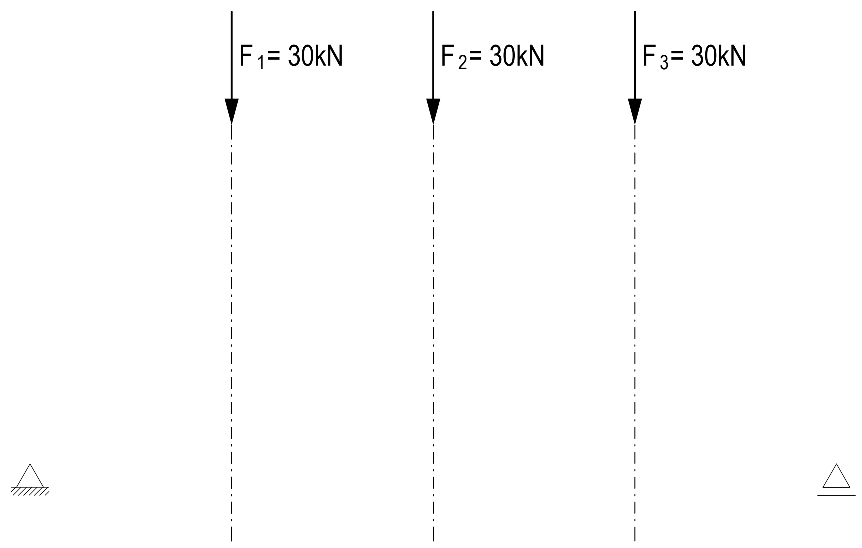
Additional Task 1.1 Form-Finding: Arch-Cable

Find the arch-cable-structure that forms under the given loading situation. The tension force in the bottom chord equals 60kN. Draw the corresponding force diagram. Use red for tension and blue for compression.

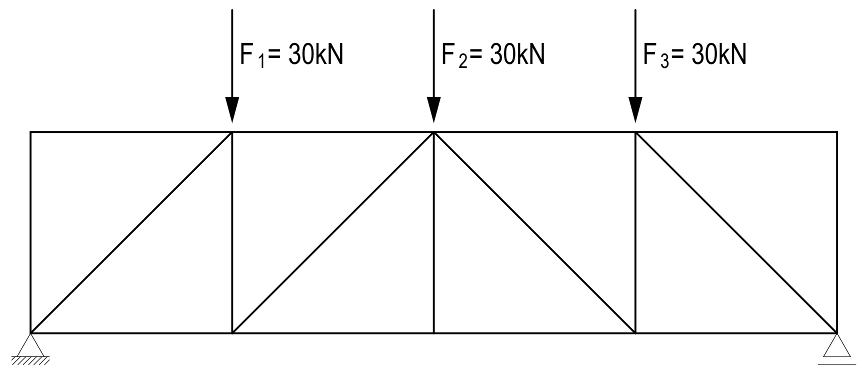


form diagram 1:100

force diagram 1cm ≙ 10kN

Additional Task 1.2 Analysis: Truss 1

This loading case corresponds to that of 1.1, but here a truss is analysed. Draw the corresponding force diagram for the given situation. First identify possible zero members. Indicate tension forces with red and compression forces with blue.

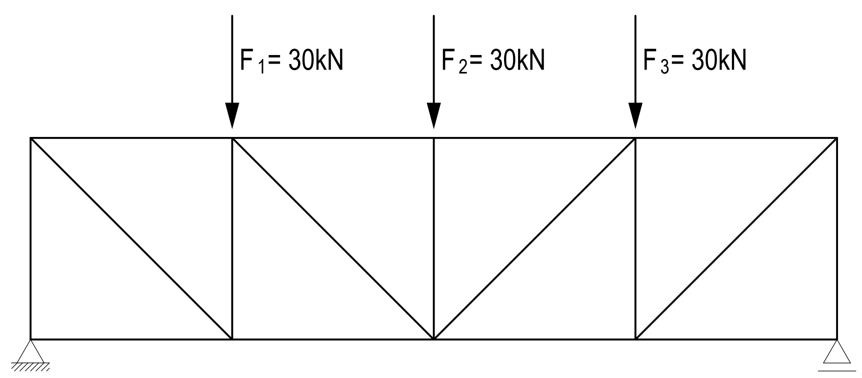


form diagram 1:100

force diagram 1cm ≙ 10kN

Additional Task 1.3 Analysis: Truss 2

This loading case corresponds to that of 1.1 and 1.2, but here a different truss is analysed. Draw the corresponding force diagram for the given situation. Indicate tension forces with red and compression forces with blue.

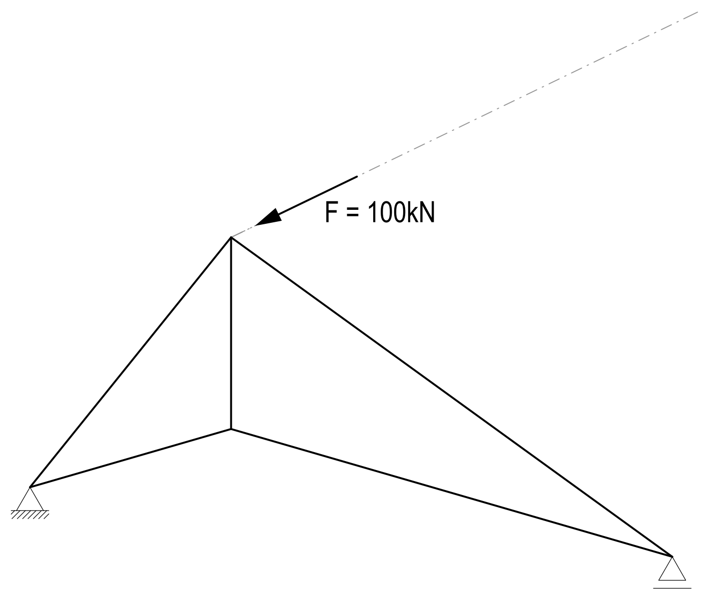


form diagram 1:100

force diagram 1cm ≙ 10kN

Additional Task 3 Truss

Draw the corresponding force diagram for the given truss. First, find the global equilibrium. Indicate tension forces with red and compression forces with blue.



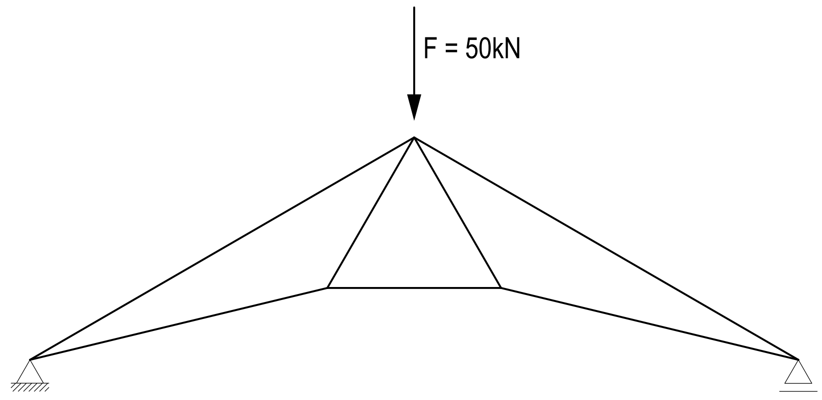
form diagram 1:100

force diagram 1cm ≙ 10kN

subsystems

Additional Task 4 Truss

Draw the corresponding force diagram for the given truss. Indicate tension forces with red and compression forces with blue.



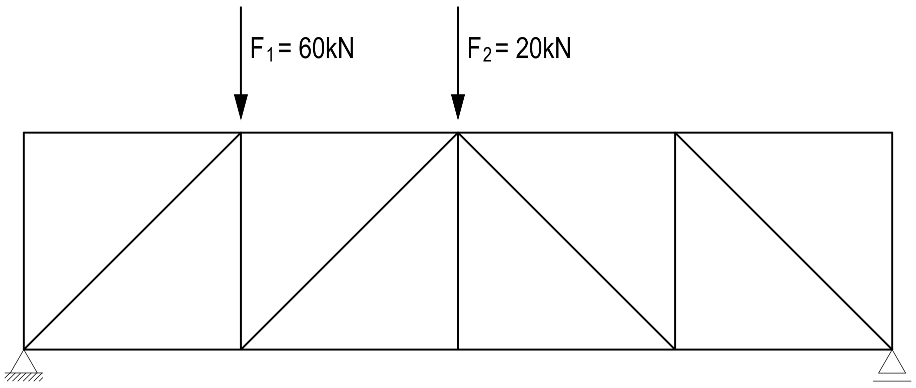
form diagram 1:100

force diagram 1cm ≙ 10kN

subsystem

Additional Task 1 Truss under non-Uniformly Distributed Load

Determine both reaction forces A and B for the following truss. Draw the corresponding force diagram for the given case. Indicate tension forces with red and compression forces with blue.



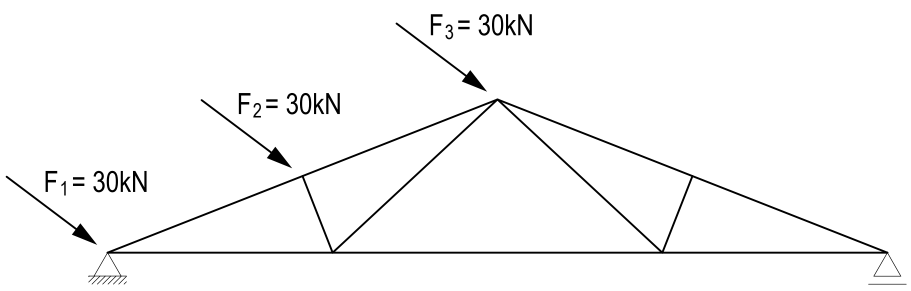
form diagram 1:100

force diagram 1cm ≙ 10kN

Subsystem

Additional Task 2 Truss under Inclined Load

Determine the resultant force R and both reaction forces A and B for the following truss. Draw the corresponding force diagram for the given case. Indicate tension forces with red and compression forces with blue.



form diagram 1:100

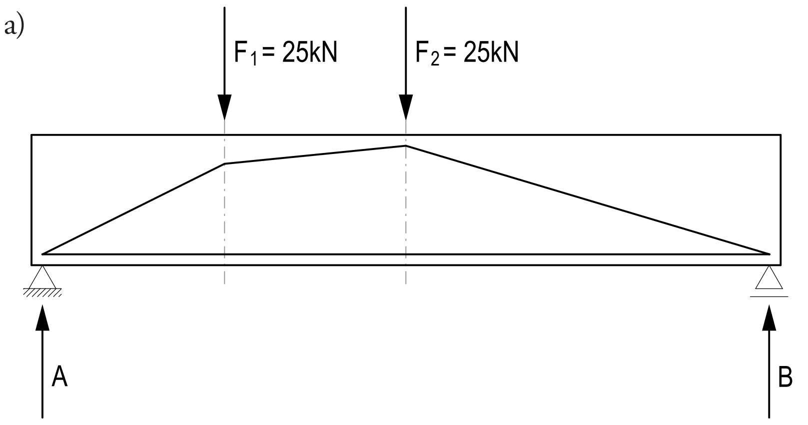
force diagram 1cm ≙ 10kN

subsystem

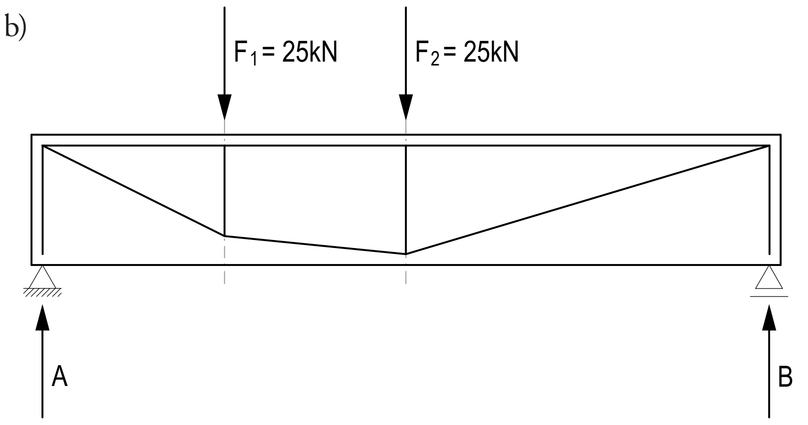
Task 1 Internal Force Distribution in a Simple Beam

Draw the force diagrams for the given distribution of internal forces for the beams in a) - c). For the cases d) and e), the force diagram is already provided. Indicate tension forces with red and compression forces with blue. Compare in f) the distribution of internal forces in a) - c) with the versions in d) and e).

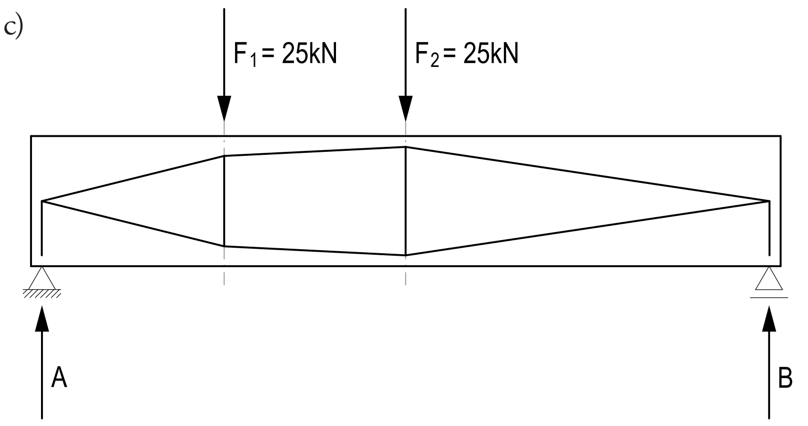
a)



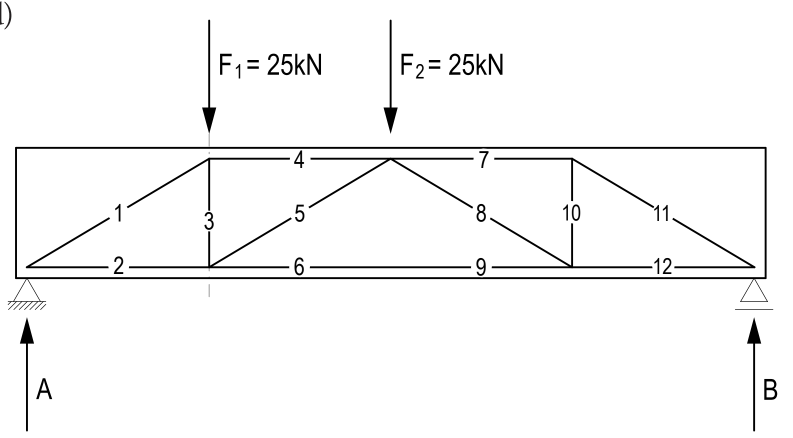
b)

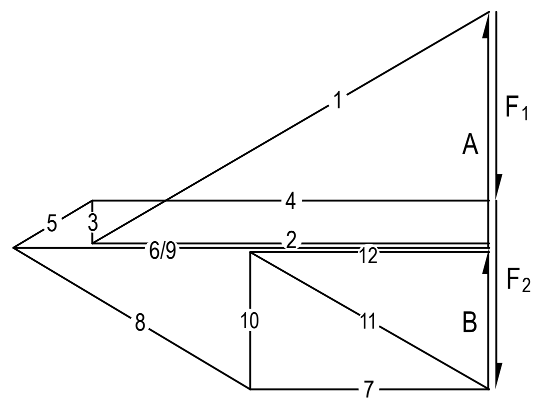


c)

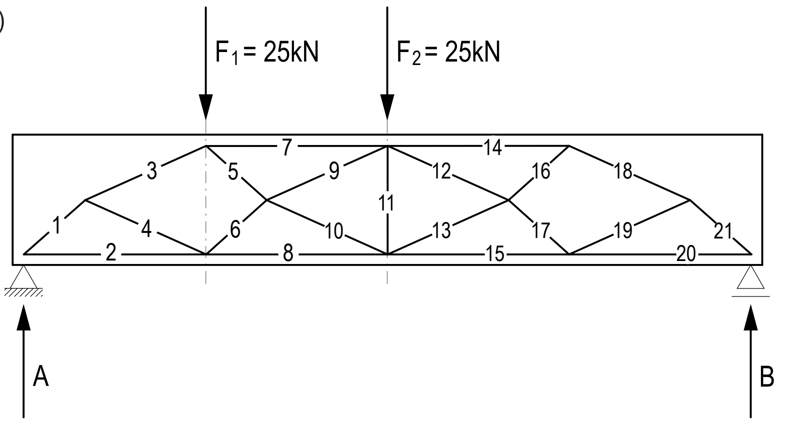


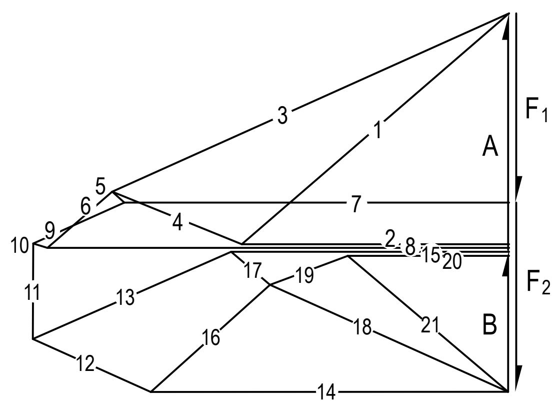
d)





e)





form diagrams 1:100 *force diagrams 1cm ≙ 10kN*

f)

Die Situationen a) bis c) zeigen eine Lösung mit einem Bogen-Seiltragwerk innerhalb des Balkens. Für eine solche Lösung in Stahlbeton, müssen die Zugelemente vorgespannt werden. Ansonsten können grosse Risse im Beton entstehen. Bei den Variante d) und e) wird ein Fachwerk im Balken ausgebildet. Hier sind die Kräfte besser verteilt, und dadurch auch die Risse (viele kleine Risse anstatt einem grossen Riss). Somit muss nicht vorgespannt werden.

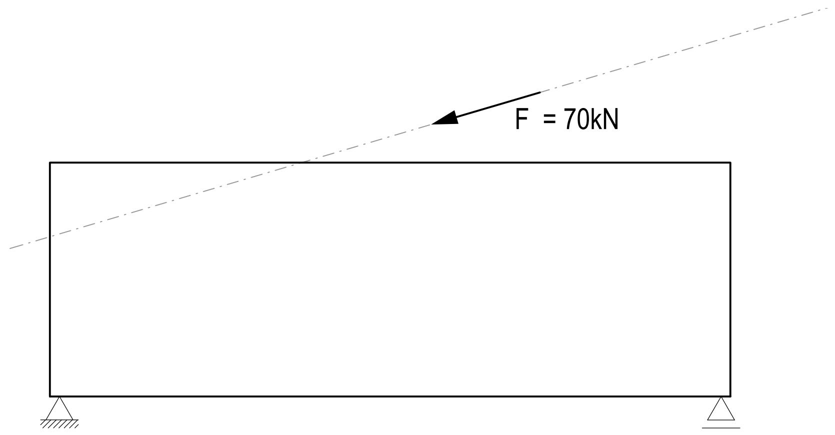
Additional Task 1

Statically determined supported wall slab

Four equal wall slabs in reinforced concrete but with different supports or loads are given. In situations a) to c) draw a possible internal force distribution as an arch-cable-structure with the aid of the force diagram.

Draw the corresponding force diagram to the given force distribution in d). Indicate tension forces with red and compression forces with blue.

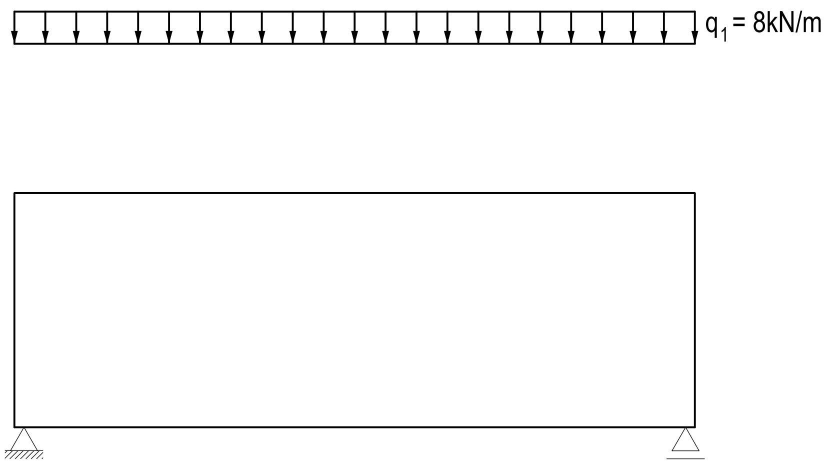
a)



form diagram 1:100

force diagram 1cm ≙ 10kN

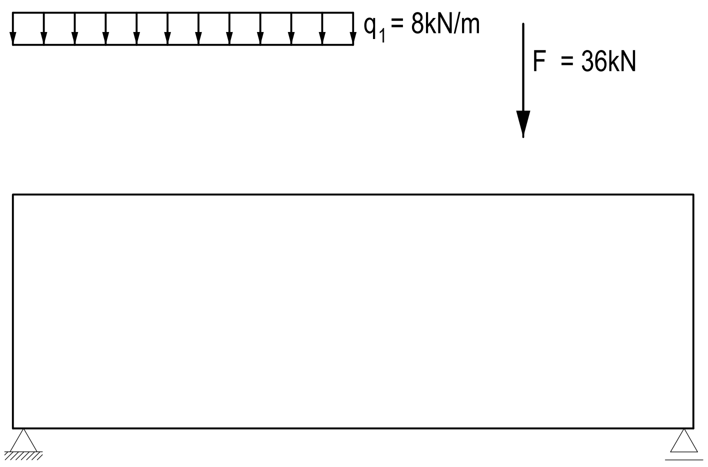
b)



form diagram 1:100

force diagram 1cm ≙ 10kN

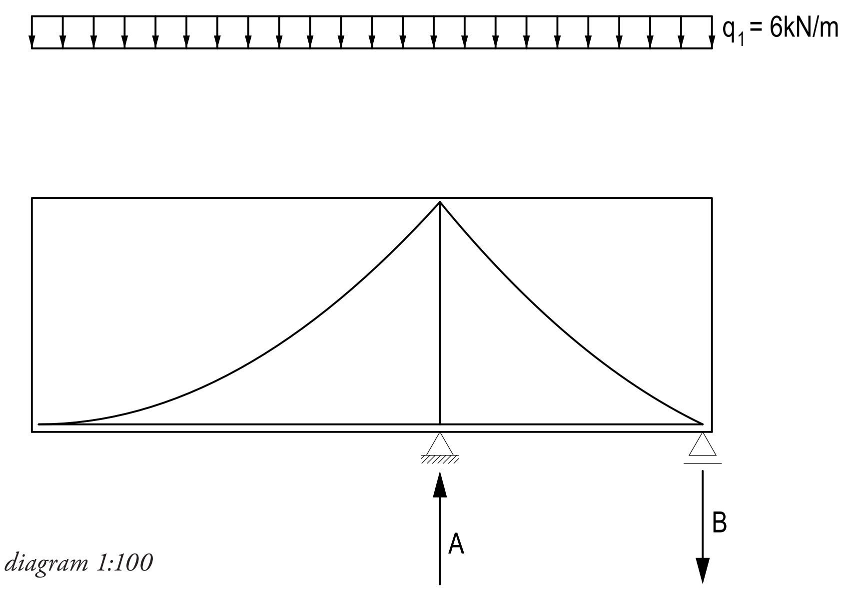
c)



form diagram 1:100

force diagram 1cm ≙ 10kN

d)

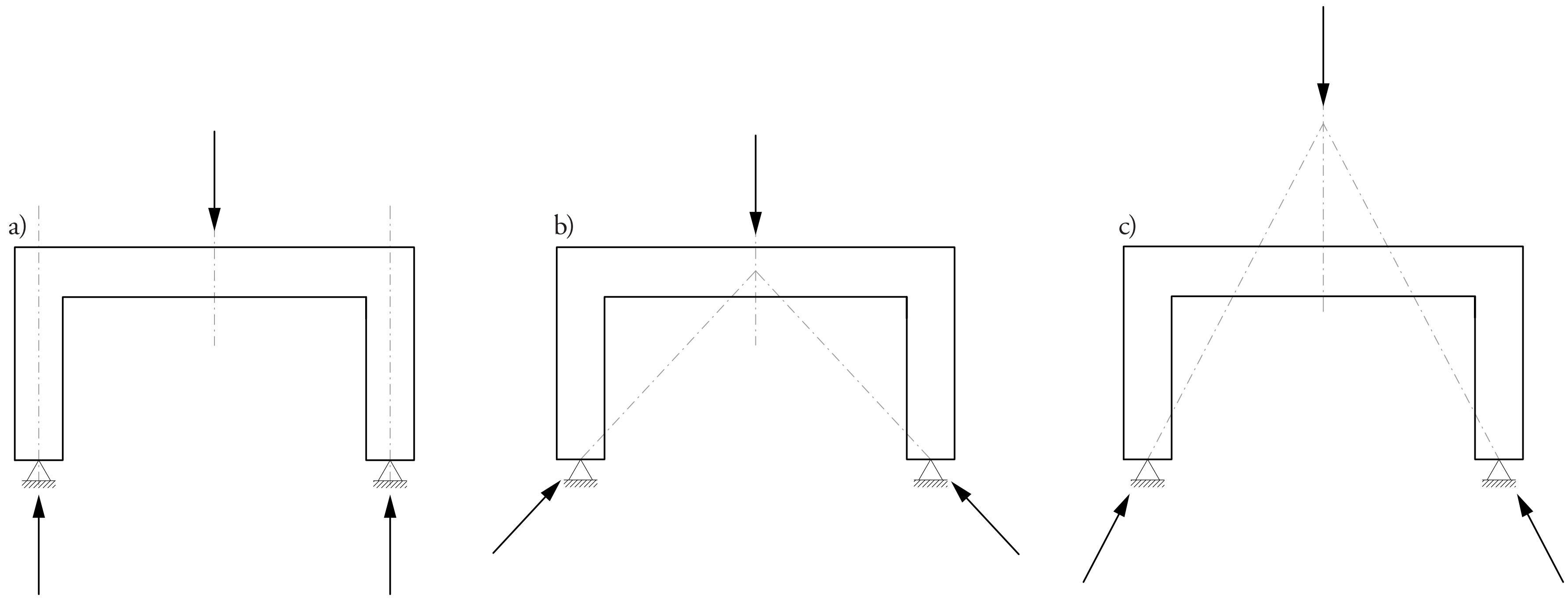


form diagram 1:100

force diagram 1cm ≙ 10kN

Task 3 Qualitative Inner Force Distribution in a Reinforced Concrete Frame

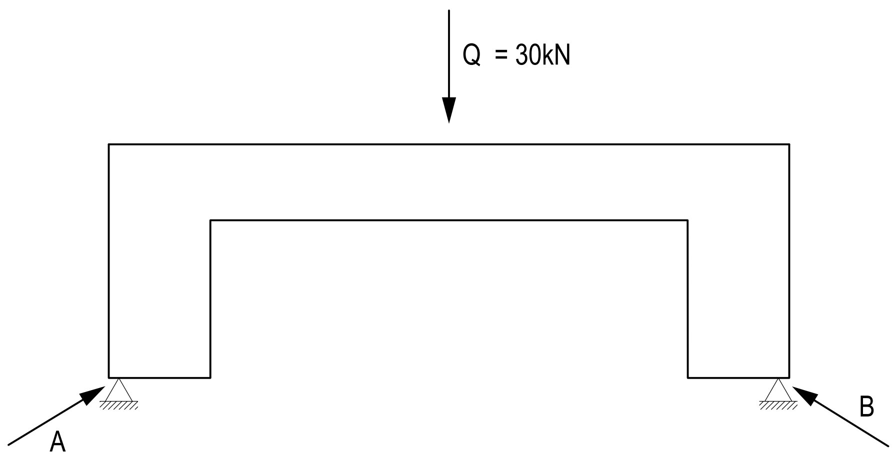
Three identical reinforced concrete frames with different support conditions are given. Draw the possible inner force distribution for each case. Indicate tension forces with red and compression forces with blue.



Additional Task 1 Statically indetermined supported frame

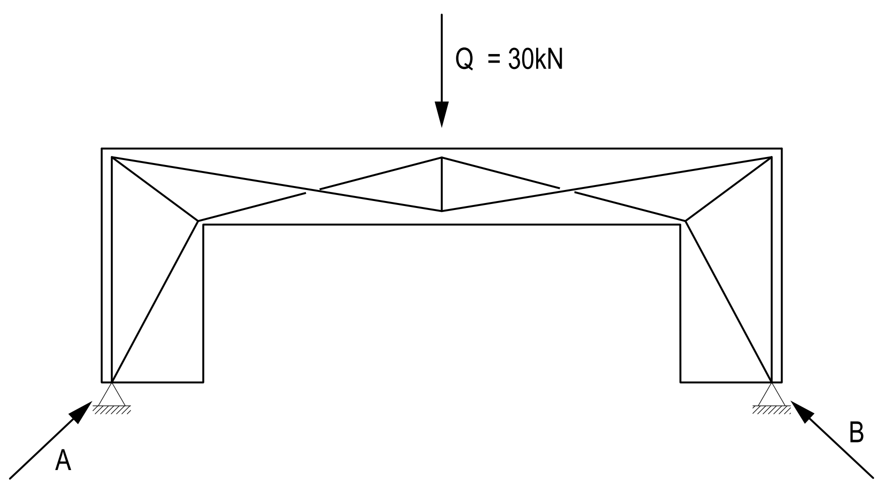
Two equal frames in reinforced concrete with different supports are given. In situation a) draw a possible internal force distribution as an arch-cable-construction with the aid of the force diagram. Draw the corresponding force diagram to the given force distribution in b). Indicate in both a) and b) tension forces with red and compression forces with blue.

a)



form diagram 1:100 *force diagram 1cm ≙ 10kN*

b)

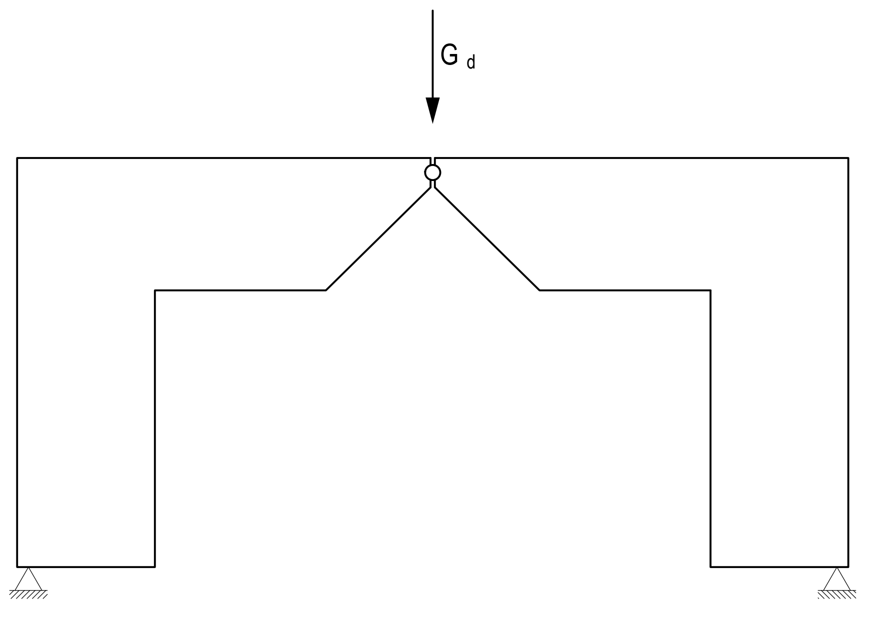


form diagram 1:100 *force diagram 1cm ≙ 10kN*

Task 1 Internal Force Flow in Frames

Draw a possible internal force flow for the reinforced concrete frame with help of the thrust line. Draw the corresponding force diagram and indicate tension forces with red, compression forces with blue and reaction forces with green.

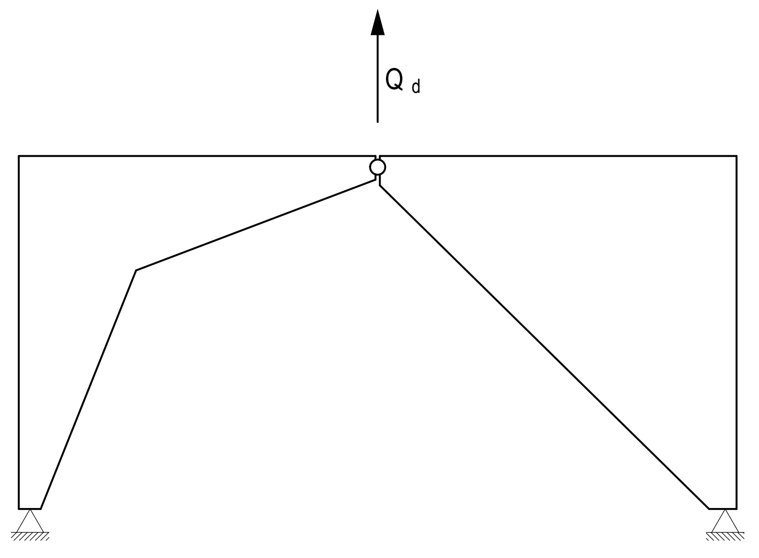
a)



form diagram 1:100

force diagram 1cm ≙ 10kN

b)



form diagram 1:100

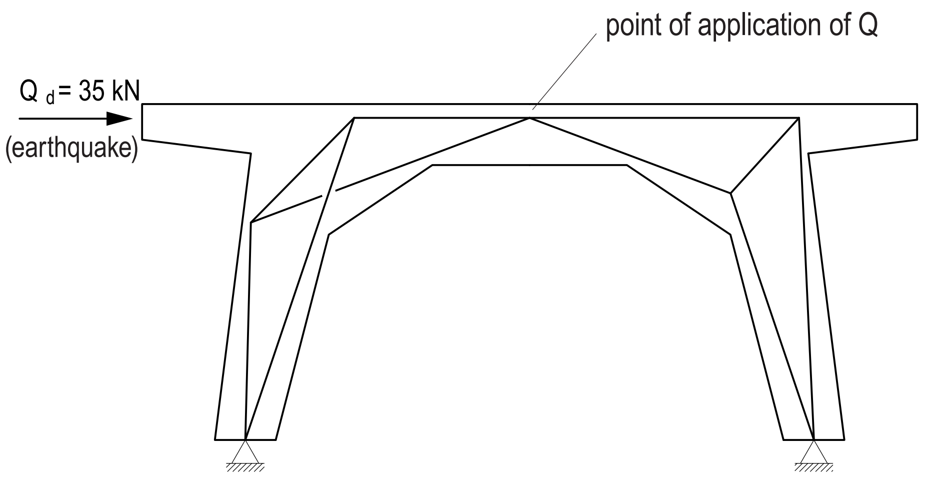
force diagram 1cm ≙ 10kN

Additional Task 2 Axial Force Proof

Check whether the reinforcement in the reinforced concrete in additional task 1a) can withstand the relevant tension force. The reinforcement has a round section with a diameter of 16 mm and is made of steel S235.

Additional Task 3 Reinforced Concrete Frame

Given is the possible distribution of the internal forces for a reinforced concrete frame. Draw the corresponding force diagram. Indicate tension forces with red and compression forces with blue.



form diagram 1:100

force diagram 1cm ≙ 10kN

subsystem

Additional Task 2 Dimensioning

a) Dimension the reinforcement within the reinforced concrete for the relevant tension force of task 2 a). Use steel S235 to calculate the diameter and round the result off to mm. (Round up!)

b) Verify whether the frame in task 2 b) can keep up with the relevant compression force. The slab is 8 cm thick and is constructed in concrete C12/15. Presume the force would affect the frame over the width of 10 cm.

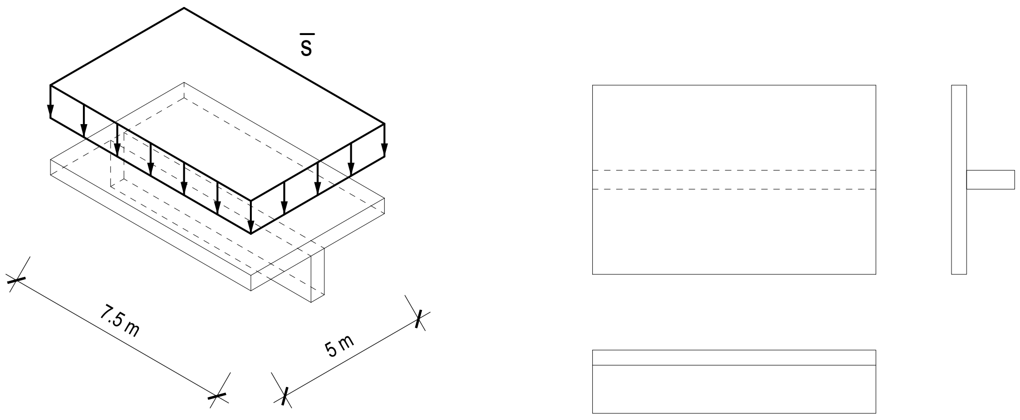
Task 1 Load-influenced Area

The plate is loaded by a dead area load of $\bar{s}_k$ = 1 kN/m^2. Calculate the design value of the constant area load.

Draw the relevant load-influenced area into the floor plan for both of the following cases, a) and b).

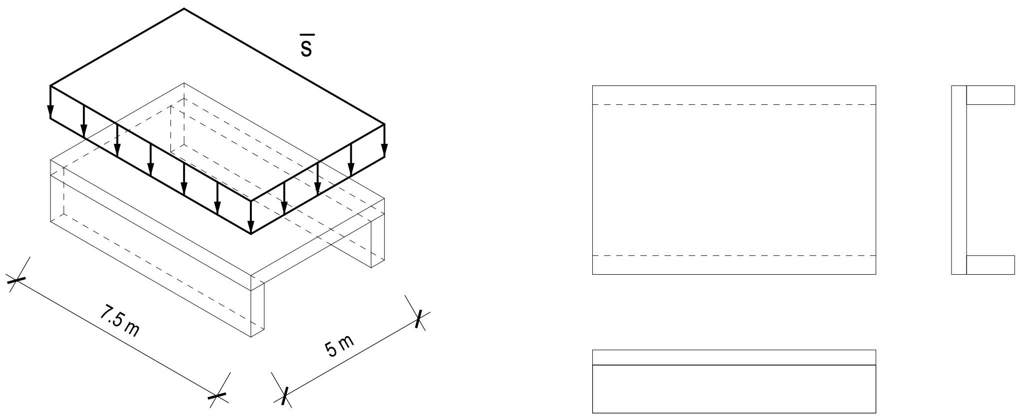
Then calculate the point load R and the line load g over the relevant beam and complete the table.

a)



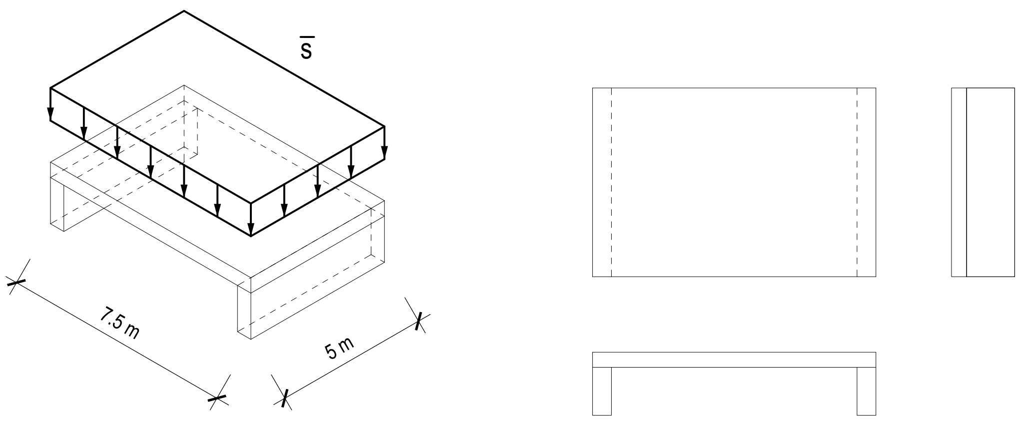
A	
$\bar{s}_d$	
R	
g	

b)



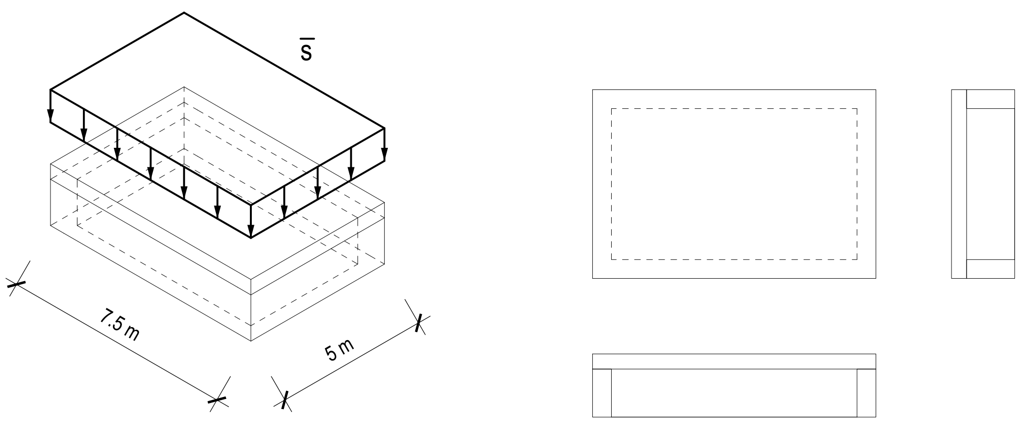
A	
$\bar{s}_d$	
R	
g	

c)



A	
$\bar{s}_d$	
R	
g	

d)



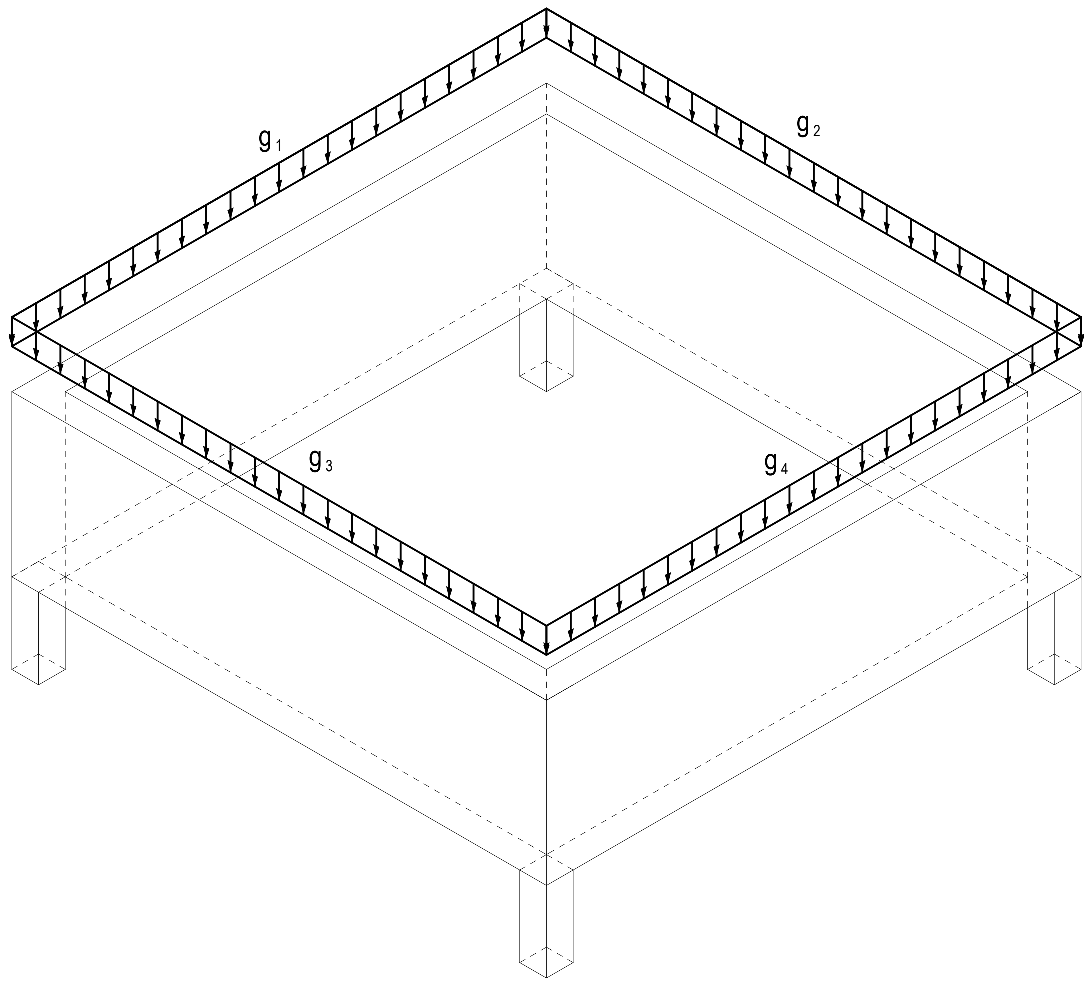
A	
$\bar{s}_d$	
R	
g	

axonometric drawings *plans 1:200*

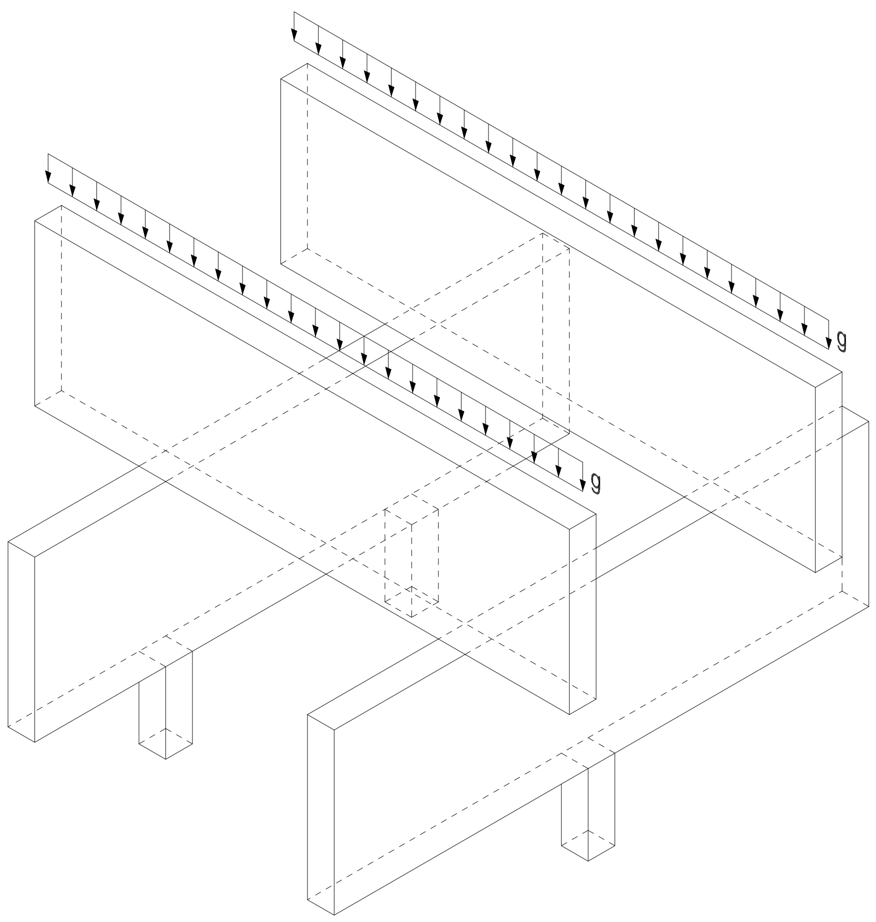
Task 3 Qualitative internal Force Flow

Draw a qualitative internal force flow in the axonometric drawing of the supporting structure. Use red for tension, blue for compression and green for the external forces.

a)



b)



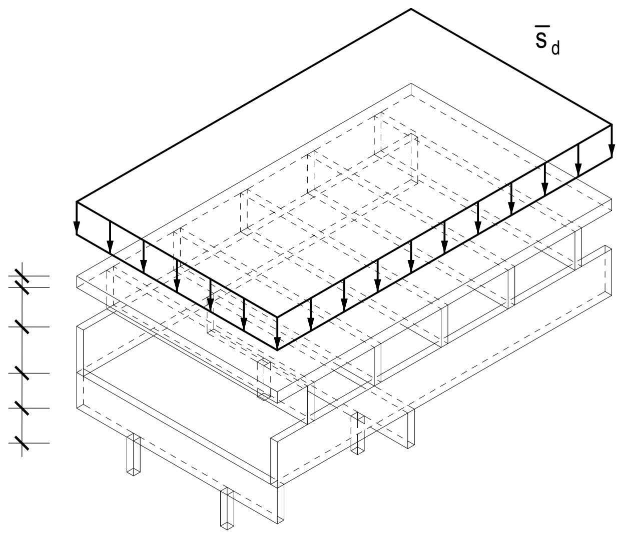
Additional Task 1

Transferring vertical Loads

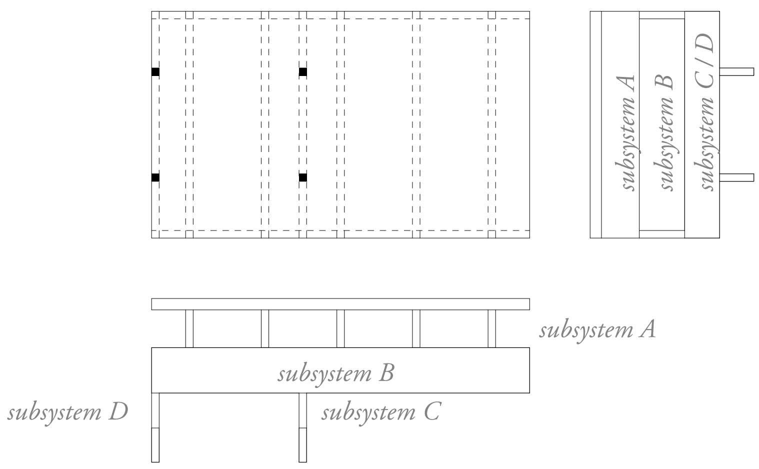
The plate is loaded by the same dead area load of task 4.

a) The reaction forces of the five beams in task 4a) (subsystem A) are further transferred to two other beams (Subsystem B). Note the different support condition of subsystem B. Find the inner force flow by the aid of the force diagram. Use red for tension, blue for compression and green for the reaction forces.

b) Again the reaction forces found in a) are further transferred to subsystems C and D. Draw the external forces in the marked position. Find an internal force flow and draw the corresponding force diagram.

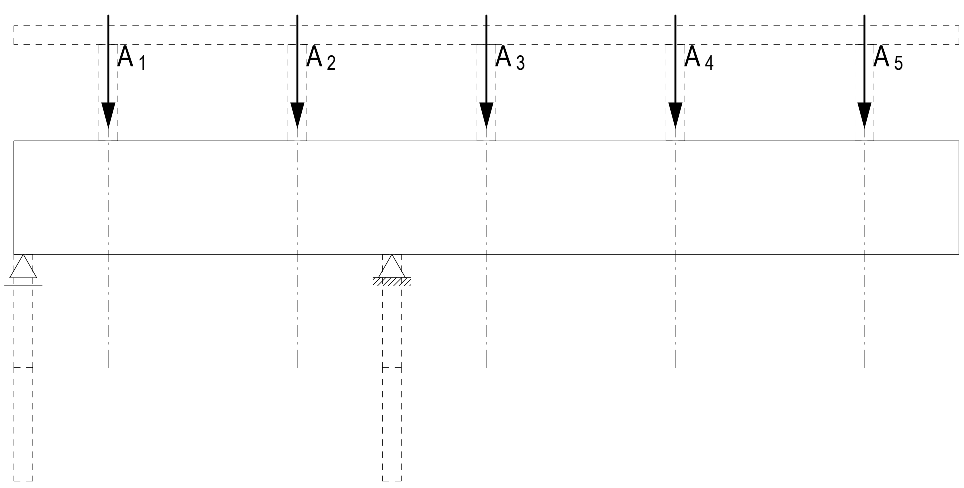


axonometric drawing



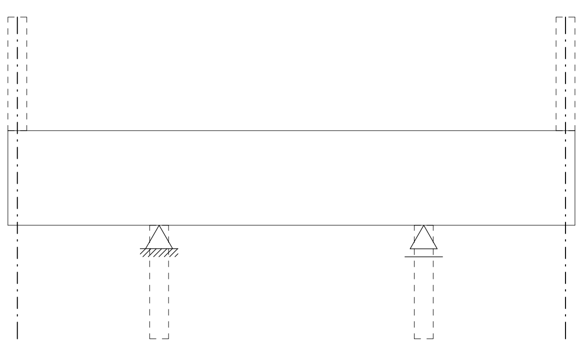
plans 1:500

a)

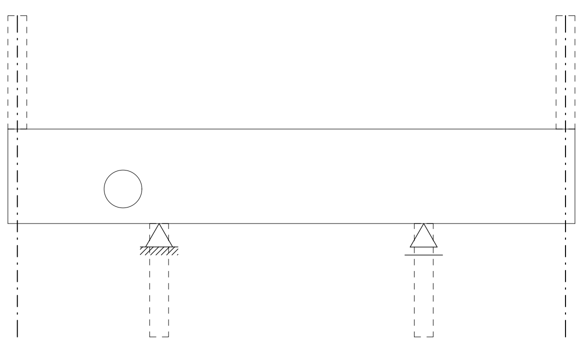


form diagram subsystem B 1:200

b)



form diagram subsystem C 1:200



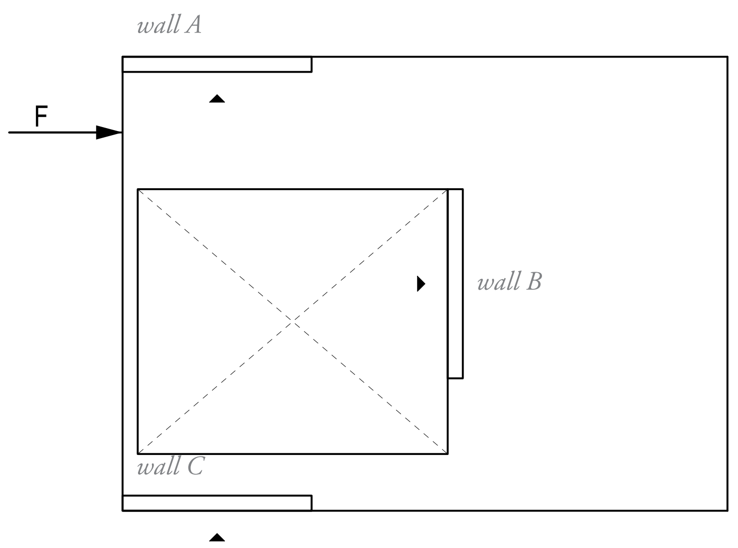
form diagram subsystem D 1:200

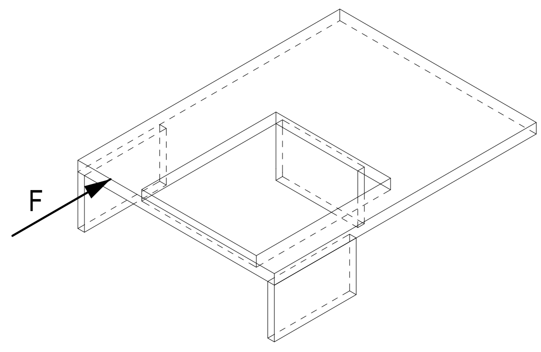
force diagram 1cm ≙ 50kN

Additional Task 1 Horizontal Forces (quantitatively)

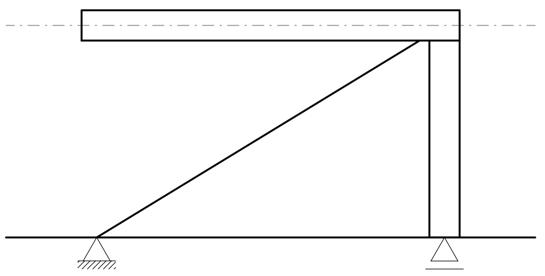
Analyse the force flow within the ceiling due to an applied horizontal force. The walls are used for bracing, therefore find the internal force flow in the plate such as it can be redirected into the ground through the walls. Draw the corresponding force diagram if F = 100 kN.

Then find a possible internal force flow in the walls A, B and C. First draw the applied horizontal force for each wall into the corresponding form diagram. Use red for tension, blue for compression and green for the external forces.

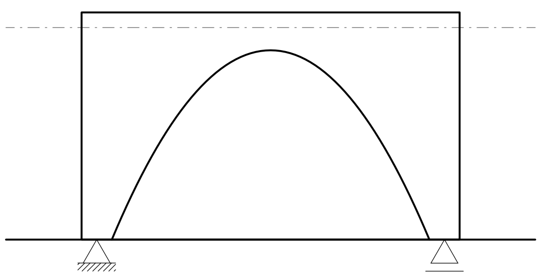




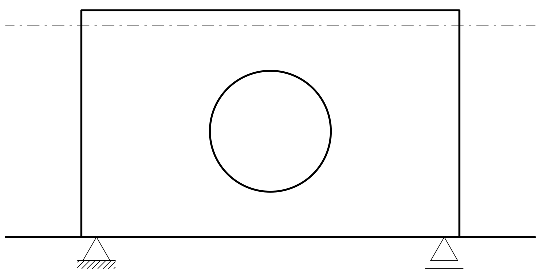
top view 1:200



form diagram wall A 1:100



form diagram wall B 1:100



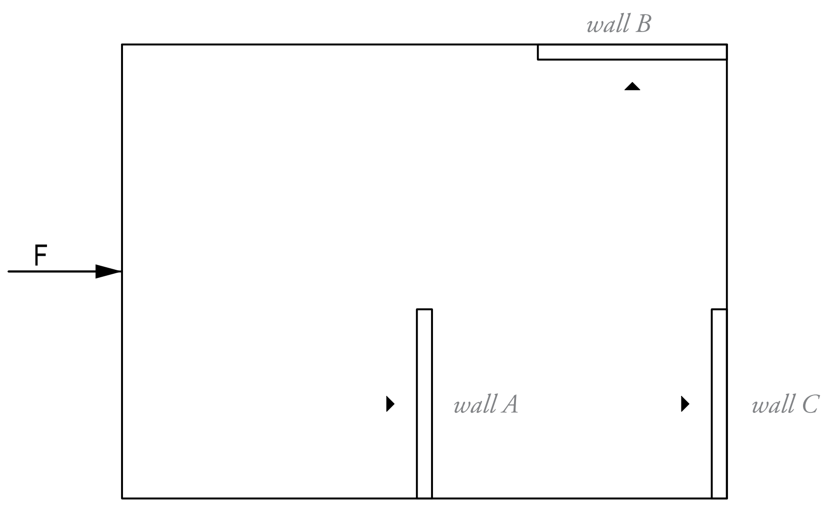
form diagram wall C 1:100

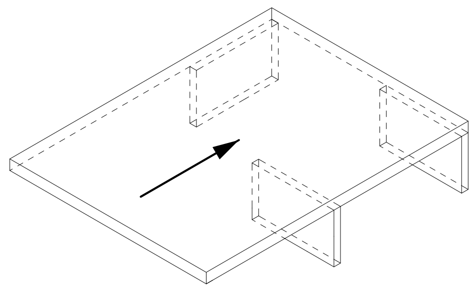
force diagrams 1cm ≙ 10kN

Additional Task 3 Horizontal Forces (quantitatively)

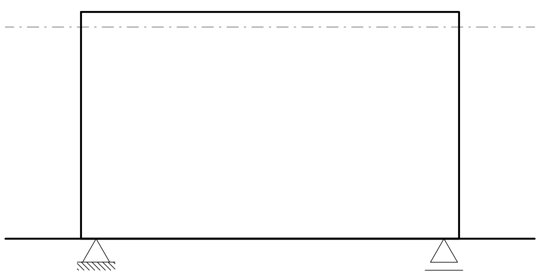
Consider the force flow within the ceiling due to an applied horizontal force. The walls are used for bracing, therefore find the internal force flow in the plate such as it can be redirected into the ground through the walls. Draw the corresponding force diagram if F = 100 kN.

Then find a possible internal force flow in the walls A, B and C. First draw the applied horizontal force for each wall into the corresponding form diagram. Use red for tension, blue for compression and green for the external forces.

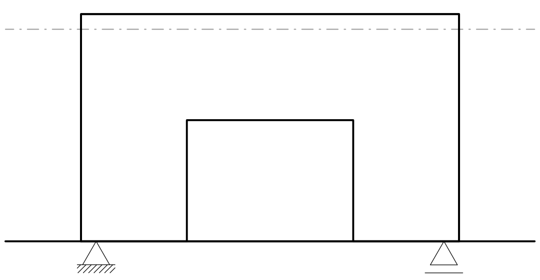




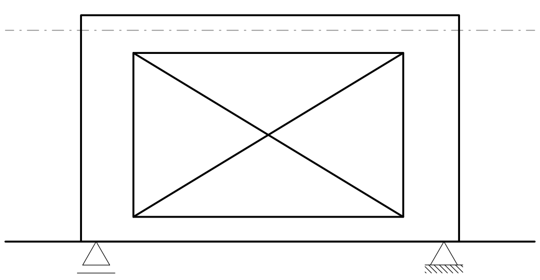
top view 1:200



form diagram wall A 1:100



form diagram wall B 1:100

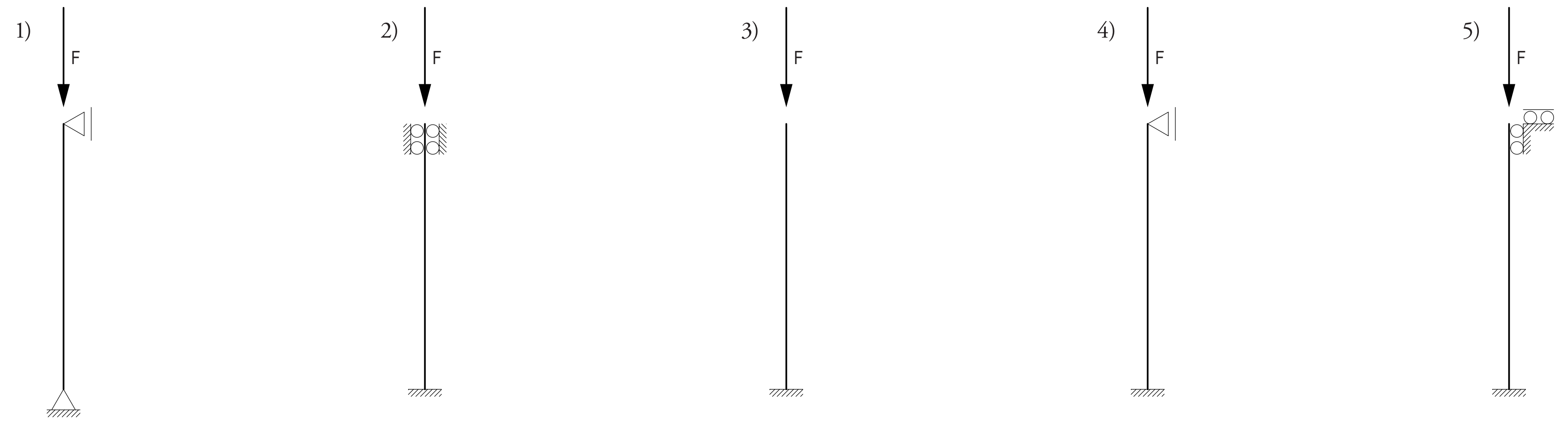


form diagram wall C 1:100

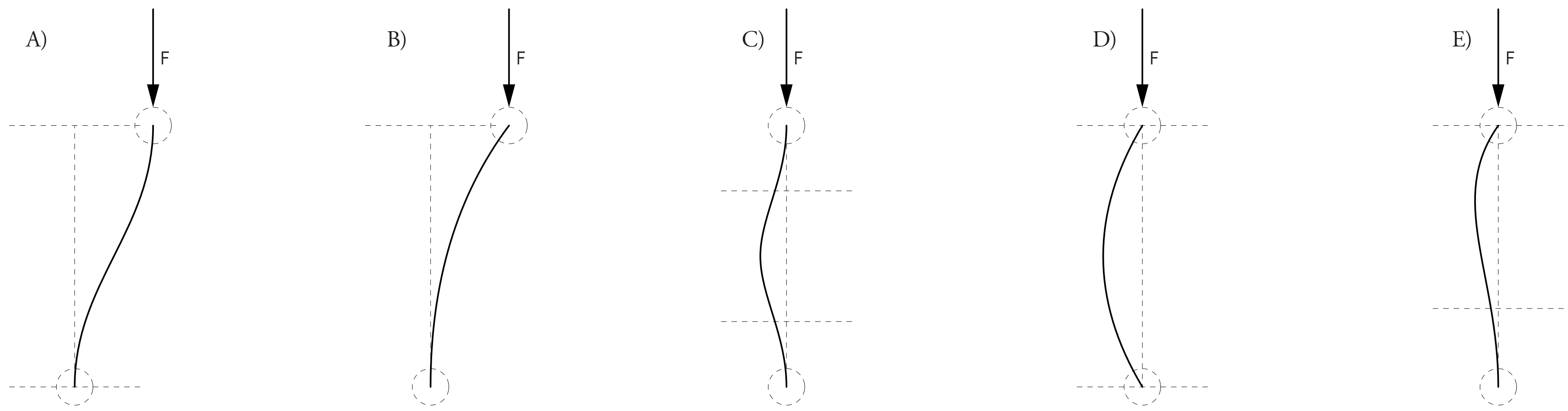
force diagrams 1cm ≙ 20kN

Task 1 Buckling behaviour

Shown below are columns with different supporting conditions and buckling behaviour. In the following table, assign to each support condition (1 - 5) the respective buckling behaviour (A - E) and the ratio of the critical and the actual length.



support condition

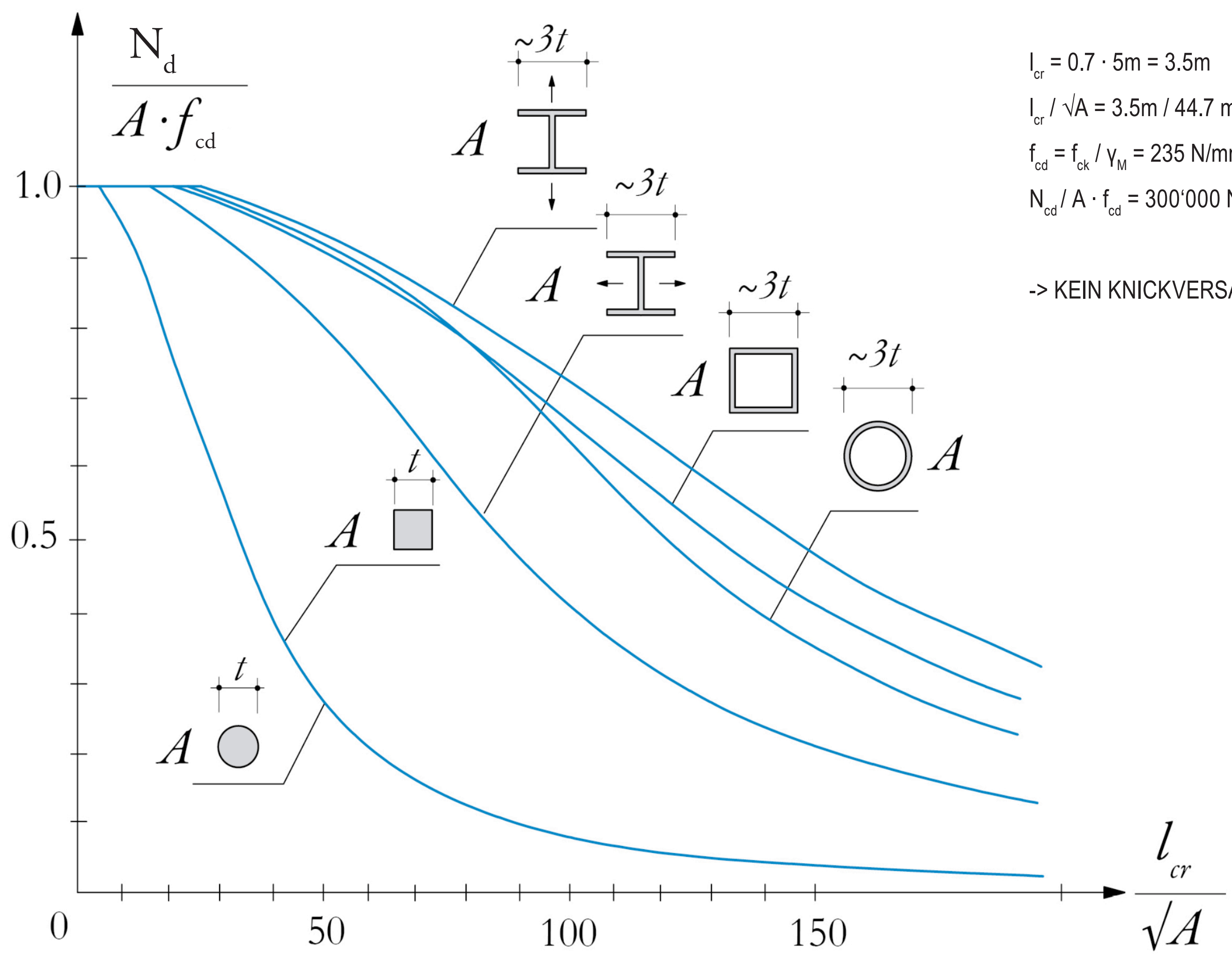


buckling behaviour

support condition	1	2	3	4	5
buckling behaviour	D	C	B	E	A
l_{cr} / l	1	0.5	2	0.7	1

Task 2 Buckling test

We are looking at a square hollow profile out of steel S 235. The element has a length of 5 m, a cross section of A = 2'000 mm² and is stressed by a compression force of N_{cd} = 300 kN. The support condition corresponds to that of example 4) in task 1.
Calculate whether buckling is occurring and draw the value in the diagram.



l_{cr} = 0.7 · 5m = 3.5m

l_{cr} / √A = 3.5m / 44.7 mm = 78 -> Diagramm

$f_{cd} = f_{ck} / \gamma_M$ = 235 N/mm² / 1.05 = 223.8 N/mm²

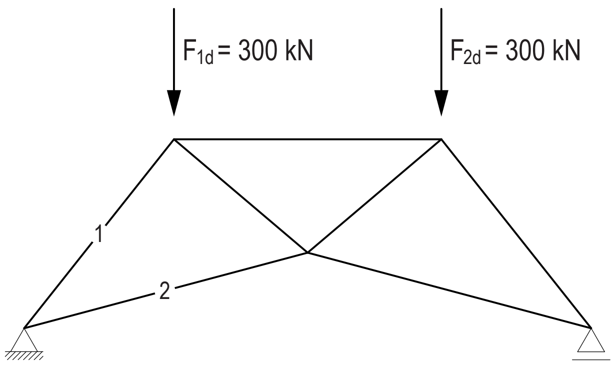
$N_{cd} / A \cdot f_{cd}$ = 300'000 N / (2'000 mm² · 223.8 N/mm²) = 0.67 -> Diagramm

-> KEIN KNICKVERSAGEN

buckling behaviour for different steel profiles

Task 3 Stability and dimensioning

a) Find the internal forces for the given structure with help of the force diagram. Use red for tension, blue for compression and green for the external forces.



form diagram 1:100

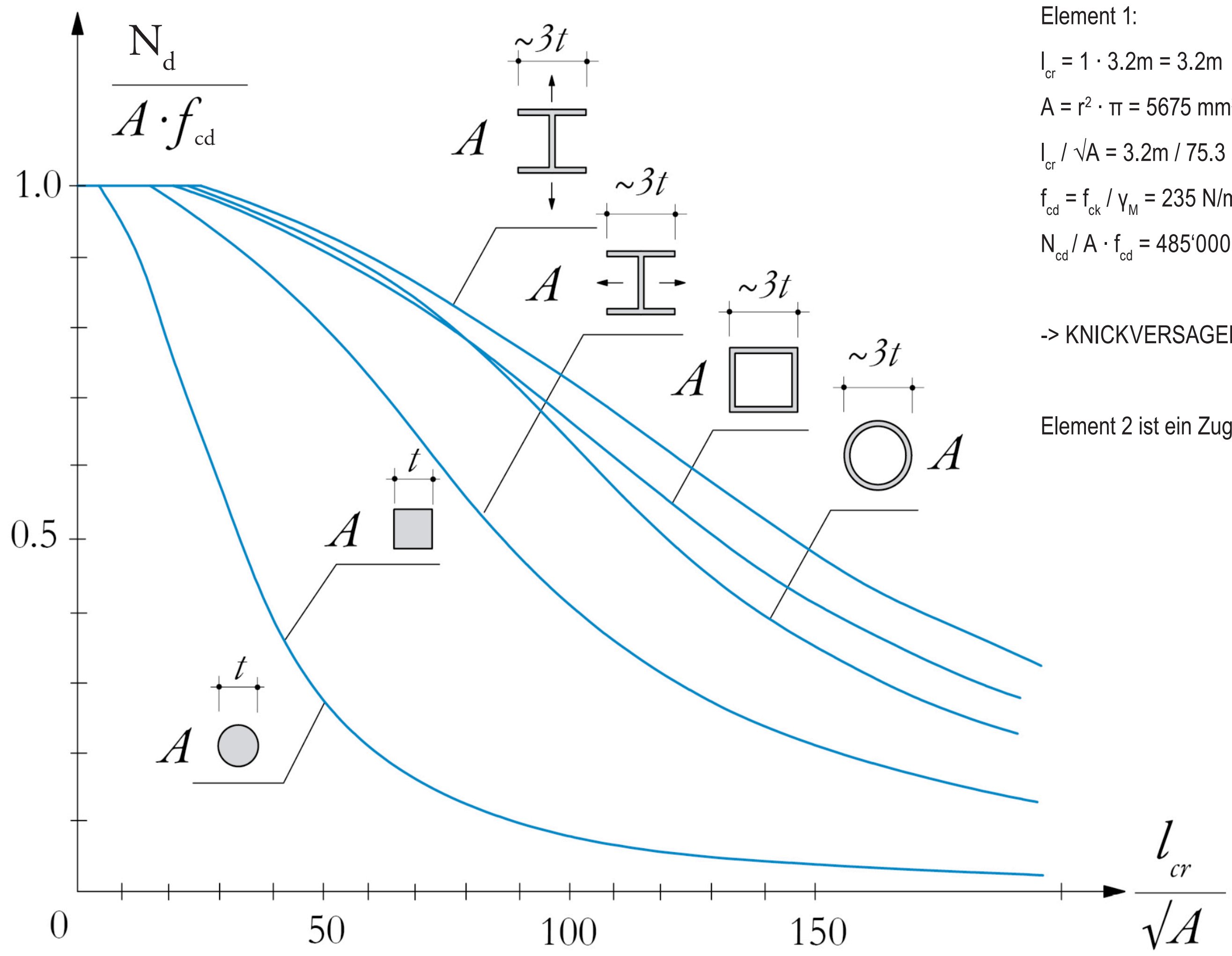
force diagram 1cm ≙ 100kN

b) The truss is built out of steel S 235 with circular solid profiles. Find the required diameter of the elements 1 and 2 (without considering buckling yet). Round the result to whole mm.

c) After considering the self-weight of the structure, the diameter for each element is 85 mm. In the given case the critical length is equal to the actual length of the elements. Use the buckling diagram to test the stability of elements 1 and 2 and draw the values into the diagram.

$A_{req} = N_d / f_{cd}$ = 485 kN / (235 N/mm² / 1.05) = 2167 mm²
$D_1 = 2 \cdot \sqrt{(A / \pi)}$ = 52.53 mm
≈ 53 mm

$A_{req} = N_d / f_{td}$ = 312 kN / (235 N/mm² / 1.05) = 1394 mm²
$D_2 = 2 \cdot \sqrt{(A / \pi)}$ = 42.13 mm
≈ 43 mm



buckling behaviour for different steel profiles

Element 1:
l_{cr} = 1 · 3.2m = 3.2m
A = r² · π = 5675 mm²
l_{cr} / √A = 3.2m / 75.3 mm = 42.5 -> Diagramm
$f_{cd} = f_{ck} / \gamma_M$ = 235 N/mm² / 1.05 = 223.8 N/mm²
$N_{cd} / A \cdot f_{cd}$ = 485'000 N / (5675 mm² · 223.8 N/mm²) = 0.38 -> Diagramm

-> KNICKVERSAGEN!

Element 2 ist ein Zugelement und kann daher nicht knicken.

d) How could buckling be prevented?

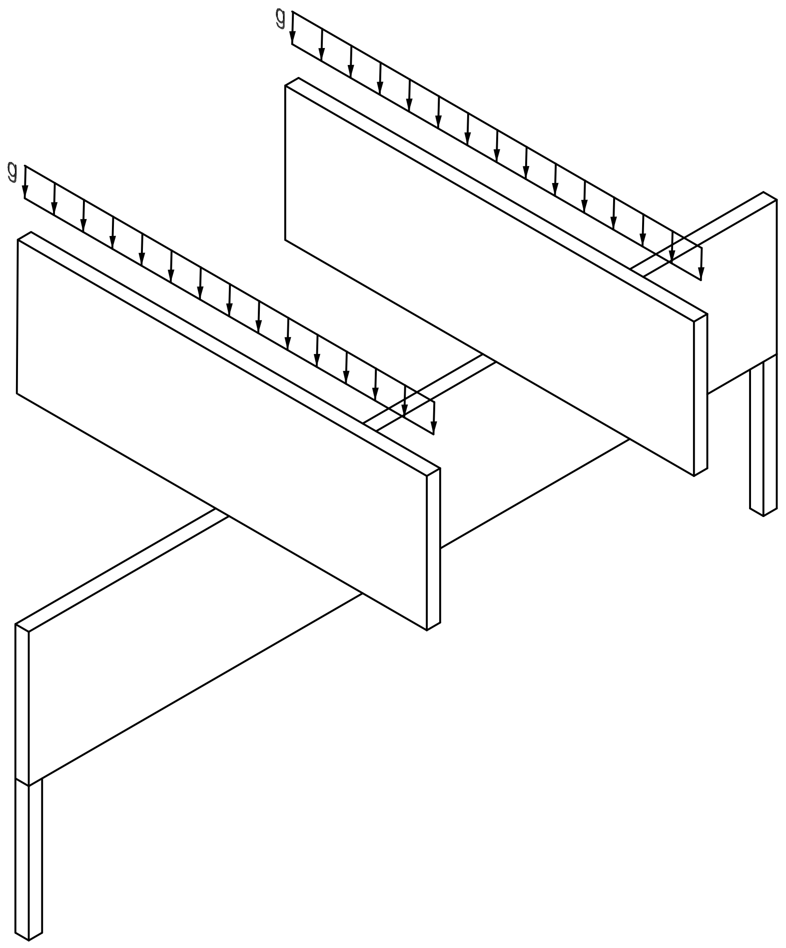
- Hohlprofil statt Vollprofil verwenden
- Anderes Material verwenden (z.B. S355 oder S500)
- Geometrie ändern (Element kürzen)

Additional Task 3 Transferring vertical loads

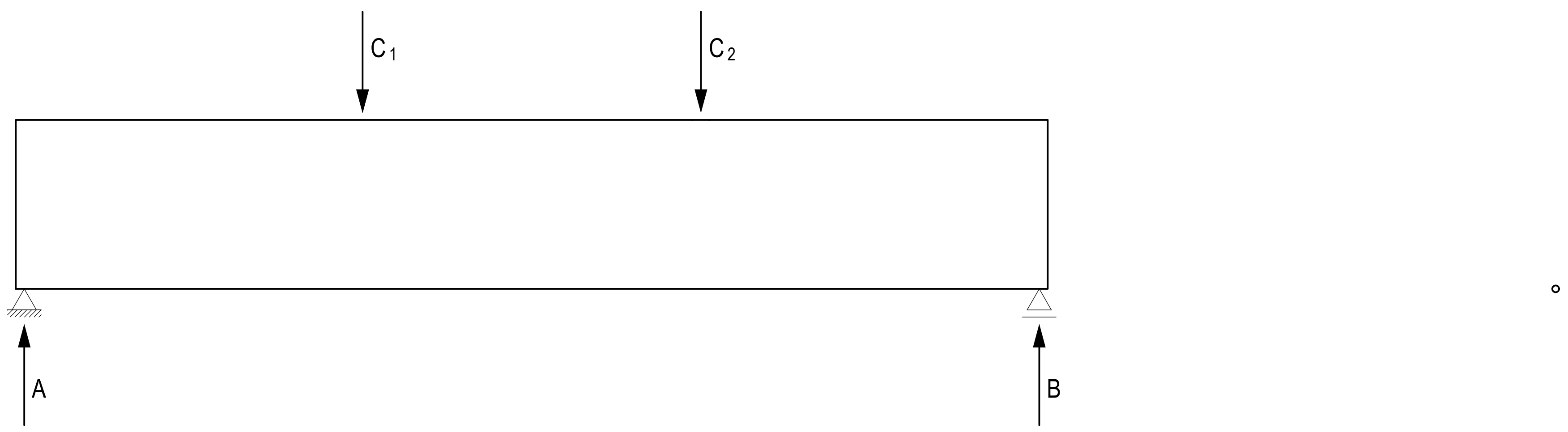
In additional task 1, you have determined the maximum load of a column of the system illustrated below. Find the maximum roof load g based on the maximum load of the two columns.

a) First draw a possible internal force flow in the lower beam as well as the corresponding force diagram. Find the maximum force that the two crossbeams can apply on the longitudinal beam. The magnitude of the reaction forces corresponds to the compression load found in additional task 1. Use red for tension, blue for compression and green for support forces.

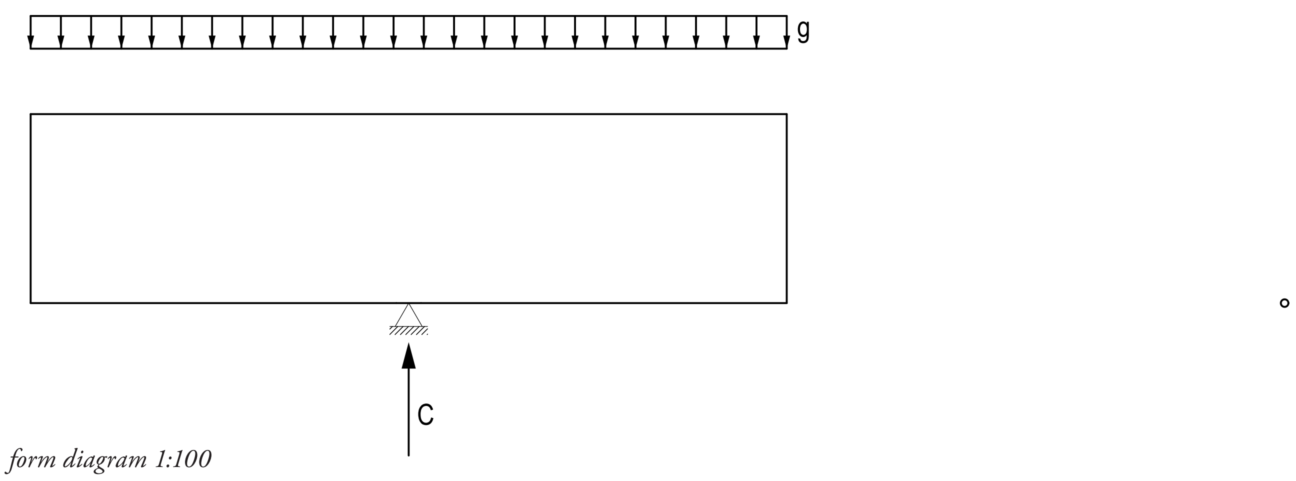
b) Then use the force diagram to find the internal force flow and the maximum line load g acting on the two crossbeams.



axonometry



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



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