

## FOUNDATION WITH FAILING TENSION ZONE

Name of program: **Foundation** V 1.03

The program computes for a rectangular foundation submitted to several vertical forces **N<sub>i</sub>** acting in yN, zN and moments **My**, **Mz** ( fig. 1) the soil pressure in consideration of failing tension stresses in the gap between soil and foundation. The dimensions of the foundation are defined by the Length **Ly**, width **Lz** and thickness **Tf**. If **Tf** > 0, the own weight **Gf** acting in the center is calculated as **Ly\*Lz\*Tf\*25**, with **25** [kN/m<sup>3</sup>] being the specific weight of reinforced concrete. Otherwise, if **Tf** is input or accepted as default value **0**, the net weight is neglected and can be taken into account by the input of **Ni** "manually". In a first calculation the program checks the criterion  $(M_z/(N \cdot L_y))^2 + (M_y/(N \cdot L_z))^2 \leq 1/9$ , which means that the gaping zone is less than 50% of the rectangle. If it applies, the stresses now are determined "normally" ( + and - ) for all four points of the contour. Then a new contour is created by the neutral axis ( $\sigma=0$ ) and those parts of the foundation being under pressure.

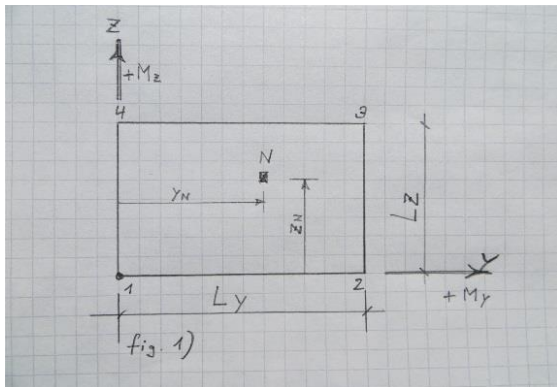


fig. 1) - Moments positive as indicated!

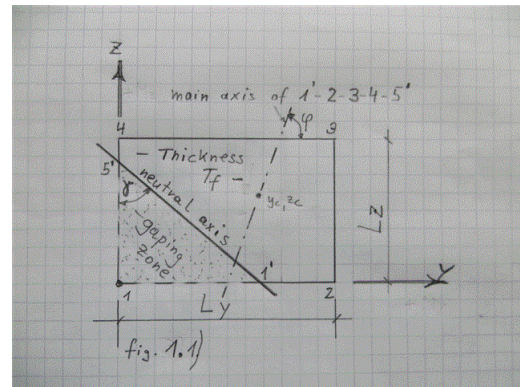


fig. 1.1) - Basis for iterations

In fig. 1.1 this area is defined by the points 1'-2-3-4-5'. With new section properties A,p (= A,pressure), ly, lz, lyz the next calculation is performed. This procedure is continued until  $\sigma_{max}$  is less than **10<sup>-4</sup>**.

Each iteration is depicted by the area A,p of the contour under pressure, its center yc, zc and the points of the contour and its stresses  $\sigma$ . If there is a change of sign between  $\sigma(i)$  and  $\sigma(i+1)$  an additional line shows the coordinates  $y(i \rightarrow i+1)$  and  $z(i \rightarrow i+1)$  where  $\sigma = 0$  and the angle  $\gamma$  of the neutral axis. At last the quantities of  $\sigma_{min}$  and  $\sigma_{max}$  are indicated. After the last iteration ( as a rule 3 – 6 iterations ) the program shows the equations of the main- and neutral axis. On page 1.2 the graph of the last calculation is depicted, page 1.3 shows the results of the recent iteration as a spreadsheet. The procedure of the execution of the program is explained by the following example.

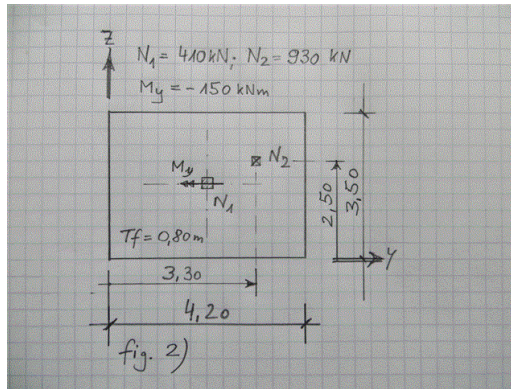


fig. 2)

### EXAMPLE:

A rectangular foundation with  $L_y = 4.2$  m,  $L_z = 3.5$  m,  $T_f = 0.8$  m bears two vertical loads  $N_1 = 410$  kN ( $y_{N1}$ ,  $z_{N1}$  as default in the center of the rectangle),  $N_2 = 930$  kN in (3.3, 2.5) and a Moment  $M_y = -150$  kNm ( fig. 2 ). Find the maximum (negative) soil pressure .

To start the program, go on page 1.1, press the **var**-key and select **found()**. Continue the input:

### PROMPT > INPUT

$L_y = 4.2$  ,  $L_z = 3.5$   $T_f = .8$  (Default: 0)

$G_f = 294$  kN

$N_1 = 410$  ,  $y_{N1} = 2.1$  (=  $y_c$  as default) ,  $z_{N1} = 1.75$  (=  $z_c$  as default)

$N_2 = 930$  ,  $y_{N2} = 3.3$  ,  $z_{N2} = 2.5$

$N_3 = 0$  ( to conclude the input of vertical loads, enter  $N_i = 0$  )

$M_y = -150$   $M_z = 0$

An excerpt of the total result is depicted in fig. 3) - fig. 8):

```

1.1 1.2 1.3 Foundation DEG
found()

Ly = 4.2 | Lz = 3.5 | Tf = 0.8
Gf = -294.
A, p|yc|zc = 14.700 | 2.100 | 1.750
ΣN|y, z, N = -1634.000 | 2.783 | 2.177
My(+→) = -150 , Mz(+↑) = 0
(ey/Ly)2 + (ez/Lz)2 = 0.0484 ≤ 1/9
-----

```

fig. 3)

```

1.1 1.2 1.3 Foundation DEG
= 1.861 | 0.000 | -42.441
Point 2: σ2 = -120.777
Point 3: σ3 = -318.445
Point 4: σ4 = -101.535
σ = 0 at y, 4 ⇒ 1 | z, 4 ⇒ 1 | γ
= 0.000 | 1.702 | -42.441
σmin | max = -318.445 | 96.132
----- ITERATION 1 -----
A, p|yc|zc = 13.116 | 2.279 | 1.893

```

fig. 4)

```

1.1 1.2 1.3 Foundation DEG
----- ITERATION 4 -----
A, p|yc|zc = 12.376 | 2.353 | 1.950
Point 1: σ1 = 4.075E-6
σ = 0 at y, 1 ⇒ 2 | z, 1 ⇒ 2 | γ
= 2.263 | 0.000 | -42.225
Point 2: σ2 = -114.247
Point 3: σ3 = -341.746
Point 4: σ4 = -93.993

```

fig. 5)

```

1.1 1.2 1.3 Foundation DEG
σ = 0 at y, 4 ⇒ 5 | z, 4 ⇒ 5 | γ
= 0.000 | 2.054 | -42.225
Point 5: σ5 = 4.019E-6
σmin | max = -341.746 | 4.075E-6
-----
Main axis: 1.8145 · x - 2.3189
Neutral axis: 2.0539 - 0.9075 · x
Fertig

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fig. 6)

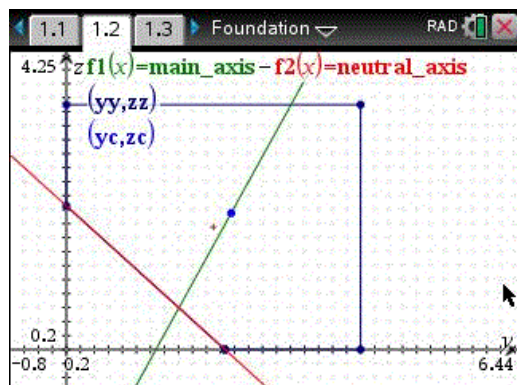


fig. 7

	A yy	B zz	C σ	D γ_neut.a
1	2.26323...	0	0.000004...	-42.22459
2	4.2	0	-114.247...	
3	4.2	3.5	-341.745...	
4	0	3.5	-93.9927...	
5	0	2.05394...	0.000004...	

fig. 8)

Fig. 7) depicts the neutral line (red), the main axis (green), the center (yc,zc) as a blue point, a + marks the center of the foundation.

### **HINTS and WARNINGS**

There must be at least one vertical force  $N_i$ , which may be input positive or negative.

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