Solution innovante pour ouvrages d'art courants:

Poutre mixte Preco avec connexion par decoupe

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Jacques BERTHELLEMY - Setra

Pierre-Olivier MARTIN - Cticm

Günter SEIDL - SSF

Prefabricated Composite beam => **PRECOBEAM**

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  – **Structural concept**
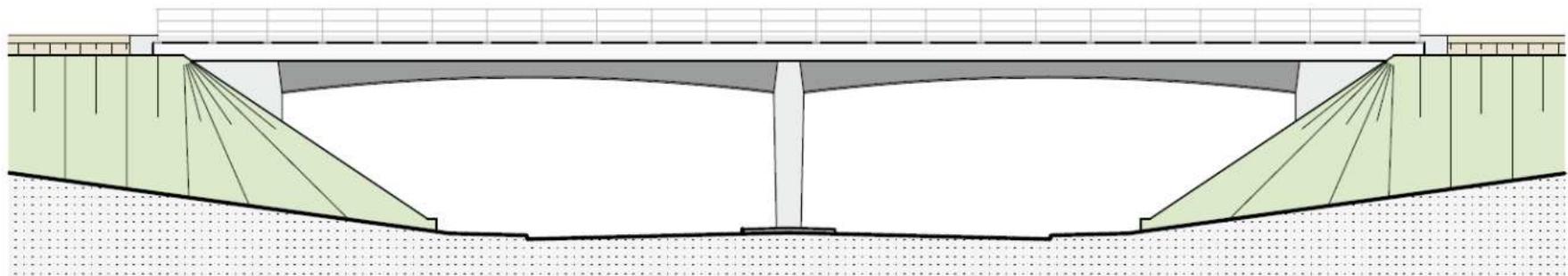
  – Dowel design

  – Conclusion

New generation of standard rail overpasses

- Frame structures, no joints and bearings
- Easy maintenance and inspection, robust structures
- Prefabrication for quality and quick erection phase
- Economic aspects

Zweifeldbauwerke

Übersichtspläne mit Varianten A–C

A

Source: DB Netze: Leitfaden Gestalten von Eisenbahnbrücken, 2008

Rail overpass in Pöcking, Germany (2003)

Bauherr: Gemeinde Pöcking
Planer: Schmitt Stumpf Frühauf und Partner, München
Baufirma: Wadle-Ari Bau, Landshut
Stahlbau: Arcelor, Luxemburg
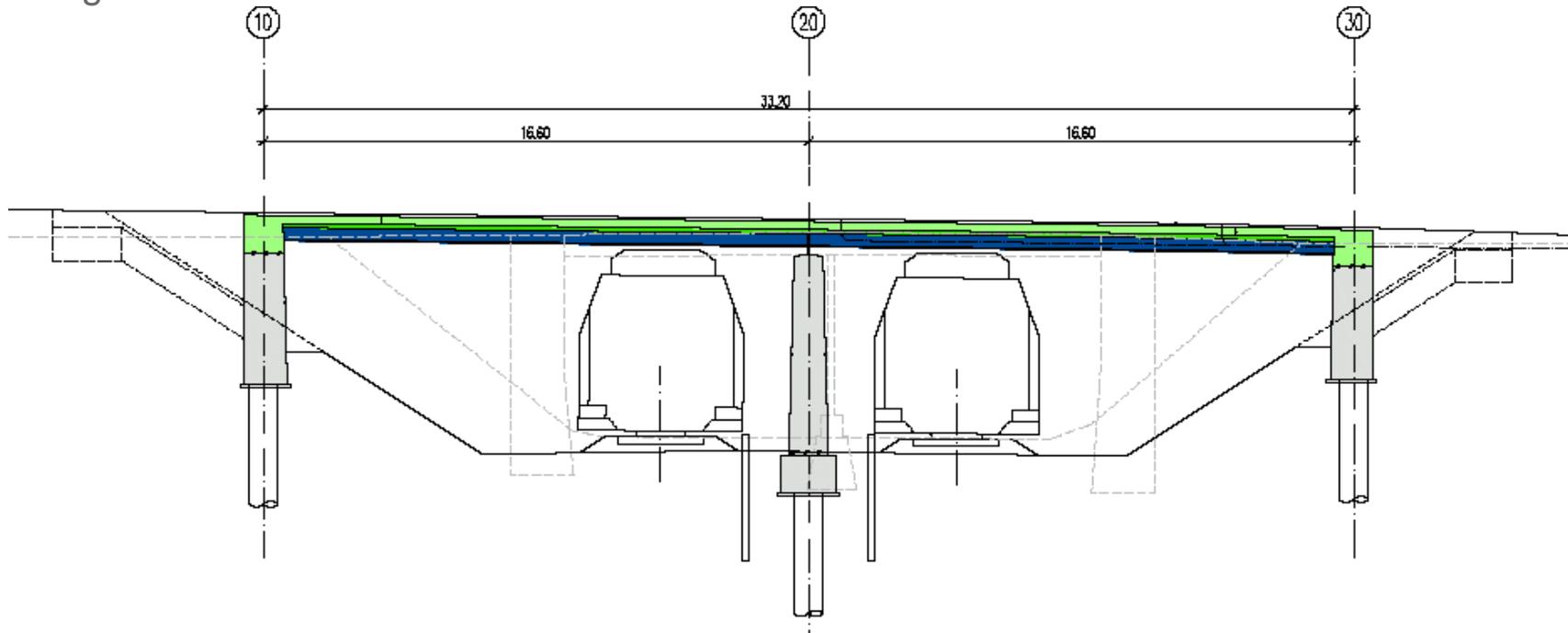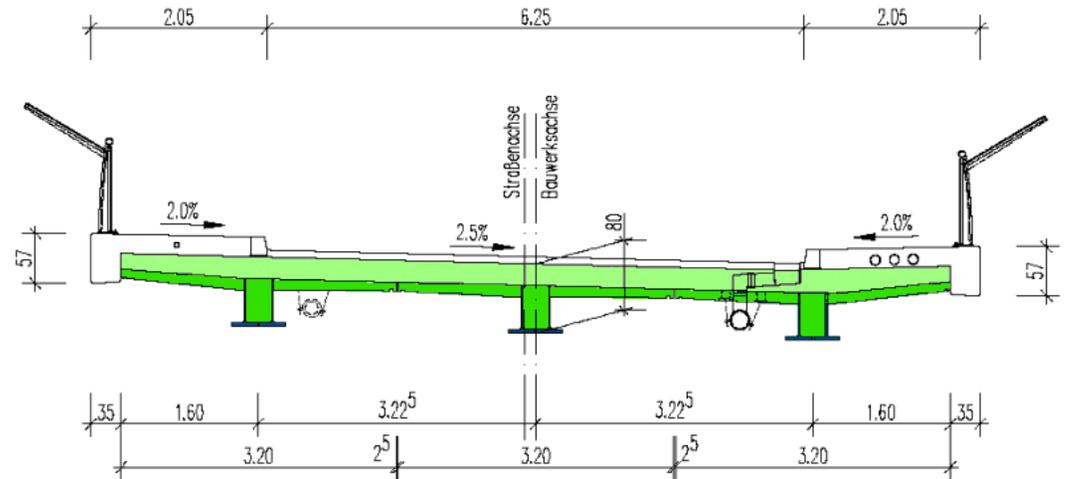VFT-WIB-Träger: Oberhessisches SpBwerk, Nidda

Rail overpass in Pöcking, Germany (2003)

System	frame over 2 spans	
Span	2 x 16,60 m	
Width	10,35 m	
Slenderness	1 : 21	
Bridge surface	354 m²	
Total costs	1892 €/m2	

Deck:

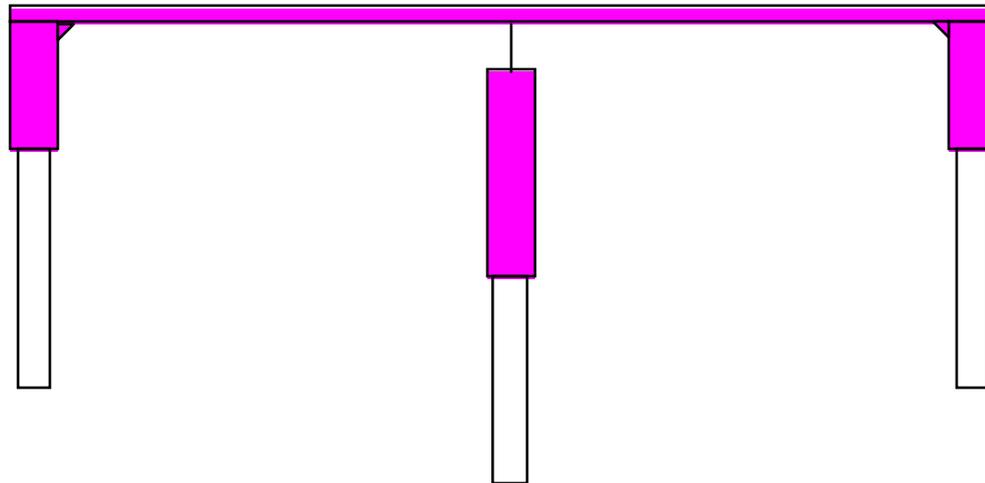|		
Steel weight	34 tons	95 kg/m2
Rebars	30 tons	220 kg/m3
Concrete	135 m3	38cm / m2
El. weight	49 tons	

Rail overpass in Pöcking, Germany (2003)

Statical system

Self weight
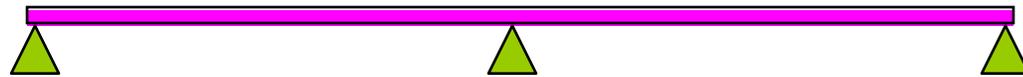
Permanent and
live loads

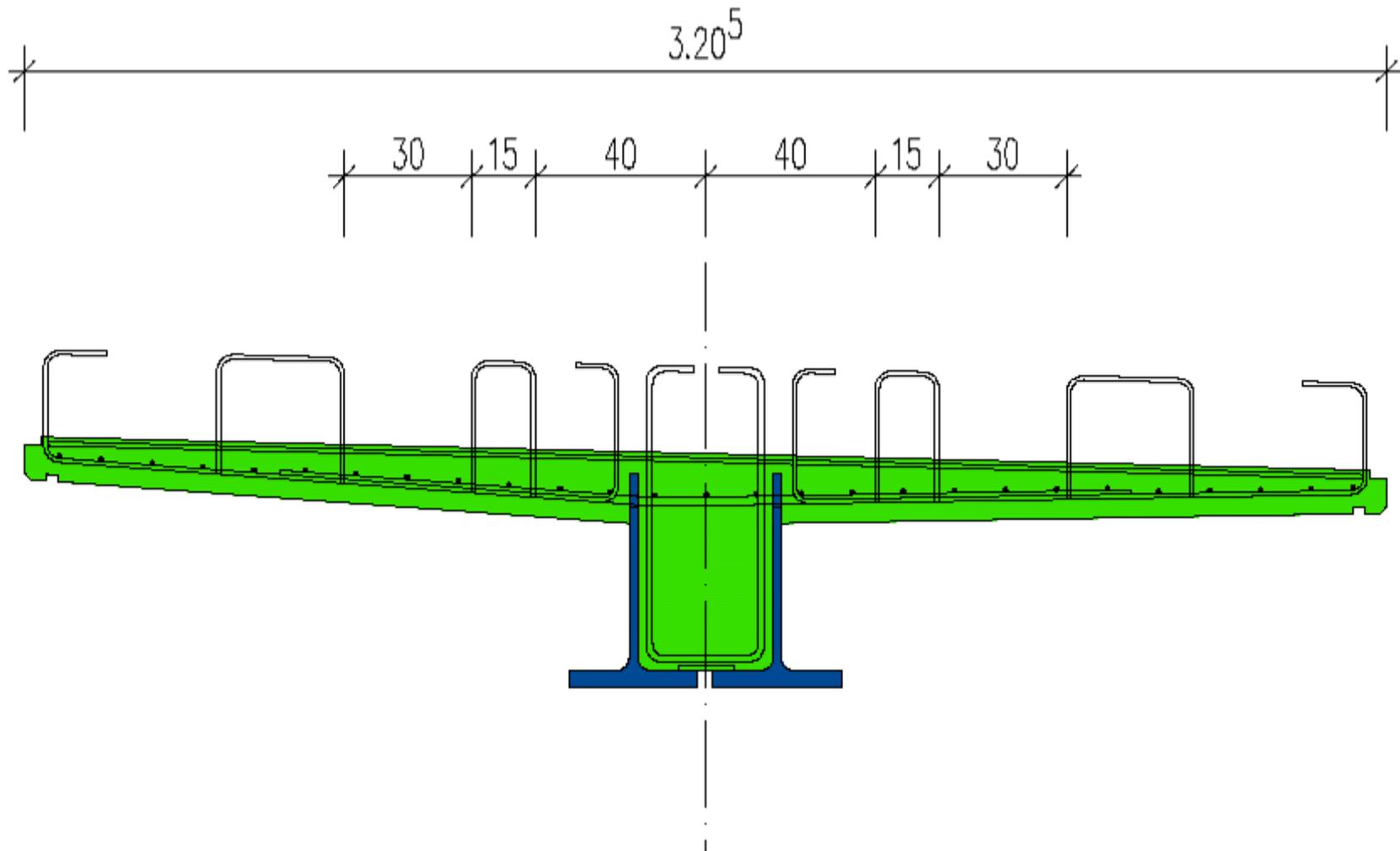# Rail overpass in Pöcking, Germany (2003)

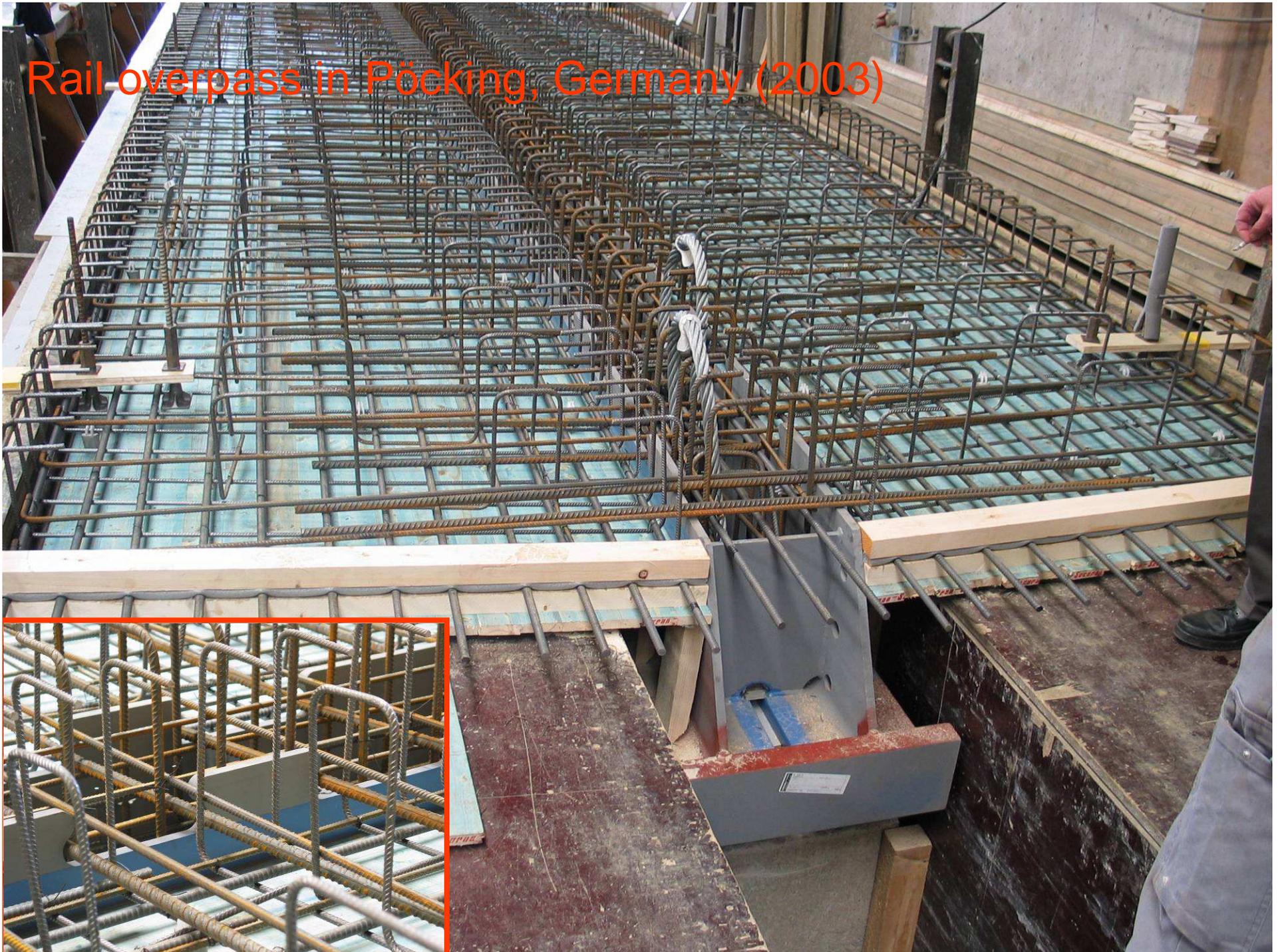- Fabrication of the steel girder directly in the plant

Rail overpass in Pöcking, Germany (2003)

- Prefabricated composite beam

Rail overpass in Pöcking, Germany (2003)

Rail overpass in Pöcking, Germany (2003)

- Transport and erection phase
- Element weight about 50tons

Rail overpass in Pöcking, Germany (2003)
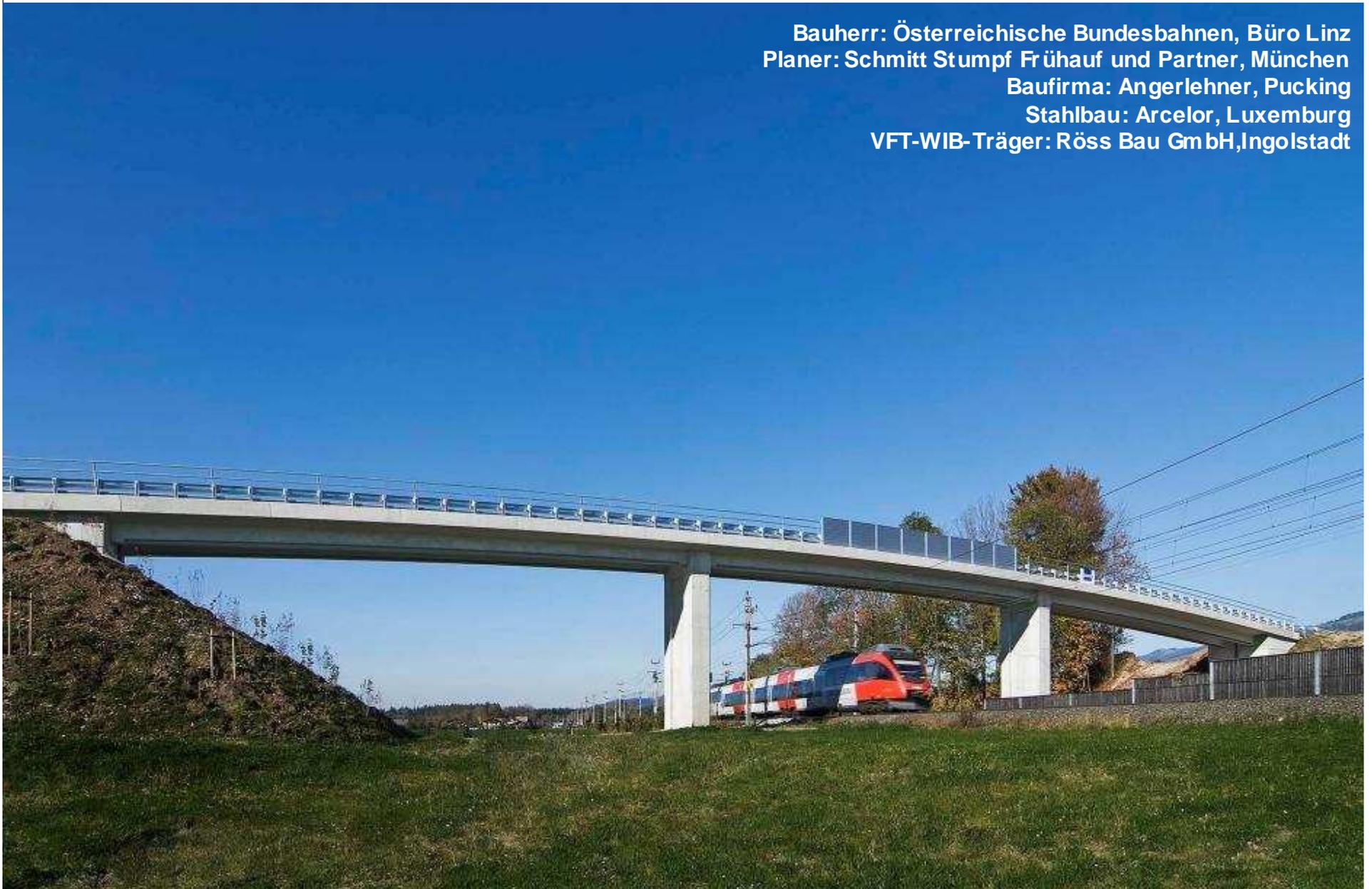

- In-situ concreting

PreCoBeam – Pöcking bridge

Rail overpass in Vigaun, Austria (2008)

Bauherr: Österreichische Bundesbahnen, Büro Linz
Planer: Schmitt Stumpf Frühauf und Partner, München
Baufirma: Angerlehner, Pucking
Stahlbau: Arcelor, Luxemburg
VFT-WIB-Träger: Röss Bau GmbH, Ingolstadt

Rail overpass in Vigaun, Austria (2008)

System	frame over 3 spans		
Span	3 x 26,15 m		
Width	5,26 m		
Slenderness	1 : 23		
Bridge surface	336 m²		
Total costs	1030 €/m2		

Deck:

Steel weight	32 tons	94 kg/m2
Rebars	36 tons	220 kg/m3
Concrete	164 m3	48cm / m2
El. Weight	34 tons	
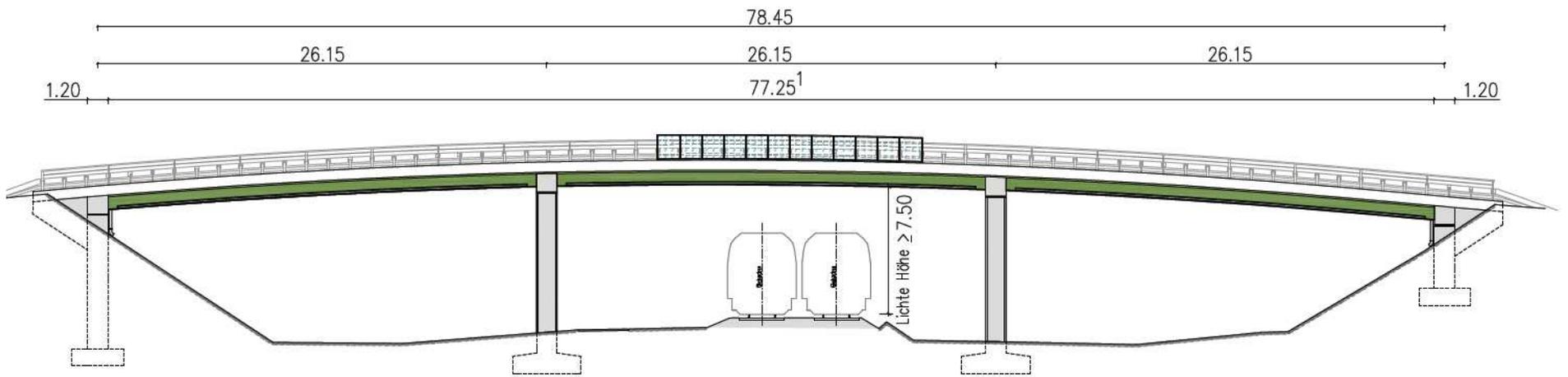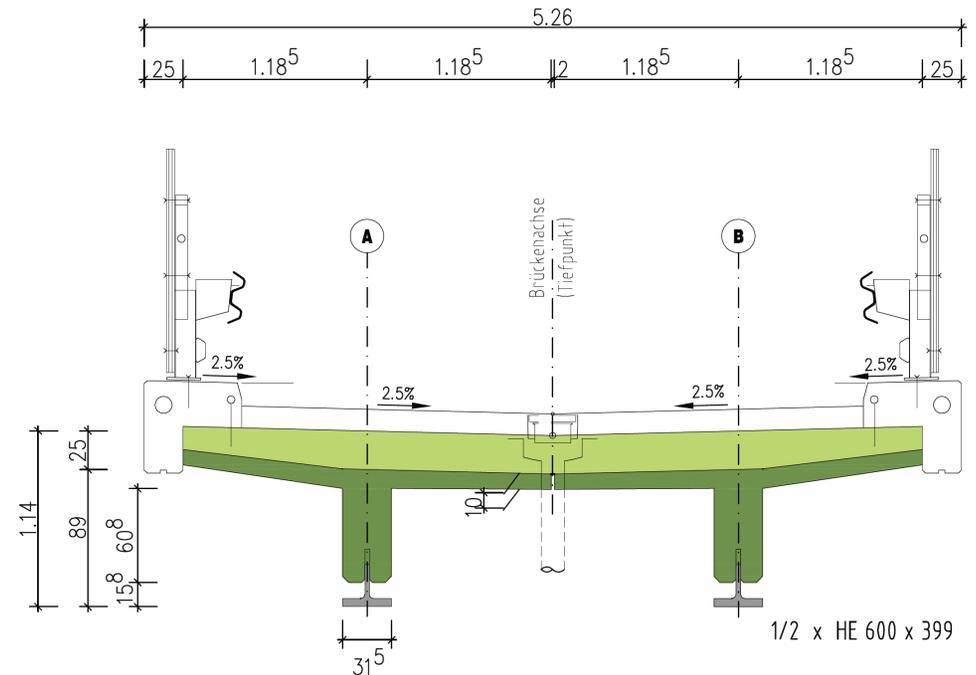
Rail overpass in Vigaun, Austria (2008)
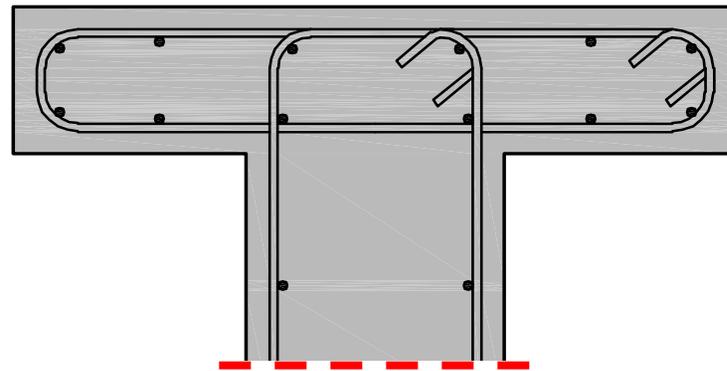
M_{Deck} = 18 000kNm
H_{Deck} = 1.15m
B_{Deck} = 5.65m
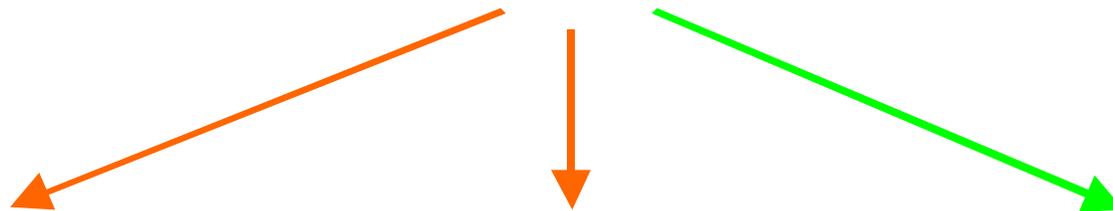
Reinforced concrete
Casted in situ
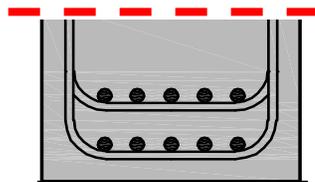
Prestressed concrete
+ 20cm in situ
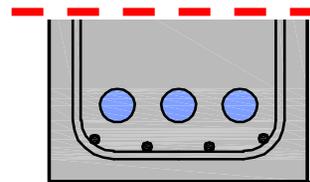
Precobeam element
+ 25cm in situ

Full slab
100 bars Φ 25

6 girders
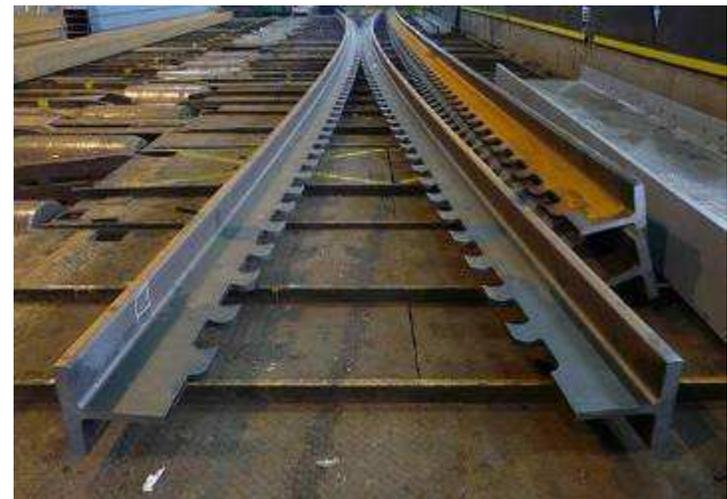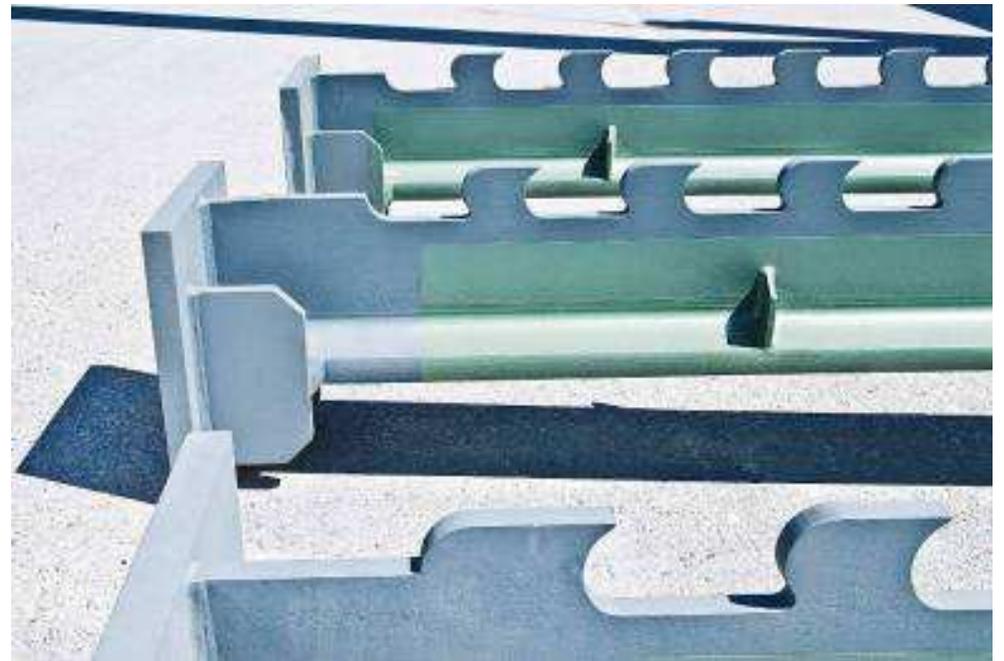96 strands Φ15.7
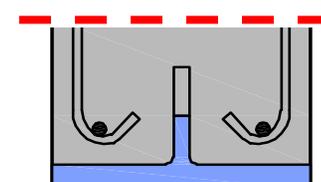
2 girders
HEM600x399

Rail overpass in Vigaun, Austria (2008)

Steel fabrication in Differdange workshop (LUX)

Rail overpass in Vigaun, Austria (2008)

Coated girders before transportation by rail to concreting shop in Ulm (DE).

Rail overpass in Vigaun, Austria (2008)

Positioning of reinforcement

Rail overpass in Vigaun, Austria (2008)

Concreting in workshop

Rail overpass in Vigaun, Austria (2008)

Erection of prefabricated elements during night

PreCoBeam – Vigaun bridge

Rail overpass in Kratzerau, Austria (2012)

Bauherr: Österreichische Bundesbahnen, Büro Linz
Planer: Schmitt Stumpf Frühauf und Partner, München
Baufirma: Angerlehner, Pucking
Stahlbau: Arcelor, Luxemburg
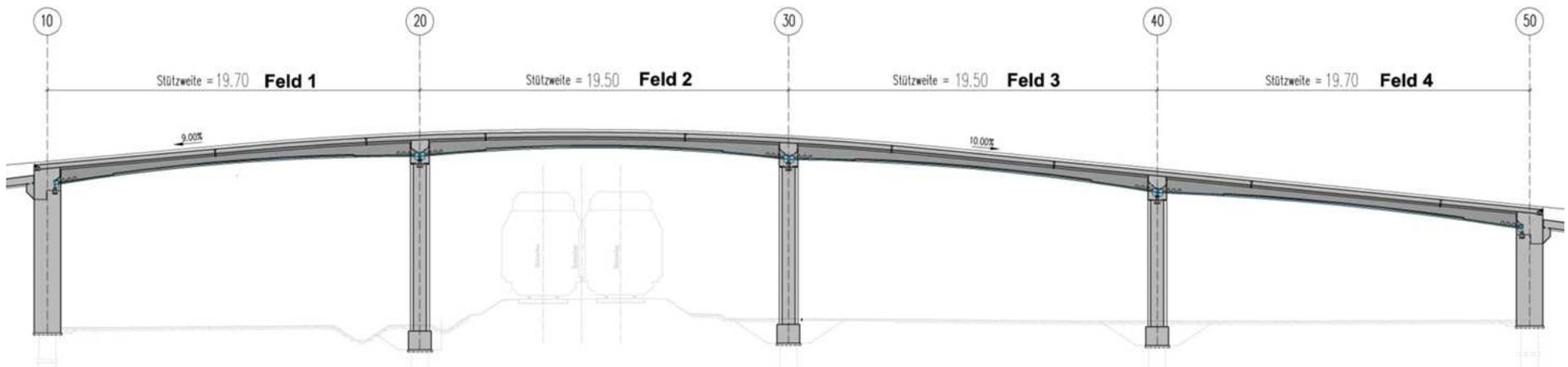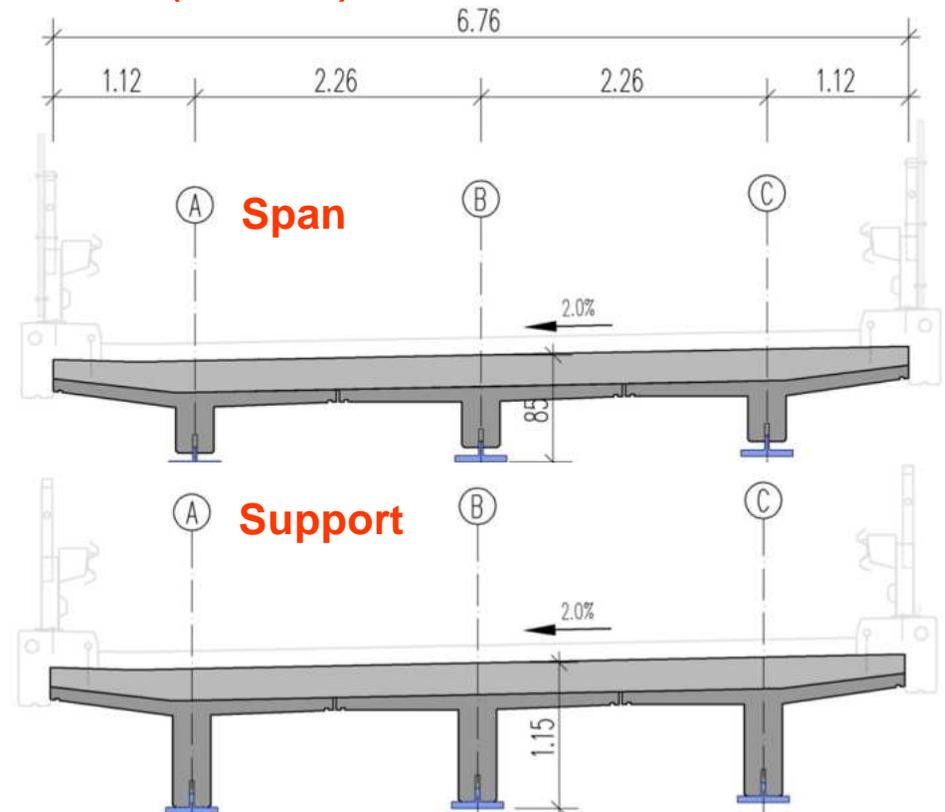VFT-WIB-Träger: Röss Bau GmbH, Ingolstadt

Rail overpass in Kratzerau, Austria (2012)

System	frame over 4 spans
Span	19.70m – 2x19.50m – 19.70m
Width	6,76 m
Slenderness	1 : 17 / 1 : 23
Bridge surface	540 m²
Total costs	990 €/m2

Deck:

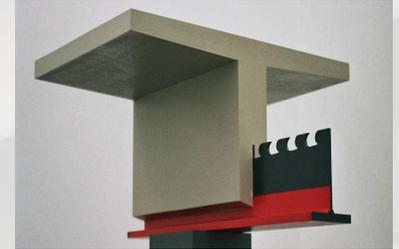|		
Steel weight	49 tons	91 kg/m2
Rebars	48 tons	220 kg/m3
Concrete	242 m3	45cm / m2
El. Weight	26 tons	

Rail overpass in Kratzerau, Austria (2012)
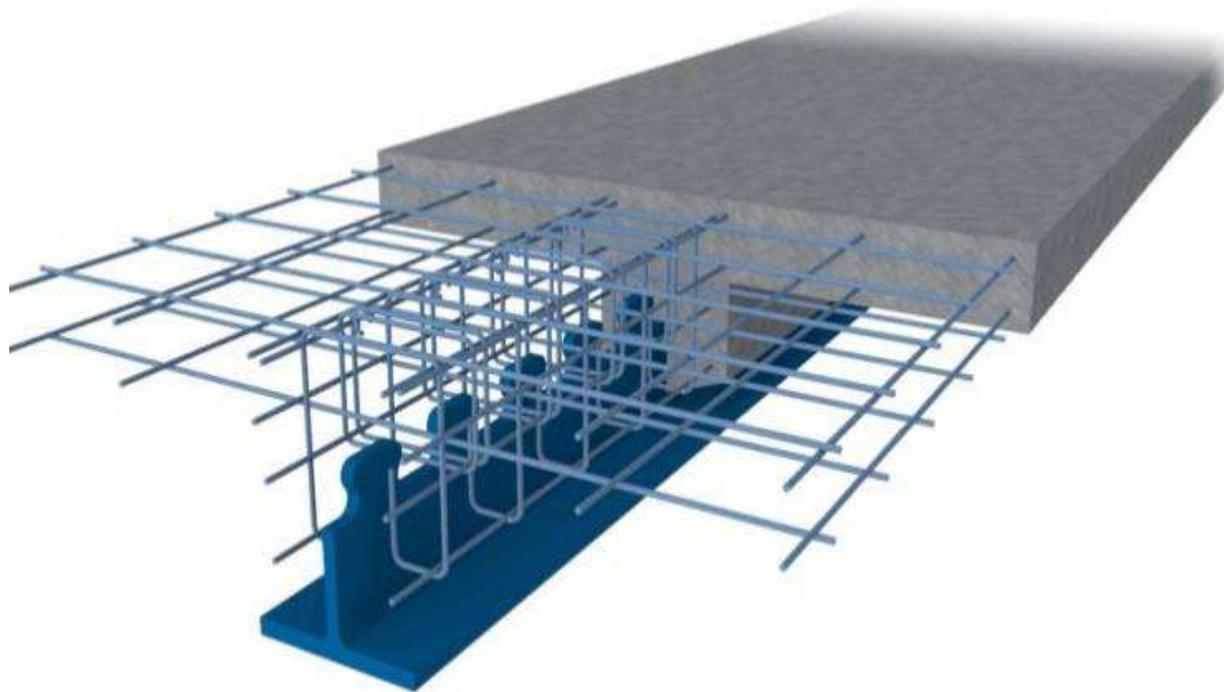
PreCoBeam – Kratzerau
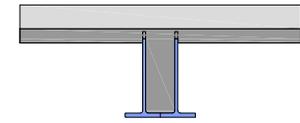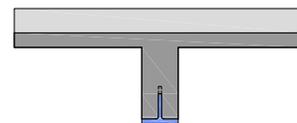
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  - Structural concept

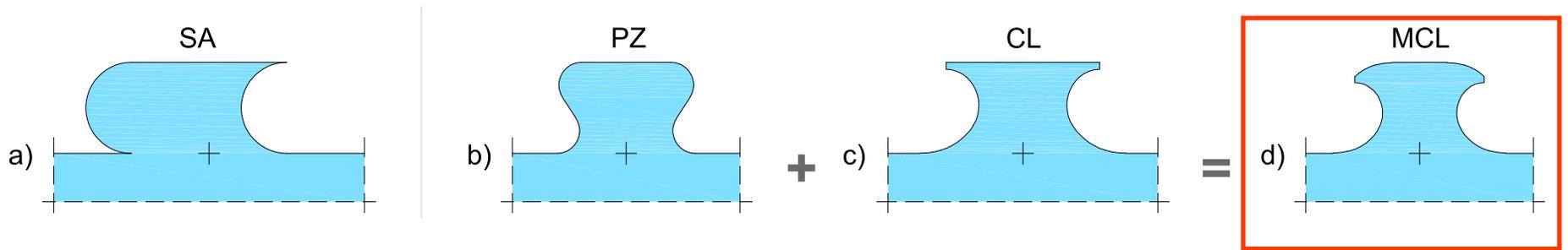 - **Dowel design**

  - Conclusion

Field of application

- Simple or double Precobeam

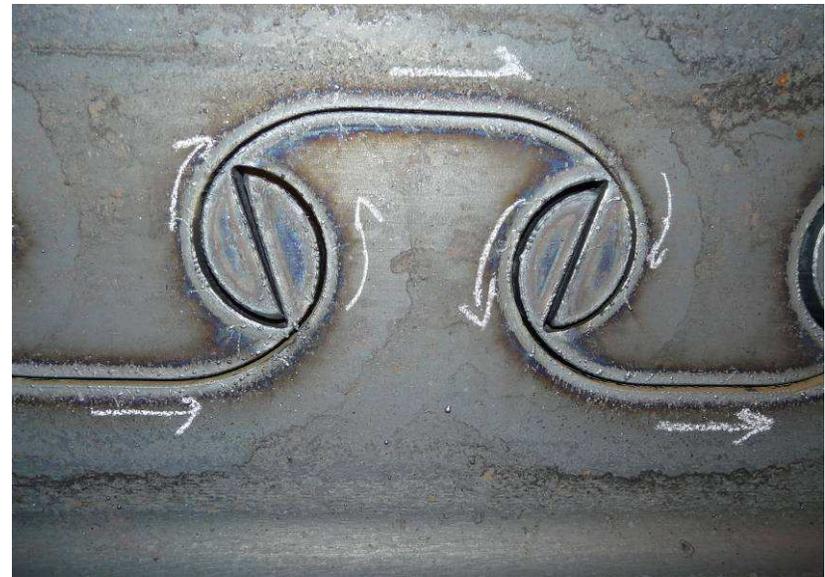- Steel grades: S235 - S460

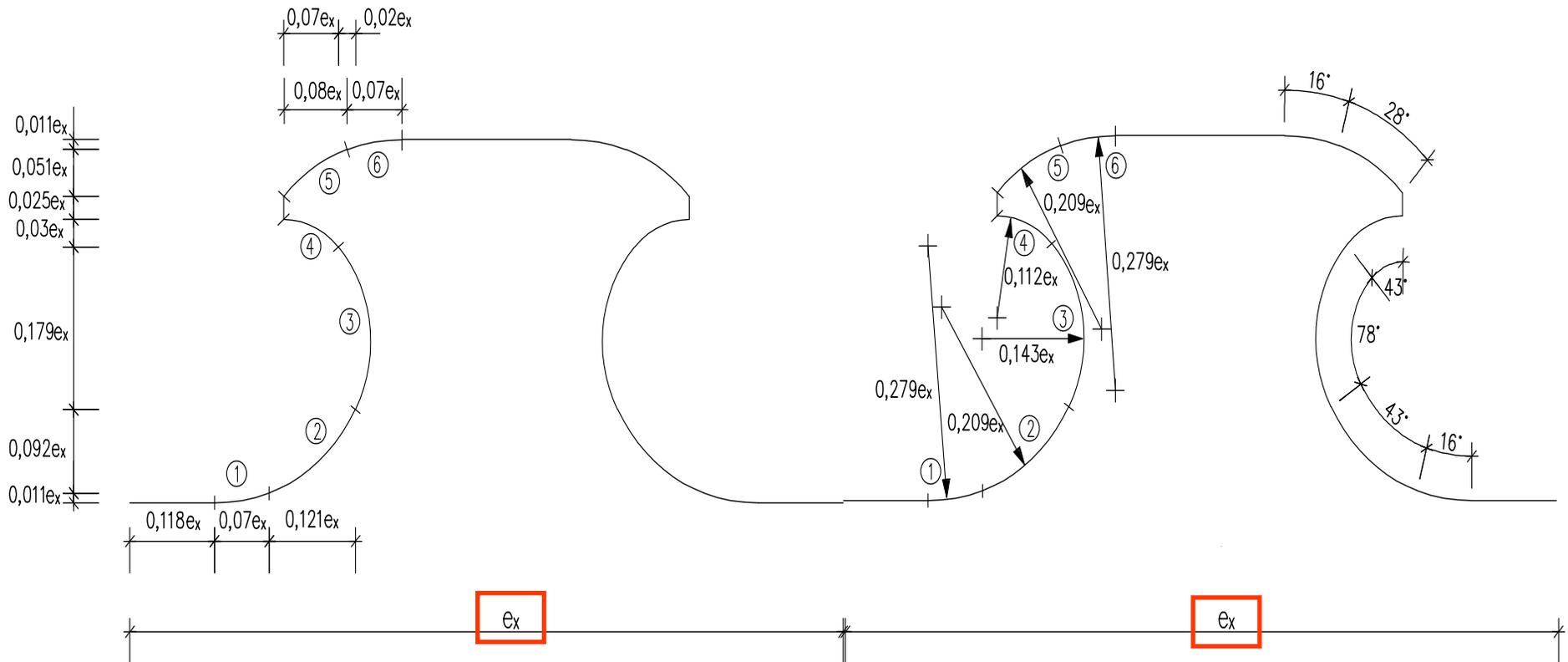- Concrete grades: C20/25 – C60/75

Steel dowel geometry

SA a)   PZ b)   **+**   CL c)   **=**   MCL d)

- On the basis of the past experience, which showed a better fatigue behaviour and easy fabrication process, it is advised to use the *modified clothoidal shape (MCL)* for the design of road and railway bridges.
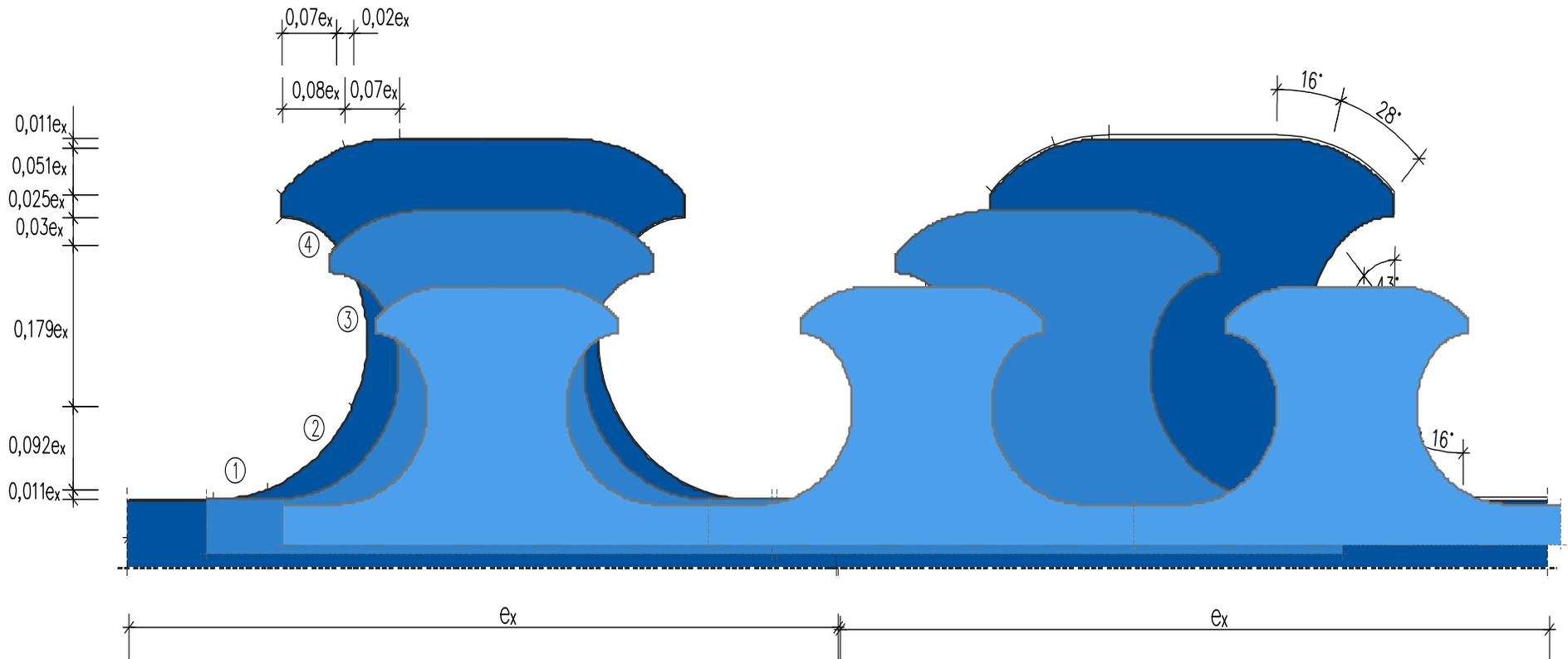
Steel dowel geometry EN

- The principle is that the basic shape can be scaled in function of e_x.
- The dowel axis distance e_x is the considered as the basis dimension:

  150 mm $\leq e_x \leq$ 500mm, usually e_x = 250mm, h_D = 115mm, h_D / e_x = 0.46
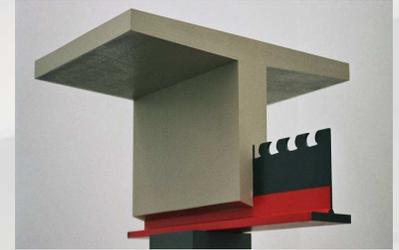
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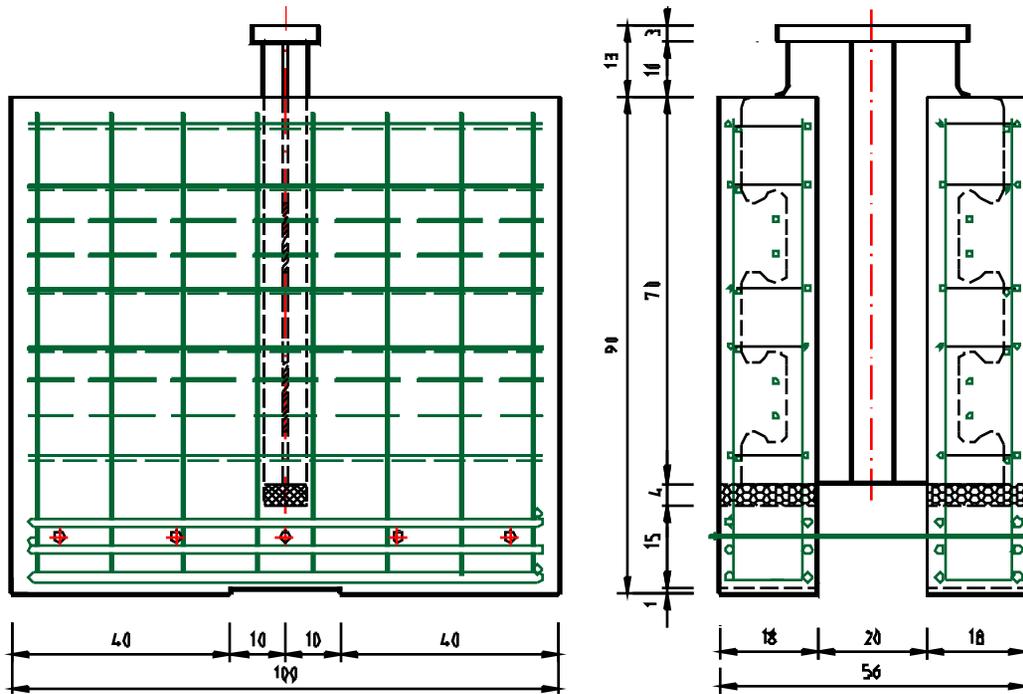
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  – Introduction to structural concept
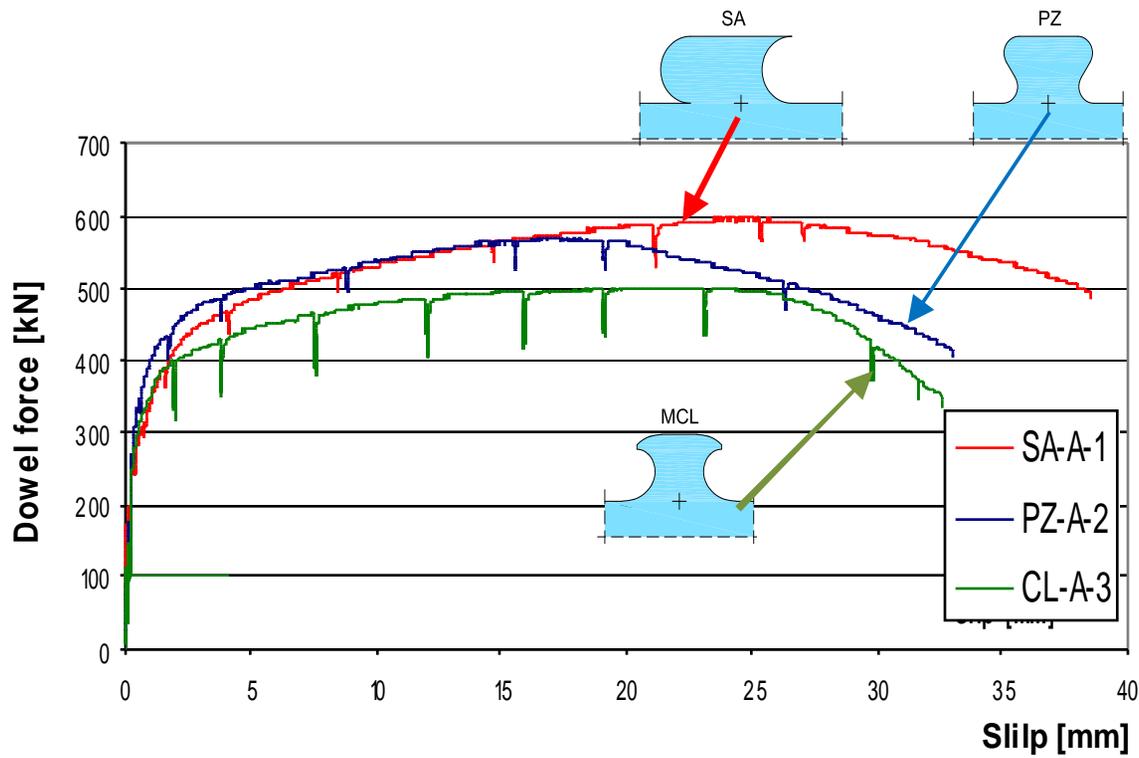
  – **Dowel design**

  – Conclusion

Load Bearing Behavior– Static loading

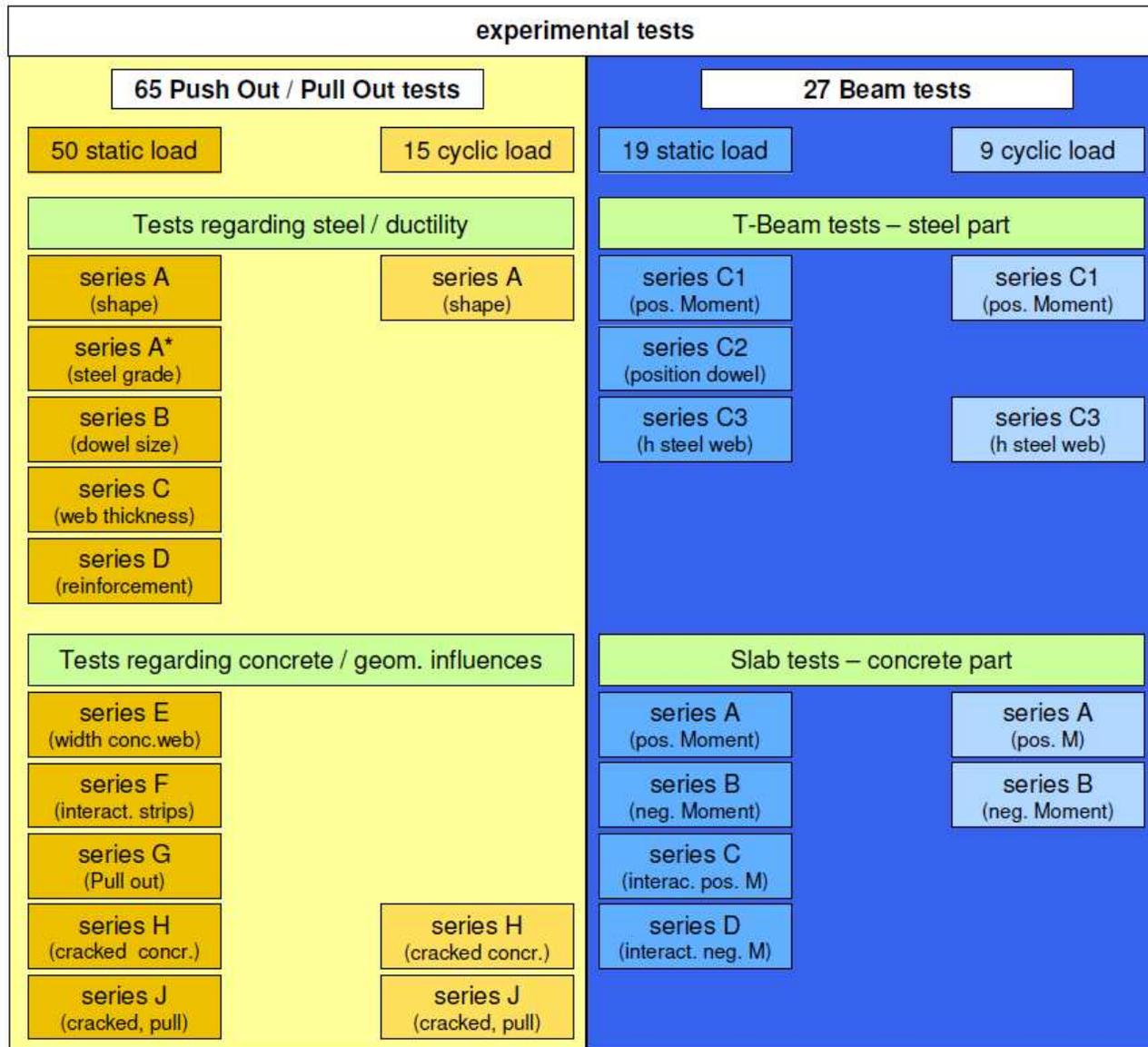- Standard Push-out tests for composite dowels:

Load Bearing Behavior– Static loading

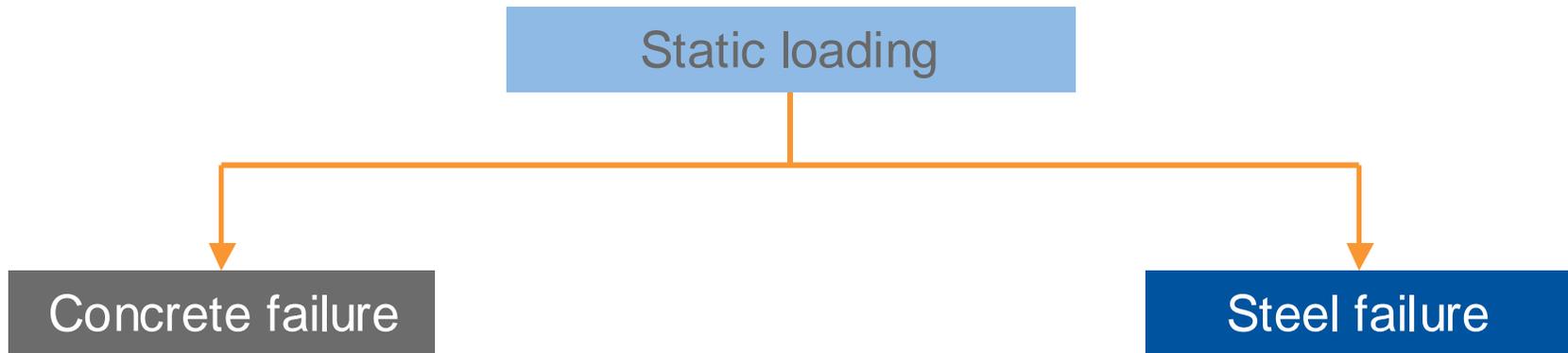- Standard Push-out tests for composite dowels:
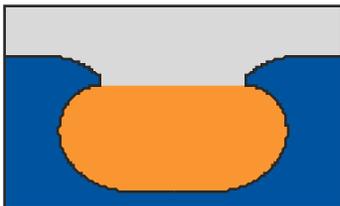
Experimental background

Dowel design – Static loading

- Verification of longitudinal shear transmission:

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                    ┌─────────────────────┐
                    │    Static loading   │
                    └──────────┬──────────┘
            ┌──────────────────┴──────────────────┐
   ┌────────────────┐                      ┌────────────────┐
   │ Concrete failure│                      │  Steel failure │
   └────────────────┘                      └────────────────┘
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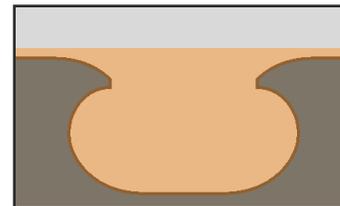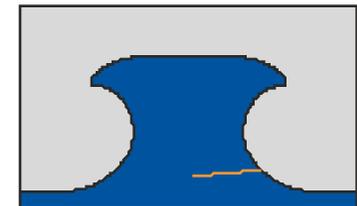
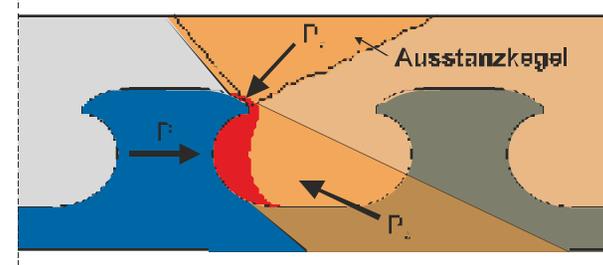- Failure criteria:

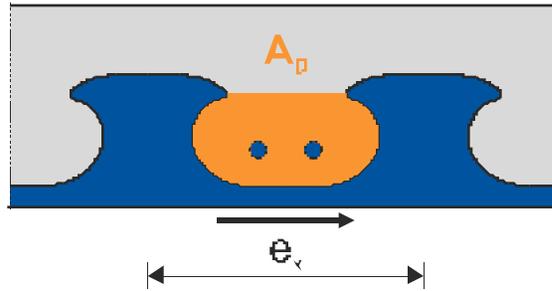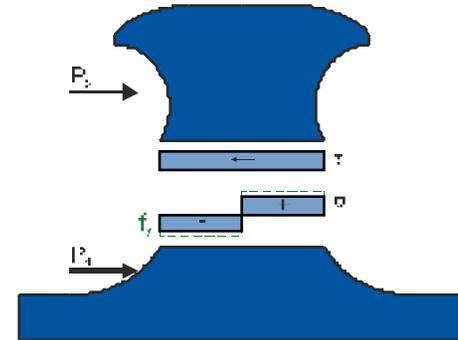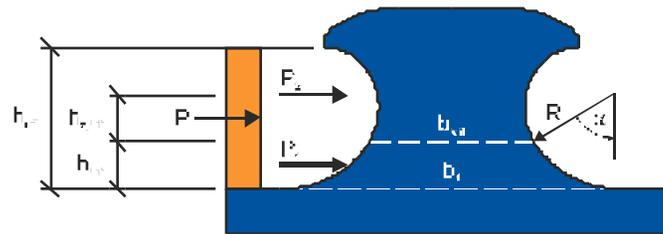Concrete shearing   Pry-Out   Spalling concrete coverage   Steel failure

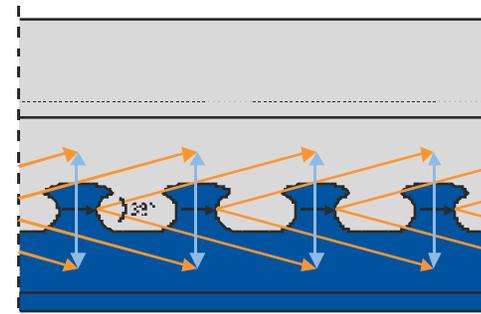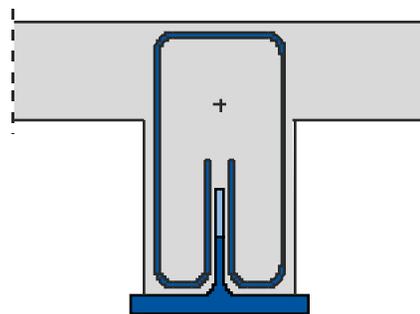# Dowel design – Steel failure

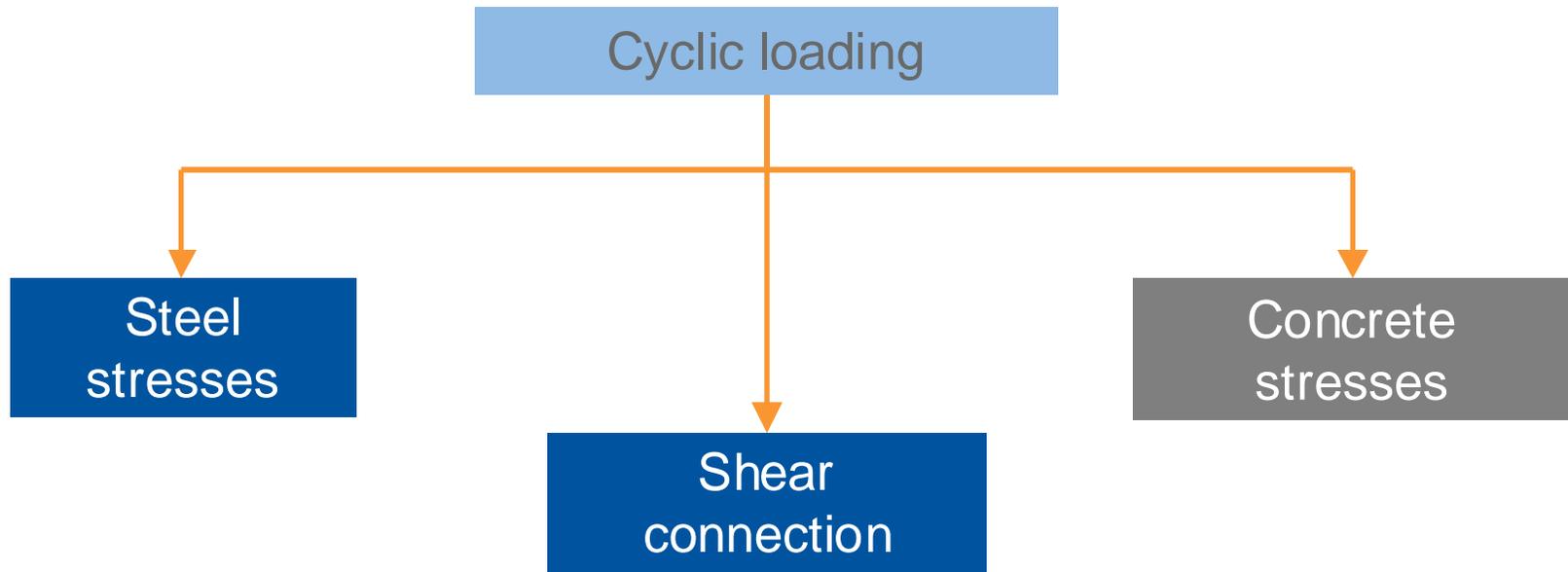- Concrete:

- Steel:

- Reinforcement:

Dowel design ULS – verifications:

| Vérification à l'état limite ultime :	
Résistance au cisaillement du béton compris entre les dents de la découpe	$P_{sh,k} = \eta_D \cdot e_x^2 \cdot \sqrt{f_{ck}} \cdot (1 + \rho_D)$ $\rho_D = \dfrac{E_s \cdot A_{sq,1}}{E_{cm} \cdot A_D} \quad \eta_{D,CL} = \left(3 - \dfrac{e_x}{180}\right) \quad \eta_{D,PZ} = \left(2 - \dfrac{e_x}{400}\right)$
Résistance à l'éclatement du béton aux alentours de la dent (à ne pas considérer en présence d'une armature minimale de confinement)	$P_{po,k} = \chi_x \cdot \chi_y \cdot 90 \cdot h_{po}^{1,5} \cdot \sqrt{f_{ck}} \cdot (1 + \rho_{D,i})$ $\rho_{D,i} = \dfrac{E_s \cdot A_{sq}}{E_{cm} \cdot A_{D,i}} \quad \chi_x = \dfrac{e_x}{4,5 \cdot h_{po}} \quad \chi_y = \dfrac{1}{2} \cdot \left(\dfrac{e_y}{9 \cdot h_{po}} + 1\right)$
Résistance d'une dent en acier	$P_{pl,k} = 0,25 \cdot e_x \cdot t_w \cdot f_y$
Aire minimale d'armature de confinement	$A_{s,conf} = 0,3 \cdot \dfrac{P}{f_{sd}}$

Dowel design – Cyclic loading

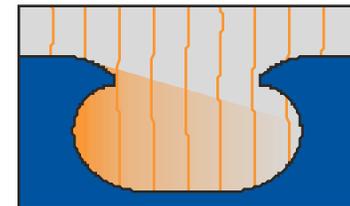- Verification of longitudinal shear transmission:

- Failure criteria:
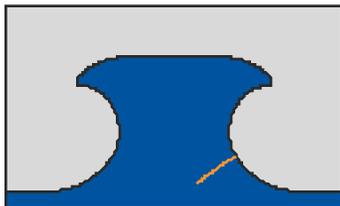
Steel failure	Cyclic pry-out	Concrete loosening

Dowel design – Stress verification

- Stress pattern in the composite dowel:

• Surface of increased stresses :
  o Consideration of stress concentration factors for both **local dowel action** and **global bending**

• Local Forces

• σ_x

• σ_x

• σ_x

• σ_x

• Influence from local dowel-action
• Influence from global bending
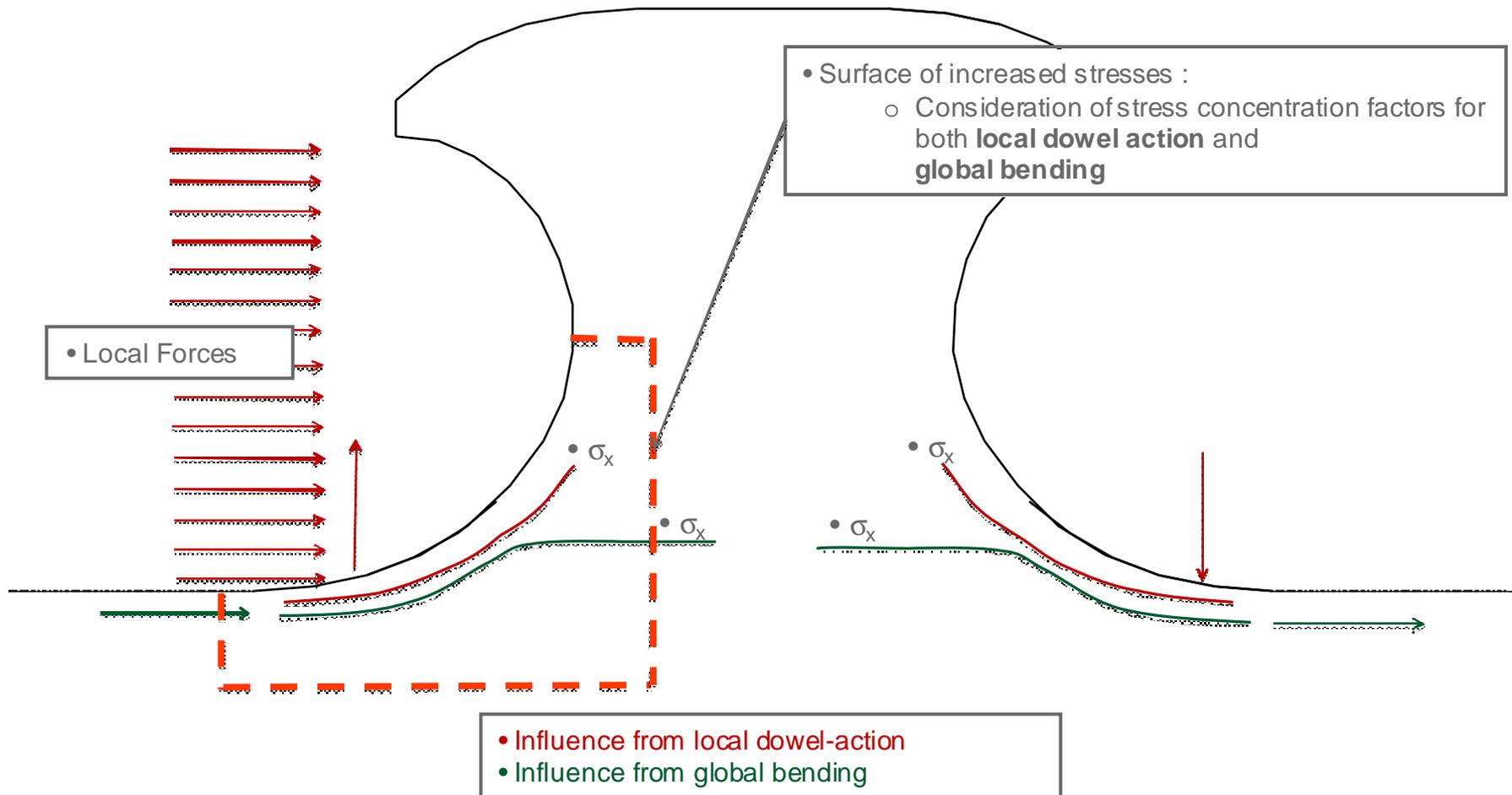
Dowel design SLS – verifications:

- Characteristic combination - Limitation of steel stresses:

$$\sigma_s = k_{f,L} \cdot \frac{V \, x \, S_y}{I_y \times t_w} + k_{f,G} \cdot \left(\frac{N}{A} + \frac{M}{I_y} \cdot z_D \right) \leq f_y$$

$f_{global} = 1{,}5$ $\qquad$ $f_{Local} = 7{,}95$

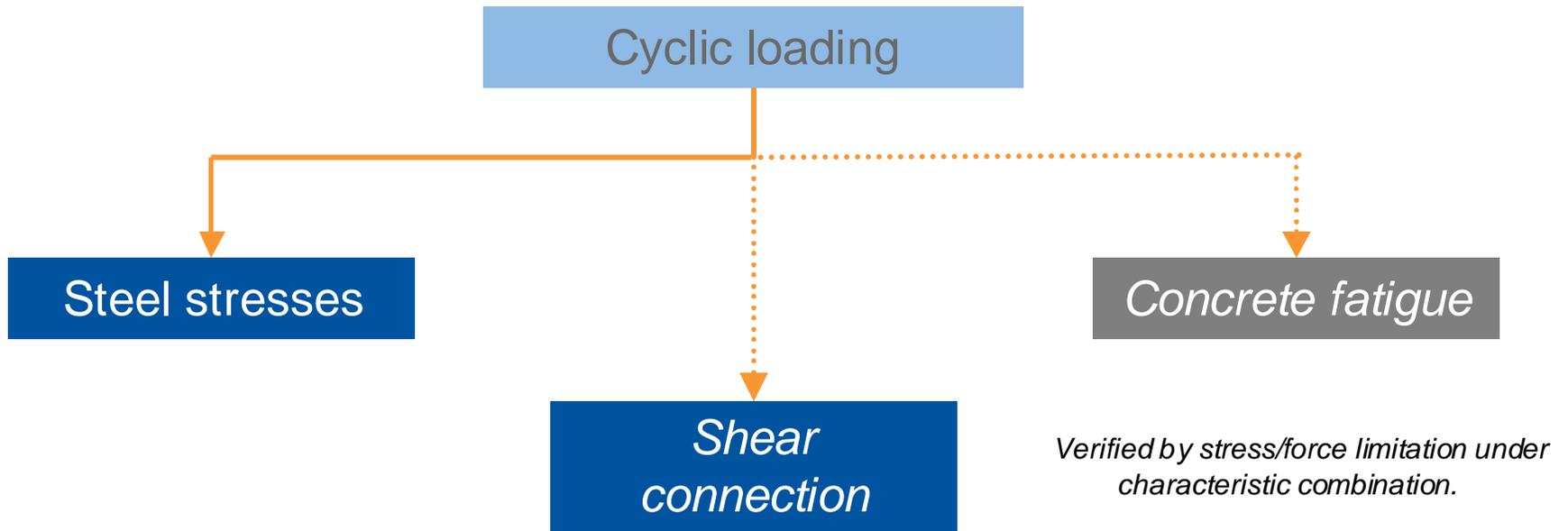- Characteristic combination – Limitation of force in the concrete dowel:

$$P_{LD,ser} \leq 0.7 \min \left(P_{sh.k} ; P_{po.k} ; P_{co.k} \right)$$

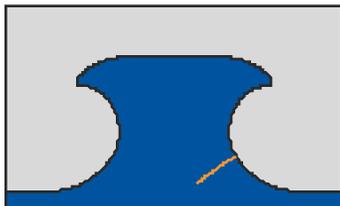- Characteristic combination – Limitation of force in the concrete dowel:

$$P_{LD,ser} \leq P_{cyc} = 3.1 \cdot t_w \cdot h_d \cdot f_{ck}$$

Dowel design – Fatigue
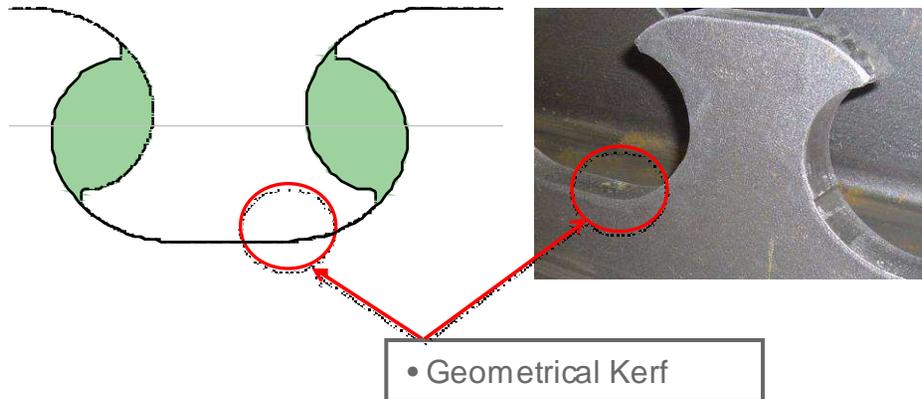
- Verification of longitudinal shear transmission:

Cyclic loading

Steel stresses

Shear connection

Concrete fatigue

Verified by stress/force limitation under characteristic combination.

- Failure criteria:

Steel failure

Dowel design – Fatigue verification

▪ Stress concentration for local and global action:

• Geometrical Kerf

▪ Design according the structural stress concept – EN1993-1-9:

$$\Delta\sigma = k_{f,L} \cdot \frac{\Delta V \, x \, S_y}{I_y \times t_w} + k_{f,G} \cdot \left(\frac{\Delta N}{A} + \frac{\Delta M}{I_y} \cdot z_D \right) \leq \frac{\Delta\sigma_S}{\gamma_{Mf}}$$
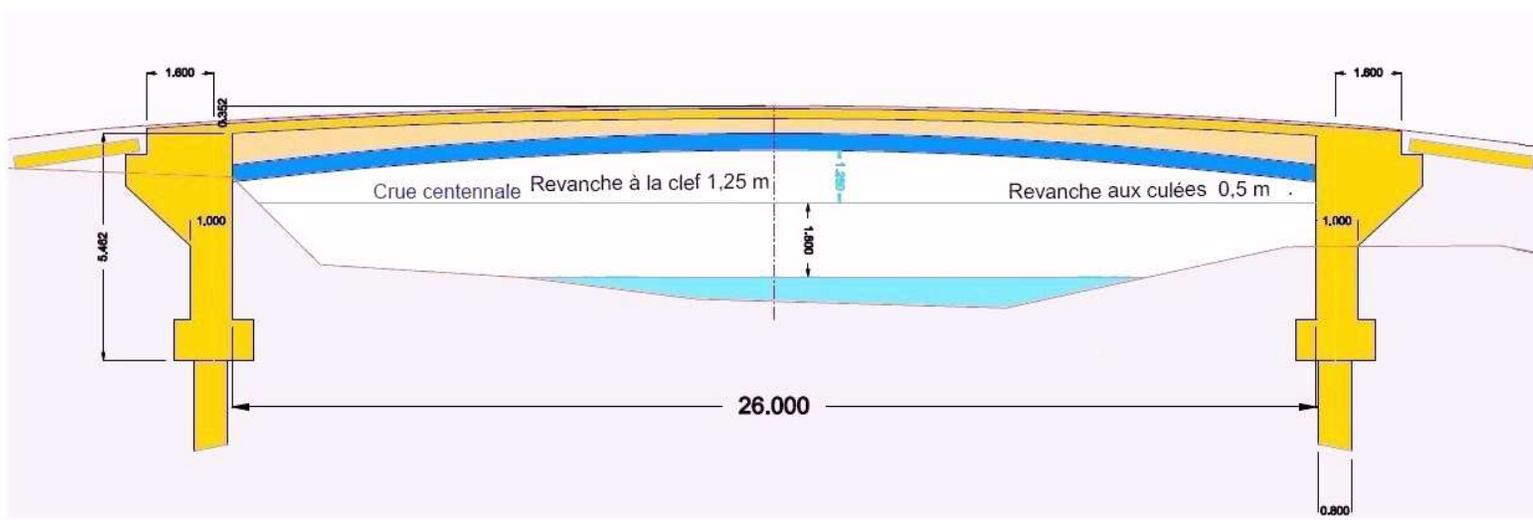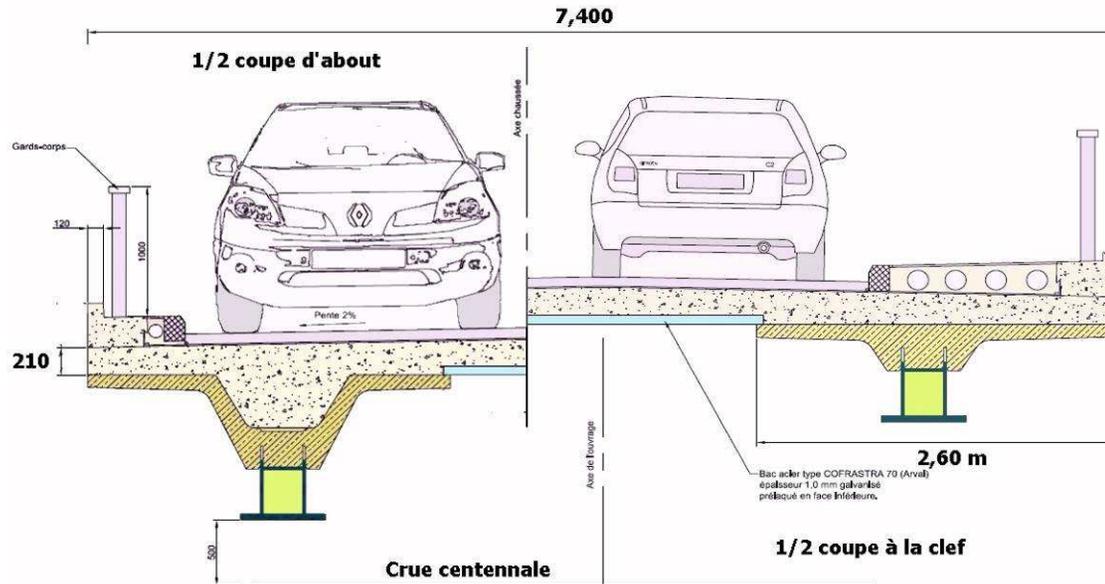
- $\Delta\sigma_s$ = 125 for machine gas-cut edges with shallow or regular drag-lines
- $\Delta\sigma_s$ = 140 for machine gas cut or sheared material with grinded edges
- In general re-entrant corners have to be improved by grinding (slope $<^1/_4$)

Table of content

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  – Introduction to structural concept

  – Dowel design

  – **Conclusion**

Franchissement de l'Arve près de Chamonix

Conclusion

Many thanks for
your kind attention!