Finite Element Analysis of Flat Slab

Using numerical formulation of Bogner-Fox-Schmit (BFS) plate element

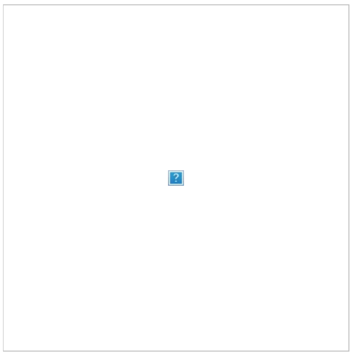
Input data

Span lengths

$a = \mathbf{hp}([3.6;\ 4.2;\ 4.2;\ 3.6]) = [3.6\ \ 4.2\ \ 4.2\ \ 3.6]$ m

$b = \mathbf{hp}([3;\ 3.6;\ 3]) = [3\ \ 3.6\ \ 3]$ m

Number of axes - $n_{sa} = \mathbf{len}(a) + 1 = 5$, $n_{sb} = \mathbf{len}(b) + 1 = 4$



Axis coordinates - $x_s = [0\ \ 3.6\ \ 7.8\ \ 12\ \ 15.6]$ m, $y_s = [0\ \ 3\ \ 6.6\ \ 9.6]$ m

Slab dimensions - $l_a = x_{s.5} = 15.6$ m, $l_b = y_{s.4} = 9.6$ m

Thickness - $t = 0.2$ m

Load - $q = 10$ kN/m²

Modulus of elasticity - $E = 35000$ MPa

Poisson`s ratio - $\nu = 0.2$

Finite element mesh

We will use Bogner-Fox-Schmit rectangular finite element with $n_{DOFs} = 16$

Element dimensions - $a_1 = 0.6$ m, $b_1 = 0.6$ m

Number of elements and joints along *a* and *b* -

$$n_a = \mathbf{ceiling}\left(\frac{a}{a_1}\right) = \mathbf{ceiling}\left(\frac{a}{0.6}\right) = [6\ \ 7\ \ 7\ \ 6]\ ,\ n_{ea} = \mathbf{sum}(n_a) = 26\ ,\ n_{ja} = n_{ea} + 1 = 26 + 1 = 27$$

$$n_b = \mathbf{ceiling}\left(\frac{b}{b_1}\right) = \mathbf{ceiling}\left(\frac{b}{0.6}\right) = [5\ \ 6\ \ 5]\ ,\ n_{eb} = \mathbf{sum}(n_b) = 16\ ,\ n_{jb} = n_{eb} + 1 = 16 + 1 = 17$$

Total number of elements - $n_e = n_{ea} \cdot n_{eb} = 26 \cdot 16 = 416$

Total number of joints - $n_j = n_{ja} \cdot n_{jb} = 27 \cdot 17 = 459$

Supported joints count - $n_s = n_{sa} \cdot n_{sb} = 5 \cdot 4 = 20$

Joint coordinates

$x_j = [0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0.6\ 0.6\ 0.6\ \ldots\ 15.6]$ m

$y_j = [0\ 0.6\ 1.2\ 1.8\ 2.4\ 3\ 3.6\ 4.2\ 4.8\ 5.4\ 6\ 6.6\ 7.2\ 7.8\ 8.4\ 9\ 9.6\ 0\ 0.6\ 1.2\ \ldots\ 9.6]$ m

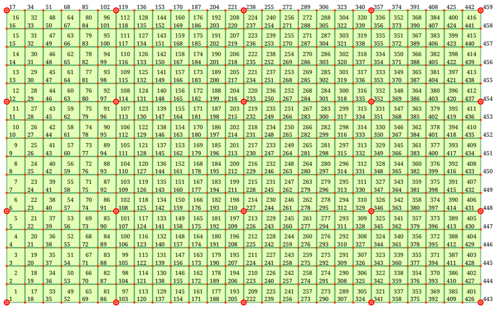
Numbers of joints at elements' corners

$$\mathbf{transp}(e_j) = \begin{bmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 18 & 19 & 20 & 21 & \cdots & 441 \\ 18 & 19 & 20 & 21 & 22 & 23 & 24 & 25 & 26 & 27 & 28 & 29 & 30 & 31 & 32 & 33 & 35 & 36 & 37 & 38 & \cdots & 458 \\ 19 & 20 & 21 & 22 & 23 & 24 & 25 & 26 & 27 & 28 & 29 & 30 & 31 & 32 & 33 & 34 & 36 & 37 & 38 & 39 & \cdots & 459 \\ 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 & 19 & 20 & 21 & 22 & \cdots & 442 \end{bmatrix}$$

Supported joints

$s_j = [1\ 6\ 12\ 17\ 103\ 108\ 114\ 119\ 222\ 227\ 233\ 238\ 341\ 346\ 352\ 357\ 443\ 448\ 454\ 459]$

Joints for element e - $j_e(e) = \mathbf{row}(e_j;\ e)$



Finite element formulation

Shape functions

Along dimension *a*

Base functions

$\Phi_{1a}(\xi) = 1 - \xi^2 \cdot (3 - 2 \cdot \xi)$

$\Phi_{2a}(\xi) = \xi \cdot a_1 \cdot (1 - \xi \cdot (2 - \xi))$

$\Phi_{3a}(\xi) = \xi^2 \cdot (3 - 2 \cdot \xi)$

$\Phi_{4a}(\xi) = \xi^2 \cdot a_1 \cdot (-1 + \xi)$

First derivatives

$\Phi'_{1a}(\xi) = -6 \cdot \dfrac{\xi}{a_1} \cdot (1 - \xi)$

$\Phi'_{2a}(\xi) = 1 - \xi \cdot (4 - 3 \cdot \xi)$

$\Phi'_{3a}(\xi) = 6 \cdot \dfrac{\xi}{a_1} \cdot (1 - \xi)$

$\Phi'_{4a}(\xi) = -\xi \cdot (2 - 3 \cdot \xi)$

Second derivatives

$\Phi''_{1a}(\xi) = -\dfrac{6}{a_1^2} \cdot (1 - 2 \cdot \xi)$

$\Phi''_{2a}(\xi) = -\dfrac{2}{a_1} \cdot (2 - 3 \cdot \xi)$

$\Phi''_{3a}(\xi) = \dfrac{6}{a_1^2} \cdot (1 - 2 \cdot \xi)$

$\Phi''_{4a}(\xi) = -\dfrac{2}{a_1} \cdot (1 - 3 \cdot \xi)$

Along dimension *b*

Base functions

$\Phi_{1b}(\eta) = 1 - \eta^2 \cdot (3 - 2 \cdot \eta)$

$\Phi_{2b}(\eta) = \eta \cdot b_1 \cdot (1 - \eta \cdot (2 - \eta))$

$\Phi_{3b}(\eta) = \eta^2 \cdot (3 - 2 \cdot \eta)$

$\Phi_{4b}(\eta) = \eta^2 \cdot b_1 \cdot (-1 + \eta)$

First derivatives

$\Phi'_{1b}(\eta) = -6 \cdot \dfrac{\eta}{b_1} \cdot (1 - \eta)$

$\Phi'_{2b}(\eta) = 1 - \eta \cdot (4 - 3 \cdot \eta)$

$\Phi'_{3b}(\eta) = 6 \cdot \dfrac{\eta}{b_1} \cdot (1 - \eta)$

$\Phi'_{4b}(\eta) = -\eta \cdot (2 - 3 \cdot \eta)$

Second derivatives

$\Phi''_{1b}(\eta) = -\dfrac{6}{b_1^2} \cdot (1 - 2 \cdot \eta)$

$\Phi''_{2b}(\eta) = -\dfrac{2}{b_1} \cdot (2 - 3 \cdot \eta)$

$\Phi''_{3b}(\eta) = \dfrac{6}{b_1^2} \cdot (1 - 2 \cdot \eta)$

$\Phi''_{4b}(\eta) = -\dfrac{2}{b_1} \cdot (1 - 3 \cdot \eta)$

For vertical displacements w	For rotations θ_x	For rotations θ_y
$N_{1,w}(\xi;\eta) = \Phi_{1a}(\xi)\cdot\Phi_{1b}(\eta)$	$N_{1,\theta_x}(\xi;\eta) = \Phi_{2a}(\xi)\cdot\Phi_{1b}(\eta)$	$N_{1,\theta_y}(\xi;\eta) = \Phi_{1a}(\xi)\cdot\Phi_{2b}(\eta)$
$N_{2,w}(\xi;\eta) = \Phi_{3a}(\xi)\cdot\Phi_{1b}(\eta)$	$N_{2,\theta_x}(\xi;\eta) = \Phi_{4a}(\xi)\cdot\Phi_{1b}(\eta)$	$N_{2,\theta_y}(\xi;\eta) = \Phi_{3a}(\xi)\cdot\Phi_{2b}(\eta)$
$N_{3,w}(\xi;\eta) = \Phi_{3a}(\xi)\cdot\Phi_{3b}(\eta)$	$N_{3,\theta_x}(\xi;\eta) = \Phi_{4a}(\xi)\cdot\Phi_{3b}(\eta)$	$N_{3,\theta_y}(\xi;\eta) = \Phi_{3a}(\xi)\cdot\Phi_{4b}(\eta)$
$N_{4,w}(\xi;\eta) = \Phi_{1a}(\xi)\cdot\Phi_{3b}(\eta)$	$N_{4,\theta_x}(\xi;\eta) = \Phi_{2a}(\xi)\cdot\Phi_{3b}(\eta)$	$N_{4,\theta_y}(\xi;\eta) = \Phi_{1a}(\xi)\cdot\Phi_{4b}(\eta)$

For twist ψ

$N_{1,\psi}(\xi;\eta) = \Phi_{2a}(\xi)\cdot\Phi_{2b}(\eta)$

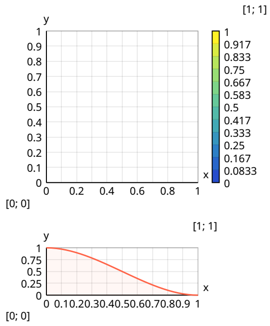
$N_{2,\psi}(\xi;\eta) = \Phi_{4a}(\xi)\cdot\Phi_{2b}(\eta)$

$N_{3,\psi}(\xi;\eta) = \Phi_{4a}(\xi)\cdot\Phi_{4b}(\eta)$

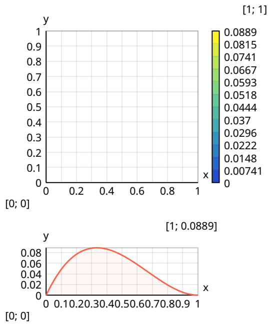
$N_{4,\psi}(\xi;\eta) = \Phi_{2a}(\xi)\cdot\Phi_{4b}(\eta)$

plane-elemen.png

$N_{1,w}$ shape function plot



N_{1,θ_x} shape function plot



Shape functions vector

$N(i;\xi;\eta) = \mathbf{take}(i; N_{1,w}(\xi;\eta); N_{1,\theta_x}(\xi;\eta); N_{1,\theta_y}(\xi;\eta); N_{1,\psi}(\xi;\eta); N_{2,w}(\xi;\eta); N_{2,\theta_x}(\xi;\eta); N_{2,\theta_y}(\xi;\eta); N_{2,\psi}(\xi;\eta); N_{3,w}(\xi;\eta); N_{3,\theta_x}(\xi;\eta); N_{3,\theta_y}(\xi;\eta); N_{3,\psi}(\xi;\eta); N_{4,w}(\xi;\eta); N_{4,\theta_x}(\xi;\eta); N_{4,\theta_y}(\xi;\eta); N_{4,\psi}(\xi;\eta))$

Constitutive matrix (stress - strain relationship)

$$\boldsymbol{D} = \frac{E\cdot t^3}{12\cdot(1-\nu^2)}\cdot\mathbf{hp}\left(\left[1;\nu;0 \mid \nu;1;0 \mid 0;0;\frac{1-\nu}{2}\right]\right) = \frac{35000\cdot 0.2^3}{12\cdot(1-0.2^2)}\cdot\mathbf{hp}\left(\left[1;0.2;0 \mid 0.2;1;0 \mid 0;0;\frac{1-0.2}{2}\right]\right) = \begin{bmatrix} 24.305556 & 4.861111 & 0 \\ 4.861111 & 24.305556 & 0 \\ 0 & 0 & 9.722222 \end{bmatrix} \text{kNm}$$

Strain-displacement matrix

$B_1(j;\xi;\eta) = \mathbf{take}(j; \Phi''_{1a}(\xi)\cdot\Phi_{1b}(\eta); \Phi''_{2a}(\xi)\cdot\Phi_{1b}(\eta); \Phi''_{1a}(\xi)\cdot\Phi_{2b}(\eta); \Phi''_{2a}(\xi)\cdot\Phi_{2b}(\eta); \Phi''_{3a}(\xi)\cdot\Phi_{1b}(\eta); \Phi''_{4a}(\xi)\cdot\Phi_{1b}(\eta); \Phi''_{3a}(\xi)\cdot\Phi_{2b}(\eta); \Phi''_{4a}(\xi)\cdot\Phi_{2b}(\eta); \Phi''_{3a}(\xi)\cdot\Phi_{3b}(\eta); \Phi''_{4a}(\xi)\cdot\Phi_{3b}(\eta); \Phi''_{3a}(\xi)\cdot\Phi_{4b}(\eta); \Phi''_{4a}(\xi)\cdot\Phi_{4b}(\eta); \Phi''_{1a}(\xi)\cdot\Phi_{3b}(\eta); \Phi''_{2a}(\xi)\cdot\Phi_{3b}(\eta); \Phi''_{1a}(\xi)\cdot\Phi_{4b}(\eta); \Phi''_{2a}(\xi)\cdot\Phi_{4b}(\eta))$

$B_2(j;\xi;\eta) = \mathbf{take}(j; \Phi_{1a}(\xi)\cdot\Phi''_{1b}(\eta); \Phi_{2a}(\xi)\cdot\Phi''_{1b}(\eta); \Phi_{1a}(\xi)\cdot\Phi''_{2b}(\eta); \Phi_{2a}(\xi)\cdot\Phi''_{2b}(\eta); \Phi_{3a}(\xi)\cdot\Phi''_{1b}(\eta); \Phi_{4a}(\xi)\cdot\Phi''_{1b}(\eta); \Phi_{3a}(\xi)\cdot\Phi''_{2b}(\eta); \Phi_{4a}(\xi)\cdot\Phi''_{2b}(\eta); \Phi_{3a}(\xi)\cdot\Phi''_{3b}(\eta); \Phi_{4a}(\xi)\cdot\Phi''_{3b}(\eta); \Phi_{3a}(\xi)\cdot\Phi''_{4b}(\eta); \Phi_{4a}(\xi)\cdot\Phi''_{4b}(\eta); \Phi_{1a}(\xi)\cdot\Phi''_{3b}(\eta); \Phi_{2a}(\xi)\cdot\Phi''_{3b}(\eta); \Phi_{1a}(\xi)\cdot\Phi''_{4b}(\eta); \Phi_{2a}(\xi)\cdot\Phi''_{4b}(\eta))$

$B_3(j;\xi;\eta) = 2\cdot\mathbf{take}(j; \Phi'_{1a}(\xi)\cdot\Phi'_{1b}(\eta); \Phi'_{2a}(\xi)\cdot\Phi'_{1b}(\eta); \Phi'_{1a}(\xi)\cdot\Phi'_{2b}(\eta); \Phi'_{2a}(\xi)\cdot\Phi'_{2b}(\eta); \Phi'_{3a}(\xi)\cdot\Phi'_{1b}(\eta); \Phi'_{4a}(\xi)\cdot\Phi'_{1b}(\eta); \Phi'_{3a}(\xi)\cdot\Phi'_{2b}(\eta); \Phi'_{4a}(\xi)\cdot\Phi'_{2b}(\eta); \Phi'_{3a}(\xi)\cdot\Phi'_{3b}(\eta); \Phi'_{4a}(\xi)\cdot\Phi'_{3b}(\eta); \Phi'_{3a}(\xi)\cdot\Phi'_{4b}(\eta); \Phi'_{4a}(\xi)\cdot\Phi'_{4b}(\eta); \Phi'_{1a}(\xi)\cdot\Phi'_{3b}(\eta); \Phi'_{2a}(\xi)\cdot\Phi'_{3b}(\eta); \Phi'_{1a}(\xi)\cdot\Phi'_{4b}(\eta); \Phi'_{2a}(\xi)\cdot\Phi'_{4b}(\eta))$

$B(j;\xi;\eta) = \mathbf{hp}([B_1(j;\xi;\eta); B_2(j;\xi;\eta); B_3(j;\xi;\eta)])$

The coefficients of the stiffness matrix will be calculated by using the equation

$$K_{e,ij} = a_1\cdot b_1\cdot\int_0^1\int_0^1 B_i(\xi;\eta)^T\cdot D\cdot B_j(\xi;\eta)\,d\xi\,d\eta$$

Element stiffness matrix

(above the main diagonal only)

$BTDB_e(i;j;\xi;\eta) = \mathbf{transp}(B(i;\xi;\eta))\cdot\boldsymbol{D}\cdot B(j;\xi;\eta)$

$$K_e(i;j) = a_1\cdot b_1\cdot\int_0^1\int_0^1 BTDB_e(i;j;\xi;\eta)\,d\eta\,d\xi$$

$Repeat{$Repeat{$\boldsymbol{K}_{e.i,j} = K_e(i;j)$ for $j = i...n$} for $i = 1...n$} = 0.9777823

$\boldsymbol{K}_e =$

$$\begin{bmatrix}
796.296296 & 135.185185 & 135.185185 & 16.736111 & -391.203704 & 84.953704 & -13.657407 & 4.097222 & -13.888889 & 36.574074 & 36.574074 & -8.541667 & -391.203704 & -13.657407 & 84.953704 & 4.097222 \\
0 & 46.666667 & 21.597222 & 4.666667 & -84.953704 & 14.027778 & -4.094824 & 0.7083333 & -36.574074 & 10.277778 & 8.541667 & -1.624997 & -13.657407 & 1.944444 & 4.097222 & -0.5833333 \\
0 & 0 & 46.666667 & 4.666667 & -13.657407 & 4.094824 & 1.944444 & -0.5833333 & -36.574074 & 8.541667 & 10.277778 & -1.625 & -84.953704 & -4.097222 & 14.027778 & 0.7083333 \\
0 & 0 & 0 & 0.9777823 & -4.097222 & 0.7083333 & 0.5833333 & -0.1611111 & -8.541667 & 1.624997 & 1.625 & -0.2305541 & -4.097222 & 0.5833333 & 0.7083333 & -0.1611111 \\
0 & 0 & 0 & 0 & 796.296296 & -135.185185 & 135.185185 & -16.736111 & -391.203704 & 13.657407 & 84.953704 & -4.097222 & -13.888889 & -36.574074 & 36.574074 & 8.541667 \\
0 & 0 & 0 & 0 & 0 & 46.666667 & -21.597222 & 4.666667 & 13.657407 & 1.944444 & -4.097222 & -0.5833333 & 36.574074 & 10.277778 & -8.541667 & -1.624997 \\
0 & 0 & 0 & 0 & 0 & 0 & 46.666667 & -4.666667 & -84.953704 & 4.097222 & 14.027778 & -0.7083333 & -36.574074 & -8.541667 & 10.277778 & 1.625 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.9777823 & 4.097222 & 0.5833333 & -0.7083333 & -0.1611111 & 8.541667 & 1.624997 & -1.625 & -0.2305541 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 796.296296 & -135.185185 & -135.185185 & 16.736111 & -391.203704 & -84.953704 & 13.657407 & 4.097222 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 46.666667 & 21.597222 & -4.666667 & 84.953704 & 14.027778 & -4.094824 & -0.7083333 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 46.666667 & -4.666667 & 13.657407 & 4.094824 & 1.944444 & 0.5833333 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.9777823 & -4.097222 & -0.7083333 & -0.5833333 & -0.1611111 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 796.296296 & 135.185185 & -135.185185 & -16.736111 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 46.666667 & -21.597222 & -4.666667 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 46.666667 & 4.666667 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.9777823
\end{bmatrix}$$

Element load vector

$$F_{e,i} = a_1\cdot b_1\cdot\int_0^1\int_0^1 N_i(\xi;\eta)^T\cdot q\,d\xi\,d\eta$$

$F_e = [0.9\ \ 0.09\ \ 0.09\ \ 0.009\ \ 0.9\ \ -0.09\ \ 0.09\ \ -0.009\ \ 0.9\ \ -0.09\ \ -0.09\ \ 0.009\ \ 0.9\ \ 0.09\ \ -0.09\ \ -0.009]$ kN

Solution

Global stiffness matrix

$\boldsymbol{K} =$

$$\begin{bmatrix}
10^{20} & 135.185185 & 135.185185 & 16.736111 & -391.203704 & -13.657407 & 84.953704 & 4.097222 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 \\
135.185185 & 46.666667 & 21.597222 & 4.666667 & -13.657407 & 1.944444 & 4.097222 & -0.5833333 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 \\
135.185185 & 21.597222 & 46.666667 & 4.666667 & -84.953704 & -4.097222 & 14.027778 & 0.7083333 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 \\
16.736111 & 4.666667 & 4.666667 & 0.9777823 & -4.097222 & 0.5833333 & 0.7083333 & -0.1611111 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 \\
-391.203704 & -13.657407 & -84.953704 & -4.097222 & 1592.592593 & 270.37037 & 0 & 0 & -391.203704 & -13.657407 & 84.953704 & 4.097222 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 \\
-13.657407 & 1.944444 & -4.097222 & 0.5833333 & 270.37037 & 93.333333 & 0 & 0 & -13.657407 & 1.944444 & 4.097222 & -0.5833333 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 \\
84.953704 & 4.097222 & 14.027778 & 0.7083333 & 0 & 0 & 93.333333 & 9.333333 & -84.953704 & -4.097222 & 14.027778 & 0.7083333 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 \\
4.097222 & -0.5833333 & 0.7083333 & -0.1611111 & 0 & 0 & 9.333333 & 1.955565 & -4.097222 & 0.5833333 & 0.7083333 & -0.1611111 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 \\
0 & 0 & 0 & 0 & -391.203704 & -13.657407 & -84.953704 & -4.097222 & 1592.592593 & 270.37037 & 0 & 0 & -391.203704 & -13.657407 & 84.953704 & 4.097222 & 0 & 0 & 0 & 0 & \cdots & 0 \\
0 & 0 & 0 & 0 & -13.657407 & 1.944444 & -4.097222 & 0.5833333 & 270.37037 & 93.333333 & 0 & 0 & -13.657407 & 1.944444 & 4.097222 & -0.5833333 & 0 & 0 & 0 & 0 & \cdots & 0 \\
0 & 0 & 0 & 0 & 84.953704 & 4.097222 & 14.027778 & 0.7083333 & 0 & 0 & 93.333333 & 9.333333 & -84.953704 & -4.097222 & 14.027778 & 0.7083333 & 0 & 0 & 0 & 0 & \cdots & 0 \\
0 & 0 & 0 & 0 & 4.097222 & -0.5833333 & 0.7083333 & -0.1611111 & 0 & 0 & 9.333333 & 1.955565 & -4.097222 & 0.5833333 & 0.7083333 & -0.1611111 & 0 & 0 & 0 & 0 & \cdots & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -391.203704 & -13.657407 & -84.953704 & -4.097222 & 1592.592593 & 270.37037 & 0 & 0 & -391.203704 & -13.657407 & 84.953704 & 4.097222 & \cdots & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -13.657407 & 1.944444 & -4.097222 & 0.5833333 & 270.37037 & 93.333333 & 0 & 0 & -13.657407 & 1.944444 & 4.097222 & -0.5833333 & \cdots & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 84.953704 & 4.097222 & 14.027778 & 0.7083333 & 0 & 0 & 93.333333 & 9.333333 & -84.953704 & -4.097222 & 14.027778 & 0.7083333 & \cdots & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 4.097222 & -0.5833333 & 0.7083333 & -0.1611111 & 0 & 0 & 9.333333 & 1.955565 & -4.097222 & 0.5833333 & 0.7083333 & -0.1611111 & \cdots & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -391.203704 & -13.657407 & -84.953704 & -4.097222 & 1592.592593 & 270.37037 & 0 & 0 & \cdots & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -13.657407 & 1.944444 & -4.097222 & 0.5833333 & 270.37037 & 93.333333 & 0 & 0 & \cdots & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 84.953704 & 4.097222 & 14.027778 & 0.7083333 & 0 & 0 & 93.333333 & 9.333333 & \cdots & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 4.097222 & -0.5833333 & 0.7083333 & -0.1611111 & 0 & 0 & 9.333333 & 1.955565 & \cdots & 0 \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0.9777823
\end{bmatrix}$$

Global load vector

$F = [0.9\ \ 0.09\ \ 0.09\ \ 0.009\ \ 1.8\ \ 0.18\ \ 0\ \ 0\ \ 1.8\ \ 0.18\ \ 0\ \ 0\ \ 1.8\ \ 0.18\ \ 0\ \ 0\ \ 1.8\ \ 0.18\ \ 0\ \ 0\ \ \ldots\ \ 0.009]$ kN

Solution of the system of equations

$Z = \mathbf{slsolve}(K; F) = [0\ \ 0.5523613\ \ 0.3827392\ \ -0.4161287\ \ 0.2028064\ \ 0.3732832\ \ 0.2648463\ \ -0.1937261\ \ 0.2989047$
$0.3091182\ \ 0.04830843\ \ -0.02501454\ \ 0.261207\ \ 0.3426386\ \ -0.1651493\ \ 0.1275073\ \ 0.1211489$
$0.4681287\ \ -0.2671179\ \ 0.2293302\ \ \ldots\ \ -0.4161286]$ mm

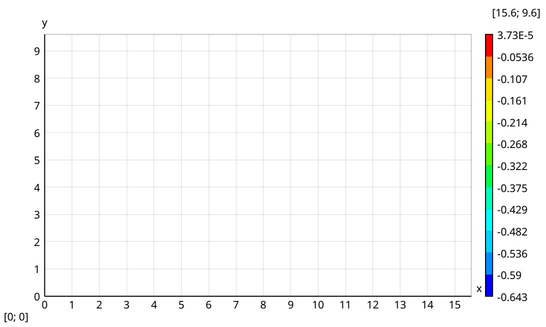
Results

Joint displacements

$\mathbf{transp}(W_z) =$

$$\begin{bmatrix}
0 & 0.303 & 0.488 & 0.512 & 0.383 & 0.165 & 0 & 0.139 & 0.34 & 0.469 & 0.472 & 0.347 & 0.146 & 0 & 0.146 & 0.347 & 0.472 & 0.469 & 0.34 & 0.139 & \cdots & 0 \\
0.203 & 0.419 & 0.562 & 0.581 & 0.485 & 0.337 & 0.25 & 0.31 & 0.438 & 0.531 & 0.533 & 0.443 & 0.311 & 0.242 & 0.311 & 0.443 & 0.533 & 0.531 & 0.438 & 0.31 & \cdots & 0.203 \\
0.299 & 0.482 & 0.605 & 0.62 & 0.537 & 0.417 & 0.35 & 0.387 & 0.485 & 0.562 & 0.564 & 0.489 & 0.387 & 0.338 & 0.387 & 0.489 & 0.564 & 0.562 & 0.485 & 0.387 & \cdots & 0.299 \\
0.261 & 0.461 & 0.593 & 0.608 & 0.513 & 0.375 & 0.299 & 0.342 & 0.455 & 0.542 & 0.544 & 0.46 & 0.345 & 0.289 & 0.345 & 0.46 & 0.544 & 0.542 & 0.455 & 0.342 & \cdots & 0.261 \\
0.121 & 0.386 & 0.55 & 0.565 & 0.443 & 0.253 & 0.138 & 0.217 & 0.381 & 0.493 & 0.497 & 0.389 & 0.225 & 0.134 & 0.225 & 0.389 & 0.497 & 0.493 & 0.381 & 0.217 & \cdots & 0.121 \\
0 & 0.34 & 0.527 & 0.542 & 0.404 & 0.173 & 0 & 0.135 & 0.336 & 0.463 & 0.467 & 0.345 & 0.145 & 0 & 0.145 & 0.345 & 0.467 & 0.463 & 0.336 & 0.135 & \cdots & 0 \\
0.139 & 0.398 & 0.556 & 0.566 & 0.44 & 0.247 & 0.129 & 0.206 & 0.367 & 0.478 & 0.481 & 0.374 & 0.211 & 0.121 & 0.211 & 0.374 & 0.481 & 0.478 & 0.367 & 0.206 & \cdots & 0.139 \\
0.299 & 0.487 & 0.608 & 0.612 & 0.511 & 0.369 & 0.287 & 0.325 & 0.433 & 0.516 & 0.519 & 0.437 & 0.324 & 0.27 & 0.324 & 0.437 & 0.519 & 0.516 & 0.433 & 0.325 & \cdots & 0.299 \\
0.363 & 0.526 & 0.632 & 0.635 & 0.544 & 0.42 & 0.35 & 0.376 & 0.464 & 0.536 & 0.538 & 0.467 & 0.373 & 0.329 & 0.373 & 0.467 & 0.538 & 0.536 & 0.464 & 0.376 & \cdots & 0.363 \\
0.299 & 0.487 & 0.608 & 0.612 & 0.511 & 0.369 & 0.287 & 0.325 & 0.433 & 0.516 & 0.519 & 0.437 & 0.324 & 0.27 & 0.324 & 0.437 & 0.519 & 0.516 & 0.433 & 0.325 & \cdots & 0.299 \\
0.139 & 0.398 & 0.556 & 0.566 & 0.44 & 0.247 & 0.129 & 0.206 & 0.367 & 0.478 & 0.481 & 0.374 & 0.211 & 0.121 & 0.211 & 0.374 & 0.481 & 0.478 & 0.367 & 0.206 & \cdots & 0.139 \\
0 & 0.34 & 0.527 & 0.542 & 0.404 & 0.173 & 0 & 0.135 & 0.336 & 0.463 & 0.467 & 0.345 & 0.145 & 0 & 0.145 & 0.345 & 0.467 & 0.463 & 0.336 & 0.135 & \cdots & 0 \\
0.121 & 0.386 & 0.55 & 0.565 & 0.443 & 0.253 & 0.138 & 0.217 & 0.381 & 0.493 & 0.497 & 0.389 & 0.225 & 0.134 & 0.225 & 0.389 & 0.497 & 0.493 & 0.381 & 0.217 & \cdots & 0.121 \\
0.261 & 0.461 & 0.593 & 0.608 & 0.513 & 0.375 & 0.299 & 0.342 & 0.455 & 0.542 & 0.544 & 0.46 & 0.345 & 0.289 & 0.345 & 0.46 & 0.544 & 0.542 & 0.455 & 0.342 & \cdots & 0.261 \\
0.299 & 0.482 & 0.605 & 0.62 & 0.537 & 0.417 & 0.35 & 0.387 & 0.485 & 0.562 & 0.564 & 0.489 & 0.387 & 0.338 & 0.387 & 0.489 & 0.564 & 0.562 & 0.485 & 0.387 & \cdots & 0.299 \\
0.203 & 0.419 & 0.562 & 0.581 & 0.485 & 0.337 & 0.25 & 0.31 & 0.438 & 0.531 & 0.533 & 0.443 & 0.311 & 0.242 & 0.311 & 0.443 & 0.533 & 0.531 & 0.438 & 0.31 & \cdots & 0.203 \\
0 & 0.303 & 0.488 & 0.512 & 0.383 & 0.165 & 0 & 0.139 & 0.34 & 0.469 & 0.472 & 0.347 & 0.146 & 0 & 0.146 & 0.347 & 0.472 & 0.469 & 0.34 & 0.139 & \cdots & 0
\end{bmatrix}$$

mm



Bending moments

$Z_j(j) = \mathbf{slice}(Z; k_1 \cdot (j-1) + 1; k_1 \cdot j)$

$Z_e(e) = \mathbf{hp}([Z_j(e_{j.e,1}); Z_j(e_{j.e,2}); Z_j(e_{j.e,3}); Z_j(e_{j.e,4})])$

Average bending moments at joints, kNm/m

$M_j =$

$$\begin{bmatrix}
1.498465 & 0.3097372 & 0.2197322 & 0.1563433 & 0.1570519 & 0.9983302 & 0.1564193 & 0.1519741 & 0.19422 & 0.1519742 & 0.1564197 & 0.9983303 & 0.1570475 & 0.1563397 & 0.2197486 & 0.3098808 & 1.49858 & 8.502998 & 6.479199 & 5.777684 & \cdots & 1.498434 \\
1.566914 & 7.805101 & 9.33778 & 7.668097 & 3.333 & -28.361735 & 3.14639 & 7.323888 & 8.895019 & 7.323888 & 3.14639 & -28.361734 & 3.332997 & 7.668093 & 9.337791 & 7.80518 & 1.566813 & 0.3205972 & 5.382201 & 7.126518 & \cdots & 1.56695 \\
8.091391 & 3.766896 & 0.4863938 & -2.479308 & -4.459199 & 0.1550864 & 4.780359 & 2.842723 & 1.18852\times10^{-8} & -2.842723 & -4.780359 & -0.1550866 & 4.459199 & 2.479312 & -0.4863957 & -3.766967 & -8.09139 & 4.110857 & 2.572942 & 0.367139 & \cdots & 8.09139
\end{bmatrix}$$

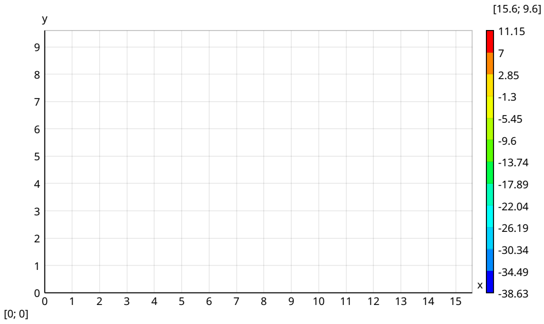
Bending moments for the plate

Bending moments - M_x

$\mathbf{transp}(Mx) =$

$$\begin{bmatrix}
1.498465 & 8.502998 & 11.06652 & 10.47741 & 6.797477 & 0.8838727 & -31.235271 & 0.3015017 & 5.644442 & 8.779995 & 8.877612 & 5.920011 & 0.6854447 & -30.133041 & 0.6854451 & 5.92001 & 8.877613 & 8.779995 & 5.644443 & 0.3015014 & \cdots & 1.498543 \\
0.3097372 & 6.479199 & 9.4322 & 8.877275 & 4.922637 & -2.695317 & -10.242892 & -3.260294 & 3.808797 & 7.250425 & 7.361393 & 4.127752 & -2.764349 & -9.733242 & -2.764349 & 4.127752 & 7.361393 & 7.250426 & 3.808797 & -3.260293 & \cdots & 0.3098324 \\
0.2197322 & 5.777684 & 8.716293 & 8.135055 & 4.039483 & -2.257879 & -6.060711 & -2.819291 & 2.932144 & 6.516758 & 6.640543 & 3.291674 & -2.294253 & -5.615624 & -2.294253 & 3.291674 & 6.640543 & 6.516758 & 2.932144 & -2.819291 & \cdots & 0.2197447 \\
0.1563433 & 5.993176 & 9.125993 & 8.492789 & 4.05777 & -3.257751 & -7.98846 & -3.832677 & 2.913674 & 6.797469 & 6.926822 & 3.304597 & -3.205198 & -7.381383 & -3.205198 & 3.304597 & 6.926822 & 6.797469 & 2.913674 & -3.832677 & \cdots & 0.1563395 \\
0.1570519 & 7.269644 & 10.372249 & 9.556604 & 4.972553 & -5.268409 & -16.118864 & -5.865491 & 3.766832 & 7.713228 & 7.838243 & 4.157472 & -5.096284 & -15.086013 & -5.096284 & 4.157472 & 7.838243 & 7.713228 & 3.766832 & -5.865491 & \cdots & 0.1570491 \\
0.9983302 & 9.038525 & 11.080418 & 10.122777 & 5.76385 & -2.135317 & -38.650059 & -2.745557 & 4.52179 & 8.190804 & 8.315041 & 4.904088 & -2.088413 & -36.536458 & -2.088413 & 4.904088 & 8.315041 & 8.190804 & 4.52179 & -2.745557 & \cdots & 0.9983301 \\
0.1564193 & 7.221047 & 10.282001 & 9.436465 & 4.848242 & -5.358009 & -16.18287 & -5.96302 & 3.624262 & 7.560111 & 7.698855 & 4.05327 & -5.138805 & -15.091525 & -5.138805 & 4.05327 & 7.698855 & 7.560111 & 3.624262 & -5.96302 & \cdots & 0.1564295 \\
0.1519741 & 5.873186 & 8.92795 & 8.229755 & 3.773453 & -3.419119 & -8.032747 & -4.009042 & 2.594259 & 6.469761 & 6.626453 & 3.062913 & -3.269947 & -7.306587 & -3.269947 & 3.062913 & 6.626453 & 6.469761 & 2.594259 & -4.009042 & \cdots & 0.151956 \\
0.19422 & 5.514147 & 8.380213 & 7.692931 & 3.468337 & -2.491105 & -5.742638 & -3.073384 & 2.310468 & 5.979222 & 6.14265 & 2.786902 & -2.376825 & -5.118402 & -2.376825 & 2.786902 & 6.14265 & 5.979222 & 2.310468 & -3.073384 & \cdots & 0.1942406 \\
0.1519742 & 5.873186 & 8.92795 & 8.229755 & 3.773453 & -3.419119 & -8.032747 & -4.009042 & 2.594259 & 6.469761 & 6.626453 & 3.062913 & -3.269947 & -7.306587 & -3.269947 & 3.062913 & 6.626453 & 6.469761 & 2.594259 & -4.009042 & \cdots & 0.1519563 \\
0.1564197 & 7.221047 & 10.282001 & 9.436465 & 4.848242 & -5.358009 & -16.18287 & -5.96302 & 3.624262 & 7.560111 & 7.698855 & 4.05327 & -5.138805 & -15.091525 & -5.138805 & 4.05327 & 7.698855 & 7.560111 & 3.624262 & -5.96302 & \cdots & 0.1564287 \\
0.9983303 & 9.038524 & 11.080418 & 10.122777 & 5.76385 & -2.135317 & -38.650059 & -2.745557 & 4.52179 & 8.190804 & 8.315041 & 4.904088 & -2.088413 & -36.536458 & -2.088413 & 4.904088 & 8.315041 & 8.190804 & 4.52179 & -2.745557 & \cdots & 0.99833 \\
0.1570475 & 7.269646 & 10.372249 & 9.556604 & 4.972554 & -5.268409 & -16.118864 & -5.865491 & 3.766832 & 7.713228 & 7.838243 & 4.157472 & -5.096284 & -15.086013 & -5.096284 & 4.157472 & 7.838243 & 7.713228 & 3.766832 & -5.865491 & \cdots & 0.1570551 \\
0.1563397 & 5.993177 & 9.125994 & 8.492789 & 4.05777 & -3.257751 & -7.98846 & -3.832677 & 2.913674 & 6.797469 & 6.926822 & 3.304597 & -3.205198 & -7.381383 & -3.205198 & 3.304597 & 6.926822 & 6.797469 & 2.913674 & -3.832677 & \cdots & 0.1563387 \\
0.2197486 & 5.777685 & 8.716292 & 8.135052 & 4.039485 & -2.25788 & -6.060711 & -2.819291 & 2.932144 & 6.516758 & 6.640543 & 3.291674 & -2.294252 & -5.615624 & -2.294253 & 3.291674 & 6.640543 & 6.516758 & 2.932144 & -2.819291 & \cdots & 0.2197395 \\
0.3098808 & 6.479177 & 9.432178 & 8.877282 & 4.922634 & -2.695314 & -10.242892 & -3.260293 & 3.808797 & 7.250426 & 7.361393 & 4.127752 & -2.764349 & -9.733242 & -2.764349 & 4.127752 & 7.361393 & 7.250426 & 3.808797 & -3.260293 & \cdots & 0.309677 \\
1.49858 & 8.502893 & 11.066537 & 10.477401 & 6.797487 & 0.8838683 & -31.23527 & 0.301501 & 5.644443 & 8.779994 & 8.877614 & 5.920009 & 0.6854455 & -30.133041 & 0.6854449 & 5.920011 & 8.877613 & 8.779995 & 5.644442 & 0.3015017 & \cdots & 1.498434
\end{bmatrix}$$

kNm/m

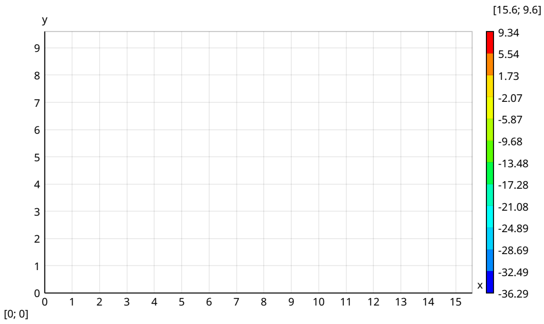


Bending moments M_y

transp(*My*) =

1.566914	0.3205972	0.2333587	0.2147852	0.1682816	0.1798035	1.015789	0.1794301	0.1669894	0.2098191	0.2091906	0.1663467	0.1776119	0.9891482	0.1776123	0.1663459	0.2091915	0.2098181	0.1669903	0.1794296	⋯	1.566846
7.805101	5.382201	4.308412	4.134952	4.742331	6.340395	8.230714	6.28316	4.611981	3.89228	3.867499	4.530534	6.12258	7.985896	6.12258	4.530534	3.867499	3.89228	4.611981	6.28316	⋯	7.805153
9.33778	7.126518	5.800074	5.553032	6.414898	8.11577	9.046666	8.014704	6.188836	5.14485	5.116777	6.090589	7.821224	8.777225	7.821225	6.090589	5.116777	5.14485	6.188836	8.014704	⋯	9.337789
7.668097	5.41756	4.262493	3.920413	4.233692	5.419822	6.344591	5.301104	3.979478	3.477998	3.480904	3.968582	5.222837	6.181459	5.222837	3.968582	3.480904	3.477998	3.979478	5.301104	⋯	7.668093
3.333	-0.3280779	0.5396346	0.405616	-1.17438	-3.412974	-0.3301829	-3.531204	-1.399574	0.09964996	0.1609008	-1.210571	-3.234664	-0.2184219	-3.234664	-1.210571	0.1609008	0.09964995	-1.399574	-3.531204	⋯	3.332998
-28.361735	-7.038366	-1.936162	-1.646652	-4.993974	-13.644678	-36.317523	-13.771126	-5.215881	-1.858171	-1.764027	-4.886867	-13.033174	-34.571125	-13.033174	-4.886867	-1.764027	-1.858171	-5.215881	-13.771126	⋯	-28.361736
3.14639	-0.5066696	0.3485146	0.1799353	-1.456247	-3.762435	-0.7233495	-3.922981	-1.765819	-0.2520091	-0.1968807	-1.596341	-3.661657	-0.6661947	-3.661657	-1.596341	-0.1968807	-0.2520091	-1.765819	-3.922981	⋯	3.146398
7.323888	5.094548	3.908978	3.489139	3.675468	4.685865	5.49873	4.483969	3.254199	2.794376	2.788549	3.214495	4.349964	5.243651	4.349964	3.214495	2.788549	2.794376	3.254199	4.483969	⋯	7.323874
8.895019	6.740122	5.350863	4.96126	5.608937	6.913063	7.572529	6.693158	5.141784	4.180525	4.149637	5.027791	6.456862	7.212973	6.456862	5.027791	4.149637	4.180525	5.141784	6.693158	⋯	8.895035
7.323888	5.094548	3.908978	3.489139	3.675468	4.685865	5.49873	4.483969	3.254199	2.794376	2.788549	3.214495	4.349964	5.243651	4.349964	3.214495	2.788549	2.794376	3.254199	4.483969	⋯	7.323874
3.14639	-0.5066695	0.3485145	0.1799354	-1.456247	-3.762435	-0.7233495	-3.922981	-1.765819	-0.2520091	-0.1968807	-1.596341	-3.661657	-0.6661947	-3.661657	-1.596341	-0.1968807	-0.2520091	-1.765819	-3.922981	⋯	3.146397
-28.361734	-7.038366	-1.936162	-1.646652	-4.993974	-13.644678	-36.317523	-13.771126	-5.215881	-1.858171	-1.764027	-4.886867	-13.033174	-34.571125	-13.033174	-4.886867	-1.764027	-1.858171	-5.215881	-13.771126	⋯	-28.361736
3.332997	-0.3280781	0.5396345	0.405616	-1.174379	-3.412974	-0.3301829	-3.531204	-1.399574	0.09964994	0.1609008	-1.210571	-3.234664	-0.2184219	-3.234664	-1.210571	0.1609008	0.09964996	-1.399574	-3.531204	⋯	3.333003
7.668093	5.41756	4.262493	3.920414	4.233691	5.419822	6.344591	5.301104	3.979478	3.477998	3.480904	3.968582	5.222837	6.181459	5.222837	3.968582	3.480904	3.477998	3.979478	5.301104	⋯	7.668093
9.337791	7.126529	5.800079	5.553029	6.414899	8.115769	9.046667	8.014704	6.188836	5.14485	5.116777	6.090589	7.821225	8.777225	7.821225	6.090589	5.116777	5.14485	6.188836	8.014704	⋯	9.337788
7.80518	5.382247	4.308397	4.134958	4.742326	6.340398	8.230713	6.283161	4.61198	3.892281	3.867498	4.530534	6.12258	7.985896	6.12258	4.530534	3.867499	3.89228	4.611981	6.28316	⋯	7.805067
1.566813	0.3204128	0.2333748	0.2147746	0.1682944	0.1797983	1.015789	0.1794292	0.1669914	0.2098169	0.2091927	0.166345	0.1776128	0.9891482	0.177612	0.1663463	0.209191	0.2098187	0.1669898	0.1794301	⋯	1.56695

kNm/m

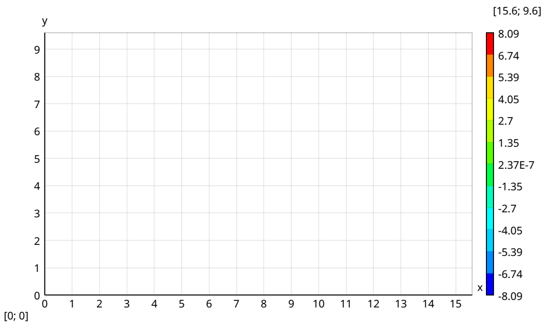


Bending moments M_{xy}

transp(*Mxy*) =

8.091391	4.110857	1.417137	-0.9458016	-3.233923	-4.783472	0.02175397	4.840696	3.336369	1.142106	-1.025808	-3.195694	-4.675291	8.203632×10^{-9}	4.675291	3.195694	1.025808	-1.14210
3.766896	2.572942	0.9831798	-0.5157529	-2.056961	-3.229076	0.05823395	3.354953	2.213405	0.7311327	-0.6697977	-2.124616	-3.226088	-1.924384×10^{-8}	3.226088	2.124615	0.6697977	-0.731132
0.4863938	0.367139	0.2104715	0.08573235	-0.1195606	-0.3138301	0.07348128	0.4612966	0.2667083	0.05683469	-0.07988453	-0.2739108	-0.4318273	4.135681×10^{-9}	0.4318273	0.2739109	0.07988453	-0.056834
-2.479308	-1.795977	-0.6012575	0.6167458	1.746893	2.092654	0.07628287	-1.948193	-1.634066	-0.5814737	0.4919345	1.536254	1.879329	-9.399297×10^{-10}	-1.879329	-1.536254	-0.4919345	0.581473
-4.459199	-3.239942	-0.8977427	0.6826669	2.370922	4.524997	0.07578146	-4.382303	-2.264662	-0.6817699	0.6007663	2.152105	4.210878	2.347034×10^{-10}	-4.210878	-2.152105	-0.6007663	0.681769
0.1550864	0.1611718	0.1492474	0.1245987	0.09639145	0.07797703	0.07388198	0.06988651	0.05125056	0.02105121	-0.008413693	-0.02659669	-0.02344966	-6.046931×10^{-11}	0.02344966	0.02659669	0.008413693	-0.021051
4.780359	3.565968	1.189369	-0.4505428	-2.206755	-4.399285	0.06348492	4.535454	2.37937	0.7252095	-0.6263983	-2.225358	-4.279277	1.578955×10^{-11}	4.279277	2.225358	0.6263983	-0.725209
2.842723	2.13438	0.8682924	-0.4377229	-1.679594	-2.084069	0.03778704	2.16835	1.796129	0.6296557	-0.5417072	-1.677932	-2.037682	-4.744667×10^{-12}	2.037682	1.677932	0.5417072	-0.629655
1.18852×10^{-8}	-6.576042×10^{-9}	-7.016847×10^{-10}	1.244056×10^{-10}	2.191792×10^{-10}	-7.501514×10^{-11}	1.8954×10^{-11}	-1.177769×10^{-13}	3.047327×10^{-12}	1.092988×10^{-12}	-4.777445×10^{-12}	5.435255×10^{-12}	-3.554444×10^{-12}	3.228026×10^{-12}	-2.990397×10^{-12}	1.375859×10^{-12}	-1.298123×10^{-12}	7.488428×1
-2.842723	-2.13438	-0.8682924	0.4377229	1.679594	2.084069	-0.03778704	-2.16835	-1.796129	-0.6296557	0.5417072	1.677932	2.037682	-7.622464×10^{-12}	-2.037682	-1.677932	-0.5417072	0.629655
-4.780359	-3.565968	-1.189369	0.4505428	2.206755	4.399285	-0.06348492	-4.535454	-2.37937	-0.7252095	0.6263983	2.225358	4.279277	2.756043×10^{-11}	-4.279277	-2.225358	-0.6263983	0.725209
-0.1550866	-0.1611716	-0.1492474	-0.1245987	-0.09639145	-0.07797703	-0.07388197	-0.06988651	-0.05125056	-0.02105121	0.008413693	0.02659669	0.02344966	-1.059221×10^{-10}	-0.02344966	-0.02659669	-0.008413693	0.021051
4.459199	3.239941	0.8977427	-0.6826669	-2.370922	-4.524997	-0.07578147	4.382303	2.264662	0.6817699	-0.6007663	-2.152105	-4.210878	4.094768×10^{-10}	4.210878	2.152105	0.6007663	-0.681769
2.479312	1.795976	0.6012571	-0.6167458	-1.746893	-2.092654	-0.07628286	1.948193	1.634066	0.5814737	-0.4919345	-1.536254	-1.879329	-1.611647×10^{-9}	1.879329	1.536254	0.4919345	-0.581473
-0.4863957	-0.3671418	-0.2104716	-0.08573185	0.1195605	0.3138302	-0.07348132	-0.4612966	-0.2667083	-0.05683469	0.07988452	0.2739109	0.4318273	6.850159×10^{-9}	-0.4318273	-0.2739109	-0.07988453	0.056834
-3.766967	-2.57294	-0.9831755	0.5157536	2.056962	3.229076	-0.05823381	-3.354953	-2.213405	-0.7311327	0.6697977	2.124615	3.226088	-3.125512×10^{-8}	-3.226088	-2.124615	-0.6697977	0.731132
-8.09139	-4.110792	-1.417137	0.9457983	3.233922	4.783472	-0.02175395	-4.840696	-3.336369	-1.142106	1.025808	3.195694	4.675291	1.254052×10^{-8}	-4.675291	-3.195694	-1.025808	1.14210

kNm/m



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