Release Note

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Product Ver.: Civil 2019 (v1.1)
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.
1. Traffic Load Models for Turkey

Load/Moving Load Analysis Data > Vehicles

- Standard Vehicular Load, H30-S24
- Standard Vehicular Load, H30-S24L
- Standard Vehicular Load, H20-S16
- 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
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**
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**

Bi-linear Elastic Links representing soil resistance
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**

![Image of GSD Crack Width Calculation]

- Crack Status:
  - Elastic
  - Cracked elastic
- Report on stress and crack width calculation obtained.
6. AASHTO LRFD 2016 update

- **Load Combination**

<table>
<thead>
<tr>
<th>Load Combination Limit State</th>
<th>DC</th>
<th>DD</th>
<th>DW</th>
<th>EH</th>
<th>EV</th>
<th>ES</th>
<th>PL</th>
<th>CR</th>
<th>LS</th>
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<th>BL</th>
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<td>—</td>
<td>—</td>
<td>1.00</td>
<td>0.50</td>
<td>1.20</td>
<td>γT0</td>
<td>γT0</td>
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<tr>
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<td>Fatigue I—LL, BM &amp; CE only</td>
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</tr>
</tbody>
</table>

- 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 γp to 1.0. AASHTO-LRFD 2012 used a value for γp greater than 1.0.
6. AASHTO LRFD 2016 update

- **Resistance Factor**

\[
\phi = 0.583 + 0.25 \left( \frac{d_t}{c} - 1 \right)
\]

- **\( \varepsilon_{cl} \)**: compression-controlled strain limit in the extreme tension steel
- **\( \varepsilon_{tl} \)**: 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

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

#### Results Table

<table>
<thead>
<tr>
<th>Elem</th>
<th>Node</th>
<th>POS</th>
<th>CHK</th>
<th>Dir-1</th>
<th>Dir-2</th>
<th>Conc</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Loom</td>
<td>Loom</td>
<td>Loom</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ftd</td>
<td>Ftd</td>
<td>Sig_cd</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(kN/m²)</td>
<td>(kN/m²)</td>
<td>(kN/mm²)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ratio</td>
<td>Ratio</td>
<td>siglim (kN/mm²)</td>
</tr>
</tbody>
</table>

| 2   | 2    | TOP | NG  | 5726.27 | 808.63 | 5726.27 | 808.63 | 7.67 | LC3-at | 1155.22 | 743.06 | 1.55 | LC3-at | 28.70 | 4000.00 | 0.01 |
| 2   | 2    | BOT | NG  | 139.52  | 771.16 | 0.18 | LC3-at | 20.18 | 721.21 | 0.04 | LC3-at | 5855.31 | 4000.00 | 1.46 |
| 2   | 3    | TOP | NG  | 5714.92 | 808.63 | 7.67 | LC3-at | 1140.37 | 743.06 | 1.55 | LC3-at | 19.97 | 4000.00 | 0.05 |
| 2   | 3    | BOT | NG  | 139.52  | 771.16 | 0.18 | LC3-at | 20.18 | 721.21 | 0.04 | LC3-at | 5855.31 | 4000.00 | 1.46 |
| 2   | 7    | TOP | NG  | 2992.12 | 808.63 | 3.70 | LC3-at | 524.62 | 743.06 | 0.71 | LC3-at | 69.89 | 4000.00 | 0.92 |
| 2   | 7    | BOT | OK  | 72.98  | 771.16 | 0.09 | LC3-at | 12.80 | 721.21 | 0.02 | LC3-at | 3849.47 | 4000.00 | 0.76 |
| 2   | 8    | TOP | NG  | 3020.07 | 808.63 | 3.82 | LC3-at | 630.71 | 743.06 | 0.85 | LC3-at | 27.22 | 4000.00 | 0.01 |
| 2   | 8    | BOT | OK  | 75.42  | 771.16 | 0.10 | LC3-at | 15.38 | 721.21 | 0.02 | LC3-at | 3163.91 | 4000.00 | 0.79 |
7. Shell Design

Shell Shear Checking

The followings can be displayed.

1. V_Edo
2. Shear Resistance for Concrete
3. Resistance Ratio

Results Table

<table>
<thead>
<tr>
<th>Elem</th>
<th>Sub-Domain</th>
<th>Lcom</th>
<th>Node</th>
<th>CHK</th>
<th>V_Edx (kN/m)</th>
<th>V_Edy (kN/m)</th>
<th>V_Edo (kN/m)</th>
<th>phi_e</th>
<th>V_Rdc (kN/m)</th>
<th>V_Rds (kN/m)</th>
<th>Asw/s (m²/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>L-B</td>
<td>LC2-ser</td>
<td>7</td>
<td>OK</td>
<td>-44.70</td>
<td>1.76</td>
<td>44.73</td>
<td>-0.04</td>
<td>117.78</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>2</td>
<td>L-B</td>
<td>LC2-ser</td>
<td>8</td>
<td>OK</td>
<td>-43.10</td>
<td>1.76</td>
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<td>117.78</td>
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<td>0.00</td>
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<td>L-B</td>
<td>LC2-ser</td>
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<td>126.37</td>
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<td>44.70</td>
<td>-0.00</td>
<td>126.37</td>
<td>0.00</td>
<td>0.00</td>
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</tbody>
</table>
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

![Diagram of Shell Element](image)

*Figure LL.1 — Shell element*

![Diagram of Sandwich Model](image)

*Figure LL.2 — The sandwich model*
7. Shell Design

**Procedure of Shell Design**

1. **Check plate force by analysis**: Get from ‘Plate force(UL:UCS)’ tap of Plate Stress Table
2. **Crack Checking**
   - **Uncracked**: Max. Compression stress < Strength → O.K.
   - **Cracked**: Define Sandwich model
3. **Calculate Membrane Force**
4. **Calculate stress of reinforcement and concrete**
5. **Define Rebar Arrangement**
6. **Calculate strength of reinforcement and concrete**
7. **Stress < Strength → O.K.**
7. Shell Design

Procedure of Shell Design

Crack Checking

\[ \Phi = \alpha \frac{J_2}{J_1} + \lambda \sqrt{\frac{J_2}{J_1}} + \beta \frac{J_1}{J_1} - 1 \leq 0 \]

\[ \Rightarrow \text{Uncracked, If } \Phi > 0.0, \text{ Cracked} \]

where:

\[ J_2 = \frac{1}{6} [(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2] \]
\[ J_3 = (\sigma_1 - \sigma_m)(\sigma_2 - \sigma_m)(\sigma_3 - \sigma_m) \]
\[ J_1 = \sigma_1 + \sigma_2 + \sigma_3 \]
\[ \sigma_m = (\sigma_1 + \sigma_2 + \sigma_3)/3 \]
\[ \alpha = \frac{1}{9x^{1.4}} \]

\[ \sigma_1 = \text{Max. } [\sigma_x, \sigma_y] = \text{Max. } [F_{xx}, F_{yy}] \]
\[ \sigma_2 = \text{Min. } [\sigma_x, \sigma_y] = \text{Min. } [F_{xx}, F_{yy}] \]
\[ \sigma_3 = 0 \]

\[ \sigma_1 = \max \{ \sigma_{xx}, \sigma_{yy} \} = \max \{ F_{xx}, F_{yy} \} \]
\[ \sigma_2 = \min \{ \sigma_{xx}, \sigma_{yy} \} = \min \{ F_{xx}, F_{yy} \} \]
\[ \sigma_3 = 0 \]

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

\[ \beta = \frac{1}{3.7x^{1.1}} \]

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

\[ c_1 = \frac{1}{0.7x^{0.9}} \]

\[ c_2 = 1 - 6.8(k - 0.07)^2 \]

\[ k = \frac{f_{cm}}{f_{cm}} \]

Plate Stress (UL : UCS) Table
### Procedure of Shell Design

**Define Sandwich model**

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

**Calculate Membrane Force**

- The geometry of sandwich element has to be known to compute the membrane forces \((N_xk, Nyk, Nxyk)\).

\[
N_{xt} = N_x \frac{a_t}{a} - \frac{M_x}{a} \\
N_{xb} = N_x \frac{a_t}{a} + \frac{M_x}{a} \\
N_{yt} = N_y \frac{a_t}{a} - \frac{M_y}{a} \\
N_{yb} = N_y \frac{a_t}{a} + \frac{M_y}{a} \\
N_{xyt} = N_{xy} \frac{a_t}{a} - \frac{M_{xy}}{a} \\
N_{xyb} = N_{xy} \frac{a_t}{a} + \frac{M_{xy}}{a}
\]
7. Shell Design

**Procedure of Shell Design**

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

- Define Comp. / Tens. by sign of moment
- \( k = \text{compression layer} \)
- \( j = \text{tension layer} \)

**Check main moment**

1. \( M_1 = \text{Max}(|M_x|, |M_y|) \)
2. \( M = M_x \) if \( N = N_y \), \( M = M_y \) if \( N = N_x \)
3. \( M \) compresses top fiber
   - \( k = t \), \( j = b \)
4. \( M \) does not compress top fiber
   - \( k = b \), \( j = t \)

**Cal. of Resultant moment, \( M_a \)**

\[
M_a = M - N e_j = d_j - h/2
\]

**Cal \( c_{k0} \) by Equations**

\[
c_{k0} = d_j \left(1 - \sqrt{\max[1.0 - 2\mu, 0]} \right)
\]

\( ck0 \) : 1st estimation of \( ck \)

\( ck \) : the depth of the compression block
7. Shell Design

Procedure of Shell Design

Calculation of Sandwich Thickness for Optimal Design - 2

Membrane force in compression layer.

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

\[
N_{aj} = N_{aj} \left( \frac{a_j}{a} - \frac{M_j}{a} \right)
\]

\[
N_{ak} = N_{ak} \left( \frac{a_k}{a} - \frac{M_k}{a} \right)
\]

\[
N_{ajk} = N_{ajk} \left( \frac{a_j}{a} - \frac{M_{jk}}{a} \right)
\]

Compression Force of Concrete.

**When** \( N_{ak} < -|N_{aj}|, N_{aj} < -|N_{aj}| \)

\[
N_{ak} = \frac{1}{2} (N_{aj} + N_{ajk}) - \frac{1}{2} \sqrt{(N_{aj} + N_{ajk})^2 + 4N_{ajk}}
\]

**When excluding** \( N_{aj} < -|N_{aj}|, N_{aj} < -|N_{aj}| \)

\[
N_{ek} = |N_{ajk}| \left( \tan \alpha_k + \cot \alpha_k \right)
\]
7. Shell Design

**Procedure of Shell Design**

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

![Diagram of calculation steps]

- Calculate membrane force in tensioned layer.

\[
\begin{align*}
N_{sk}, N_{jk}, N_{yjk} & \quad \text{Eq. (1)} \\
N_{xsk}, N_{yjk} & \quad \text{Eqs. (2) & (3)} \\
N_{xy} &= N_{x} - N_{sk} \\
N_{yf} &= N_{y} - N_{yjk} \\
N_{xyf} &= N_{xy} - N_{yjk} \\
N_{xaj}, N_{yaj} & \quad \text{Eqs. (2) & (3)} \\
N_{cj} & \quad \text{Eqs. (4) or (8)} \\
A_{req,x} &= \frac{N_{xaj}}{f_{yd}} \\
A_{req,y} &= \frac{N_{yaj}}{f_{yd}}
\end{align*}
\]

- Calculate tension forces in reinforcement in tension layer.

- Calculate Comp. forces in reinforcement in compressed layer.

In Gen, Ignore Comp. forces in reinforcement (Required rebar Area by comp. is 0)
Procedure of Shell Design

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

\[ N_{xk} < -|N_{xyk}|, \quad N_{yk} \geq -|N_{xyk}| \]

\[ N_{xak} = 0 \]

\[ \alpha_k = \arctan \left( \frac{|N_{xyk}|}{-N_{xk}} \right) \]

\[ N_{yak} = N_{yk} + |N_{xyk}| \tan \alpha_k \]

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

\[ N_{xk} < -|N_{xyk}|, \quad N_{yk} < -|N_{xyk}| \]

\[ N_{xak} = N_{yak} = 0 \]

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

\[ N_{yk} \geq -|N_{xyk}|, \quad N_{xk} \geq -|N_{xyk}| \]

\[ \alpha_k = 45^\circ \]

\[ N_{xak} = N_{xk} + |N_{xyk}| \cot \alpha_k = N_{xk} + |N_{xyk}| \]

\[ N_{yak} = N_{yk} + |N_{xyk}| \tan \alpha_k = N_{yk} + |N_{xyk}| \]

\[ N_{ck} = |N_{xyk}| (\tan \alpha_k + \cot \alpha_k) = 2N_{xyk} \]

\[ N_{xk} < -|N_{xyk}|, \quad N_{yk} \geq -|N_{xyk}| \]

\[ N_{yak} = 0 \]

\[ \alpha_k = \arctan \left( \frac{-N_{yk}}{-N_{xyk}} \right) \]

\[ N_{xak} = N_{xk} + |N_{xyk}| \cot \alpha_k \]

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

\( N_{xak}, N_{yak} \): 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 outerRebar

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

The actual positions of y reinforcement in top and bottom layer are \(z^*_{yar} = 53 \text{ mm}\) and \(z^*_{yab} = -23 \text{ mm}\), the corresponding tension forces at those levels, \(N^*_{yar}\) and \(N^*_{yab}\), can be obtained from:

\[
N^*_{yar} = \sum N_{ya} \cdot \frac{z_{ya} - z^*_{yar}}{z^*_{yar} - z^*_{yab}} = 398.18 \cdot \frac{-17.72 + 23}{53 + 23} = 27.68 \text{ N/mm}
\]

\[
N^*_{yab} = \sum N_{ya} \cdot \frac{z^*_{yar} - z_{ya}}{z^*_{yar} - z^*_{yab}} = 398.18 \cdot \frac{53 + 17.72}{53 + 23} = 370.50 \text{ N/mm}
\]

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.

\[ E_A = E_S + E_H \]
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**

<table>
<thead>
<tr>
<th>Time History Energy Graph</th>
<th>Structure Energy Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time History Energy Graph Select</td>
<td></td>
</tr>
<tr>
<td>□ Dispersed Inelastic Energy (Eh) [Inelastic Hinge]</td>
<td></td>
</tr>
<tr>
<td>□ Kinetic Energy (Ek)</td>
<td></td>
</tr>
<tr>
<td>□ Elastic Strain Energy (Es)</td>
<td></td>
</tr>
<tr>
<td>□ Damping Energy (Ed)</td>
<td></td>
</tr>
<tr>
<td>□ Maxwell Damping Energy (Em) [Oil Damper]</td>
<td></td>
</tr>
<tr>
<td>□ Velocity Dependent Device Energy (Ev) [Viscous</td>
<td>Viscelastic Damper]</td>
</tr>
<tr>
<td>□ Strain Dependent Device Energy (Ee) [Eles. + Ind.] [Steel</td>
<td>Hyst. Isolator]</td>
</tr>
<tr>
<td>□ Isolator Device Energy (Eo)</td>
<td></td>
</tr>
<tr>
<td>□ Plastic Strain Energy (Ep) [Plastic Material (Plate)]</td>
<td></td>
</tr>
<tr>
<td>□ Input Energy (Ei)</td>
<td></td>
</tr>
</tbody>
</table>

Type of Display
- □ Cumulative Value Type 
- □ Percentage 

Time History Load Case

Display Options
- □ No Fill 
- □ Solid Fill

Percentage Text Result

---

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

<table>
<thead>
<tr>
<th>Energy Graph</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Dissipated Inelastic Energy [Inelastic Hinge]</td>
<td>Eh 9.196</td>
</tr>
<tr>
<td>(2) Kinetic Energy</td>
<td>Ek 6.503</td>
</tr>
<tr>
<td>(3) Elastic Strain Energy</td>
<td>Es 0.237</td>
</tr>
<tr>
<td>(4) Damping Energy</td>
<td>Ed 37.396</td>
</tr>
<tr>
<td>(5) Maxwell Damping Energy [Oil Damper]</td>
<td>Em 9.149</td>
</tr>
<tr>
<td>(6) Velocity Dependent Device Energy</td>
<td>Ev 0.000</td>
</tr>
<tr>
<td>(7) Strain Dependent Device [Steel</td>
<td>Hyst. Isolator]</td>
</tr>
<tr>
<td>(8) Isolator Device Energy</td>
<td>Eo 30.559</td>
</tr>
<tr>
<td>(9) Plastic Strain Energy [Plastic Material (Plate)]</td>
<td>Ep 0.000</td>
</tr>
<tr>
<td>(10) Input Energy</td>
<td>Ei 100.000</td>
</tr>
<tr>
<td>Error (Input Energy[Ei] - Energy Sum[(1)-(9))]</td>
<td>0.000</td>
</tr>
</tbody>
</table>
1. Energy Result Graph for Time History Analysis

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

- **Table:**
  - StrtGrp 1F
  - StrtGrp 2F
  - StrtGrp 3F
  - BndrGrp 1
  - BndrGrp 2
  - BndrGrp 3

- **Group Energy Graph:**
  - Elastic Strain Energy (Es)
  - Inelastic Energy (En)
  - Kinetic Energy (Ek)
  - Plastic Strain Energy (Ps)
  - Damping Energy (Ed)
  - Input Energy (Ei)

- **Time History Energy Graph Select:**
  - Elastic Strain Energy (Es)

- **Type of Display:**
  - Cumulative Value Type
  - Value

- **Time History Load Case:**
  - DYNA

- **Display Options:**
  - No Fill
  - Solid Fill

- **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.

![Image of strain output and options](image-url)
2. Strain Output for Material Nonlinear Analysis

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

![Plate Strain (local) menu](image1)

![Solid Strain (local) menu](image2)

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**

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

<table>
<thead>
<tr>
<th>Node</th>
<th>Element</th>
<th>Boundary</th>
<th>Mass</th>
<th>Load</th>
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</thead>
<tbody>
<tr>
<td>Point Spring Supports</td>
<td>Boundary Group Name</td>
<td>Default</td>
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<tr>
<td>Options</td>
<td>Add</td>
<td>Replace</td>
<td>Delete</td>
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<tr>
<td>Point Spring (Local Direction)</td>
<td>Type</td>
<td>Multi-linear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deformation-Forces Function</td>
<td>Multi-linear Type</td>
<td>Unsymmetric</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Civil 2019 (v1.1)**

- Multi-linear curve can be defined as a function without limitation in terms of number of data.

<table>
<thead>
<tr>
<th>Node</th>
<th>Element</th>
<th>Boundary</th>
<th>Mass</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Spring</td>
<td>Boundary Group Name</td>
<td>Default</td>
<td></td>
<td></td>
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<tr>
<td>Options</td>
<td>Add</td>
<td>Replace</td>
<td>Delete</td>
<td></td>
</tr>
<tr>
<td>Point Spring (Local Direction)</td>
<td>Type</td>
<td>Multi-linear</td>
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<tr>
<td>Deformation-Forces Function</td>
<td>Multi-linear Type</td>
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<tr>
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<td></td>
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</tr>
</tbody>
</table>

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

| Name | Type | | |
|------|------|| |
| 01   | Force | | |
| 02   | Moment | | |
| 03   | Symmetric | | |

<table>
<thead>
<tr>
<th>Node</th>
<th>Element</th>
<th>Boundary</th>
<th>Mass</th>
<th>Load</th>
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<tbody>
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<tr>
<td>Options</td>
<td>Add</td>
<td>Replace</td>
<td>Delete</td>
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<tr>
<td>Elastic Link Data</td>
<td>Type</td>
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<tr>
<td>Direction</td>
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</tr>
</tbody>
</table>

**Deformation-Forces Function**

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Features</th>
<th>Tekla &lt;&gt; Gen</th>
</tr>
</thead>
<tbody>
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<td>MATERIAL</td>
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<tr>
<td></td>
<td>pre cast - wood and other types</td>
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<td>Material user defined</td>
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<td>curved beam</td>
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<td>2D ELEMENTS</td>
<td>Concrete panels and slab</td>
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<td>STATIC LOAD</td>
<td>self weigh</td>
<td>&gt;</td>
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<td></td>
<td>linear load (uniform or trapezoidal)</td>
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<td>MERGE OPTION</td>
<td>new element</td>
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<tr>
<td></td>
<td>new element that divide other elements</td>
<td>&lt;&gt;</td>
</tr>
<tr>
<td></td>
<td>topology changes</td>
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</tr>
</tbody>
</table>