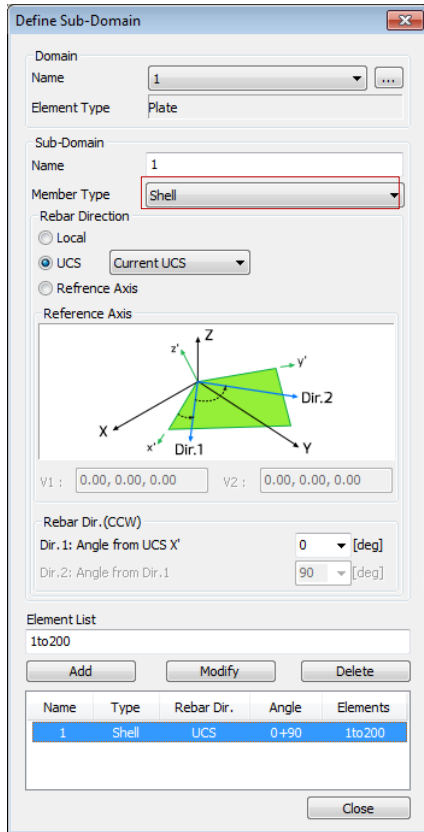
## 7. Shell Design

### Shell Design

Step 1. Define as a shell member

Step 2. Define Rebar Data and Layer Thickness

Step 3. Run Shell Design and 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

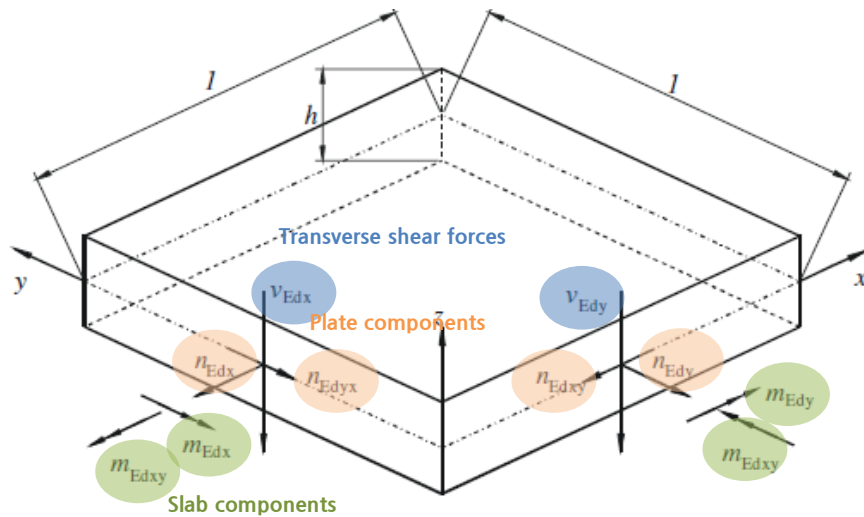


Figure LL.1 — Shell element

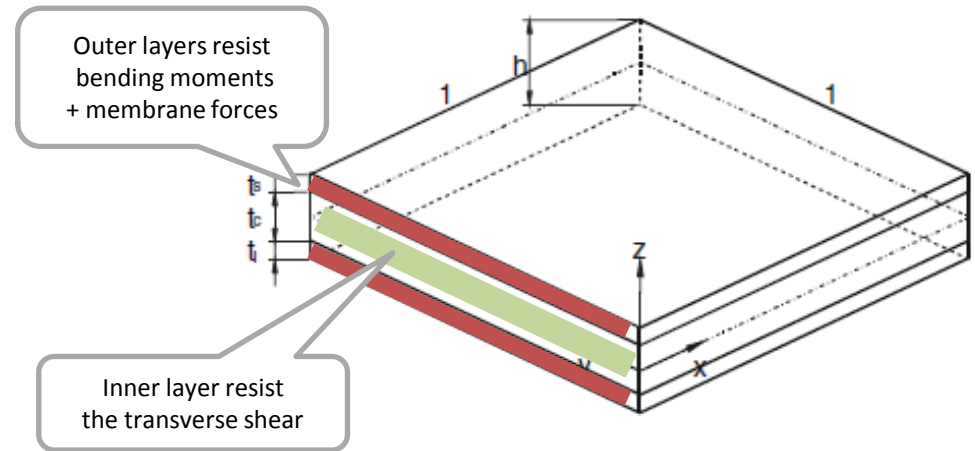
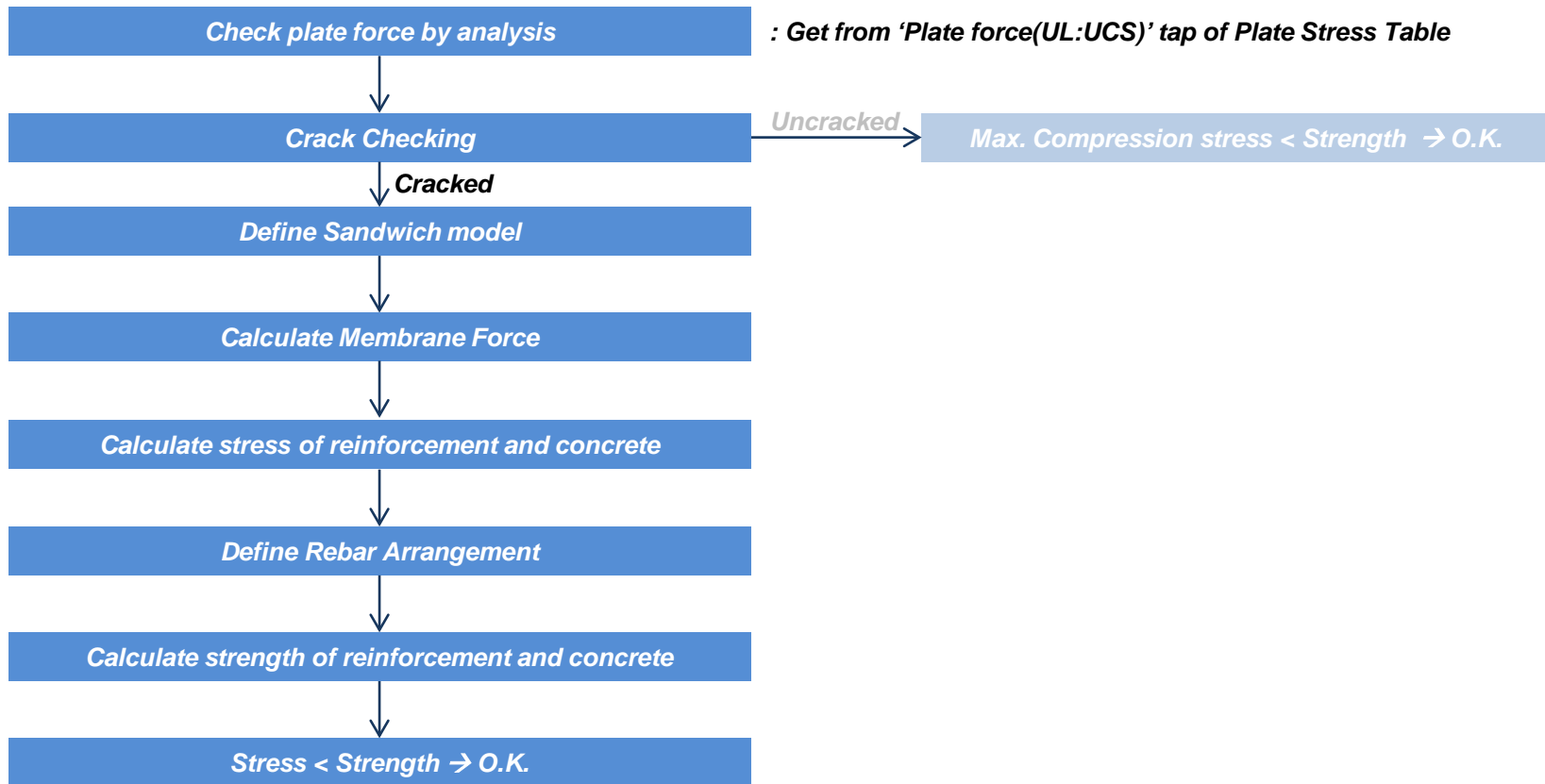


Figure LL.2 — The sandwich model

## 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:

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

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

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

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

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

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

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

$$\sigma_3 = 0$$

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

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

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

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

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

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

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

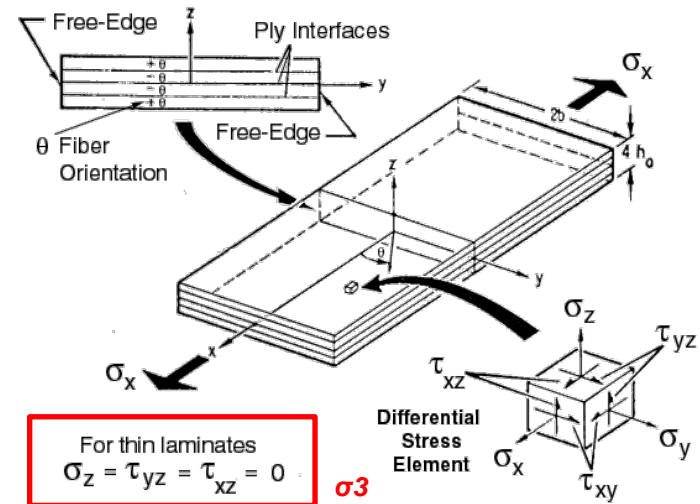


Plate Stress (UL : UCS) Table

	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)** \ F

## 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

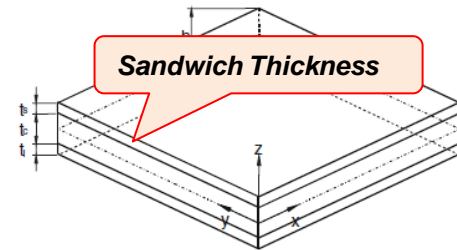
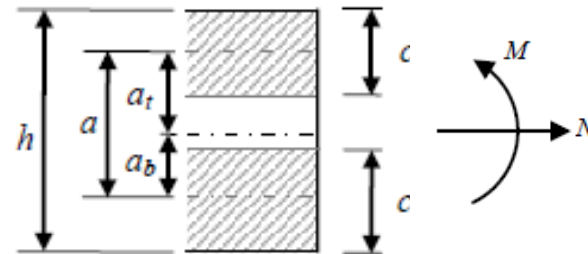


Figure LL.2 — The sandwich model

#### Calculate Membrane Force

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

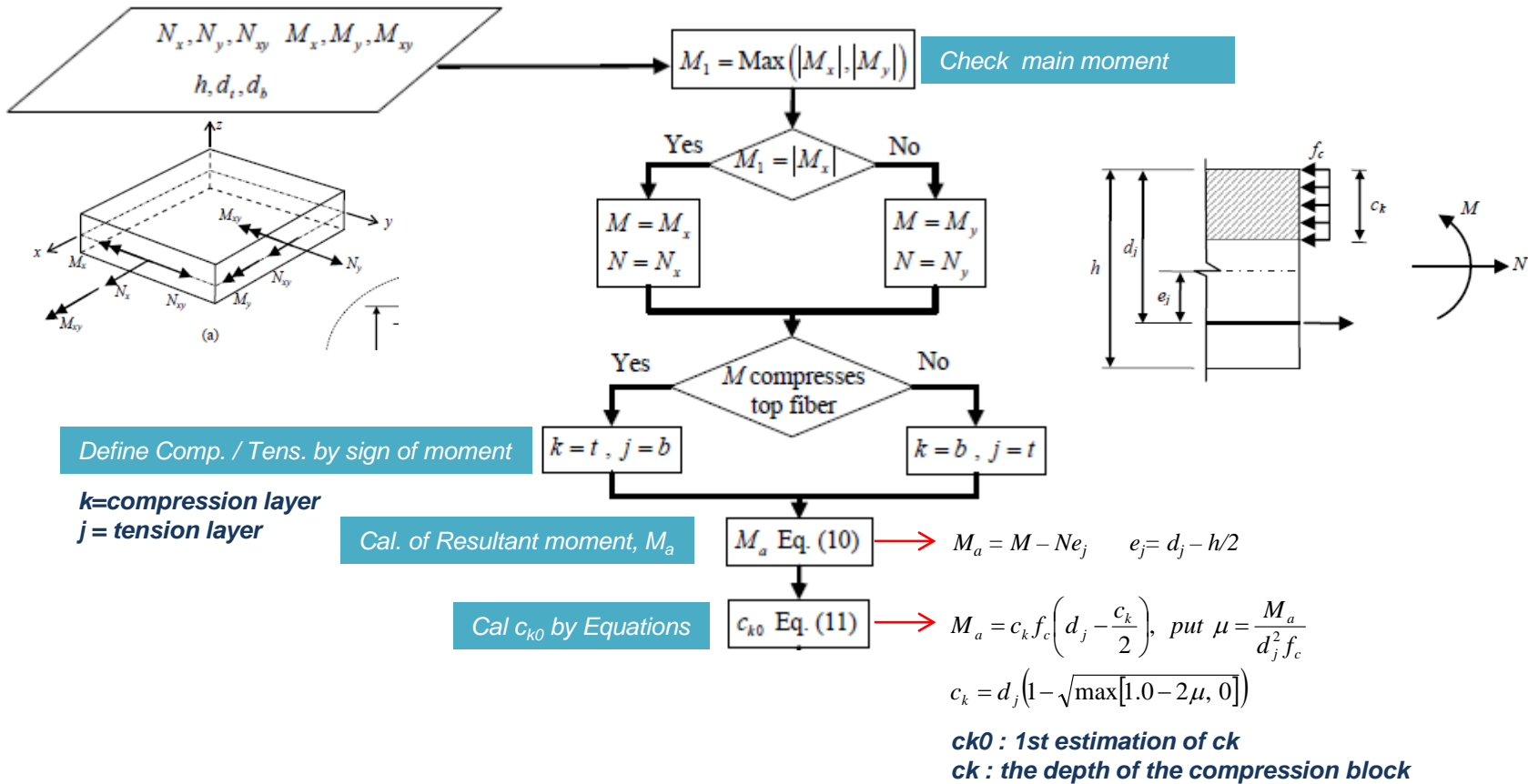
$$\begin{aligned}
 N_{xt} &= N_x \frac{a_b}{a} - \frac{M_x}{a} & N_{xb} &= N_x \frac{a_t}{a} + \frac{M_x}{a} \\
 N_{yt} &= N_y \frac{a_b}{a} - \frac{M_y}{a} & N_{yb} &= N_y \frac{a_t}{a} + \frac{M_y}{a} \\
 N_{xyt} &= N_{xy} \frac{a_b}{a} - \frac{M_{xy}}{a} & N_{xyb} &= N_{xy} \frac{a_t}{a} + \frac{M_{xy}}{a}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



## 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

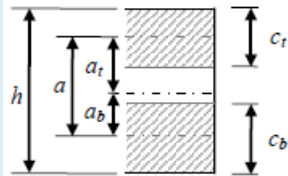
Membrane force in compression layer.

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

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

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

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



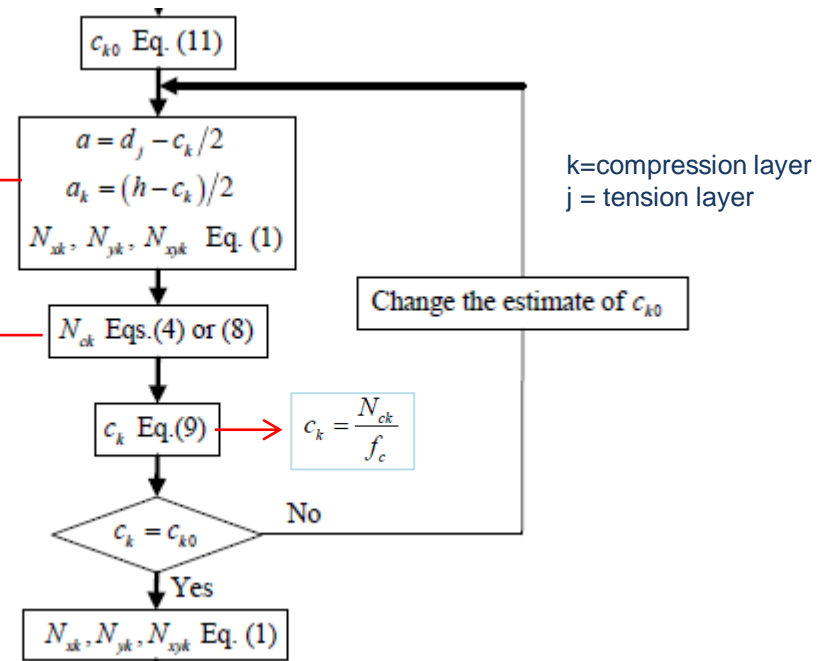
Compression Force of Concrete .

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

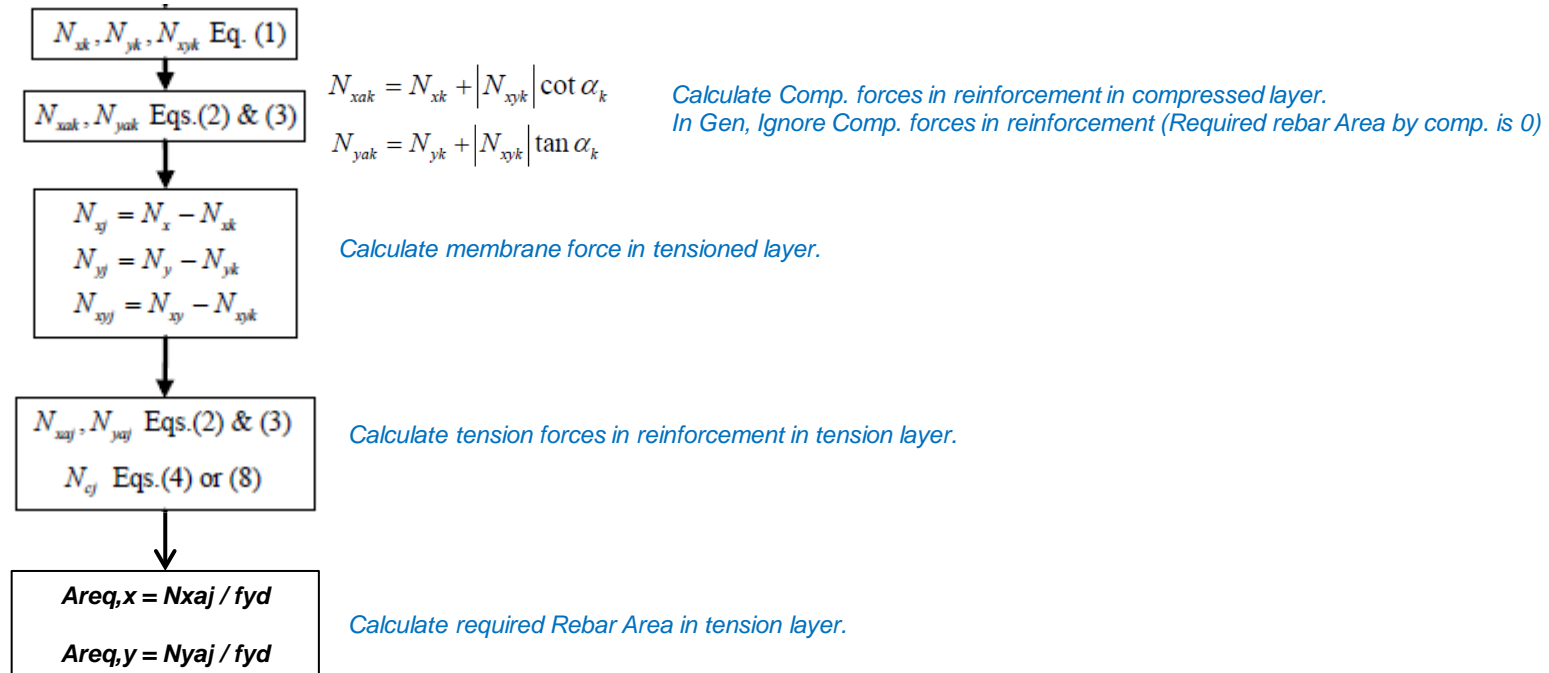
$$N_{ck} = |N_{xyk}|(\tan \alpha_k + \cot \alpha_k)$$



## 7. Shell Design

### Procedure of Shell Design

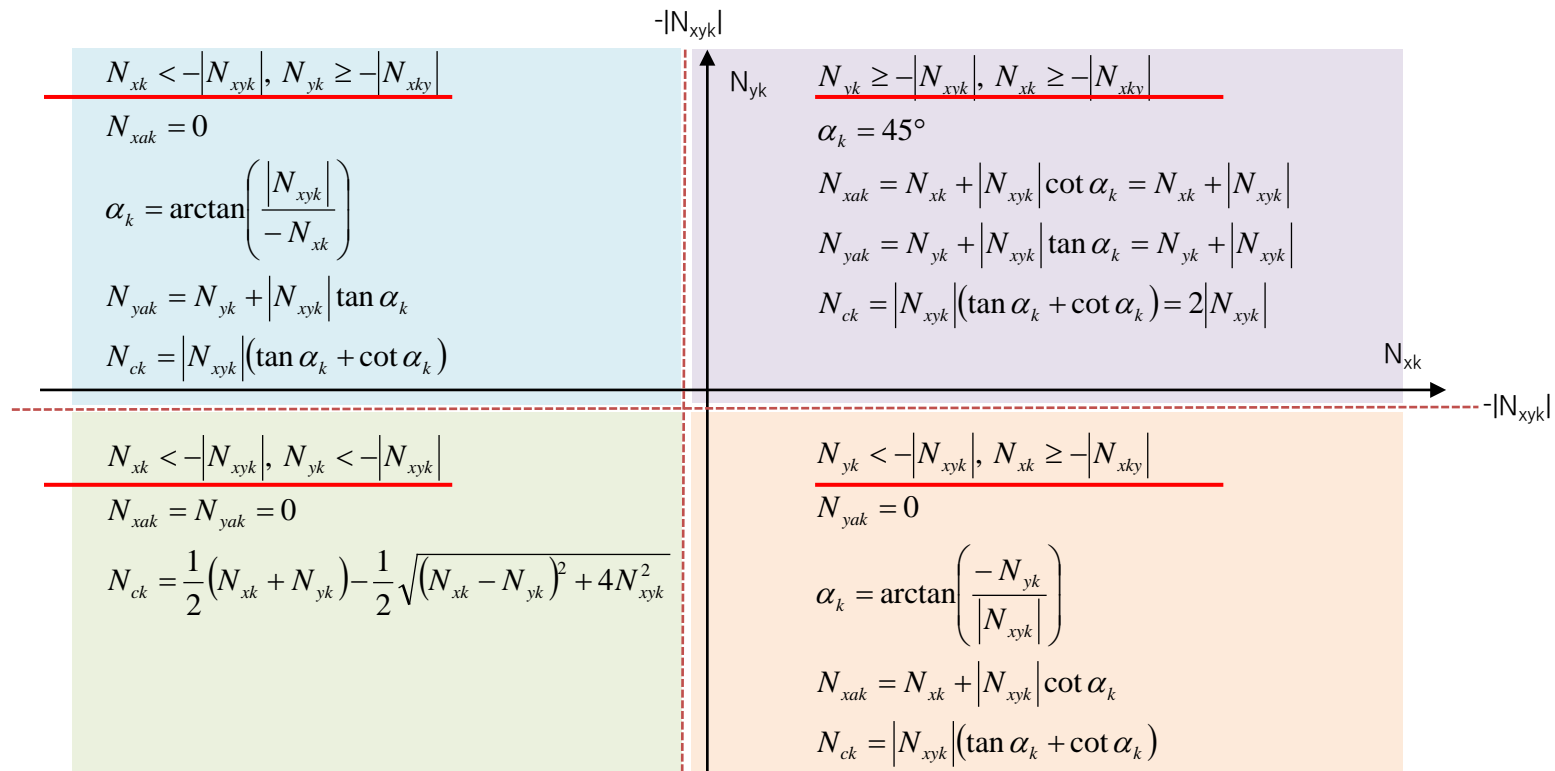
#### Calculation of Membrane Force in tension layer and Required Rebar Area



## 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

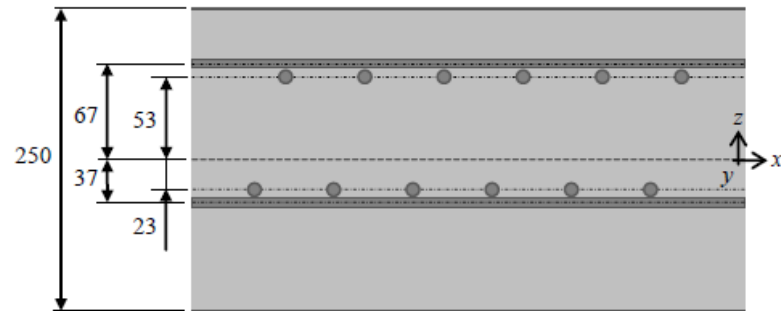
$z_{yab}^* = -23 \text{ mm}$ , the corresponding tension forces at those levels,  $N_{yat}^*$  and  $N_{yab}^*$ , can be

obtained from:

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

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

All the measurements in 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.

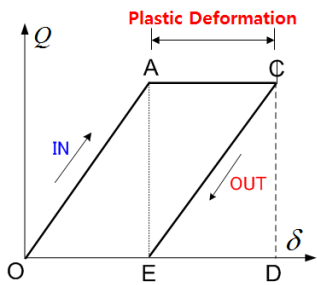
Result > T.H. Graph/Text > Time History Energy Graph

Time History Energy Graph

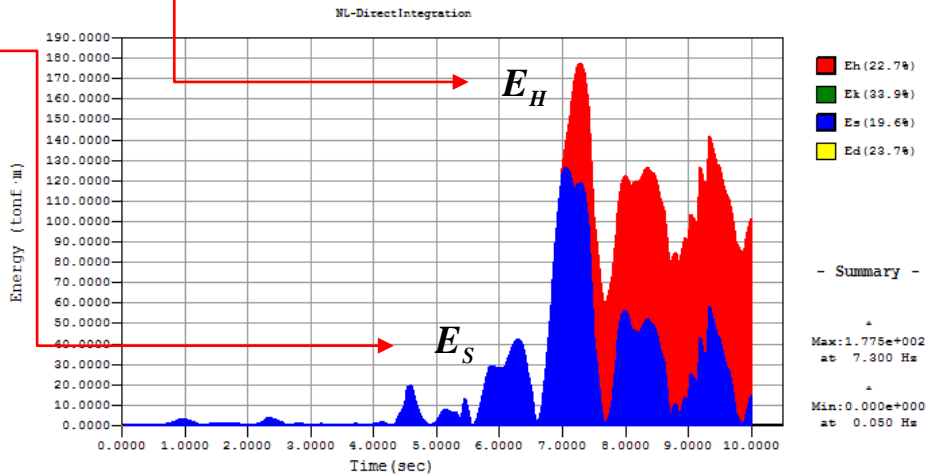
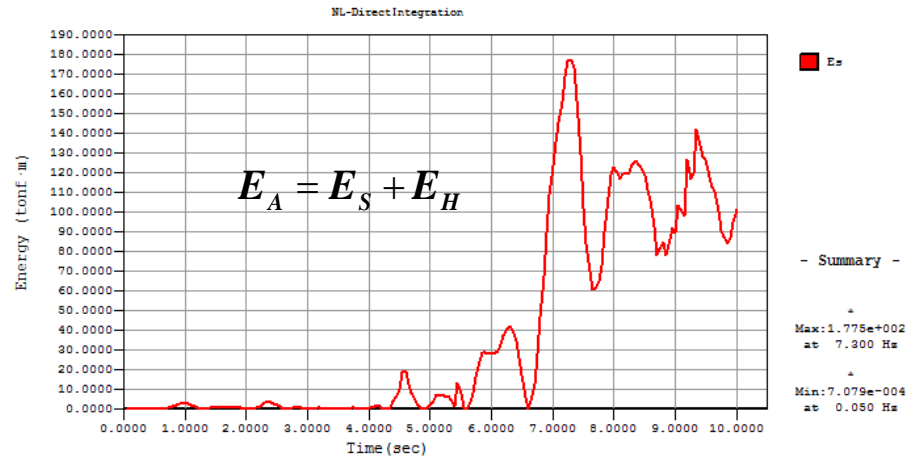
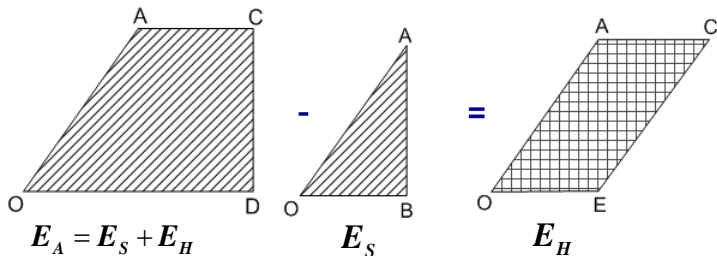
Structure Energy Graph

Time History Energy Graph Select

- Dissipated Inelastic Energy (Eh) [Inelastic Hinge]
- Kinetic Energy (Ek)
- Elastic Strain Energy (Es)
- Damping Energy (Ed)



■ Input Energy    ■ Elastic Energy    ■ Dissipated Energy





## 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

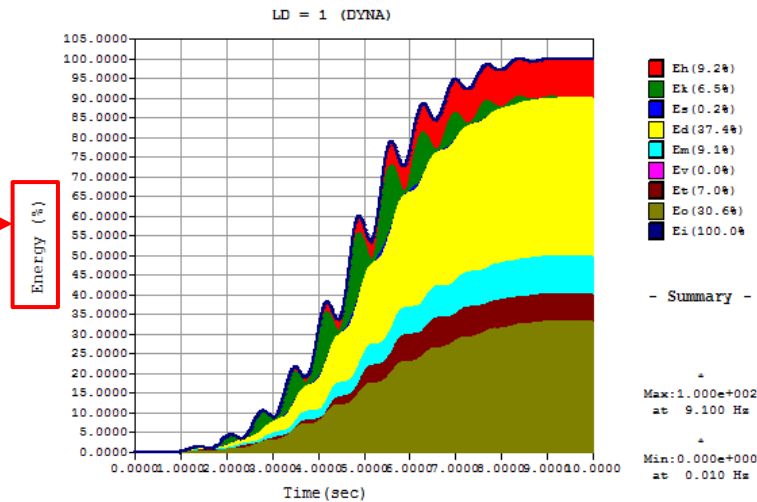
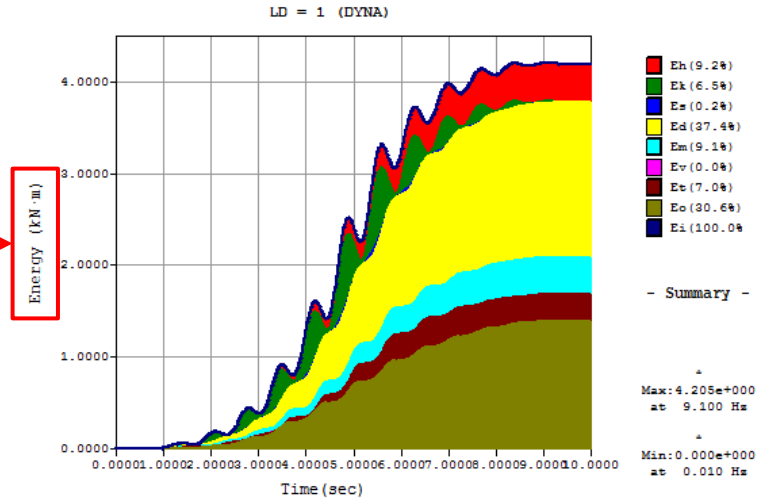
- Cumulative Value Type
- Value
- Percentage

Time History Load Case

Display Options

- No Fill
- Solid Fill

Percentage Text Result



## 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

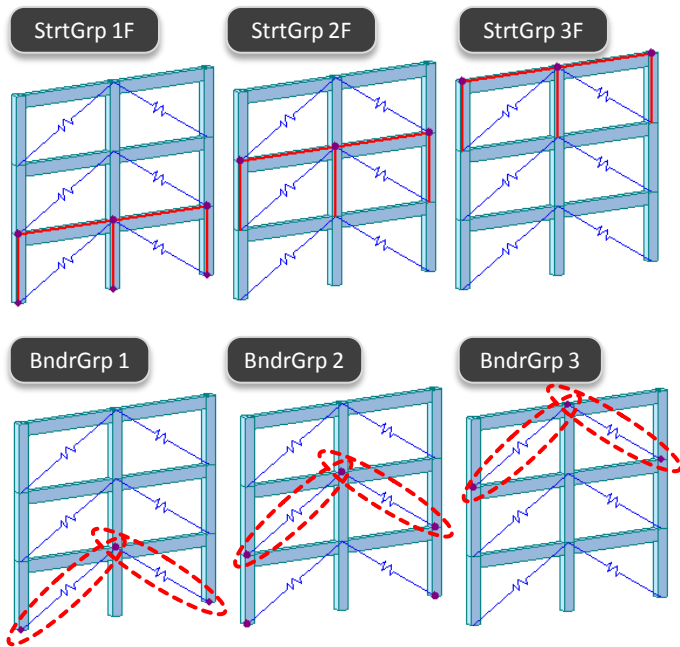
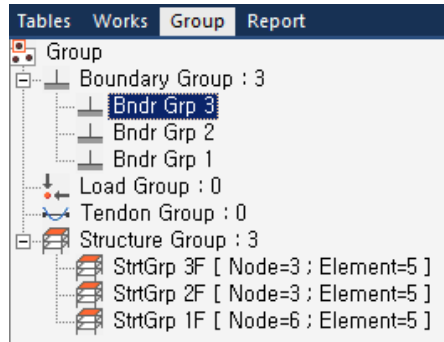
```

00001
00002 TIME HISTORY ANALYSIS | ENERGY RESULT PERCENTATE ; TIME HISTORY LOADCASE NO. = 1
00003
00004
00005
00006
00007
00008
00009
00010
00011
00012
00013
00014
00015
00016
00017
00018
00019
00020
00021
00022
00023
00024
00025
00026
00027
00028
00029
00030
00031
00032
00033
    
```

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 >

Tree Menu

**Time History Energy Graph**

Group Energy Graph

Time History Energy Graph Select

Elastic Strain Energy (Es)

Structure Group / Boundary Group

Structure Total Energy

- StrtGrp 3F
- StrtGrp 2F
- StrtGrp 1F
- Bndr Grp 3
- Bndr Grp 2
- Bndr Grp 1

Group Check

Type of Display

Cumulative Value Type

Value  Percentage

Time History Load Case

DYNA

Display Options

No Fill  Solid Fill

Percentage Text Result

Elastic Strain Energy (Es)

Inelastic Energy (Eh)

Kinetic Energy (Ek)

Elastic Strain Energy (Es)

Damping Energy (Ed)

Input Energy (Ei)

DYNA

Energy (J)

Time (sec)

- StrtGrp 2F(12.1)
- StrtGrp 2F(21.1)
- StrtGrp 1F(40.1)
- Bndr Grp 3(10.8)
- Bndr Grp 2(12.4)
- Bndr Grp 1(11.4)

Summary

Max: 1.000e+032 at 4.620 Hz

Min: 0.000e+000 at 0.000 Hz

## 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

Strains

- Plate Strains
- Solid Strains

Plate Strain

Load Cases/Combinations  
ST: LOAD

Step  
NL Step: 10

Total Strain  Plastic Strain  Damage Ratio

Strain Options

Local  
 UCS Current UCS  
 Print UCS Axis

Element  Avg. Nodal  
 Avg. Nodal Active Only

Top  Bottom  
 Both Sides  Abs Max

Components

Stn-xx  Stn-yy  Stn-xy  
 Vector

Positive  Negative

Vector Scale Factor

Length   
Thickness

MIDAS/Civil  
POST-PROCESSOR  
PLATE STRAIN  
STN-xy TOP

7.80281e-003
6.38828e-003
4.97376e-003
3.55923e-003
2.14470e-003
7.30170e-004
0.00000e+000
-2.09889e-003
-3.51341e-003
-4.92794e-003
-6.34247e-003
-7.75700e-003

ST: LOAD  
AVG NODAL  
STEP:10 S.F:1.000  
MAX : 1304  
MIN : 2872  
FILE: MAT NONLINE-  
UNIT:  
DATE: 07/16/2018  
VIEW-DIRECTION  
X: -0.483  
Y: -0.837  
Z: 0.259

## 2. Strain Output for Material Nonlinear Analysis

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

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
				Bot	-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	-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
				Bot	-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_003	Cent	Top	-4.181e-004	2.482e-004	0.000e+000	2.482e-004	-4.181e-004	90.0000	3.332e-004	2.788e-001	1.197e-007	2.788e-001
				Bot	-4.181e-004	2.482e-004	0.000e+000	2.482e-004	-4.181e-004	90.0000	3.332e-004	2.788e-001	1.197e-007	2.788e-001
1	LDC1	nl_004	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
				Bot	-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_005	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
				Bot	-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_006	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
				Bot	-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_007	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
				Bot	-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_008	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
				Bot	-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_009	Cent	Top	-3.193e-003	1.896e-003	0.000e+000	1.896e-003	-3.193e-003	90.0000	2.545e-003	7.099e-001	1.197e-007	7.099e-001
				Bot	-3.193e-003	1.896e-003	0.000e+000	1.896e-003	-3.193e-003	-90.0000	2.545e-003	7.099e-001	1.197e-007	7.099e-001
1	LDC1	nl_010	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
				Bot	-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_011	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
				Bot	-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_012	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
				Bot	-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_013	Cent	Top	-5.203e-003	3.089e-003	0.000e+000	3.089e-003	-5.203e-003	90.0000	4.146e-003	7.996e-001	1.197e-007	7.996e-001
				Bot	-5.203e-003	3.089e-003	0.000e+000	3.089e-003	-5.203e-003	-90.0000	4.146e-003	7.996e-001	1.197e-007	7.996e-001
1	LDC1	nl_014	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
				Bot	-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_015	Cent	Top	-6.209e-003	3.686e-003	0.000e+000	3.686e-003	-6.209e-003	90.0000	4.948e-003	8.206e-001	1.197e-007	8.206e-001
				Bot	-6.209e-003	3.686e-003	0.000e+000	3.686e-003	-6.209e-003	-90.0000	4.948e-003	8.206e-001	1.197e-007	8.206e-001
1	LDC1	nl_016	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
				Bot	-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_017	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
				Bot	-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_018	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
				Bot	-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

<Plate Strain (local) menu>

<Solid Strain (local) menu>

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 >

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

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

< Civil 2019 (v1.1) >

**Add/Modify/Show Deformation-Forces Function**

Name: 01    Type: Force     Symmetric     Unsymmetric

d(x) (mm)	F(y) (kN)
1	0.000000
2	10.000000
3	20.000000
4	30.000000
5	40.000000
6	50.000000
7	60.000000
8	70.000000
9	80.000000
10	90.000000
11	100.000000
12	14860.0000

**Add/Modify/Show Deformation-Forces Function**

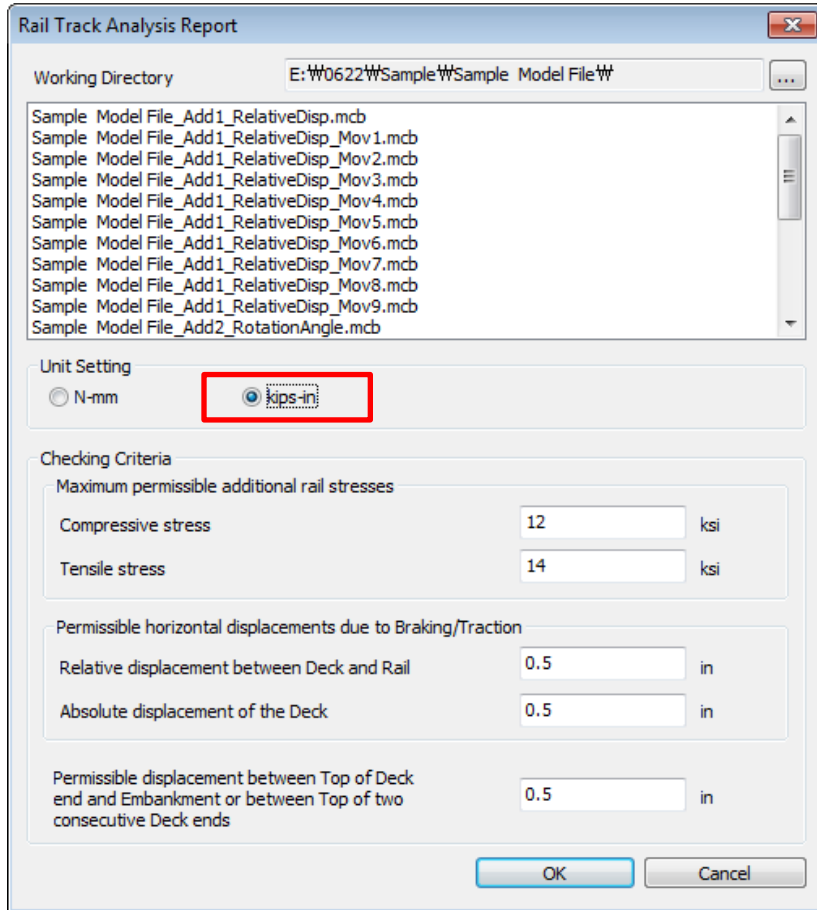
Name: 02    Type: Force     Symmetric     Unsymmetric

d(x) (mm)	F(y) (kN)
1	0.000000
2	10.000000
3	20.000000
4	30.000000
5	40.000000
6	50.000000
7	60.000000
8	70.000000
9	80.000000
10	90.000000
11	100.000000
12	14860.0000

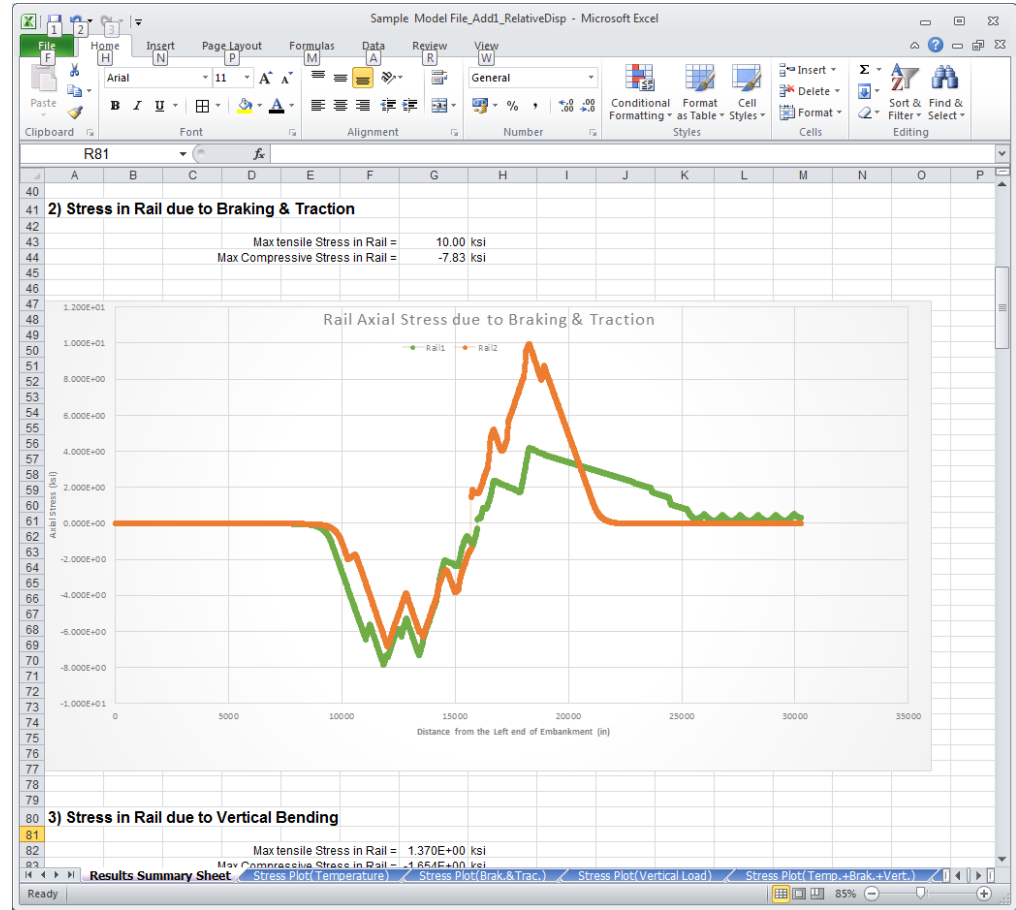
### 4. Rail Track Analysis Report with the US Unit Setting

- 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**



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

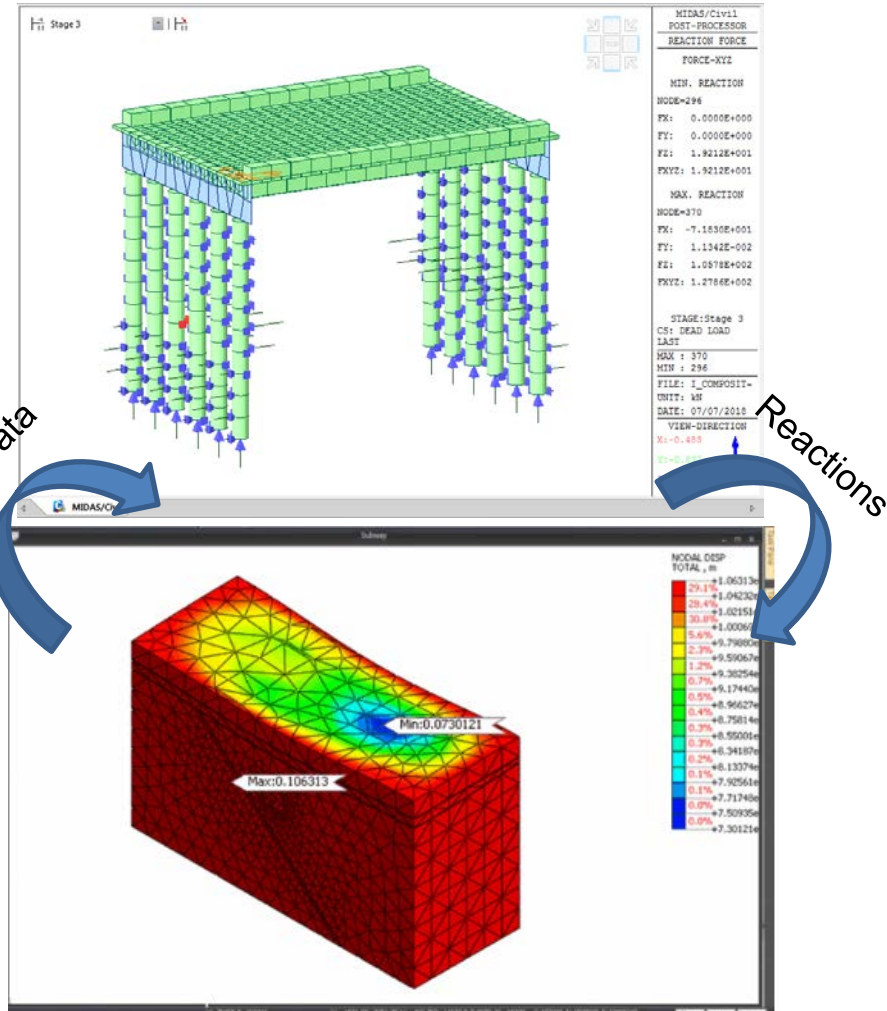


**Export Nodal Results**

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

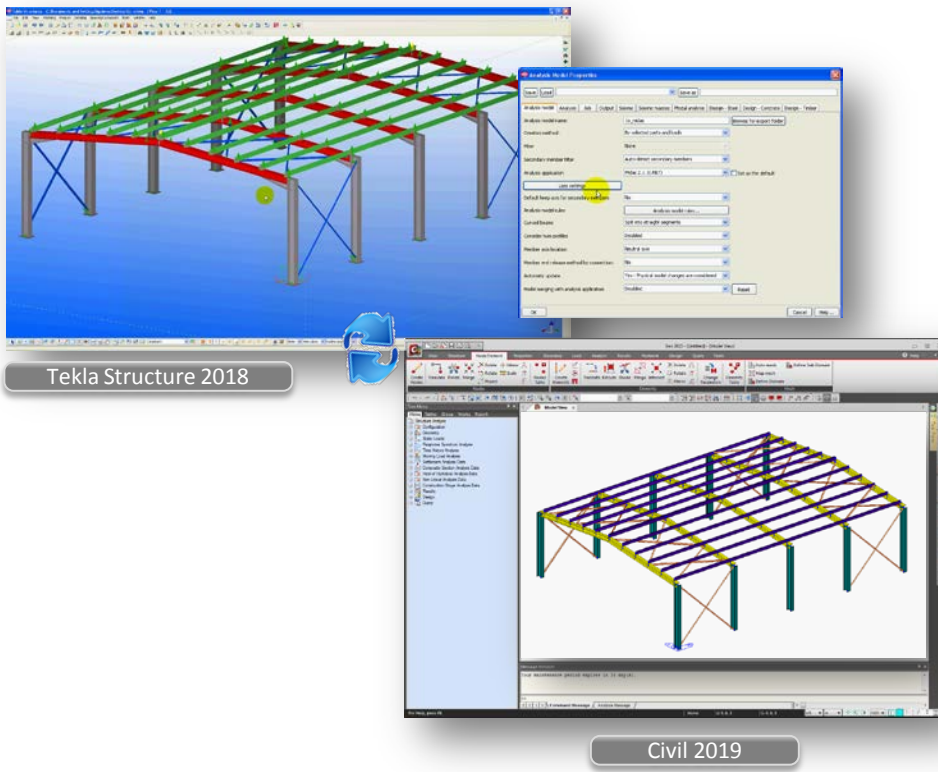




## 6. Tekla Structure 2018 Interface

- 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	<>