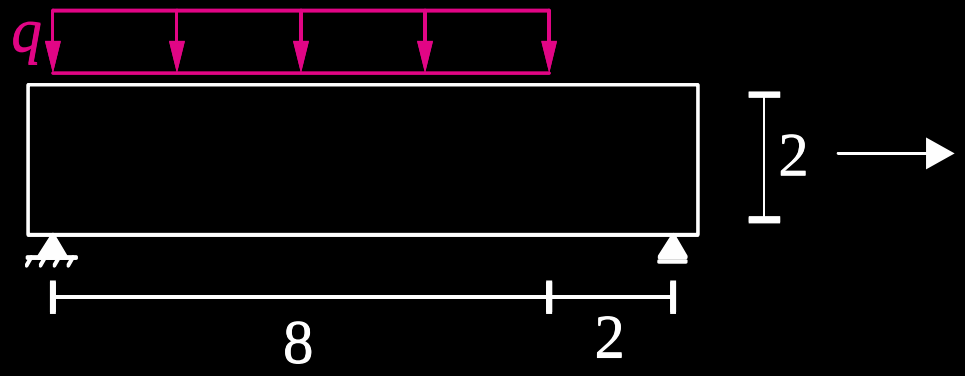
# Advanced Structural Concrete

Colloquium 1

# Colloquium 1

***Goal of this colloquium:***
Strengthen the understanding of how to design structural elements with stress fields and strut-and-tie models

to get from here

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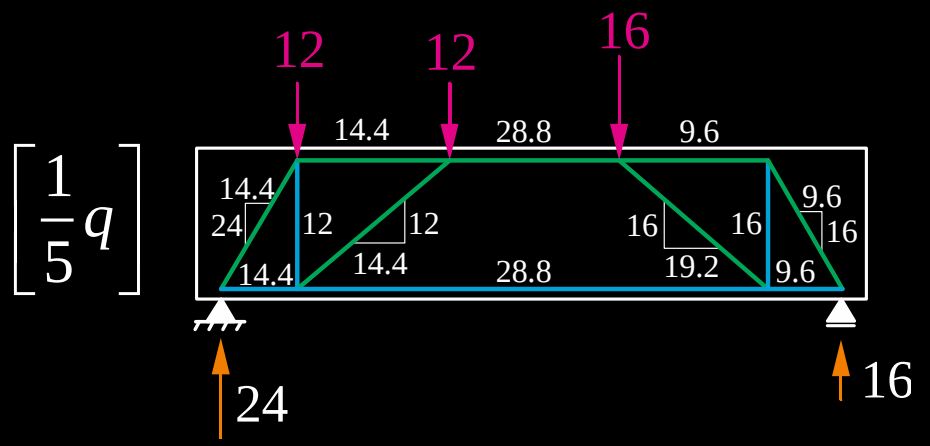
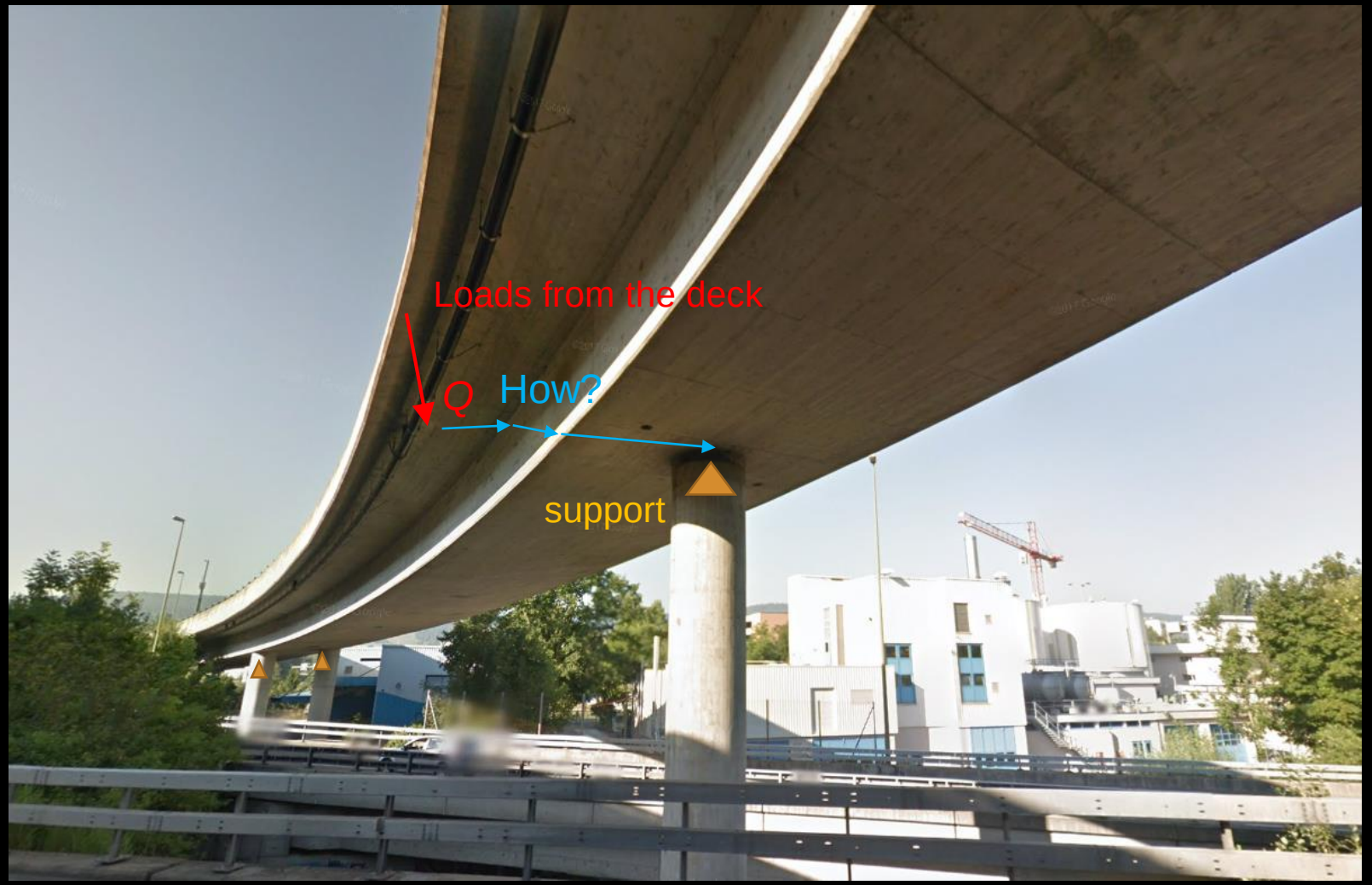


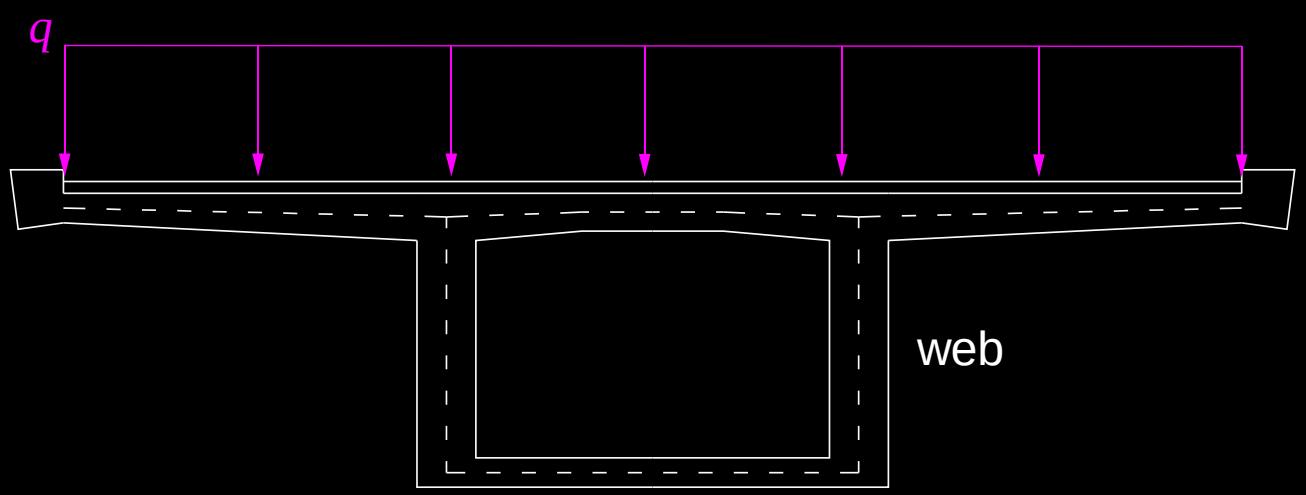

…BUT for problems including 3D effects

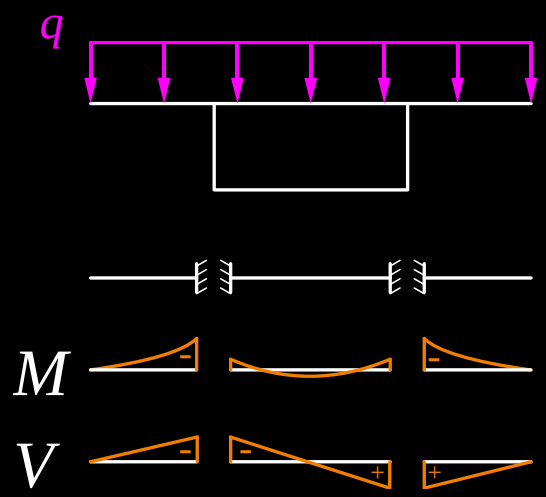
# Colloquium 1




[ *Quelle: google maps* ]

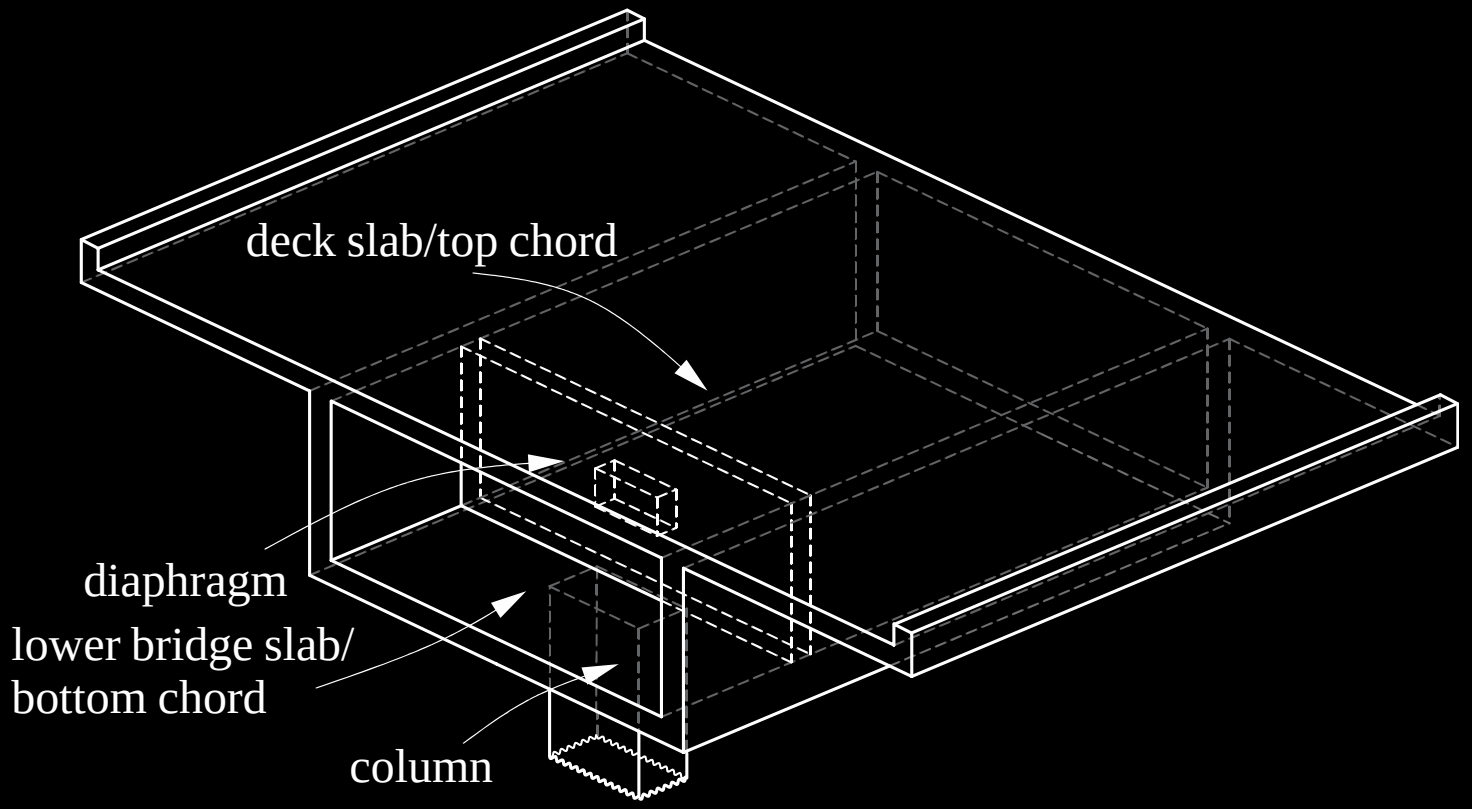
# Colloquium 1



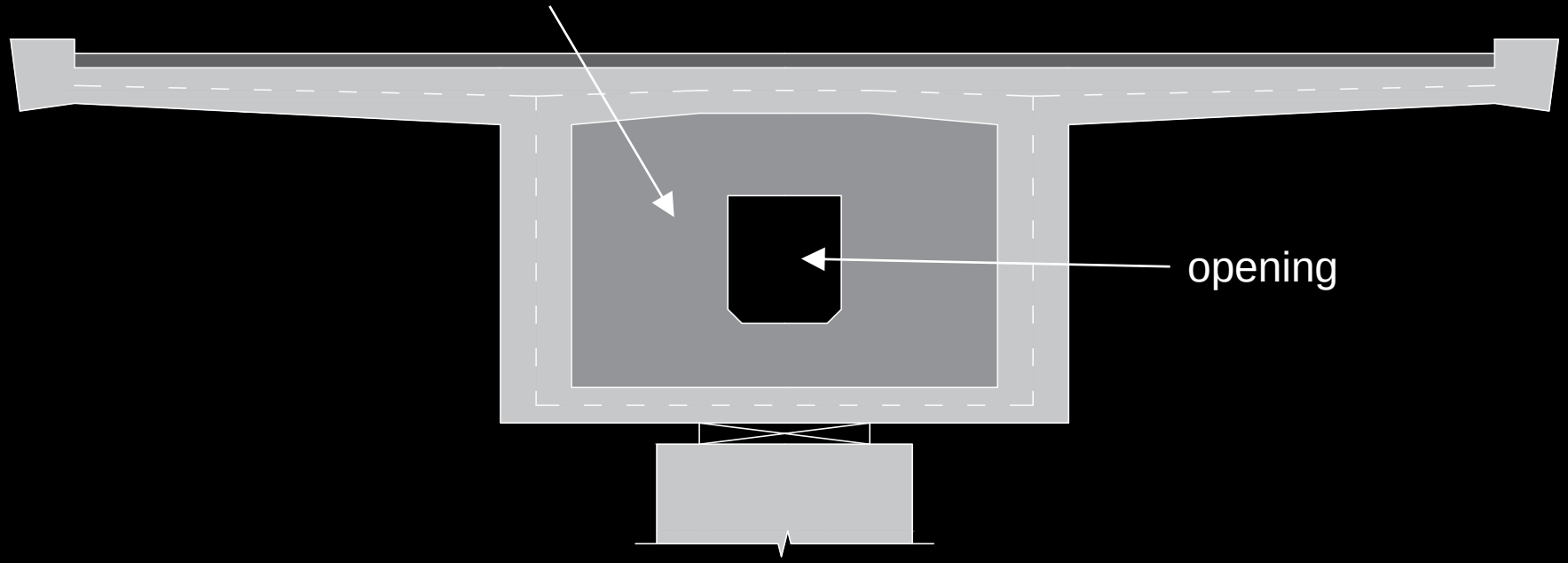

Loads applied to the deck (e.g., distributed load $q$) are transferred to the web as shear forces and transverse bending moments. For simplicity, we focus on the transfer of shear forces.

# Colloquium 1



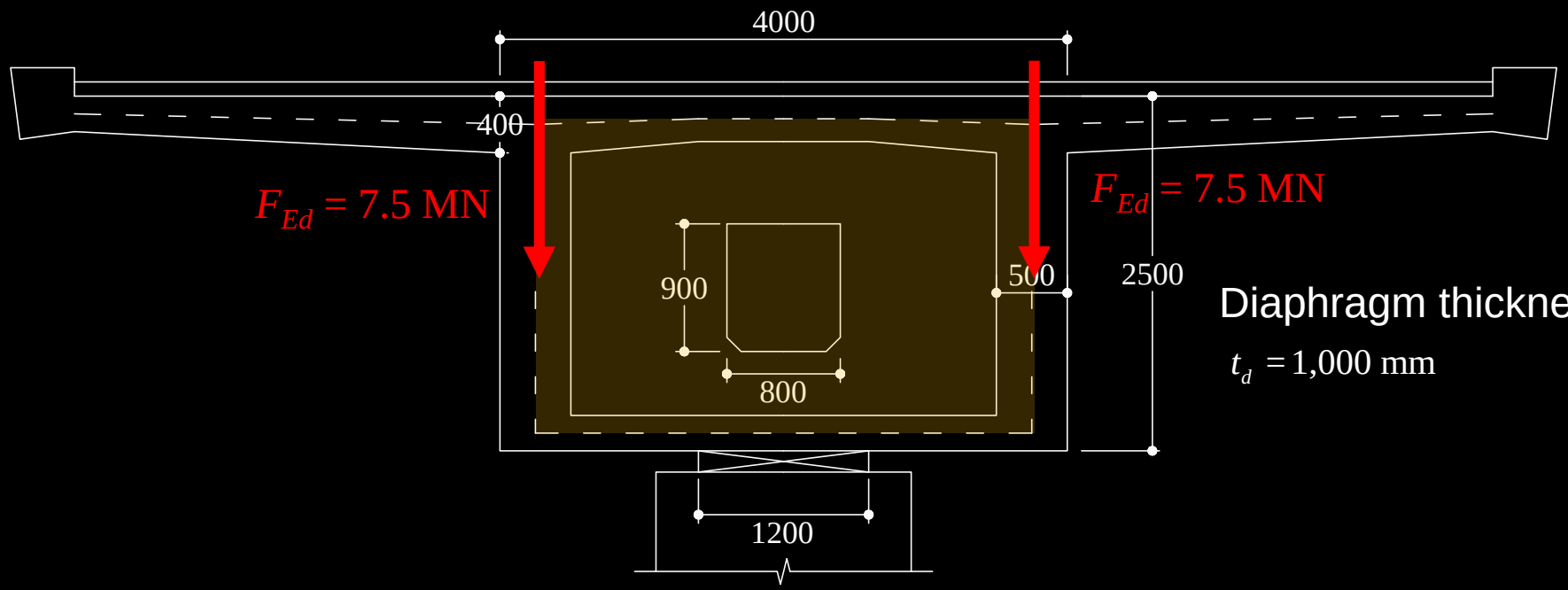
# Colloquium 1

Load introduction through the diaphragm, from the web to the column



# Colloquium 1

## Overview



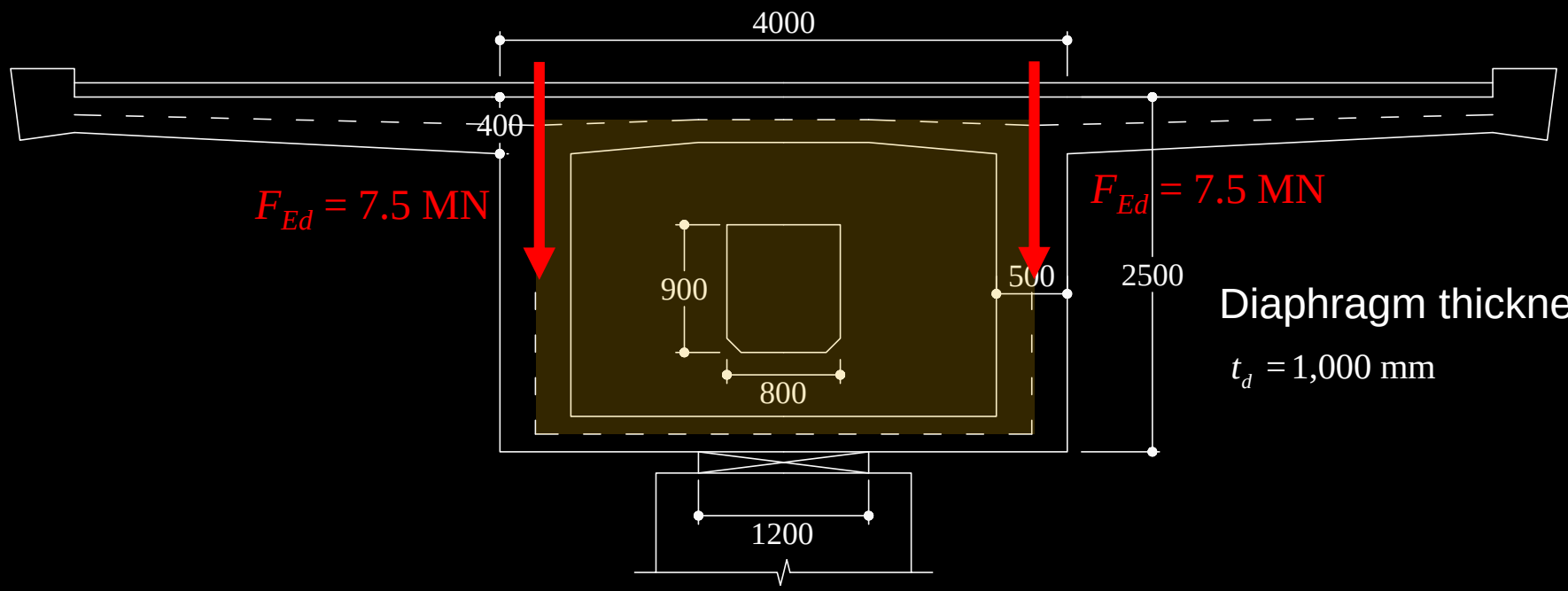

Diaphragm thickness

$t_d$ = 1,000 mm

Material:
- Concrete C40/50 → $f_{cd}$ = 24 MPa, $f_{ctm}$ = 3.5 MPa
- Steel B500B → $f_{sd}$ = 435 MPa
- Concrete cover → $c_{nom}$ = 45 mm

# Colloquium 1

## Task




Diaphragm thickness

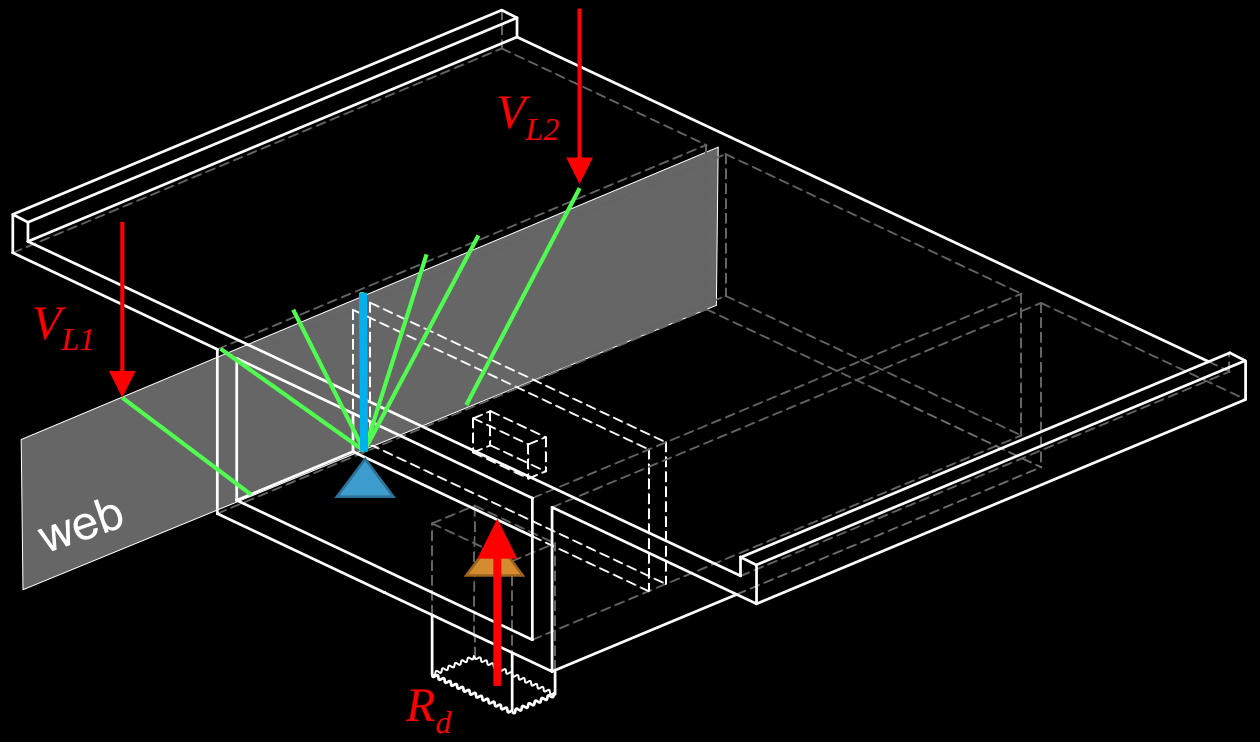
$t_d$ = 1,000 mm

1. Development of a strut-and-tie model/stress field and dimensioning of the reinforcement
   a. With suspension reinforcement
   b. Without suspension reinforcement

# Colloquium 1

## Task 1a

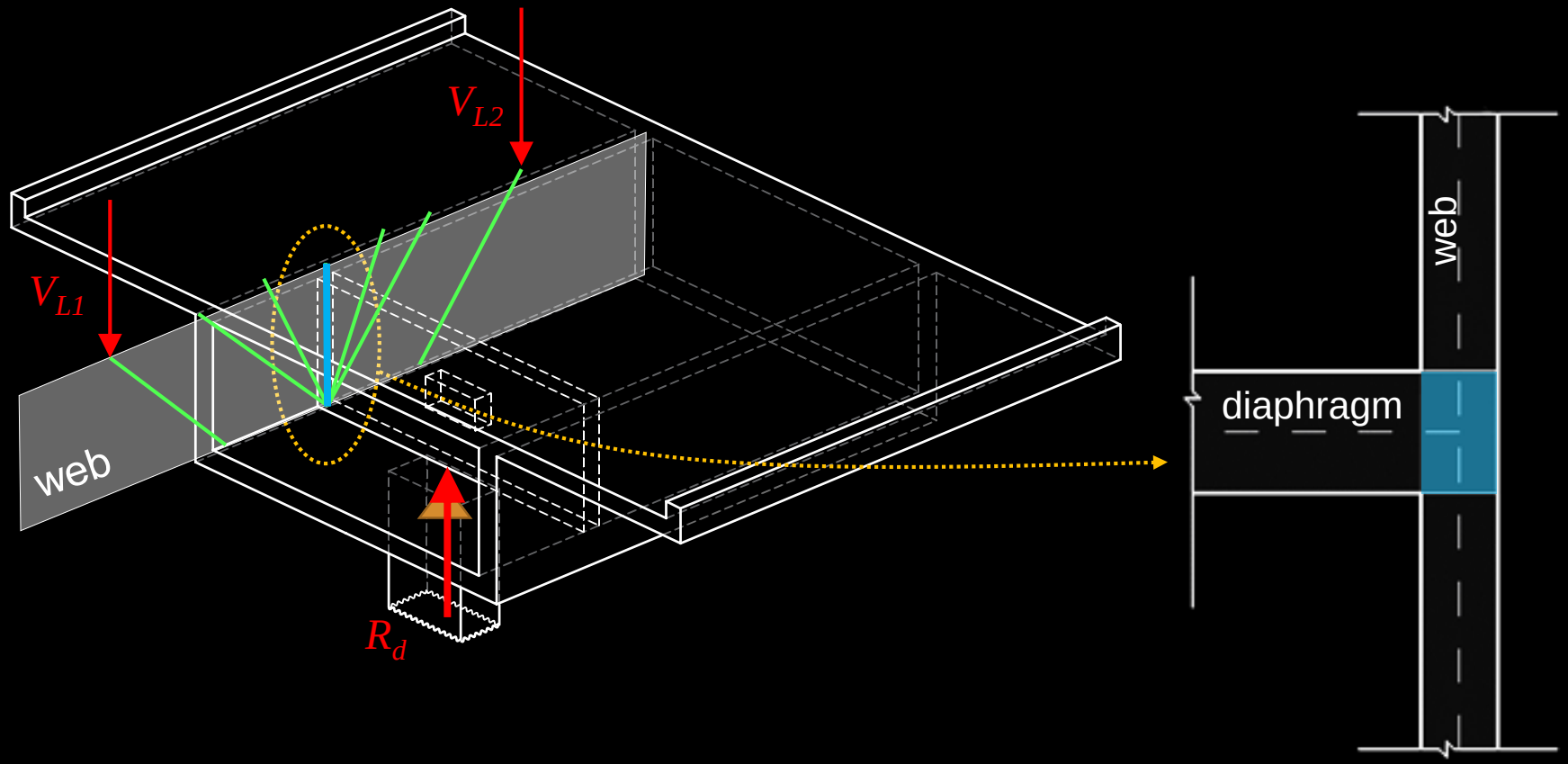
Point-centred fan in longitudinal girder for the load introduction in the diaphragm with suspension



# Colloquium 1

## Task 1a

Point-centred fan in longitudinal girder for the load introduction in the diaphragm with suspension



# Colloquium 1

## Task 1a

Point-centred fan in longitudinal girder for the load introduction in the diaphragm with suspension

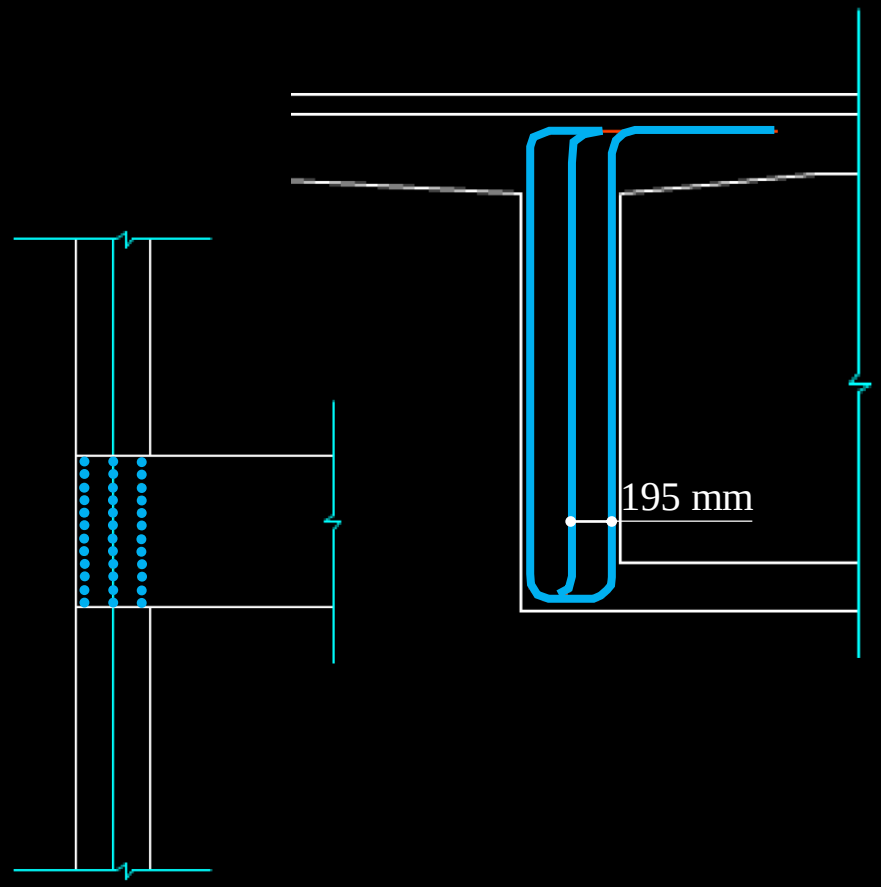
i) Dimension suspension reinforcement

$$F_{Ed} = \frac{R_d}{2} = 7.5 \text{ MN}$$

$$A_s(\varnothing = 26 \text{ mm}) = \frac{26^2 \pi}{4} = 531 \text{ mm}^2$$

$$A_{s,reqA} = \frac{F_{Ed}}{f_{sd}} = 17250 \text{ mm}^2 \rightarrow \text{Choice}: 36\varnothing 26$$

$$\rightarrow F_{Ed,Rd} = 36 \cdot 531 \cdot 0.435 = 8.3 \text{ MN} > F_{Ed}$$



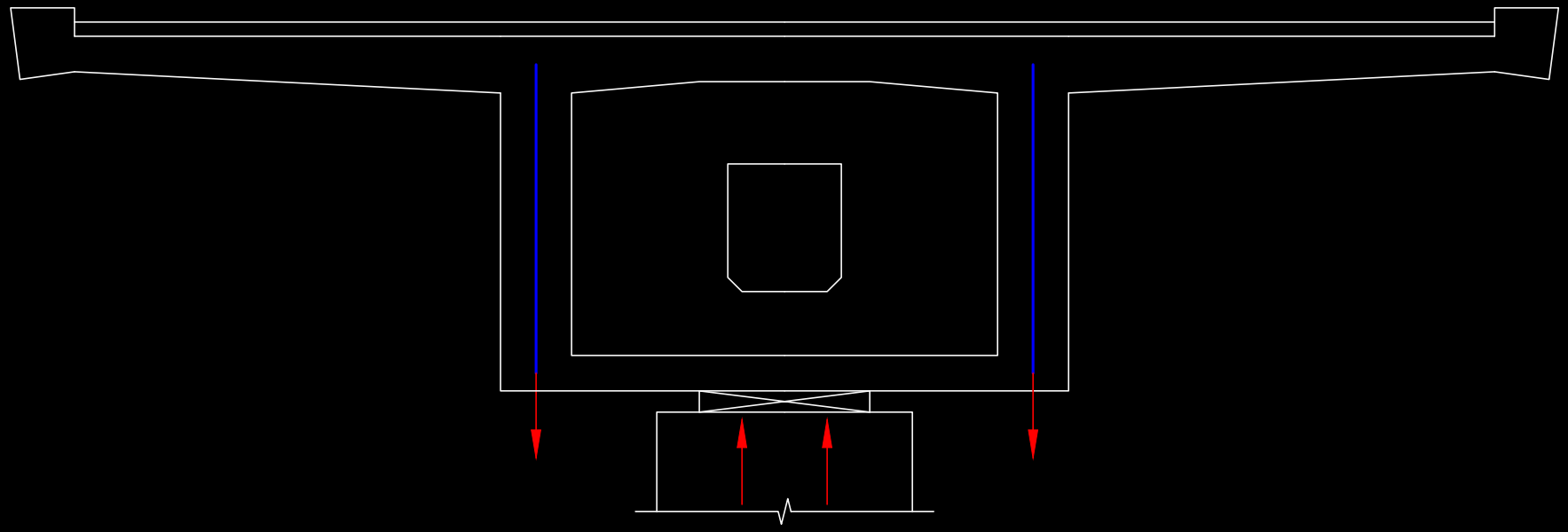

Remark:

- Large bending radius of ∅26-bars
  → anchorage problems?

# Colloquium 1

## Task 1a

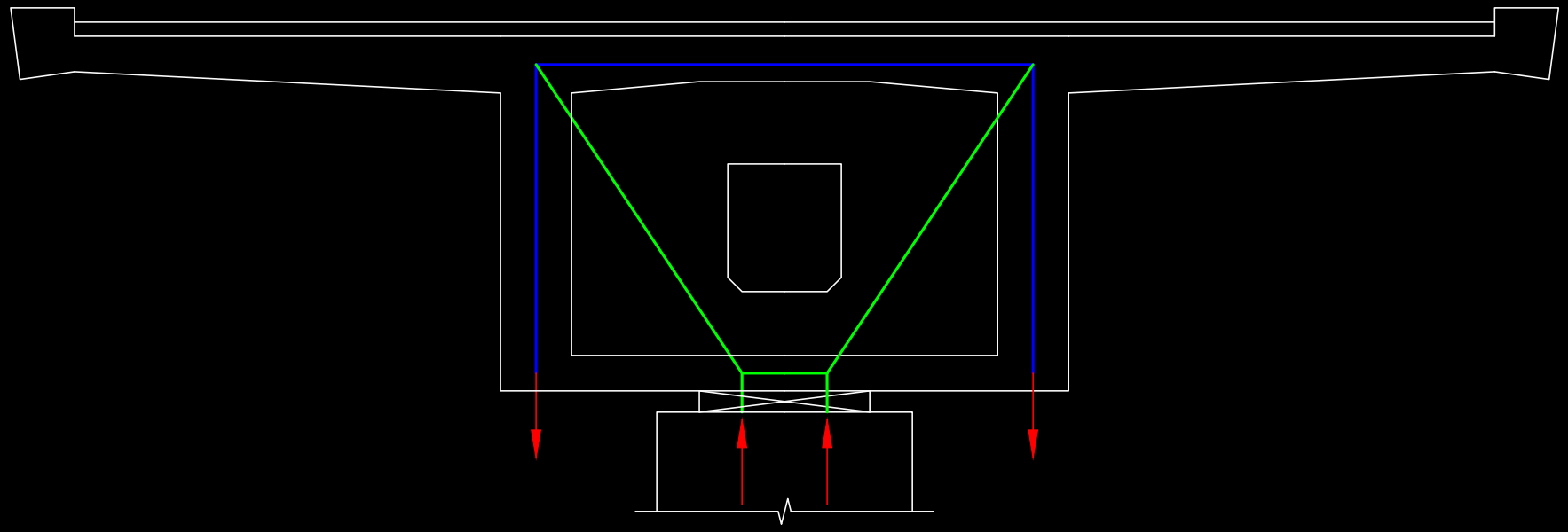
Having decided on the suspension reinforcement
→ How could the strut-and-tie model for the diaphragm look like?



# Colloquium 1

## Task 1a

Strut-and-tie model – Option 1

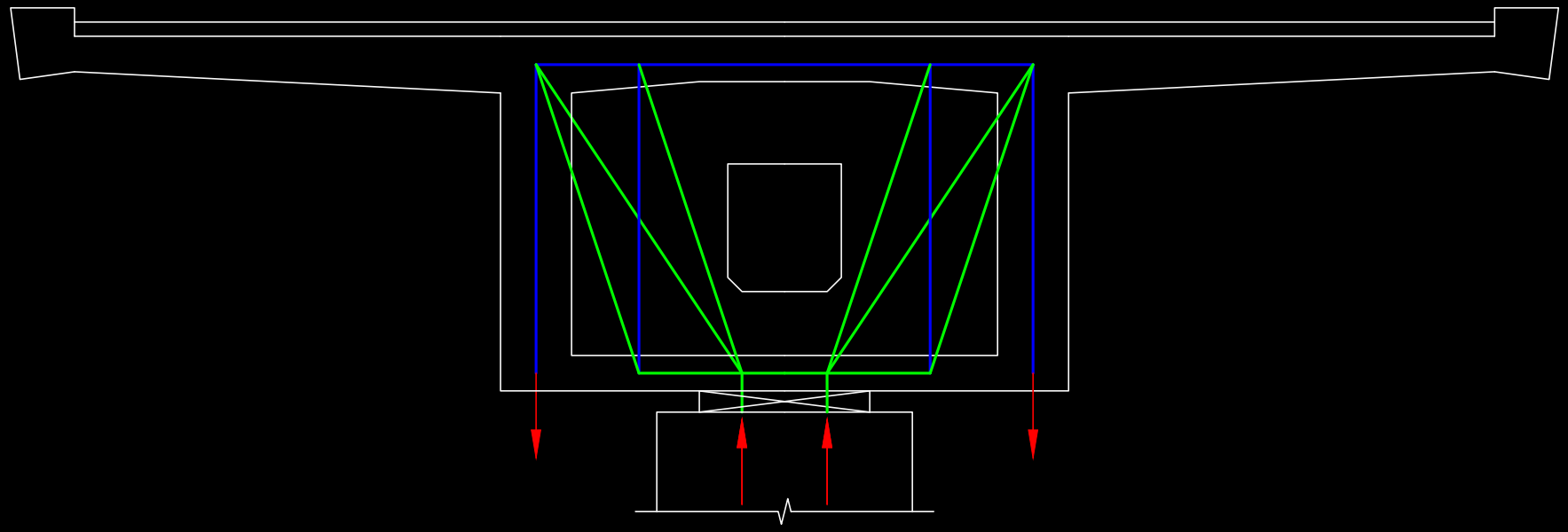


- Membrane shear action rather than bending action (very low slenderness)
  → direct strut-load transfer
- Minimum reinforcement in membrane element is not activated

# Colloquium 1

## Task 1a

Strut-and-tie model – Option 2

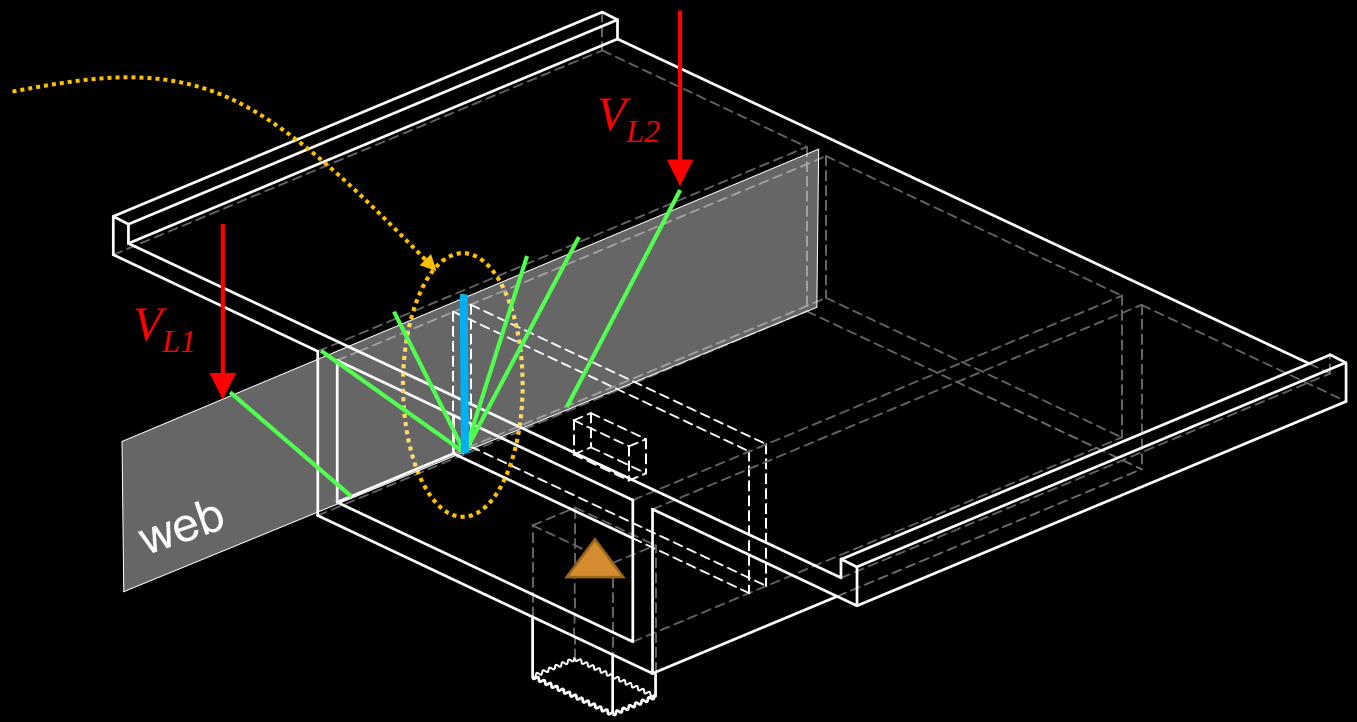


- Activation of the minimum shear reinforcement
- Truss model statically indetermined
  → «Engineering judgement» = “we can decide on force distribution”

# Colloquium 1

## Summary Task 1a

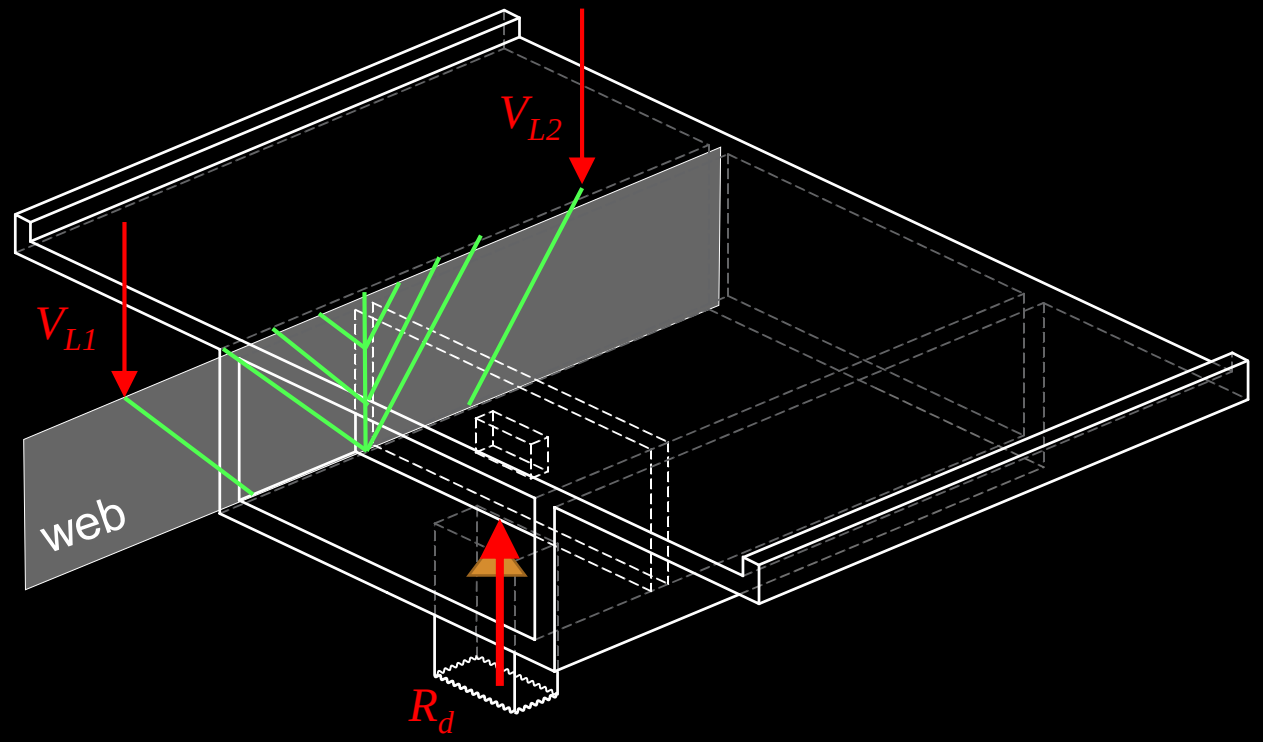
- The reinforcement content necessary for the suspension of the shear forces in the intersection area is very high (36∅26) and results in very complex detailing.
- Influence on formwork, reinforcement work and casting of the concrete
- Alternative: Task 1b or approach by Leonhardt/Menn (Task 2, Exercise)



# Colloquium 1

## Task 1b

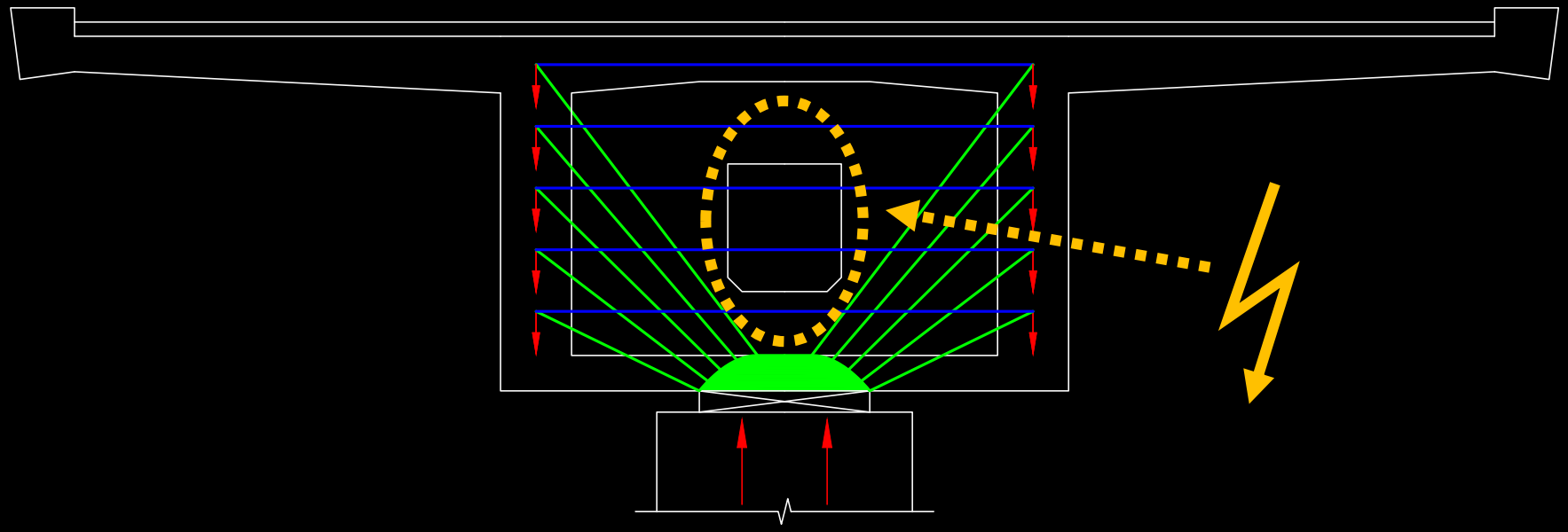
Parallel field in longitudinal girder for the load introduction in the diaphragm without suspension reinforcement



# Colloquium 1

## Task 1b

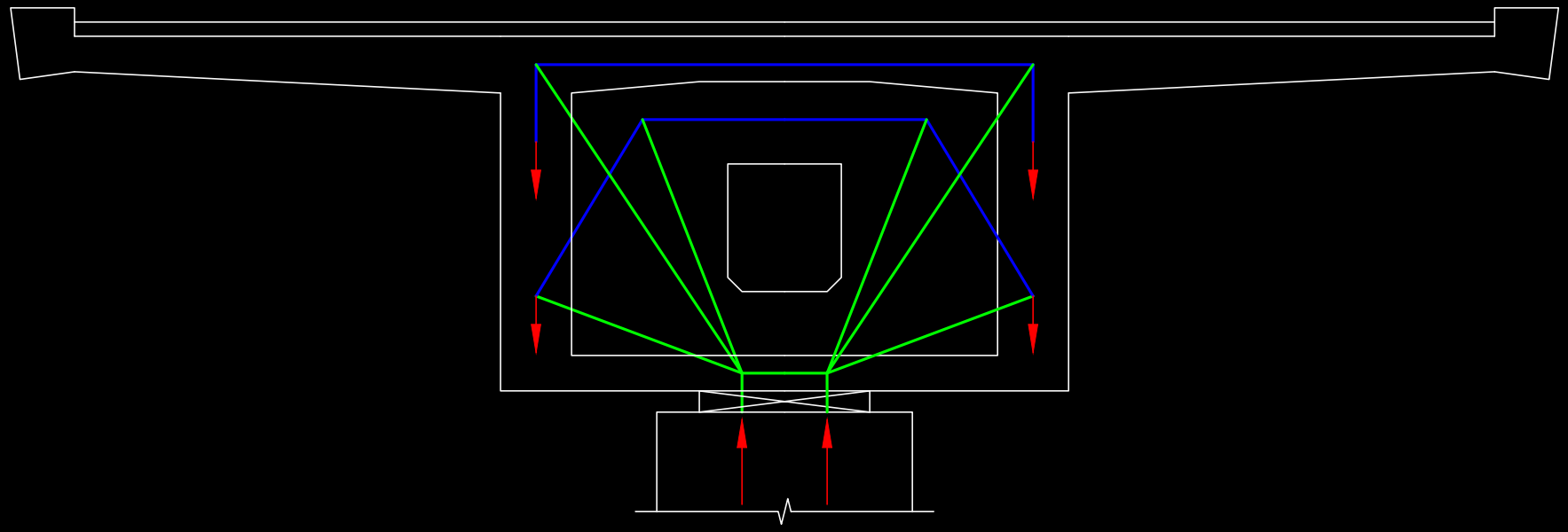
Strut-and-tie model – Trial



# Colloquium 1

## Task 1b

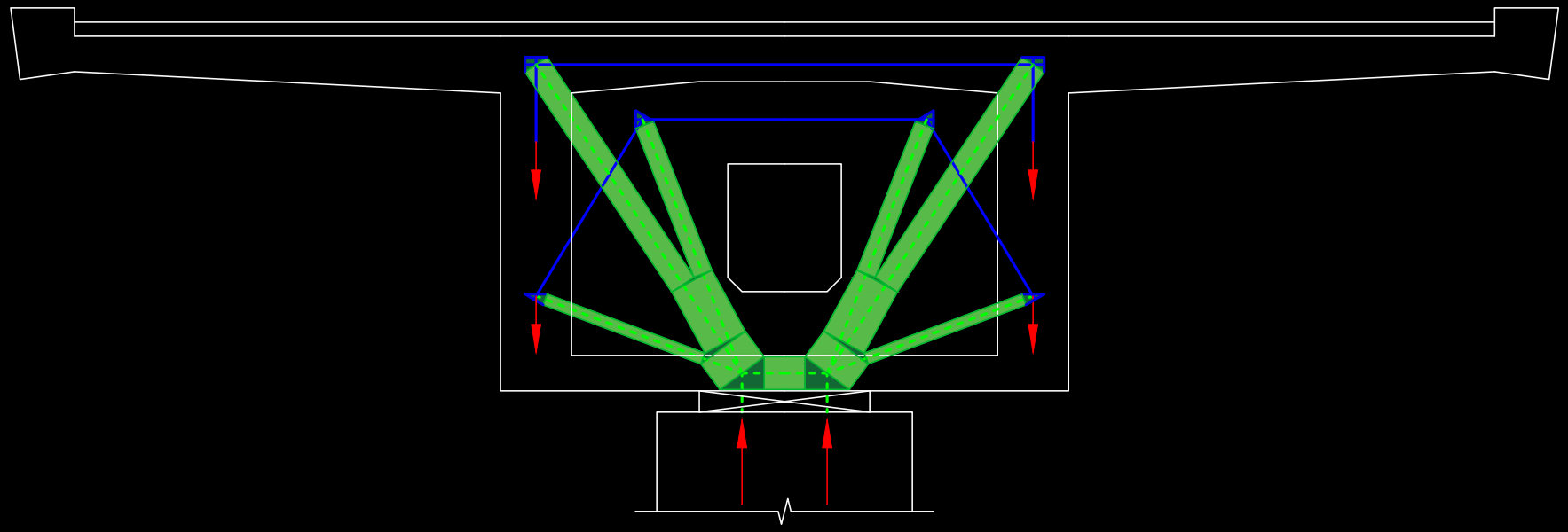
Strut-and-tie model



# Colloquium 1

## Task 1b

Strut-and-tie model – Check effective concrete compressive stresses and nodal zones

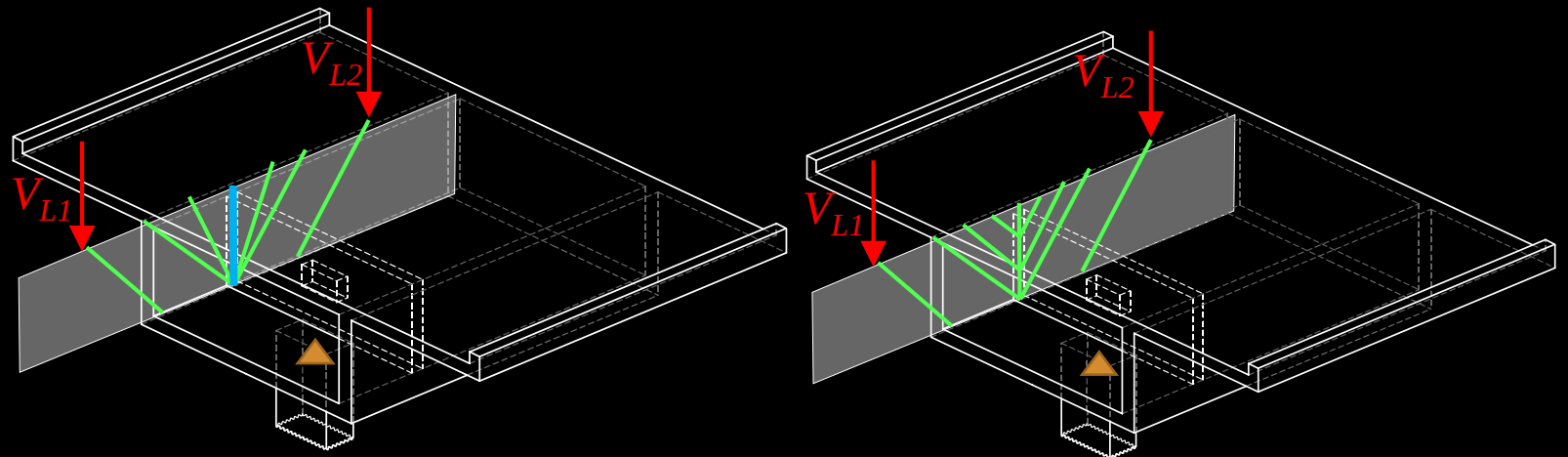


# Colloquium 1

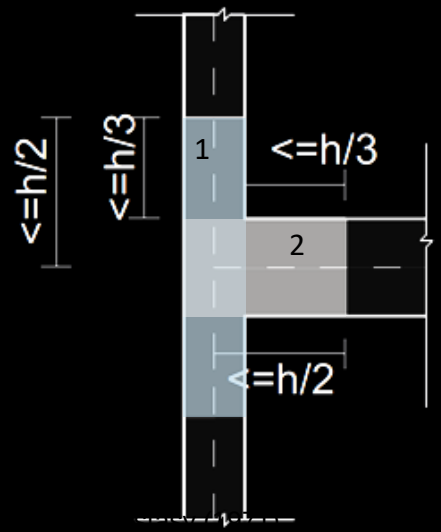
## Hints for the exercise (*slender diaphragm*)

- Task 1a) and b)

  Procedure analogous to colloquium, assume a diaphragm's thickness of $t_d$ = 1 m



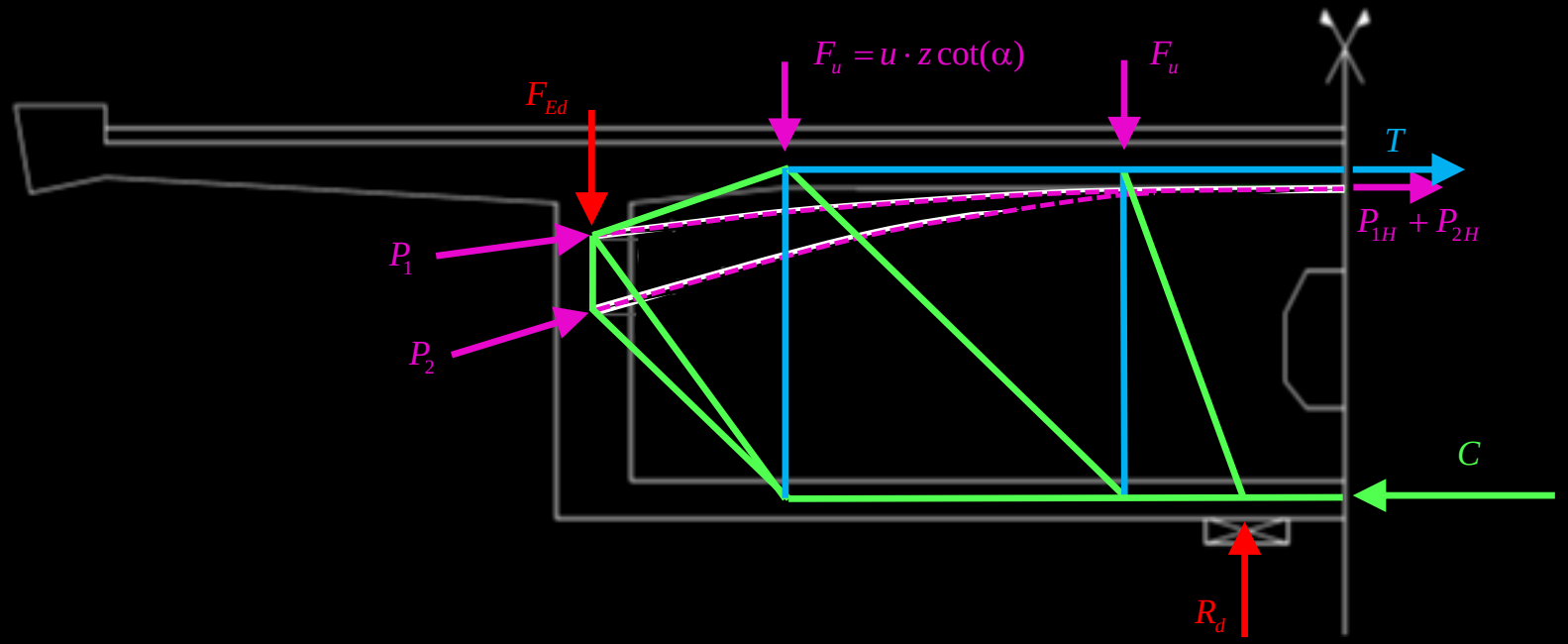

- Task 2
  - Stress fields, (with and without suspension reinforcement, and partially activated web or diaphragm for suspension)



# Colloquium 1

## Hints for the exercise (*slender diaphragm*)

- Task 3
  - Treat prestressing as anchorage and deviation forces
  - Evaluate the introduction of the anchorage forces $u = \frac{8 P_\infty f}{l^2}$



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## Exercise 1: Organisation

Handout: 12.10.2023

Voluntary submission for correction: 25.10.2023

Publication of solution: 26.10.2023