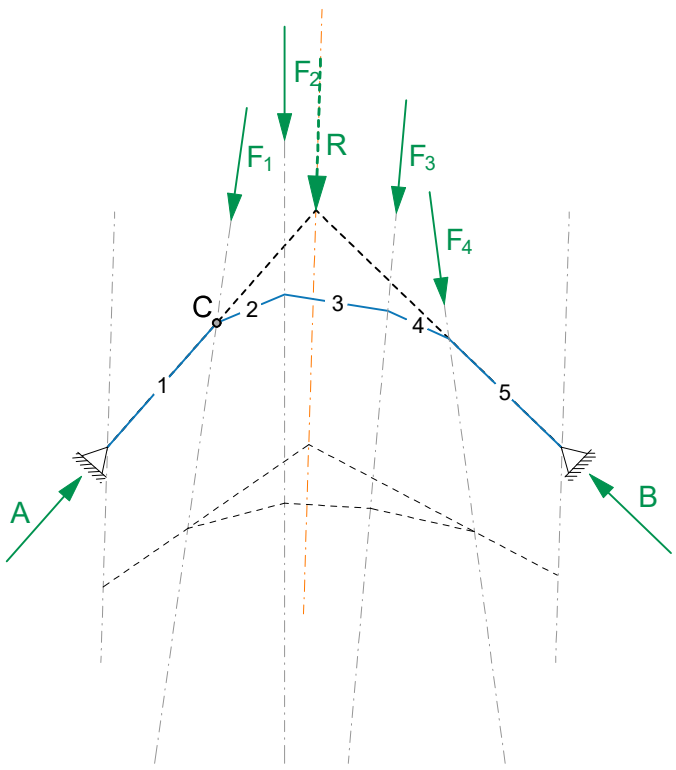
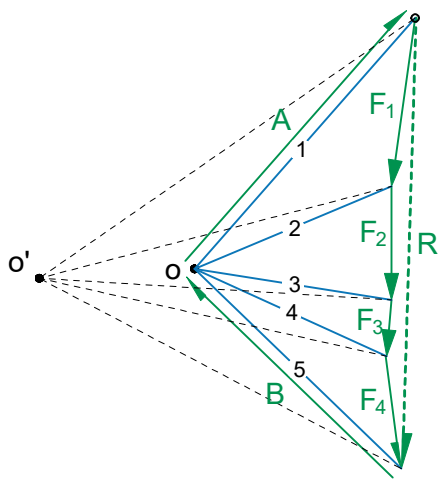
Task 1 Finding the thrust line using the Trial Funicular

Find the position and magnitude of the resultant R. Draw the thrust line through points A, B and C. Indicate the dominant stress in the arch. Draw the direction and determine the magnitude of the reaction force. (See Fig. 6)



F_1 = 45 kN
F_2 = 30 kN
F_3 = 15 kN
F_4 = 30 kN
R = 119.3 kN
$N_{max} = N_1$ = 88.4 kN
A = 88.4 kN
B = 76 kN

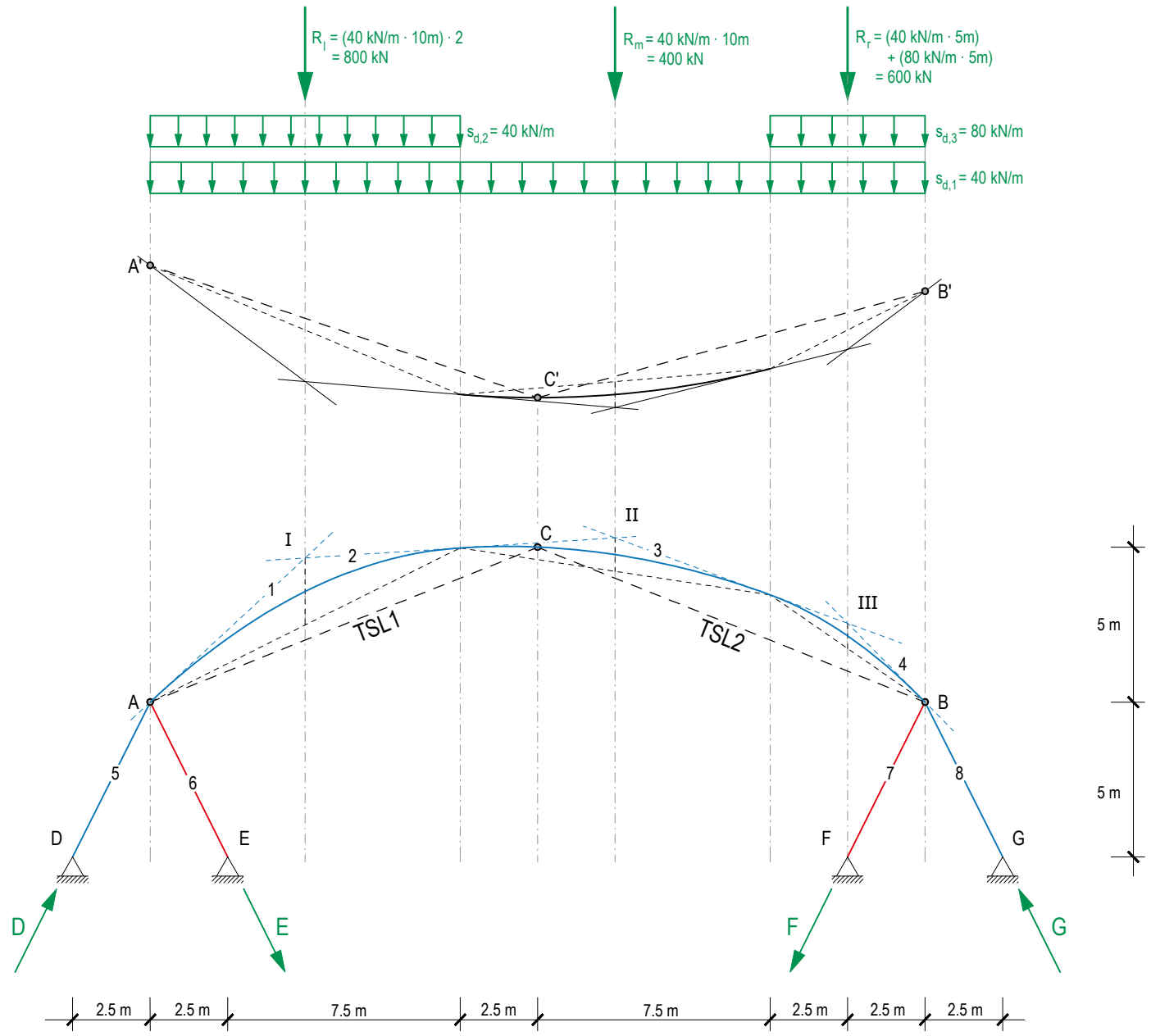


Form diagram 1:250

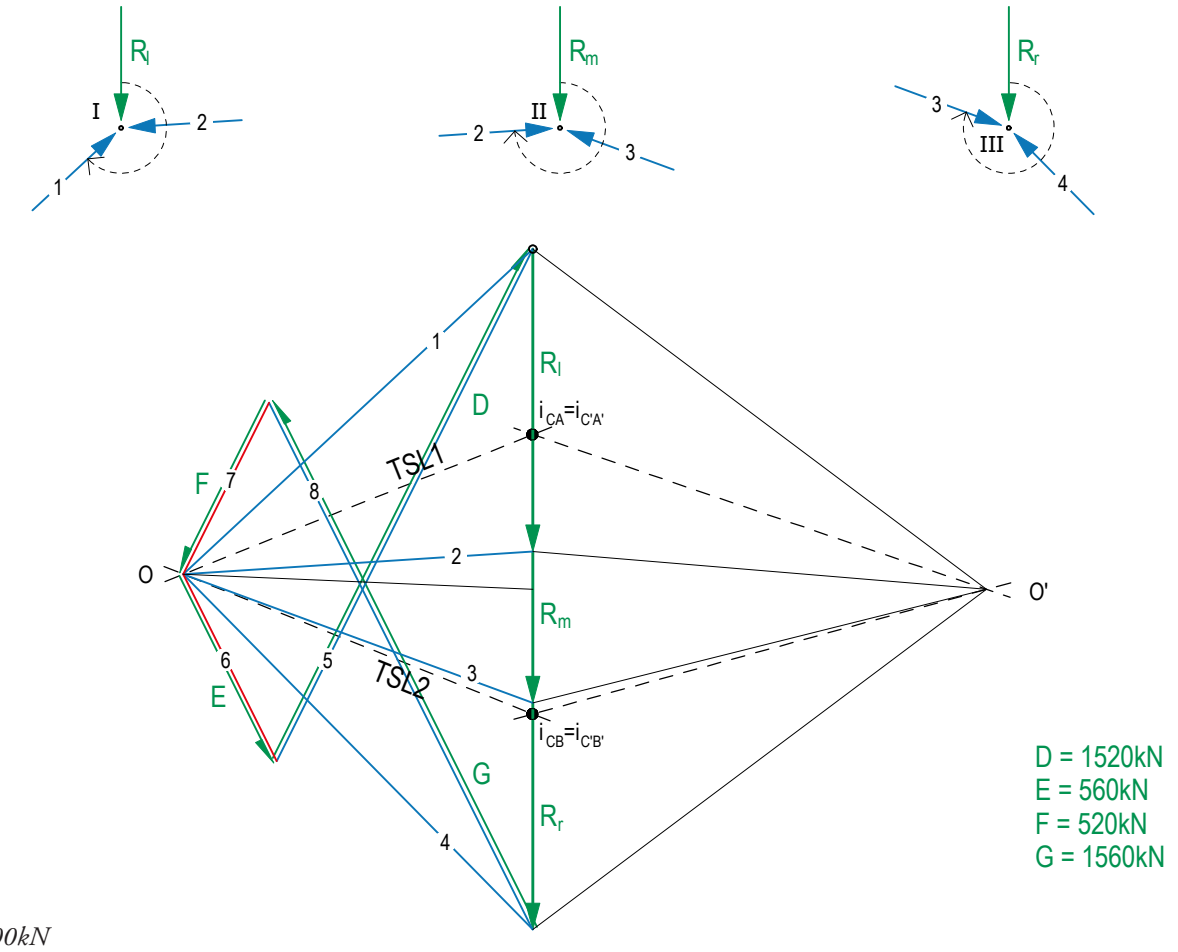
Force diagram 1cm ≙ 20kN

Task 2 Finding the thrust line using Partial Closing Strings

There is a given case with two support points A and B. Find the thrust line of the arch that spans between supports A and B and passes through point C. Draw the form and force diagrams. How big are the reaction forces D to G? Use partial closing strings as help for your construction. (See Fig. 8)



form diagram 1:200

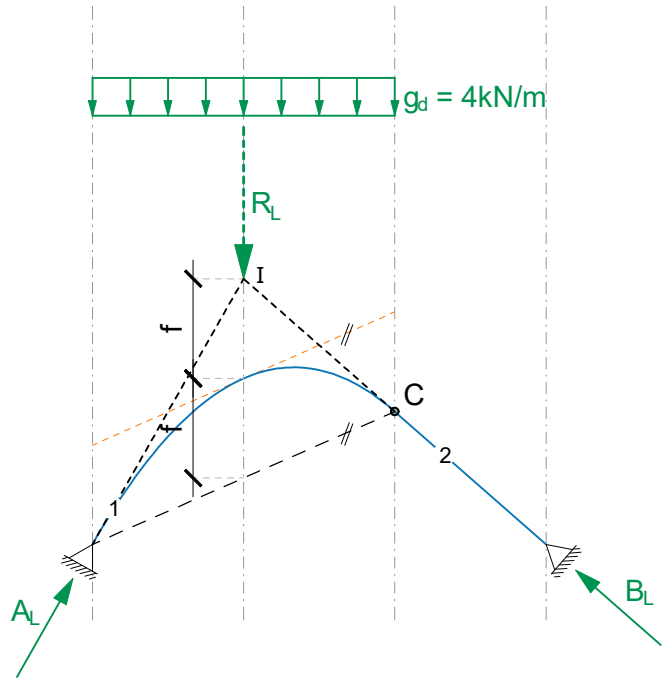


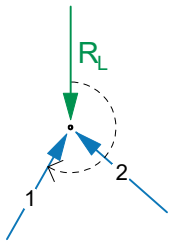
force diagram 1cm≙200kN

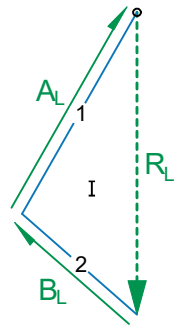
Task 3 Finding the thrust line using Superposition

Find the thrust line through points A, B and C in cases a) and b). Draw the corresponding force diagrams.
Draw the thrust line and the corresponding force diagram for case c), that consists of the combination of a) and b) by applying superposition.
Indicate the dominant stress in the arch as well as the support reactions. (See Fig. 7)

a)



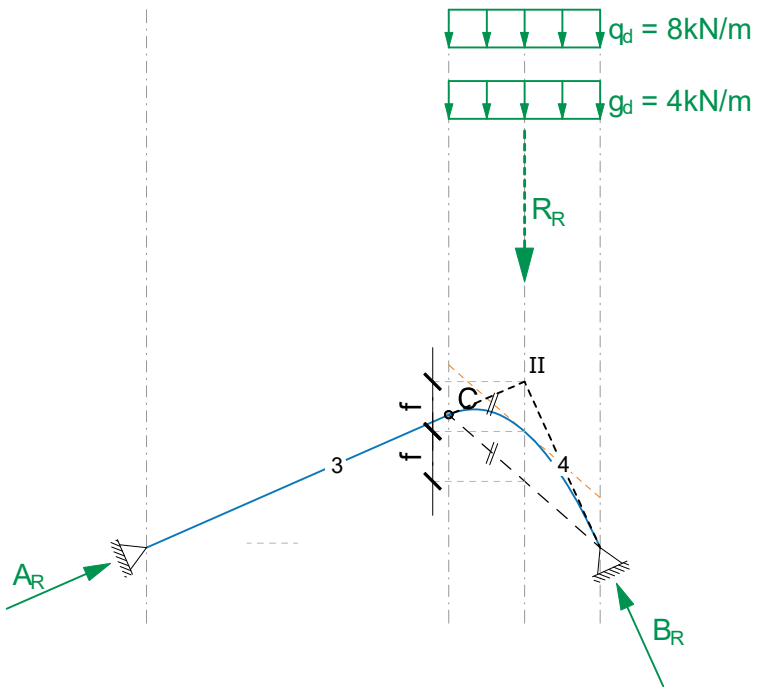


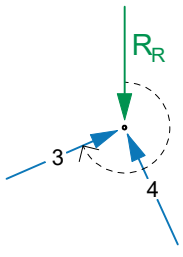


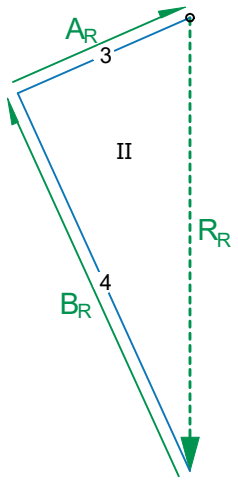
form diagram 1:250

force diagram 1cm ≙10kN

b)



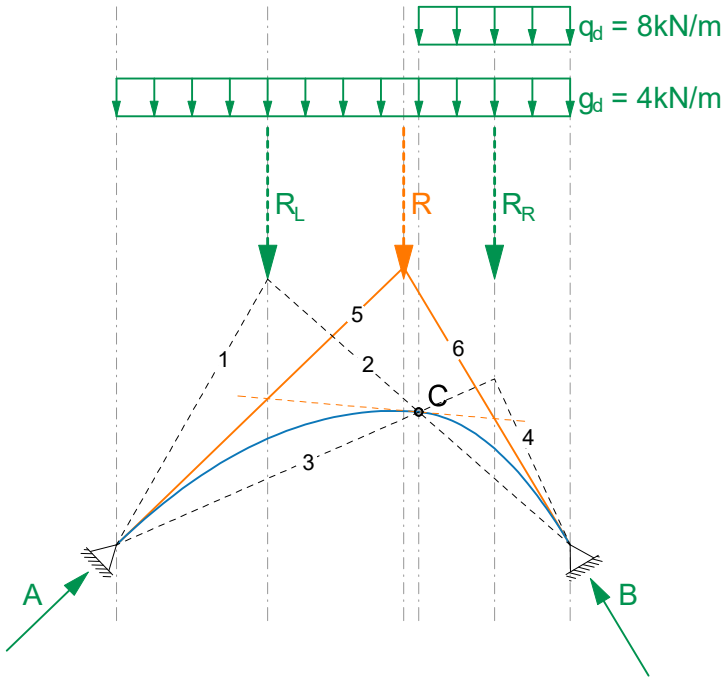


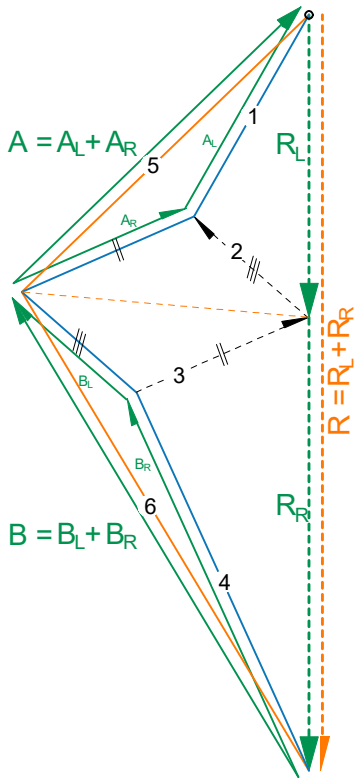


form diagram 1:250

force diagram 1cm ≙10kN

c)





R = 100 kN
$N_{max} = N_6$ = 73.8 kN
A = 52.8 kN
B = 73.8 kN

form diagram 1:250

force diagram 1cm ≙10kN

EX 4

Structural Design I – HS 17

Arch structures

Lösungsvorschlag

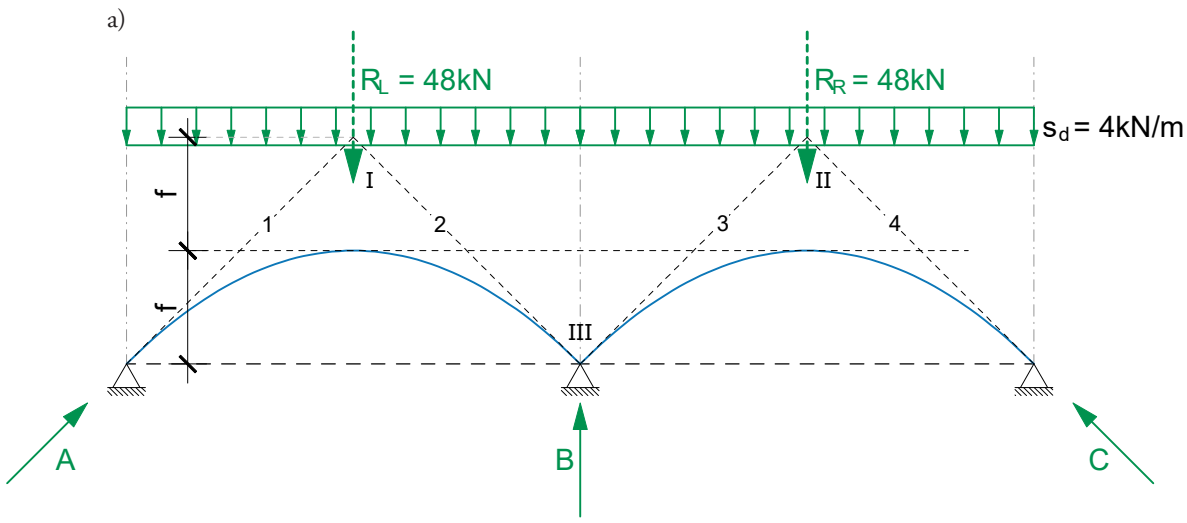
Proposal for solution

Additional Task 1

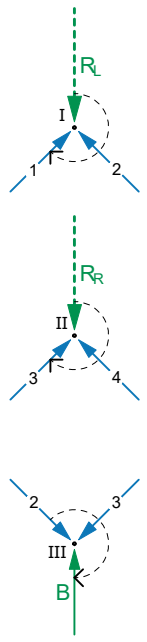
Support reactions of arch structures

In scenarios a) and b), two arches are placed adjacent to one other. Determine the reaction forces (A-C) by means of graphic statics.
In scenario c), the middle support B can only take vertical forces. Find the shape of the left arch using the force diagram, such that the horizontal thrust (horizontal force) of both arches at the support B cancel each other out. Indicate the magnitude of the reaction forces (A-C).
Compare the three arch structures. How does the direction and magnitude of the reaction force B change?

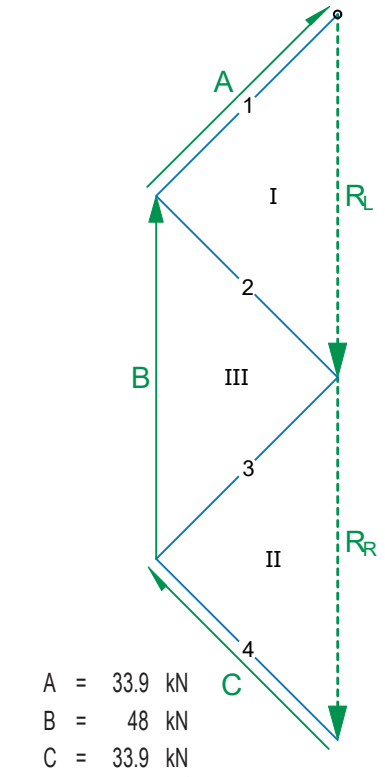
a)



Form diagram 1:200

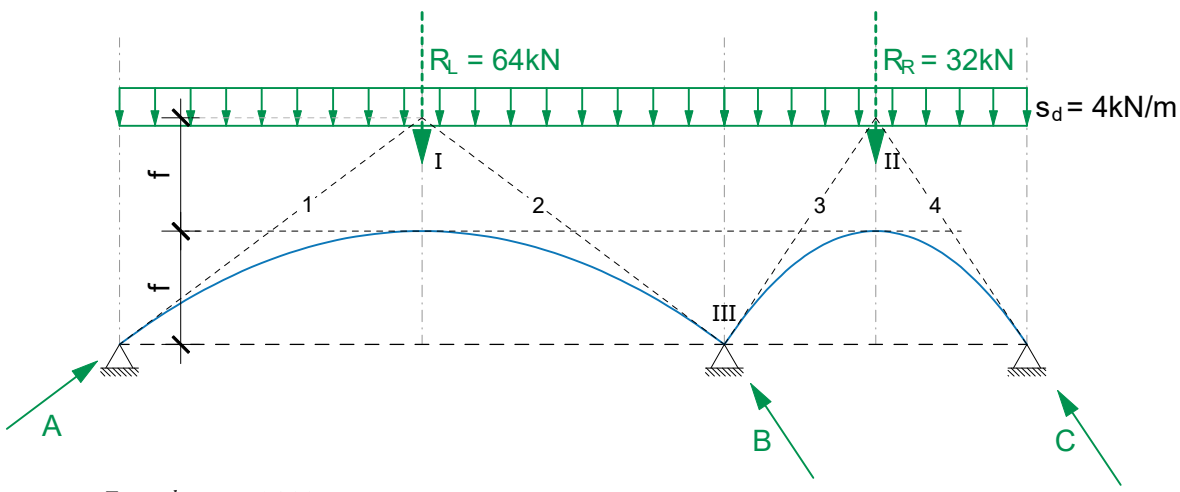


Subsystem

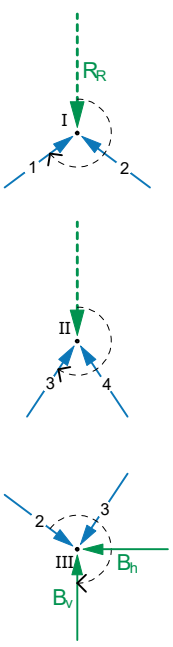


Force diagram 1cm ≙ 10kN

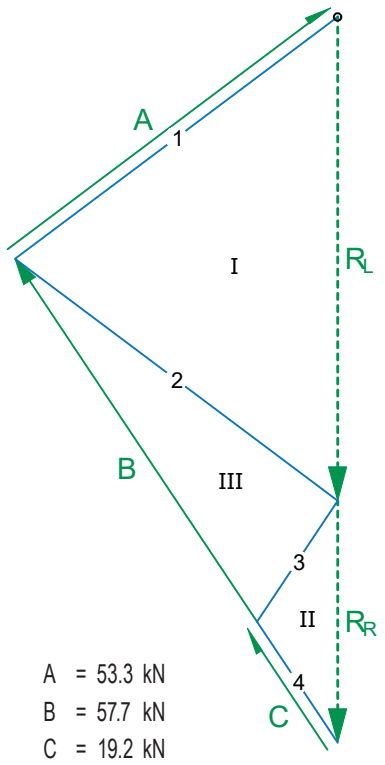
b)



Form diagram 1:200

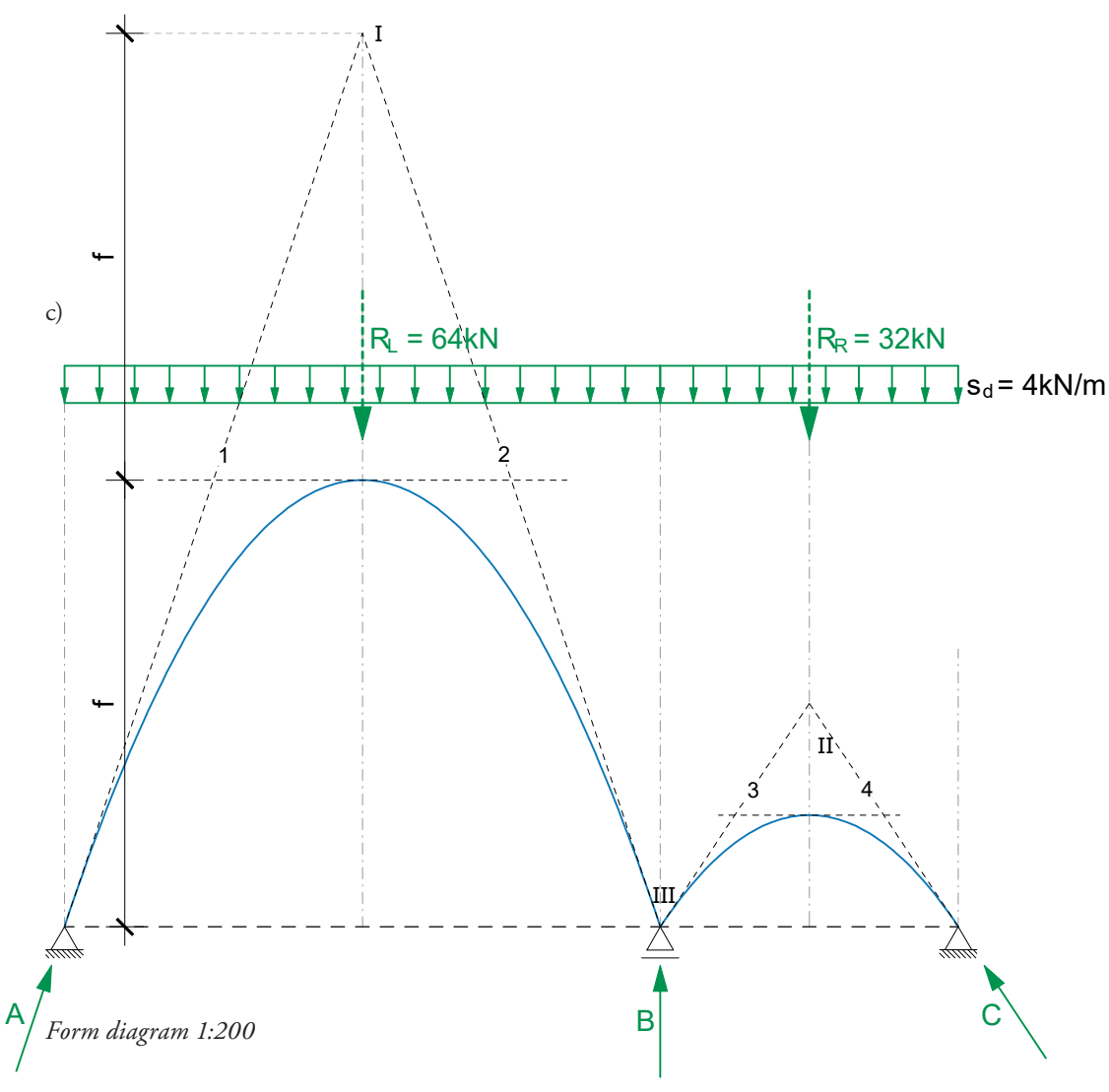


Subsystem

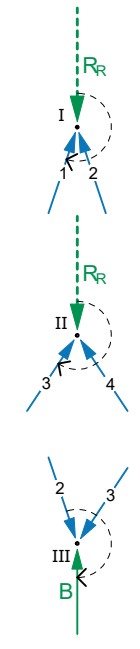


Force diagram 1cm ≙ 10kN

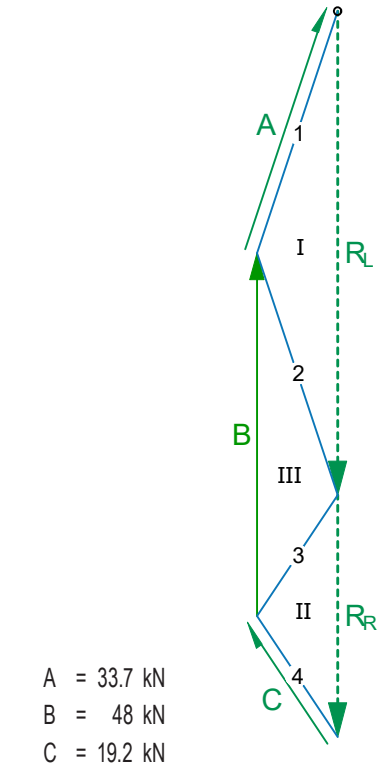
c)



Form diagram 1:200



Subsystem



Force diagram 1cm ≙ 10kN

In a) and c) the horizontal push cancels eachother out. The result is only a vertical reaction force B. In b) the wider span results in a asymmetric reaction force B, which reacts to the additional horizontal push of the left arch.

EX 4

Structural Design I – HS 17

Arch structures

Lösungsvorschlag

Proposal for solution

Additional Task 2

Laon Cathedral, France

Construct a parabola through the points A, B and C. Take into account that the support reaction A is supposed to be horizontal. In the next step, construct the parabola through C, D and E. Find g_2 such that the thrust line leads vertically from point C through point F into the ground.

On E also acts a point load F1 resulting from the weight of the buttress. Determine F1 so that the thrust line runs from point E to point G.

Find g_3 and the parabola shape between the points F, G and L, such that the thrust line, including the loads from the upper arches, goes through the points H and K.

Draw the corresponding force diagram for each case. Indicate the magnitudes of the support reactions.