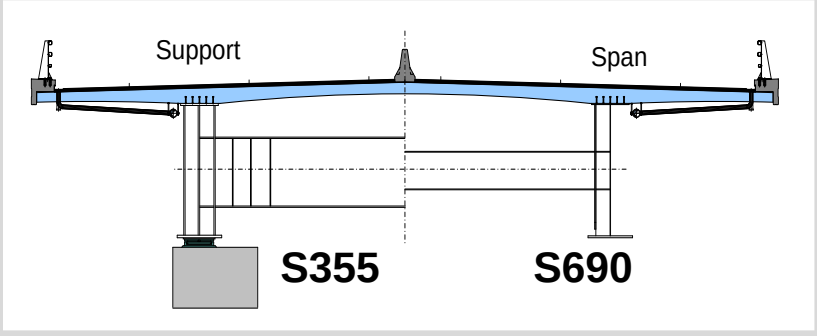
A.M. Habraken, L. Duchêne, C. Bouffioux, C. Canalès



OPTIBRI

Opening and Project Overview

OptiBri-Workshop

"Design Guidelines for Optimal Use of HSS in Bridges„

3 May 2017

Anne Marie Habraken

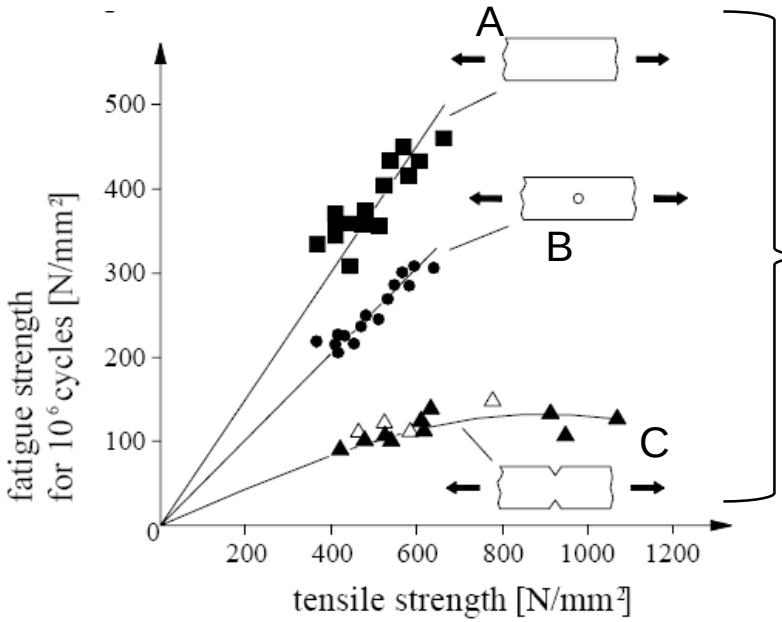
Partners	Core Expertise
University of Liège Be (Ulg)	*(Coordinator)* Material scientist Modelling, Experimental Lab
Industeel Be	Producer of high quality steels
GRID Pt	Civil Engineering
University of Stuttgart Ge (USTUTT)	Bridge, Stability, Euro code, Experimental Lab
University of Coimbra Pt (UC)	Environmental and cost impact assessment
Belgian Welding Institute Be (BWI)	Welding procedure and Post Weld treatments

How the project was born ?

Research Fund for Coal & Steel

For a **material scientist**, studying also forming process, High Strength Steel (**HSS**) means

- higher stress value, higher fatigue limit, specific microstructures,
- logical ways to decrease weight (cars, planes: transport industry)



Sheet sample
Bulk sample
→ Material study case A

Beams, Plate with or without welding joints ? Where ?

How the project was born ?

For civil engineers, **HSS** means:

- higher material cost but **potential decrease**
  of the amount of material
  of welding time
  of transport
  of environmental impact…

Objectives of OPTIBRI Project

- **Quantification** of the interest of HSS use under current euro code rules
- Scientific study to define the need of **Eurocode enhancement (Stability, Fatigue)**
- Check **fatigue issues** of post treated weld joint of HSS
- Study **weld joint and post treatment quality** in HSS

University of Liège - Argenco department – MS²F sector – MSM division

My netwok + the one of my Civil Eng. colleagues → Partnership → Brain storming in Summer 2013

Research Fund for Coal & Steel

ULG
HSS Material
Civil Eng Market ?
Industeel

GRID
Fatigue issues for bridge if slender structures

IBW
Weld joint quality & effect on fatigue
→ PIT, TIG

USTUTT
Stability issues if slender structures

UC
Tools to assess the interest of HSS
LCA LCC LCP

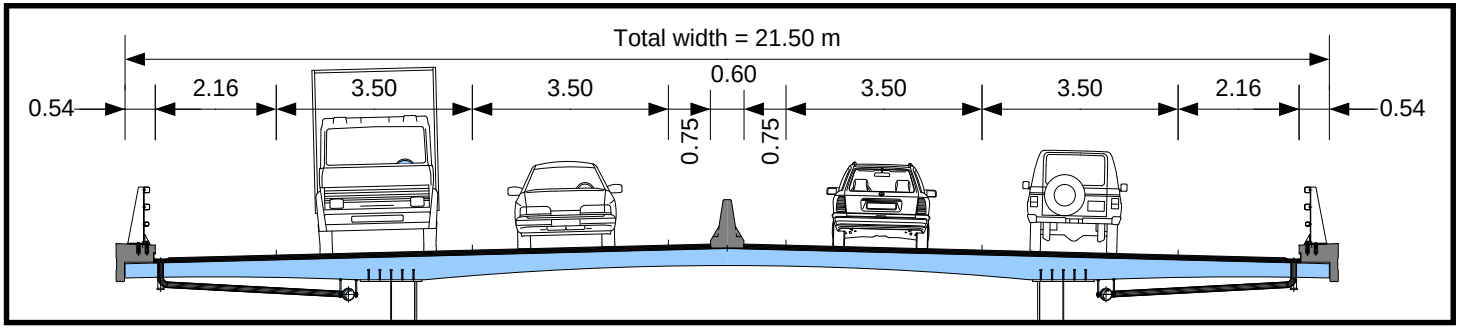
LCA Life cycle Assessment
LCC Life cycle Cost
LCP Life cycle Performance

Case study = road bridge (continuous plate girder steel concrete composite deck, with internal spans 80 meters)

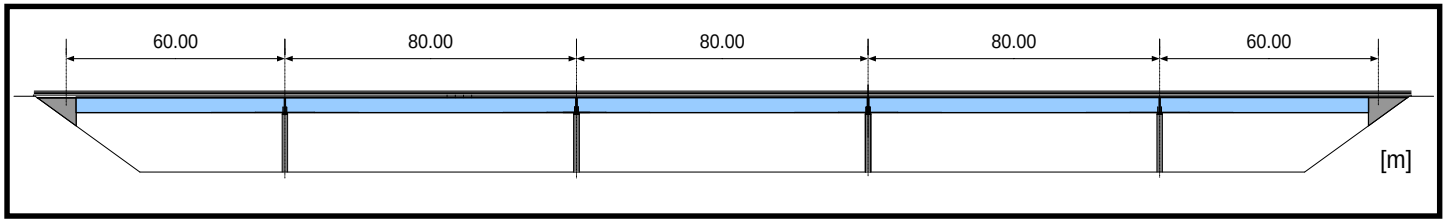
OPTImal use of HSS in BRIdges = OPTIBRI

Case Design

- **Road bridge with four traffic lanes**



- **Five spans: 60 + 3 x 80 + 60 = 360 m**



3 designs for the same bridge

Research Fund for Coal & Steel

Design A : classical design using S355 steel
based on current state of Eurocodes and national rules

Design B : design using S690QL steel, where it has an interest
based on current state of Eurocodes and national rules

Design C : design using S690QL steel, where it has an interest based on

-real material behavior
(experimental tests and fatigue damage simulations of bridge details)

-advanced stability law
(experimental + FE anlysis of the buckling of multiaxially stressed plates
→ enhanced formula within of the code rules EN 1993-1-5)

J.O Pedro's presentation: Challenges and Benefits of High Strength Steel (HSS) in Highway Bridges

P. Toussaint's presentation: Usual application of High Strength Steel (HSS) Plates with focus on S690

WP5 UC

Impact of Bridge Design

Life Cycle Assessment

Life Cycle Cost

Life Cycle Performance

WP1 GRID

Design of BRIDGES

A: classical cases (no HSS) with current EUrocode

B: with optimal use of HSS with current Eurocode

C: with optimal use of HSS and studied behaviour

Fatigue study

- Tests
  - small scale
  - large(r) scale
- Models

WP2 ULg

Stability study

- Tests
- Models

WP3 UStutt

Welding Study

- Samples Generation
- Post treatment Qualification

WP4 BWI

DELIVRABLES

Quantification of interest to use HSS in bridges

Design guidelines for optimal use of HSS in bridges

Proposals of Eurocode modifications

Post treatment qualification procedure

WP6 UC — Results dissemination

WP7 ULg — **COORDINATION OF THE PROJECT**

WP1 Design of Bridges by GRID

Design A provides a reference

Design B allows investigating different designs based on S690QL use

discussions between USTUTT and GRID
oriented the choices and verifications done (current Eurocode use)

Design C ongoing work based on the results of experimental
fatigue curves of welded plates (Ulg) and beams (USTUTT)
(with weld post treatments) + new formula of buckling verification
(USTUTT)

Delays in material delivery → in test results → in model identification
→ in the simulation of bridge details → in Design C

C. Batista's presentation: Improved Bridge Design by Use of High Strength Steel (HSS) with OPTIBRI Developments

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WP2 Fatigue study (Ulg, USTUTT, BWI)

Ulg : *material scientist's approach*

- Static tests ≠ loadings, **B**ase **M**etal, **H**eat **A**ffected **Z**one and **W**eld **M**etal (WBI) - ***3 elasto plastic models (BM, HAZ, WM)***

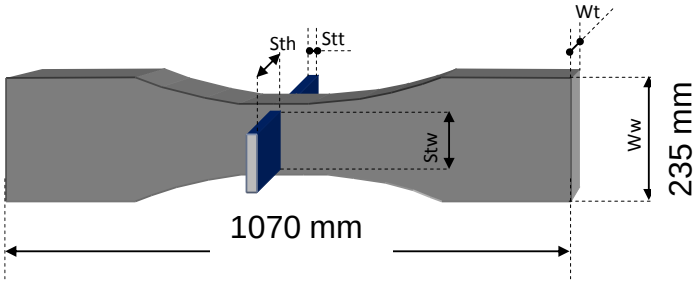
- Fatigue tests on small specimens (mm)

→ parameters of ***Lemaitre damage model (1)***

- Static and Fatigue tests on plates + welded transversal stiffeners (Ulg) + post treatment (PIT,TIC) (residual stress distribution)

→ parameters of ***Lemaitre damage model (2)***

1st validation of the fatigue simulations with Lemaitre model



C Bouffioux's presentation: Characterization of Fatigue Behaviour, from Material Science to Civil Engineering Applications

WP2 Fatigue study (Ulg, USTUTT, BWI)

- Fatigue tests on Beams + welded transversal stiffeners (USTUTT)

-2st validation of the fatigue simulations with Lemaitre model

Simulations of Bridge C detail:

Loading from Eurocode FLM5

→ 1 stress history

→ 1 damage distribution of the studied bridge detail

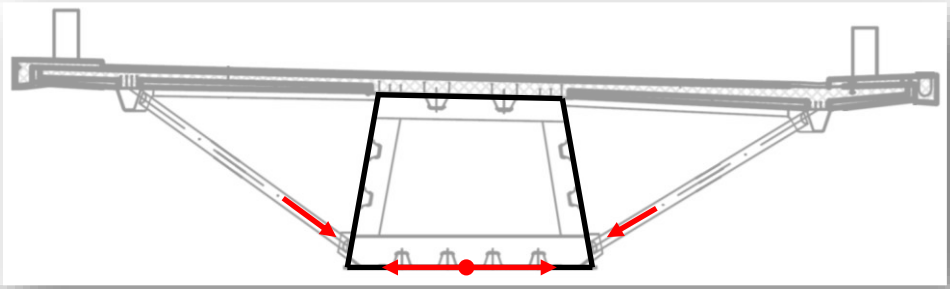
→ detail category confirmed or not

→ sensitivity analysis *not performed* : 1st approach of real behavior in HSS in bridges, *ongoing work*

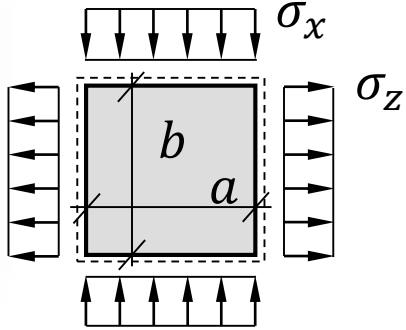
-Representative HSS bridge potential rupture

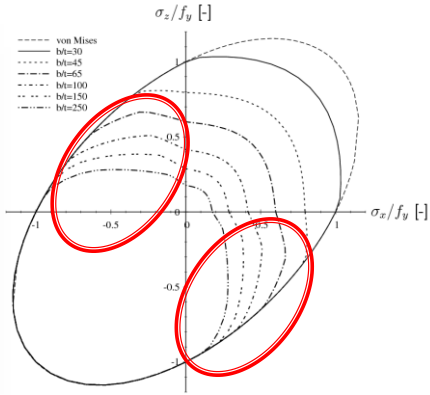
S. Breunig's presentation: Categorization of Fatigue Details in View of Post-Weld Treatments

WP3 Stability study (USTUTT)



Panel with bi axial loading





V. Pourostad's presentation: Buckling Behavior of Slender Plates under Multiaxial Stresses

- FE element simulations that are validated by experiments
- Parametric study
- Enhancement of the reduced stress method, introduction of V factor in Eurocode formulae

WP4 Welding study (BWI)

Research Fund for Coal & Steel

Study of Fatigue crack
and microstructure
to identify optimal welding
procedure and Post Treatment
Qualification.

Welding of all plates and beams

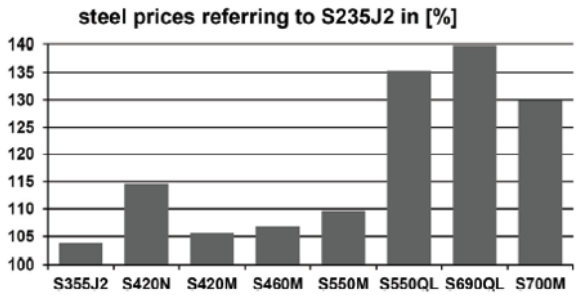
PIT (Pneumatic Impact Treatment)
TIG (Tungsten Inert Gas) remelting
were used as Post Treatments.

Initial choice LTT (Low Temperature
Transformation filler material) dropped

LTT could not reach required toughness
values (50 to 60 J) in bridges
(results of FATWELDHSS project 2015)

T. Baaten's presentation: Welding and Post-Welded Treatments of High Strength Steel (HSS) joints

WP5 Impact of Bridge Design (UC)

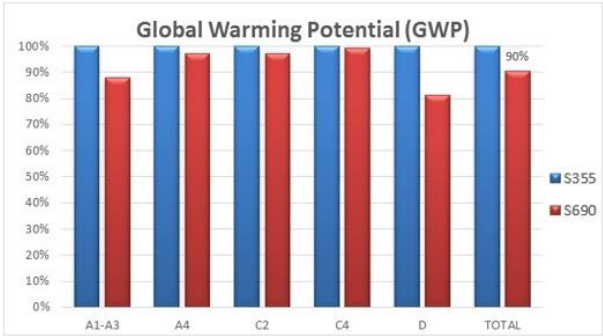


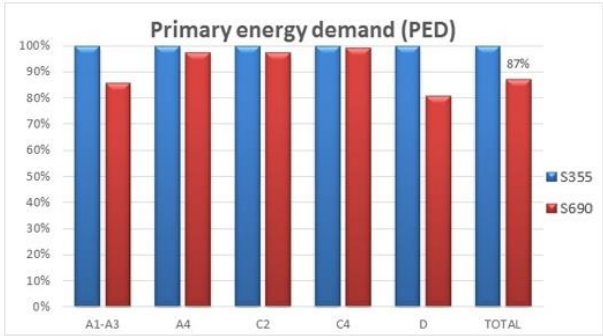
Stroetmann R. Eurosteel 2011

Work on
LCA Life cycle Assessment
LCC Life cycle Cost
LCP Life cycle Performance

Design A // B : on going work,

Design C = future





C. Rigueiro's presentation:
Comparative Life-Time Assessment of the Use of High Strength Steel (HSS) in Bridges

Thank you for your attention!

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