Elastic analysis of (concrete) plates on grade

Annex: Two relevant examples

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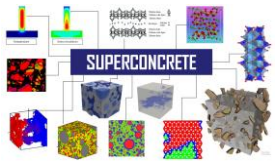

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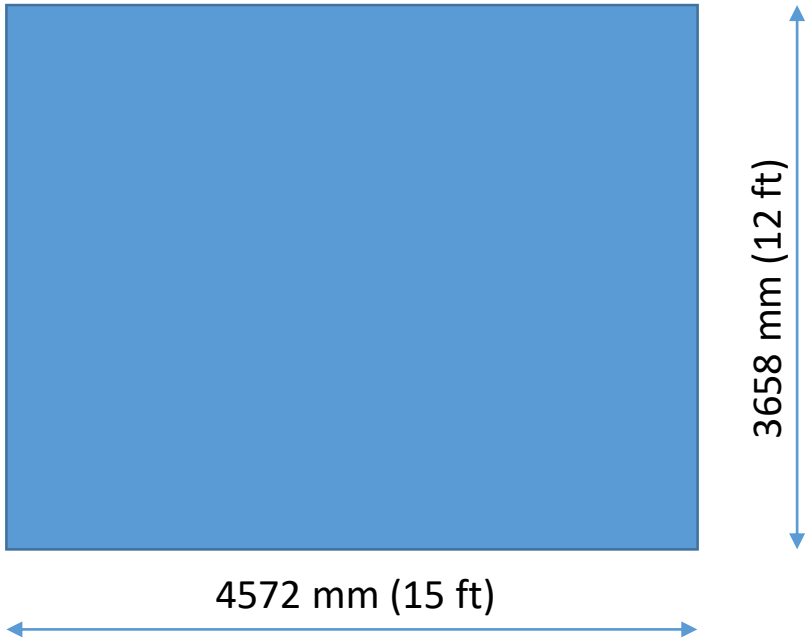
Ann Arbor, MI - 20 October 2016

Overview

Two relevant cases:

Case #1: Center point load and positive ΔT (mid-day on sunny days)

Case #2: Point loads near corners and negative ΔT (mid-day on sunny days)



k_0= 0.04073 N/mm^3
=150 psi/in

$\Delta=\Delta x=\Delta y$=304.8 mm
(1 ft)

Case #1

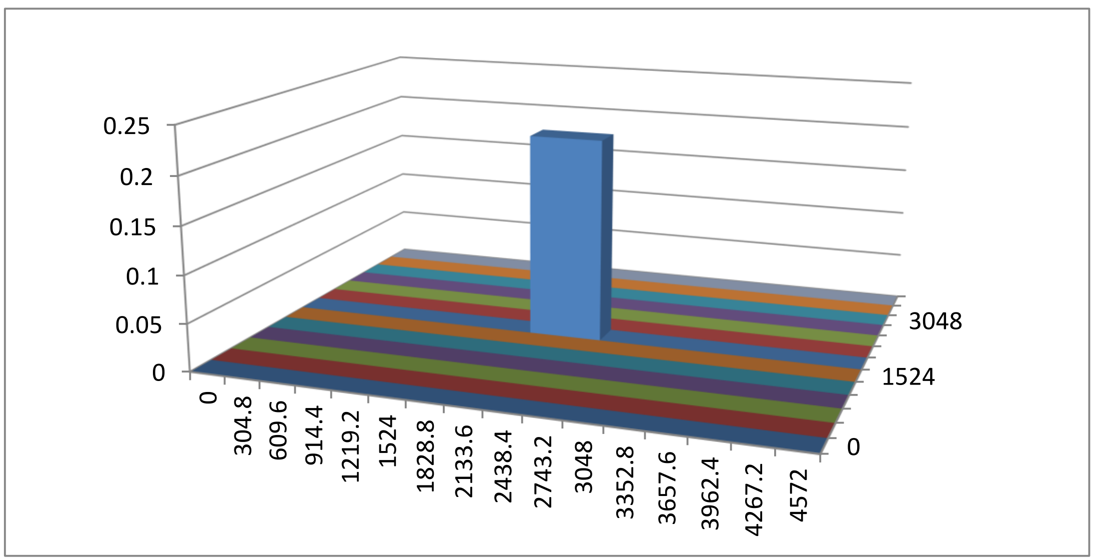
Geometric data and mechanical properties

$E=$	27586	MPa	**Self-weight multiplier**			**Center-point force**			**Thermal effects**		
$s=$	250	mm	$\gamma_g=$	0.00		$F=$	40.00	kN	$\Delta t=$	10	°C
$\nu=$	0.2		$g=$	6.25	kN/m^2				$\alpha_c=$	1.20E-05	$°C^{-1}$
$\gamma=$	25.0	kN/m^3							$\chi^*=$	-4.80E-07	mm^{-1}
$D=$	3.742E+10	Nmm									
$k_0=$	0.04073	N/mm^3									
$L_x=$	5000	mm									
$L_y=$	5000	mm									
$n=$	10										
$\Delta=$	304.8	mm									

Case #1

Point load: assumptions

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0.215	0.215	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



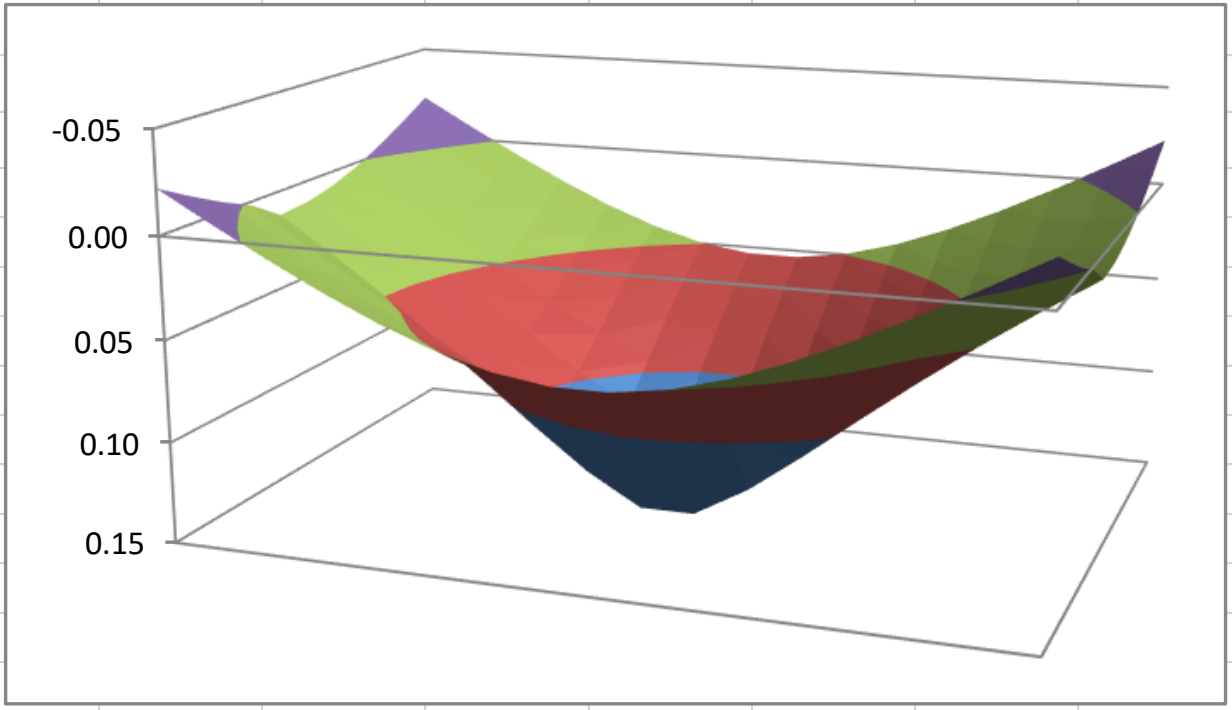
Due to symmetry reasons, the point load (P=40 kN) is distributed over 2 nodes/celles:

$$q_{P,eq} = \frac{P}{2 \cdot \Delta} = 0.215 \text{ N} / \text{mm}^2$$

Case #1

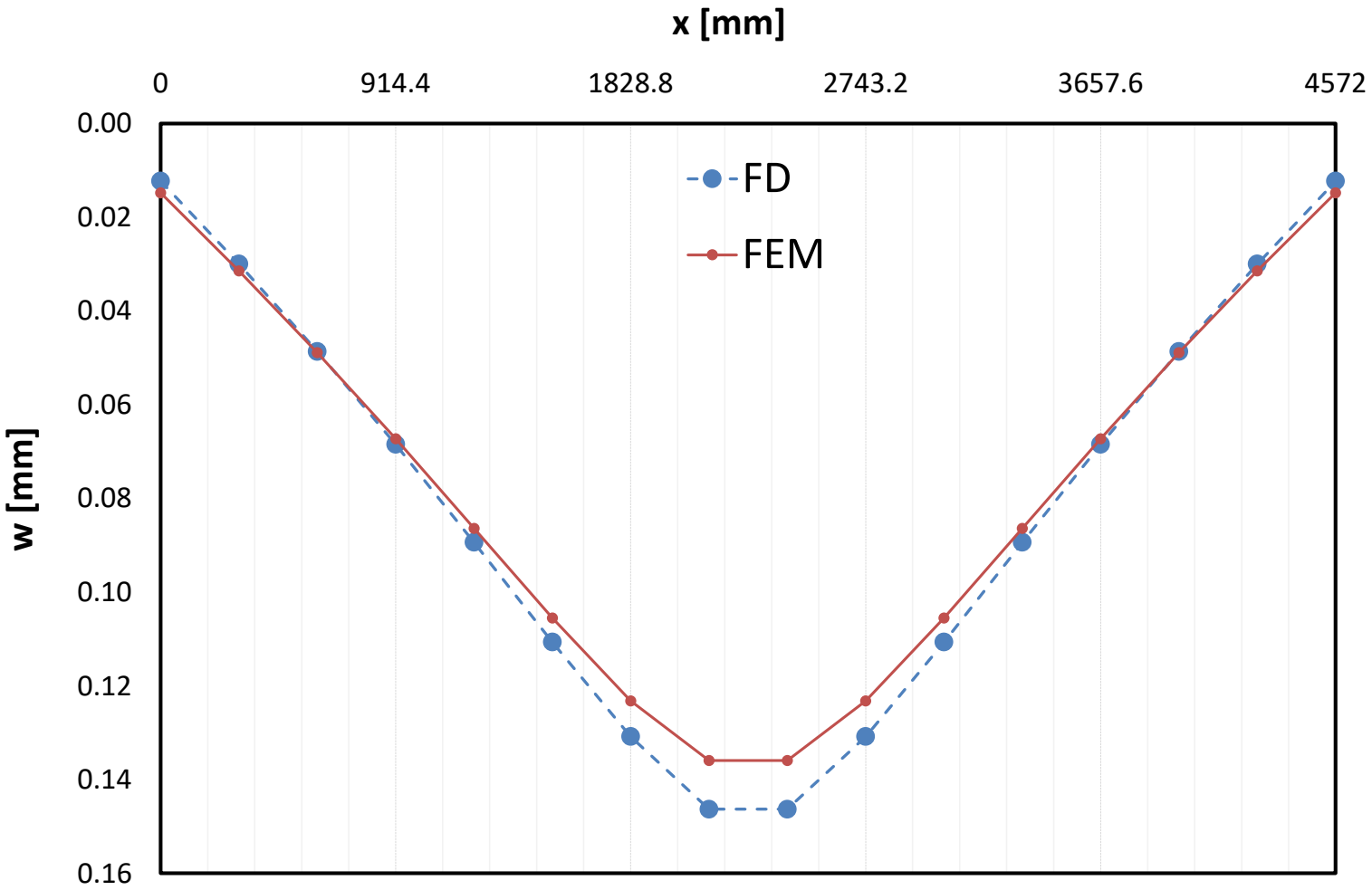
Point load: displacement field

E=	27586	MPa	**Self-weight multiplier**			**Center-point force**			**Thermal effects**	
s=	250	mm	γ_g=	0.00		F=	40.00	kN	Δt=	0
ν=	0.2		g=	6.25	kN/m^2				α_c=	1.20E-05
γ=	25.0	kN/m^3							χ*=	0.00E+00
D=	3.742E+10	Nmm								
k_0=	0.04073	N/mm^3								
L_x=	5000	mm								
L_y=	5000	mm								
n=	10									
Δ=	304.8	mm								



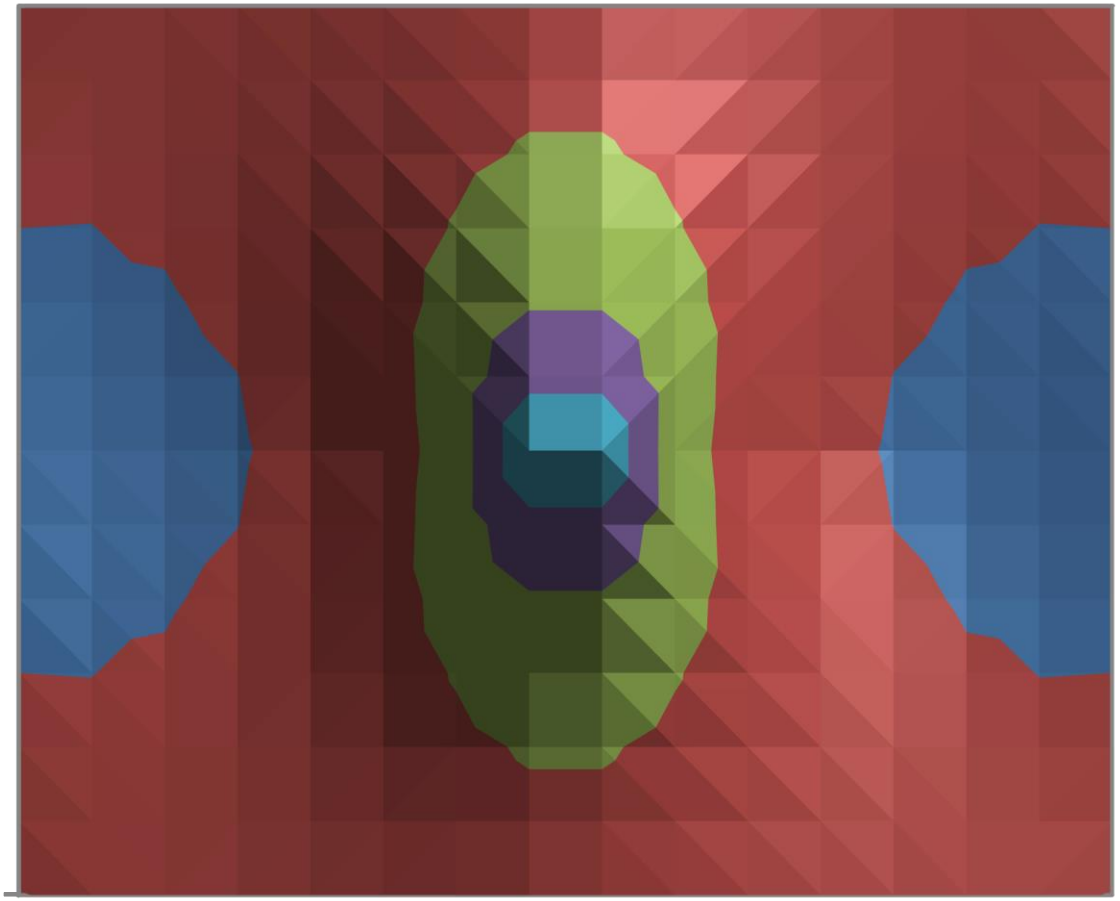
Case #1

Point load: displacement field (FD/FEM comparison)



Case #1

Point load: bending moments M_x

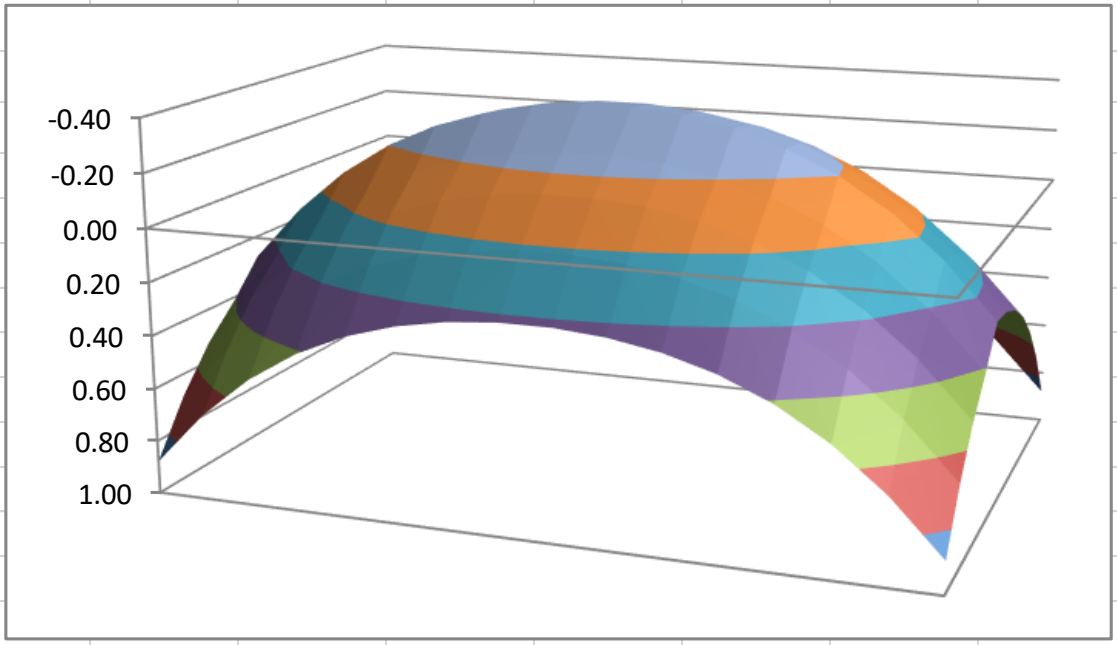


$M_{x,max}$=7764.33 Nmm/mm

Case #1

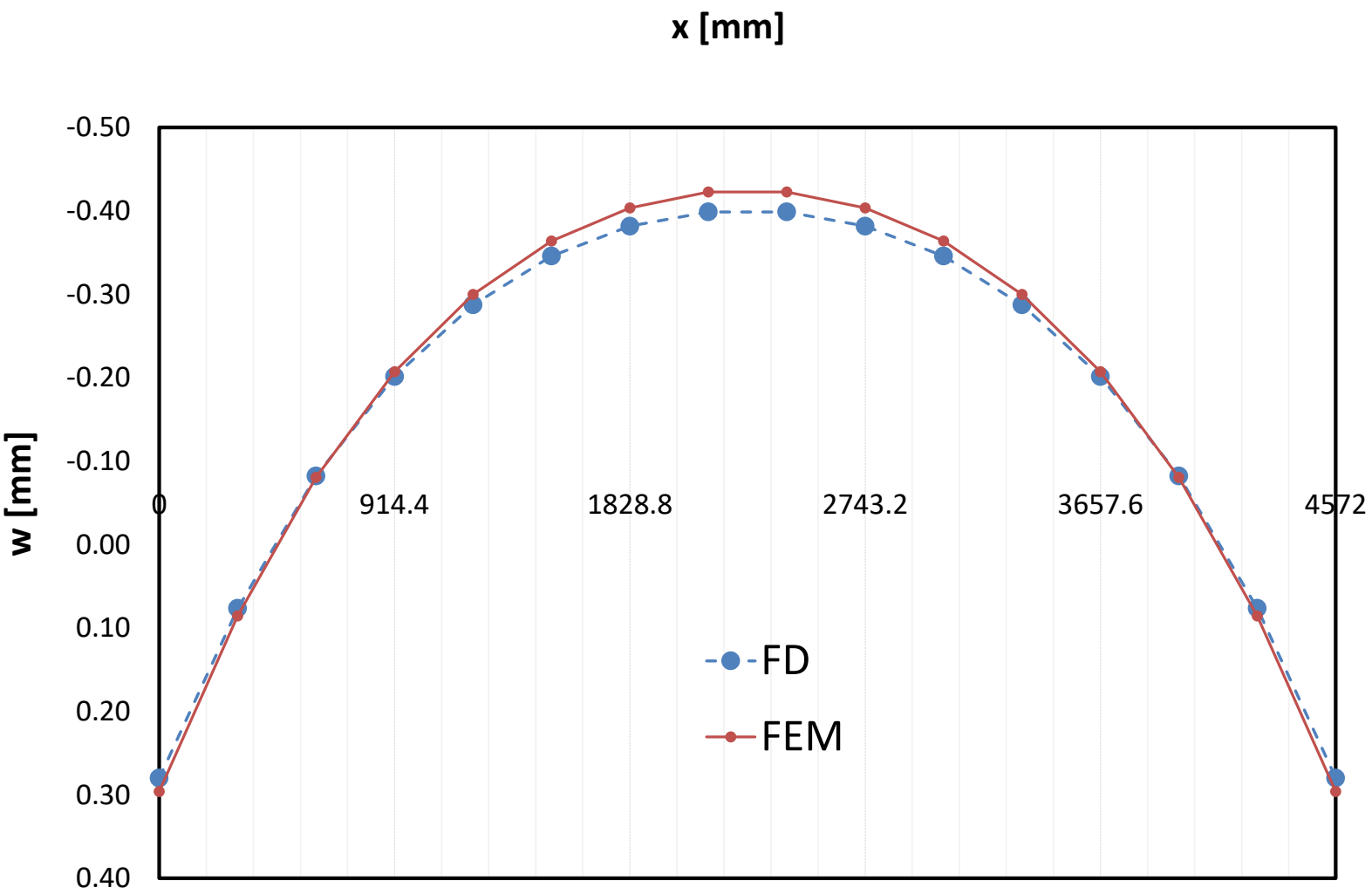
Thermal effects: displacement field

E=	27586	MPa	**Self-weight multiplier**			**Center-point force**			**Thermal effects**		
s=	250	mm	γ_g=	0.00		F=	0.00	kN	Δt=	10	°C
ν=	0.2		g=	6.25	kN/m^2				α_c=	1.20E-05	°C^{-1}
γ=	25.0	kN/m^3							χ*=	-4.80E-07	mm^{-1}
D=	3.742E+10	Nmm									
k_0=	0.04073	N/mm^3									
L_x=	5000	mm									
L_y=	5000	mm									
n=	10										
Δ=	304.8	mm									



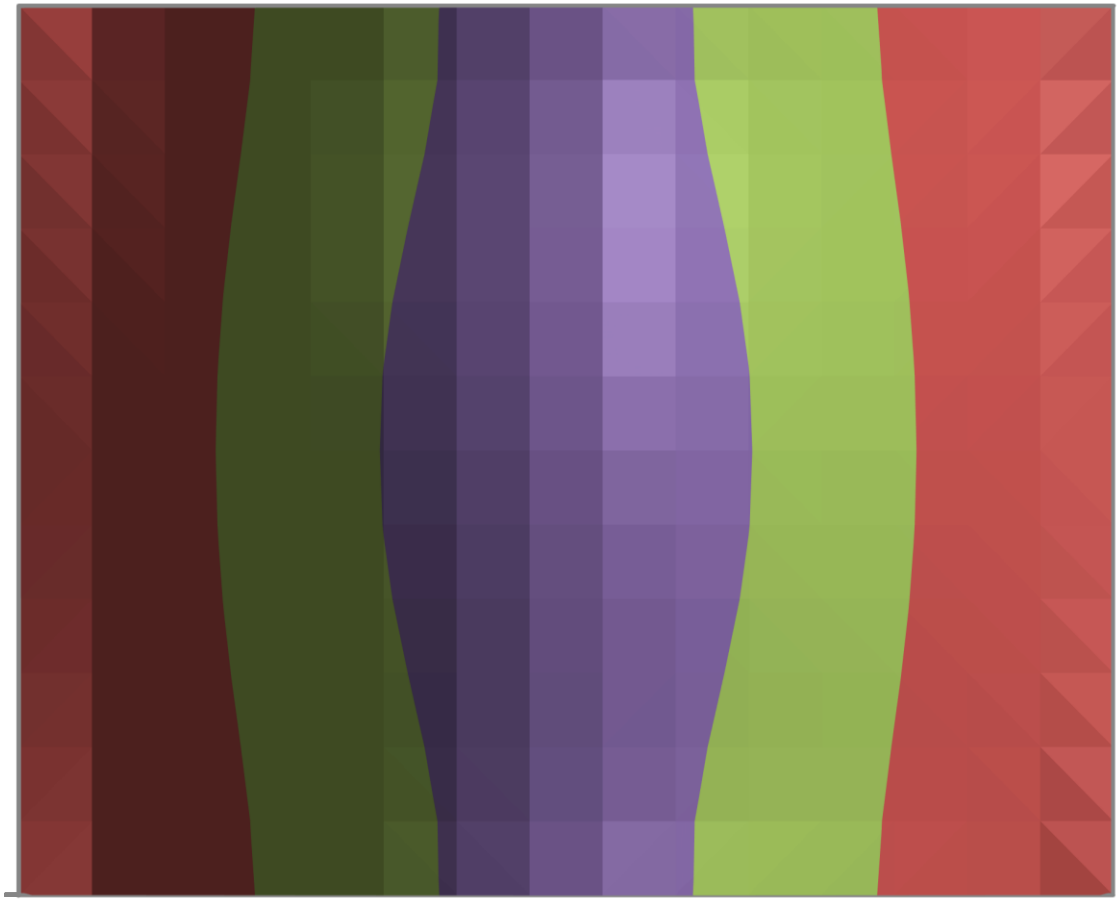
Case #1

Thermal effects: displacement field (FD/FEM comparison)



Case #1

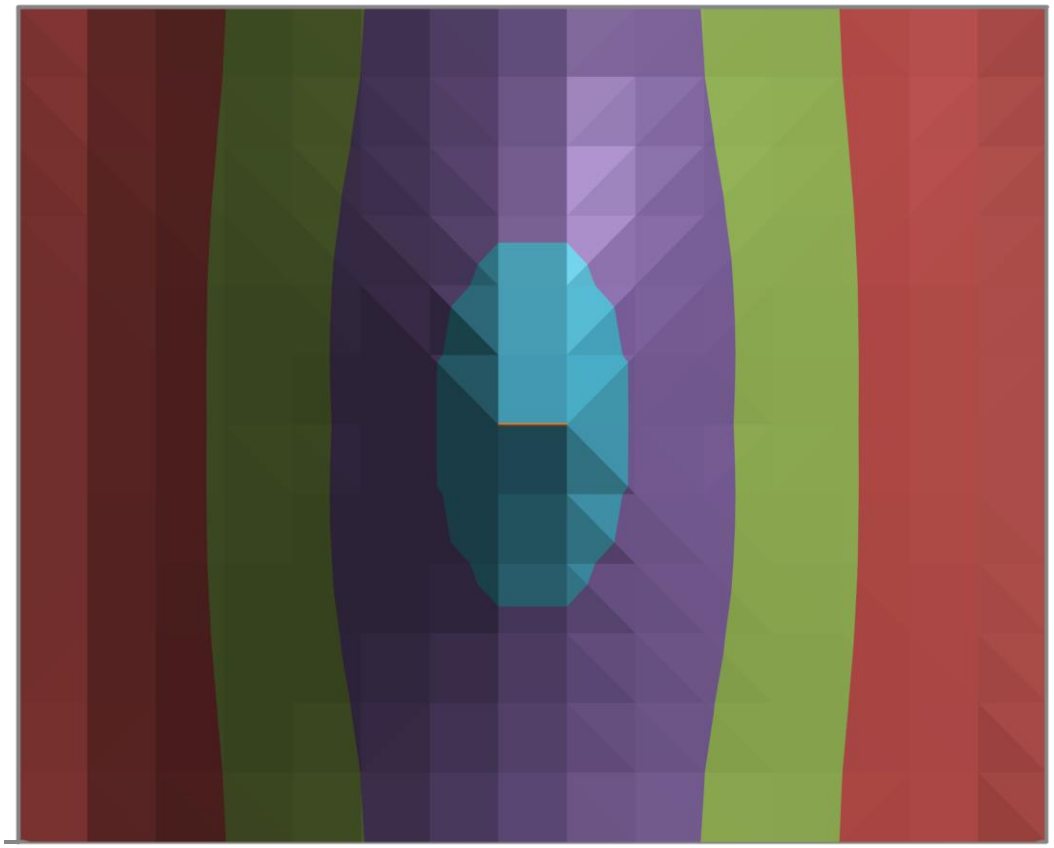
Thermal effects: bending moments M_x



$M_{x,max}$=12288.99 Nmm/mm

Case #1

Thermal effects: maximum tensile stresses σ_x

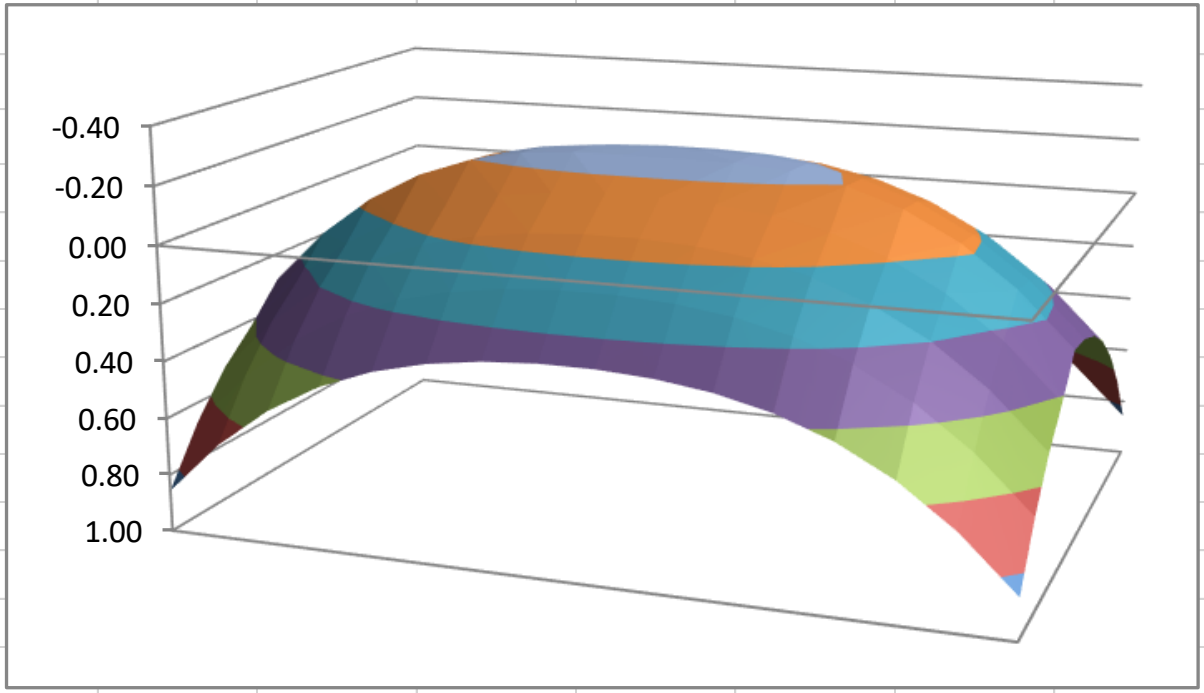


$$\sigma_{s,max} = \frac{6 \cdot M_{x,max}}{s^2} = \frac{6 \cdot (7764.33 + 12288.99)}{250^2} = 1.92 \text{ MPa}$$

Case #1

Load Combination: displacements

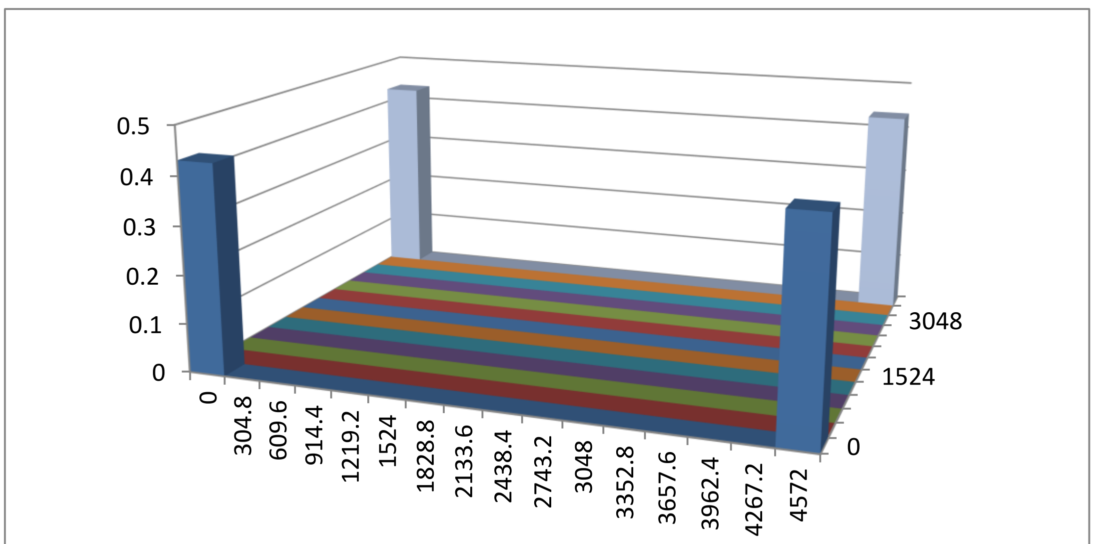
E=	27586	MPa	**Self-weight multiplier**			**Center-point force**			**Thermal effects**	
s=	250	mm	γ_g=	1.00		F=	40.00	kN	Δt=	10
ν=	0.2		g=	6.25	kN/m^2				α_c=	1.20E-05
γ=	25.0	kN/m^3							χ^*=	-4.80E-07
D=	3.742E+10	Nmm								
k_0=	0.04073	N/mm^3								
L_x=	5000	mm								
L_y=	5000	mm								
n=	10									
Δ=	304.8	mm								



Case #2

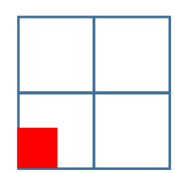
Point load: assumptions

0.430556	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.430556
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.430556	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.430556



The point load (P=40 kN) is distributed over 1 node/cell close to the corners:

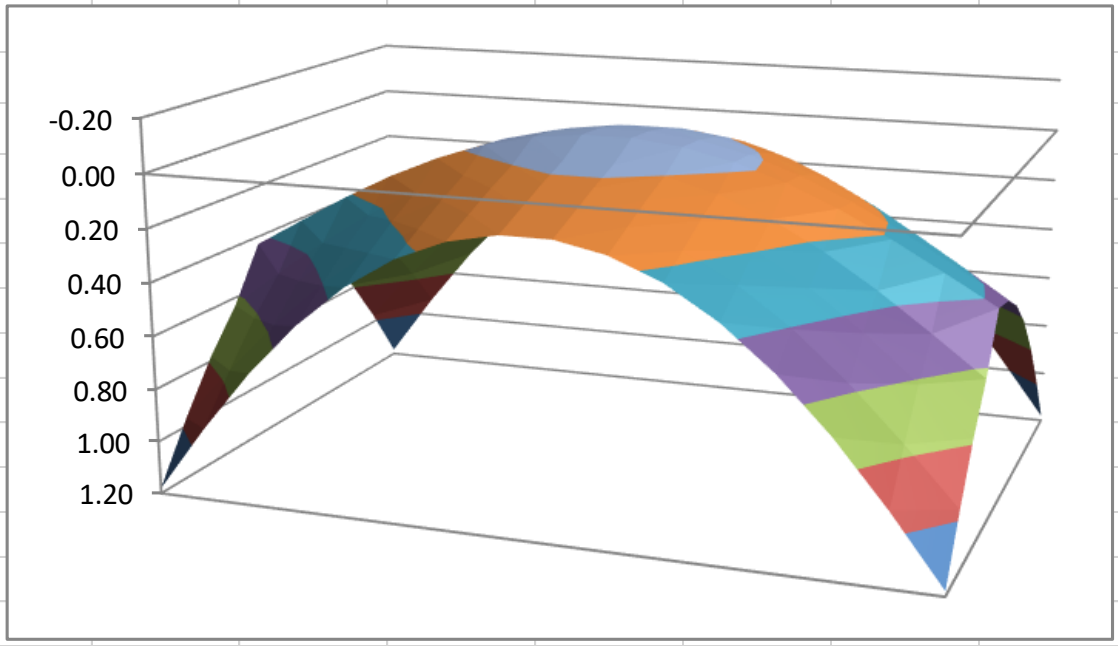
$$q_{P,eq} = \frac{P}{(\Delta / 2)^2} = 1.722 \text{ N / mm}^2$$



Case #2

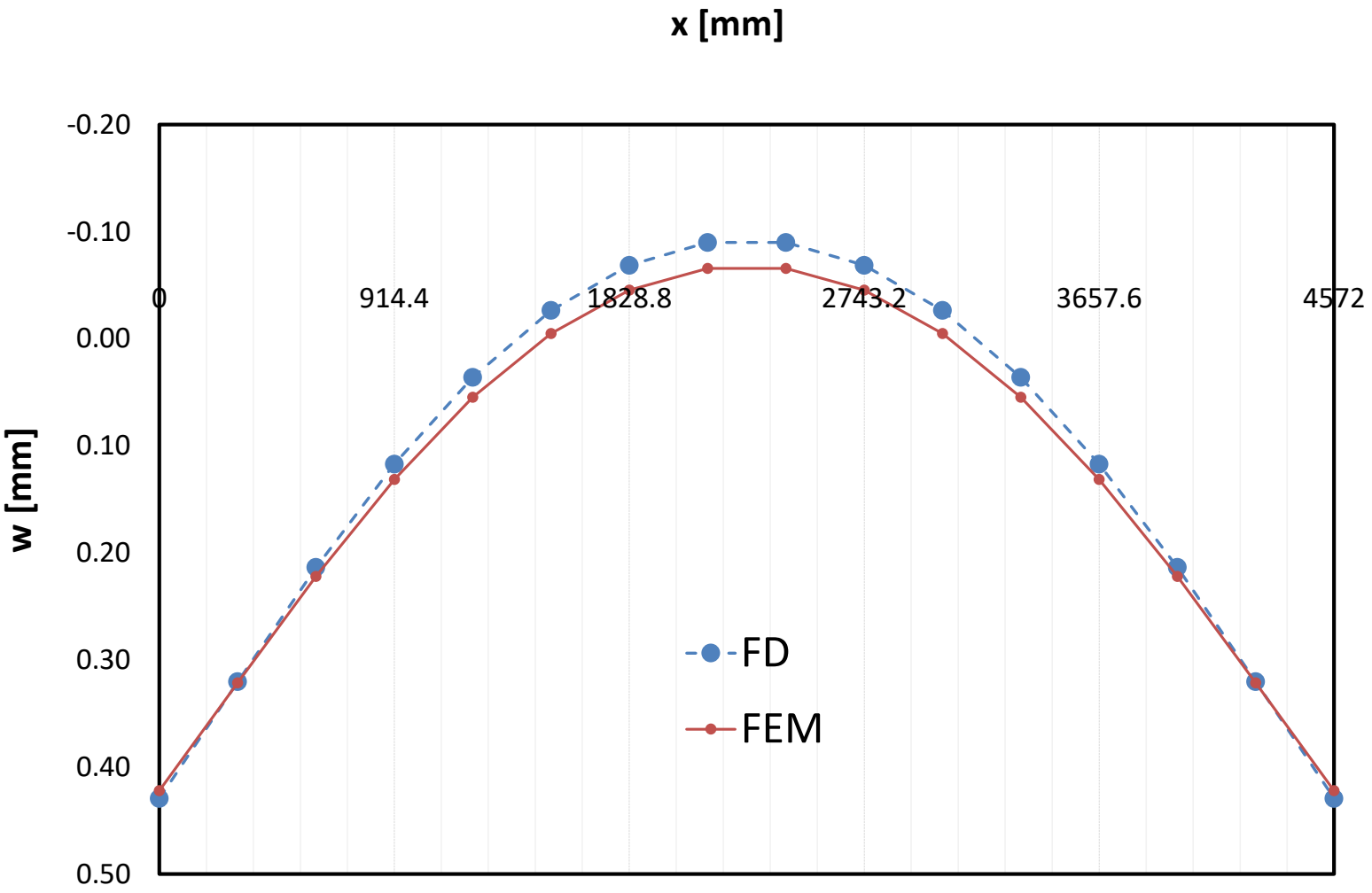
Point loads: displacement field

$E=$	27586	MPa	**Self-weight multiplier**			**Center-point force**			**Thermal effects**		
$s=$	250	mm	$\gamma_g=$	0.00		$F=$	40.00	kN	$\Delta t=$	0	°C
$\nu=$	0.2		$g=$	6.25	kN/m^2				$\alpha_c=$	1.20E-05	$°C^{-1}$
$\gamma=$	25.0	kN/m^3							$\chi^*=$	0.00E+00	mm^{-1}
$D=$	3.742E+10	Nmm									
$k_0=$	0.04073	N/mm^3									
$L_x=$	5000	mm									
$L_y=$	5000	mm									
$n=$	10										
$\Delta=$	304.8	mm									



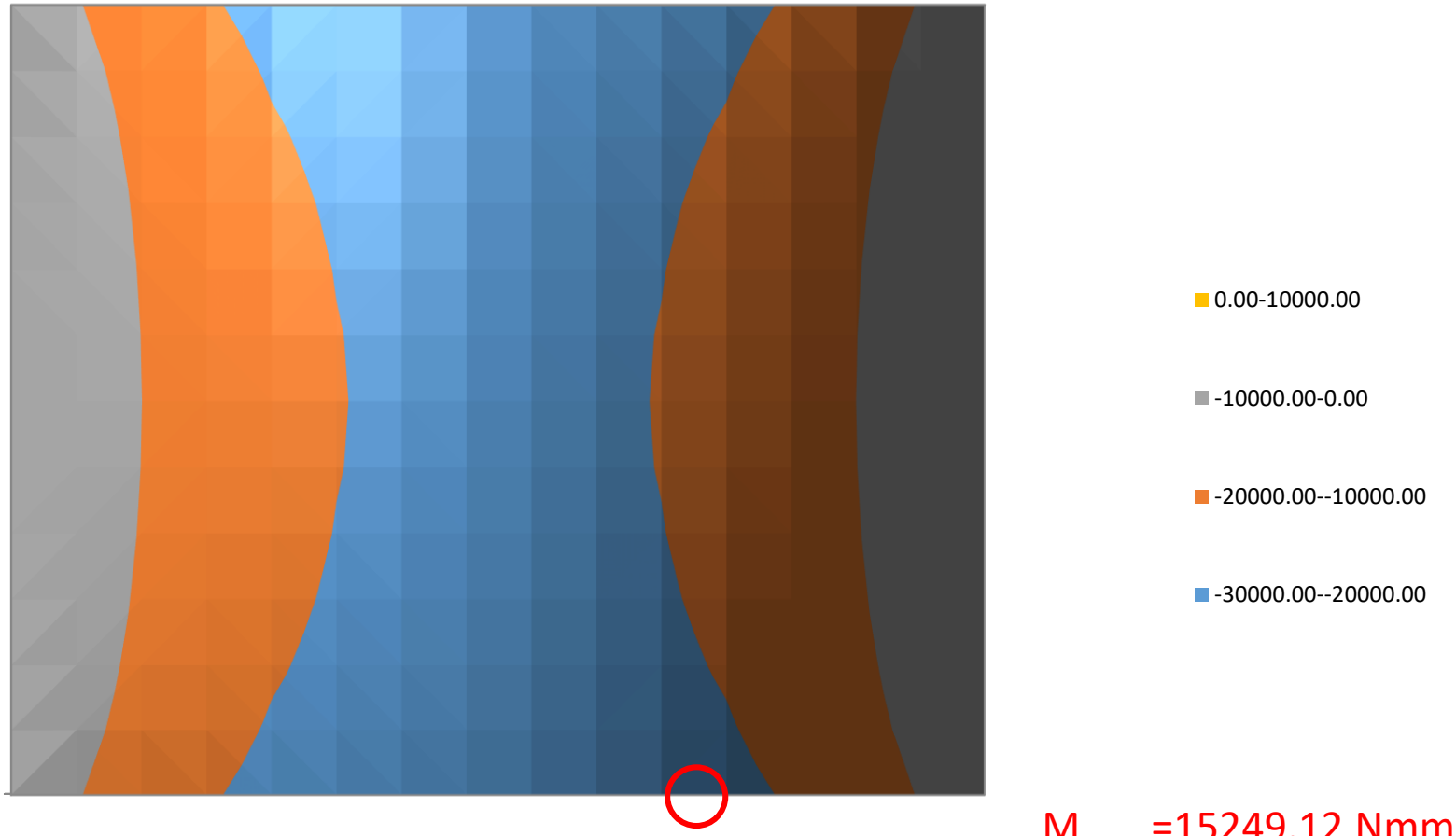
Case #2

Point loads: displacement field (FD/FEM comparison)



Case #2

Point loads bending moments M_x

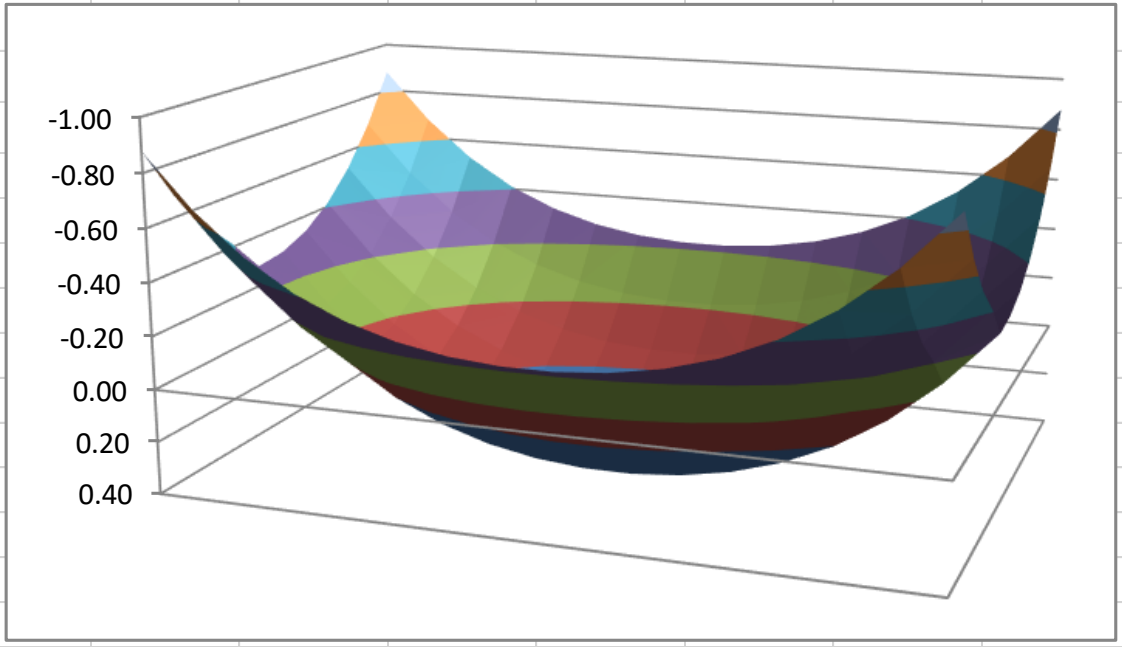


$M_{x,max}$=15249.12 Nmm/mm

Case #2

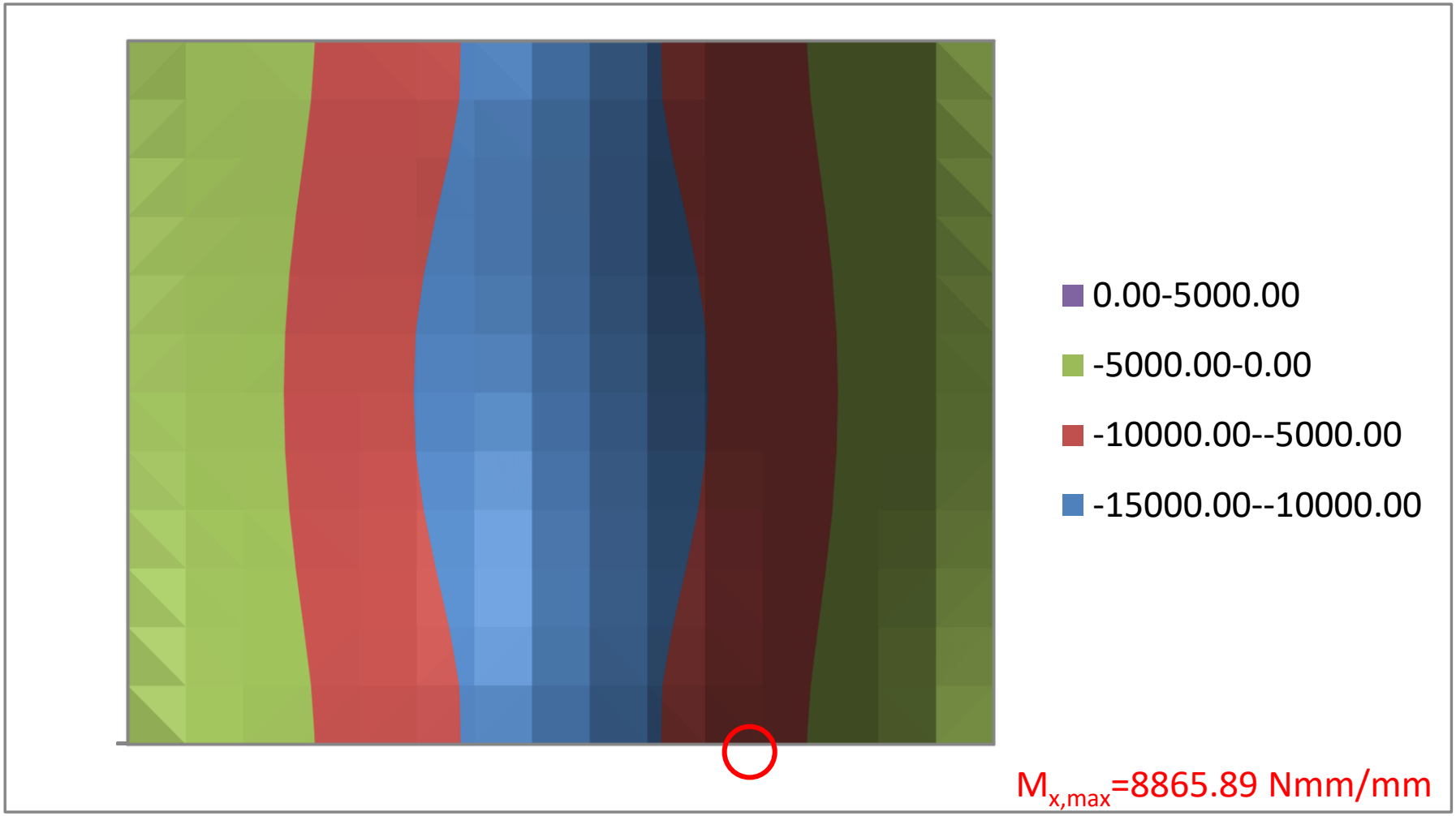
Thermal effects: displacement field

$E=$	27586	MPa	**Self-weight multiplier**			**Center-point force**			**Thermal effects**		
$s=$	250	mm	$\gamma_g=$	0.00		$F=$	0.00	kN	$\Delta t=$	-10	°C
$\nu=$	0.2		$g=$	6.25	kN/m^2				$\alpha_c=$	1.20E-05	$°C^{-1}$
$\gamma=$	25.0	kN/m^3							$\chi^*=$	4.80E-07	mm^{-1}
$D=$	3.742E+10	Nmm									
$k_0=$	0.04073	N/mm^3									
$L_x=$	5000	mm									
$L_y=$	5000	mm									
$n=$	10										
$\Delta=$	304.8	mm									



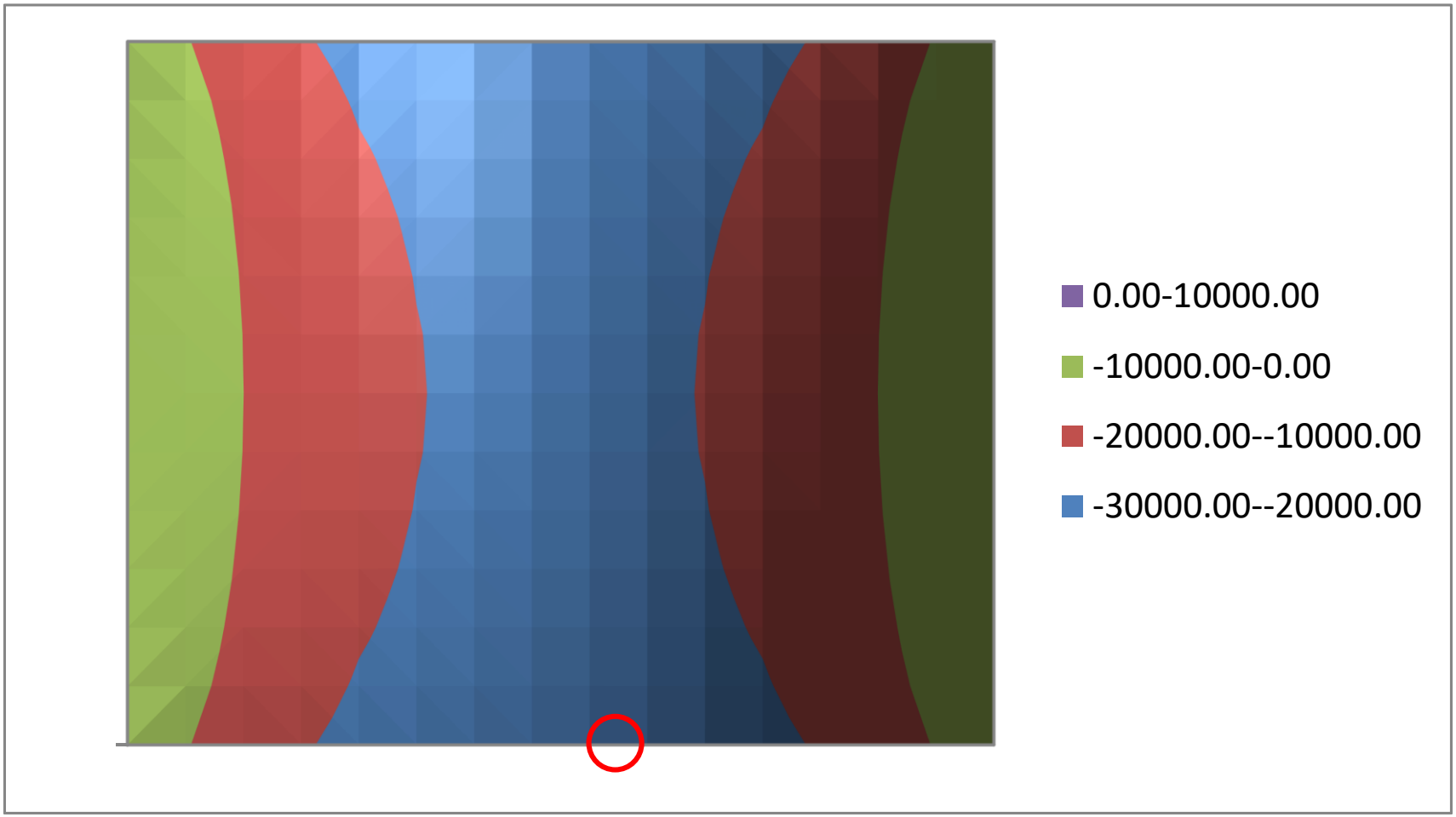
Case #2

Thermal effects: bending moments M_x



Case #2

Thermal effects: maximum tensile stresses σ_x

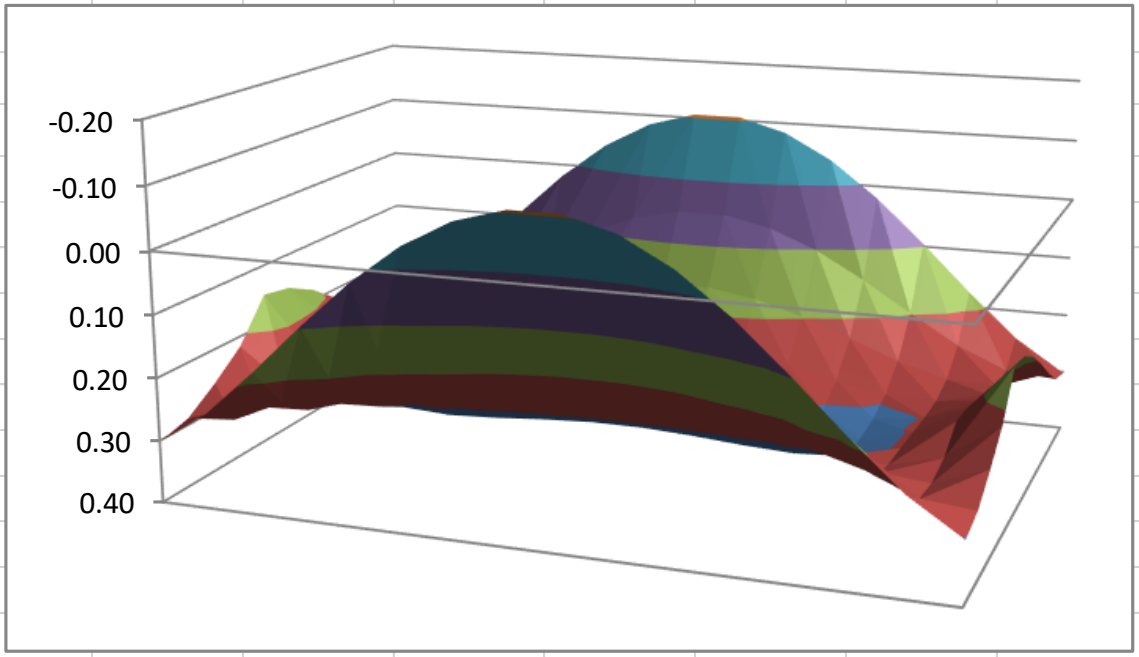


$$\sigma_{s,max} = \frac{6 \cdot M_{x,max}}{s^2} = \frac{6 \cdot 25930.50}{250^2} = 2.48 \text{ MPa}$$

Case #2

Load Combination: displacements

E=	27586	MPa	**Self-weight multiplier**			**Center-point force**			**Thermal effects**		
s=	250	mm	γ_g=	1.00		F=	40.00	kN	Δt=	-10	°C
ν=	0.2		g=	6.25	kN/m^2				α_c=	1.20E-05	$°C^{-1}$
γ=	25.0	kN/m^3							χ^*=	4.80E-07	mm^{-1}
D=	3.742E+10	Nmm									
k_0=	0.04073	N/mm^3									
L_x=	5000	mm									
L_y=	5000	mm									
n=	10										
Δ=	304.8	mm									



The End

Thank you for your attention

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