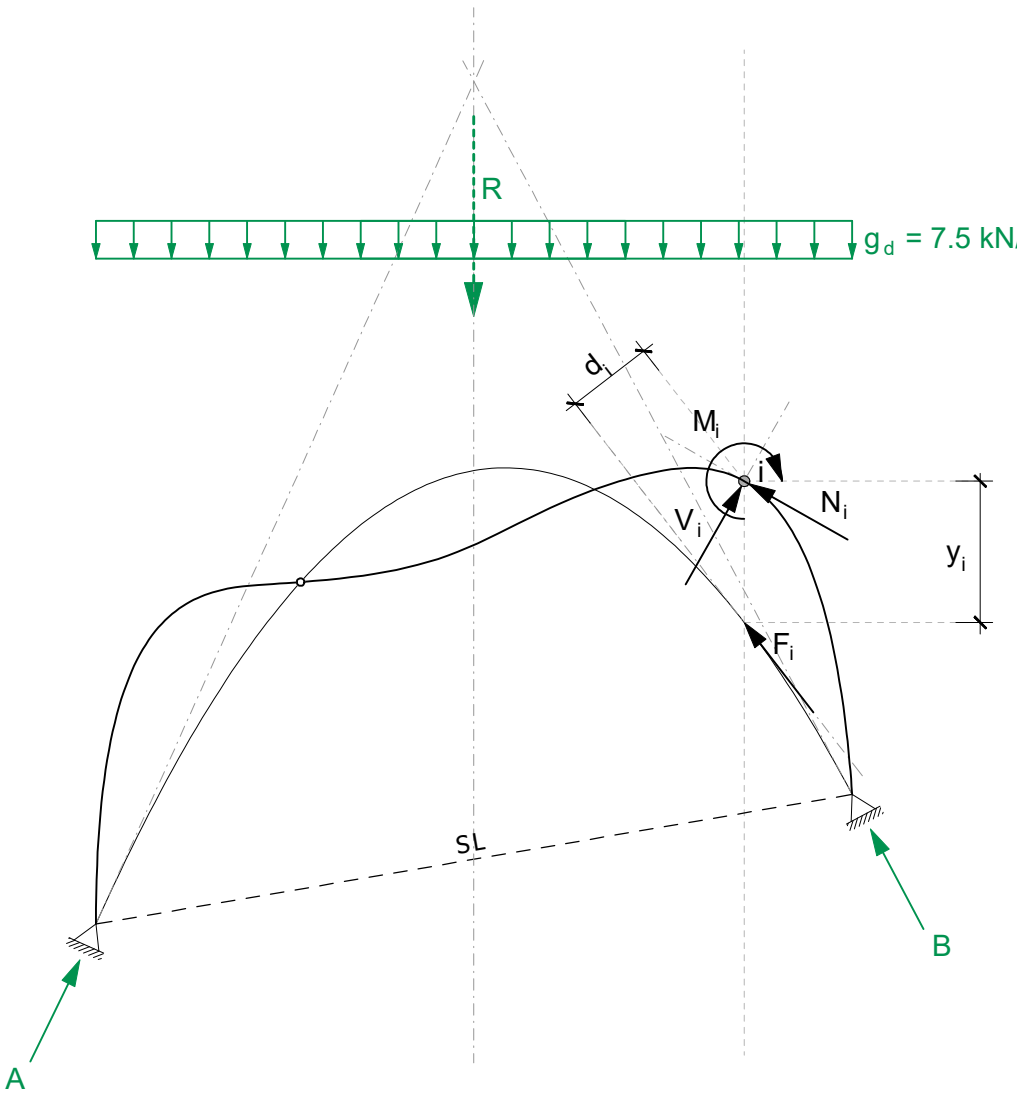
Task 1 Bending moment in frame owing to point load

The form of a load-bearing structure out of steel as well as the line load g_d are given. As shown, the ideal form for this loading condition is a parabola. (Check figure 5 to see how the parabola is drawn through an arbitrary point.)

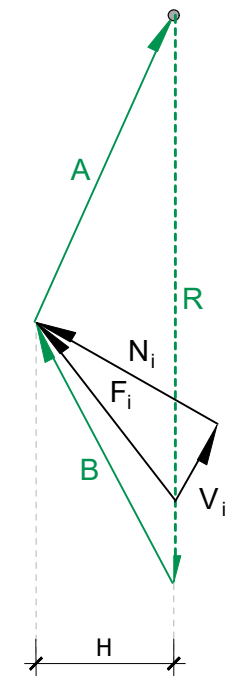
a) Draw the force diagram for the ideal loading structure. Find the dimension of the tangential force F_i using graphic statics. Then determine the magnitude of the normal force N_i and the lateral force V_i within the beam. Hint: F_i equals the addtion of these two forces.

b) Calculate the occuring moment M_i in point i.

a)



form diagram 1:100



force diagram 1cm ≙ 10kN

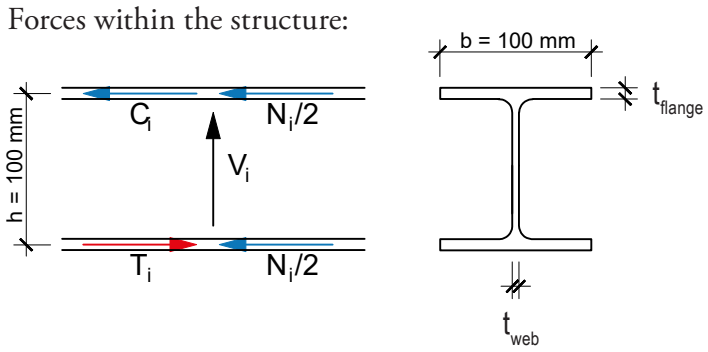
b) Moment in point i: $M_i = F_i \cdot d_i = F_{ih} \cdot y_i = H \cdot y_i = 30\ kN \cdot 1.1\ m = 33\ kNm$

c) The load-bearing structure shall be made out of steel S355. The occuring moment M_i results in the two forces C_i und T_i in the upper and lower flange. Also the normal force N_i appears therein. Determine the resulting forces within the flange.

d) Take the relevant force and calculate the required cross-sectional area of the flange as well as its thickness $t_{Flansch}$. Round up the result to mm.

e) The web of the beam is 10 mm thick. Check whether it would withstand the cross-sectional force V_i appearing within. The load action of V_i is over the width of 20 mm.

c) Forces within the structure:



elevation of the beam

section through the beam

$M_i = C_i \cdot h$ and $-C_i = T_i$

$C_i = M_i / h = 33\ kNm / 0.1\ m = 330\ kN$

$F_{upper\ flange} = C_i + N_i / 2 = 330\ kN + 27.5\ kN / 2 = 343.75\ kN$ -> relevant

$F_{lower\ flange} = T_i + N_i / 2 = -330\ kN + 27.5\ kN / 2 = -316.25\ kN$

d) $A_{req} = N_d / f_{cd} = b \cdot t$

$f_{cd} = f_{ck} / \gamma_M = 355\ N/mm^2 / 1.05 = 338.1\ N/mm^2$

$t_{flange} = N_d / f_{cd} / b$

$= 343750\ N / 338.1\ N/mm^2 / 100\ mm$

$= 10.17\ mm \approx 11\ mm$

e) Proof of normal force:

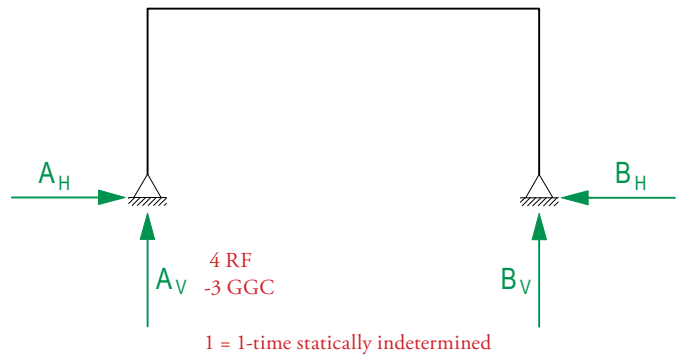
$N_d \leq N_{allow}$

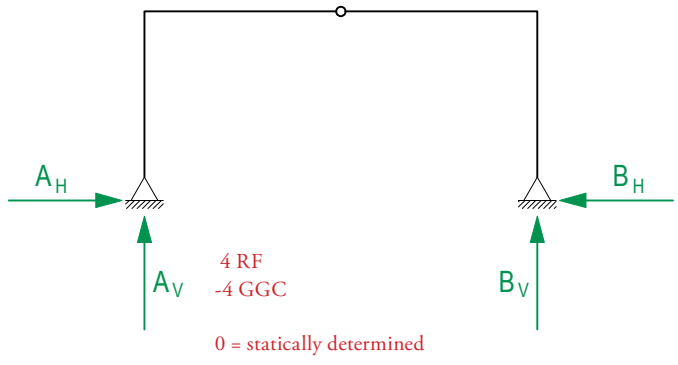
$N_d = V_i = 11.6\ kN$

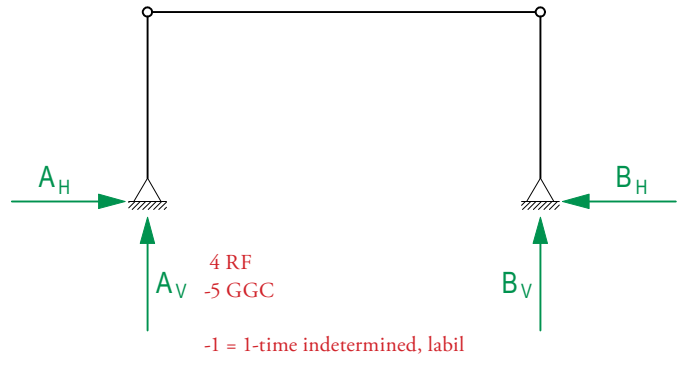
$N_{allow} = f_{cd} \cdot A_{ef} = 355\ N/mm^2 / 1.05 \cdot 10\ mm \cdot 20\ mm = 67.62\ kN$

Task 1 Static Determinacy

Draw the possible support reactions for all four cases and determine the degree of external static determinacy.

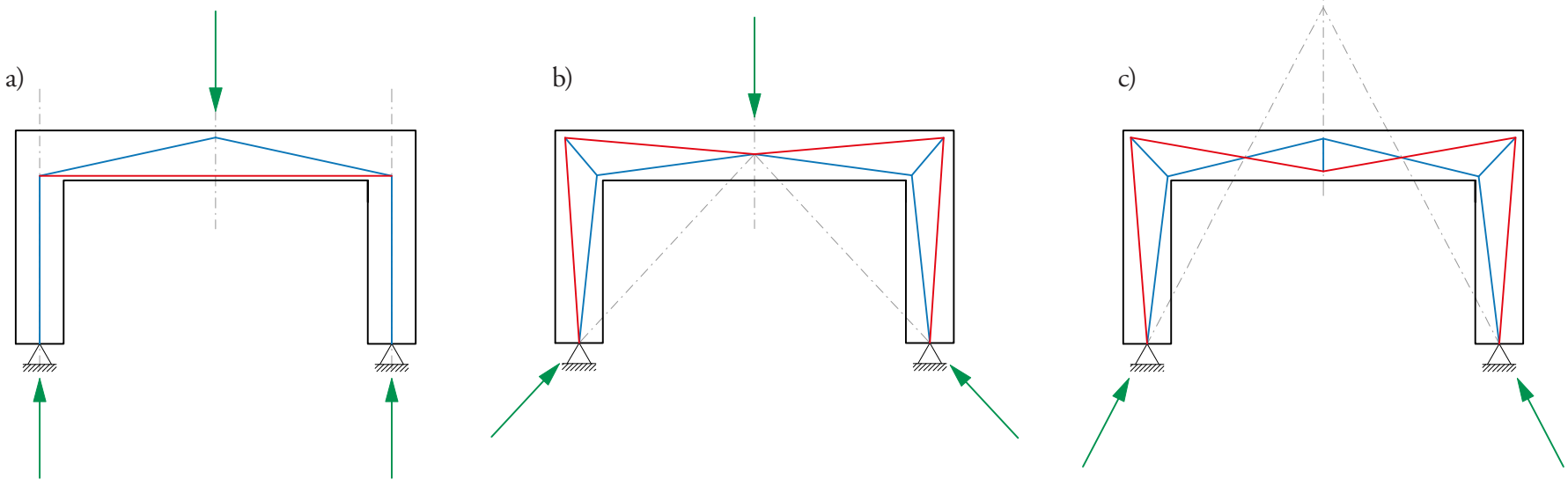






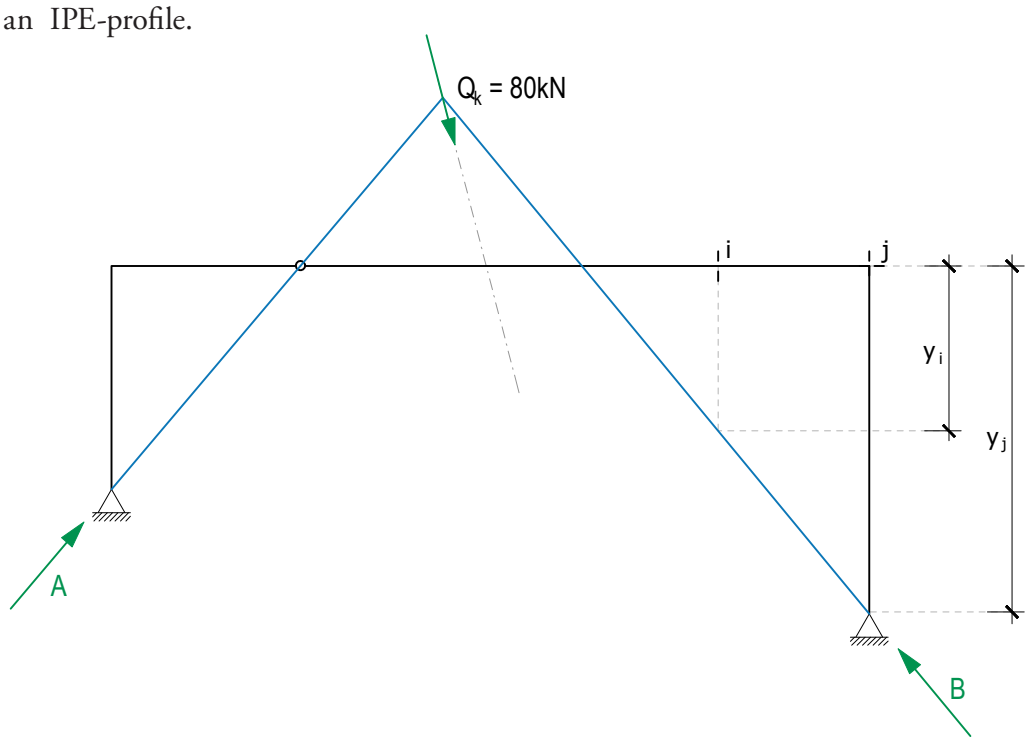
Task 2 Inner Force Distribution in Reinforced Concrete Frame

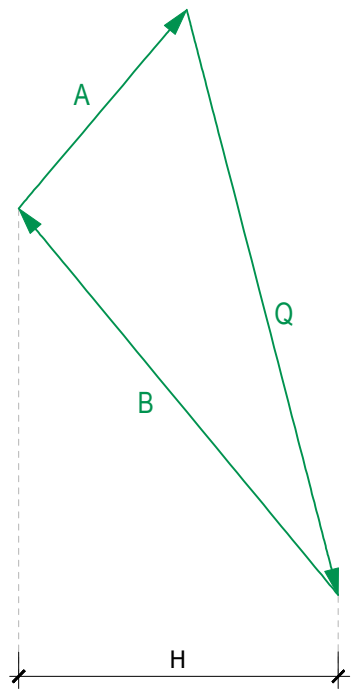
Three identical reinforced concrete frames with different support conditions are given. Draw the possible inner force distribution for each case. Indicate tension forces with red and compression forces with blue.



Additional Task 1 — Bending moment in frame under point load

Calculate the bending moment with the aid of the support line in the frame, in point i and in point j. Dimension the frame in steel S355 and find an IPE-profile.





form diagram 1:100

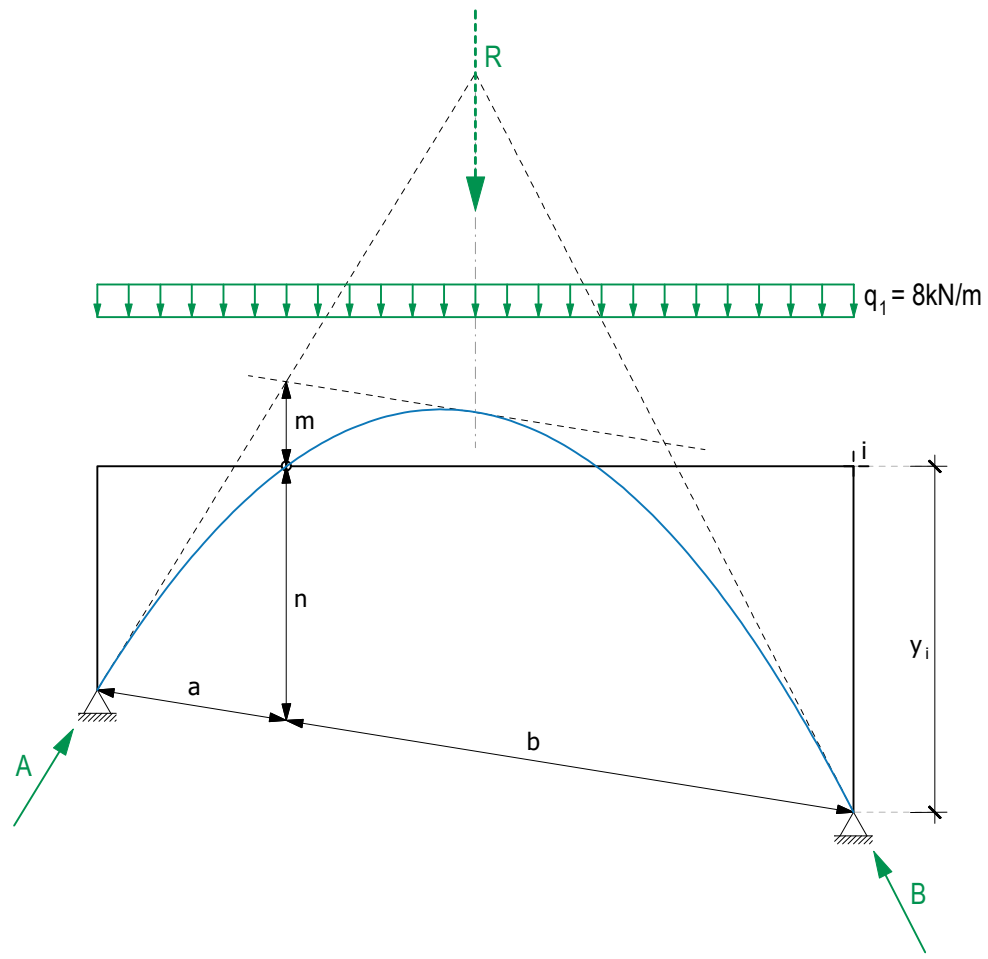
force diagram 1cm ≙ 10kN

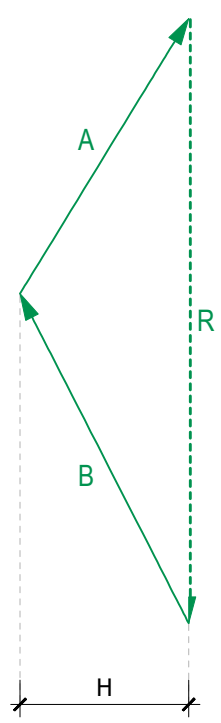
Moment:
$H = 42$ kN
$y_i = 2.2$ m
$y_j = 4.6$ m
$M_i = y_i \cdot H = 2.2\ m \cdot 42\ kN = 92.4$ kNm
$M_j = y_j \cdot H = 4.6\ m \cdot 42\ kN = 193.2$ kNm

Dimensioning:
$M_{K\,max} = M_j = 193.2$ kNm
$\gamma_Q = 1.50$
$M_d = M_K \cdot \gamma_Q = 290$ kNm
$f_{md} = f_{mk} / \gamma_M = 355\ N/mm^2 / 1.05 = 338\ N/mm^2$
$W_{req} = M_d / f_{md} = 858 \cdot 10^3\ mm^3$
Profil = IPE 360 -> $W_{vorhanden} = 904 \cdot 10^3\ mm^3$ (Daten aus der Stahlbautabelle)

Additional Task 2 — Bending moment in frame under line load

Calculate the bending moment with the aid of the support line in the frame, in point i and the hinge.





form diagram 1:100

force diagram 1cm ≙ 10kN

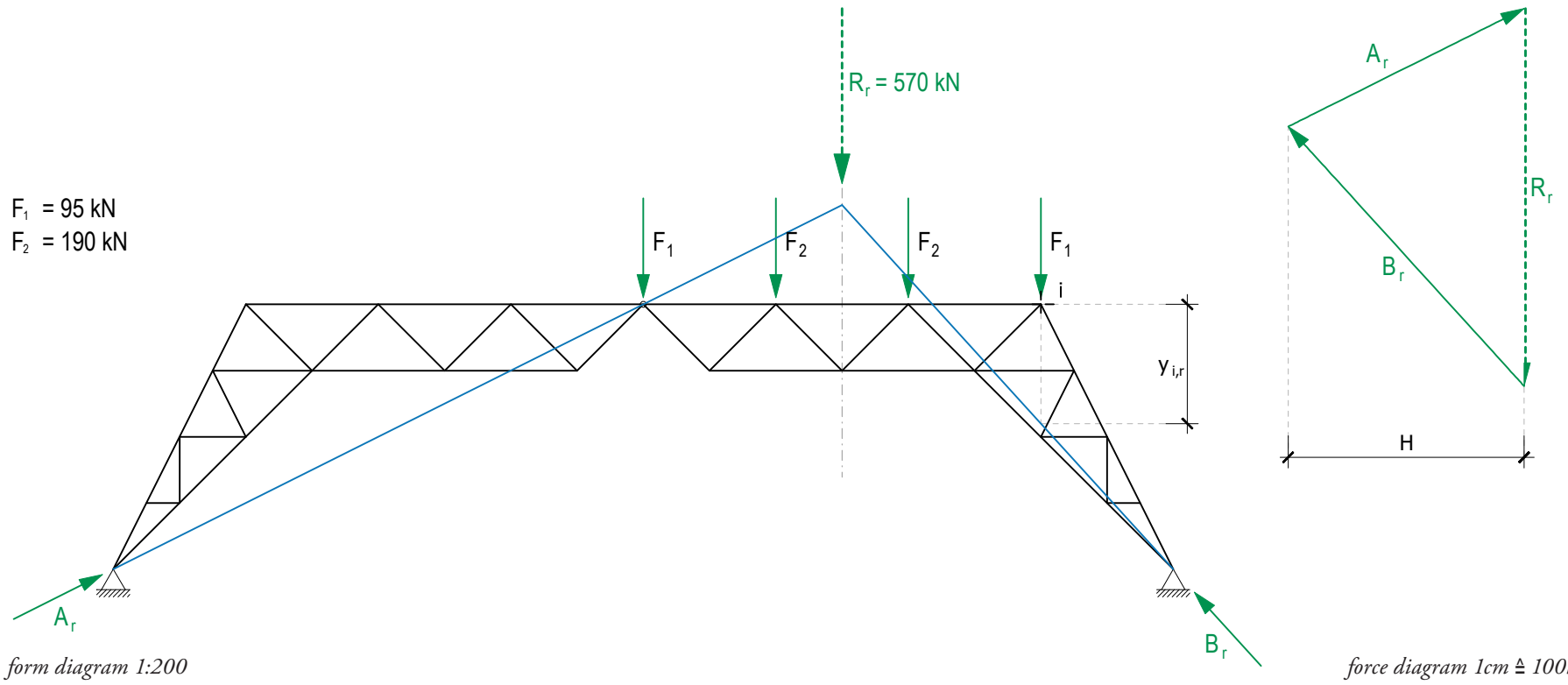
a : b ≙ m : n => m = 1.1 m

Moment:
$H = 22$ kN
$y_i = 4.6$ m
$M_i = y_i \cdot H = 4.6\ m \cdot 22\ kN = 101.2$ kNm
$M_{hinge} = y_{hinge} \cdot H = 0.0\ m \cdot 22\ kN = 0$ kNm

Additional Task 3 — Three-hinged truss frame

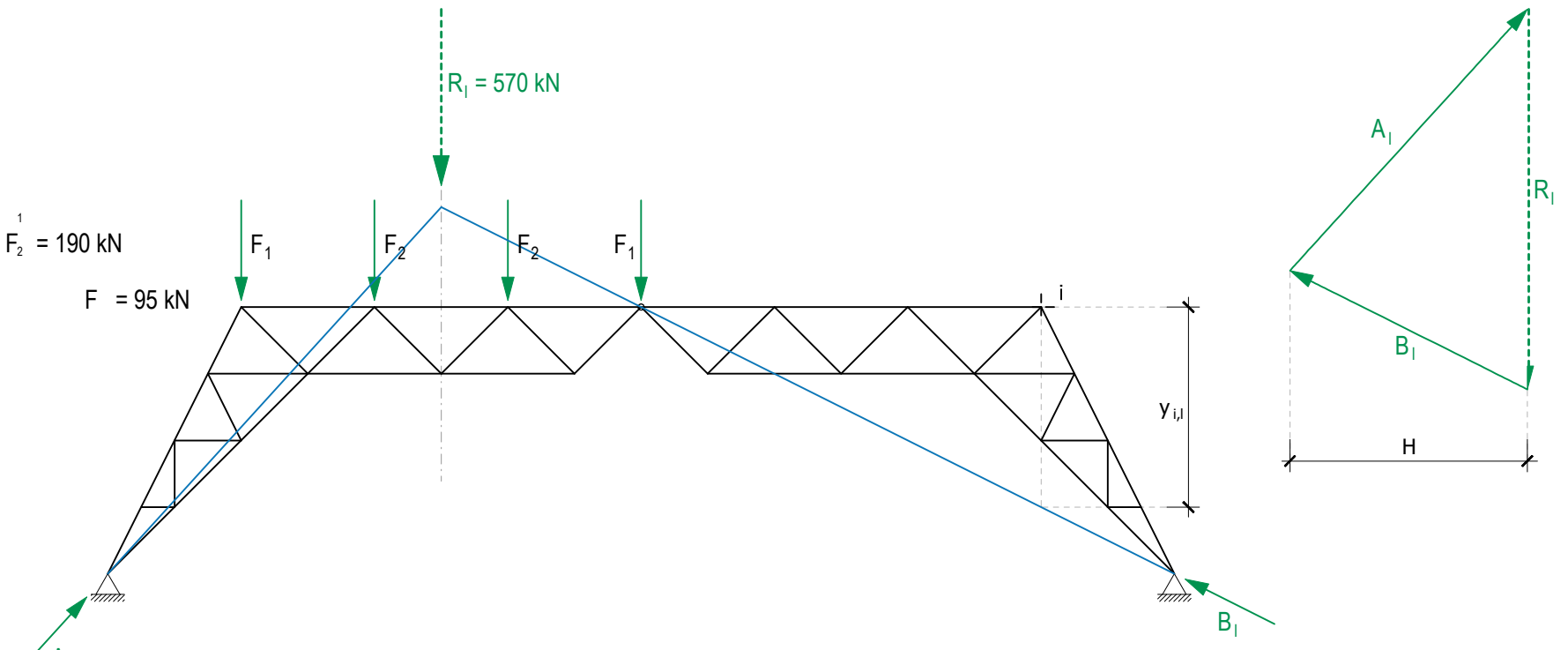
Determine the supporting forces A and B of the three-hinged truss frame by the use of superposition and calculate the bending moment in point i.

Right side



form diagram 1:200 — *force diagram 1cm ≙ 100kN*

Left side



form diagram 1:200 — *force diagram 1cm ≙ 100kN*

Superposition of the supporting forces

Moment:

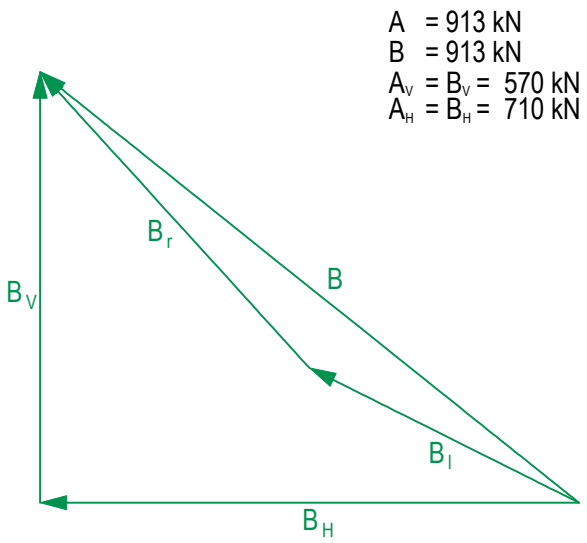
$H = 356$ kN

$y_{i,r} = 3.6$ m

$y_{i,l} = 6$ m

$M_i = M_{i,r} + M_{i,l} = y_{i,r} \cdot H + y_{i,l} \cdot H = 3.6\ \text{m} \cdot 356\ \text{kN} + 6\ \text{m} \cdot 356\ \text{kN}$

$= 3417.6$ kNm



force diagram 1cm ≙ 100kN