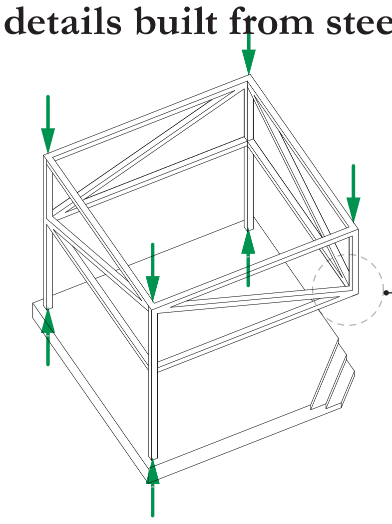
Analysis and developement of construction details

Name: ______________________________

Task 1 Construction details built from steel

Axonometry

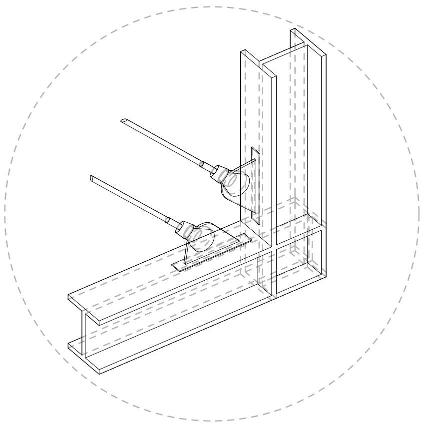


Detail: tension strut connected compression element

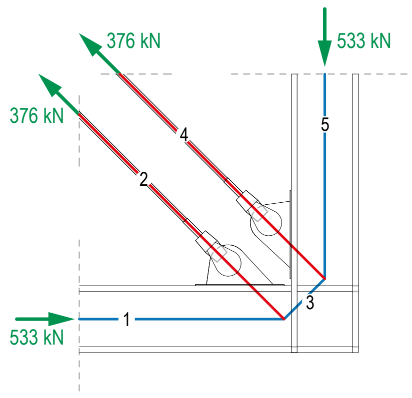
1a Centric connection of tension struts to compression elements

In the drawing below, a possible connection detail attaching the tension structs to the compression elements is shown. Determine a possible internal forceflow for the given external load case and draw its associated force diagram.

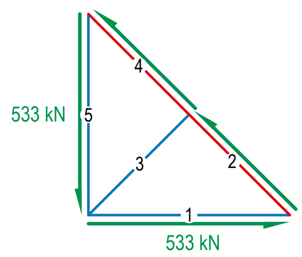
Connection detail



Vertical section



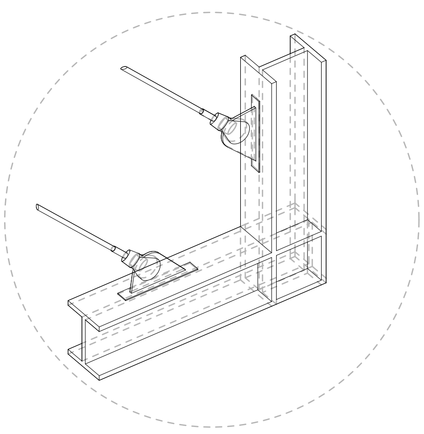
Force diagram (1cm=200kN)



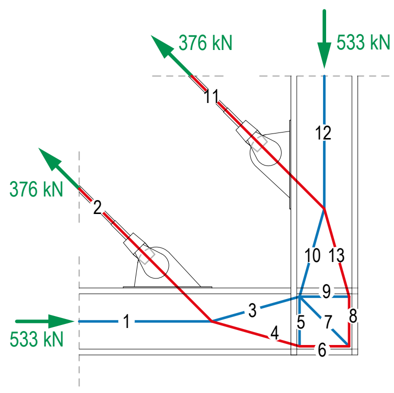
1b Excentric connection of tension struts to compression elements

In the following, the connection detail is designed in a similar manner with the sole difference of an increased attachement distance of the tension struts with respect to the corner. Adapt the internal forceflow to the new geometry and draw the associated force diagram. Then, compare both design variations with respect to their force flow. Which of the variations is more advantageous and why?

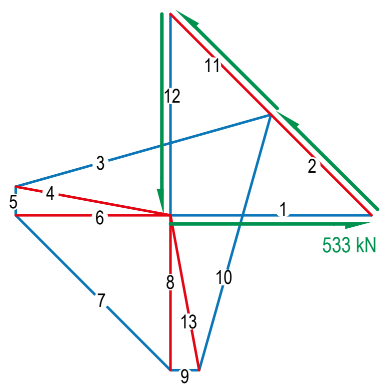
Connection detail



Vertical section



Force diagram (1cm=200kN)

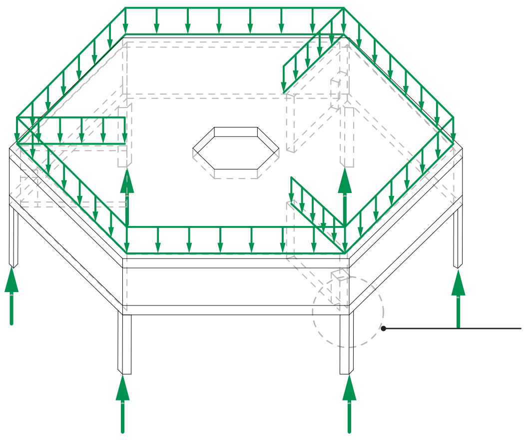


Disadvantage: Forces are deviated through the corner acting as a frame -> Internal forces can become bigger, hence greater material utilization.

Name: ______________________

Task 2 Construction details built from reinforced concrete

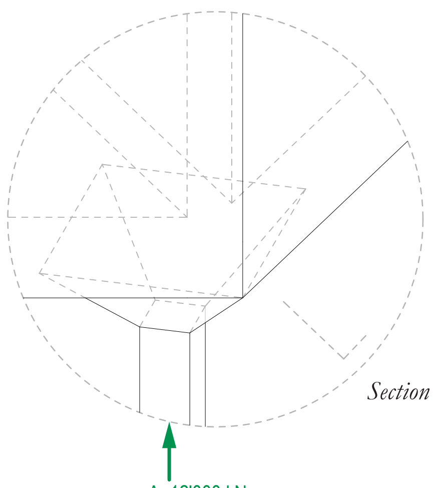
Axonometry



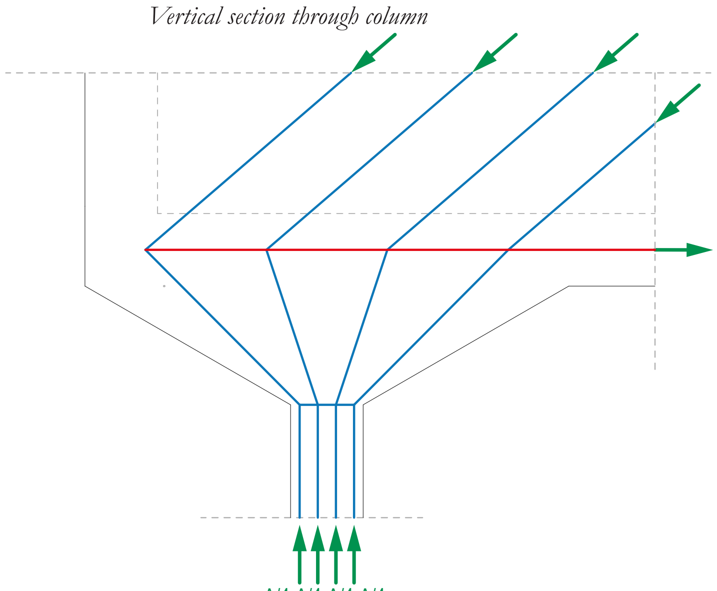
2a Forceflow in a mushroom column

In the following, mushroom columns are analyzed as a design solution for the structure shown above. For the given external load case, draw a qualitative force flow within the connection detail. Where do the largest compression stresses occur? What is the magnitude of these compression stresses? Is the concrete able to sustain the acting compression stresses? If not, what should be the dimensions of the column such that the concrete strength is not exceeded. For the calculations, assume column dimensions of 30cm x 30cm and use C30/37 concrete. It has to be noted that only the construction detail is considered here without paying attention to global effects such as buckling.

Detail mushroom column



Vertical section through column



Largest stresses occur in the location with the smallest area, hence in the column (acting force remains the same).

Stress [σ] = Force [N] /Area [A] = 12000kN/(30cm)^2 = 12'000'000N/90'000mm^2 = 133N/mm^2,>> f_{cd}= 20 N/mm^2 (Design compression strength C30/37 concrete)

The required area Areq = N/f_{cd} = 12'000'000N/20 N/mm^2 = 600'000mm^2

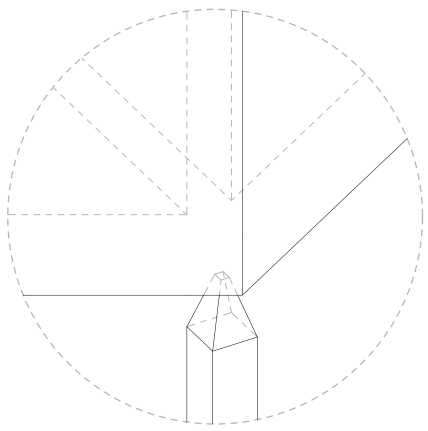
The column has to be at least (axb) 775mm x 775mm = 600'000mm^2. In a next step, the columns resistence against buckling has to be checkecd.

2b Forceflow in pyramid column

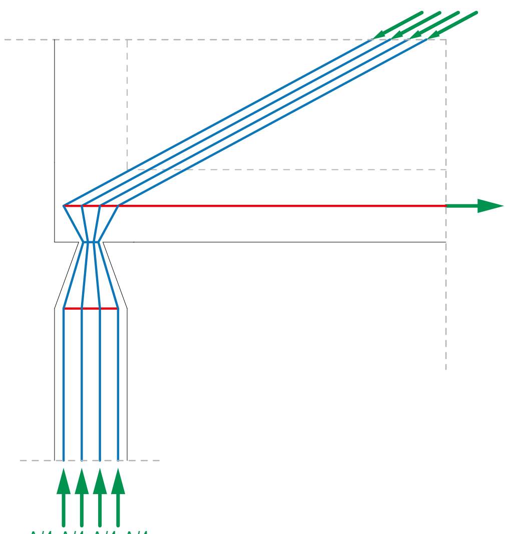
Help: Appendix «Lasten und Kennwerte» →

In the following, pyramid columns are analyzed as a design solution for the structure shown above. For the given external load case, draw a qualitative force flow within the connection detail. Where do the largest compression stresses occur? What is the magnitude of these compression stresses? Is the concrete able to sustain the acting compression stresses? If not, how could an alternative design look like such that the material strength is not exceeded. For the calculations, assume dimensions of 10cm x 10cm in the most narrow part and use C40/45 high strength concrete. In case you decide to use a different construction material for the detail alternative, you can chose a suitable material strength class.

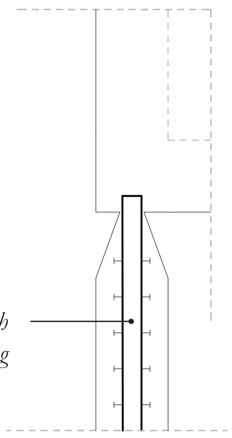
Detail pyramid column



Section through pyramid column



Implementation of pyramid column



Largest stresses in most narrow part of the column (smallest surface area, same acting load)

Stress [σ] = Force/Area = 12000kN/(10cm)^2 = 12'000'000N/10'000mm^2 = 1200N/mm^2 >> f_{cd} (C40/45) = 24 >> f_{sd}(S355) = 355 N/mm^2

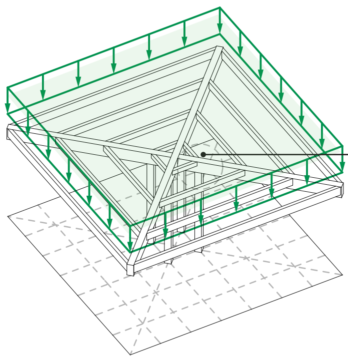
Minimal surface area needed using S355 Steel: 12 000 000 N / 355 N/mm^2 = 33 803 mm^2

The column has to be at least (axb) 183mm x 183mm. In a next step, the columns resistence against buckling has to be checkecd.

Name: ______________________

Task 3 Construction details built from wood

Axonometry

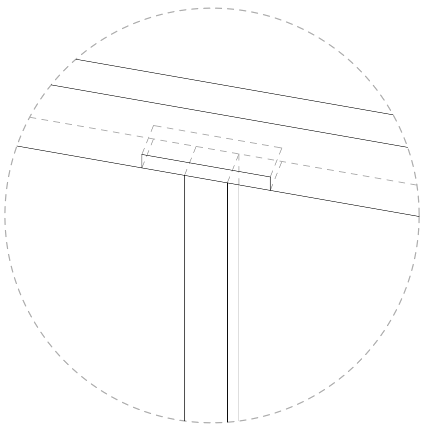


3a Connection between column and main beam using steel plate

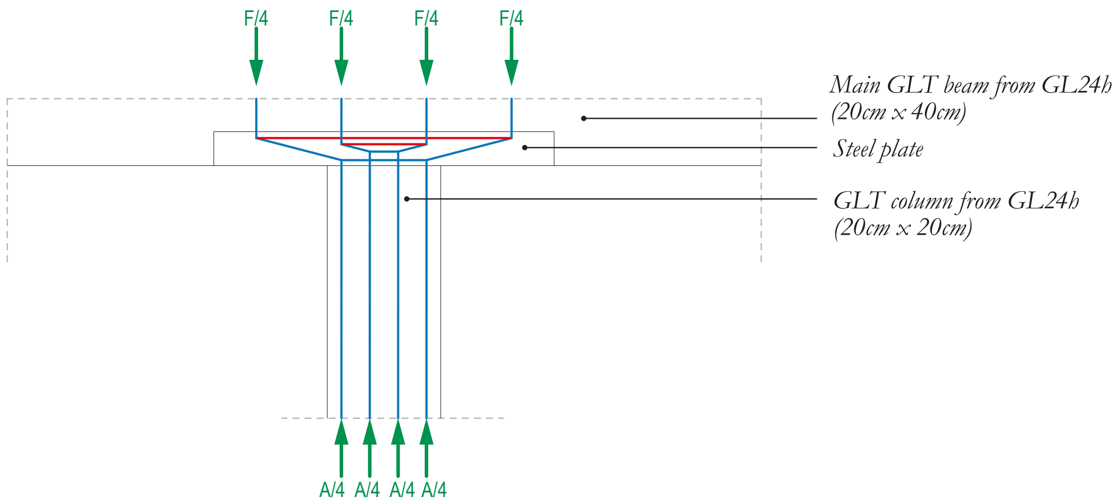
Help: Skript «TE 3/4» p. 174 →

For the wooden structure above, a connection detail using a steel plate as a load transfering element between main beam and column is analyzed. For the given external load case, draw a qualitative force flow within the connection detail. What maximum load can be taken with this construction detail? Note that in this case, normal GLT GL24h is used as construction material. The main beam has a width of 20cm, the column has a surface area of 20cm x 20cm and the length of the steel plate is 60cm.

Connection detail



Section of the connection



Width steel plate: 20cm, length steel plate: 60cm

Column: area: $A = 20*20cm=400cm^2$; max. compr stress [σ_{max}] =14.5N/mm^2; where $\sigma = F/A$; force [F]= $\sigma * A = 14.5N/mm^2 * 40'000mm^2 = 580kN$;

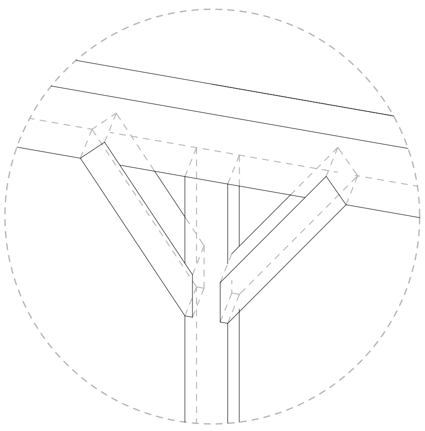
Main beam: available area for force transfer: $20cm*60cm=120'000mm^2$; max. compr stress [σ_{max}]: 1.9N/mm^2; max. force: $1.9*120'000 = 228kN$

3b Connection between column and main beam using wooden diagonals

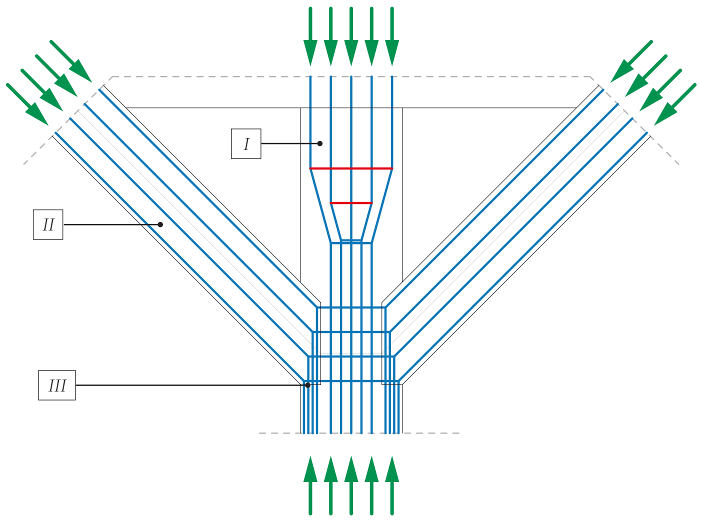
Help: Skript «TE 3/4» S. 49, 54 Vorlesung TE 3 «Mauerwerk», S.93, 94 →

For the wooden structure above, another connection detail using additional diagonals made from GL24h is analyzed. For the given external load case, draw a possible qualitative force flow within the connection detail. The grey lines indicate the location of the resultants in each of the stress fields. Assign stress states I to IV of the biaxial stress diagram to the corresponding points in the stress fields of the connection. Which points show potential weak links in the system?

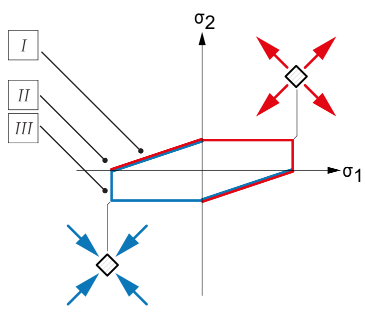
Connection detail



Section of the connection



Biaxial Stress diagram for Wood



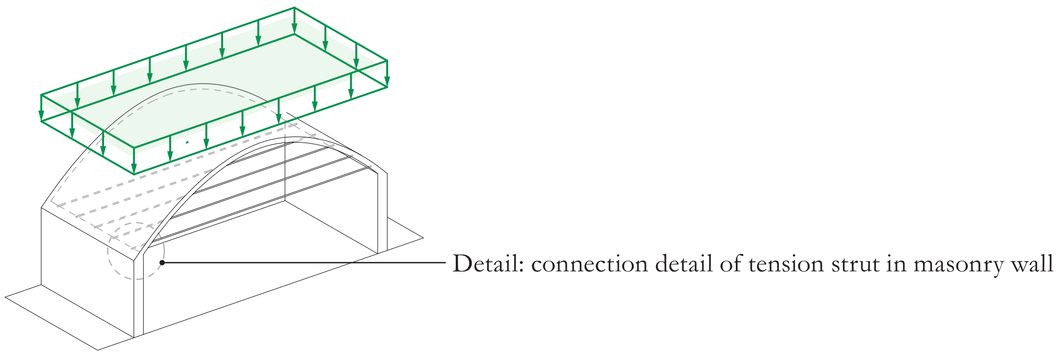
Point I: overlapping of compression and tenison -> max. applicable stresses within the wood are halved

Point II: Compression parallel to fibres

Point III: Compression perpendicular to fibre -> max. applicable stresses perpendicular to fibre much smaller than parallel

Task 4 Construction details built from masonry

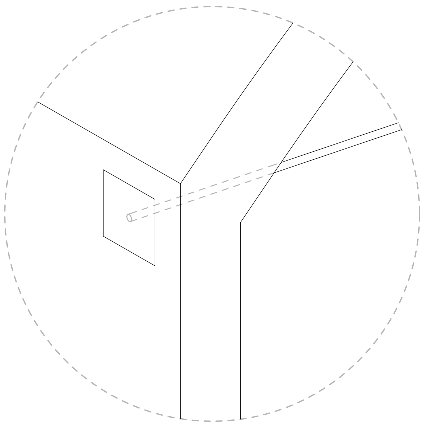
Axonometry



4a Steel plate in middle or on outside of masonry wall

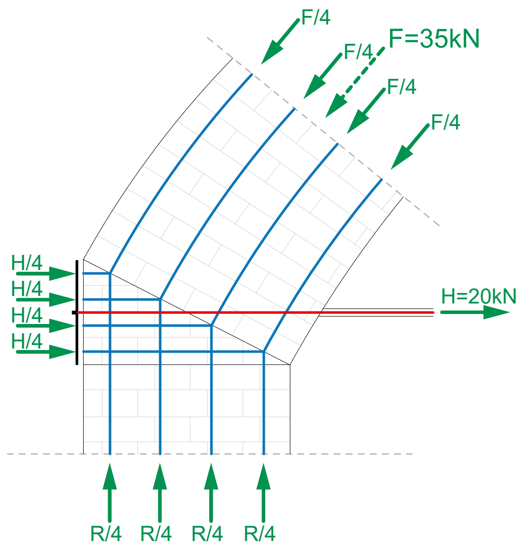
You want to compare two construction details for the structure shown above, with the goal of attaching the tension struts to the masonry wall. This is done by anchoring the tension strut with a metal plate at the outside of the masonry wall (variant 1). Draw a qualitative internal forceflow for the given external load case. The grey lines are meant as guide lines. Next, you want to analyze in what way the position of the metal plate within the wall influences the internal forceflow. Therefore, the plate is placed in the center of the wall (variant 2). Draw its internal forceflow and discuss for each case, which part of the cross section is used for the force transfer. Where in the corss section does the resultant arch force act? What are the advantages and disadvantages of both connection details and why?

connection detail



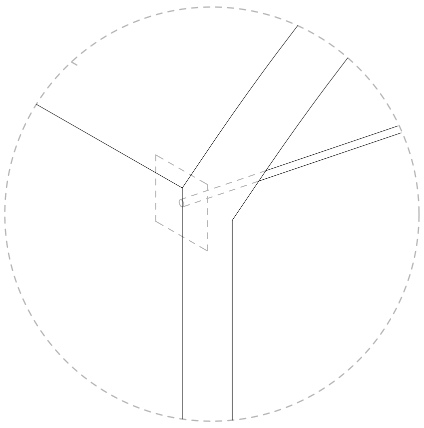
variation 1

section through connection

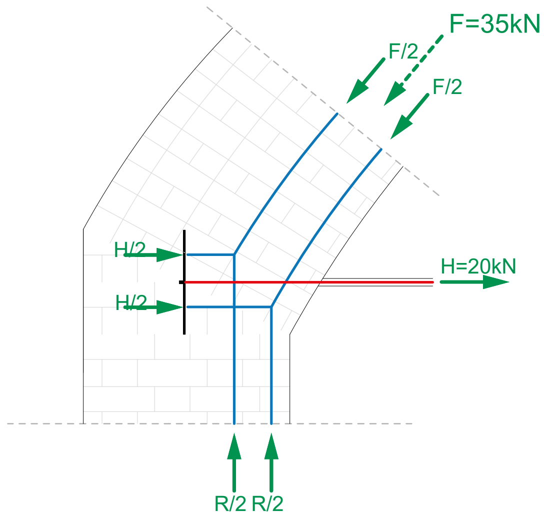


Advantage: Uniform deviation of compression stresses, full utilization of cross section

Disadvantage: Visible steel plate on the outside may disturb the architectural appearance.



variation 2



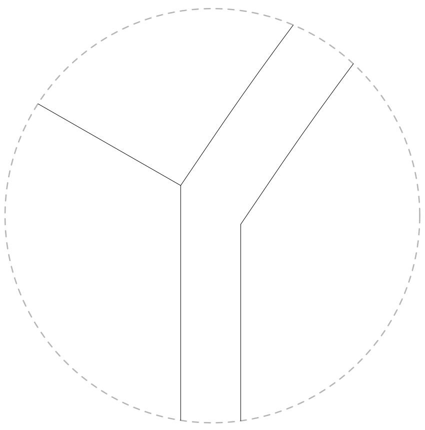
Advantage: Steel plate not visible

Disadvantage: No efficient utilization of entire crosssection and resulting increased risk of buckling.

4b Deviation of compression forces without tension struts

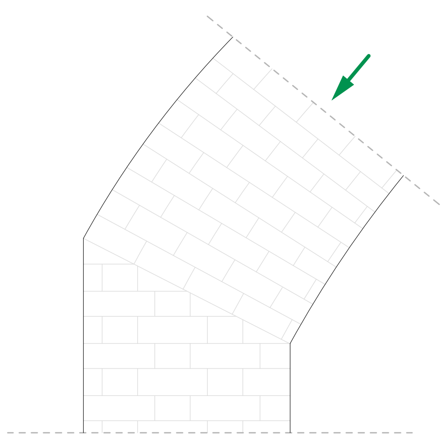
As a third variation (variant 3), you want to avoid using tension struts. What solution do you recommend, in order to deviate the arch forces into the vertical walls? What has to be paid attention to regarding the wall structure?

connection detail



variation 3

section through connection



The line of action of the load emerging from the compression arch can not have an angle of incidence on the walls larger than 30 deges. (skript p.191)