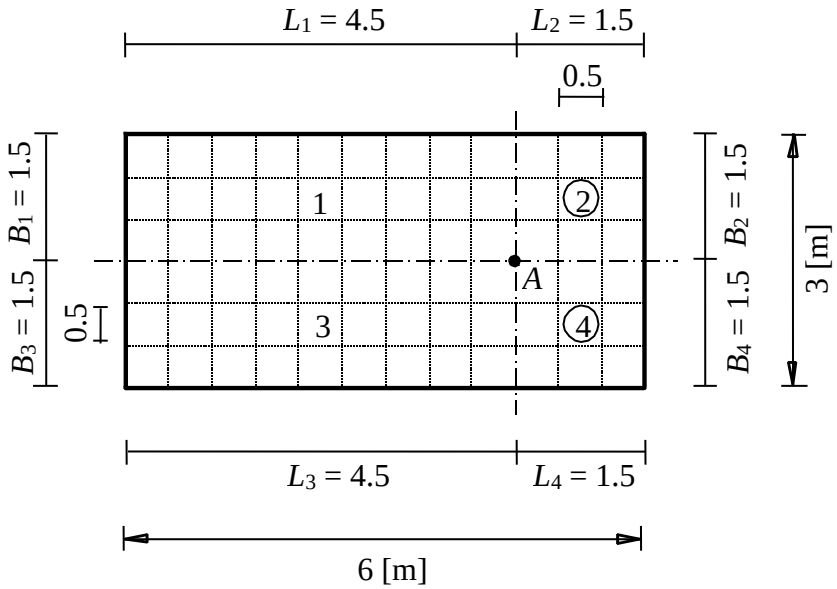
Example 1: Verifying stress on soil under a rectangular loaded area

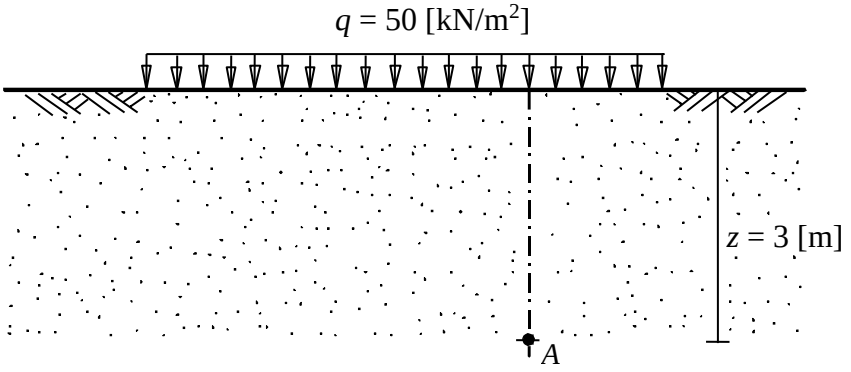
1 Description of the problem

To verify the vertical stress at any point *A* below a rectangular loaded area, the stress on soil obtained by *Das* (1983), Example 6.3, page 370, using influence coefficients of *Newmark* (1935) is compared with that obtained by *ELPLA.*

A distributed load of q = 50 [kN/m^2] acts on a flexible rectangular area 6 [m] × 3 [m] as shown in Figure 1. It is required to determine the vertical stress at a point *A*, which is located at a depth of z = 3 [m] below the ground surface.



a)



b)

Figure 1 a) Plan of the loaded area with dimensions and FE-Net

b) Cross section through the soil under the loaded area

2 Hand calculation of stress on soil

According to *Das* (1983), the stress on soil can be obtained by hand calculation as follows:

Newmark (1935) has shown that the stress on soil σ_z at a depth z below the corner of a uniformly loaded rectangular area $L \times B$ is given by

$$\sigma_z = q\, I_\sigma \text{ [kN/m}^2\text{]} \quad (1)$$

where I_σ [-] is the influence coefficient of the soil stress and is given by

$\mathbf{m^2}$

where $m = B/z$; $n = L/z$ [-]

The soil stress σ_z at a point A may be evaluated by assuming the stresses contributed by the four rectangular loaded areas using the principle of superposition as shown in Figure 1. Thus,

$$\sigma_z = q(\, I_{\sigma 1} + I_{\sigma 2} + I_{\sigma 3} + I_{\sigma 4}) \text{ [kN/m}^2\text{]} \quad (2)$$

The determination of influence coefficients for the four rectangular areas is shown in Table 1.

Table 1 Determination of influence coefficients for the four rectangular areas

Area No.	B [m]	L [m]	z [m]	$m = B/z$ [-]	$n = L/z$ [-]	I_σ [-]
1	1.5	4.5	3.0	0.5	1.5	0.131
2	1.5	1.5	3.0	0.5	0.5	0.085
3	1.5	4.5	3.0	0.5	1.5	0.131
4	1.5	1.5	3.0	0.5	0.5	0.085

The stress on soil is given by

$$\sigma_z = 50(\, 0.131 + 0.085 + 0.131 + 0.085) = 21.6 \text{ [kN/m}^2\text{]}$$

3 Stress on soil by *ELPLA*

The contact pressure in this example is known and distributed uniformly on the ground surface. Therefore, the available method "Flexible foundation 9" in *ELPLA* may be used here to determine the stress on soil due to a uniformly rectangular loaded area at the surface. This can be carried out by choosing the option "Determination of limit depth", where the limit depth calculation requires to know the stress on soil against the depth under the foundation. The location of the stress on soil under the loaded area can be defined at any position in *ELPLA*. Here the position of the point *A* is defined by coordinates x = 4.5 [m] and y = 1.50 [m]. In this example only the stress on soil is required. Therefore, any reasonable soil data may be defined. A net of square elements is chosen. Each element has a side of 0.5 [m] as shown in Figure 1a.

The stress on soil obtained by *ELPLA* under the loaded area at depth 3 [m] below the ground surface is σ_z = 21.5 [kN/m²] and nearly equal to that obtained by hand calculation.