Winkler subsoil model for foundation pad

IDEA StatiCa

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1 Winkler subsoil model

Winkler subsoil model provides stiffness corresponding to the stiffness of concrete foundation pad in bearing under each node of a base plate. Using this simplification, the number of nodes and therefore the calculation time are drastically decreased.

2 Concrete bearing stiffness

2.1 EC model

The stiffness of T-stub in compression including grout is specified in EN 1993-1-8, Table 6.11 as:

$$k_{13} = \frac{E_c \sqrt{b_{eff}/l_{eff}}}{1.275E}$$

where:

- E_c – Young modulus of elasticity of concrete
- b_{eff} – width of the T-stub
- l_{eff} – length of the T-stub
- E – Young modulus of elasticity of steel

The resulting unit is [m].

2.2 Soil mechanics

Winkler subsoil model is often used in soil mechanics for infinite subsoil under a foundation. The stiffness is specified as:

$$k = \frac{\Delta p}{\Delta s}$$

where:

- Δp – pressure increment
- Δs – deformation increment

The resulting unit is [kN/mm^3]. For solid rock, the stiffness of $k = 5000 \div 15000$ kN/mm^3 is recommended.

2.3 Numerical experiments

The stiffness of concrete in bearing is nearly impossible to measure experimentally because it is very high. Measurement of both stress in concrete and deformation is difficult. Therefore, numerical experiments were performed to determine the stiffness of concrete in bearing. Two software were used – Midas FEA and ATENA. Various parameters were selected:

- Concrete grade
- Concrete pad dimensions
- Column cross-section shape and dimensions
- Subsoil stiffness under the foundation pad
- Compressive load magnitude

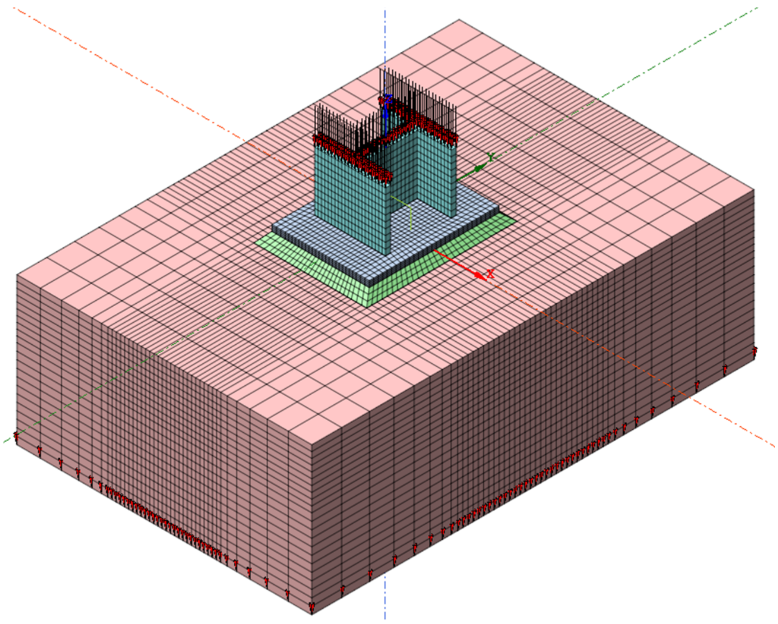

Figure 1: Typical finite element model to determine concrete stiffness in bearing

The parametric study led to graphs of stiffness in dependence on the selected variable. By curve-fitting, a formula for concrete stiffness in bearing was derived:

$$k = \frac{E_c}{(\alpha_1 + \nu)\sqrt{\frac{A_{eff}}{A_{ref}}}} \left(\frac{1}{\frac{h}{\alpha_2 d} + \alpha_3} + \alpha_4 \right)$$

where:

- E_c – Young modulus of elasticity of concrete [Pa]
- ν – Poisson coefficient of concrete [-]
- A_{eff} – base plate area in contact with concrete [m^2]
- $A_{ref} = 10$ m^2 – reference area
- h – concrete pad height [m]

- d – width of the effective area [m]
- parameters for curve-fitting:

$$\alpha_1 = 1.65$$
$$\alpha_2 = 0.5$$
$$\alpha_3 = 0.3$$
$$\alpha_3 = 1.0$$

3 Comparison

The shortcoming of the Winkler subsoil model is that the stiffness under the base plate is not constant. While the highest deformation is usually in the middle, the principal stress is the largest in the corner.

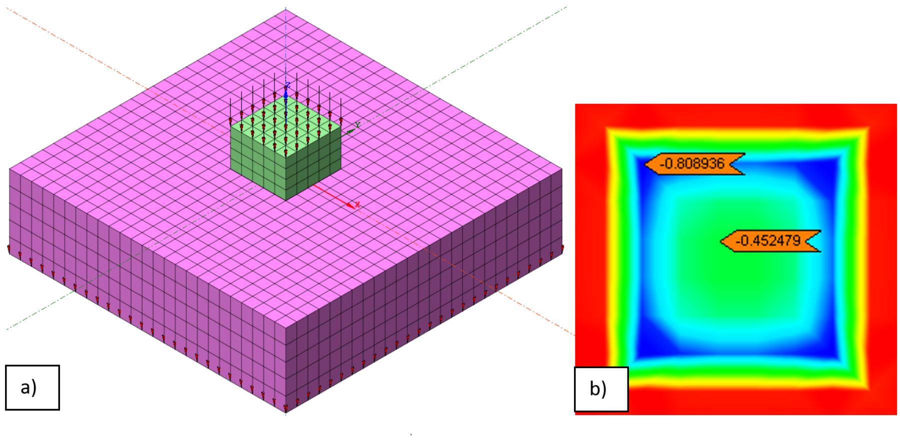

Figure 2: a) Model of steel block being pushed into concrete pad, b) principal stress in concrete

However, as can be seen from the comparison in the following figure, the stresses under the base plate using solid 3D elements and Winkler subsoil are nearly identical.

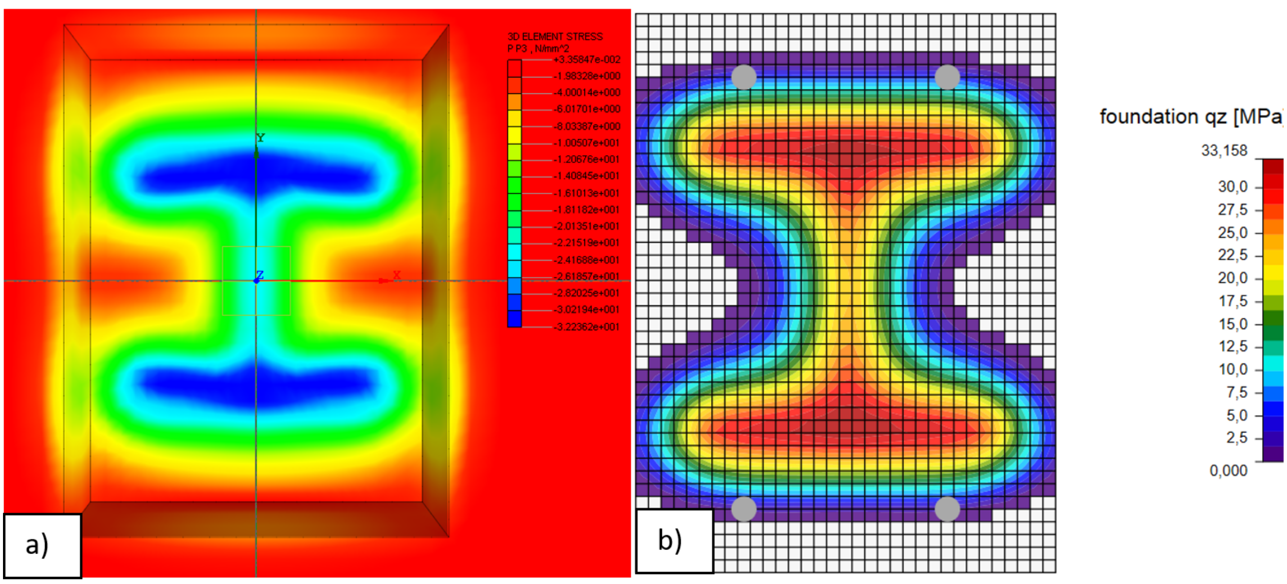

Figure 3: a) principal stress in the concrete 3D model, b) compressive stress under base plate using Winkler subsoil model