VERIFICATION OF CONCRETE COMPRESSIONS

Verification of concrete compressions per Eurocode

In which cases does PROFIS Engineering verify compressions in concrete

PROFIS Engineering with option CBFEM verifies compressions in concrete, in case there is external compression and/or bending moment acting on the base plate.

Background about compression verification performed by PROFIS Engineering

For steel-to-concrete joints under compression, the T-Stub method in EN1993-1-8 is used to assess base plates in compression.

This method is especially applicable for joint foundations in I-shape beams, where the compressed area near a compressed flange is considered.

The resistance of concrete in 3D compression is determined based on EN 1993-1-8 [1] by calculating the design bearing strength of concrete in the connection, f_{jd}, under the effective area, A_{eff}, of the base plate. The design bearing strength of the joint, f_{jd}, is evaluated according to Cl. 6.2.5 in EN 1993-1-8 and Cl. 6.7 in EN 1992-1-1. The grout quality and thickness is introduced by the connection coefficient, β_{jd}. For grout quality equal or better than the quality of the concrete block, $\beta_{jd} = 1.0$ is expected. The effective area, $A_{eff,cm}$ under the base plate is estimated to be of the shape of the column cross-section increased by additional bearing width, c.

$$c = t\sqrt{\frac{f_y}{3 f_i \gamma_{M0}}}$$

where t is the thickness of the base plate, f_y is the base plate yield strength and γ_{M0} is the partial safety factor for steel.

The effective area is calculated by iteration until the difference between the additional bearing widths of current and previous iteration $|ci - ci - 1|$ is less than 1 mm.

The area where the concrete is in compression is taken from results of FEA. This area in compression, $A_{eff,FEM}$, allows determining the position of the neutral axis.

The intersection of the area in compression, $A_{eff,FEM}$, and the effective area, $A_{eff,cm}$, allows to assess the resistance for generally loaded column base of any column shape with any stiffeners and is labeled A_{eff}. The average stress σ on the effective area, A_{eff}, is determined as the compression force divided by the effective area. Check of the component is in stresses $\sigma \leq f_{jd}$

Concrete resistance at concentrated compression:

$$f_{jd} = \beta_j k_j \frac{f_{ck}}{\gamma_c}$$

Average stress under the base plate:

$$\sigma = \frac{N}{A_{eff}}$$

Utilization in compression [%]:

$$Ut = \frac{\sigma}{f_{jd}}$$

where:

- f_{ck} – characteristic compressive concrete strength
- $\beta_j = 0.67$ – factor of grout quality editable in Code setup
- k_j – concentration factor
- γ_c – safety factor for concrete
- A_{eff} – effective area on which the column normal force *N* is distributed, per Table 1.

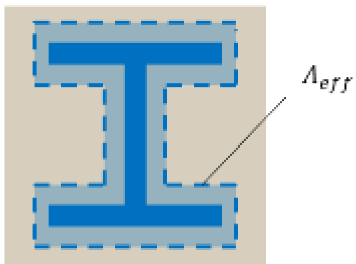
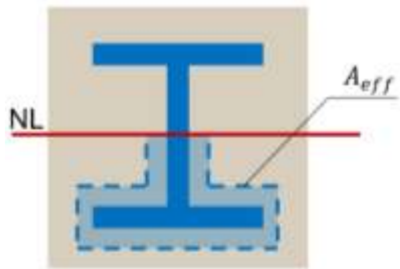
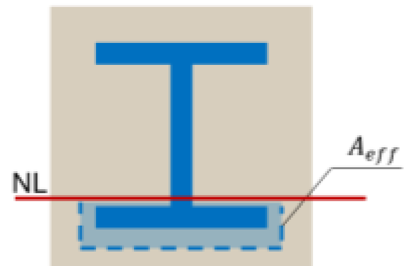
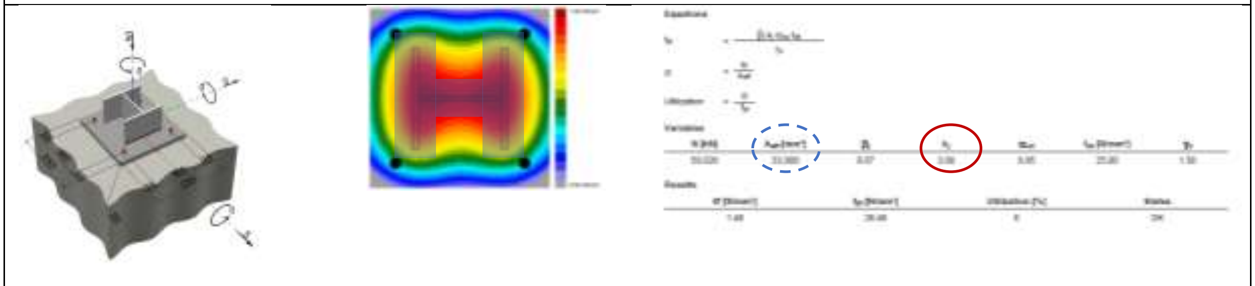
Case 1:	**Case 2:**	**Case 3:**
Compressions only	Bending and compression	Bending and compression
		
Effective area around the column	Effective area around the compressed part of the column	Effective area around the compressed part of the column
NL = Neutral Line		

Table 1: Effective area of the column, adapted from EC3 – FAQ, Watford, September 2003

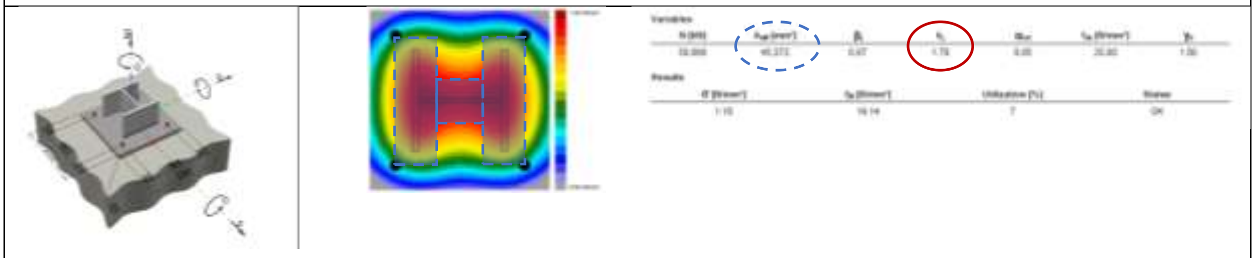
In Table 2 there are some examples of calculations of A_{eff} and k_j factors in PROFIS Engineering. The A_{eff} is mainly dependent on the area of compression around the profile, whereas k_j is related to the concrete element dimensions.

Both these variables are determined iteratively within the finite element.

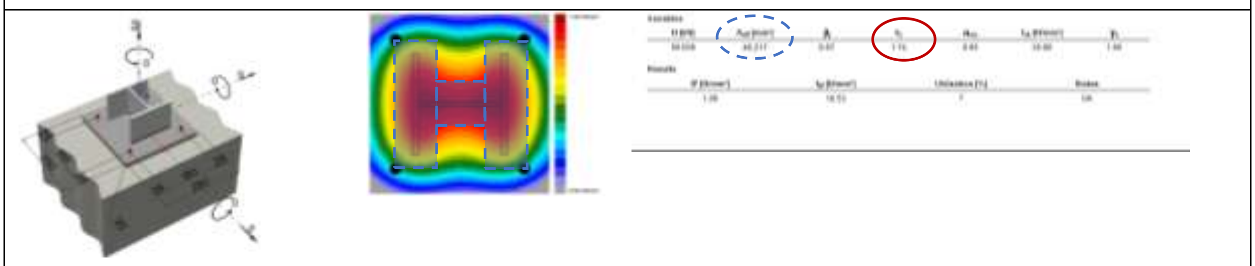
Example 1 : Large edge distance, large concrete thickness – Compression only



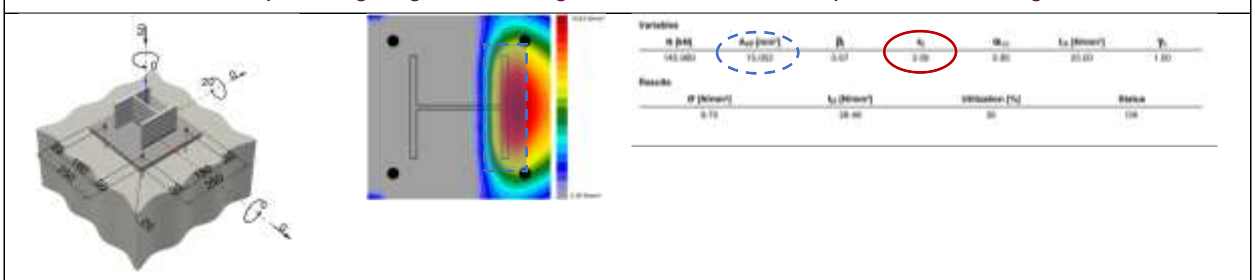
Example 2: Large edge distance, small concrete thickness – Compression only



Example 3: Small edge distance, large concrete thickness – Compression only



Example 4: Large edge distance, large concrete thickness – Compression and Bending



Example 5 – Small edge distance, large concrete thickness – Compression and Bending

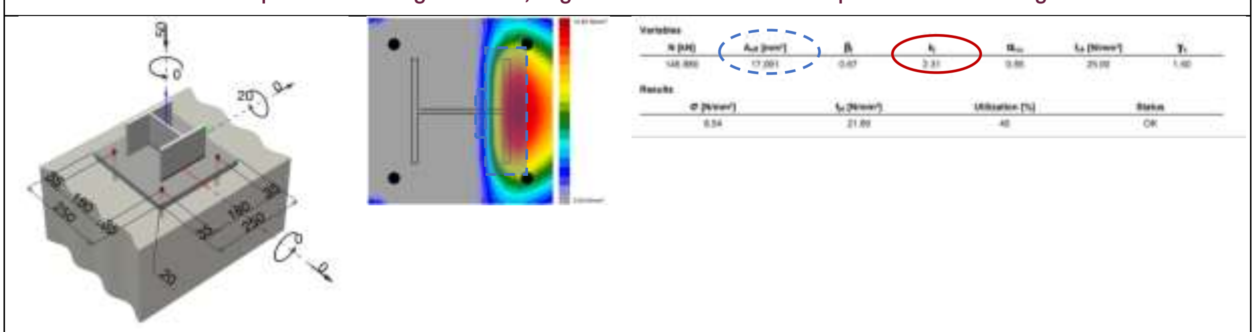
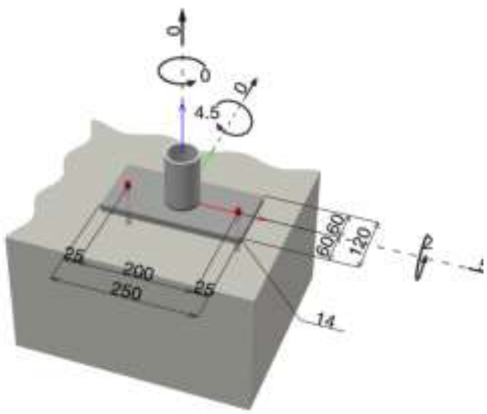


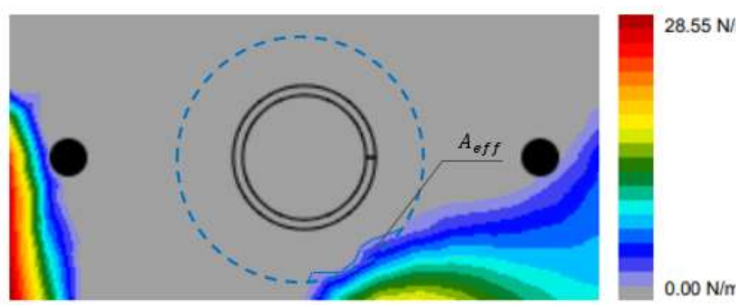
Table 2: Examples of base plate calculations for A_{eff} and k_j.

Understanding results where concrete resistance to compression is very low, although no significant compressions are applied.

In the example below, a base plate is subjected to bi-axial bending, and the compression area is acting far away from the profile. In PROFIS Engineering, A_{eff} is considered the area of compression around the profile.

In this case, the area of compression is very close to zero, hence the resistance to concrete compressions is very small.





2.5.2 Verification of compression in concrete under the anchor plate around the profile as per EN1992-1 section 6.7 and EN1993-1-8, section 6.2.5

Equations

$$f_{jd} = \frac{\beta_j \, k_j \, \alpha_{cc} \, f_{ck}}{\gamma_c}$$

$$\sigma = \frac{N}{A_{eff}}$$

$$\text{Utilization} = \frac{\sigma}{f_{jd}}$$

Variables

N [kN]	A_{eff} [mm²]	β_j	k_j	α_{cc}	f_{ck} [N/mm²]	γ_c
56.530	129	0.67	3.00	0.85	25.00	1.50

Results

σ [N/mm²]	f_{jd} [N/mm²]	Utilization [%]	Status
437.22	28.48	1,536	NOT OK

Possible solutions to still verify Cl. 6.2.5 in EN 1993-1-8 pass by increasing the area A_{eff}.

Some examples that help in general:

- Reducing the base plate area
- Increase thickness of the plate
- Add stiffeners

However, there are cases where, there is simply no overlap between the areas of compression below the plate, and the profile. These cases must be determined per engineering judgement, outside of PROFIS Engineering.