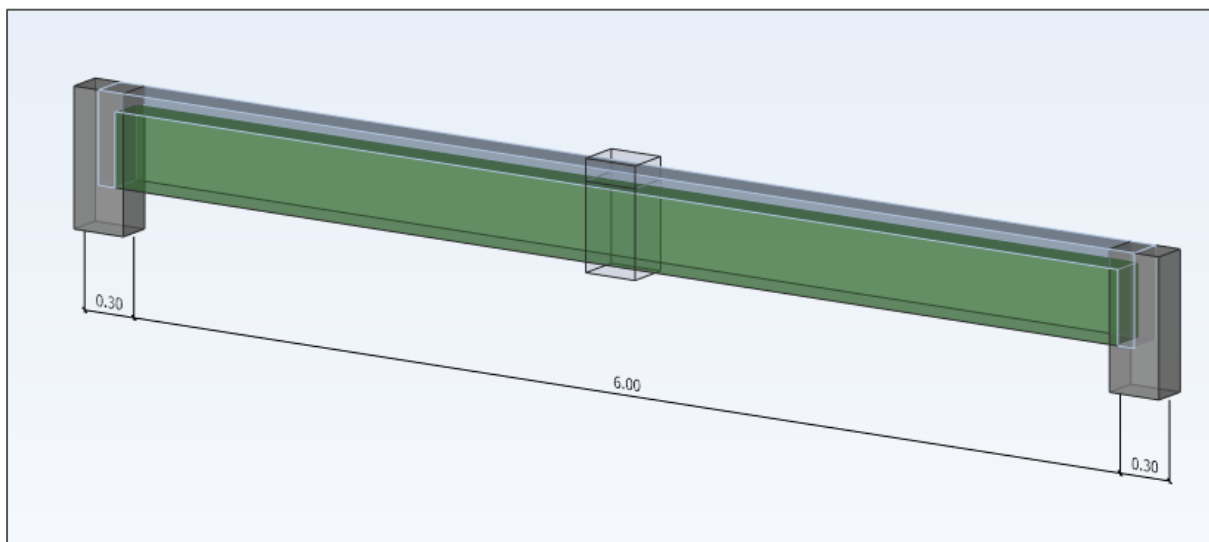


# Lifting hooks calculation

## 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:

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

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  $0.2 \cdot 6.10\text{m} = 1.22\text{m}$ .

**Precast Beam**

Provide precast beam    Beam span 1

**Formwork**

Element height (H): 40 cm

Left support width (a l): 5 cm

Right support width (a r): 5 cm

Slip block

Position: Left side

Width (s 1): 0.05 m

**Reinforcement**

Assembly reinforcement

Assembly reinforcement

Top concrete cover (T 1): 2.5 cm

Extend (L 1): 5.0 cm

Diameter: ø10

Stirrups

Additional stirrups

Stirrups spacing: 50.0 cm

**Lifting hooks**

Number of lifting hooks (Q): 2

Diameter:  AUTO (except ø10)  AUTO ø12

Smooth bar type: S235C

Span ratio: 20.00 %

Top length (T): 10.0 cm

Bottom concrete cover (c): 0.05 m

Anchorage length factor: 19.00

Maximum sling angle: 60 (k = 1.15)

Dynamic factor: 1.40

Uncertainty factor +/-: 0.00 %

Representation

Hatch

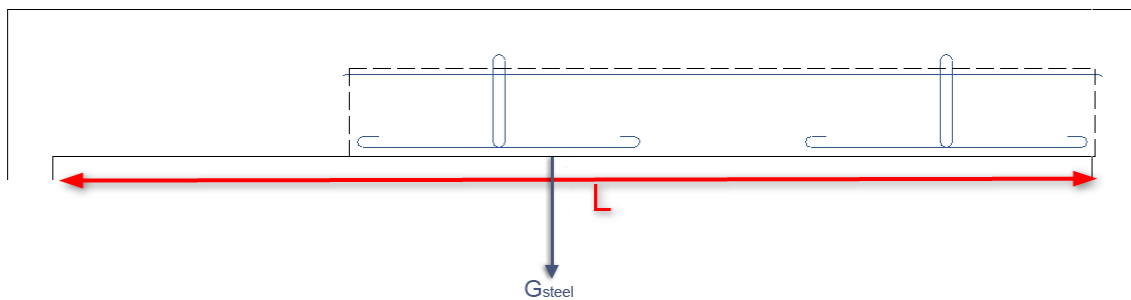
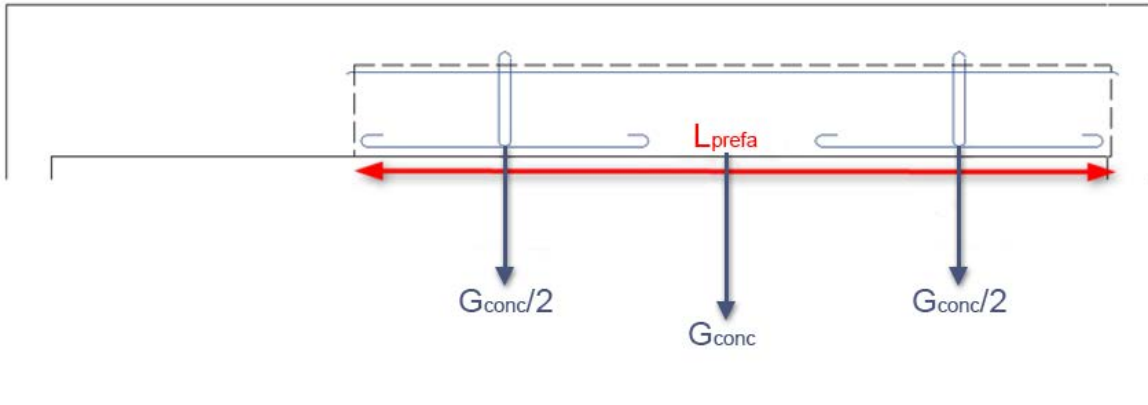
Representation: Elevations and Section

Ok    Apply    Close

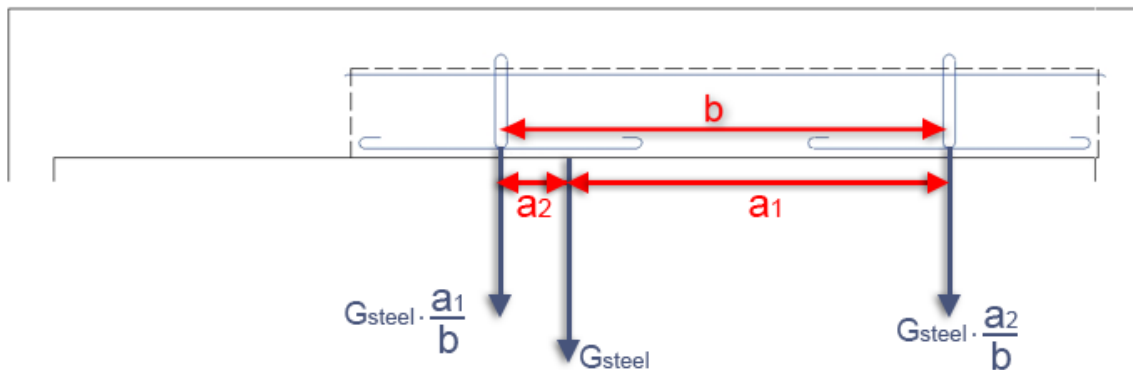
The lifting hooks are determined considering the effort resulted from the precast beam self-weight (concrete + reinforcement) multiplied by several coefficients.

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 rebar weight is distributed in accordance with the image below:



**Note:** Only rebars that intersect the precast beam are considered in rebar 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 :  $G_{conc} = \rho_{unreinforced} \times V_{precast}$

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

The density of unreinforced concrete:

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

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

The volume of the precast beam:

$$V_{\text{precast}} = L_{\text{precast}} \times \text{Section}_{\text{precast}}$$

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

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

$$a_1 = \frac{L}{2} + a_l - \text{Spanratio} \times L_{\text{precast}}$$

$$a_1 = \frac{6.00\text{m}}{2} + 0.05\text{m} - 0.2 \times 6.10\text{m} = 1.83\text{m}$$

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

$$a_2 = \frac{L}{2} + a_r - \text{Spanratio} \times L_{\text{precast}}$$

$$a_2 = \frac{6.00\text{m}}{2} + 0.05\text{m} - 0.2 \times 6.10\text{m} = 1.83\text{m}$$

The total distance between the hooks :

$$b = a_1 + a_2$$

$$a_1 = 1.83\text{m} + 1.83\text{m} = 3.66\text{m}$$

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

$$G_{\text{steel}} = 0.33\text{kN}$$

The total weight of the precast beam is:

$$G_{\text{precast}} = G_{\text{conc}} + G_{\text{steel}}$$

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

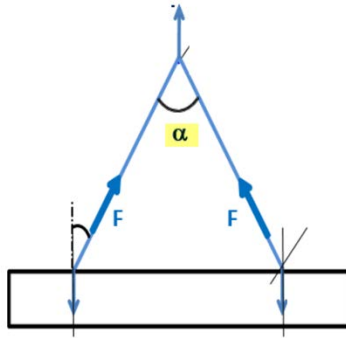
## **Coefficients**

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

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

$$\gamma_{\text{dyn}} = 1.6$$

- Slings coefficient ( $\gamma_{\alpha}$ ): depends on the top slinging angle ( $\alpha$ ); the weight of the precast beam will also be increased.

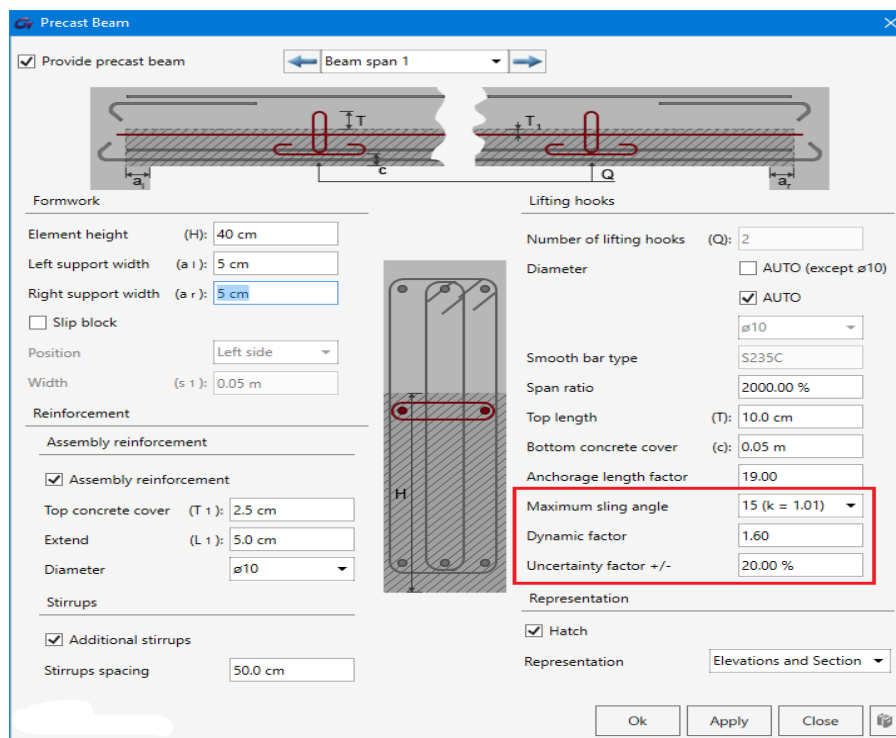


Angle α	0°	15°	22,5°	45°	60°
Slinging coefficient	1	1,0086	1,0205	1,08	1,15

Sling angle:  $\alpha=15^\circ \Rightarrow$  Slinging coefficient  $\gamma_\alpha = 1.0086$

- 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:

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

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

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

- First lifting hook minimum effort:

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

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

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

- Second lifting hook maximum effort:

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

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

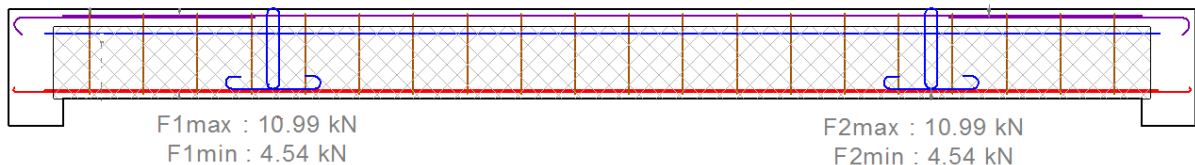
$$F_{2\max} = 10.99\text{kN}$$

- Second lifting hook minimum effort:

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

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

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



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

## 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-  $\gamma_w$ ”, in which  $\gamma_w$  is a weakening hook factor:

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

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

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

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

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.

The screenshot shows the 'Precast Beam' software interface. The 'Formwork' section includes settings for Element height (40 cm), Left support width (5 cm), Right support width (5 cm), Slip block (unchecked), Position (Left side), and Width (0.05 m). The 'Reinforcement' section includes Assembly reinforcement (checked), Top concrete cover (2.5 cm), Extend (5.0 cm), Diameter (ø10), and Stirrups (checked) with a spacing of 50.0 cm. The 'Lifting hooks' section includes Number of lifting hooks (2), Diameter (ø10, with 'AUTO (except ø10)' and 'AUTO' options unchecked), Smooth bar type (S235C), Span ratio (20.00%), Top length (10.0 cm), Bottom concrete cover (0.05 m), Anchorage length factor (19.00), Maximum sling angle (15 (k = 1.01)), Dynamic factor (1.60), and Uncertainty factor +/- (20.00%). The 'Representation' section includes Hatch (checked) and Representation (Elevations and Section). Buttons for 'Ok', 'Apply', and 'Close' are visible at the bottom.