Exercise 1. Internal forces of a flat dome

a) Determine the necessary amount of steel reinforcement in the tension ring!

b) Draw the N_φ, N_ϑ diagrams for the flat dome in case the total load is the **self-load**!

Data: $P_{Ed} = 2.6\ kN/m^2, L = 32\ m, f = 7\ m, f_{yd} = 435\ N/mm^2$

SOLUTION:

$\varphi_{max} = 27.27°$

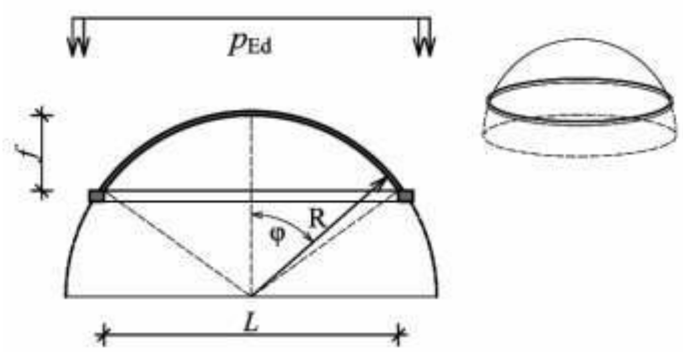
$N_{ring} = 366\ kN$

$A_s^{min} = 842\ mm^2$

$N_\varphi(0) = N(0) = -28.37\ kN/m$

$N_\varphi(bottom) = -33.78\ kN/m$

$N_\vartheta(t) = -4.68\ kN/m$



Exercise 2. Spherical dome with an opening (opeion)

a) Which is the tension ring of the dome? Mark the appropriate structural element on the figure!

b) Determine the normal force in the **tension ring** of the spherical dome! The dome is flat → the self-weight can be approximated with a uniformly distributed load. Neglect the opening when calculating the total load!

c) Is there disturbance in the edge zone?

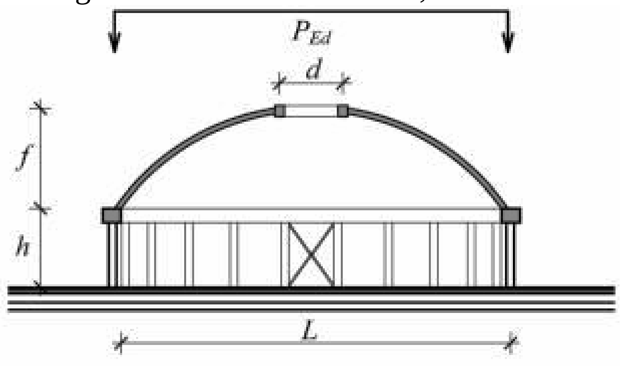
Data: P_{Ed}=4,0 kN/m2, L=35 m, d=2,0 m, f=5,0 m. Strength of the concrete: fcd=13,3 N/mm2.

SOLUTION:

a) the bottom ring (the upper ring is under compression!)

b) $\varphi_{max} = 31.9°$, $N_{ring} = 985\ kN$

c) Yes, because $\varphi_{max} < 45°, N_\vartheta(bottom)$ is compression.



Exercise 3. Hyperbolic paraboloid with 2 skew edges

There is a steel chord between the supports **A** and **C**. The chord has a tubular profile with a diameter d=6 cm, and the thickness $v = 5\ mm$. Check the chord assuming total load (acting over the whole structure)!

Data: $P_{Ed} = 2.5\ kN/m^2, f_1 = 1.34\ m, a = b = 5\ m$. Material of the chord: S235.

SOLUTION:

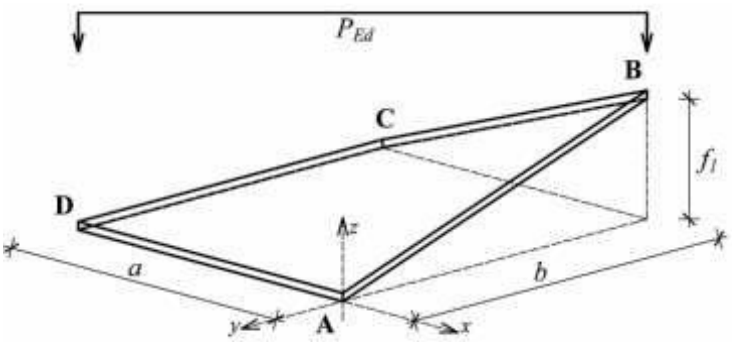
$A_z = 31.25\ kN$

$S_x = S_y = 116.6\ kN$

$N_{Ed}^{chord} = 165\ kN$

$N_{Rd}^{chord} = 202\ kN$

OK!



Exercise 4. Hyperbolic paraboloid with 4 skew edges

a) Calculate the normal force in all edges of the hyperbolic paraboloid!

b) The structure is supported in point A and B. Calculate the reaction forces at the supports!
Data: P_{Ed}= 2,2 kN/m^2; a=5 m; b=4,2 m; f_1=f_2=2 m.

SOLUTION:

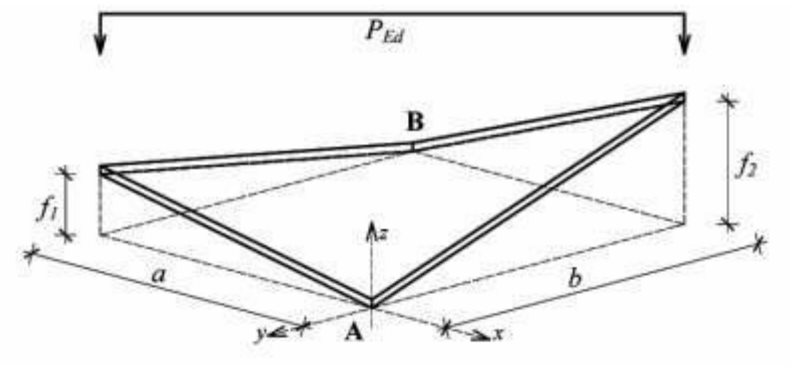
$N_a = 6.22\ kN/m$

$N_b = 6.4\ kN/m$

$A_x = 28.875\ kN$

$A_y = 24.25\ kN$

$A_z = 23.1\ kN$



Exercise 5. Masonry vault

a) Check the barrel vault based on the resistance of the vault for combined bending and axial compression in the quarter point!

b) Calculate the eccentricity at the bottom of the wall if the loads are transferred from the vault to the walls at a height of H=3m. The walls are loaded by additional vertical forces (including the self-weight): $N_{Ed} = 320\ kN/m$.

c) Draw the thrust line on the figure (assume that the plastic hinges form on the axis of the arch)!
Data: $P_{Ed} = 15\ kN/m^2, L = 6\ m, f = 1.2\ m, t = 0.15\ m$.
The strength of the brick is $f_{c,d} = 1.2\ N/mm^2$.

SOLUTION:

$e_D = 27.8\ mm$

$N_{Rd} = 113.4\ kN > N_{Ed} = 60.55\ kN$

$e_{bottom}^{wall} = 462\ mm$