

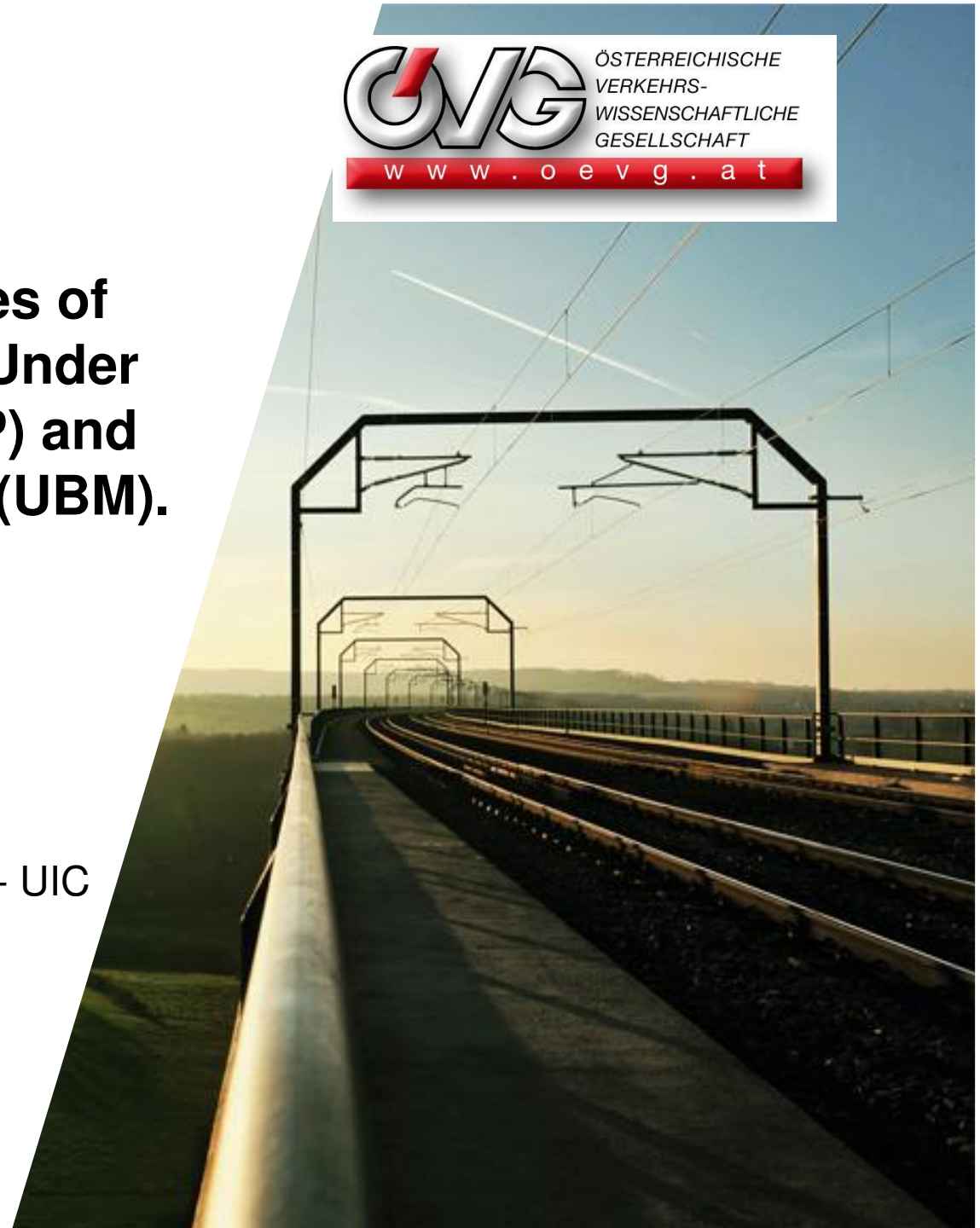
Experience and types of application using Under Sleeper Pads (USP) and Under Ballast Mats (UBM).

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Chairman Track Expert Group - UIC

17/09/2015

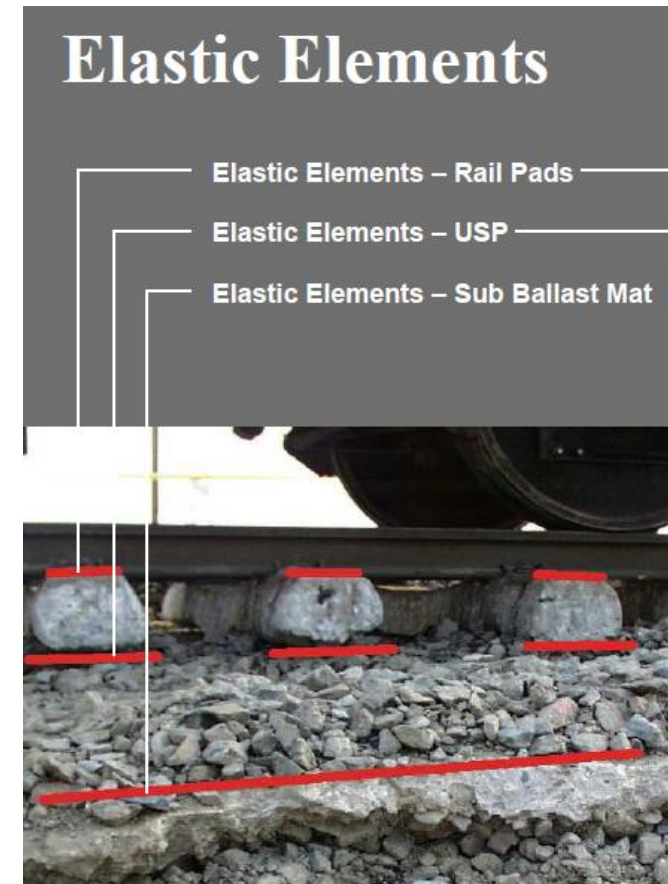


Summary

1. Elasticity in Tracks – Track Stiffness
2. International cooperation for the developments of Under Sleeper Pads (USP) and Under Ballast Mats (UBM).
3. Practical applications at Infrabel :
 1. USP on the line Brussels – Antwerp
 2. UBM on the line Brussels – Ghent
 3. USP with UBM in the tunnel under the National Bank in Brussels.
4. Conclusion :
 1. international cooperation ,
 2. recommendations for use

Elasticity in Tracks – Track Stiffness

- What is the optimal track stiffness ?
 - Numerous theoretical studies;
 - How to measure, evaluate results ?
 - Limit values, static, dynamic ?
 - Limit values for stiffness variations ?
 - At which level : under the rail, sleeper, ballast ?
 - Ballasted track versus Slab track ?
- Up to now : no right answer to this question.



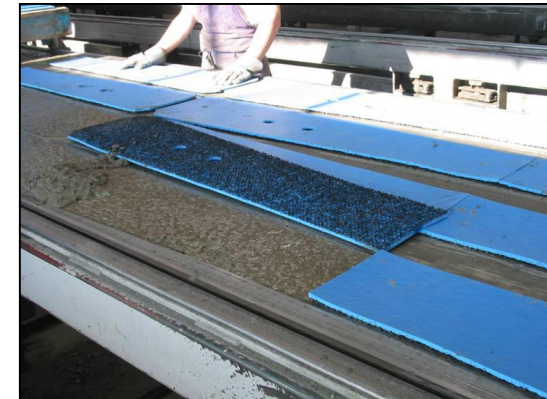
International cooperation

- UIC - International Union of Railways
TEG – Track Expert Group : exchange platform
Members : track specialists from Infrastructure managers in the field of track design and maintenance).
Deliverables : UIC leaflets, guidelines, state of the art reports, participation to European research projects, ...
- CEN - European Committee for Standardization
CEN TC 256 / SC 1 – Railway applications – Track Infrastructure
Members : representatives from railway companies, industry, universities, ...
Deliverables : European standards



Under Sleeper Pads (USP)

- Tests with USP since more then 20 years.
- Needs:
 - collect the results, experiences,...
 - prepare state of report, guidelines,...
- UIC TEG decides in 2004 : project **USP's in Track** :
- First project : from 2005 to 2007 R. Schilder
 - 6 Work packages :
 - WP 1 : State of the Art F. Maier
 - WP 2 : Theoretical investigations P. Plic ,M.Krüger
 - WP 3 : Acoustics and vibration R. Garburg, D. Stiebel
 - WP 4 : Standardization of materials P. Schneider
 - WP 5 : Laboratory measurements R. Potvin
 - WP 6 : Test track measurements P. Schneider



USP – Under Sleeper Pads
Date: 26. March 2009
Page: 1/40

UIC Project

Under Sleeper Pads – Semelles sous traverses –
Schwellenbesohlungen

Summarising Report
Pages 1 – 40

(4th Edition)

Under Sleeper Pads

- Second project : from 2009 to 2012
USP's in Track : F. Auer, R. Potvin
- WP1 Recommendations for prEN16730
- WP2 Lateral Track Resistance and UIC-LTR Project
- WP3 & 4 Sleeper Design Approach (P. PLICA Study)
- WP4 SNCF model
- WP5 Noise and Vibration (INFRABEL measurements)
- WP6 LCC Studies (ÖBB and SNCF)

- 23 members from 12 countries

Open point remaining : effect of USP on Lateral Track Resistance (LTR) : new group with the following objectives:

- define a standardized method to measure LTR in track and in laboratory;
- find an explanation for the differences between measurement methods .



Project n° P000047 formerly I/05/Ui/440: USP – Under Sleeper Pads– Semelles sous traverses – Schwellenbeschlungen
Draft Leaflet Code 713-1 R: "Recommendations for the use of Under Sleeper Pads – USP"
Approved by the Track Experts Group on February 2008
Page: 1/17

Infrastructure Forum

Technology Support Group
Track Experts Group

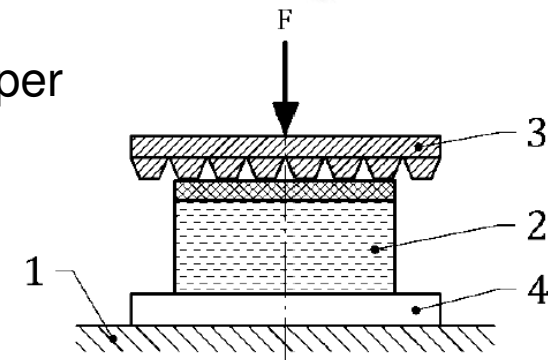
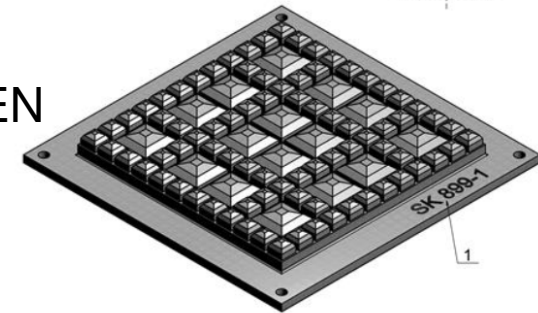
Project No I/05/Ui/440
Under Sleeper Pads – Semelles sous traverses – Schwellenbeschlungen

LEAFLET 713 - 1 R:
"Recommendations for the use of Under
Sleeper Pads – USP"

Approved by the Track Experts Group on February 2008

Under Sleeper Pads

- Memorandum Of Understanding between UIC and CEN
- Groupe CEN/TC256/SC1/WG16-4 –
 - European Standard prEN 16730 :
 - Railway application – Track Infrastructure – Concrete sleepers and bearers with under sleeper pads
- Content :
 - Design approval and routine tests methods
 - Tests for USP alone, on concrete blocks
 - Tests for USP on concrete sleepers and bearers
 - Description of GBP Geometric Ballast Plate for the static and dynamic bedding modulus.
 - Standard without requirements for use.



CEN/TC 256

Date: 2015-08

TC 256 WI 00256679

CEN/TC 256

Secretariat: DIN

Railway applications — Track — Concrete sleepers and bearers with under sleeper pads

Bahnwendungen — Oberbau Gleis — Und Weichenschwellen aus beton mit schwellenbeschlungen

Applications ferroviaires — Voie — Traverses et supports en béton avec semelles sous traverse

Under Ballast Mats (UBM)

UIC TEG decides in 2004 : project **UBM in Track** M.Testa, S. Rossi

- Complete the examination about the use of elastic materials installed on the different layers of the track
- Unifying the know how at railways and giving guidance to IM's about the use and condition of installation and purchase of UBM
- Homogenizing the technical requirements in order to reduce technical qualification costs and, finally, the purchase costs
- 11 members from 7 countries



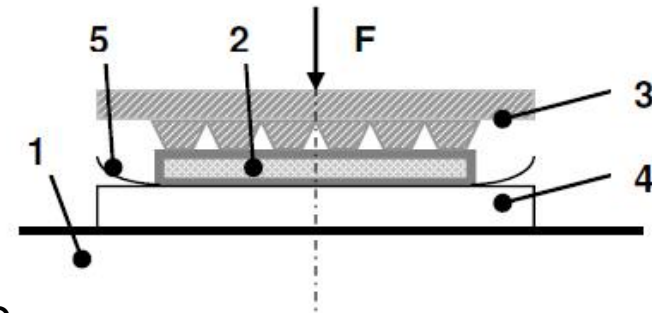
2010 : UIC Leaflet Code 719-1 R

“Recommendations for the use of Under Ballast Mats”



Under Ballast Mats (UBM)

- Group CEN/TC256/SC1/WG16-4
 - European Standard prEN xxxxx :
 - Railway application – Track Infrastructure – Under Ballast Mats
- Content:
 - Qualification and routines tests
 - Static and dynamic (low and high frequency) stiffness (bedding modulus)



Date: 2015-07

TC 256 WI 00256XXX.16

CEN/TC 256

Secretariat: DIN

Railway applications — Track — Under ballast mats

Eisenbahnanwendungen — Oberbau — Unter Schotter Matten

Applications ferroviaires — Voie — Tapis sous ballast

Under Ballast Mats (UBM)

Second group started in 2014 :

- Proposal to update the leaflet on UBM to match with the work done by CEN/TC256/SC1/WG16-5.
- Update UIC leaflet 719-1: “Recommendations for the use of under ballast mats”;
- Update the leaflet in the domain of acoustics and vibrations in function of European project (RIVAS);
- Cooperation with UIC Network Noise and Vibration group.
- 7 members from 5 countries



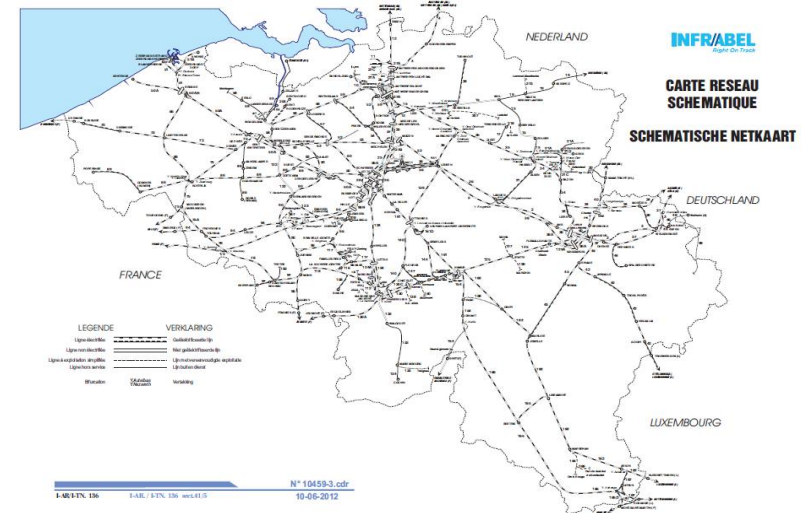
Elasticity in Tracks – Track Stiffness

- Today there are a lot of methods to put elasticity in the tracks :
 - Resilient pads under the sleepers;
 - Under Sleeper Pads
 - Under Ballast Mats
- Standards / leaflets for defining these products:
 - Resilient pads : EN 13146-9 ;
 - USP : prEN 16730, UIC 713-1;
 - UBM : prEN XXXX, UIC 719-1;
- There are also few systems to measure the continuous track stiffness ;
- But there are limit values on track stiffness.
- CEN TC 256 decided to launch a Survey Group Track Stiffness :
 - State of the art reports from former European projects (Eurobalt I and II, Innotrack, ...);
 - Review recent theoretical publications;
 - Need to define track design criteria permitting validation of new track design in line with the TSI Infrastructure subsystem.



Practical applications at Infrabel :

- INFRABEL : Infrastructure manager for Belgium
- Length of main tracks : 6468 km . Length of lines : 3600 km
- L 25 – Brussels – Antwerp :
 - Long term test : 2 km, 4 suppliers, 3 stiffness.
- L 50 A – Brussels – Ghent – Ostend :
 - Comparison insertion loss UBM USP
- L 0 – Brussels North South link :
 - Combined use USP and UBM
 - Vibration problems : Tunnel under the National Bank building.



Project 1: L25 - Brussels – Antwerp – $V = 160$ km/h - UIC-USP WP5 (2008-2012)

- **Goal of WP5**
 - 5.1 Impact of a USP on **Rolling Noise**
 - 5.2 Impact of a USP on **Ground-Borne Vibrations**
 - 5.3 **Required Range of Elasticity** for Noise and Vibration protection
- **Details of installed USP (installed 2008)**
 - Installation of 13 section each 180m USP
 - Four different suppliers;
 - Different stiffness:
 - Theoretical: 0.15, 0.3, 0.15 N/mm³
 - Measured: dyn. NBP: 0.07-0.7 N/mm³



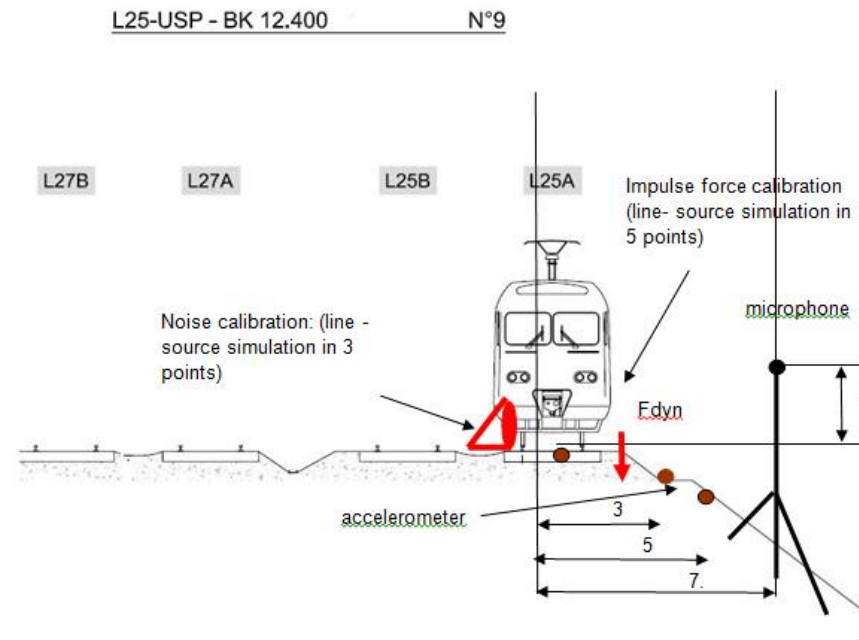
L25 - Brussels – Antwerp – $V = 160 \text{ km/h}$ -

- **Performed measurements (2010)**
 - Measurement of **Rolling Noise trains**
 - Site calibration using external noise source
 - Analysis of 3 types of rolling stock (M6, Amsterdam, Break)
 - Measurement ISO3095 at 7.5m from CL track for 13 sites
 - Measurement of track decay rate and rail roughness



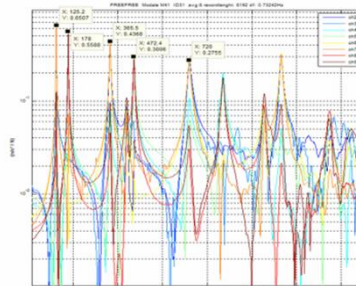
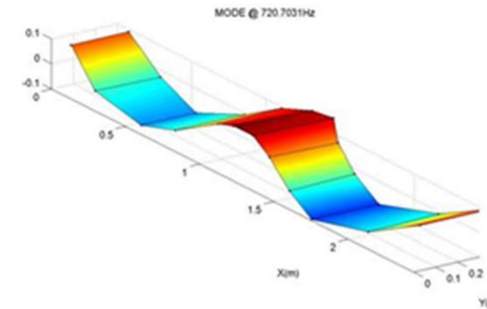
L25 - Brussels – Antwerp – $V = 160$ km/h -

- Measurement of **ground-borne vibration**
Site calibration using external vibration source
Analysis of 3 types of rolling stock (M6, Amsterdam, Break)
Measurement at 3,5 and 7m from CL track for 13 sites

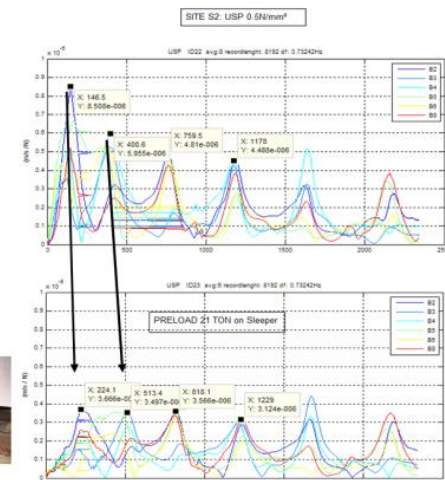
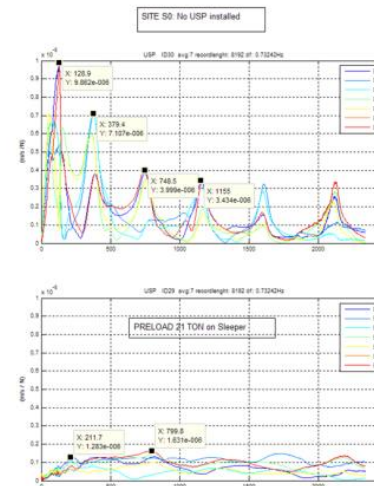


L25 - Brussels – Antwerp

- **Performed measurements (2010)**
 - **Additional measurements**
 - Modal analysis of sleepers
 - Modal behaviour of sleepers in track (damping of vibration when loaded)
 - ODS (operation deflection shape): dynamic behaviour during train passage

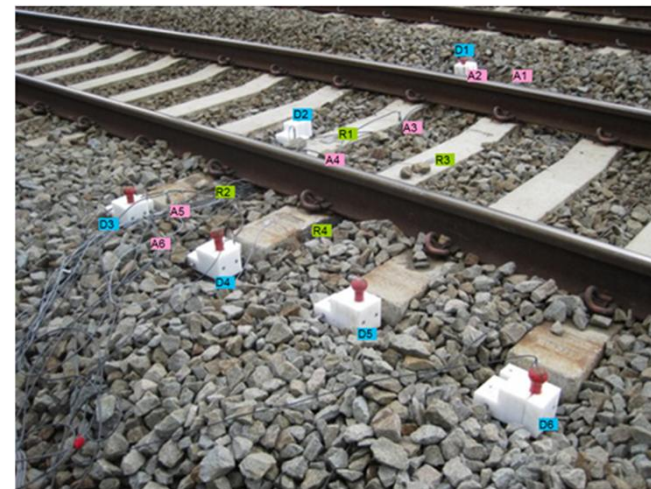


Modal analysis M41 sleeper: as installed: Vertical bending modes



L25 - Brussels – Antwerp

- Performed measurements (2010)
 - Additional measurements
 - Measurement of quasi- static absolute displacements
 - Measurement of bending moments by use of strain gauges

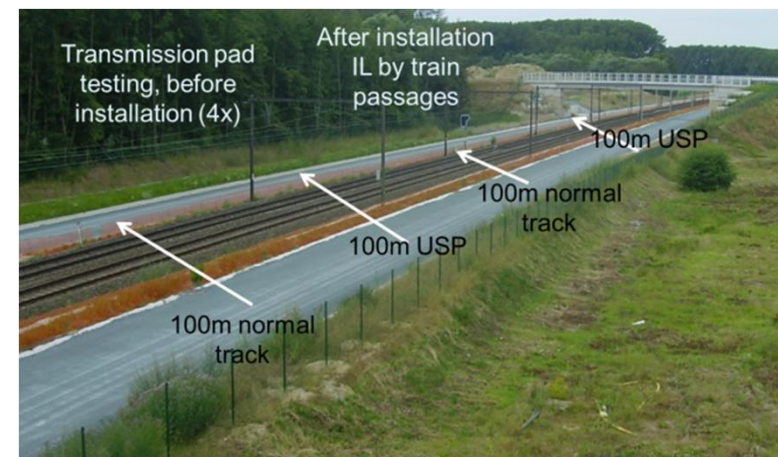
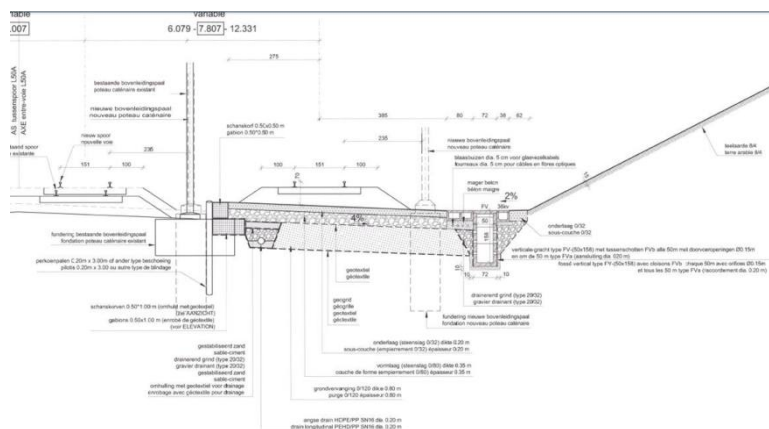


L25: Brussels – Antwerp – $V = 160$ km/h

- **Conclusions:**
 - **Task 5.1 Impact of a USP on rolling noise**
 - **Higher sleeper end vibration (+6dB), but not leading to higher global noise emission**
 - **Task 5.2 Impact of a USP on ground borne vibration**
 - **Correlation between the USP's dynamic stiffness and vibration levels in the surroundings was found.**
 - **Lowering the dynamic stiffness** of a USP from 0.7 to 0.07 N/mm³(NBP) can **lower the vibration velocity level** with 6 dB or DIN KB-value with a factor 2
 - **Task 5.3 Required Range of elasticity for noise and vibration protection**
 - **minimum 0.07 N/mm³(NBP)** is required to have a maximum efficiency of **6 dB vibration reduction** in the 5-100 Hz range.

Project 2: L50A Brussels – Ghent – Bruges – Ostend V= 160 km/h Track quadrupling in Anderlecht: UBM versus USP

- **Goal**
 - Evaluate vibration insertion loss difference UBM versus USP
 - Evaluate these measures in an area with soft sub- soil- layer
 - Use measurement data in UIC-UBM project



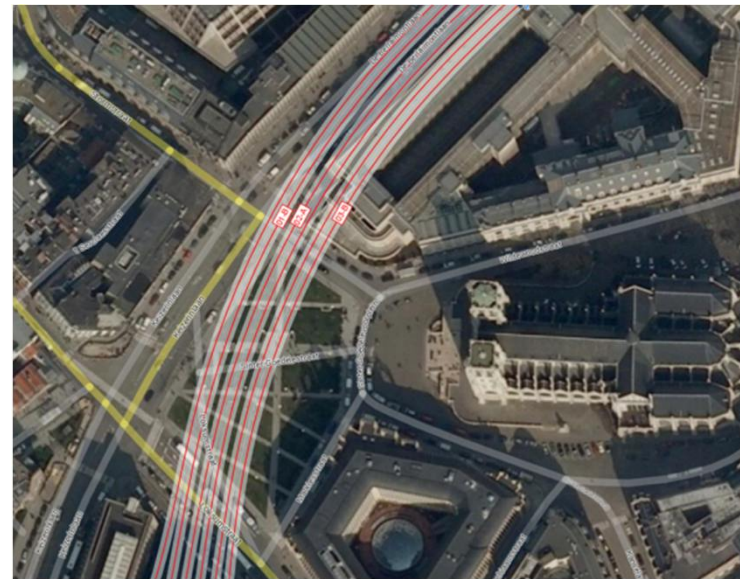
L50A Brussels – Ghent –Bruges - Ostend: $V = 160 \text{ km/h}$ UBM versus USP

- **Details of site**
 - EV2 (DIN18134) measured ($> 180\text{Mpa}$)
 - 100m USP and UBM installed in 2015, traffic foreseen from 11/2015
 - Stiffness:
 - M42 sleeper + USP: 0.3 N/mm^3 NBP of GBP
 - UBM: 0.03 N/mm^3
- **Results: end 2015**



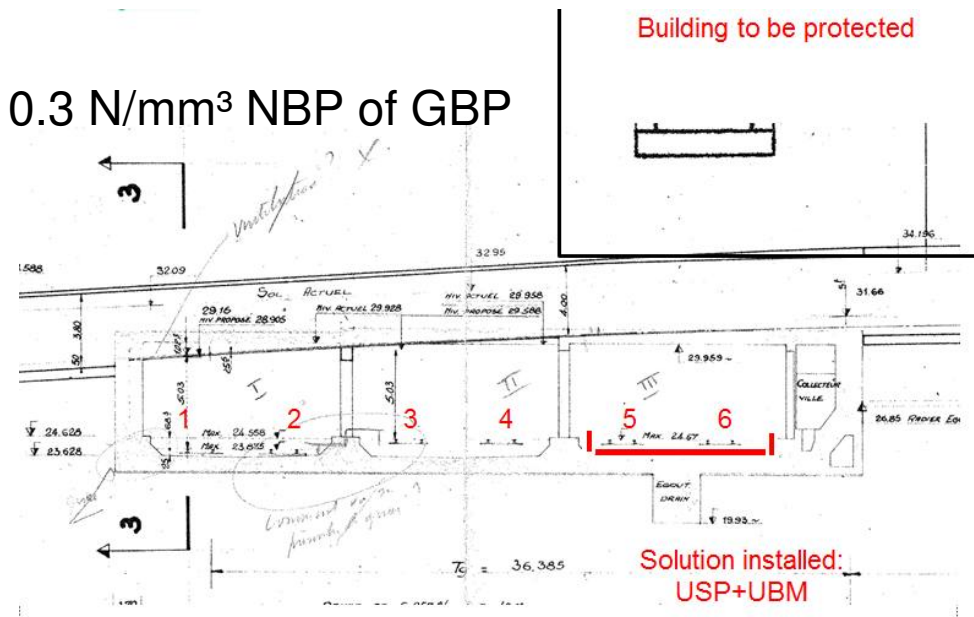
Project3: L01/02/03 Brussels National bank: UBM + USP

- **Tunnel between Brussels Midi and Brussels North station**
 - Six tracks, tunnel inaugurated in 1952;
 - No attention paid at the noise and vibration problems;
 - Up to 90 trains / hour.
- **Goal**
 - Reduce groundborne noise and vibration in offices of the National bank
 - Evaluate effects of UBM, USP



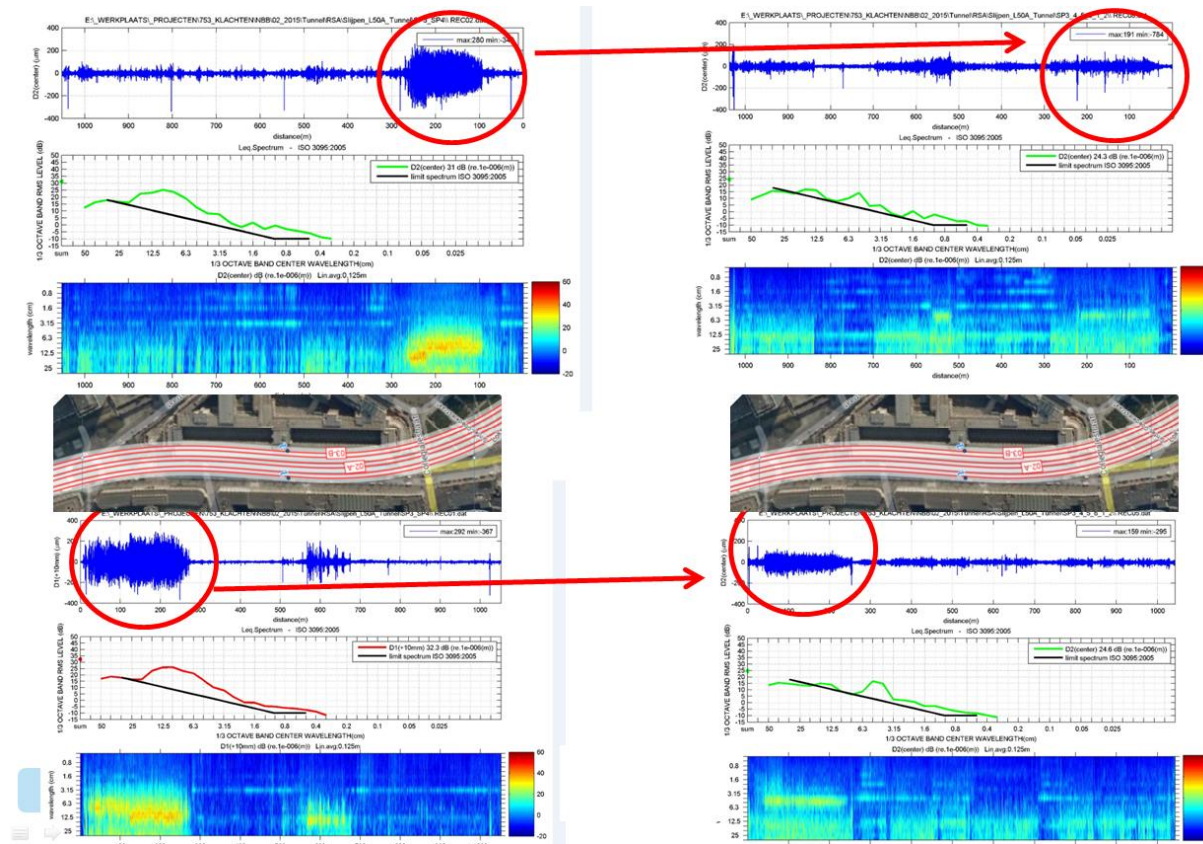
L01/02/03 Brussels National bank: UBM + USP

- **Details of site**
 - See photo an cross section
 - Track 5&6 are equipped
 - Stiffness:
 - Concrete sleeper + USP: 0.3 N/mm³ NBP of GBP
 - UBM: 0.03 N/mm³



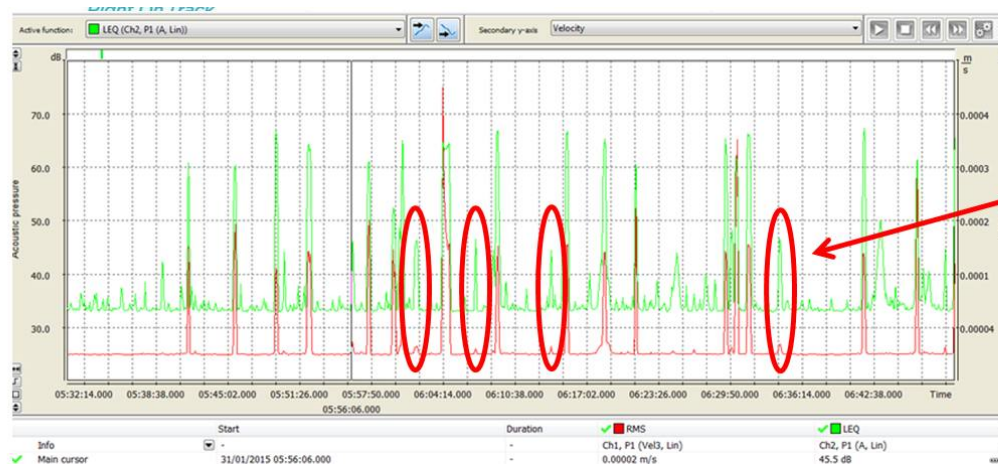
L01/02/03 Brussels National bank: UBM + USP

- Result of USP installation on corrugation: Reduction of amplitudes with a factor 2

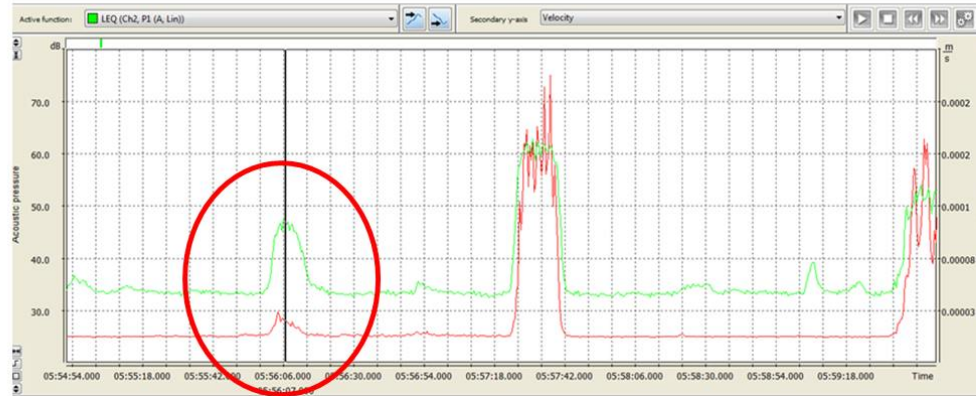


L01/02/03 Brussels National bank: UBM + USP

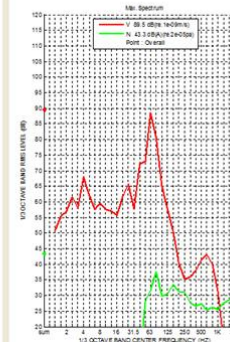
- Groundborne noise reduction with -20dB @ 60Hz



Effect ballast mat:
passages on
track 5 & 6
on UBM



Effect ballast mat -20 dB!!



Conclusion

Due to the positive effects from concrete sleepers with USP :

- **Contact surface between sleeper and ballast increased and thus contact pressure between sleeper and ballast reduced ;**
- **Better load distribution over the track length due to additional elasticity in the track;**
- **Better load distribution over the length of the sleeper;**
- **Sleepers are dynamically decoupled from the ballast bed.**

These positive effects have positive consequences on the track behaviour :

- **Improvement of initial track geometry quality ;**
- **Longer periods between tamping operations ;**
- **Lower ballast degradation and thus longer ballast life ;**
- **Reduction of long pitch corrugation in tight curves;**
- **Reduction of vibration (with soft USP).**

INFRABEL have decided to use concrete sleepers and bearers with USP :

- **In curves with $R < 500$ m together with heat treated rails (350 HT) on hard pads;**
- **Zones where normal ballast thickness cannot be ensured : bridges, ...**
- **On lines from UIC cat 1 to 4 (according UIC leaflet 714) and speed ≥ 160 km/h;**
- **Zones where vibrations can be expected after detailed vibration study;**
- **Transition zones between ballastless track and ballasted track.**
- **Level crossings on lines from UIC cat 1 to 4**

These projects are a good example of international cooperation with limited budgets but a lot of enthusiasm. Special thanks to the colleagues:

- UIC Track Expert Group : R. Schilder, M. Testa, R. Potvin, F. Auer, L. Schmitt and all the members of these groups...
- Infrabel : J. Mys, E. Verhelst and E. Heylen.
- QUESTIONS ?

