Program: RFEM 6, Geotechnical Analysis, Construction Stages, Stability Analysis

Category: Geotechnical Analysis, Isotropic Plasticity, Stability, Solid

Verification Example: 0500 – Triaxial Test of Drained Soil

0500 – Triaxial Test of Drained Soil

Description

A cylinder made of elasto-plastic soil is subjected to triaxial test conditions according to **Figure 1**. Neglecting self-weight, the goal is to determine the limit vertical stress σ_z for shear stress failure. An initial hydrostatic stress of 100 kPa is considered. The problem is described by the following set of parameters.

Material	Soil	Modulus of Elasticity	E	20000.000	kN/m^2
		Poisson's Ratio	ν	0.300	–
		Cohesion	c	3.000	kN/m^2
		Angle of Internal Friction	ϕ	35.000	°
Geometry		Radius	R	1.000	m
		Height	H	1.000	m
Load		Distributed	p	100.000	kN/m^2

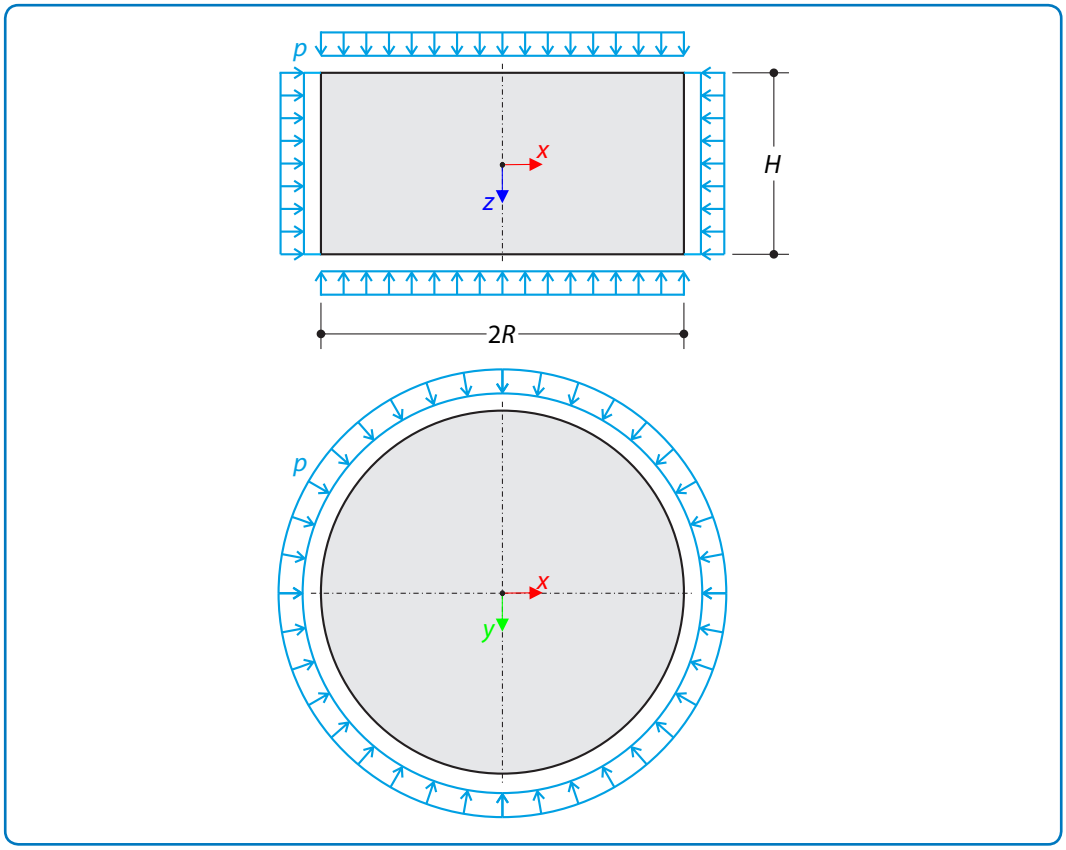

Figure 1: Problem sketch

Analytical Solution

In case of a triaxial compression test according to **Figure 1**, the principal stresses are equal to $\sigma_1 = \sigma_2 = p, \sigma_3 = \sigma_z$. The analytical solution can be derived from Mohr's circle, see **Figure 2** for the case of compression when $p > \sigma_z$.

$$\sin\varphi = \frac{|BC|}{|AB|} = \frac{\frac{\sigma_z - p}{2}}{\frac{\sigma_z + p}{2} - c\frac{\cos\varphi}{\sin\varphi}}$$

$$\sin\varphi = \frac{\sigma_z - p}{\sigma_z + p - 2c\frac{\cos\varphi}{\sin\varphi}}$$

$$\sigma_z(1 - \sin\varphi) = p(1 + \sin\varphi) - 2c\cos\varphi$$

$$\sigma_z = p\frac{1 + \sin\varphi}{1 - \sin\varphi} - 2c\frac{\cos\varphi}{1 - \sin\varphi} \approx -380.543\ \text{kN/m}^2 \qquad (500 - 1)$$

Analogously, in case of extension, when $p < \sigma_z$, it holds that

$$\sigma_z = p\frac{1 - \sin\varphi}{1 + \sin\varphi} + 2c\frac{\cos\varphi}{1 + \sin\varphi} \approx -23.976\ \text{kN/m}^2 \qquad (500 - 2)$$

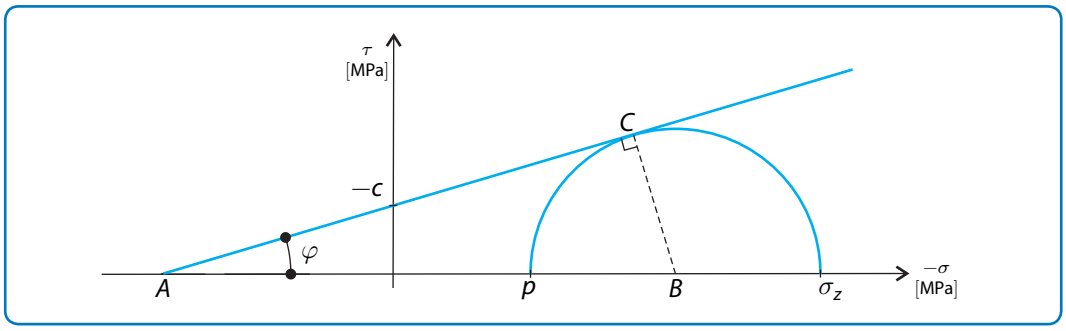

Figure 2: Mohr's circle

RFEM 6 Settings

- Modeled in RFEM 6.01
- The element size is $l_{FE} = 0.200$ m
- The number of increments is 1
- The Isotropic | Soil | Plastic | Modified Mohr-Coulomb material model is used
- Initial hydrostatic pressure is set to 100 kPa
- Critical load is attained through incremental increase of additional vertical load in a follow-up construction stage employing nonlinear stability analysis
- 0500.01 uitilizes the Construction Stages add-on, while 0500.02 uses Initial State of type Final State as special option in the particulat load cases, to simulate increase / decrease of vertical load on top of initial stress

Results

Structure Files	Program
0500.01	RFEM 6 – Construction Stages
0500.02	RFEM 6 – Inital State

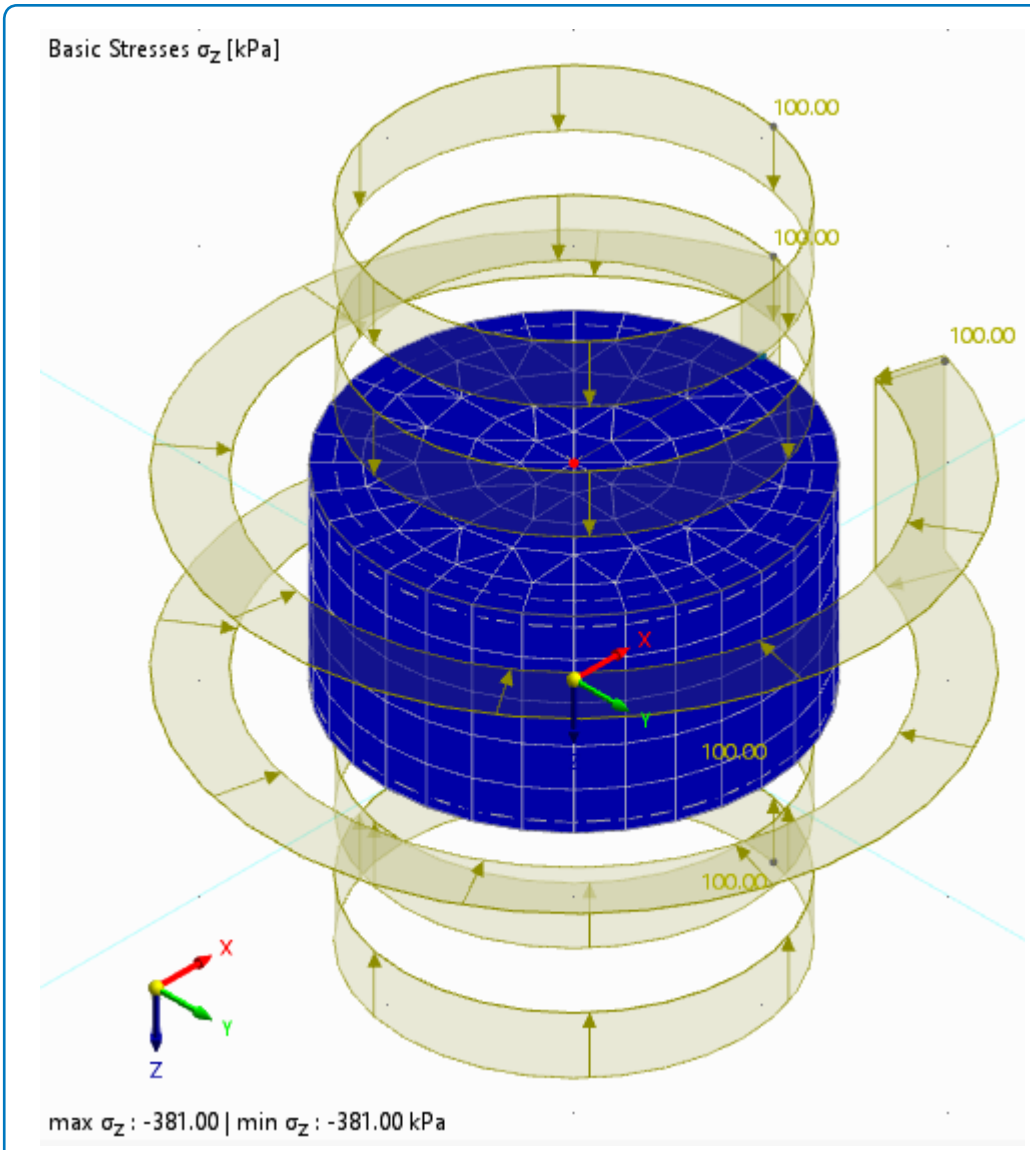

Figure 3: Constant pressure σ_z at critical load in RFEM 6

Stress	Analytical Solution	RFEM 6	
	σ_z [kN/m^2]	σ_z [kN/m^2]	Ratio [-]
Compression	−380.543	−381.000	1.001
Tension	−23.976	−23.900	0.997