Example 3.3 Influence of ground lowering on a building due to a tunnel

1 Description of the problem

Figure 3.10 shows a raft of a building that consists of two rectangular parts, which are completely connected. The raft is 50 [cm] thick and has a foundation depth of 2.50 [m] under the ground surface. It is planned to construct a tunnel diagonally to the building axis. A primary estimation expects that the tunnel will cause a settlement trough of about 9 [m] width with a maximum lowering of 3 [cm] for the building ground. The settlement trough is plotted in Figure 3.10 as contour lines, running symmetrically to the tunnel axis. The influence of the settlement trough due to construction of the tunnel is considered in the analysis of the raft. The raft carries two equal column loads, each of P = 18000 [kN] and line loads of p = 300 [kN/m] from edge walls. The edge walls have 0.30 [m] breadth and 3 [m] height.

2 Soil properties

The subsoil under the raft is defined by 3 boring logs B1 to B3 up to 14 [m] under the ground surface. The subsoil consists of two soil layers of clay and sandstone, which are not horizontally stratified as shown in Figure 3.10 and Table 3.1. *Poisson*'s ratio for the soil is ν_s = 0.3 [-].

Tabelle 3.1 Soil properties

Layer No.	Type of soil	Depth of layer underground surface z [m]	Modulus of compressibility of the soil for		Unit weight of the soil γ_s [kN/m^3]
			Loading E_s [kN/m^2]	Reloading W_s [kN/m^2]	
1 2	Clay Sandstone	5.5/ 6.3/ 7.0 14	10000 160000	30000 400000	18 21

3 Raft material and properties

The raft material is reinforced concrete and has the following properties:

Young's modulus E_b = 3 × 10^7 [kN/m^2]
Shear modulus G_b = 1.25 × 10^7 [kN/m^2]
Poisson's ratio ν_b = 0.2 [-]
Unit weight γ_b = 25 [kN/m^3]

The rigidity of the edge walls (0.30 [m] breadth and 3 [m] height) is simulated through beam elements along the raft edge with the following data:

Moment of inertia I = 0.675 [m^4]
Torsional inertia J = 0.0253 [m^4]

4 Analysis of the raft

The raft is subdivided into 112 square finite elements. Each element has a side of 1.5 [m] as shown in Figure 3.10. The analysis of the raft is carried out by the modulus of compressibility method (method 7). To consider the irregularity of subsoil under the raft, the flexibility coefficients are determined through bilinear interpolation. To examine the influence of the tunnel on the raft, the analysis of the raft is carried out first without consideration of the tunnel, then with consideration of the estimated settlements due to presence of the tunnel.

5 Results and discussion

The results of the settlements, contact pressures and moments are presented in Figures 3.11 to 3.13. It can be concluded from the figures that:

- The contact pressure under the columns become higher, while that at the field between columns become smaller

- Due to the effect of the tunnel, the settlement under the raft at area above the tunnel will increase while the contact pressure will decrease. The change in the moment at this area is also remarkable

- Moments become higher under the column, while that in the fields between columns become smaller. However, overall the change in the moments in this example is not great

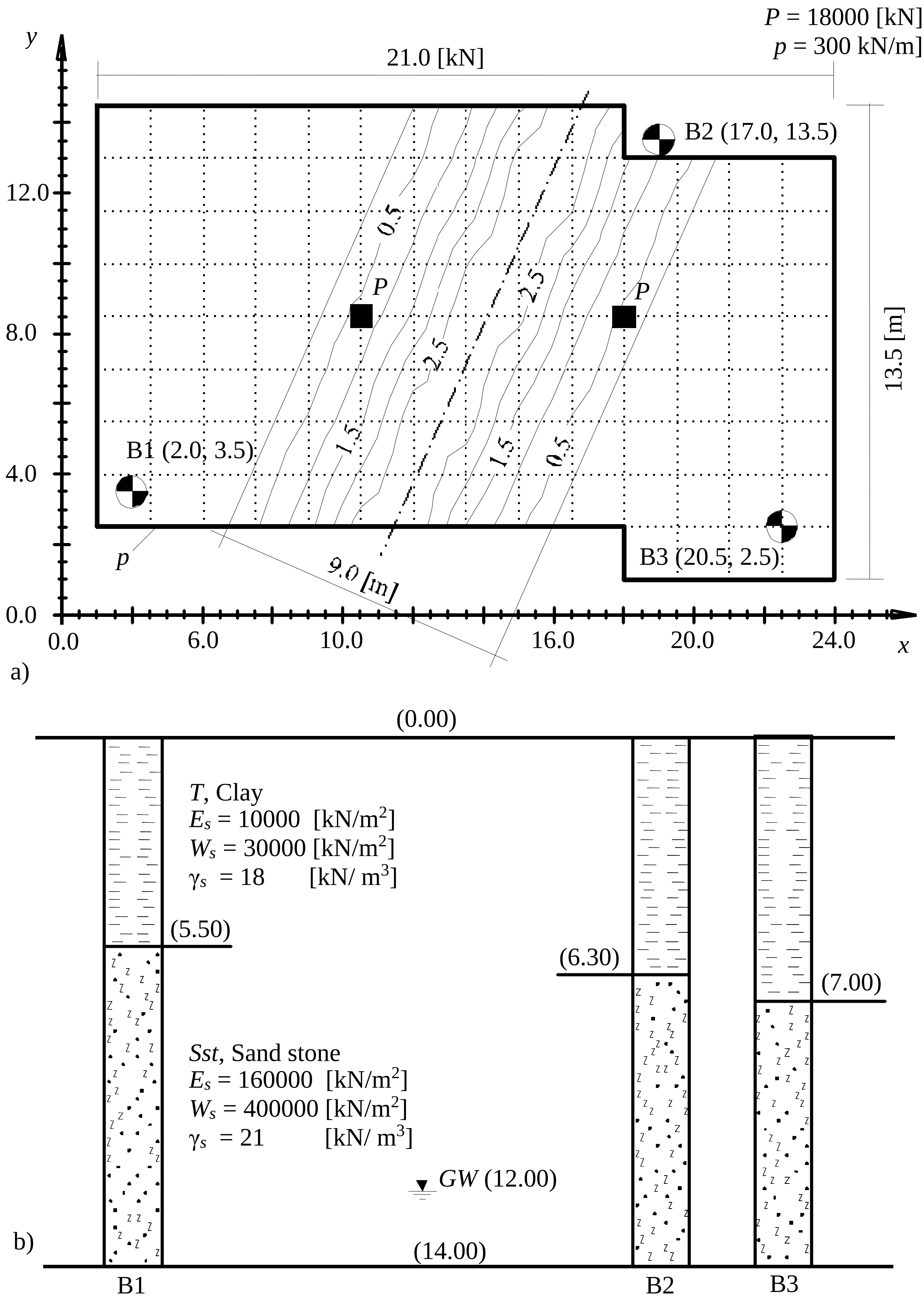
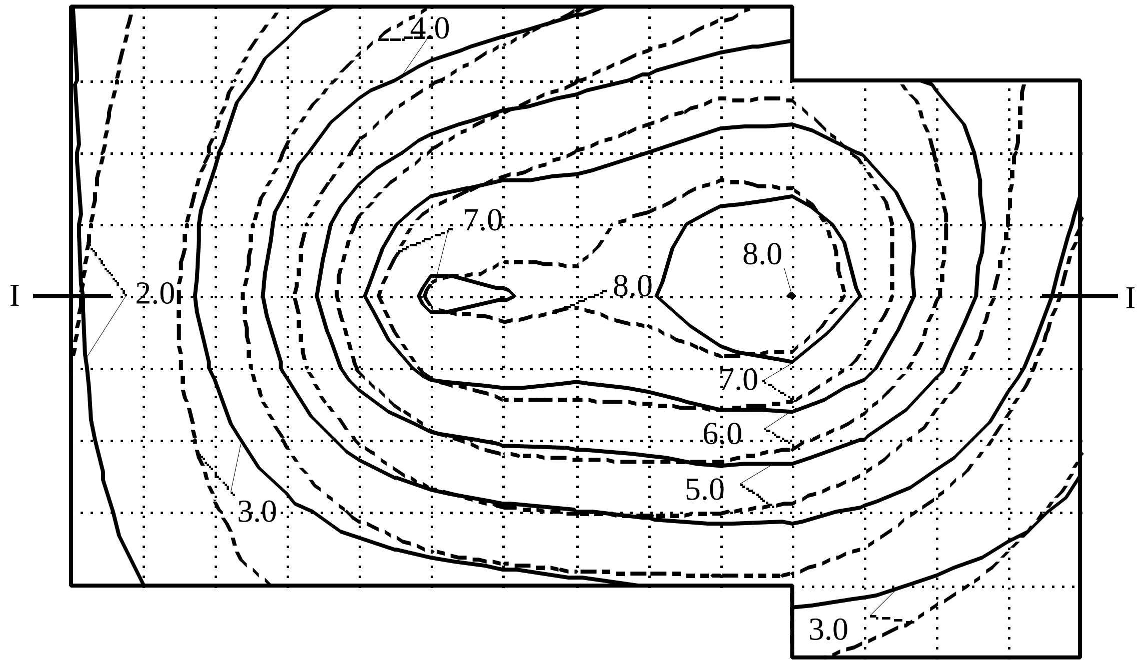
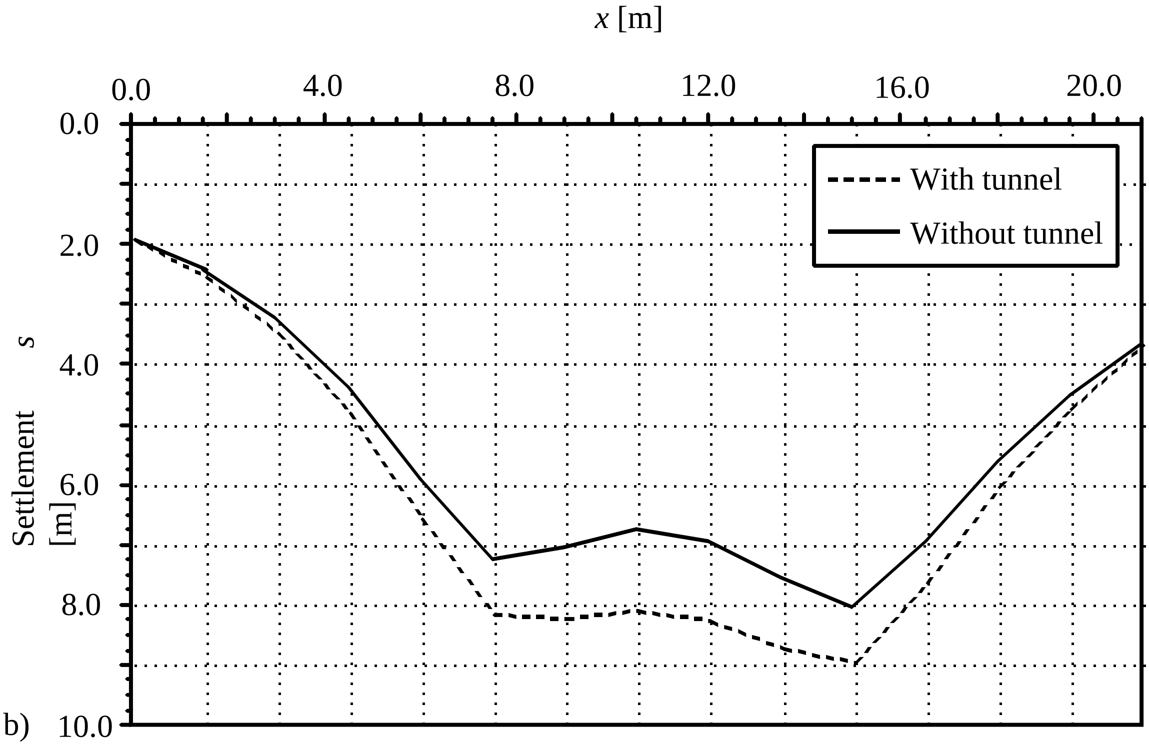


Figure 3.10 a) Raft plan, settlement trough due to tunnel as contour lines and loads
b) Boring logs B1 to B3

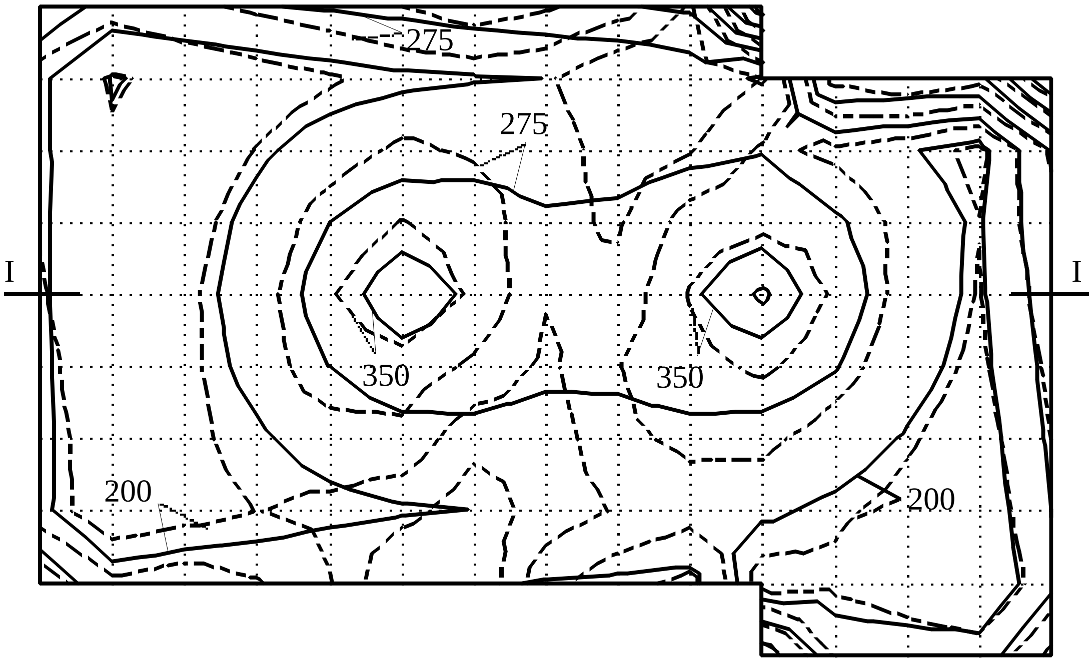


a)

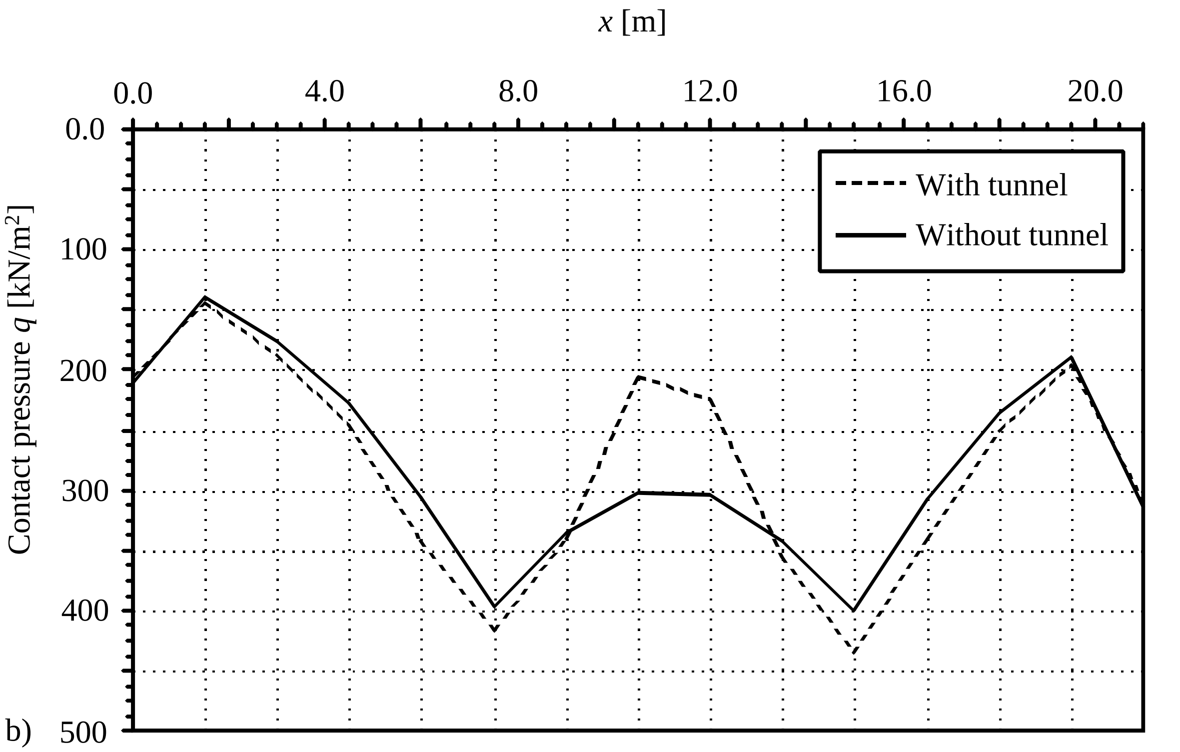


b)

Figure 3.11 Settlements *s* [cm] without and with consideration of the tunneling
a) Contour lines
b) Section I-I



a)



b)

Figure 3.12 Contact pressures q [kN/m^2] without and with consideration of the tunneling
a) Contour lines
b) Section I-I

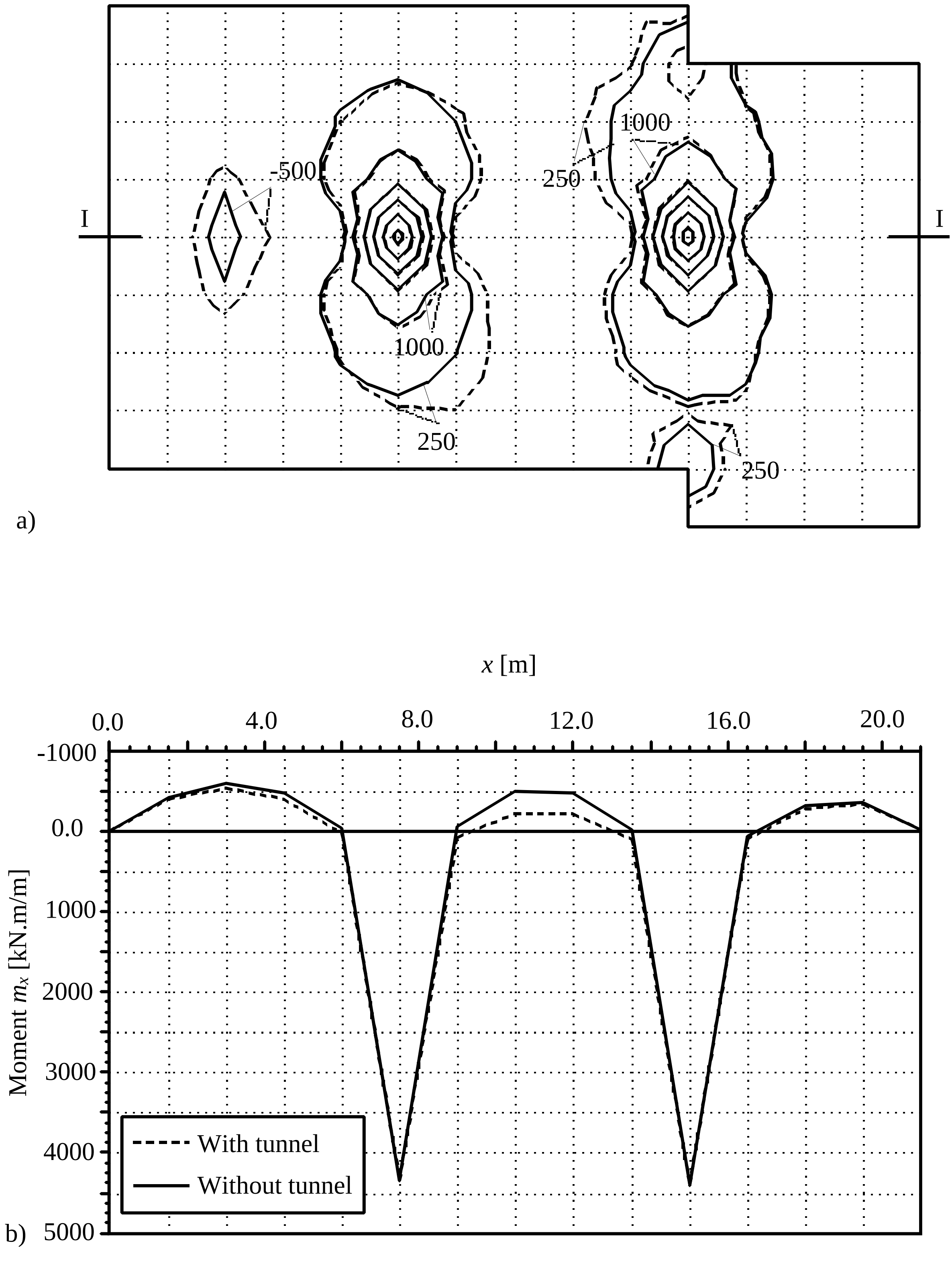


Figure 3.13 Moments m_x [kN.m/m] without and with consideration of the tunneling
a) Contour lines
b) Section I-I