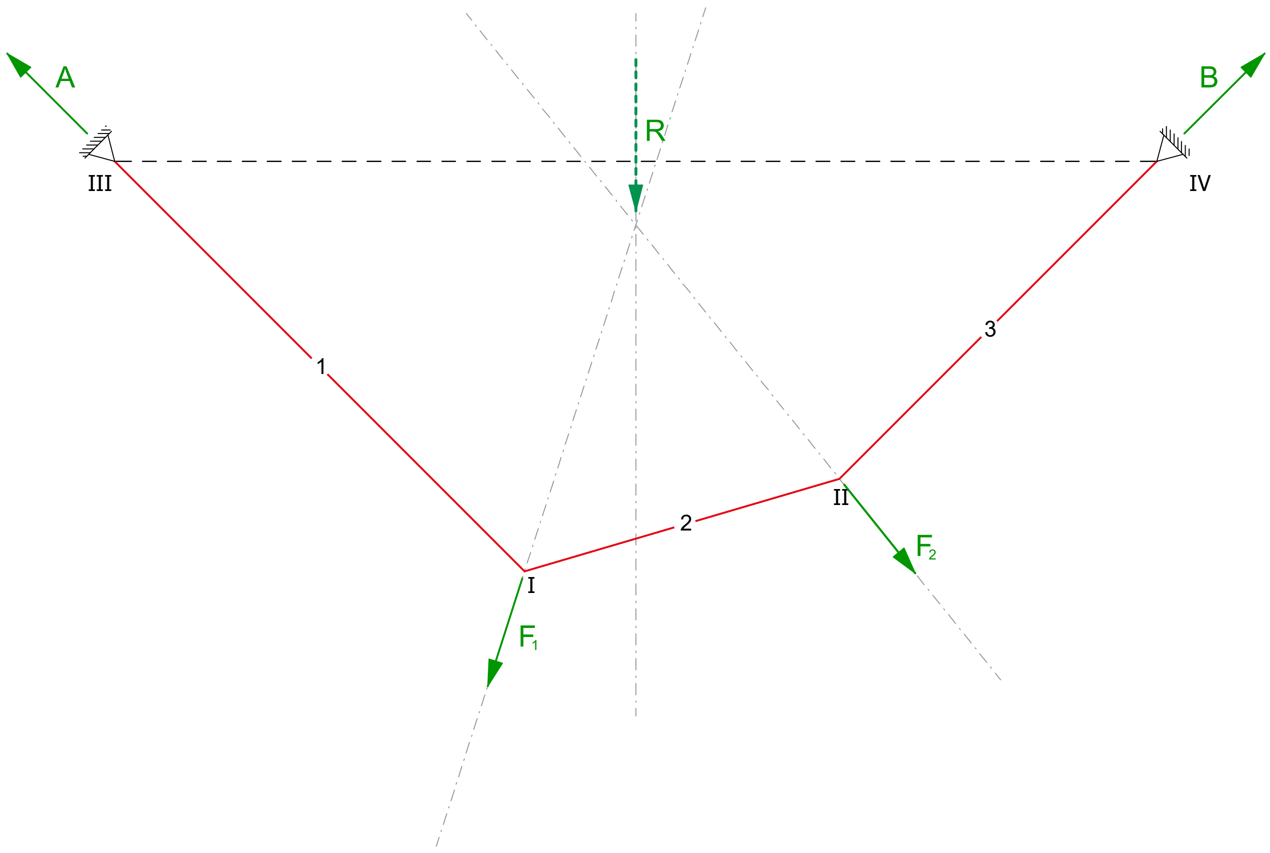
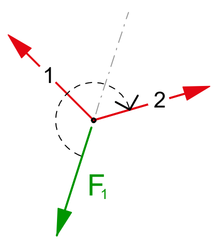
Task 1 Cable with Multiple Loads

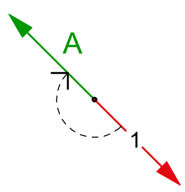
Draw a corresponding subsystem and a force diagram for the given case. Determine the magnitude of the reaction forces and the maximum force in kN. Draw the direction of the reaction force in the form diagram. In both form and force diagram, find the position of the resultant and indicate its magnitude in kN.



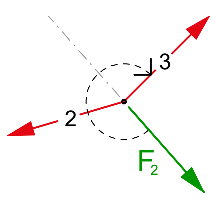
form diagram
1:50



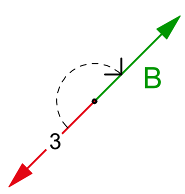
node I



node III

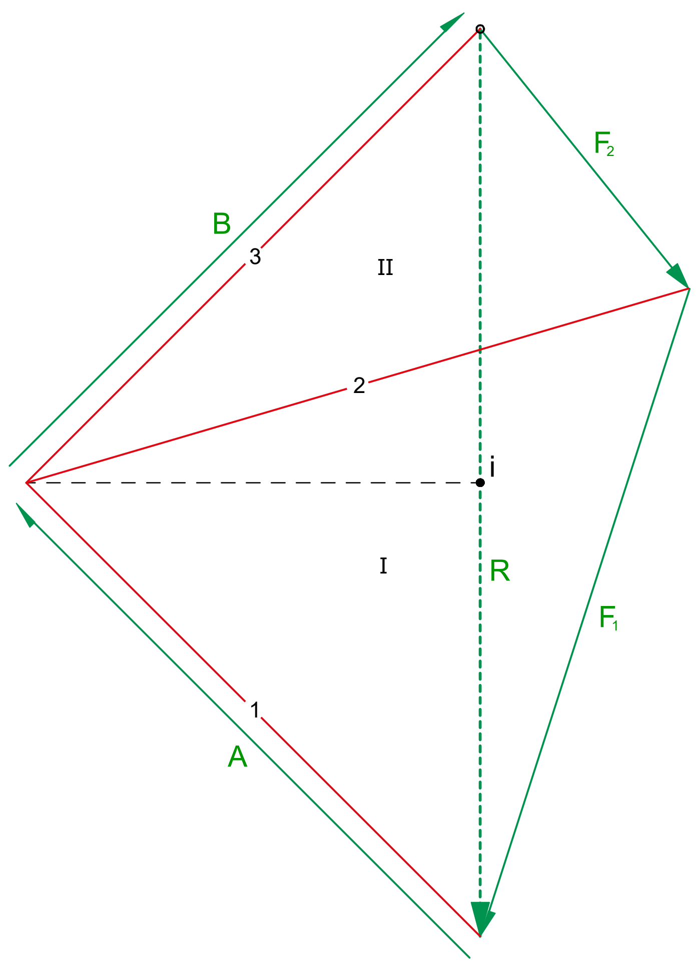


node II



node IV

subsystem

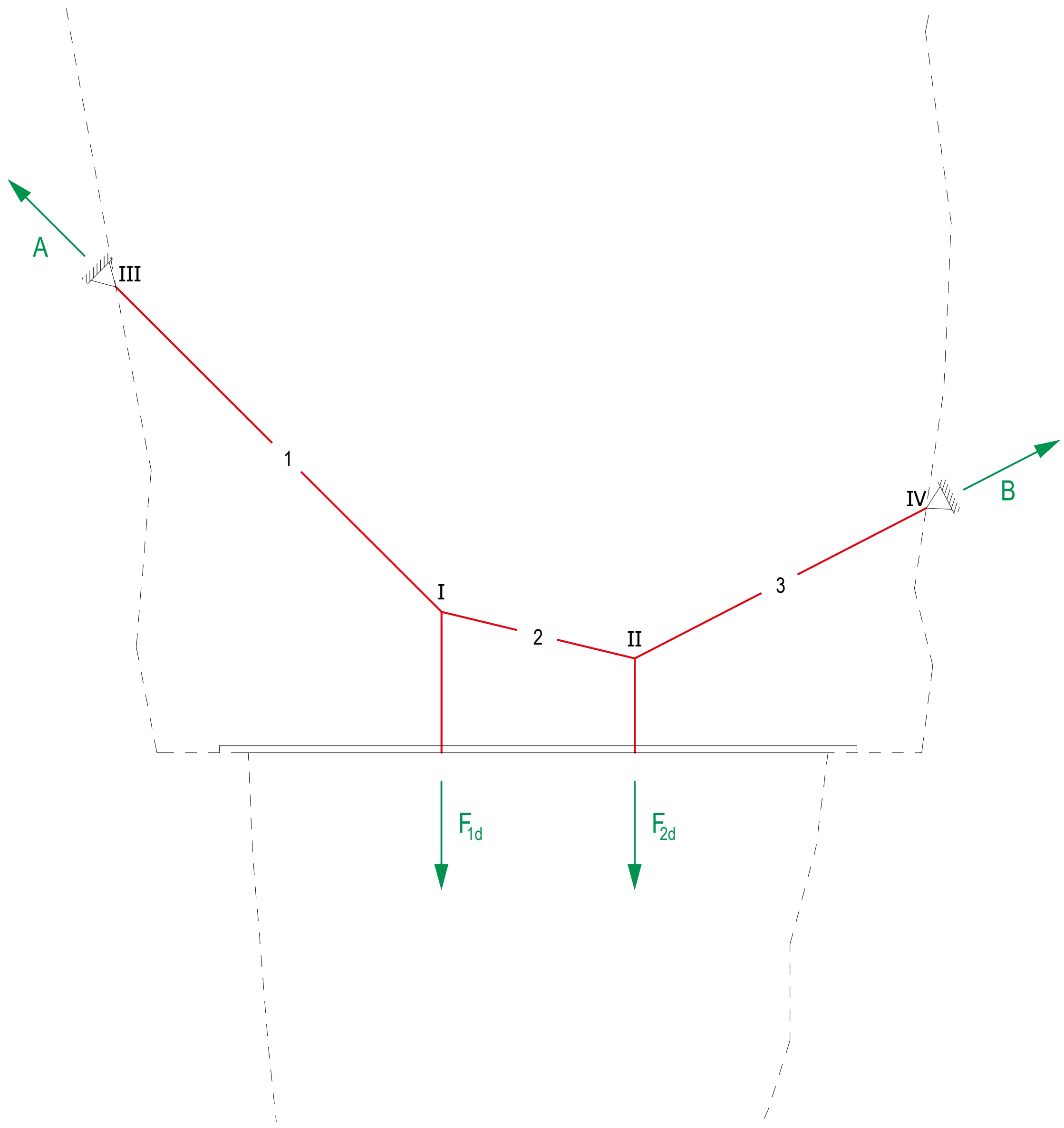


F_1	=	90	kN
F_2	=	44	kN
A	=	85	kN
B	=	85	kN
R	=	120	kN
N_{max} = N_2	**=**	**92.2**	**kN**

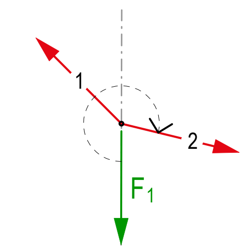
force diagram
1cm ≙ 10kN

Task 2 Dimensioning of a hanging bridge

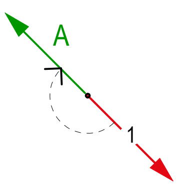
Draw the force diagram for the hanging bridge and enter the force in the main cable. Calculate the rope diameter due to the stress for the member made of steel S235. $F_{1d} = F_{2d} = 40$ kN



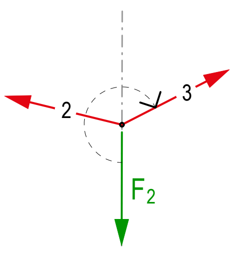
form diagram
1:500



node I



node III



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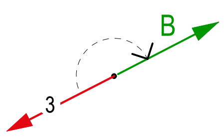
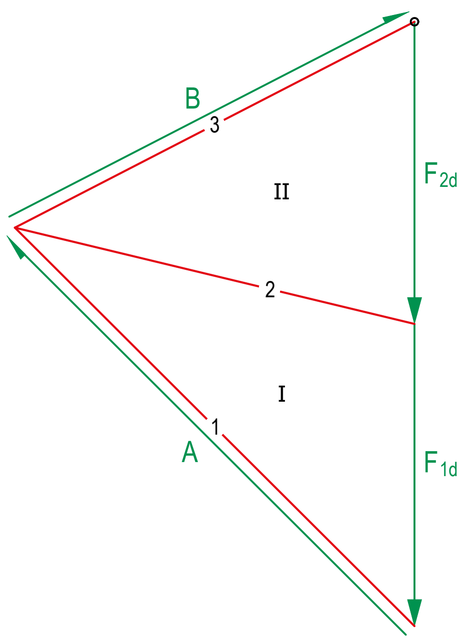


node IV

subsystem

N_d = 74'671 N
f_{td} = 223.8 N/mm²

$A_{req} = N_d / f_{td} =$ 333.6 mm²
$D = \sqrt{4 \cdot A / \pi} =$ **20.6 mm ≈ 21 mm**



force diagram
1cm ≙ 10kN

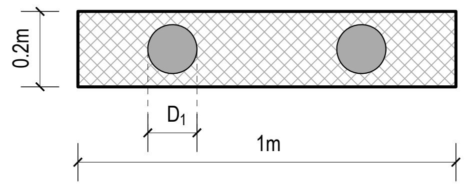
Task 3 Dimensioning of elements in tension

Given is the normal force N_d = 5900kN, which is distributed on several steel cables (steel S235) as shown in sections a) and b). (Assumption: the cables carry the full tension load, i.e. the stresses on the concrete can be neglected)

a) Calculate the minimum cable diameter D1 and D2 in steel S235 for the two cases shown in a) and b) (rounded to the next higher mm). The material values can be found in the formula sheet.

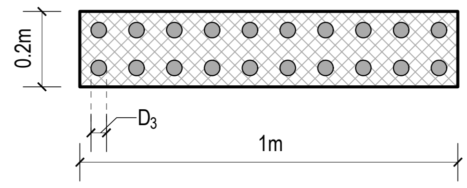
b) What could possible advantages and disadvantages of constellations a) and b) be? Specify your favorite choice and justify it.

Option 1



cross section
1:20

Option 2



cross section
1:20

Option 1

N_d = 5'900 kN
f_{tk} = 235 N/mm²
γ_M = 1.05

$f_{td} = f_{tk} / \gamma_M$ = 223.8 N/mm²
$A_{req} = N_d / f_{td}$ = 26'361.7 mm²
$A_{Seil} = A_{req} / 2$ = 13'180.9 mm²
$D = \sqrt{4 \cdot A / \pi}$ = **129.5 mm ≈ 130 mm**

Option 2

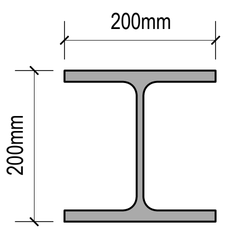
N_d = 5'900 kN
f_{tk} = 235 N/mm²
γ_M = 1.05

$f_{td} = f_{tk} / \gamma_M$ = 223.8 N/mm²
$A_{req} = N_d / f_{td}$ = 26'361.7 mm²
$A_{Seil} = A_{req} / 20$ = 1'318.1 mm²
$D = \sqrt{4 \cdot A / \pi}$ = **41.0 mm**

b) In option 1 the effort is less because of the fewer elements. Option 2 shows a better force distribution at the crosssection.

Task 4 Stress check

Find the stresses for the steelprofile S235 for the given values.



Cross section
1:10

N_d = 1'500 kN
A_{ef} = 7810 mm²

$f_{ef} = N_d / A_{ef} \leq f_{cd}$
f_{cd} = 223.8 N/mm²
f_{ef} = **192.1 N/mm²**

$f_{ef} \leq f_{cd}$ ok!

$N_d \leq N_{allow} = f_{cd} \cdot A_{ef}$
f_{cd} = 223.8 N/mm²
N_{allow} = **1747.8 kN**

$N_d \leq N_{allow}$ ok!

Additional Task 1

Different materials in tension and compression

To get a sense of how different materials behave in tension and compression, we compare the behavior of timber (spruce), steel (S235) and concrete (C20/25).

a) Refer to the formula sheet to find the characteristic values for tensile and compressive strengths, and the safety factors for each material and introduce them into the table.

b) Consider a tensile stress of N_d = 12kN. Calculate for the three materials the required square crosssectional area A_{req} and side length a required for N_d.

c) Repeat b) now with a compressive load of N_d = 12kN.

a)

	Wood Spruce	Steel S235	Concrete C20/25
γ_M	1.3	1.05	1.5
f_{tk}	14 N/mm²	235 N/mm²	1.5 N/mm²
f_{td}	**10.8 N/mm²**	**223.8 N/mm²**	**1 N/mm²**
f_{ck}	20 N/mm²	235 N/mm²	20 N/mm²
f_{cd}	**15.4 N/mm²**	**223.8 N/mm²**	**13.3 N/mm²**

b)

Wood

N_d = 12'000 N

f_{td} = 10.8 N/mm²

A_{req} = N_d / f_{td} = 1112 mm²

Steel

N_d = 12'000 N

f_{td} = 223.8 N/mm²

A_{req} = N_d / f_{td} = 54 mm²

Concrete

N_d = 12'000 N

f_{td} = 1 N/mm²

A_{req} = N_d / f_{td} = 12'000 mm²

c)

Wood

N_d = 12'000 N

f_{cd} = 15.4 N/mm²

A_{req} = N_d / f_{cd} = 780 mm²

Steel

N_d = 12'000 N

f_{cd} = 223.8 N/mm²

A_{req} = N_d / f_{cd} = 54 mm²

Concrete

N_d = 12'000 N

f_{cd} = 13.3 N/mm²

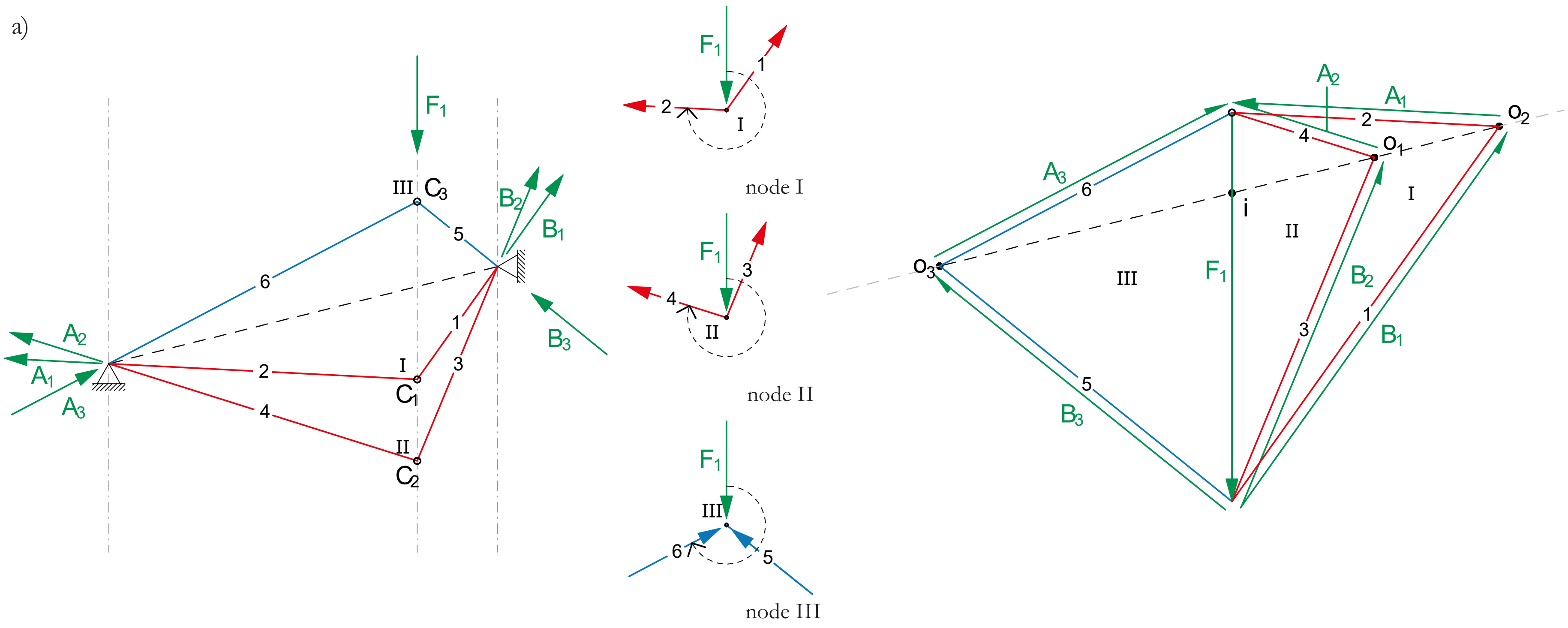
A_{req} = N_d / f_{cd} = 903 mm²

Additional Task 2 — Closing String

Draw the corresponding force diagrams for three cable polygons shown in cases a) and b). Draw the closing string in both form and force diagrams. Indicate tension forces with red and compression forces with blue.

c) Compare the relation between the closing strings, the intersection point i and the poles in the different support systems.

a)

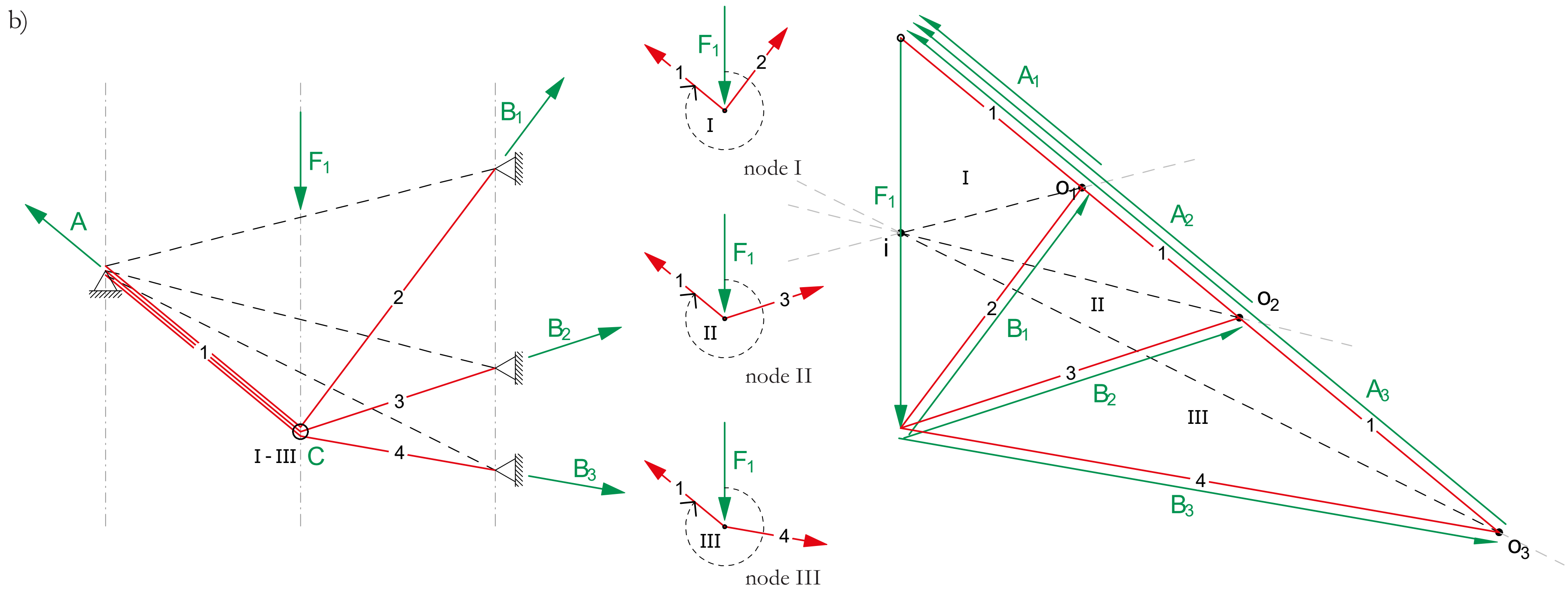


form diagram
1:50

subsystem

force diagram
1cm ≙ 20kN

b)



form diagram
1:50

subsystem

force diagram
1cm ≙ 20kN

c) All of the closing strings intersect on F in the same point i. The poles are on the matching closing strings in each specific case.