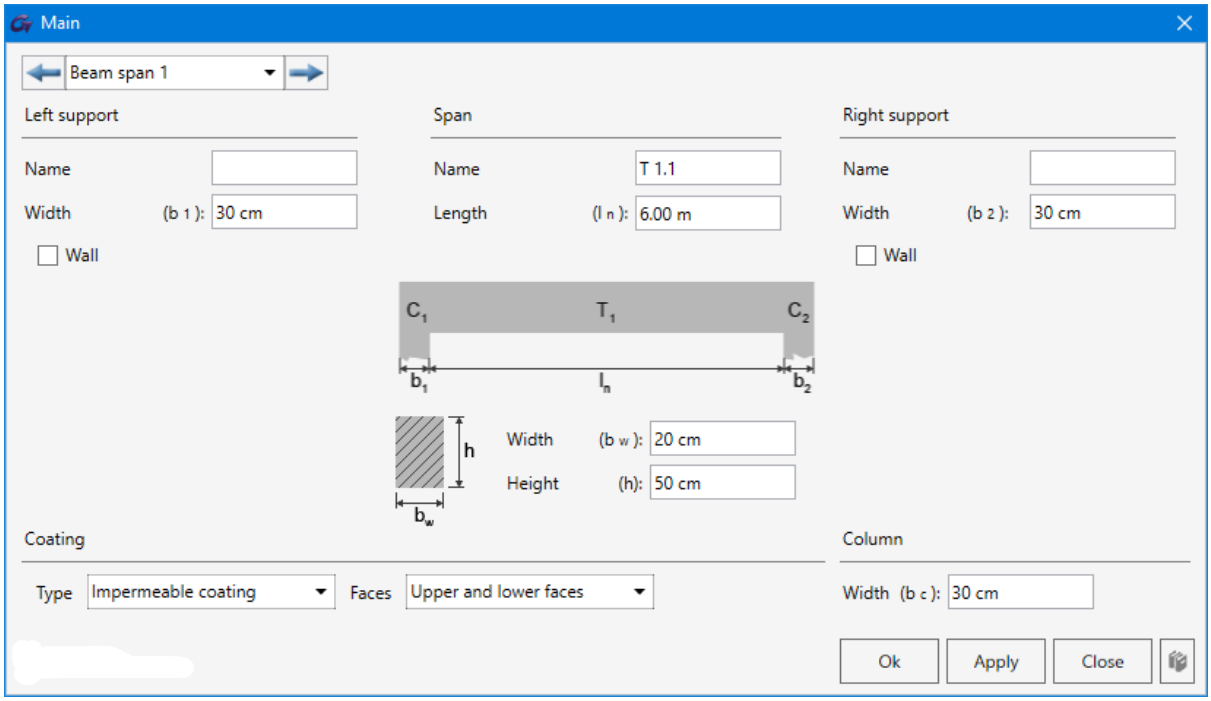
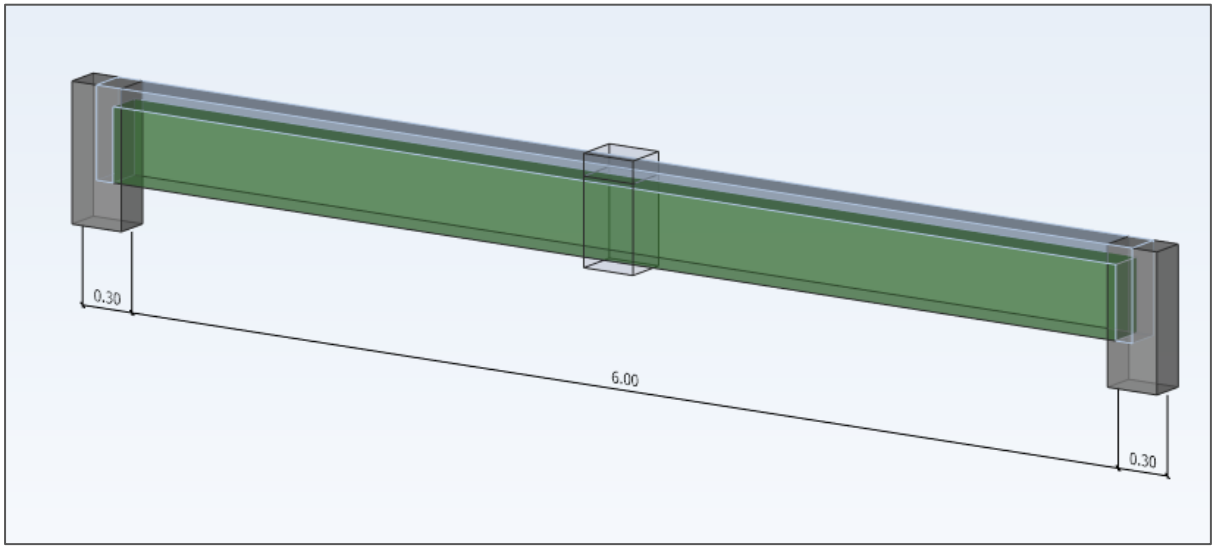
Lifting hooks calculation

General data and assumptions

A lifting hook is a looped shaped smooth rebar of S235C, anchored in the precast unit and used for demoulding, transportation and lifting.

The considered beam has a rectangular section of 0.20x0.50 m and a length of 6.00 m. The designated concrete class is 25/30, while the steel is S500.

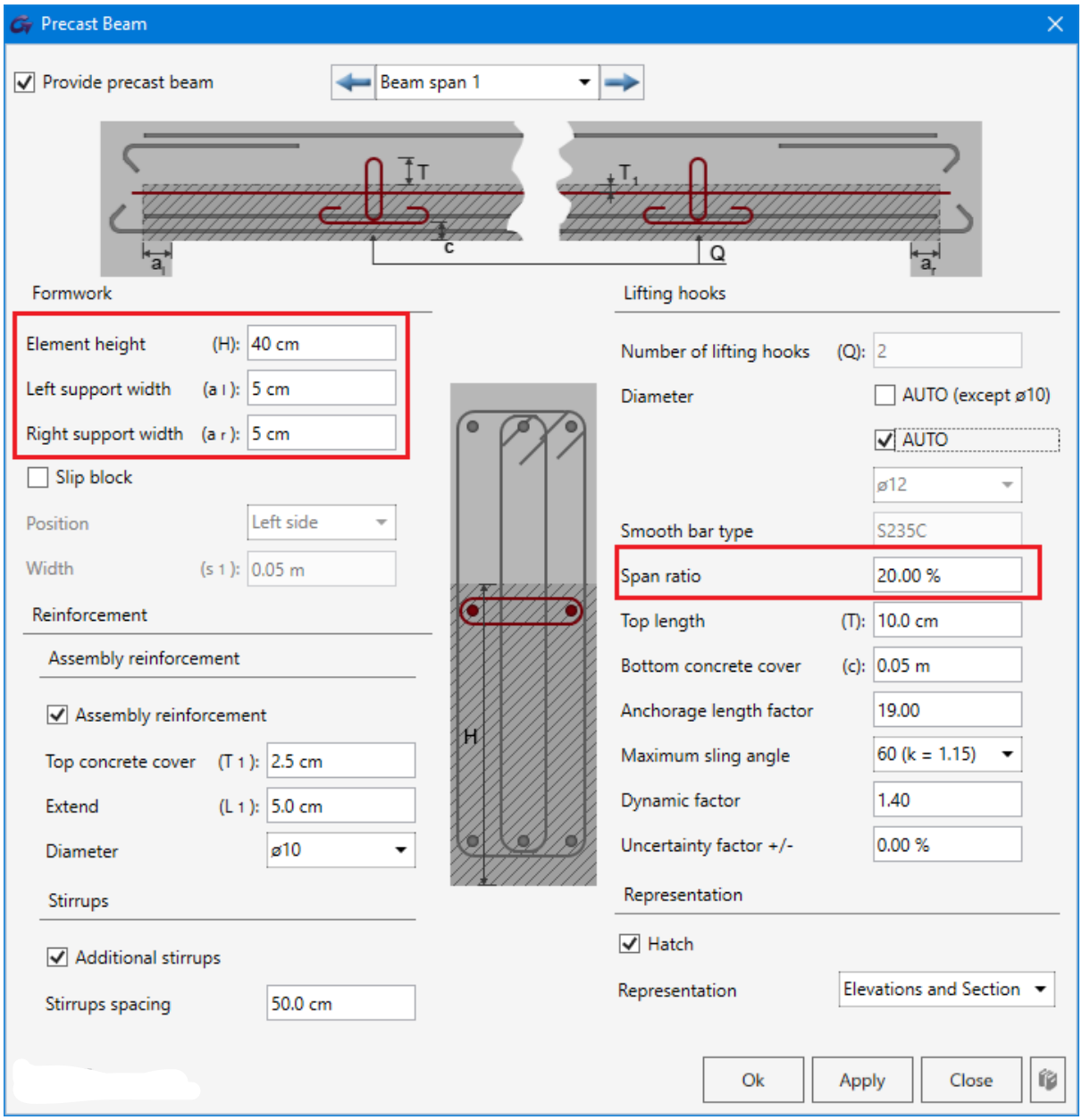




The measurements for the precast section are 0.20m x 0.40m. In addition, the precast beam stands 5 cm on the right (a_r) and the left (a_l) supports. The dimensions determine the following length of the precast beam:

$$L_{precast} = L + a_l + a_r = 6.00m + 0.05m + 0.05m = 6.10m$$

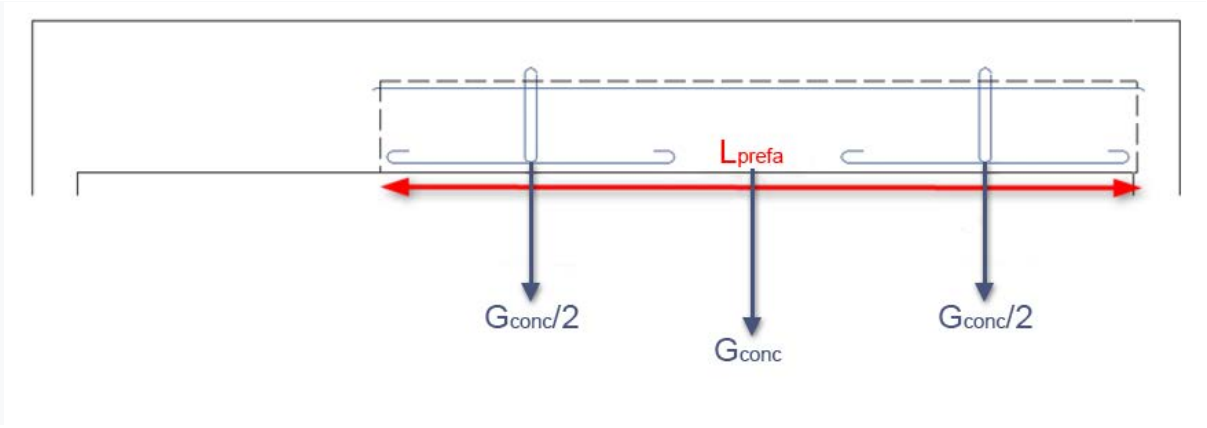
The lifting hooks will be positioned at a distance from the edge of the precast part of beam equal to 20% of the length of the precast beam. In this particular example, the hooks will be at 0.2*6.10m=1.22m.

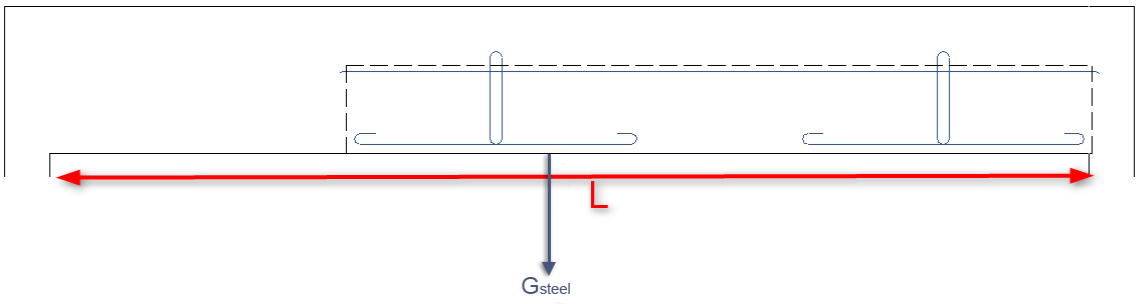


The lifting hooks are determined considering the effort resulted from the precast beam self-weight (concrete + reinforcement) multiplied by several coefficients.

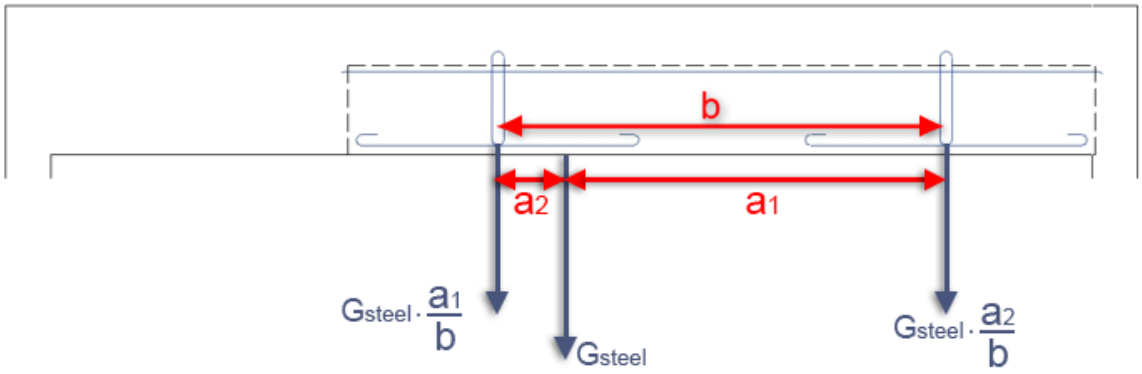
The efforts distribution in each lifting hook are represented in the following images.

Moreover, the self-weight of precast concrete is divided to each hook in the following manner:





If the precast beam is at a distance away from a support, the effort for each hook from rebars weight is distributed in accordance with the image below:



Note: Only rebars that intersect the precast beam are considered in rebars weight calculation.

The effort in the first hook: $F_1 = \frac{G_{conc}}{2} + G_{steel} \times \frac{a_1}{b}$

The effort in the second hook: $F_2 = \frac{G_{conc}}{2} + G_{steel} \times \frac{a_2}{b}$

The weight of the precast beam : $G_{conc} = \rho_{unreinforced} \times V_{precast}$

$$G_{conc} = 22.565 \frac{kN}{m^3} \times 0.488 m^3 = 11.01 kN$$

The density of unreinforced concrete:

$$\rho_{unreinforced} = 2.301 \frac{T}{m^3}$$

$$\rho_{\text{unreinforced}} = 2.301\frac{\text{T}}{\text{m}^3} \times 9.8066\frac{\text{m}}{\text{s}^2} = 22.565\frac{\text{kN}}{\text{m}^3}$$

The volume of the precast beam:

$$\text{V}_{\text{precast}} = \text{L}_{\text{precast}} \times \text{Section}_{\text{Precast}}$$

$$\text{V}_{\text{precast}} = 6.10\text{m} \times 0.20\text{m} \times 0.40\text{m} = 0.488\text{m}^3$$

The distance between the beam reinforcement's center of gravity and the right hook :

$$\text{a}_1 = \frac{\text{L}}{2} + \text{a}_\text{l} - \text{Spanratio} \times \text{L}_{\text{precast}}$$

$$\text{a}_1 = \frac{6.00\text{m}}{2} + 0.05\text{m} - 0.2 \times 6.10\text{m} = 1.83\text{m}$$

The distance between the beam reinforcement's center of gravity and the left hook :

$$\text{a}_2 = \frac{\text{L}}{2} + \text{a}_\text{r} - \text{Spanratio} \times \text{L}_{\text{precast}}$$

$$\text{a}_2 = \frac{6.00\text{m}}{2} + 0.05\text{m} - 0.2 \times 6.10\text{m} = 1.83\text{m}$$

The total distance between the hooks :

$$\text{b} = \text{a}_\text{l} + \text{a}_2$$

$$\text{a}_1 = 1.83\text{m} + 1.83\text{m} = 3.66\text{m}$$

For the selfweight of the steel, only the rebar that intersects the precast beam is considered.

$$\text{G}_{\text{steel}} = 0.33\text{kN}$$

The total weight of the precast beam is:

$$\text{G}_{\text{precast}} = \text{G}_{\text{conc}} + \text{G}_{\text{steel}}$$

$$\text{G}_{\text{precast}} = 11.01 + 0.33 = 11.34\text{kN}$$

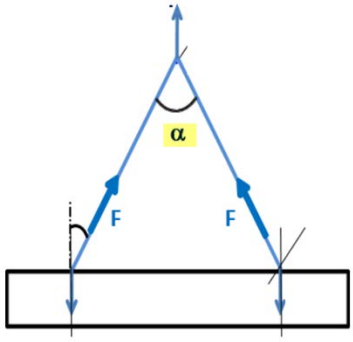
Coefficients

The effort in each lifting hook is multiplied by the following coefficients:

- Dynamic factor (γ_{dyn}): takes into account the dynamic effect of lifting the beam; the weight of the precast beam must be increased by a dynamic coefficient.

$$\gamma_{dyn}=1.6$$

- Slinging coefficient (γ_α): depends on the top slinging angle (α); the weight of the precast beam will also be increased.

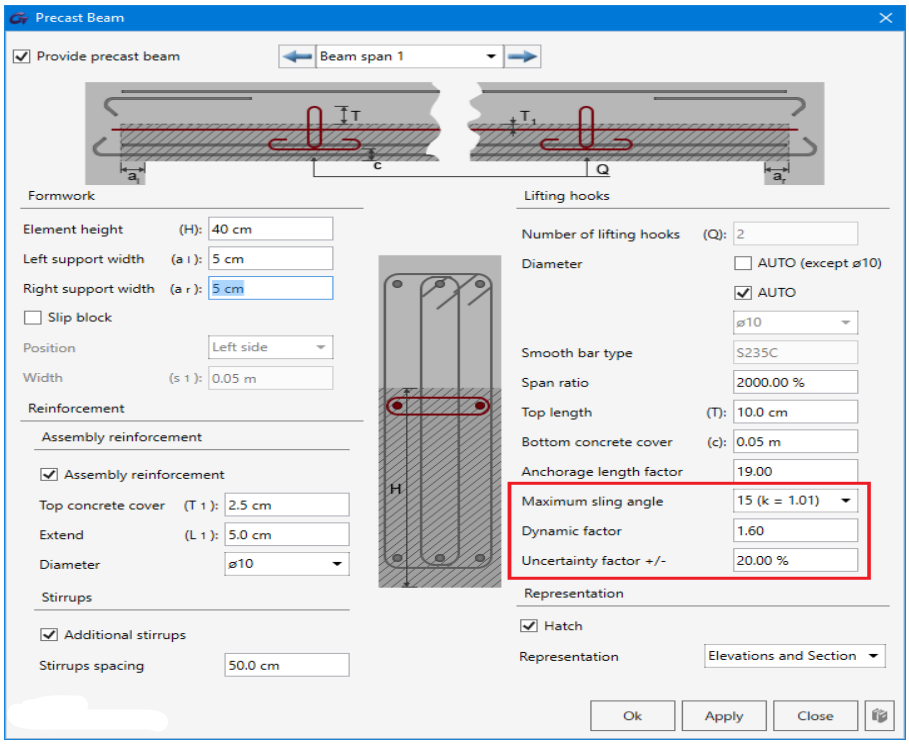


Angle α	0°	15°	22,5°	45°	60°
Slinging coefficient	1	1,0086	1,0205	1,08	1,15

Sling angle: α=15°=> Slinging coefficient γ_α =1.0086

- Uncertainty factor (p%): increases the precast beam self-weight to take into account some unexpected situations.

p%=20%



Efforts in lifting hooks

Resulting efforts for calculating lifting hooks are the following:

- First lifting hook maximum effort:

$$F_{1max} = \left(\frac{G_{conc}}{2} + G_{steel} \times \frac{a_1}{b}\right) \times \gamma_{dyn} \times \gamma_\alpha \times (1 + p\%)$$

$$F_{1max} = \left(\frac{11.01}{2} + 0.33 \times \frac{1.83}{3.66}\right) \times 1.6 \times 1.0086 \times (1 + 20\%)$$

$$F_{1max} = 10.99kN$$

- First lifting hook minimum effort:

$$F_{1min} = \left(\frac{G_{conc}}{2} + G_{steel} \times \frac{a_1}{b}\right) \times (1 - p\%)$$

$$F_{1min} = \left(\frac{11.01}{2} + 0.33 \times \frac{1.83}{3.66}\right) \times (1 - 20\%)$$

$$F_{1min} = 4.54kN$$

- Second lifting hook maximum effort:

$$F_{2max} = \left(\frac{G_{conc}}{2} + G_{steel} \times \frac{a_2}{b}\right) \times \gamma_{dyn} \times \gamma_{\alpha} \times (1 + p\%)$$

$$F_{2max} = \left(\frac{11.01}{2} + 0.33 \times \frac{1.83}{3.66}\right) \times 1.6 \times 1.0086 \times (1 + 20\%)$$

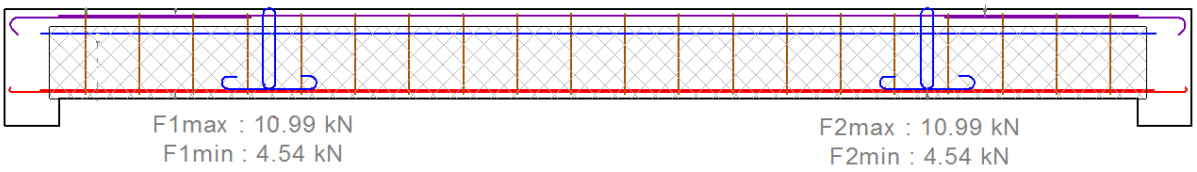
$$F_{2max} = 10.99kN$$

- Second lifting hook minimum effort:

$$F_{2min} = \left(\frac{G_{conc}}{2} + G_{steel} \times \frac{a_1}{b}\right) \times (1 - p\%)$$

$$F_{2min} = \left(\frac{11.01}{2} + 0.33 \times \frac{1.83}{3.66}\right) \times (1 - 20\%)$$

$$F_{2min} = 4.54kN$$



$$F_{max} = \max(F_{1max}; F_{2max}) = 10.99kN$$

Required diameter

Admissible forces for a lifting hook, depending on its diameter are presented in the following table:

Diamètre (mm)	10	12	14	16	20	25	32	40
Force (T)	1,5	2,2	3	4	6	9,5	15,5	24

The admissible force is multiplied by "1- γ_w ", in which γ_w is a weakening hook factor:

$$\gamma_w = \frac{\alpha}{20} \times 15\% = \frac{15}{20} \times 15\% = 0.1125$$

$$F_{max} = F_{adm} \times (1 - \gamma_w) \Rightarrow \frac{F_{max}}{1 - \gamma_w} < F_{adm} \Rightarrow required\ diameter$$

To change the units from kiloNewton to tones, the software divides the value of the acceleration due gravity:

$$\frac{F_{max}}{1 - \gamma_w} = \frac{10990N}{9.81\frac{m}{s^2} \times (1 - 0.1125)} = 1.26 < 1.5 \Rightarrow D_{rqrd} = 10mm$$

The diameter of the lifting hook can be manually imposed by unchecking the AUTO box and selecting a new diameter from the drop-down list.