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EurolinK

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INDICE

1 Executive Summary

This report describes the analyses regarding the geotechnical aspects of the anchor blocks.

The purpose of the analyses presented in the following is to:

- Determine the earth pressures acting on the anchor blocks in the design limit states, in order to verify the structural integrity of the anchor blocks. The earth pressures are applied to the anchor block in the IBDAS structural analyses, documented in Semi-local FE Model Description.
- Carry out some sensitivity analyses to evaluate the sensitivity of the earth pressures to the soil properties.

The general principles for design, which form the basis for the present report, are included in (1).

Section 2 describes the geometry used in the finite element model. A two-dimensional pseudo-static finite element model is established, and the plane strain approximation is discussed. A plane strain depth of 100 m is employed for both anchor blocks. The water levels employed for structural designs are +0.0 m for the Sicily Anchor Block and +88.0 m for the Calabria Anchor Block. The latter takes into consideration the possible drainage into the future rail tunnels adjacent to the anchor block. This is a conservative assumption for the structural design as a higher water table would result in smaller concentrated loads from the soil acting onto the anchor block.

Section 3 lists the material parameters used in the analyses, including also the properties of the anchor blocks. The mass of the Sicily Anchor Block is $\sim 850 \cdot 10^6$ kg, while the mass of the Calabria Anchor Block is $\sim 650 \cdot 10^6$ kg. The soil structure interaction is modelled by general contact with a friction coefficient of $\mu = 0.67$.

Section 4 describes how the earth pressures acting on the surfaces of the anchor blocks are calculated. A plane strain finite element model has been established using the program Abaqus and the contact stresses on the surfaces are extracted directly. The seismic event is in this analysis taken into account through horizontal and vertical seismic coefficients acting on the mass of the anchor blocks only. A total of 13 different load combinations are calculated for each anchor block, including both SLS and ULS with various combinations of seismic coefficients. Sensitivity analyses are conducted, showing that the earth pressure distribution is rather insensitive to the soil parameters applied in the model. The results are tabulated for import in IBDAS and an overview of all distributions are included in Appendices A and B.

2 Geometry

The geometries for the finite element models are derived from the geometries shown in (1). Since the FE models are two-dimensional, a plane strain approximation is needed. A longitudinal cut has been made in the centre of the anchor blocks. For the Calabria Anchor Block, the plane strain depth is directly interpreted as the width of the block, 100 m. For the Sicily Anchor Block however, the width is varying from 82 m to 122 m. Conservatively, a plane strain depth of 100 m have been applied for the Sicily Anchor Block as well. The modelled plane strain geometries are depicted in Figure 2-1.

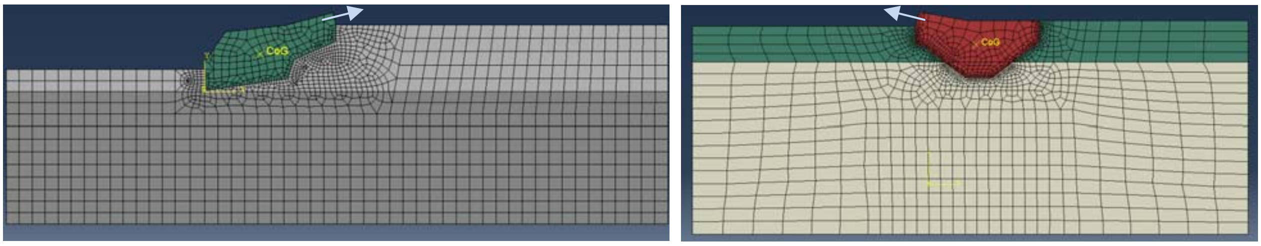


Figure 2-1 FEM geometry. The colour shift in the soil indicates the location of the water table. Left: Sicily. Right: Calabria. The blue arrows indicate the cables.

The two-dimensional analyses yield only stresses on the in-plane anchor block surfaces. Thus, no stresses are calculated on the sides of the anchor blocks parallel to the bridge longitudinal direction. As a conservative approximation for the reinforced concrete verification, the sides are assumed stress-free. In the correct three-dimensional case, the earth pressures will be distributed more evenly on the anchor blocks.

The jet-grouted soil as well as the diaphragm walls have been disregarded in the analyses.

The soil surface is not totally horizontal on either sides of the anchor blocks. However, for the present analyses horizontal soil surfaces have been adopted, which is evaluated to have none or conservative impact.

In the following, the term "anchor block" refers to both the concrete structures and the fill materials, which are treated as one, rigid whole.

2.1 Coordinate system

The reference coordinate systems have been defined as right-handed cartesian systems. Origo has been defined in the central symmetry-plane, 9.0 m behind the front of the anchor blocks (corresponding with the theoretically cable points at splay saddle) and with the vertical x-axis corresponding to the general vertical reference system.

2.2 Ground water levels

The ground water level at the Sicily Anchor Block coincides with the sea level at level +0.0 m. At the location of the Calabria Anchor Block, the ground water level is in situ located between level +94.5 m and level +105.6 m with an average value of +102.3 m. However, in order to reduce buoyancy, the ground water level is fixed at a level not higher than +88.0in the present analyses, to take the possible drainage into the future rail tunnels adjacent to the Calabria anchor block into consideration. It is noted that is a conservative assumption in relation to the structural design, as this produces the highest soil reactions onto the anchor block. (It is noted that it is not a conservative assumption for the calculation of the geotechnical bearing and sliding capacity of the anchor block, where higher ground water levels are considered).

3 Material parameters

3.1 Soil

The design soil material parameters are listed Table 3-1 and Table 3-2.

Table 3-1 Material parameters for SLS and ULS COMB 1.

	Messina Gravel Sicily	Messina Gravel Sicily	Pezzo Conglomerate Calabria
Level [m]	+58.0 to -22.0	below -22.0	All
Model	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight, γ / γ' [kPa]	20.0 / 12.5	20.0 / 12.5	20.0 / 12.5
Young's Modulus, *E* [MPa]	200	350	1000
Poisson's Ratio, ν [-]	0.30	0.30	0.30
Effective Friction Angle, φ' [°]	42	42	40
Effective Cohesion, c' [kPa]	2	2	70
Dilatation Angle, ψ [°]	0	0	0.6
Coefficient of in situ earth pressure at rest, K_0 [-]	0.47	0.47	0.75

Table 3-2 Material parameters for ULS COMB 2.

	Messina Gravel Sicily	Messina Gravel Sicily	Pezzo Conglomerate Calabria
Level [m]	+58.0 to -22.0	below -22.0	All
Model	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight, γ / γ' [kPa]	20.0 / 12.5	20.0 / 12.5	20.0 / 12.5
Young's Modulus, *E* [MPa]	200	350	1000
Poisson's Ratio, ν [-]	0.30	0.30	0.30
Effective Friction Angle, φ' [°]	35.8	35.8	33.9
Effective Cohesion, c' [kPa]	2	2	56
Dilatation Angle, ψ [°]	0	0	0.5
Coefficient of in situ earth pressure at rest, K_0 [-]	0.47	0.47	0.75

3.2 Anchor block

As the anchor blocks are very much stiffer than the surrounding soil and will be designed to resist the induced forces, they are modelled as rigid parts, i.e. with infinite stiffness. This has the significant advantage that it is very easy to accurately assign the correct mass and location of the centre of gravity to the anchor blocks, taking into consideration the true three-dimensional geometry of the blocks. It has been verified that this approximation does neither influence the earth pressures nor the bearing capacity.

The mass and location of the centre of gravity are listed in Table 3-3.

Table 3-3 Characteristic values of mass, mass moment of inertia and corresponding dead loads for the anchor blocks, excluding buoyancy. Coordinate system cf. Section 2.1, with x positive towards bridge.

	Mass [kg]	Dead load [MN]	Centre of gravity [m]		
			x	y	z
Sicily	$849.59 \cdot 10^6$	8343	-48.135	0	28.675
Calabria	$654.02 \cdot 10^6$	6422	-35.200	0	100.724

3.3 Contact

Contact between the anchor blocks and the surrounding soil has been modelled with a friction coefficient of $\mu = 0.67$, corresponding to an interface friction angle of $\delta = 33.8°$.

4 Determination of earth pressures

In the following, the analyses leading to calculation of the earth pressures acting on the surfaces of the anchor blocks for structural analyses are presented. The earth pressures are derived directly as the normal and shear stresses acting on the perimeter of the anchor block in the finite element model subjected to various action combinations. These earth pressures are subsequently imported in IBDAS to verify the structural design of the concrete structures.

The cable force resultant that is used in the calculation of the design earth pressures is taken from the global IBDAS model version 3.3c. These cable force resultant is about 2% higher than the loads from the recent global IBDAS model version 3.3f, see reference (3). The calculation is thus slightly on the safe side. The cable force resultants are listed in Table 4-2 and Table 4-3.

4.1 Design philosophy

The anchor blocks are influenced by four force groups:

- Cable force
- Dead load
- Earth pressures
- Acceleration forces from seismicity

While the cable force can be directly applied at the saddle point, the dead load is applied at the centre of gravity and the earth pressures are generated automatically in the finite element analyses, the actions generated by seismic events are not straight forward implemented in pseudo-static analyses.

The seismic coefficient is applied to the subsystem being evaluated. For slope stability analyses the coefficient is applied as equivalent inertial force to the postulated unstable mass, i.e. the rigid anchor block and soil within the slip surface. For determination of earth pressure forces applied to soil bearing against the rigid anchor blocks, the seismic coefficient is applied as an equivalent inertia force to the anchor block.

Thus, the seismic event is in this analysis taken into account through horizontal and vertical seismic coefficients acting on the mass of the anchor blocks only. The magnitude of the primary seismic coefficient (may either be horizontal or vertical) is taken as $k_{\text{primary}} = 0.5 \cdot PGA$, with PGA being the peak ground acceleration, while the other seismic coefficient is taken as $k_{\text{secondary}} = 0.3 \cdot k_{\text{primary}}$.

Several directions of the force are applied in order to account for various combinations of the seismic components.

4.2 Action combinations

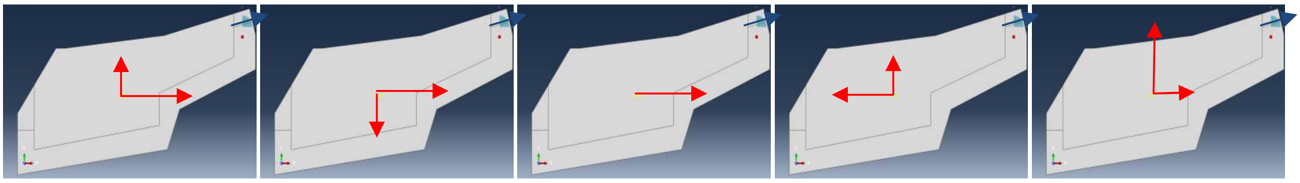
The action combinations evaluated to be the most onerous are listed in Table 4-1. They are:

- One *total* scenario, comprising only dead load and superimposed dead load, representing a basis situation.
- One SLS set, representing the maximum cable force without seismic loading.
- Five SLS sets, with seismic loading applied in various directions. The directions are sketched in Figure 4-1.
- One ULS COMB1 set, representing the maximum cable force without seismic loading.
- Five ULS COMB1 sets, with seismic loading applied in various directions. The directions are sketched in Figure 4-1.

The IDs listed in Table 4-1 are for easy and unique identification of the load cases, and are only used in the present document. The rather confusing sorting of the ID numbers is due to the calculation procedure history.

Table 4-1 Action combinations for determination of earth pressures. The direction of seismic force is oriented with horizontal force acting positive towards the bridge and the vertical force acting positive upwards, cf. Figure 4-1.

ID	Load case name	Magnitude of seismic acceleration $[\mathrm{m/s^2}]$	Direction of seismic force (hor / ver) [%]
1	Total (DL+SDL)	-	-
2	SLS_d0	-	-
20	SLS_d2_earthquakeA	1.30	0.39
21	SLS_d2_earthquakeB	1.30	-0.39
22	SLS_d2_earthquakeC	1.30	0.00
23	SLS_d2_earthquakeD	-1.30	0.39
24	SLS_d2_earthquakeE	0.39	1.30
4	ULS_STR_d0	-	-
15	ULS_STR_d2_earthquakeA	2.85	0.855
16	ULS_STR_d2_earthquakeB	2.85	-0.855
17	ULS_STR_d2_earthquakeC	2.85	0
18	ULS_STR_d2_earthquakeD	-2.85	0.855
19	ULS_STR_d2_earthquakeE	0.855	2.85



15/20, earthquakeA   16/21, earthquakeB   17/22, earthquakeC   18/23, earthquakeD   19/24, earthquakeE

Figure 4-1 Indication of direction of seismic loading components (for the Sicily Anchor Block). Numbers indicates load case IDs according to Table 4-1.

The cable forces for the load combinations are listed in Table 4-2 and Table 4-3.

Table 4-2 Cable design loads, Sicily.

ID	Load case name	Cable force horizontal [MN]	Cable force vertical [MN]	Cable force resultant [1)] [MN]
1	Total (DL+SDL)	2619	751	2724 (2681)
2	SLS_d0	3239	966	3380 (3336)
20	SLS_d2_earthquakeA	3415	1016	3563 (3501)
21	SLS_d2_earthquakeB			
22	SLS_d2_earthquakeC			
23	SLS_d2_earthquakeD			
24	SLS_d2_earthquakeE			
4	ULS_STR_d0	3960	1191	4136 (4074)
15	ULS_STR_d2_earthquakeA	4215	1254	4398 (4296)
16	ULS_STR_d2_earthquakeB			
17	ULS_STR_d2_earthquakeC			
18	ULS_STR_d2_earthquakeD			
19	ULS_STR_d2_earthquakeE			

1) Cable force positive (=tension) from global IBDAS model version 3.3c. Numbers in parenthesis are from global IBDAS model version 3.3f

Table 4-3 Cable design loads, Calabria.

ID	Load case name	Cable force horizontal [MN]	Cable force vertical [MN]	Cable force resultant [1)] [MN]
1	Total (DL+SDL)	2619	739	2721 (2679)
2	SLS_d0	3241	946	3376 (3334)
20	SLS_d2_earthquakeA	3413	993	3554 (3481)
21	SLS_d2_earthquakeB			
22	SLS_d2_earthquakeC			
23	SLS_d2_earthquakeD			
24	SLS_d2_earthquakeE			
4	ULS_STR_d0	3964	1185	4137 (4077)
15	ULS_STR_d2_earthquakeA	4208	1243	4388 (4260)
16	ULS_STR_d2_earthquakeB			
17	ULS_STR_d2_earthquakeC			
18	ULS_STR_d2_earthquakeD			
19	ULS_STR_d2_earthquakeE			

1) Cable force positive (=tension) from global IBDAS model version 3.3c. Numbers in parenthesis are from global IBDAS model version 3.3f

4.3 Calculation methodology

The calculations are divided into the following four steps:

1 Establish initial stresses, observing the value of K_0.
2 Apply the anchor block dead load.
3 Apply the cable force.
4 Apply the seismic force as acceleration times the mass of the anchor block.

4.4 Results

For all action combinations, the earth pressures have been extracted and tabulated for implementation in IBDAS, divided in normal stress and shear stress components. The distributions for all load combinations are shown in Appendices A and B. Below, two examples of results are presented for each anchor block, for the action combination IDs 2 and 15, cf. Table 4-1.

4.4.1 Sicily, SLS_d0 action combination

In Figure 4-2 and Figure 4-3, the earth pressures are shown. The *edge coordinate* in Figure 4-3 has Origo at the left hand side of the anchor block and proceeds counter-clockwise around the perimeter, as indicated by the numbers. The shear stress acts positive clockwise around the perimeter.

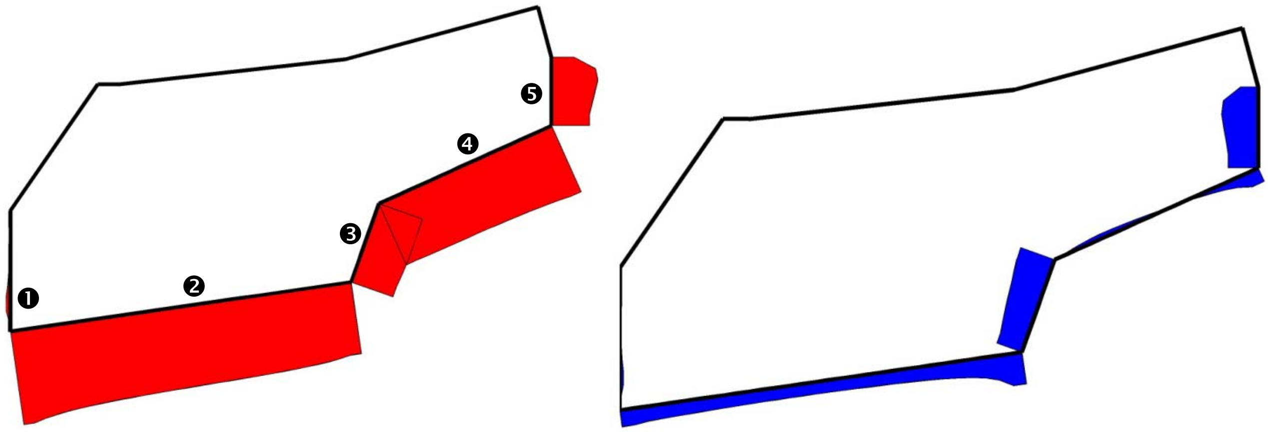


Figure 4-2 Earth pressures acting on the surface of the Sicily Anchor Block for SLS loading without seismicity (ID=2). Left: Normal stress, with maximum of $\sigma = 858\ kPa$. Right: Shear stress with maximum absolute value of $\tau = 285\ kPa$.

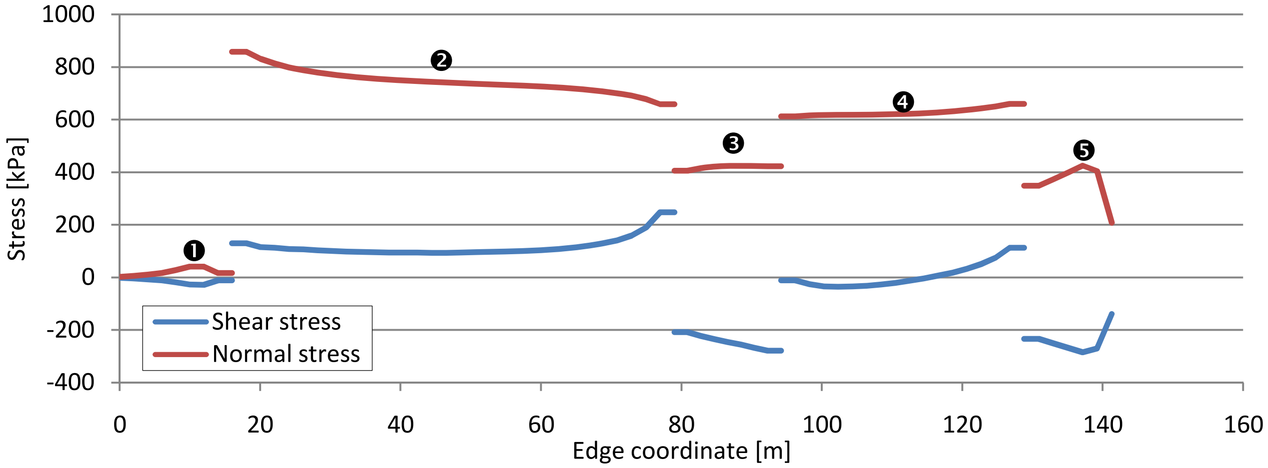


Figure 4-3 Earth pressures acting on the surface of the Sicily Anchor Block for SLS loading without seismicity (Action combination ID=2).

4.4.2 Sicily, ULS_STR_d2_earthquakeA action combination

In Figure 4-4 and Figure 4-5, the earth pressures are shown.

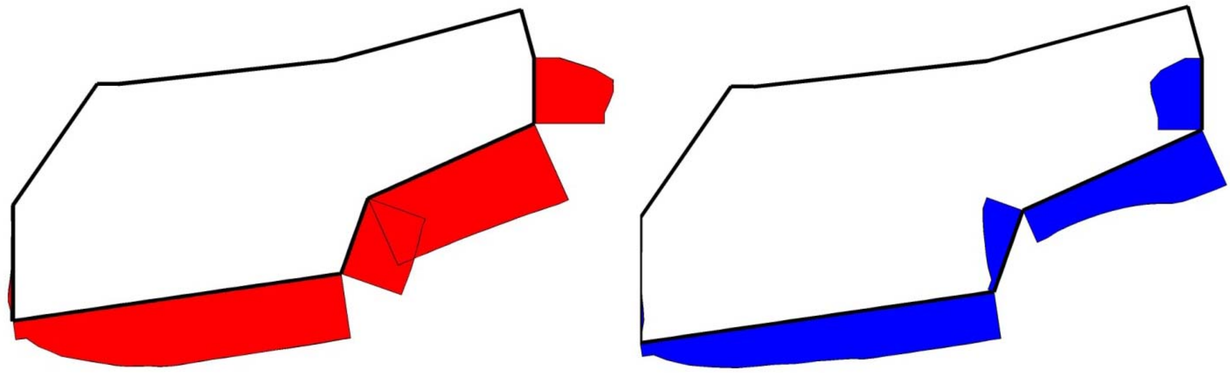


Figure 4-4 *Earth pressures acting on the surface of the Sicily Anchor Block for ULS loading with earthquakeA. (Action combination ID=15, cf. Table 4-1). Left: Normal stress, with maximum of* $\sigma = 793\ kPa$*. Right: Shear stress with maximum absolute value of* $\tau = 531\ kPa$*.*

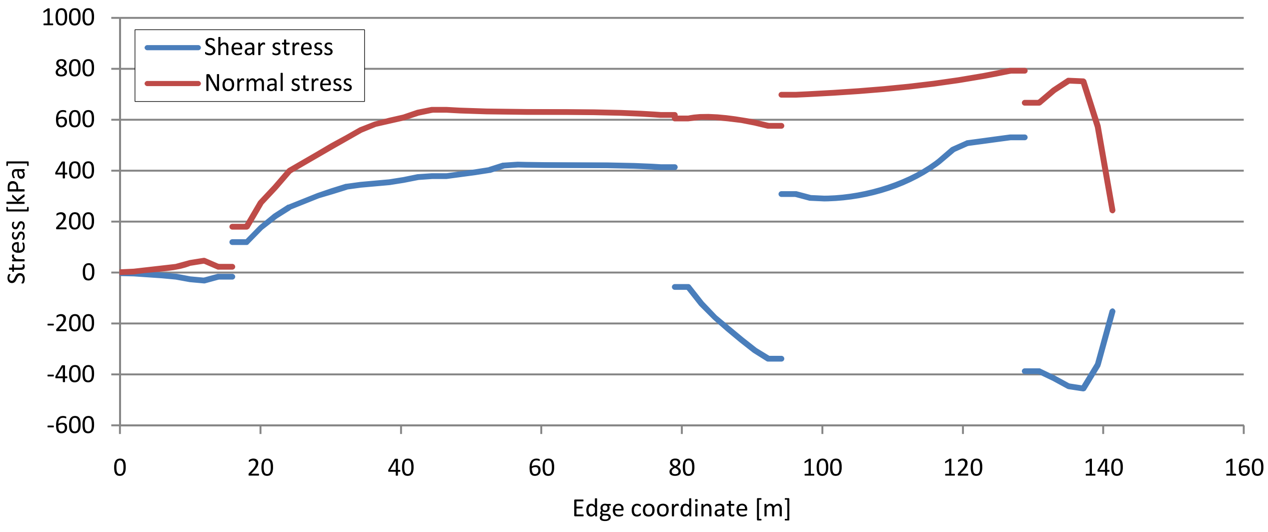


Figure 4-5 *Earth pressures acting on the surface of the Sicily Anchor Block for ULS loading with earthquakeA (Action combination ID=15, cf. Table 4-1).*

4.4.3 Calabria, SLS_d0 action combination

In Figure 4-6 and Figure 4-7, the earth pressures are shown.

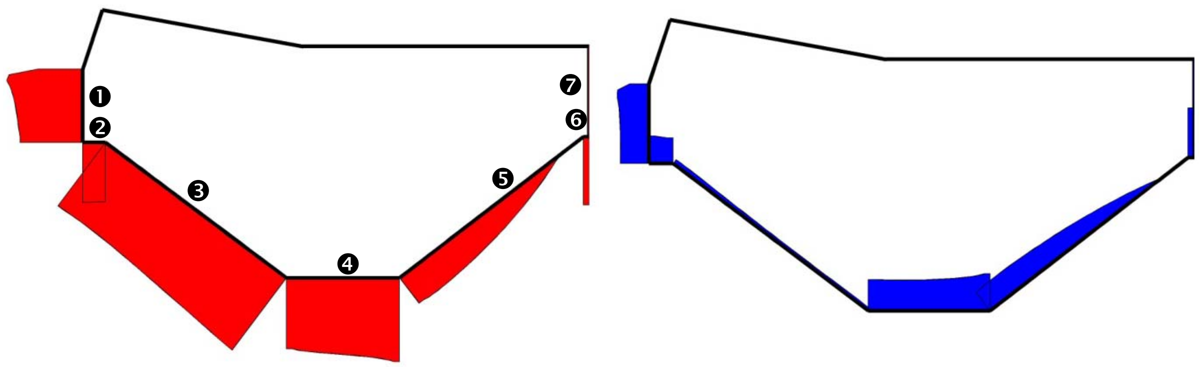


Figure 4-6 Earth pressures acting on the surface of the Calabria Anchor Block for SLS loading without seismicity (ID=2). Left: Normal stress, with maximum of $\sigma = 799\ kPa$. Right: Shear stress with maximum absolute value of $\tau = 404\ kPa$.

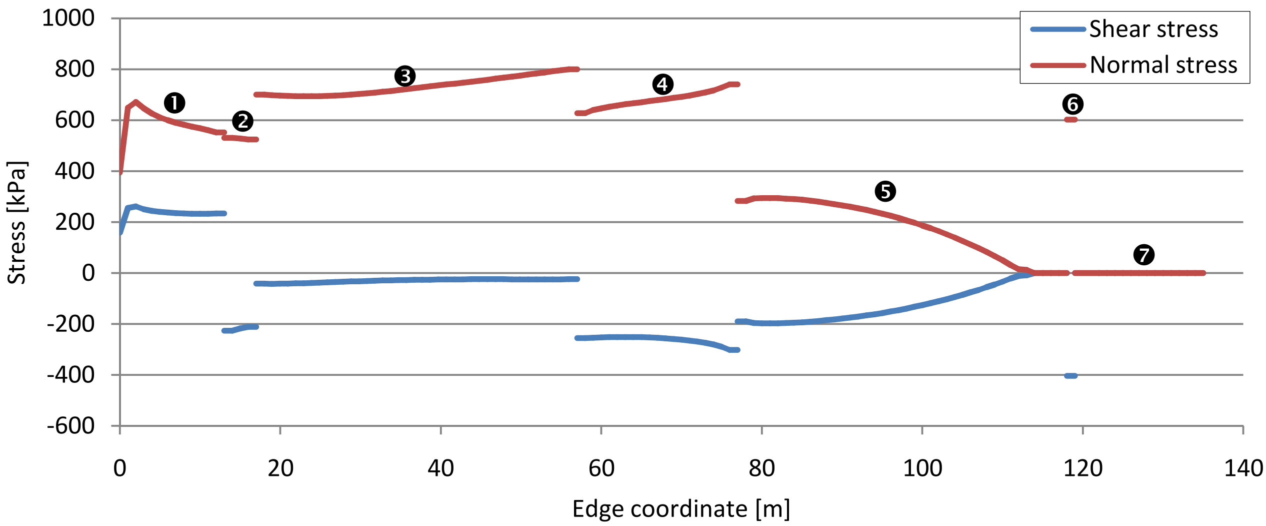


Figure 4-7 Earth pressures acting on the surface of the Calabria Anchor Block for SLS loading without seismicity (Action combination ID=2).

4.4.4 Calabria, ULS_STR_d2_earthquakeA action combination

In Figure 4-8 and Figure 4-9, the earth pressures are shown.

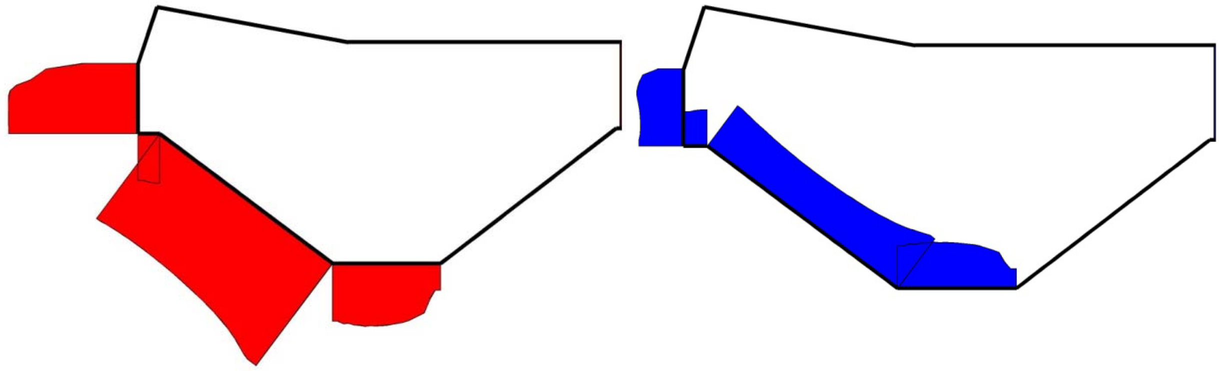


Figure 4-8 *Earth pressures acting on the surface of the Sicily Anchor Block for ULS loading with earthquakeA. (Action combination ID=15, cf. Table 4-1). Left: Normal stress, with maximum of* $\sigma = 1202\ kPa$. *Right: Shear stress with maximum absolute value of* $\tau = 522\ kPa$.

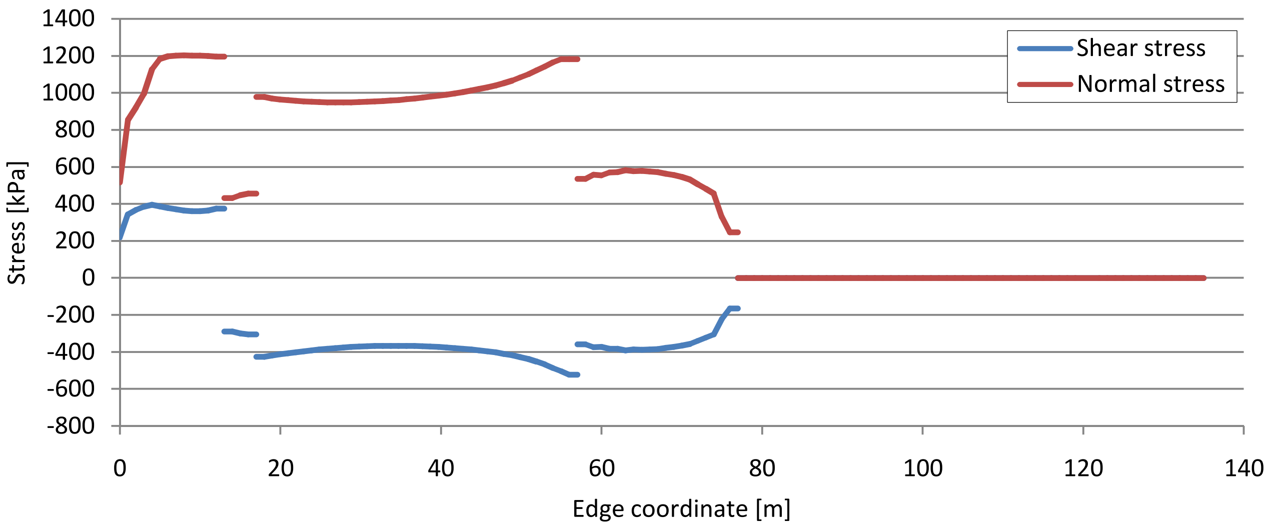


Figure 4-9 *Earth pressures acting on the surface of the Calabria Anchor Block for ULS loading with earthquakeA (Action combination ID=15, cf. Table 4-1).*

4.5 Sensitivity analyses

In order to evaluate the sensitivity of the earth pressures to the soil properties, some sensitivity analyses have been carried out.

4.5.1 Angle of friction

The angle of friction in the above analyses is taken as the characteristic value, i.e. a lower 5% quantile value. It is possible, that a 95% quantile may produce a more onerous stress distribution, and hence, an extra calculation has been carried out for sensitivity analysis. A 95% quantile corresponds to an increase of the angle of friction with two degrees, i.e. $\varphi = 44\,°$ for the Sicily Anchor Block.

In Figure 4-10, the earth pressures corresponding to an increase of the friction angle with two degrees are plotted for the Sicily Anchor Block. It can be observed that the difference is vanishing.

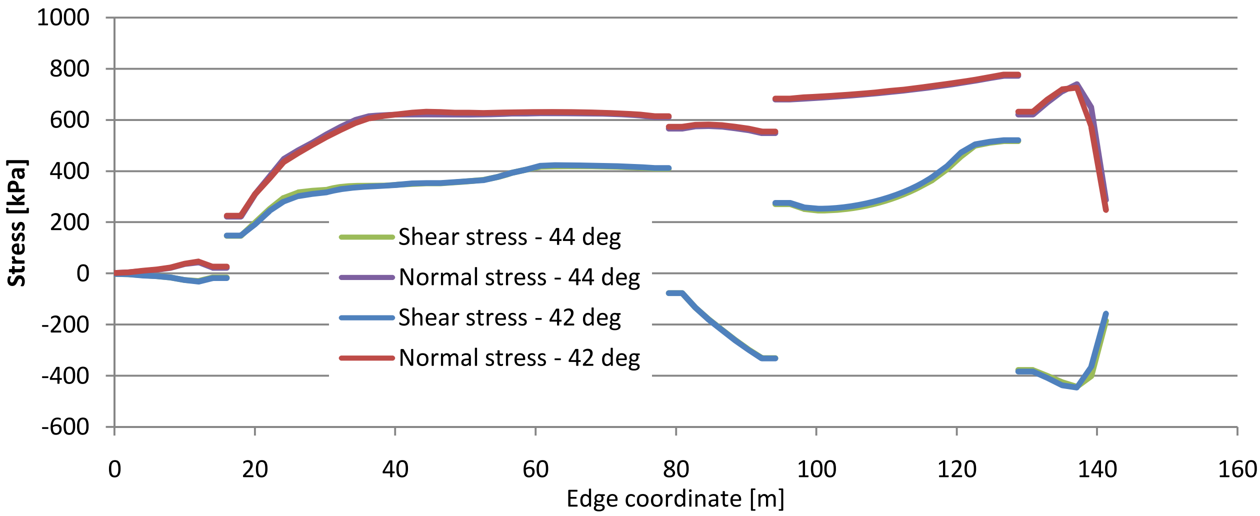


Figure 4-10 Earth pressures acting on the surface of the Sicily Anchor Block for ULS loading with earthquakeA (Action combination ID=15, cf. Table 4-1). Sensitivity analyses for friction angle either $\varphi = 42°$ or $\varphi = 44°$.

4.5.2 Young's modulus

The stiffness of the soil may also vary from the Young's modulus used in the above analyses. In order to investigate the sensitivity to the soil stiffness, two additional analyses have been carried out. The Young's modulus have been doubled and halved, i.e. 400/700 MPa and 100/175 MPa, respectively, for the Sicily Anchor Block.

The results are shown in Figure 4-11 and Figure 4-12, from which it is evident that even relatively large variations in the Young's moduli yield only minor variations in the earth pressure distribution. Hence, the analyses are rather insensitive to the value of the Young's moduli.

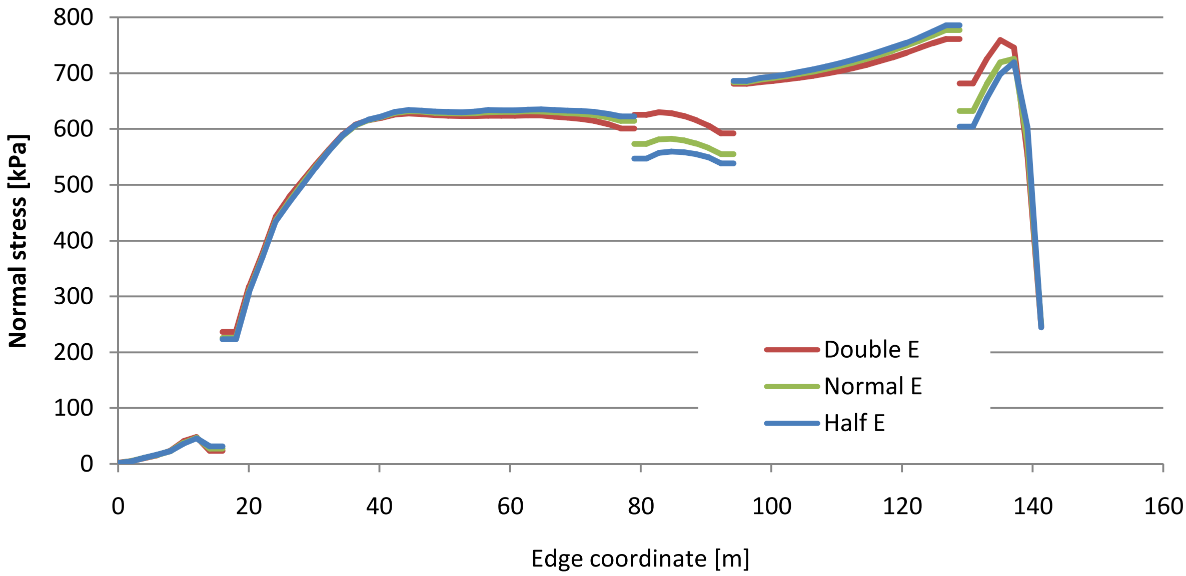


Figure 4-11 Normal stress acting on the surface of the Sicily Anchor Block for ULS loading with earthquakeA (Action combination ID=15, cf. Table 4-1). Sensitivity analyses for varying Young's moduli.

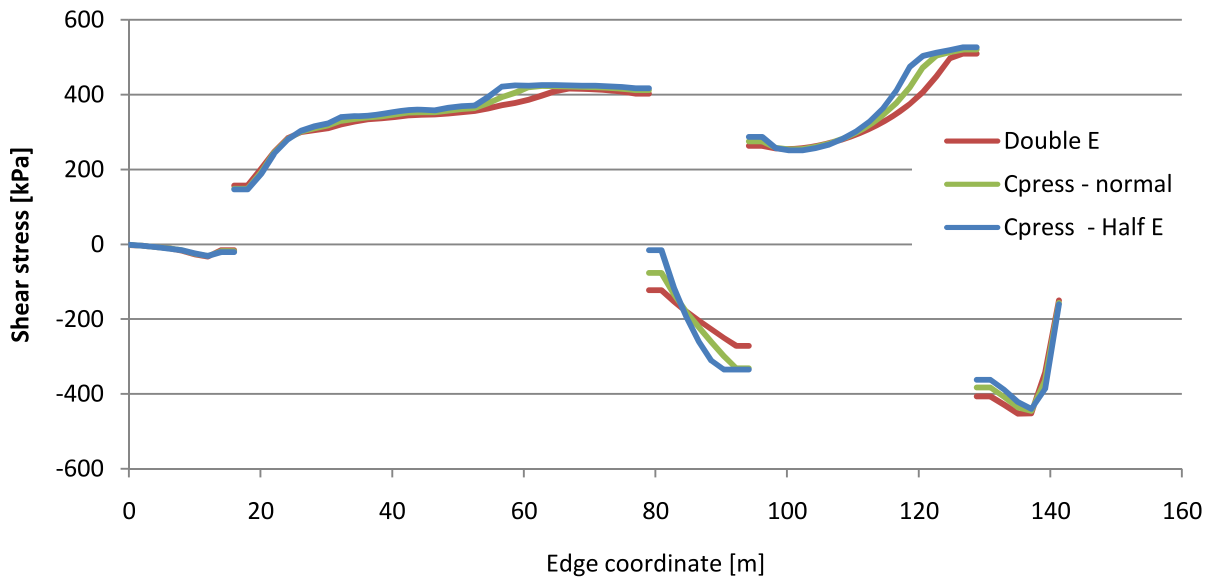


Figure 4-12 Shear stress acting on the surface of the Sicily Anchor Block for ULS loading with earthquakeA (Action combination ID=15, cf. Table 4-1). Sensitivity analyses for varying Young's moduli.

4.6 Conclusion

The earth pressures acting on the sides of the anchor blocks under various load combinations, including the effect of seismic events in SLS and ULS, have been determined using the finite element method. It has been shown that the earth pressure distribution is rather insensitive to the soil parameters applied in the model.

5 Verification of geotechnical capacity

The verification of the geotechnical bearing and sliding capacity is presented in references (4), (5) , (6) and (7).

6 References

(1) COWI for Stretto di Messina, *Specialist Technical Design Report, Annex,* Doc. no. GC-1000-P-RG-D-P-ST-B4-00-00-00-00-01_C, 19-03-2011

(2) COWI for Stretto de Messina, *Design Basis, Structural, Annex,* Doc. no. CG1000-P-RG-D-P-GE-00-00-00-00-00-02_A, 04-11-2010

(3) COWI for Stretto de Messina *Global IBDAS Model, Annex,* Doc. no. CG1000-P-RG-D-P-SV-00-00-00-00-00-01_B, 23-02-2011

(4) COWI for Stretto de Messina, *Sicily Anchor Block - earthquake induced displacements and safety against ultimate limit states, Annex,* Doc. no. CG1000-P-CL-D-P-ST-B4-BS-00-00-00-02_B, 13-02-2011

(5) COWI for Stretto de Messina, *Calabria Anchor Block - earthquake induced displacements and safety against ultimate limit states, Annex,* Doc. no. CG1000-P-CL-D-P-ST-B4-BC-00-00-00-02_B, 13-02-2011

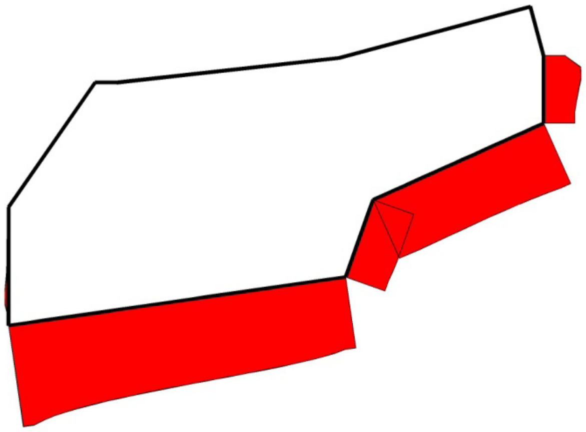
(6) COWI for Stretto de Messina, *Sicily Anchor Block - evaluation of block behaviour via 3D FE analyses and of bearing capacity, Annex,* Doc. no. CG1000-P-CL-D-P-ST-B4-BS-00-00-00-03_B, 13-02-2011

(7) COWI for Stretto de Messina, *Calabria Anchor Block - evaluation of block behaviour via 3D FE analyses and of bearing capacity, Annex,* Doc. no. CG1000-P-CL-D-P-ST-B4-BC-00-00-00-03_B, 13-02-2011

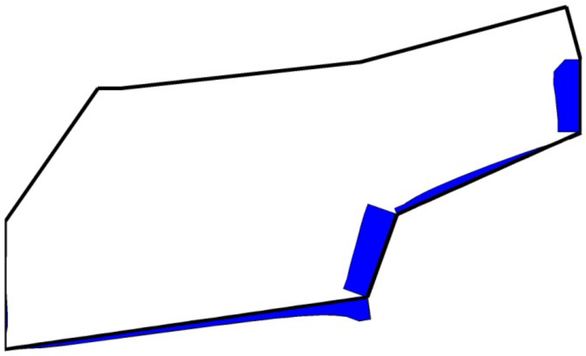
Appendix A Earth pressure distributions, Sicily

ID's refer to the action combinations in Table 4-1.

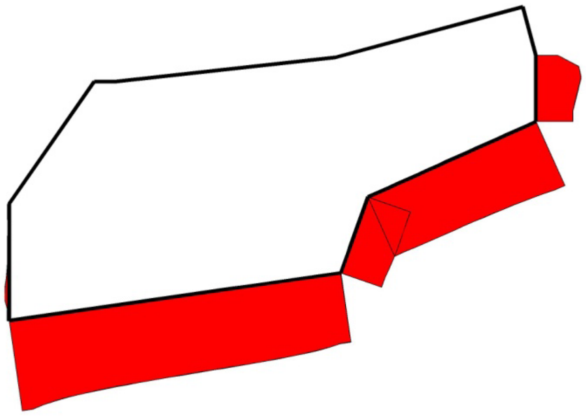
Normal stress, LC ID 1, max stress σ = 947 kPa



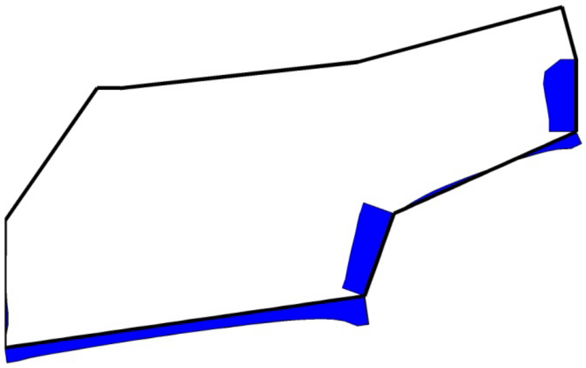
Shear stress, LC ID 1, max stress τ = 265 kPa



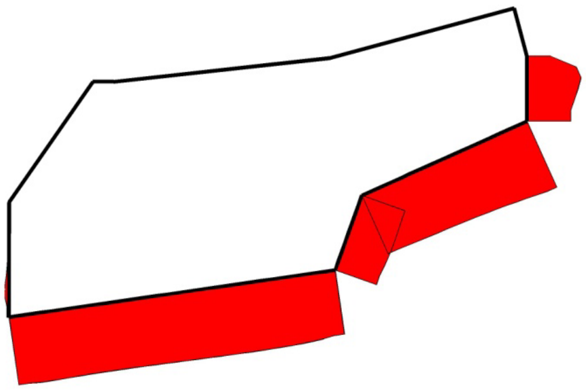
Normal stress, LC ID 2, max stress σ = 858 kPa



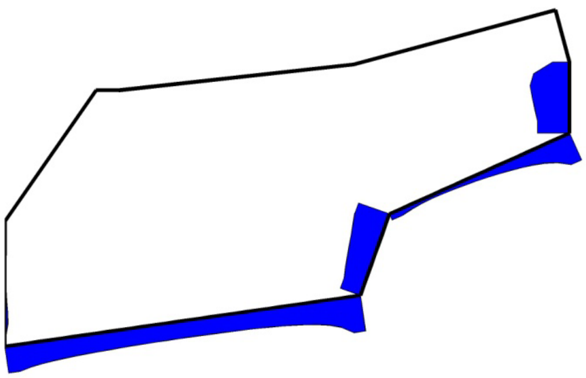
Shear stress, LC ID 2, max stress τ = 285 kPa



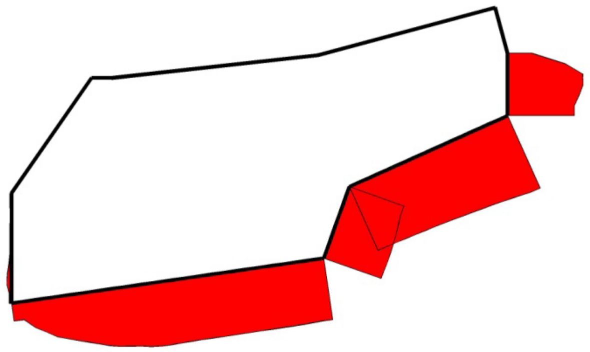
Normal stress, LC ID 4, max stress σ = 691 kPa



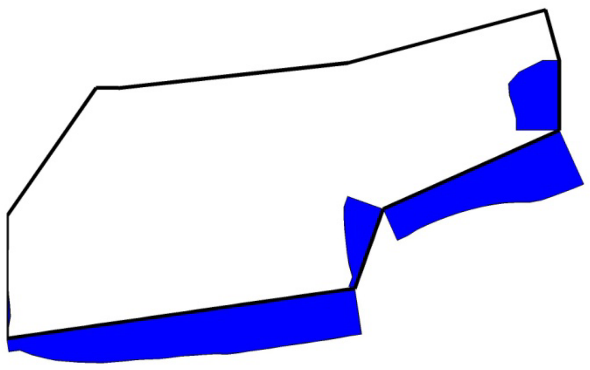
Shear stress, LC ID 4, max stress τ = 347 kPa



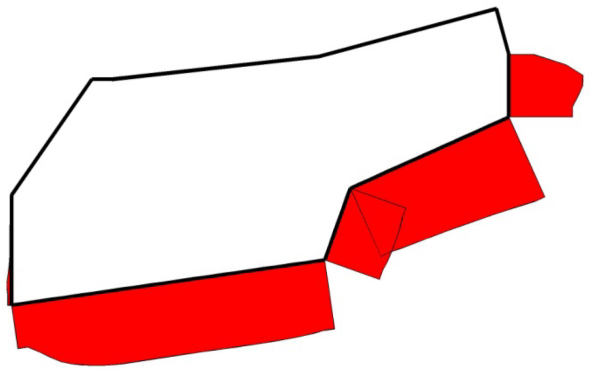
Normal stress, LC ID 15, max stress σ = 793 kPa



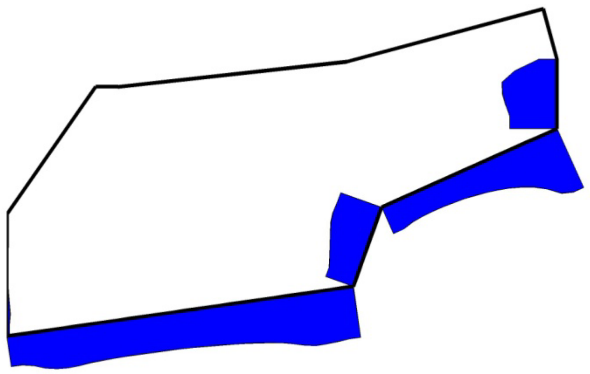
Shear stress, LC ID 15, max stress τ = 531 kPa



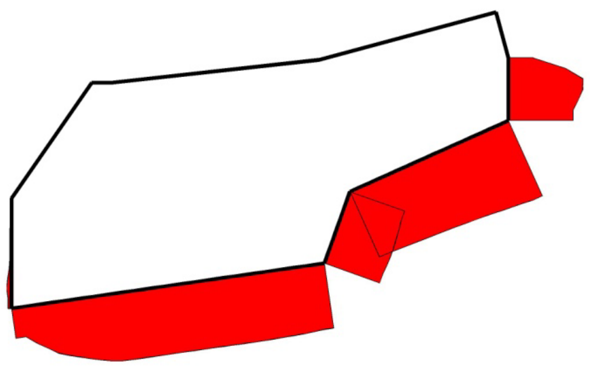
Normal stress, LC ID 16, max stress σ = 872 kPa



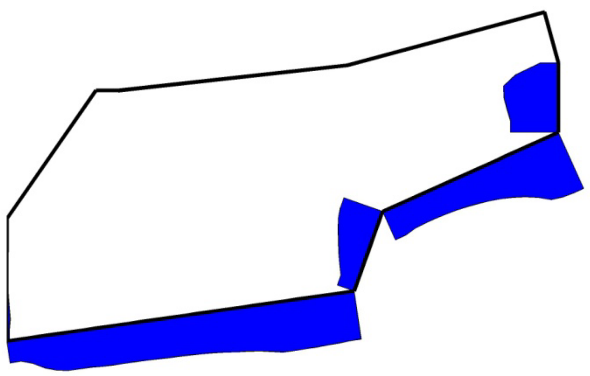
Shear stress, LC ID 16, max stress τ = 582 kPa



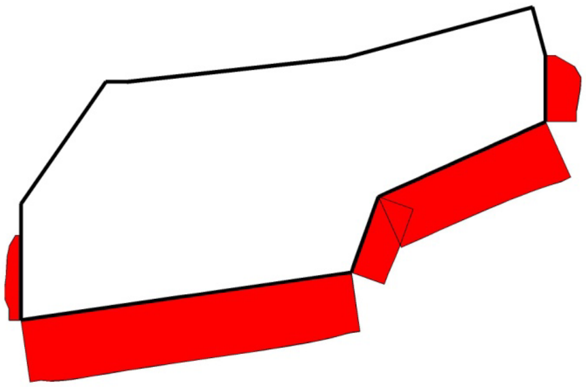
Normal stress, LC ID 17, max stress σ = 824 kPa



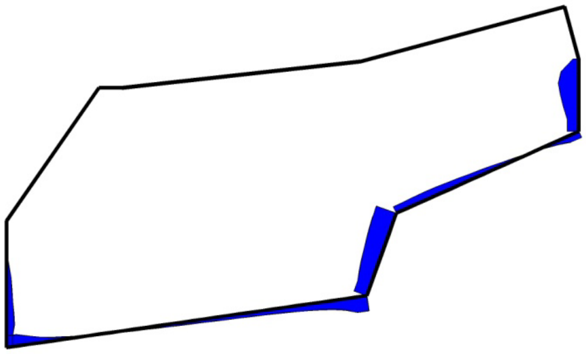
Shear stress, LC ID 17, max stress τ = 552 kPa



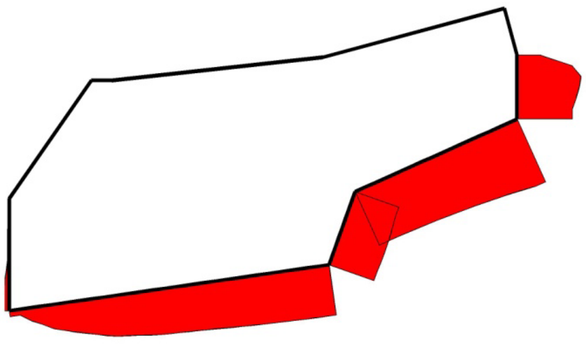
Normal stress, LC ID 18, max stress σ = 624 kPa



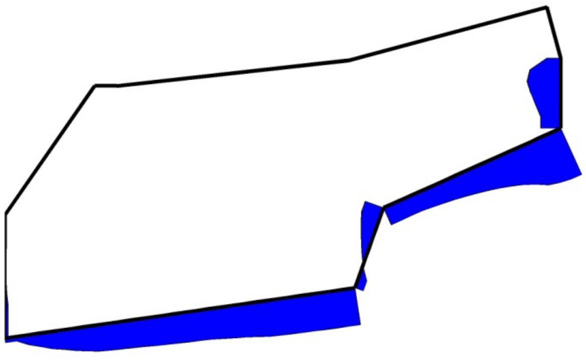
Shear stress, LC ID 18, max stress τ = 183 kPa



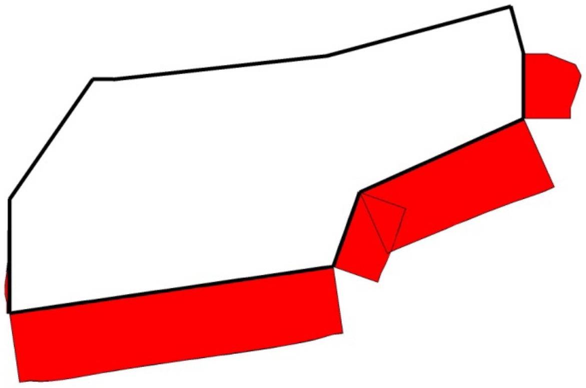
Normal stress, LC ID 19, max stress σ = 675 kPa



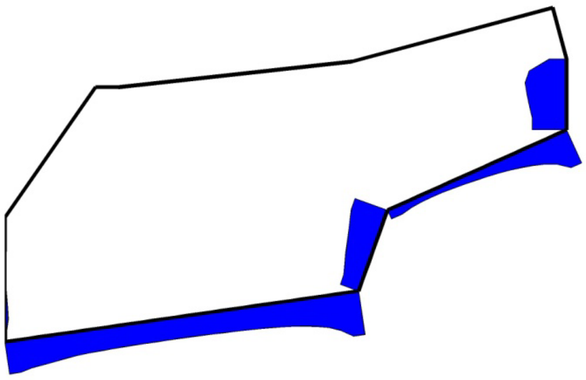
Shear stress, LC ID 19, max stress τ = 452 kPa



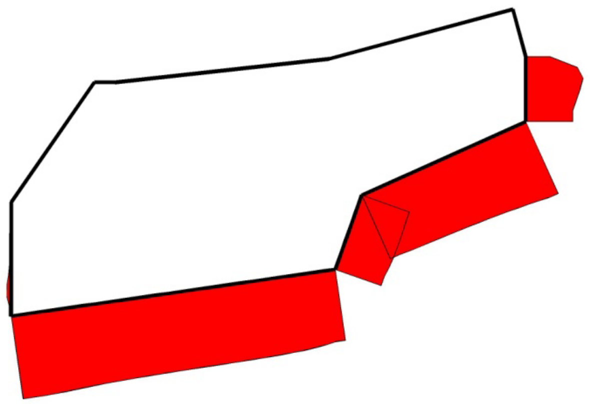
Normal stress, LC ID 20, max stress σ = 722 kPa



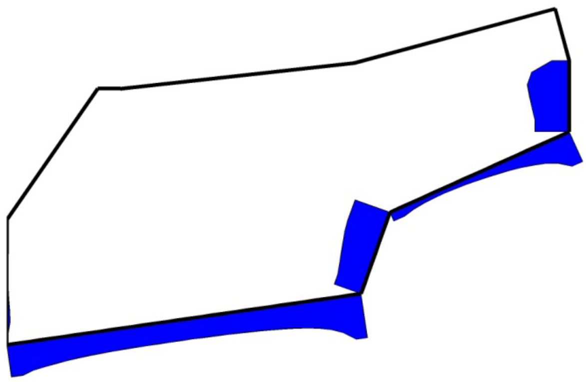
Shear stress, LC ID 20, max stress τ = 389 kPa



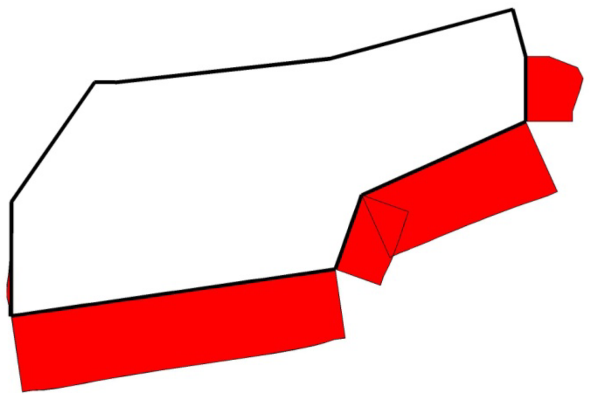
Normal stress, LC ID 21, max stress σ = 805 kPa



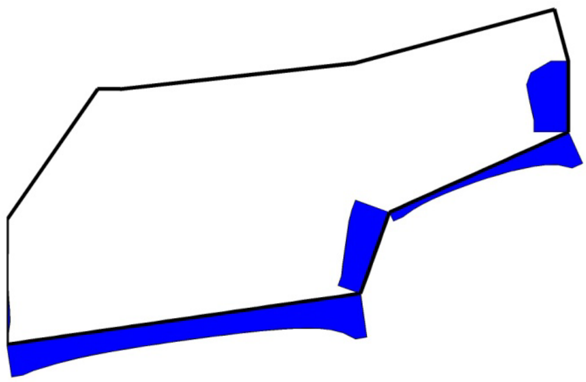
Shear stress, LC ID 21, max stress τ = 391 kPa



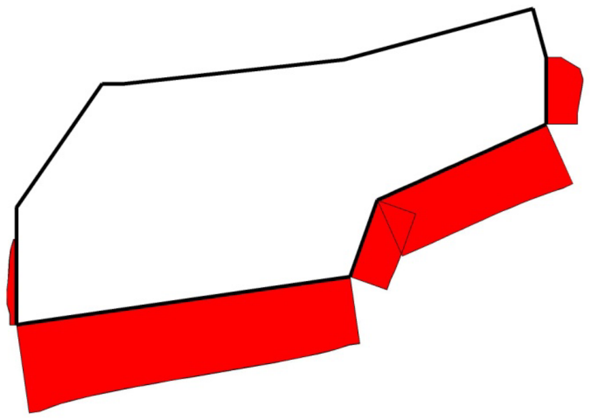
Normal stress, LC ID 22, max stress σ = 752 kPa



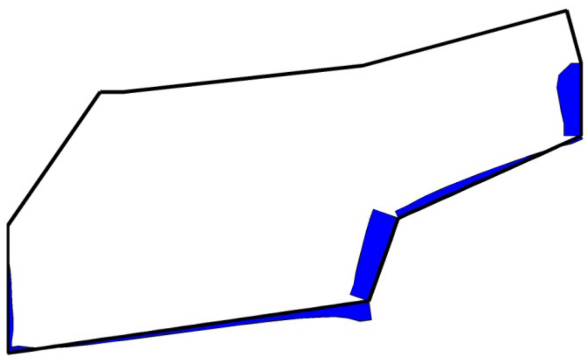
Shear stress, LC ID 22, max stress τ = 390 kPa



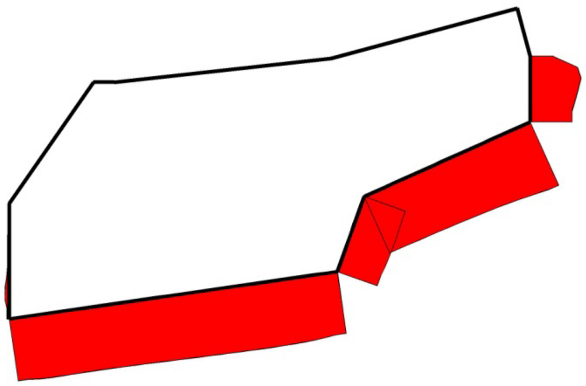
Normal stress, LC ID 23, max stress σ = 833 kPa



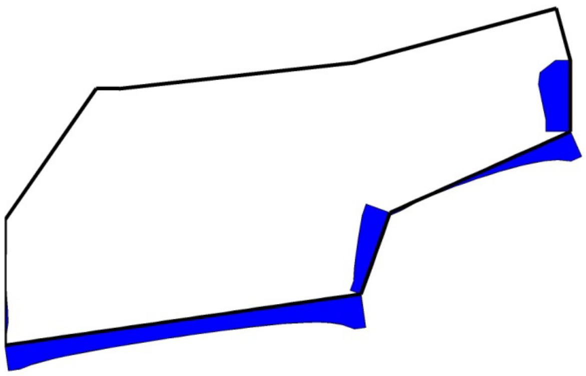
Shear stress, LC ID 23, max stress τ = 229 kPa



Normal stress, LC ID 24, max stress σ = 659 kPa



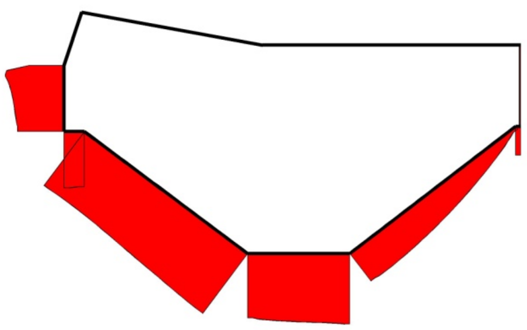
Shear stress, LC ID 24, max stress τ = 295 kPa



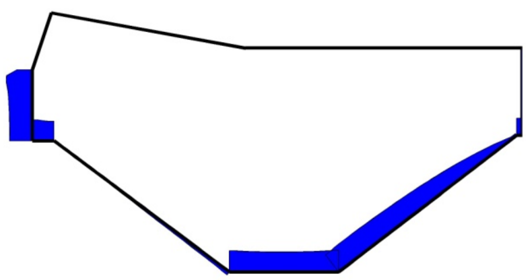
Appendix B Earth pressure distributions, Calabria

ID's refer to the action combinations in Table 4-1.

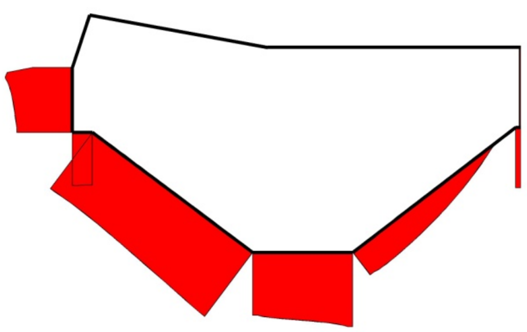
Normal stress, LC ID 1, max stress σ = 734 kPa



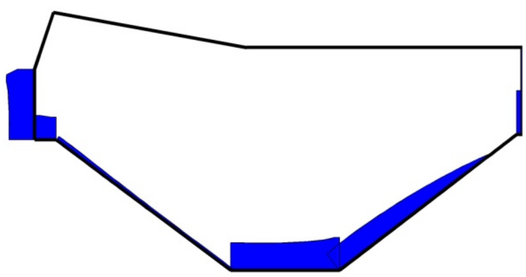
Shear stress, LC ID 1, max stress τ = 240 kPa



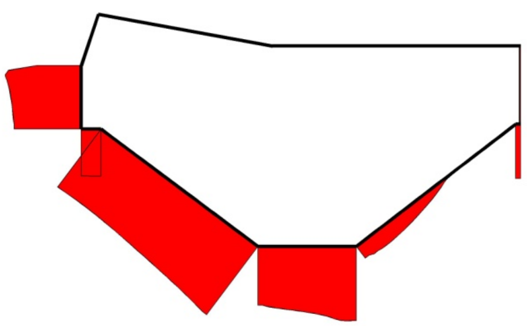
Normal stress, LC ID 2, max stress σ = 799 kPa



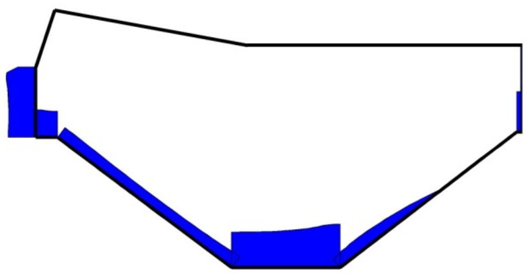
Shear stress, LC ID 2, max stress τ = 404 kPa



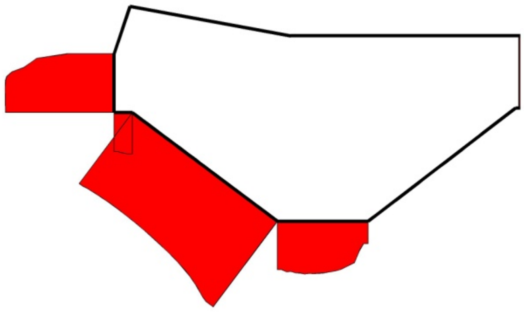
Normal stress, LC ID 4, max stress σ = 871 kPa



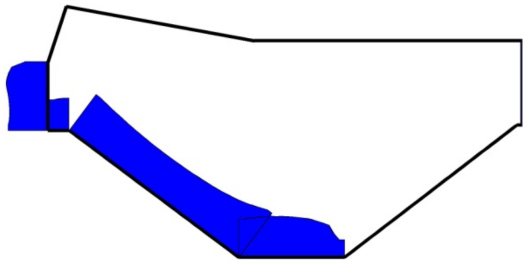
Shear stress, LC ID 4, max stress τ = 401 kPa



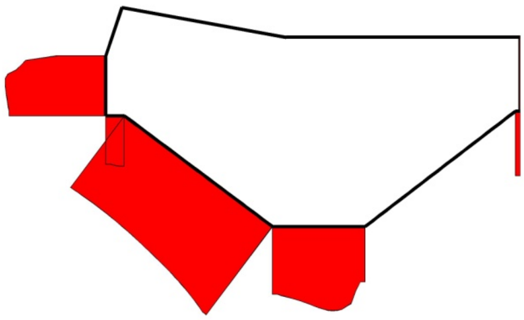
Normal stress, LC ID 15, max stress σ = 1202 kPa



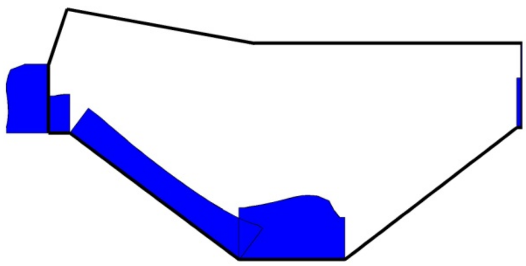
Shear stress, LC ID 15, max stress τ = 522 kPa



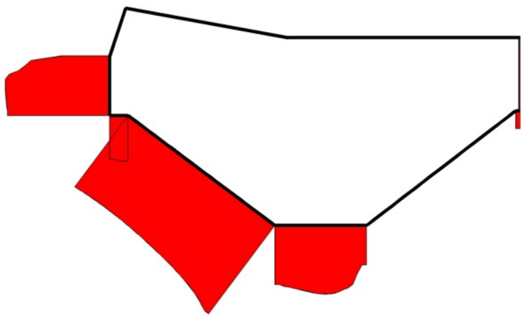
Normal stress, LC ID 16, max stress σ = 1193 kPa



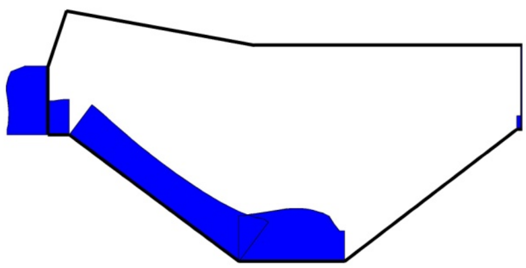
Shear stress, LC ID 16, max stress τ = 609 kPa



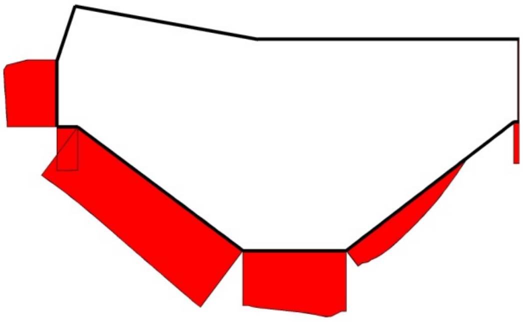
Normal stress, LC ID 17, max stress σ = 1203 kPa



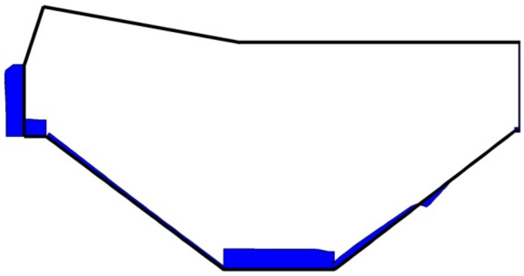
Shear stress, LC ID 17, max stress τ = 501 kPa



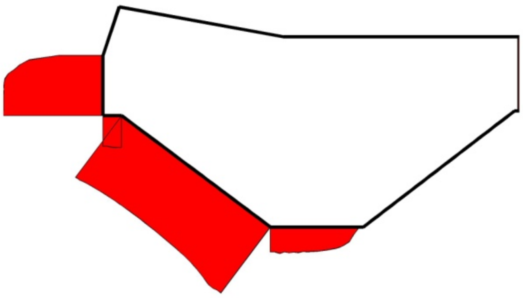
Normal stress, LC ID 18, max stress σ = 685 kPa



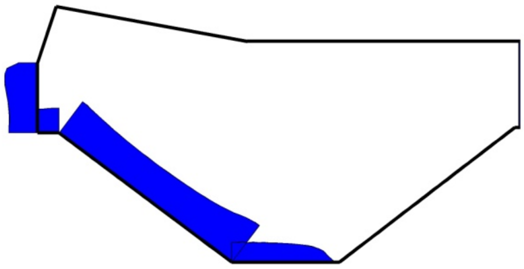
Shear stress, LC ID 18, max stress τ = 189 kPa



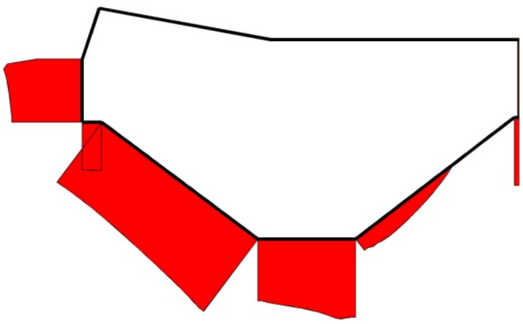
Normal stress, LC ID 19, max stress σ = 1070 kPa



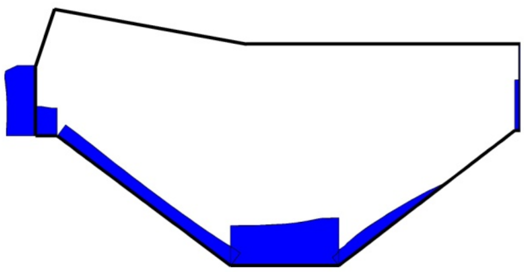
Shear stress, LC ID 19, max stress τ = 426 kPa



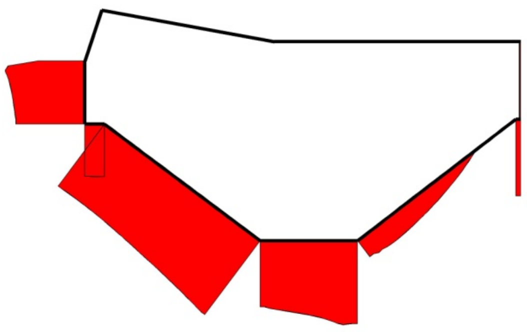
Normal stress, LC ID 20, max stress σ = 928 kPa



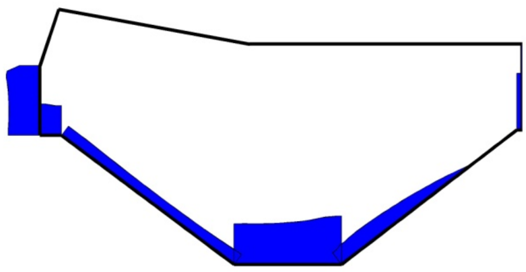
Shear stress, LC ID 20, max stress τ = 468 kPa



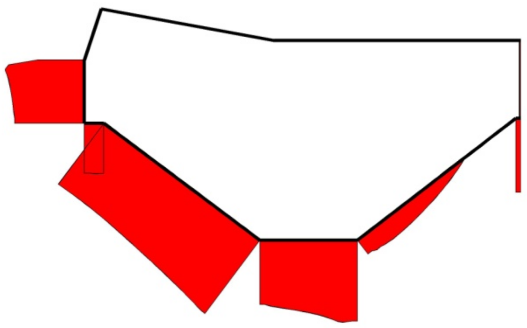
Normal stress, LC ID 21, max stress σ = 949 kPa



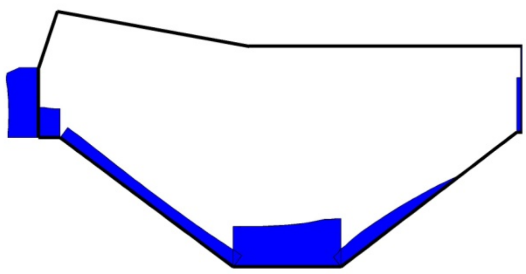
Shear stress, LC ID 21, max stress τ = 528 kPa



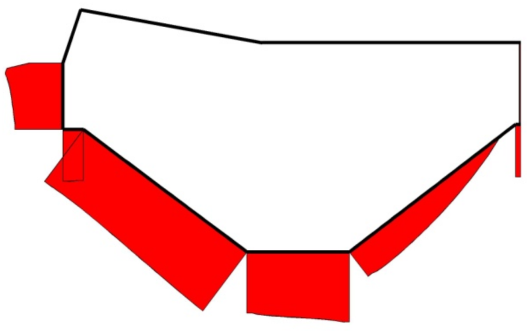
Normal stress, LC ID 22, max stress σ = 938 kPa



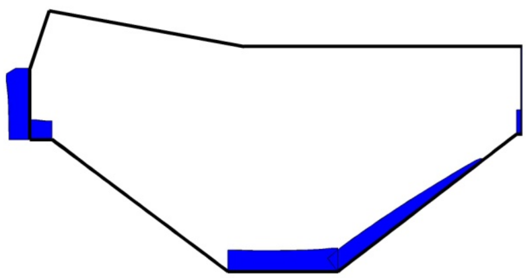
Shear stress, LC ID 22, max stress τ = 508 kPa



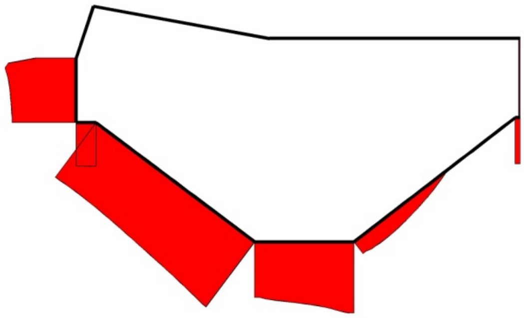
Normal stress, LC ID 23, max stress σ = 720 kPa



Shear stress, LC ID 23, max stress τ = 221 kPa



Normal stress, LC ID 24, max stress σ = 818 kPa



Shear stress, LC ID 24, max stress τ = 368 kPa