Project	Client
No More Chasing	CONTRU SOLUTIONS
Discipline **Structural Evaluation**	Prof Walter Burdzik

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1. General

1.1. Background

Prof Walter Burdzik was requested by Contru Solutions to evaluate the structural strength of the concrete channels that are to be used in conventional buildings, i.e. brick and mortar, to obviate chasing of the brickwork for the installation of services, both electrical and plumbing.

1.2. General

The assessment is based on the principles of whether the channel sections that are used to create the cavity in the walls, decrease the strength of the wall significantly.

1.3. Channel System

Concrete channels are cast from 25 MPa fibre reinforced concrete in the following sizes:

Photograph 1	Photograph 2 NMC3	Photograph 3 NMC 4
		

After further development of the NMC's, the following aspects have been addressed.

1. They have roughened up all surfaces of the channels by putting an activator in the shutters and brushing it off afterwards to expose the aggregate, thereby getting a much better bond between the channel and the brickwork as well as for plasterwork and caulking.
   - They are now casting in, 2 x 20mm x250mm long, corrugated hoop irons into each channel on both sides to be bricked in. This will give extra continuity.

- The brick force still continues on either side of the channel when it is bricked in, unlike in the case of chasing, where at least one strand of brick force is cut off completely.

2. Different channels will be used for different service applications. Small channels for single pipes and bigger channels for multiple services- waist pipe and water supply in one channel.

   - The cavity will be caulked with a river sand and cement mix prior to plastering. Due to the rough edges on the channel we will get sufficient bonding.
   - Chasing in half brick walls gets done in order to accommodate 50mm waste pipes and services to the extent that one end up with degenerated bricks and walls that does not have much structural integrity left. We all know that chasing, according to the NHBRC regulations is virtually impossible to accommodate services.
   - Furthermore, vertical chasing gets done frequently for the full height of the wall, especially in multi-story buildings. With chasing there is:
   - **1**) two smooth edges, where the grinder has cut through the bricks,
   - **2**) the brick force has been cut off,
   - **3**) the cavity is covered in grinder dust and
   - **4**) weakening of the brick work in the chased area due to chopping by hammer and chisel or, mostly, some sort of an mechanical breaker, which is very difficult to control and all of the above does not lead to cracks, then why would my channels lead to cracks?

   - **The NMC's is strengthening up the wall as this is at least 25 MPa fibre reinforced.**
   - **Gets built in, NO chopping or hammering against the wall.**
   - **Hoop irons for continuity.**
   - **Both strands off brick force stay intact.**

1.4. Applications of the Channels

The following photographs show some applications of the channels.

Photograph 4 Multiple Services

Photograph 5: Installation of DB board	Photograph 6: Multiple Plug
	

2. Assessment of Channels used horizontally

2.1. Criterion

The channel must not weaken the wall when it is installed horizontally to accommodate a 50 mm water effluent pipe as shown in Photograph 4.

The load from a single skin 2,5 m high wall of normal brick work with a density of 2300 kg/m^3, is equal to 6,4 kN/m length of wall.

2.2. Section Properties NMC1

Section Properties :

Input Tables

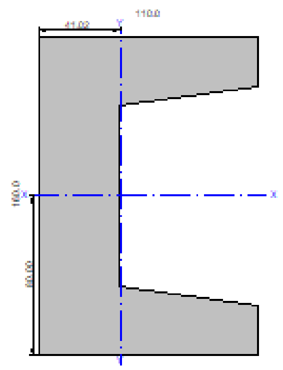
Code	X/Radius	Y/Angle
+	0	0
L	110	0
L	110	25
L	40	35
L	40	125
L	110	135
L	110	160
L	0.0	160

Settings

Title		
Rotation Angle	0	Clockwise positive
Poisson's Ratio	0.3	0.0 Minimum, 0.5 Maximum
Number of equations	5000	200 Minimum, 30000 Maximum
Units	mm	Optional

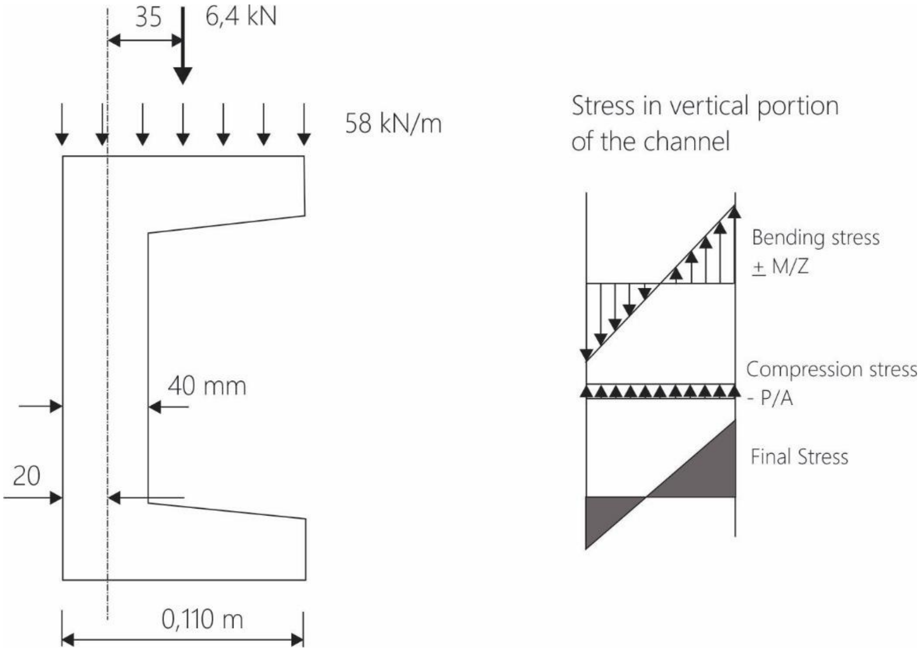
Bending Properties

A	mm^2	10.600E3
Ixx	mm^4	31.655E6
Iyy	mm^4	9.6906E6
Ixy	mm^4	0.0000
Iuu	mm^4	31.655E6
Ivv	mm^4	9.6906E6
Ir	mm^4	41.346E6
Ang	deg	0.0000°
Zxx(T)	mm^3	395.69E3
Zxx(B)	mm^3	395.69E3
Zyy(L)	mm^3	236.23E3
Zyy(R)	mm^3	140.49E3
Zuu	mm^3	395.69E3
Zvv	mm^3	140.49E3
Zplx	mm^3	528.42E3
Zply	mm^3	259.28E3
Yc	mm	80.000
Xc	mm	41.022
rx	mm	54.647
ry	mm	30.236
ru	mm	54.647
rv	mm	30.236
Xpl	mm	33.126
Ypl	mm	80.000
Perim.	mm	661.42
J	mm^4	4.6527E6
Zt	mm^3	49.151E3
Cw	mm^6	26.531E9
A-shear	mm^2	4.8669E3
Bx		0.0000
Vr		397.73E-3
Γ		466.61E-3
jx	mm	71.583
jy	mm	0.0000



2.3. Simplified Stress Assessment

The stresses that are obtained from an axial force with an eccentricity on a I m length of the channel can be calculated as follows. Calculate the stresses in the vertical section of the channel. Assume a 1 m length of the channel that is subjected to the loading from a single skin wall, 2,5 m high. The vertical load = 6,4 kN/m length.



Eccentricity = 110/2 – 20 = 35 mm

M = 0,035 x 6,6 = 0,224 kN.m per metre length of wall.

Axial force = 6,4 kN per metre length of wall

Stress on outer skin of vertical portion of channel = -P/A + M/Z

Stress on inner skin of vertical portion of channel = -P/A – M/Z

$$\sigma_{out} = \frac{-6400}{40 \times 1000} + \frac{0{,}224 \times 10^6 \times 6}{1000 \times 40^2} = 0{,}68\ MPa$$

$$\sigma_{in} = \frac{-6400}{40 \times 1000} - \frac{0{,}224 \times 10^6 \times 6}{1000 \times 40^2} = -1{,}0\ MPa$$

This gives an indication of the magnitude of the stresses. These still must be multiplied by a load factor of 1,4.

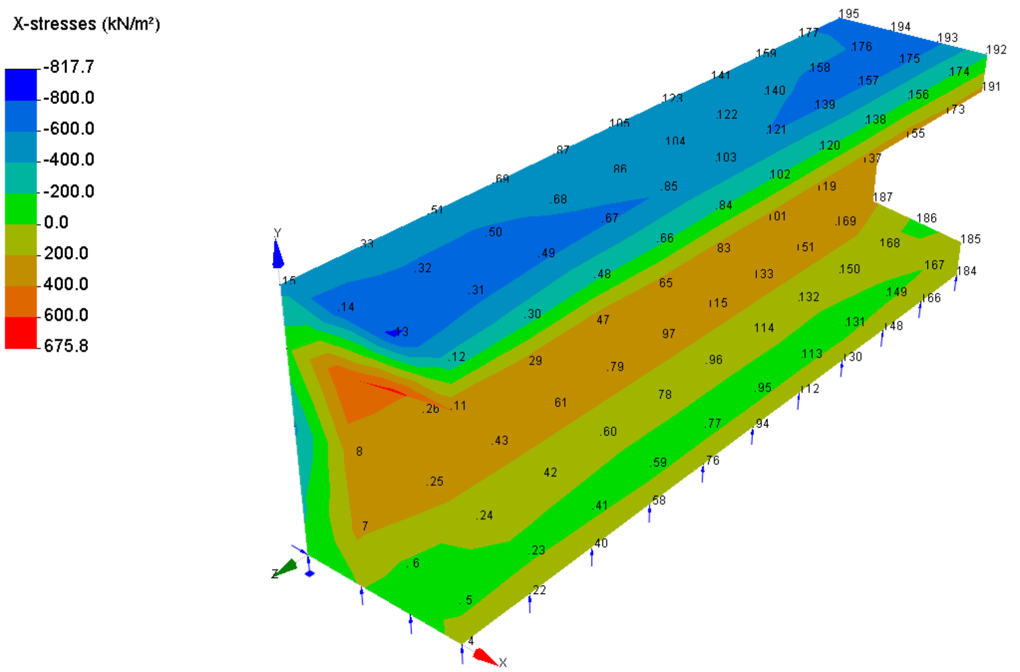
Ultimate tensile stress on outside of channel = 1,4 x 0,68 = 0,852 MPa

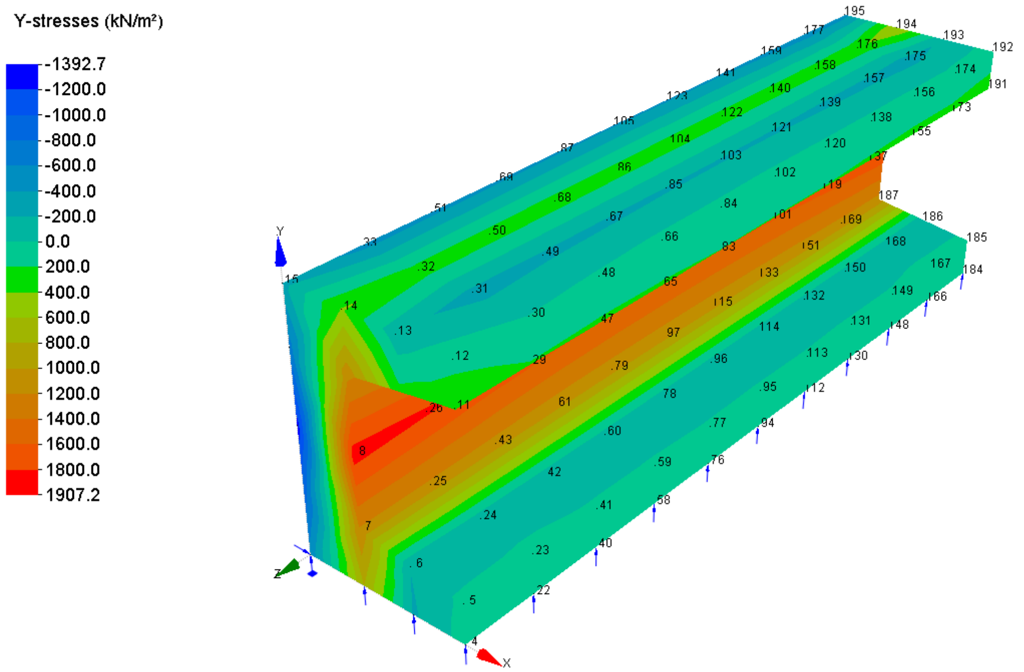
Ultimate compression stress on the inside of the channel = 1,4 x -1 = -1,4 MPa

The stresses in the deeper channel will be similar in magnitude as the eccentricity to the centreline of the vertical wall is the same.

2.4. Finite Element Structural Assessment

A finite element analysis of a 0,5 m long channel used horizontally that then supports a 2,5 m high single skin brickwork wall was undertaken. Solid elements were used to ascertain the magnitude of the stresses. This should give a more accurate indication of the stresses.

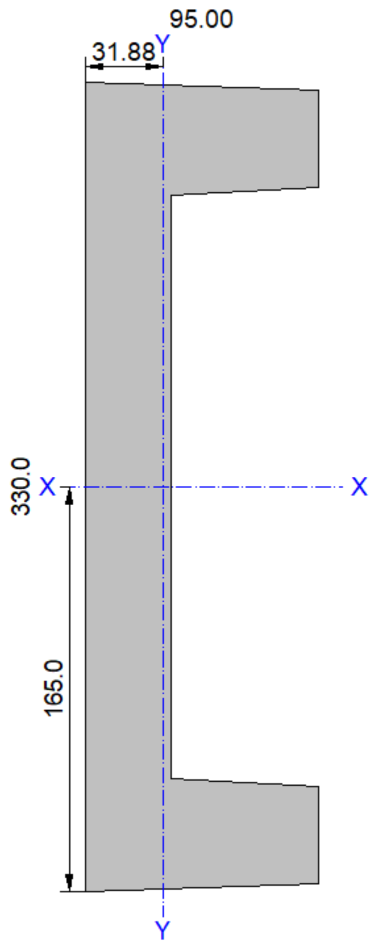




Negative values are tension and the maximum ultimate tension = 1,39 MPa.
The compression values are positive and the maximum ultimate compression = 1,91 MPa
The Y-stresses can be compared to the simplified method in Section 2.3

2.5. Properties of NMC3

Section	Properties



Bending Properties

A	mm^2	16.605E3
Ixx	mm^4	206.84E6
Iyy	mm^4	10.483E6
Ixy	mm^4	0.0000
Iuu	mm^4	206.84E6
Ivv	mm^4	10.483E6
Ir	mm^4	217.32E6
Ang	deg	0.0000°
Zxx(T)	mm^3	1.2536E6
Zxx(B)	mm^3	1.2536E6
Zyy(L)	mm^3	328.82E3
Zyy(R)	mm^3	166.08E3
Zuu	mm^3	1.2536E6
Zvv	mm^3	166.08E3
Zplx	mm^3	1.6684E6
Zply	mm^3	320.20E3
Yc	mm	165.00
Xc	mm	31.880
rx	mm	111.61
ry	mm	25.126
ru	mm	111.61
rv	mm	25.126
Xpl	mm	25.223
Ypl	mm	165.00
Perim.	mm	958.24
J	mm^4	7.8644E6
Zt	mm^3	51.076E3
Cw	mm^6	150.80E9
A-shear	mm^2	9.9509E3
Bx		0.0000
Vr		470.33E-3
Γ		457.53E-3
jx	mm	135.70
jy	mm	0.0000

2.6. NMC3 used horizontally

The stresses that are obtained from an axial force with an eccentricity on a l m length of the channel can be calculated as follows. Calculate the stresses in the vertical section of the channel. Assume a 1 m length of the channel that is subjected to the loading from a single skin wall, 2,5 m high. The vertical load = 6,4 kN/m length.

Eccentricity = 110/2 – 17,5 = 37,5 mm

M = 0,0375 x 6,4 = 0,24 kN.m per metre length of wall.

Axial force = 6,4 kN per metre length of wall

Stress on outer skin of vertical portion of channel = -P/A + M/Z

Stress on inner skin of vertical portion of channel = -P/A – M/Z

$$\sigma_{out} = \frac{-6400}{35 \times 1000} + \frac{0{,}24 \times 10^6 \times 6}{1000 \times 35^2} = 0{,}994\ MPa$$

$$\sigma_{in} = \frac{-6400}{35 \times 1000} - \frac{0{,}24 \times 10^6 \times 6}{1000 \times 35^2} = -1{,}36\ MPa$$

This gives an indication of the magnitude of the stresses. These still must be multiplied by a load factor of 1,4.

Ultimate tensile stress on outside of channel = 1,4 x 0,994 = 1.39 MPa

Ultimate compression stress on the inside of the channel = 1,4 x -1,36 = -1,904 MPa

Both these stresses are in the range of a 25 MPa concrete even after the material factor of 1,5 has been applied.

3. Assessment of Channel used vertically NMC4

The channel can be used vertically, and the forces will either be axial or axial plus bending moment about the minor axis. If the channel is tied in with the wall of a double skinned brickwork wall it will be subjected to a similar bending moment as the wall.

A finite element analysis of 2,0 metre wide by 2,6 m high wall, supported at the top and the bottom was used to determine the bending moment and axial force in a 200 x 330 channel that is connected to the wall and has a length of 1,4 m. A wind load of 0,7 kPa was applied to the wall with a load factor of 1,6.

The following properties of the channel were used in the analysis.

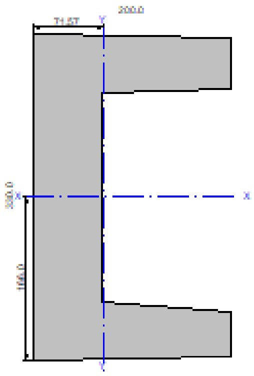
3.1. Section Properties NMC4

Code	X/Radius	Y/Angle
+	0	0
L	200	5
L	200	50
L	70	60
L	70	270
L	200	275
L	200	325
L	0	330

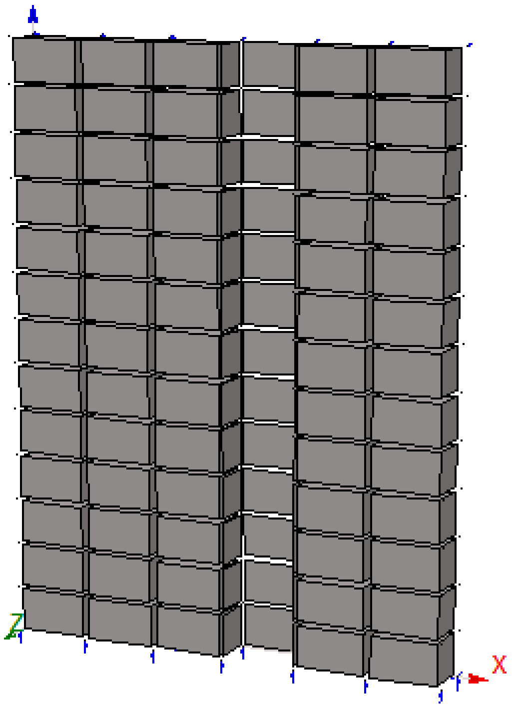
Title		
Rotation Angle	0	Clockwise positive
Poisson's Ratio	0.3	0.0 Minimum, 0.5 Maximum
Number of equations	5000	200 Minimum, 30000 Maximum
Units	mm	Optional

Bending Properties

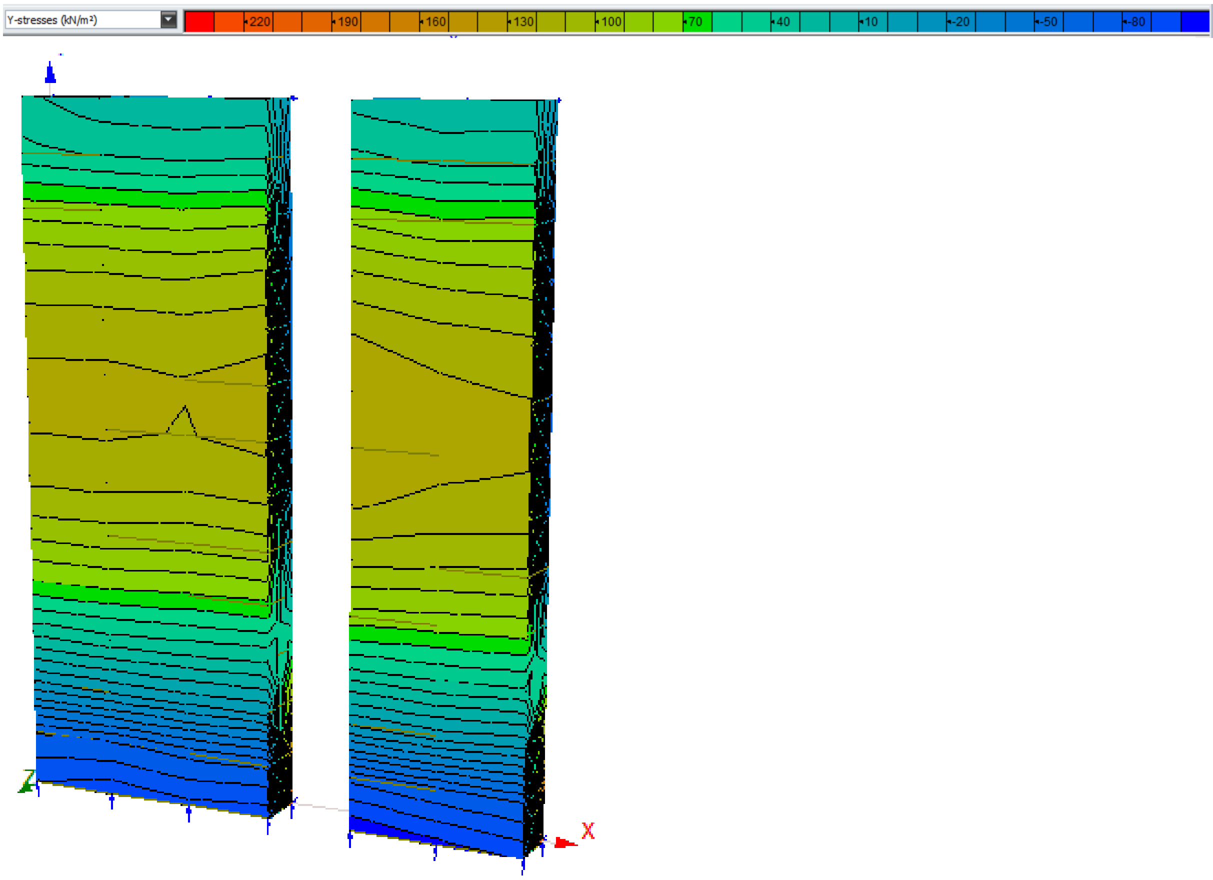
A	mm^2	36.725E3
Ixx	mm^4	460.58E6
Iyy	mm^4	111.05E6
Ixy	mm^4	3.0598E6
Iuu	mm^4	460.61E6
Ivv	mm^4	111.02E6
Ir	mm^4	571.63E6
Ang	deg	-501.52E-3°
Zxx(T)	mm^3	2.8079E6
Zxx(B)	mm^3	2.7750E6
Zyy(L)	mm^3	1.5516E6
Zyy(R)	mm^3	864.65E3
Zuu	mm^3	2.7648E6
Zvv	mm^3	855.10E3
Zplx	mm^3	3.7432E6
Zply	mm^3	1.6039E6
Yc	mm	165.97
Xc	mm	71.570
rx	mm	111.99
ry	mm	54.989
ru	mm	111.99
rv	mm	54.982
Xpl	mm	55.884
Ypl	mm	167.34
Perim.	mm	1.2956E3
J	mm^4	49.343E6
Zt	mm^3	241.15E3
Cw	mm^6	1.4389E12
A-shear	mm^2	17.542E3
Bx		5.7630
Vr		443.56E-3
Γ		460.67E-3
jx	mm	141.46
jy	mm	2.8815



3.2. Finite element analysis NMC4 Vertical in 220 mm Wall wind outwards

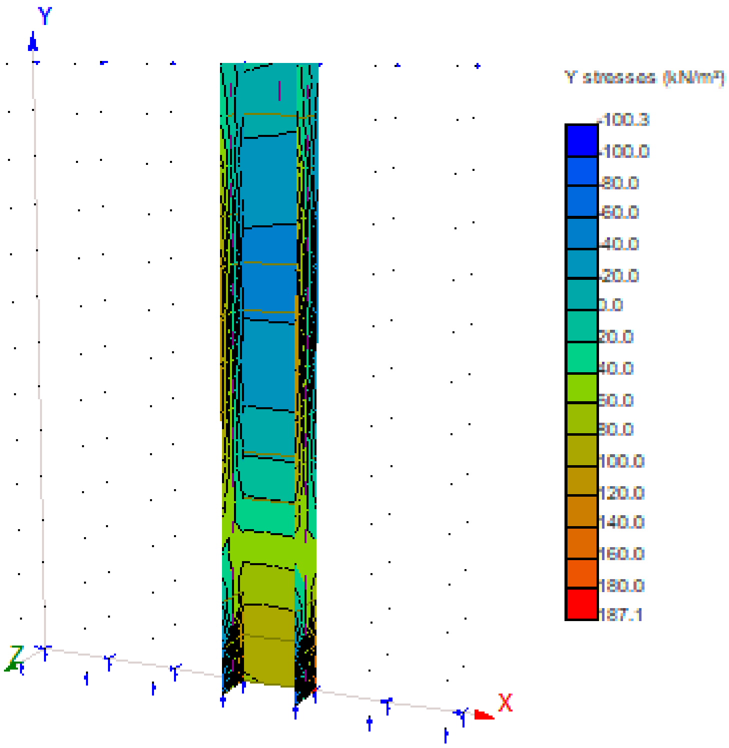


The wall section with the channel in place.



Stresses in the brickwork loading from inside outwards

Maximum tensile stress as result of the wind load on a double skin wall is about 0,09 MPa.

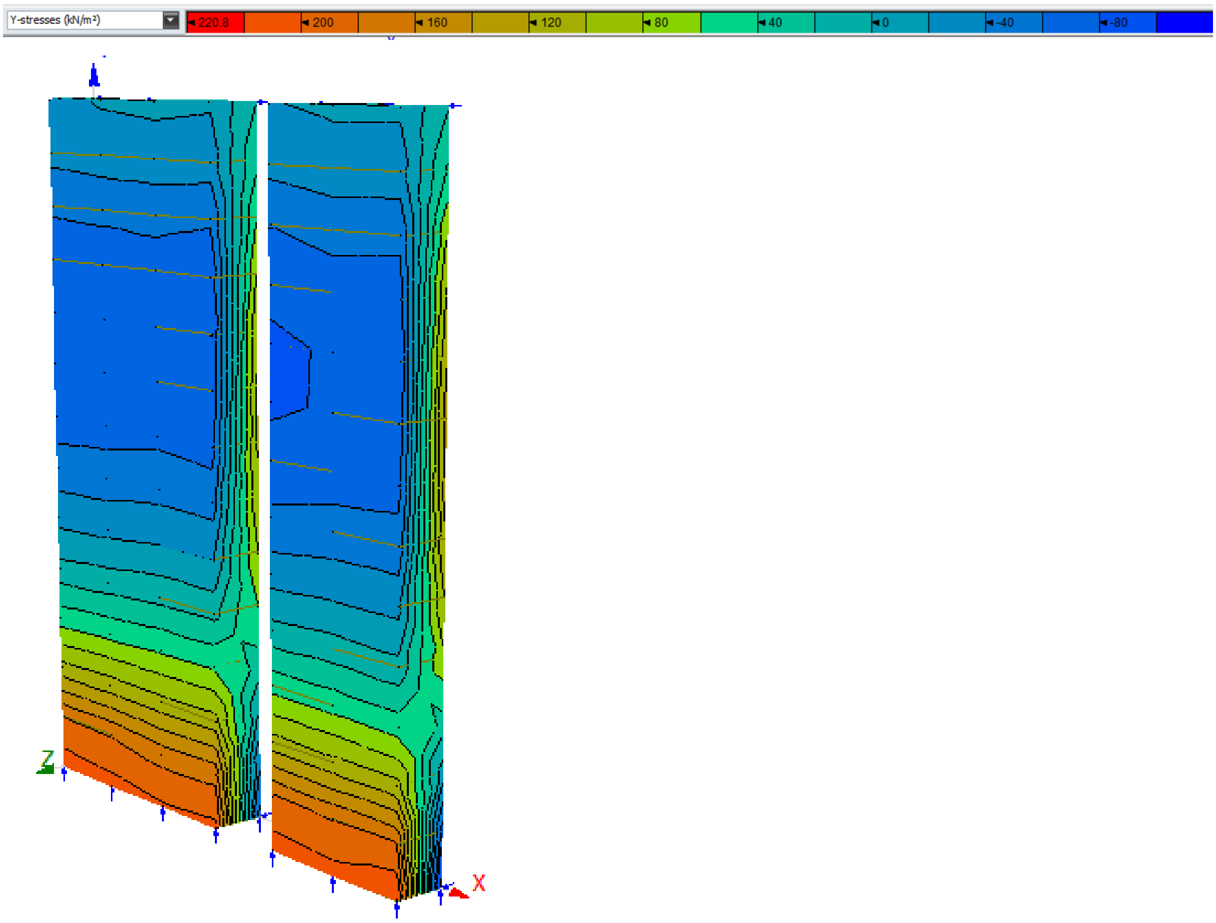


Combined Bending and Axial stresses in the channel section wind outwards.

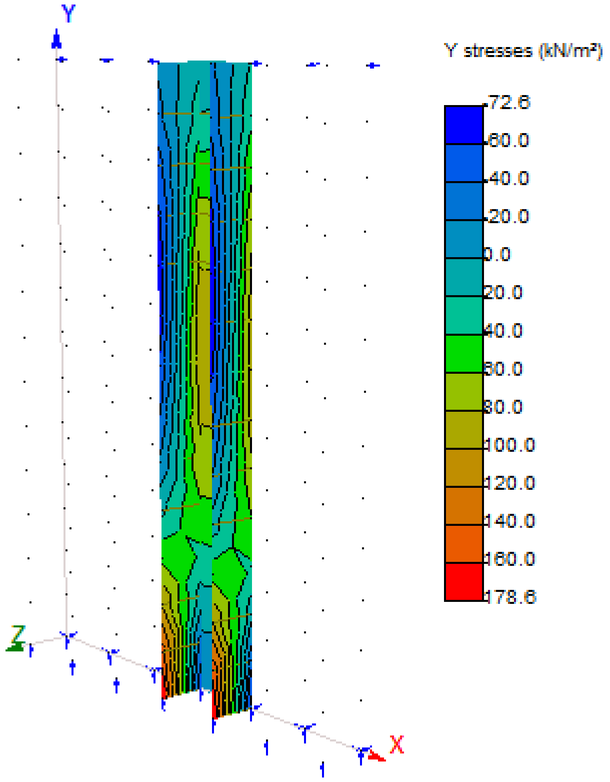
The maximum combined tensile stress in the channel is 0,100 MPa which is well within the tensile stress range of the concrete.

The 200 mm deep channel can be used vertically between floors without affecting the wall negatively.

3.3. Finite element analysis NMC4 Vertical in 220 mm Wall wind inwards



Stresses in the brickwork loading from outside inwards



Combined Bending and Axial stresses in the channel section wind inwards.

The maximum combined tensile stress in the channel is 0,072 MPa which is well within the tensile stress range of the concrete.

The 200 mm deep channel can be used vertically between floors without affecting the wall negatively.

4. Conclusion

The most critical sections have been assessed for structural strength when used either horizontally or vertically.

The channel sections can safely be used for horizontal as well as vertical replacements for the normal practice of chasing channels in brickwork. Far less damage will be done to the bearing capacity of the walls and the channels can carry the loads induced by the brickwork