



**GC'2017**

CACHAN

15 et 16 mars

**SOLUTIONS OPTIMISÉES POUR OUVRAGES  
D'ARTS COURANTS:  
PONTS MIXTES AVEC OSSATURE ACIER EN  
PROFILÉS DE COMMERCE**

**Riccardo ZANON (ARCELORMITTAL)**

# Solutions optimisées pour Ouvrages d'Art courants:

## Ponts mixtes avec ossature acier en profilés de commerce



ArcelorMittal

EuroStructures Beam Finishing Centre

Riccardo ZANON

[Riccardo.zanon@arcelormittal.com](mailto:Riccardo.zanon@arcelormittal.com)



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- Filler beam decks – Keywords
- Example: New high-speed railway line CNM
- Multi-girder composite decks – Keywords
- Example: Pont du Triangle Dunkerque
- Conclusions



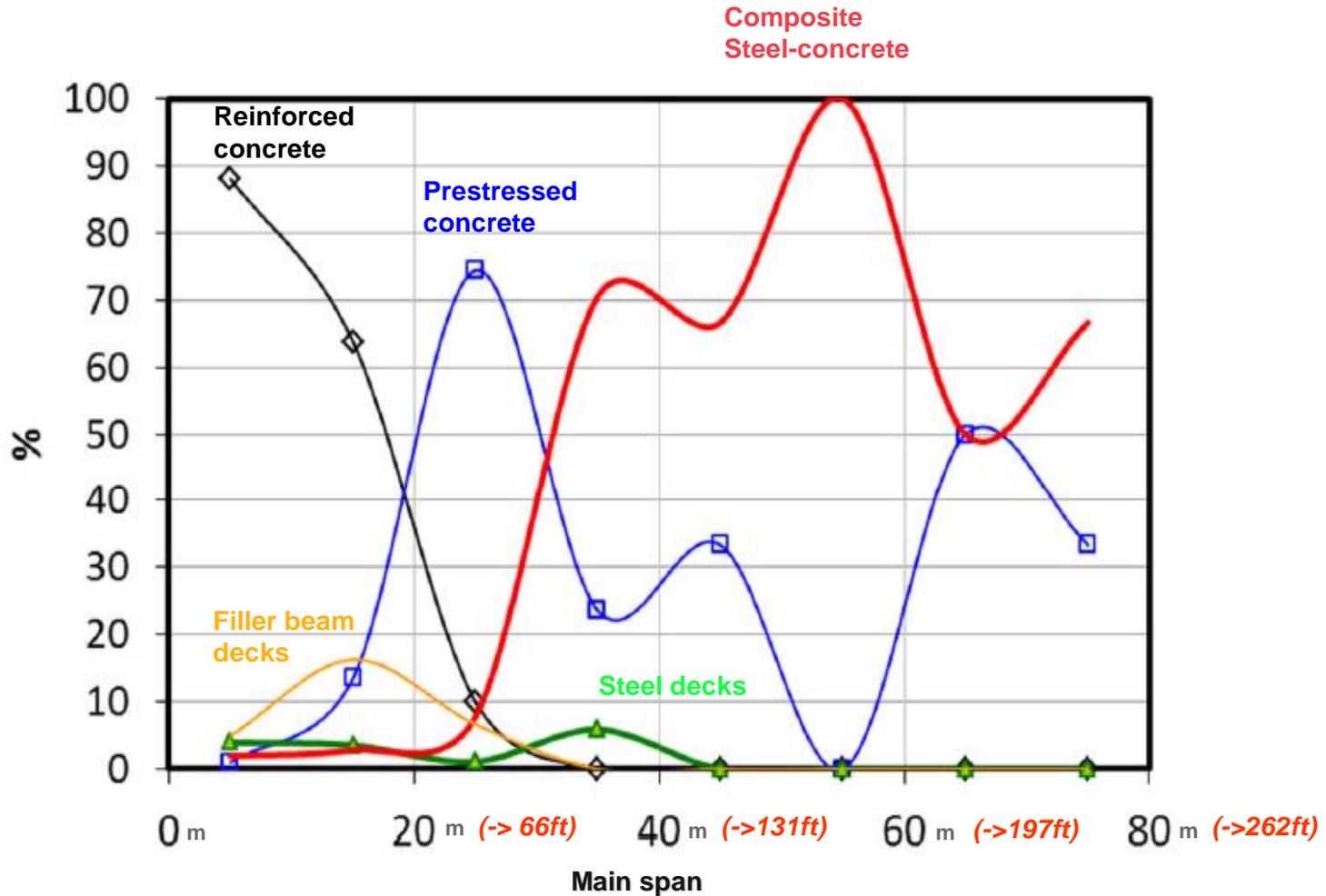
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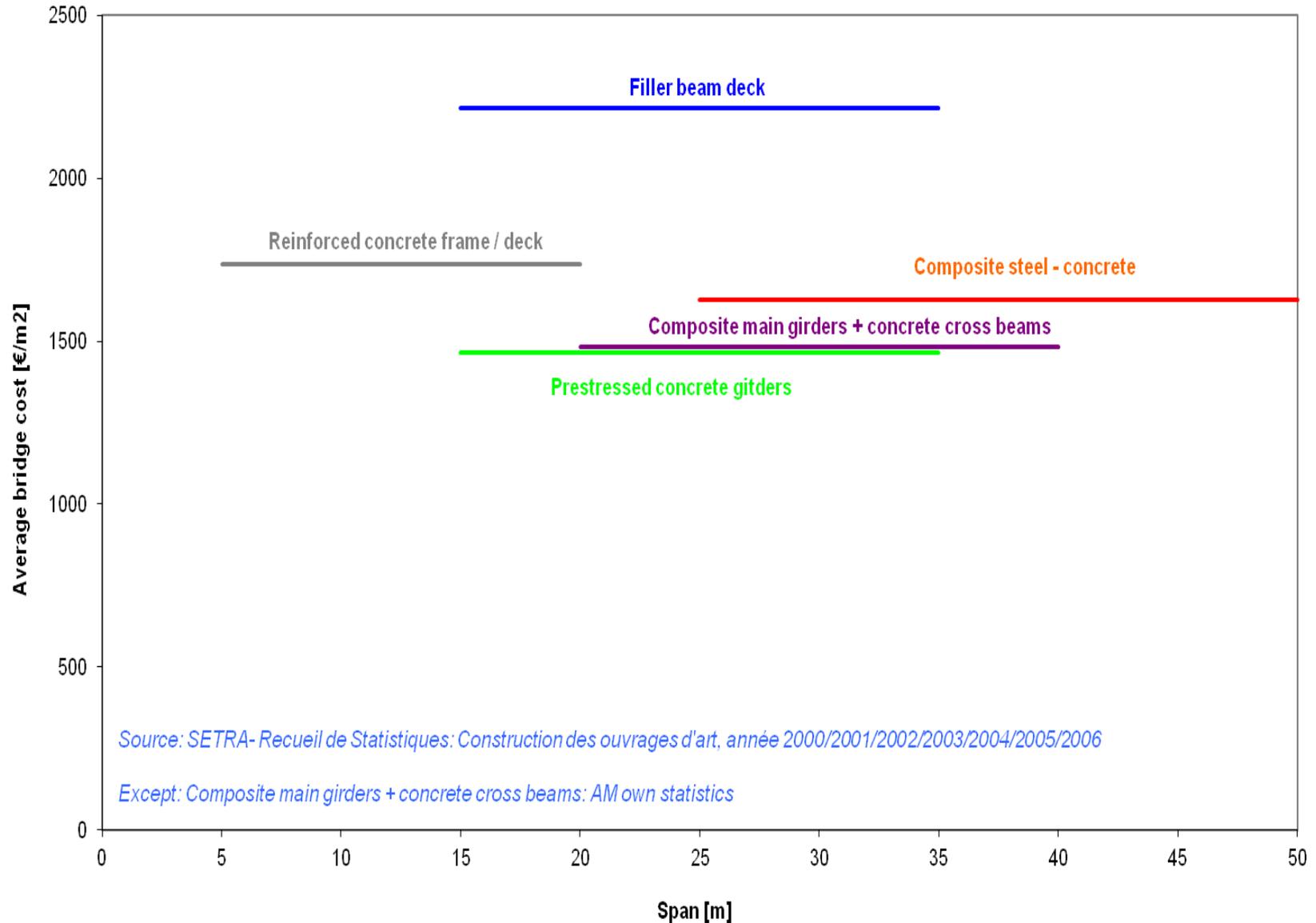
# Market share / deck typology in function of the span

Rail and road bridges built in France in the period (1998-2006):





# Market share per typology in function of the span

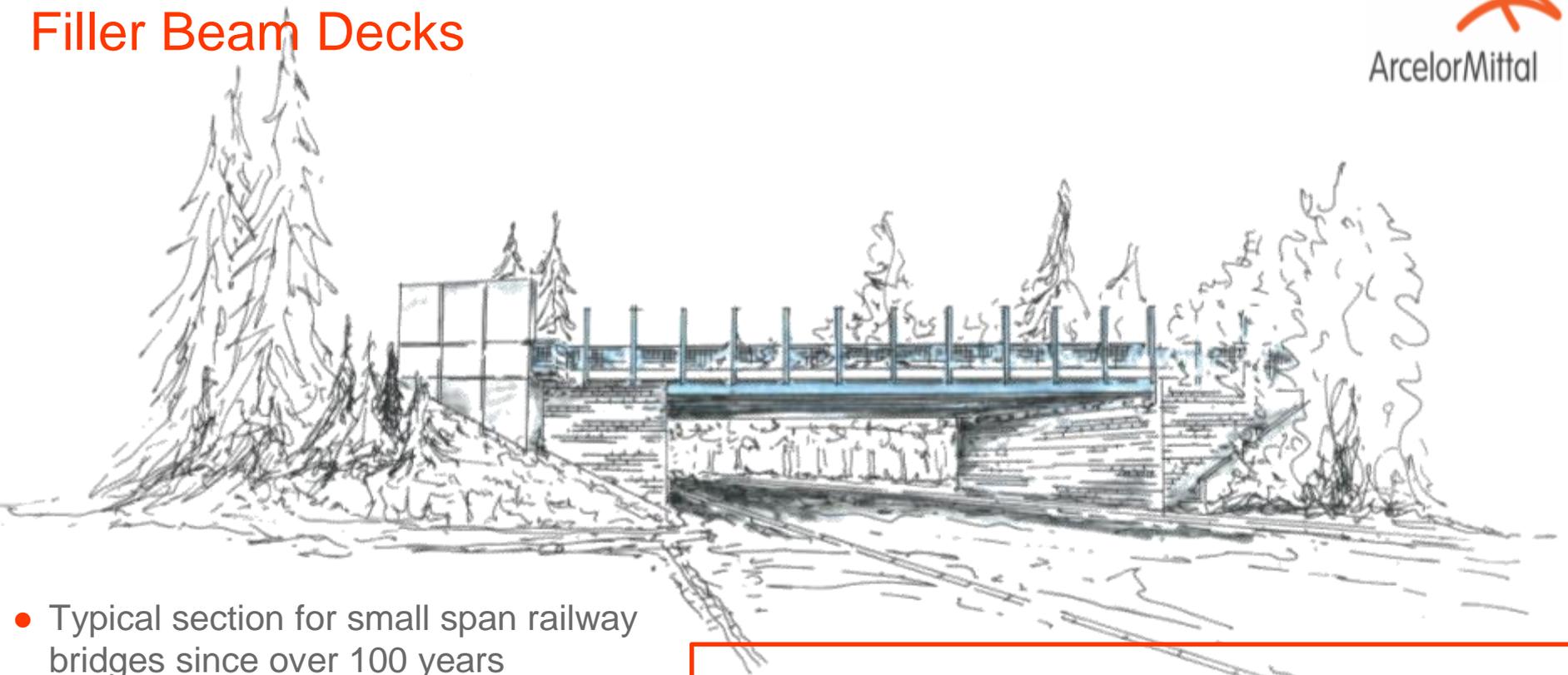


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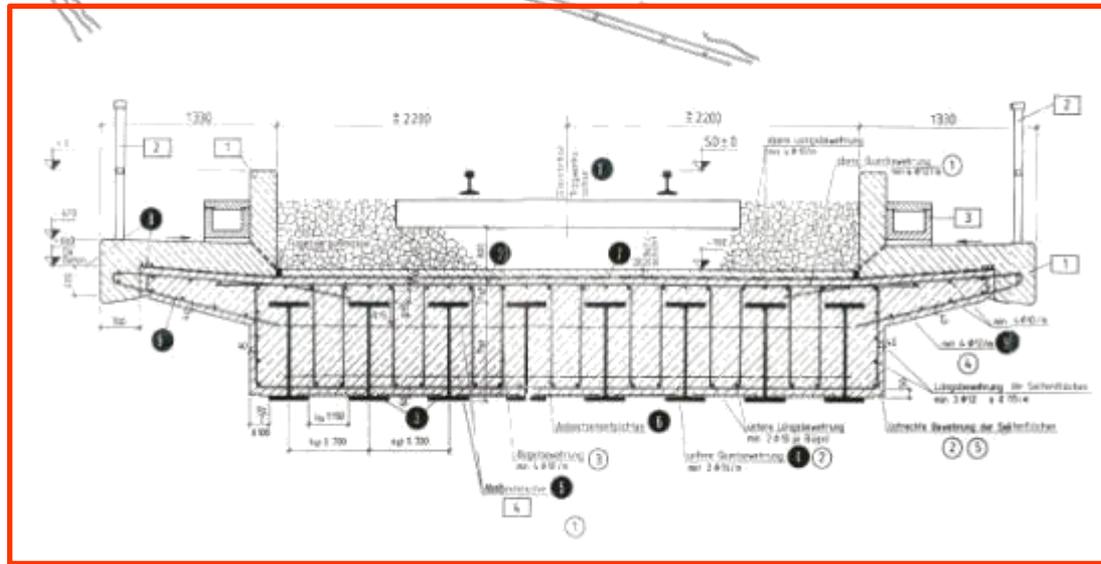
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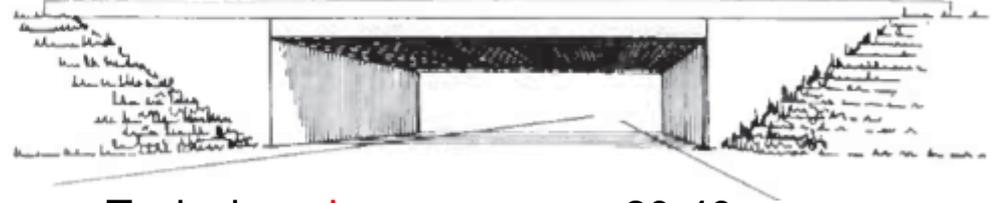
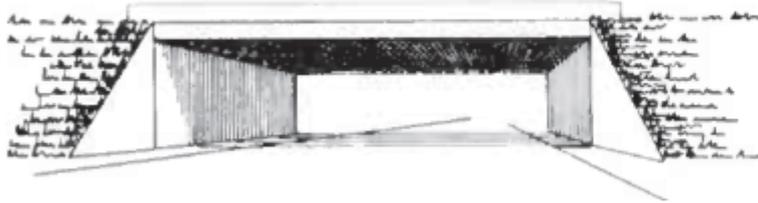
# Filler Beam Decks



- Typical section for small span railway bridges since over 100 years
- Rolled sections encased in the concrete plate except the bottom flange
- Composite design longitudinal direction
- Reinforced concrete plate transversal
- Geometrical requirements & design: according EC4 and / or national rules
- Delivery of steelwork directly from the steel plant to the g.c. on the construction site



# Filler Beam Decks



Typical **railway overpass**: 15-30m span  
Slenderness: 1 / 15 ... 25

Typical **roadway overpass**: 20-40m span  
Slenderness: 1 / 30 ... 40



Bascharage (Luxembourg)

Bridge owner: Chemins de Fer Luxembourgeois

19.8m span, 18.62m width, 81.78 gons skewness

16 x HEB800 in S355M, e = 650mm      Slenderness 1 : 25

Esch-Lallange (Luxembourg)

Bridge owner: Administration des Ponts & Chaussées

19.8m span, 18.62m width, 81.78 gons skewness

26 x HEB550 in S355M, e = 693mm      Slenderness 1 : 30

# Filler Beam Decks - Aesthetics



# Beam fabrication

- Cut, drill, camber, weld and paint at the steel plant



# Transport

## Prolongement rocade RD570 Arles

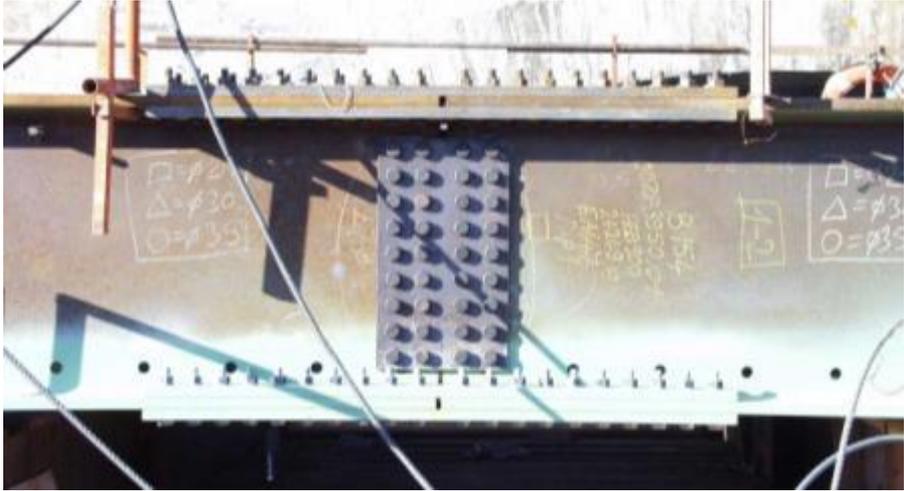


# Erection

## Prolongement rocade Arles



# Reinforcing and concreting

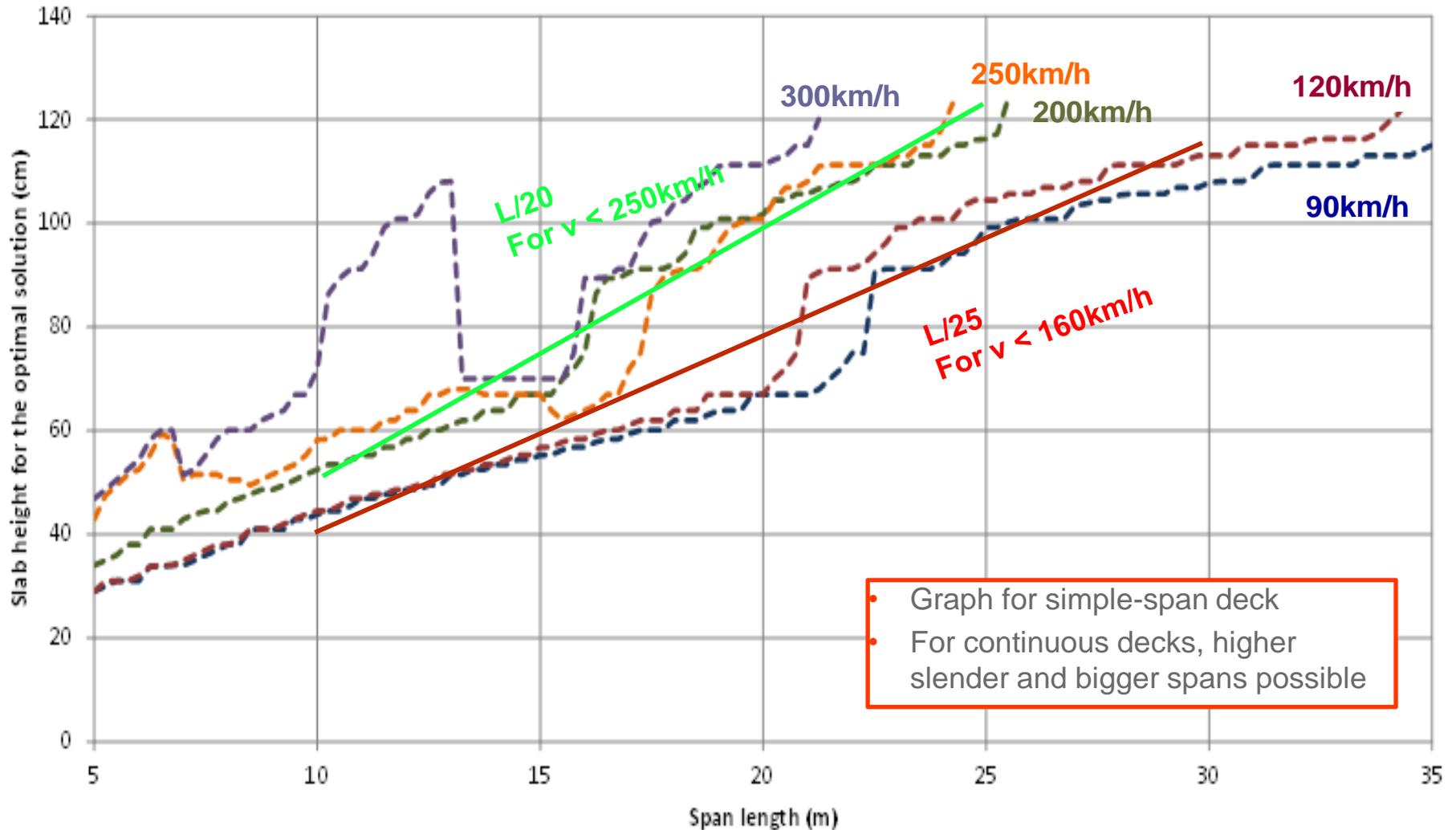


# Filler Beam Bridges

The 5-key features of filler beam decks are:

- 1. Slenderness:** High load resistance permitting very slender bridge decks
- 2. Robustness:** Resistant and resilient to unexpected loading conditions
- 3. Durability:** Longest expected lifetime amongst available bridge typologies
- 4. Adaptability:** Self-supporting w/o traffic disturb, fit-in for reconstruction
- 5. Cost effectiveness:** Very simple construction method, standardized solution

# 1) Filler beam deck - Slenderness



## 2) Filler beam deck - Robustness

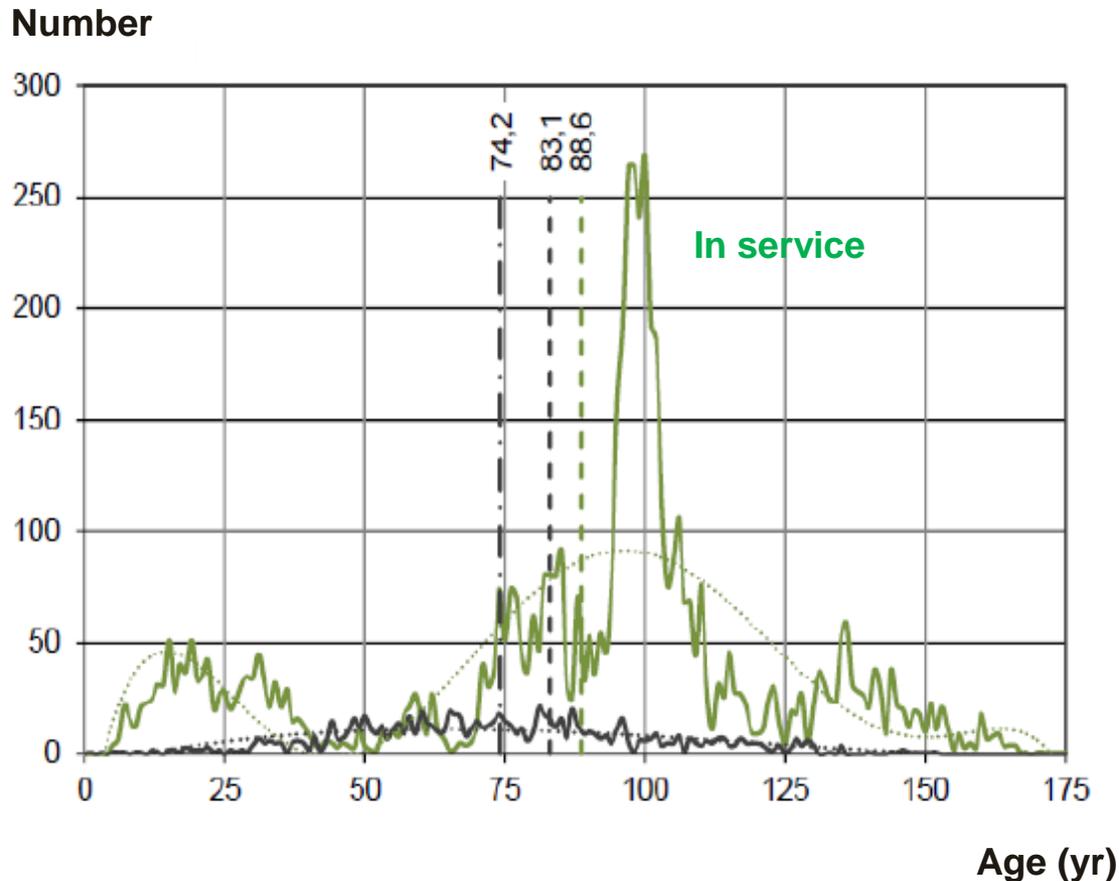


LGV SEA Franchissement RN10

## 2) Filler beam deck - Robustness



## 3) Filler beam deck - Durability



- Statistics for German railways (2012); DB Netz has about 7700 filler beam decks in service
- Filler beam decks have an average:
  - Service time of 88.6 years
  - Replacement lifetime 83.2 years
- These are consistently higher values than steel or pre-stressed concrete decks, this latter having a replacement lifetime of about 50 years
- Filler beam decks in tender competition are awarded with a 25% bonus thanks to their reliable long-life expectation.

## 4) Filler Beam Deck - Adaptability

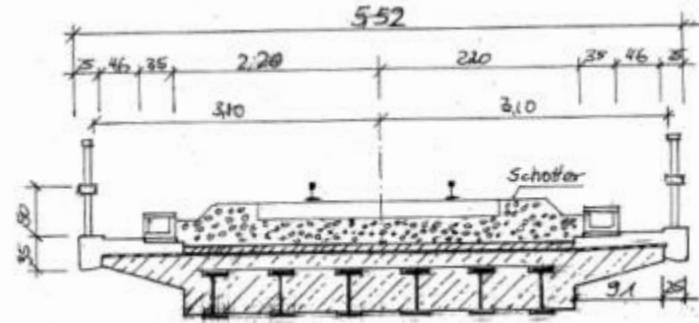


Ancient masonry bridge destroyed by Wehrmacht in 1945, only one arch still in place.

In 1947 a steel deck was put in place to reconstruct the rail link.



# 4) Filler Beam Deck - Adaptability



## 4) Filler Beam Deck - Adaptability



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## 5) Cost effectiveness Example: New CNM Line

R. Zanon, M. Somnavilla, T. Demarco; *New high-speed railway line in France – Review of filler beam bridge concept and application, Proceedings of CTA Conference, Salerno 30 September – 3 October 2015.*



# CNM – Railway project

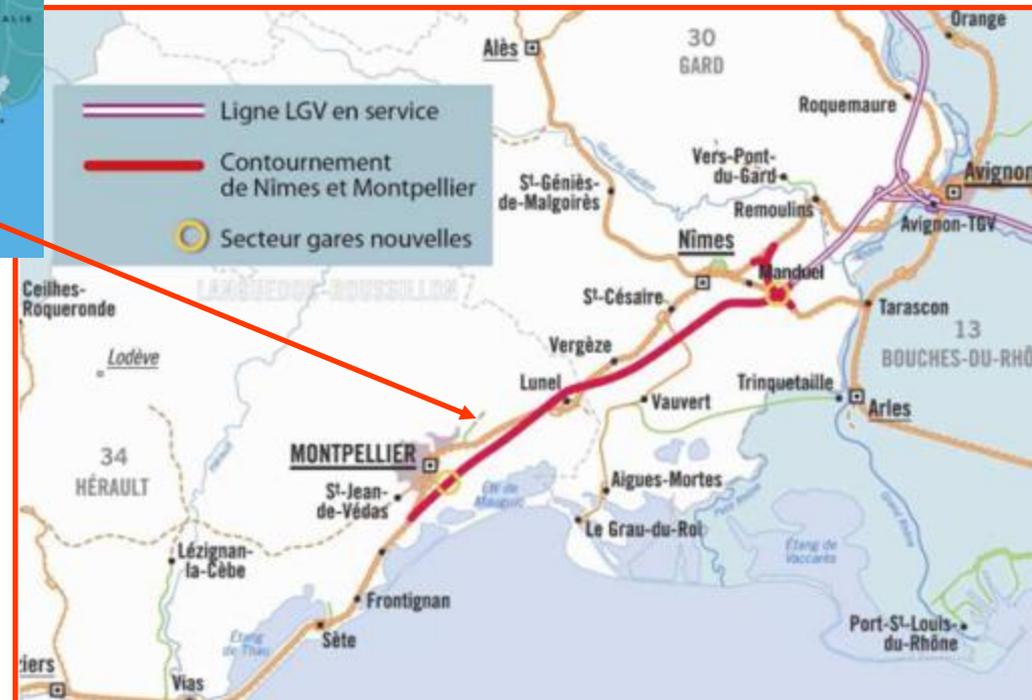


-Realization of **new railway line of 90 km** between Nimes and Montpellier

- Connection between the existing Paris-Avignon and the Frontignan – Fronteras high speed railway lines

- 2.28 milliards € investment sponsored by EU, France, RFF, regional authorities

- Tender awarded as conception – realization – operation for 25 years



- Consortium Oc'via has a public-private partnership contract for 1.5 milliards € over 25 years (consortium leader: Bouygues TP)

- Oc'via will build the infrastructure in the timeframe 2014 – 2016; afterwards operating and maintaining

# Typical landscape new line



Total: 188 bridges / overpass  
Average 1 / 500m of line

11 main bridges  
(100% steel-composite)

177 standard overpasses  
(+/- 10% steel-composite)

Intersection  
Existing railway line

Intersection  
Local water channel

Intersection  
Local roadway

Intersection  
Main roadway

# Major bridges – CNM Line



Viaduc Vistres

# Treillis Warren + RAPL de Vidourle



Bowstring sur la Lez



RAPL sur A54

# Filler beam decks

- > Standard Overpasses
- With limited construction height
- Minimize traffic disturbance



# Filler beam decks

To be used where severe slenderness constraints are given



## 5) Cost effectiveness Example: New CNM Line

R. Zanon, M. Somavilla, T. Demarco; *New high-speed railway line in France – Review of filler beam bridge concept and application, Proceedings of CTA Conference, Salerno 30 September – 3 October 2015.*

CNM: PRA overpass on RD262 à Milhaud (FR)

Span: 31m

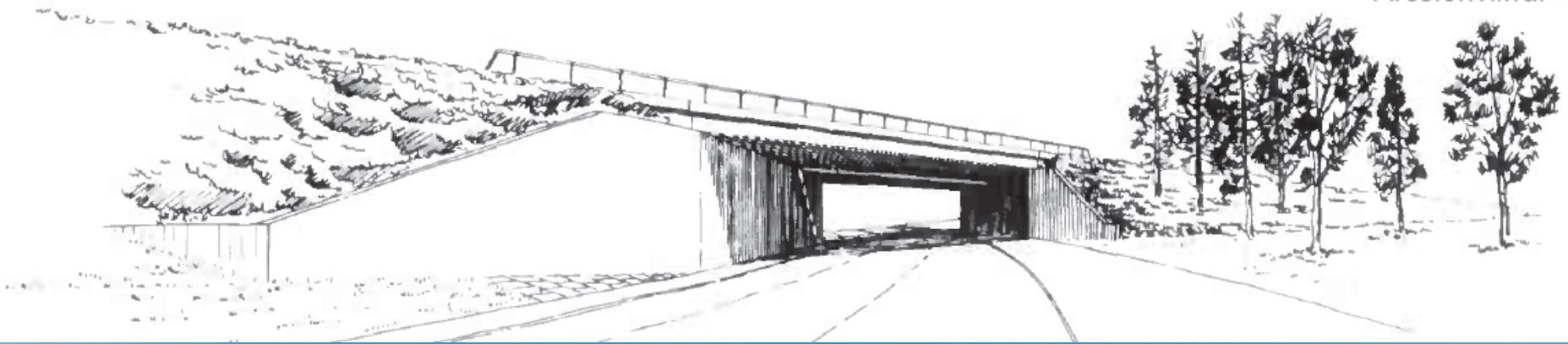


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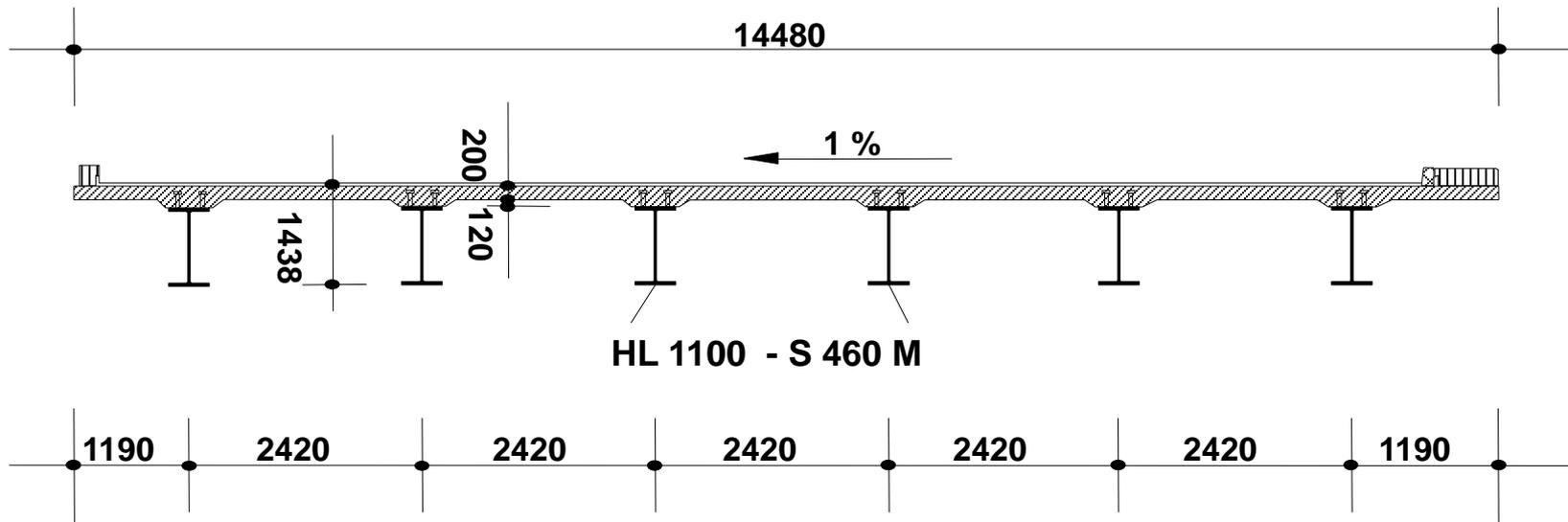
# Single-span steel-concrete composite bridge



Roadway overpasses over road / rail / river  
Span: 20m – 40m  
Slenderness: 1 / 25 ... 35

# Typical cross section

## Example: Irrgarten A1 overpass in Luxembourg



**Administration des Ponts & Chaussées**

**Span = 34 m**

**Construction height = 1400mm**

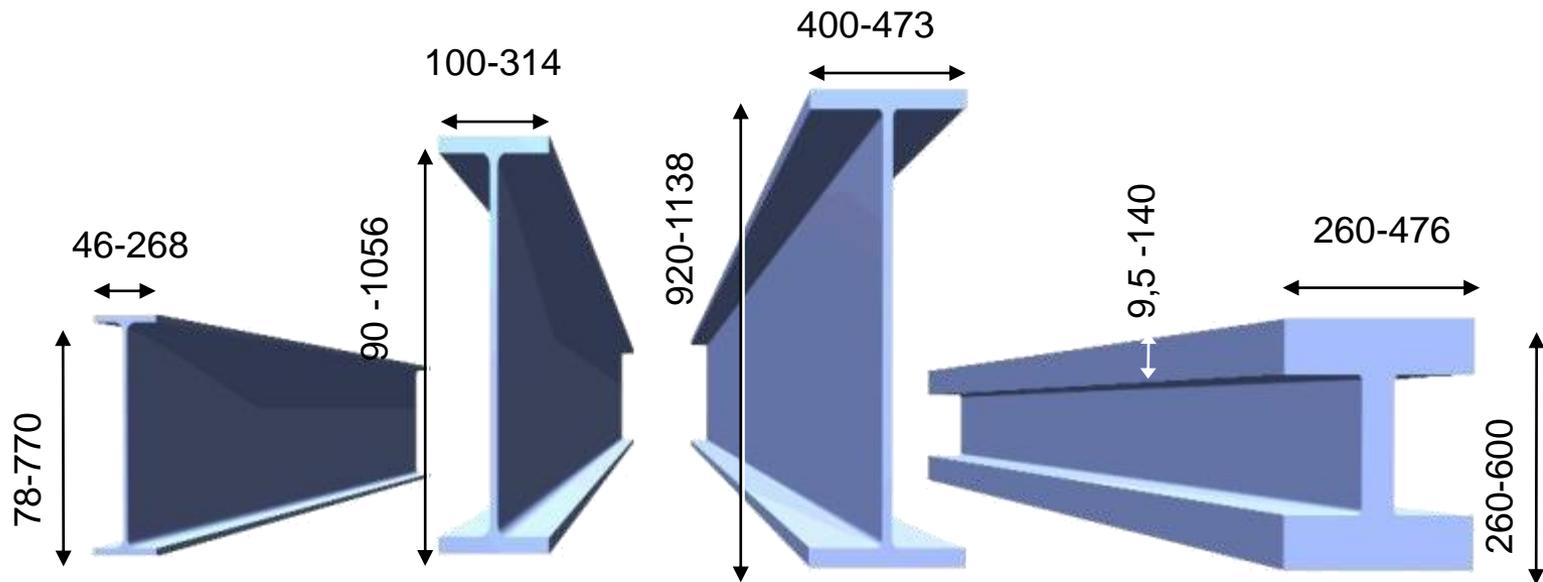
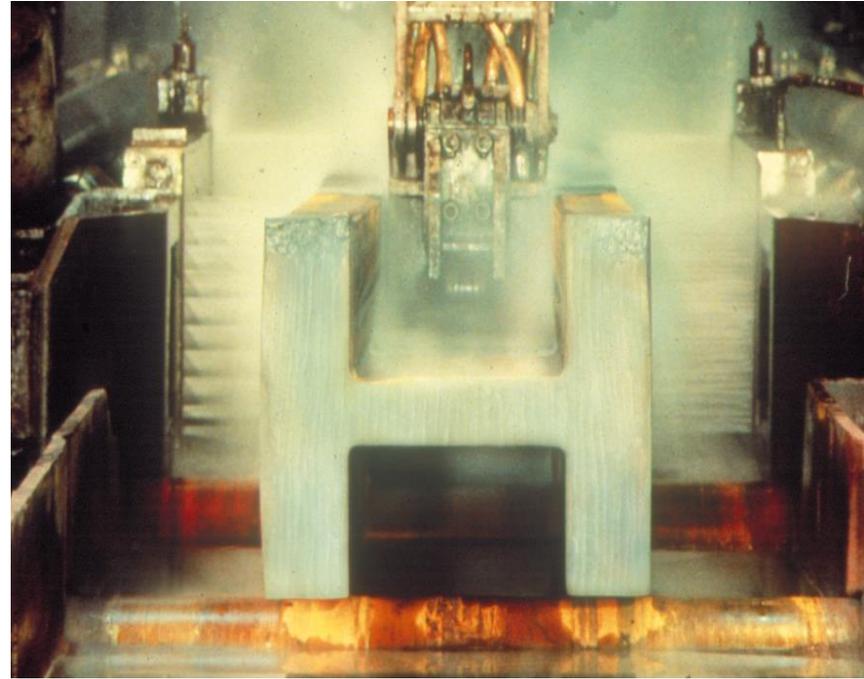
**Slenderness = 1 : 25**

# High-strength Steels

In particular for road bridges it is beneficial to consider the use of high-strength steel like **S460M/ML**, become common in EU.

This enables multiple advantages:

- Reduction of loads due to self-weight
- Reduction of lifting weights for transport and on the construction site
- Reduction of overall cost of steel structure



# Continuous steel-concrete composite bridge



# Highway overpasses

- Standard layout for highway overpasses in FR
- Two main girders linked by steel cross beams
- Very light and economical
- Requirement for skilled erection team



**Steel cross beams**

**@ Supports and span**

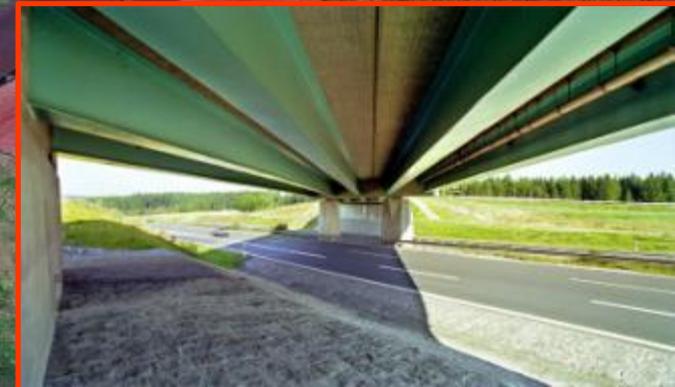
# Highway overpasses

- Concrete cross beams on piers and abutments
- No cross beams in span
- Simple and clear conception
- Easy to build, easy to inspect



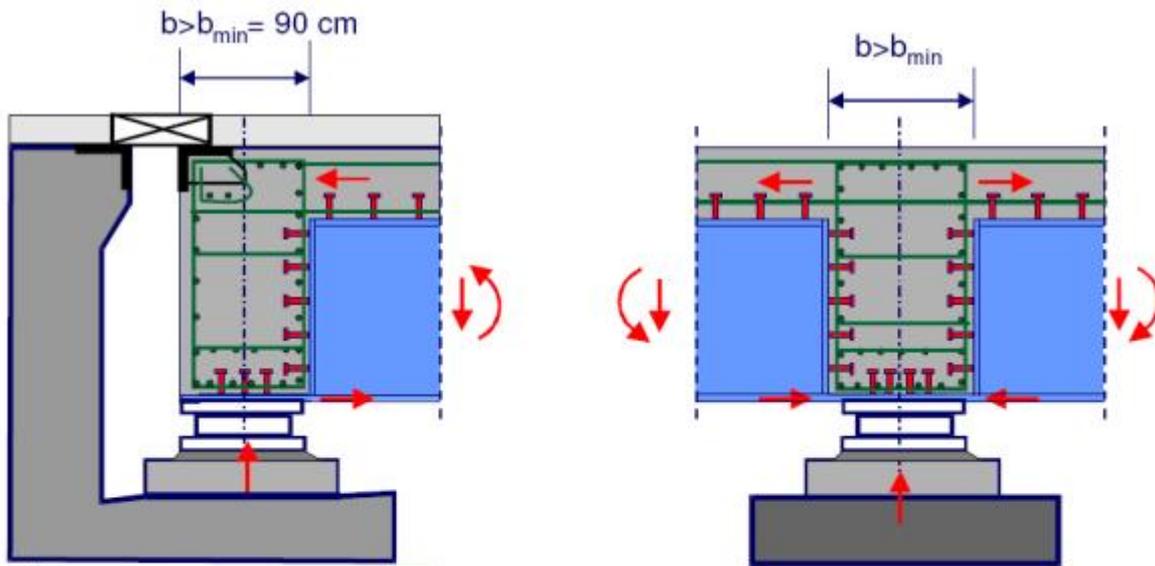
**Concrete cross beams**

**Only @ Supports**



# Concrete cross beam

- Achieve continuity of bridge girders at intermediate piers via concrete cross beams:



# Curved bridge decks



# Curved bridge decks



# Infrastructure developing countries

Colville Deverell bridge in Mauritius Island.

4 span bridge, central span 42m, in very deep valley.

Steelwork completely fabricated in EU and shipped.  
Composite deck constructed locally with concrete cross beams.



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# Example: Pont du Triangle in Dukerque (F-59)

R. Zanon, C. Pulverin, G. Miceli, P. Marano, *Solutions mixtes acier-béton pour les ouvrages d'arts courants – efficacité, économie, esthétique: Exemple du Pont du Triangle à Dunkerque, France*, Revue Technique Luxembourgeoise, 3 – 2016.



# Geographic location



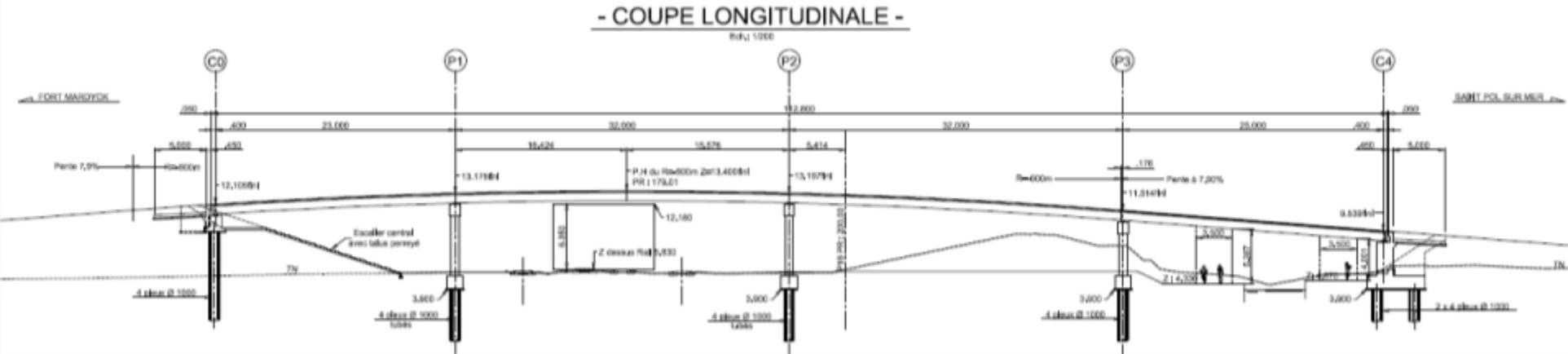
# Scope

Road overpass over railway line with following main constraints:

- Severe geometric requirements
- New road crossing green zone
- Rapid construction time
- Competitive budget
- Pleasant aesthetic appearance



# Bridge Technical Data Sheet



Total Length:	116m	Main girders:	4
Spans:	23 / 32 / 32 / 28 m	Sections:	2 x HE600B/M
Deck width:	13.29m	Steel grade:	S460M
Deck surface:	1542m <sup>2</sup>	Steel usage:	160kg/m <sup>2</sup>
Deck height:	0.95m	R.C. deck+cross beam:	510m <sup>3</sup>
Slenderness:	1 / 33	Reinforcement deck:	195tons



## Steel fabrication

Beams are tied together by a fillet weld (EXC3) which is designed for overtaking the shear stresses due to torsion, which are quite limited.

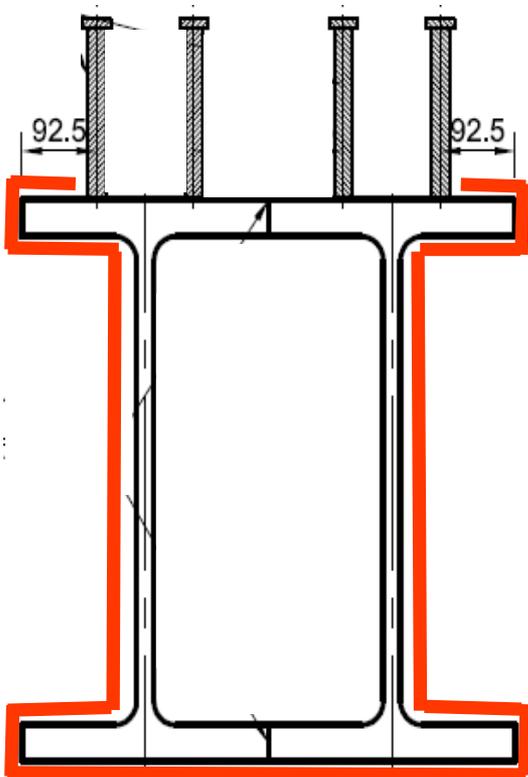
End plates are fixed with a full-strength weld on the upper side and by contact and thick fillet welds on the lower side (EXC4).





## Corrosion protection

Another main advantage is the section massivity, which permits to have a minimal ratio of surface to paint per unit of material. Only the external exposed part is painted, whereas the internal part is closed by welding so no corrosion will take place. In this way, it can be achieved a ratio of Surface to paint / Bridge deck = 0.7. This means that the incidence of the surface paint cost is only 25-30€/m<sup>2</sup> of deck.



## Erection phase

Steel girders are stable without the need of any stabilization device, permitting a simple and rapid construction phase. Max. piece weight: 20tons.



## Erection phase

Precast concrete deck placed directly on the steel girders, with pockets for shear connection.



## Erection phase

Safety elements for the workers were pre-assembled before lifting.



## Erection phase

Perfect fit between steel girder and concrete slab elements thanks to prefabrication.



## Concrete cross-beams

Effective, economical and construction-friendly solution to liaise the longitudinal main girders and achieve continuity at intermediate piers.



# Bridge Outlook

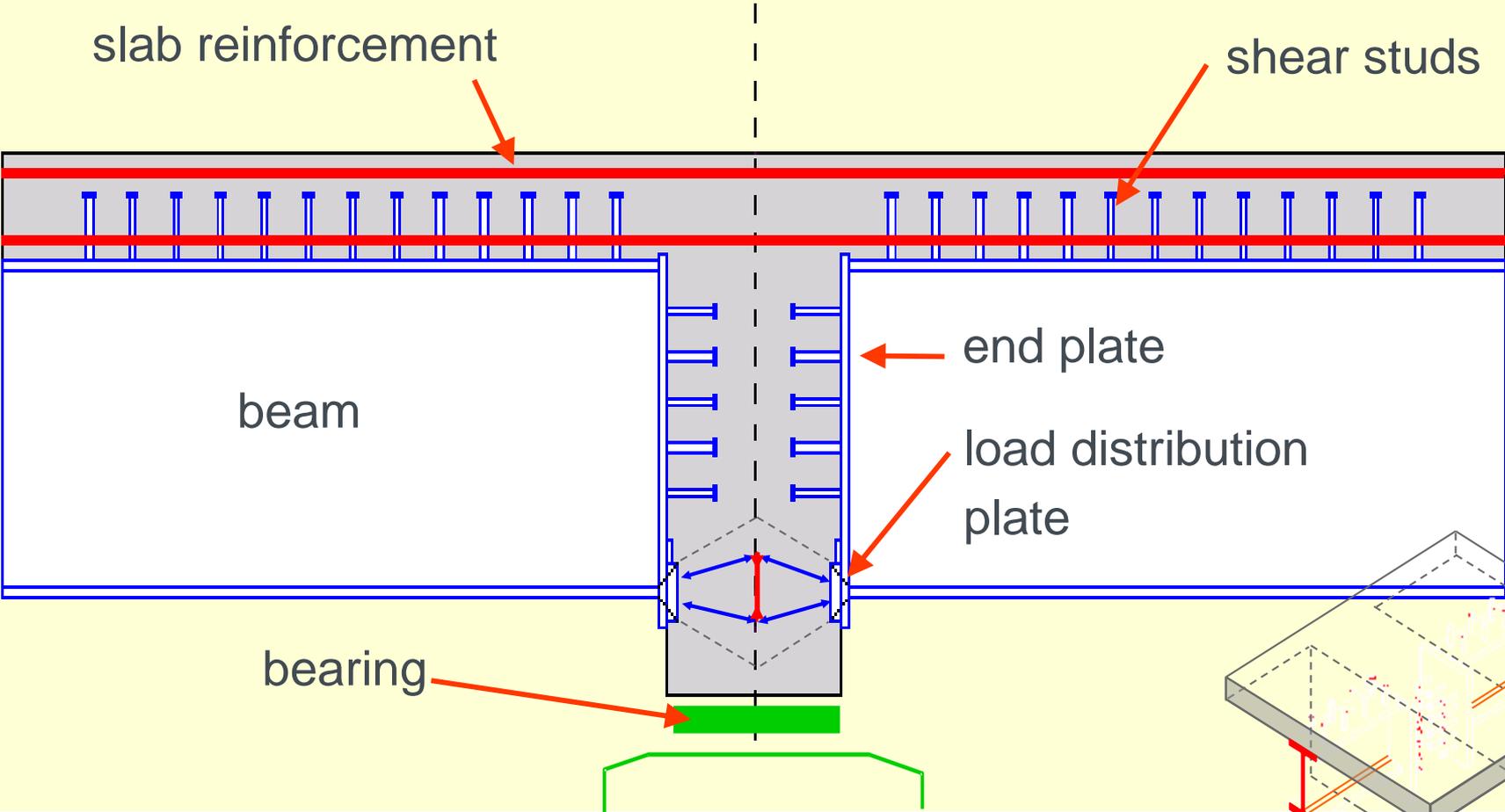


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# Concrete cross beam



slab reinforcement

shear studs

beam

end plate

load distribution plate

bearing

# R&D: SEQBRI

## Concrete cross-beams

UNIVERSITA' DEGLI STUDI ROMA TRE

Dr. Fabrizio PAOLACCI

161, Via Ostiense

00154 Roma, Italy

UNIVERSITA' DEGLI STUDI DI TRENTO

Prof. Oreste S.BURSI

12, Via Belenzani

38100 Trento, Italy

ARCELORMITTAL BELVAL & DIFFERDANGE S.A.

Mrs. Nicoleta POPA

66, rue de Luxembourg

4009 Esch-sur-Alzette, Luxembourg

Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement (CEREMA)

Dr. Christian CREMONA

110, Rue de Paris

77171 Sourdun, France

S. STATHOPOULOS - K. FARROS CONSULTING ENGINEERS

Dr. Stamatios STATHOPOULOS

14, Korgialeniou

11526 Athens, Greece

RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE  
AACHEN

Dr. Benno HOFFMEISTER

55, Templergraben 52062 Aachen, Germany



## PERFORMANCE-BASED EARTHQUAKE ENGINEERING ANALYSIS OF SHORT-MEDIUM SPAN STEEL-CONCRETE COMPOSITE BRIDGES (SEQBRI)



# R&D: SEQBRI

## Concrete cross-beams

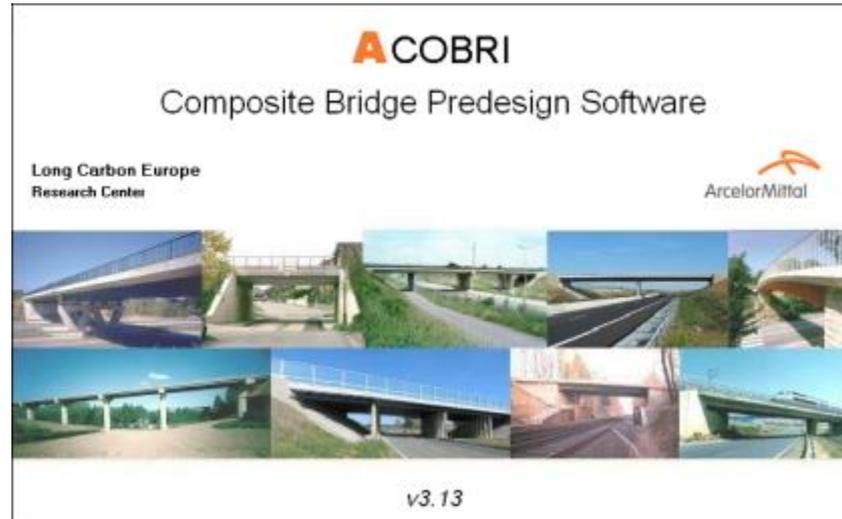
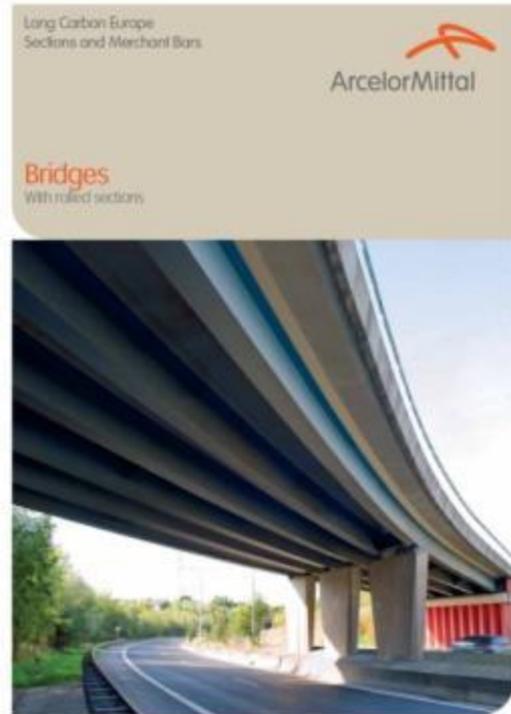


*DIN FB Cyclical load test – Monolithical connection Deck to Pile – UniRoma3 (2016)*

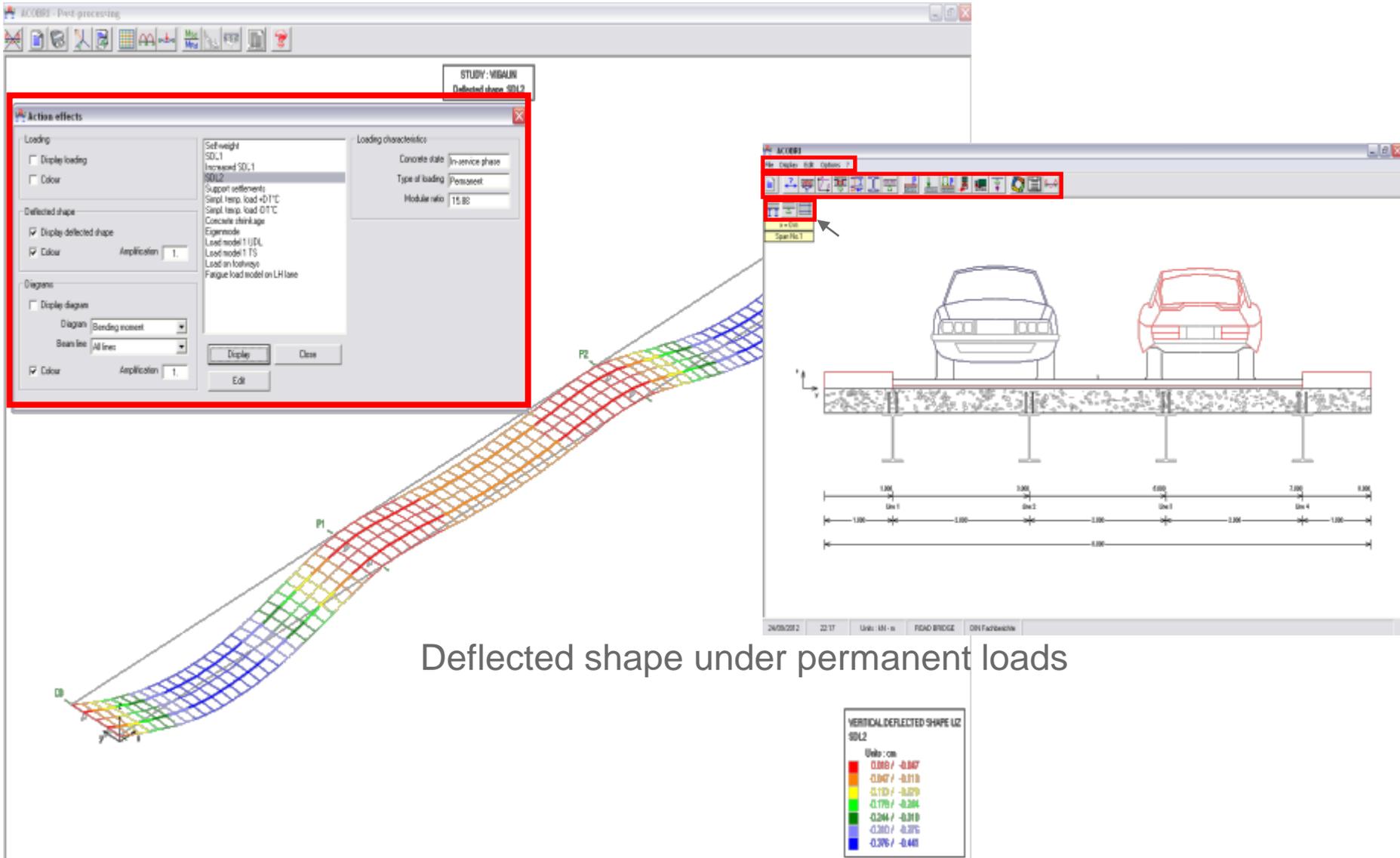
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Further information available as well as free download of predesign software according European design codes:

[www.sections.arcelormittal.com](http://www.sections.arcelormittal.com)



# ACOBRI – Free preddesign software



Deflected shape under permanent loads

*Many thanks for your kind attention*



[www.sections.arcelormittal.com](http://www.sections.arcelormittal.com)

[cs.eurostructures@arcelormittal.com](mailto:cs.eurostructures@arcelormittal.com)

