Institut français
des sciences et technologies
des transports, de l'aménagement
et des réseaux

Encontro ferroviario:

An Innovative Ballastless Railway Designed with an Asphalt Concrete Layer: Laboratory and Large Scale Studies on the Performance of this Infrastructure

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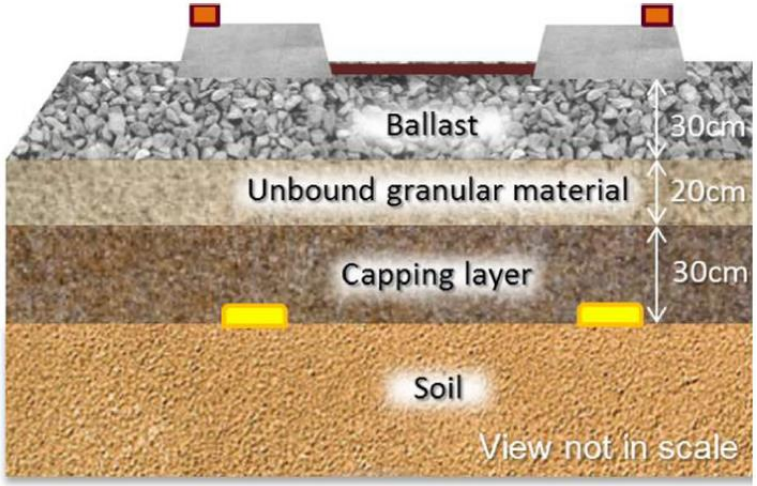
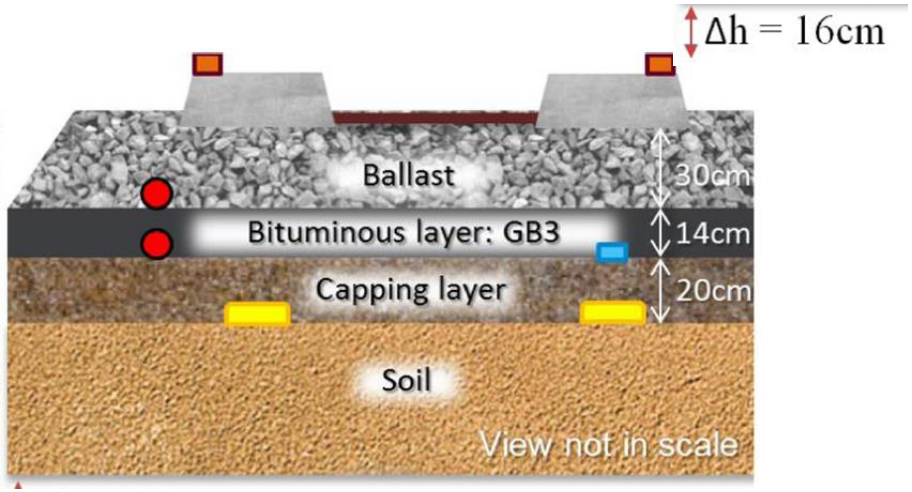
Encontro Ferroviário

Introduction

The use of asphalt concrete in railway infrastructures

- Different designs
  - ➢ The most common: AC as a subballast layer





- Why ?
  - ➢ To increase the durability of railway infra.
  - ➢ To limit the maintenance process
  - ➢ To get an thinner track (tunnels)
  - ➢ To get a furtive process of manufacturing
  - ➢ To open the railway market to AC manufacturers
  - ➢ To limit the use of ballast …

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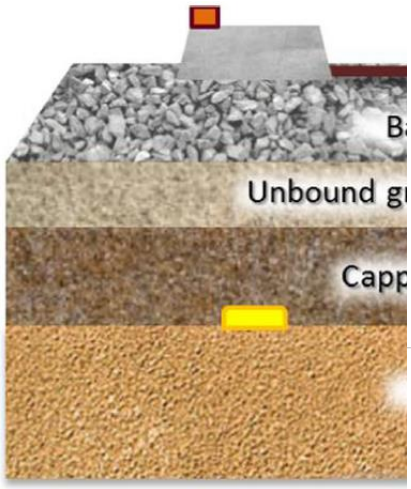
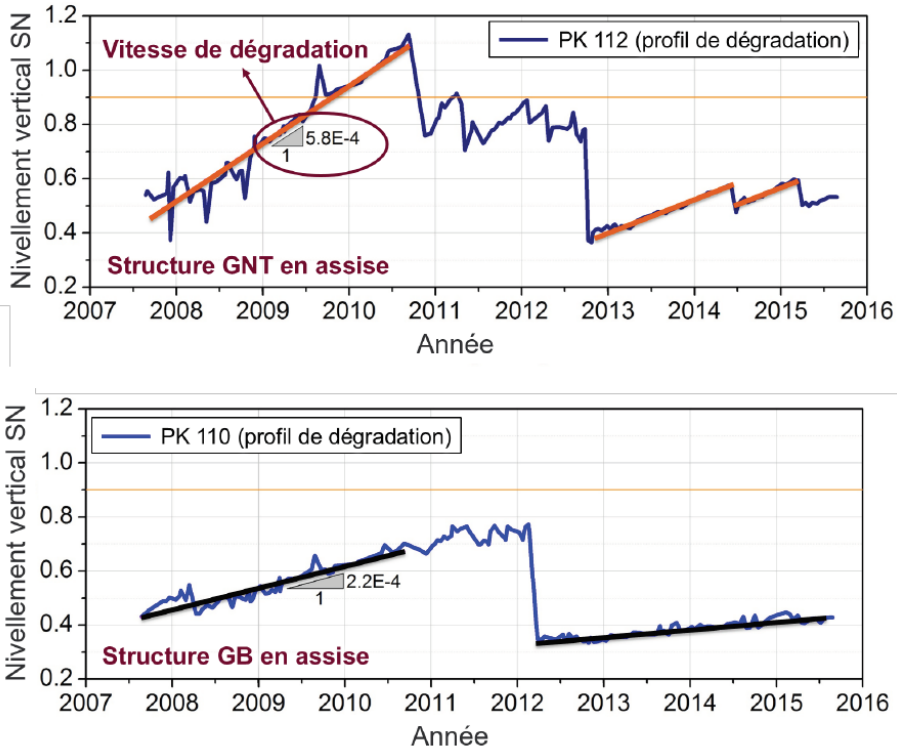
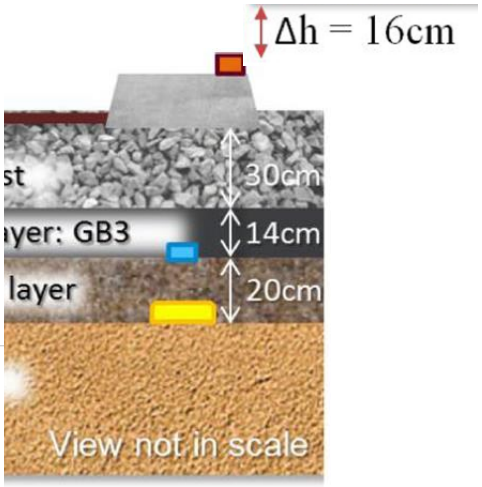






- ➢ Less maintenance: less passing tamping machines !

➔ Good effects on maintenance process !

Introduction

The use of asphalt concrete in railway infrastructures

- Different designs
  - ➢ The most common: AC as a sub ballast layer
    - ➢ An example of jobsite

Introduction

The use of asphalt concrete in railway infrastructures

- Different designs
  - ➢The most common: Asphalt Concrete as a subballast layer

French Report:
Manufacturing railway tracks with AC as sub ballast layers:
feedbacks from fast train jobsites:
https://www.idrrim.com/publications/6716.htm

French feedback:

LGV Est : 3 + 55 km
LGV BPL - 105 km
LGV SEA - 43 km
LGV CNM - 80 km

➔286 km / 30 000 km of tracks

International feedback…

Introduction

The use of asphalt concrete in railway infrastructures

- Different designs
  - ➢The Ballastless tracks…with sleepers !

Voie type GETRAC

Voie type ATD

Voie type SATO

Pose de VSB (Lingolsheim, France)

Advantages :

+ No tamping machines.
+ Loading transmitted to a homogeneous support.
+ Less fatigue.

Introduction

The use of ~~asphalt~~ concrete in railway infrastructures

- Different designs
  - ➢The Ballastless tracks…with cement concrete !

- RAILWAY : NBT Project : New Ballastless Track
- French project: Ifsttar, Alstom, Railtech, Vossloh-Cogifer, RFF
- Aim : design and building methods for a new generation of railway track on concrete slabs

- Most important features aimed at for the new concept:
  - Suitable for low-speed freight and high-speed passenger transport
  - Enable more daily traffic due to highly reduced maintenance
  - Reliability and durability of the infrastructure : lifetime >100 years
    - High speed track laying > that of a ballasted track (1km/day)
    - Reduced costs of track laying

Introduction

The use of ~~asphalt~~ concrete in railway infrastructures

- Different designs
  - ➢The Ballastless tracks…with cement concrete !

- A track laid on a continuous support:
  - No ballast
  - No sleepers

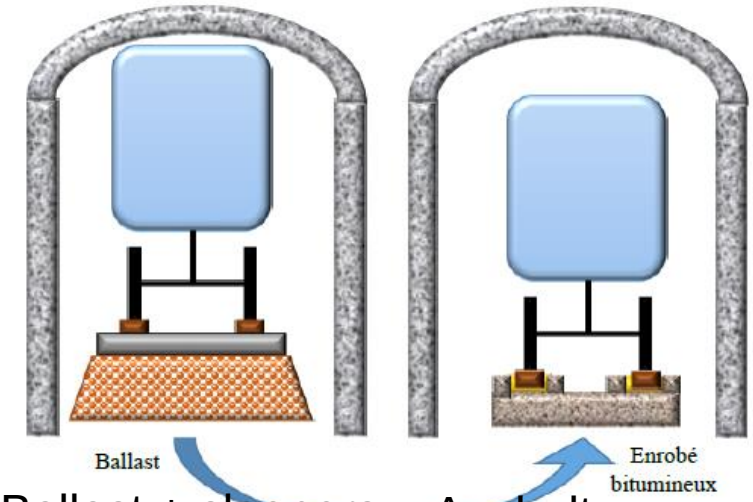
➔ **Thickness optimization**

Embedded Rail System (ERS – Edilon)(Sedra)

The French National Project REVES: summary

(Reducing railway tracks thickness in tunnels)

Goal : Increase the gauge in tunnels



Ballast + sleepers Asphalt concrete

Method: Replace ballast and sleepers by an asphalt concrete (AC) layer.
Constraint : Rails continuously supported (innovative concept).

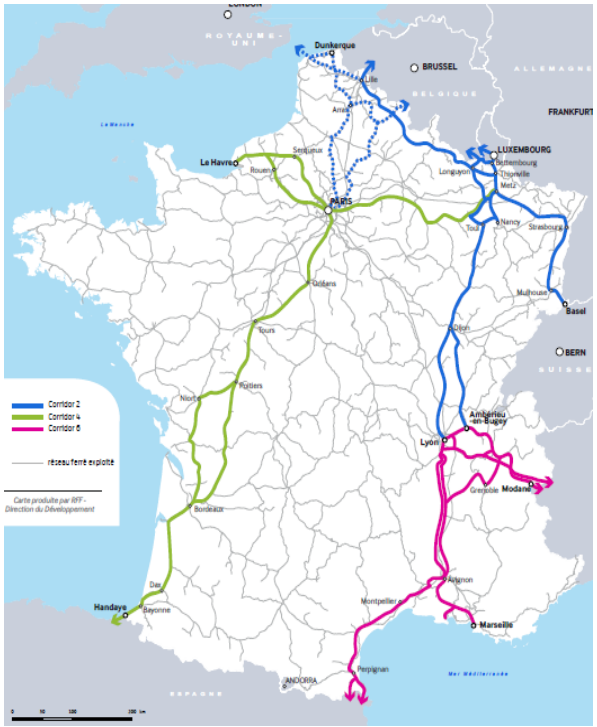
➔ AC long-term behaviour ?

The French National Project REVES: Framework

Development of the French freight railway network…

➔ Gauge tunnel adaptation !

- Willing to take 50% of the freight > 300km from road to railways.
- Need to adapt the gauge of tunnels : 50% of French railway network are not adapted to the gage « maritime containers ».
- Current techniques for increasing gage tunnel are expensive:
  - Tunnel boring machines cost a lot to use.
  - Lack of place ➔ rigid catenary
- Tunnels made in masonry are difficult to modify



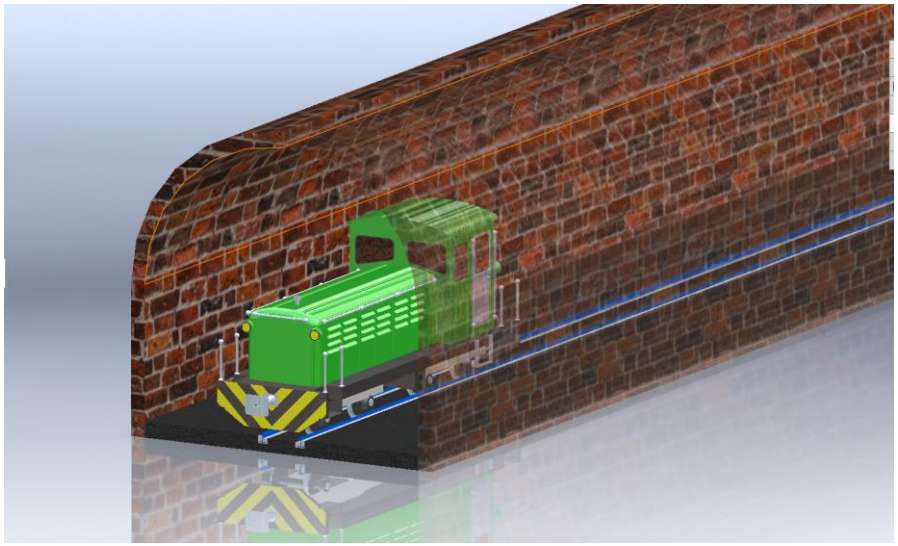
French freight corridors

The French National Project REVES: Objectives

- Increasing gauge in tunnel while limiting raft modifications and earthworks
  - ➢A thin track, as thin as possible
- If possible maintaining the traffic during the jobsites
  - ➢Not interrupting the network
- Ensuring the same level of performance than a classical track, while reducing maintenance process.

The French National Project REVES: methodology

Method: Replace ballast and sleepers by an asphalt concrete (AC) layer.



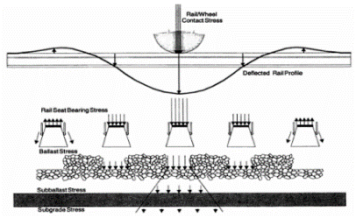
Constraint : Rails continuously supported (innovative concept).

➔ AC long-term behaviour ?

The French National Project REVES: The keypoints

- New concept, which impact ?
  - Continuous support
    - Loading diffusion is modified

Selig & waters, 1994



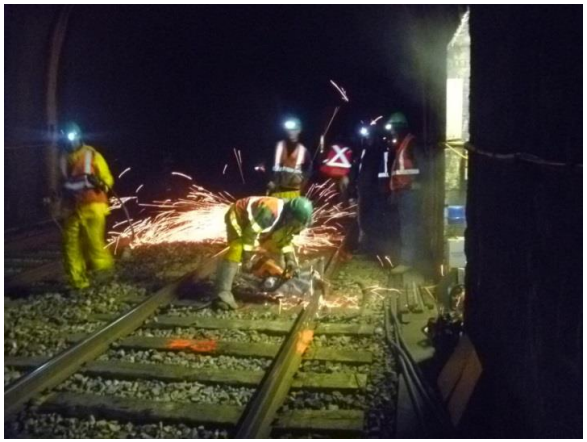
- Behaviour of the AC under heavy good trains ?
  - Rutting: guided loadings, no sweeping
  - Settlements: behaviour under static loadings

Colas belgium

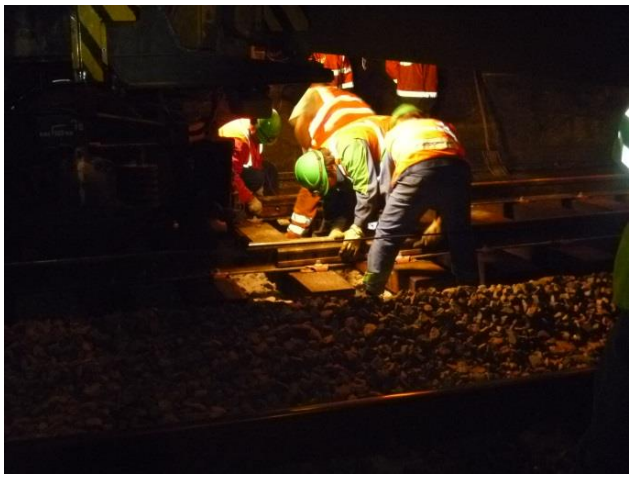
- Tunnel jobsites:
  - Earthworks limited to the size of tunnels
  - Vibrations necessary for compacting the AC but dangerous for the tunnels in masonry

Royaume uni

The French National Project REVES: The keypoints



Cutting rails



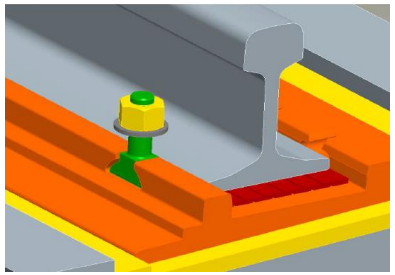
Joint bars

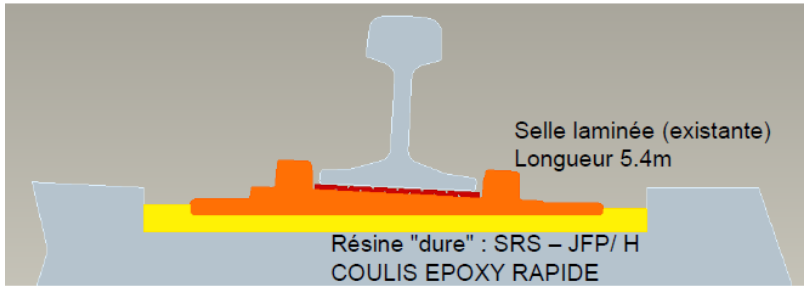
Welding rails

Rethinking of the infrastructure maintenance…

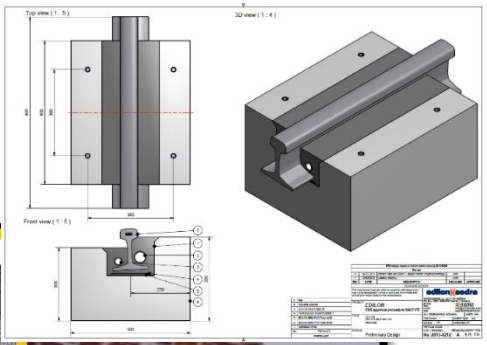
The French National Project REVES:
The technical solutions proposed

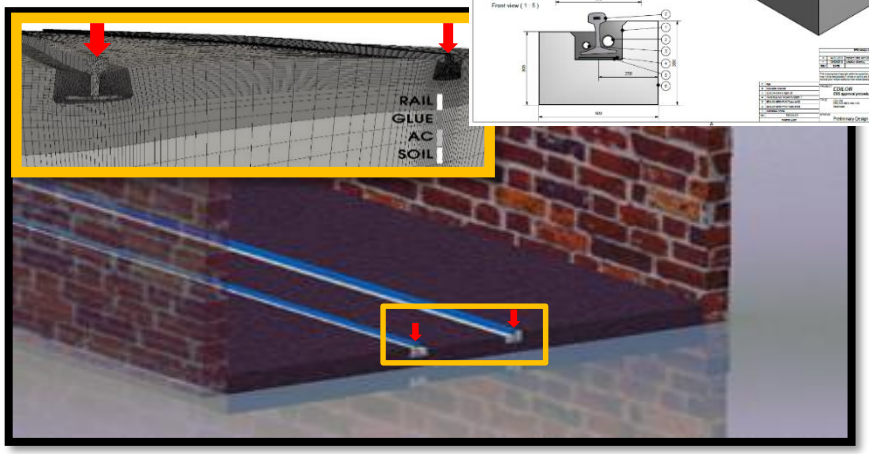
Tech. sol. 1 :

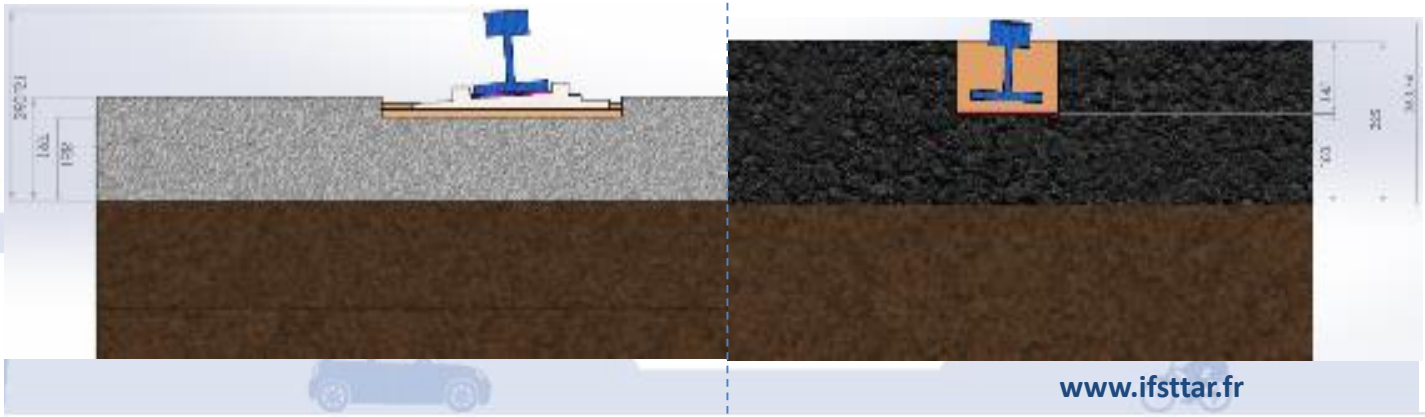




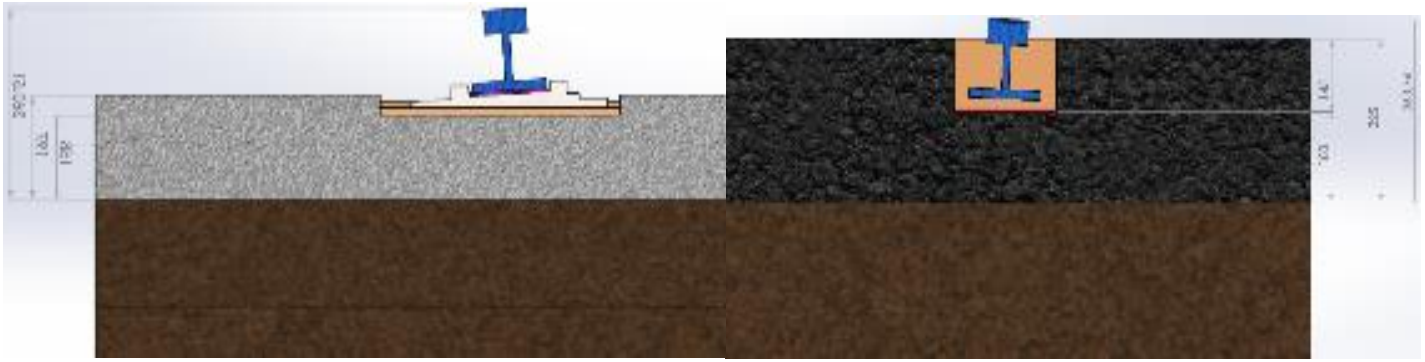
Tech. sol. 2 :



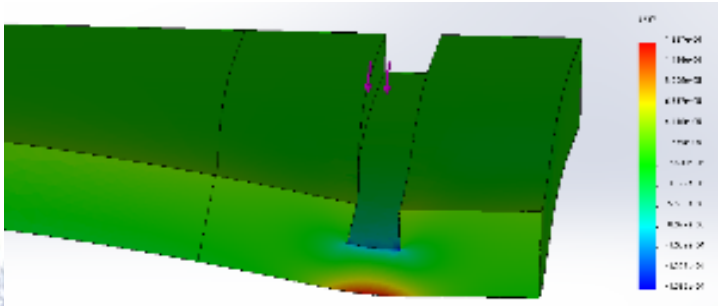




The French National Project REVES: Design assessment



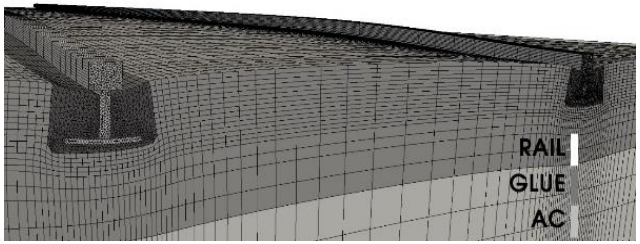
1.Structural design assessment to fatigue resistance

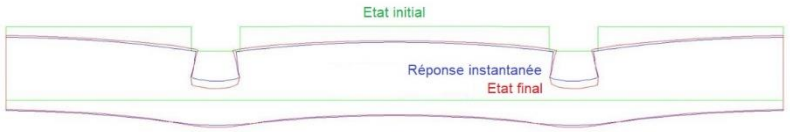


FEM study based on the analysis of the strain level at the bottom of the AC layer

2.Structural design assessment to settlements

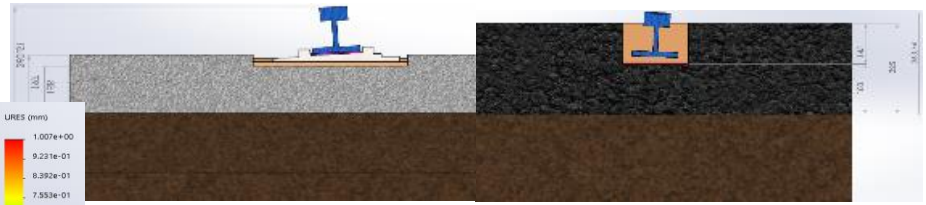
PhD thesis of O. Lopes-Polanco (2019), Viscoplastic behaviour of AC

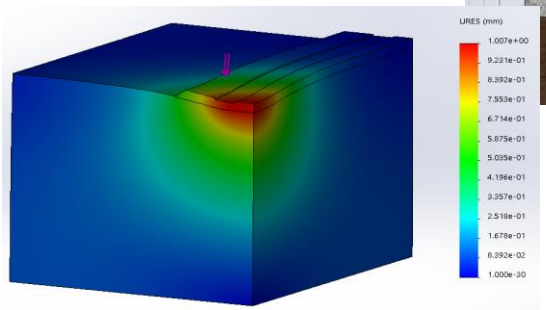


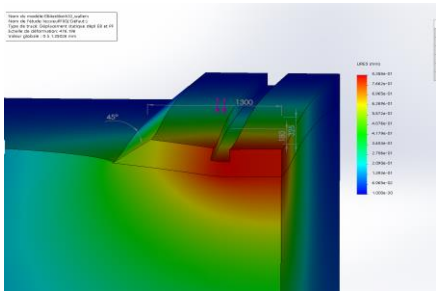


The French National Project REVES:
Structural design to fatigue

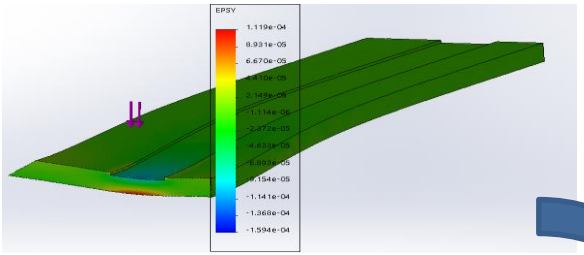
Linear elastic structural numerical simulation by finite element methods

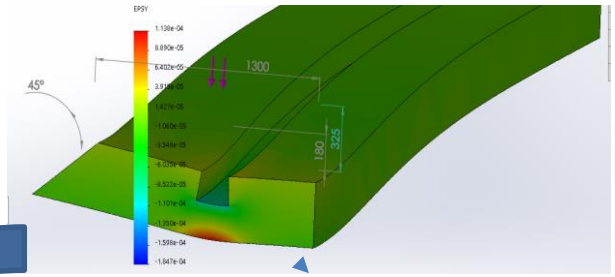






← FEM computations →





← horiz. strains at the →
bottom of the AC layer

Estimated service life:
80 years

Fatigue laws

Estimated service life:
>200 years

The French National Project REVES: Structural design to settlements

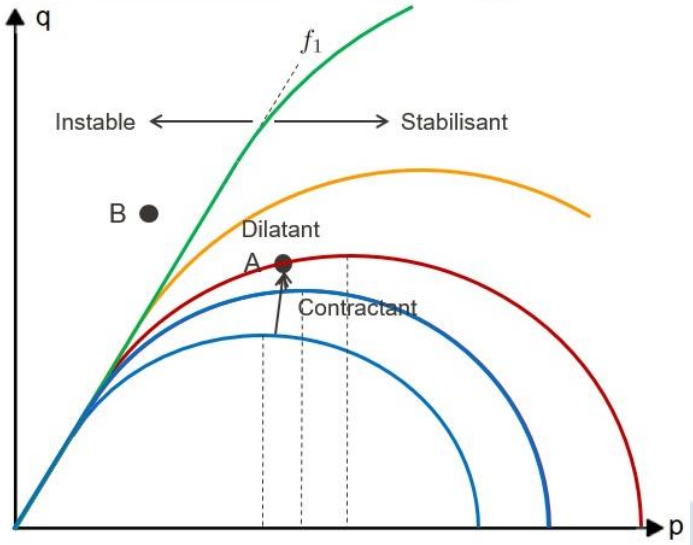
Experimental characterisation of AC:

➔ triaxial thermo-controlled creep tests

Modelling AC:
Viscoplastic laws

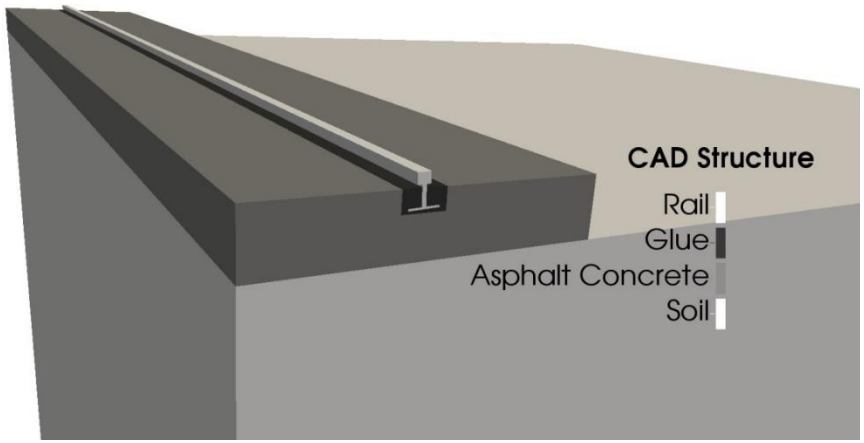
Taux de déformations VP : $\dot{\bar{\bar{\varepsilon}}}^{vp} = \frac{1}{\eta} \langle f \rangle^N \frac{\partial f}{\partial \bar{\bar{\sigma}}}$

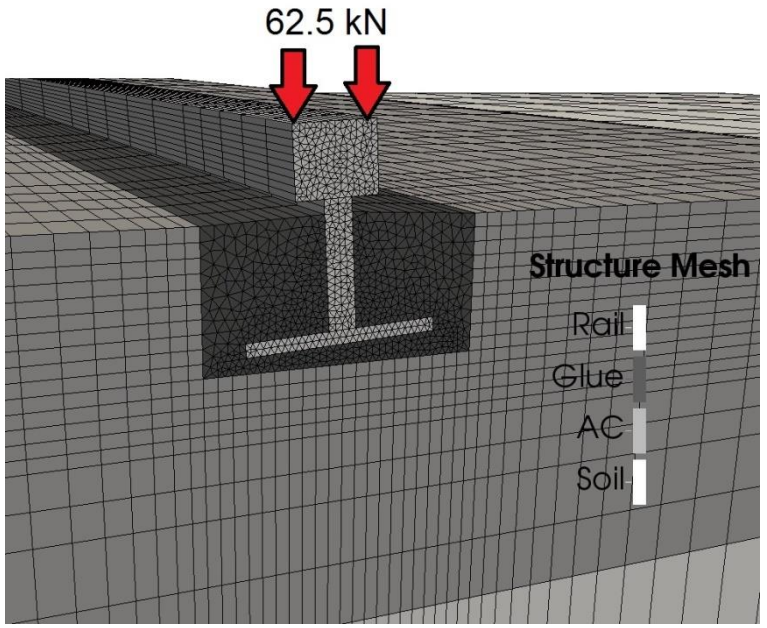
Variable d'écrouissage : $p_c = p_{c_0}(1 + b\,\varepsilon_d^{vp})$

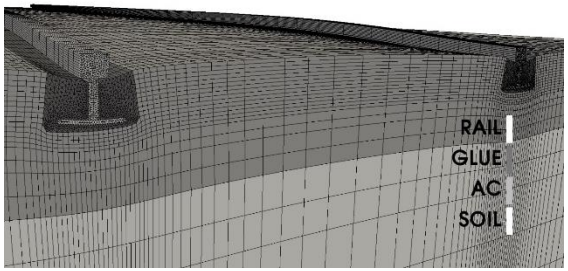


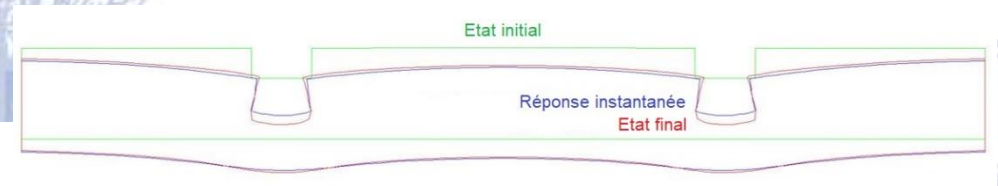
The French National Project REVES: Structural design to settlements

FEM simulation and prediction of the settlements









The French National Project REVES: Structural design to settlements

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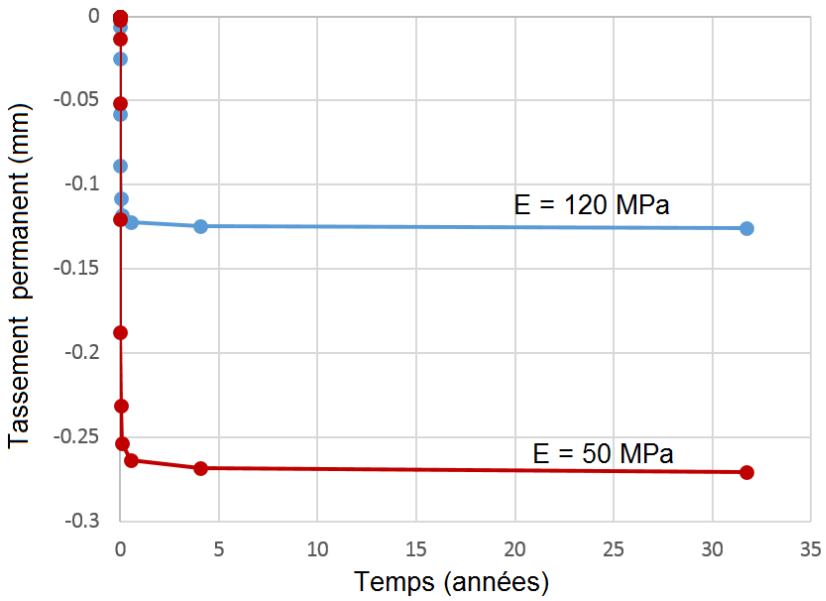
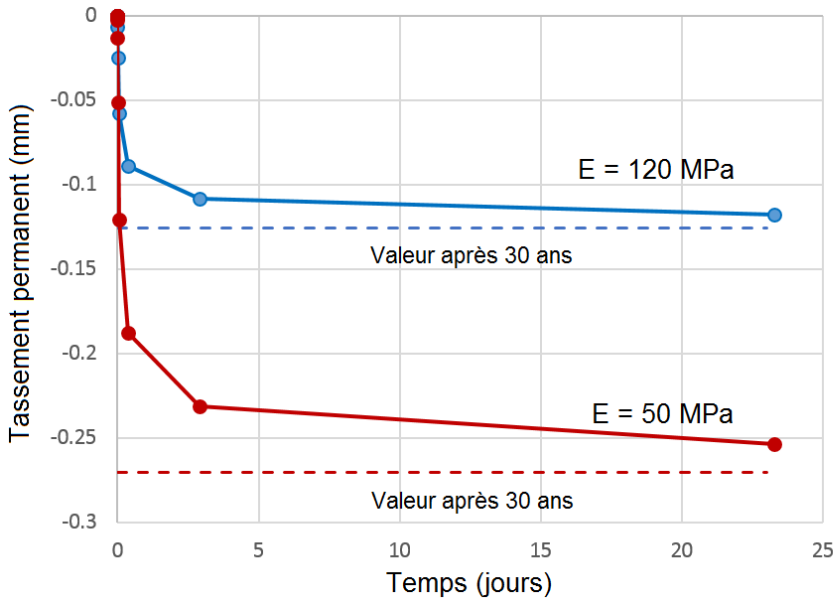




→ **Acceptable settlement / french national standards**

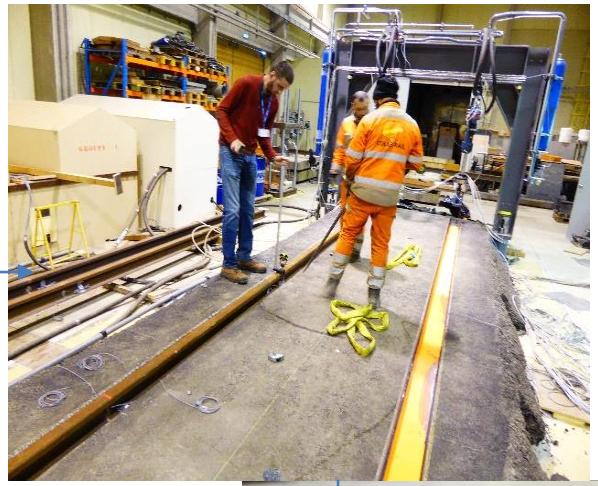
→ **Nécessité d'avoir une plateforme de qualité**

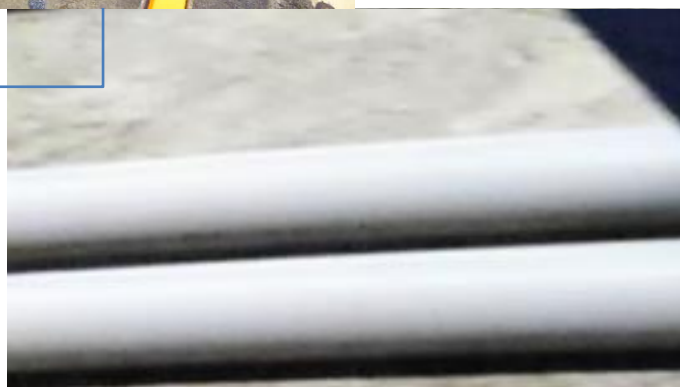
→ **Peu d'évolution après stabilisation de la voie**

The French National Project REVES: Full scale manufacturing

Plateform (untreated grave) + AC

sawing of AC + laying of the rail



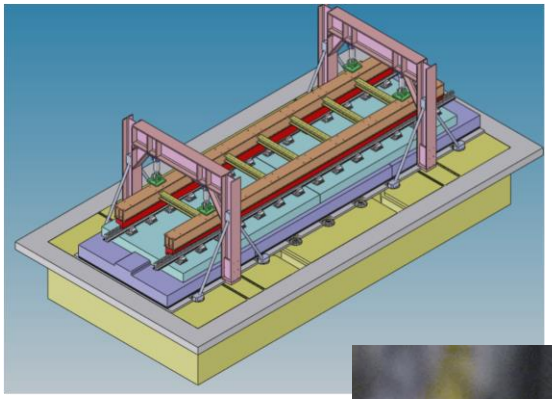


Setting the glue

The French National Project REVES: SySIFe

(Sistemo de solicitacões para infrastruturas ferroviarias)

CAD design

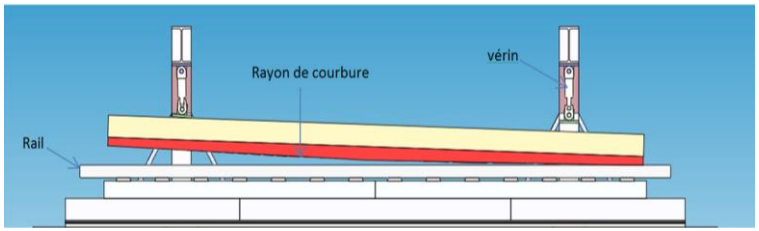


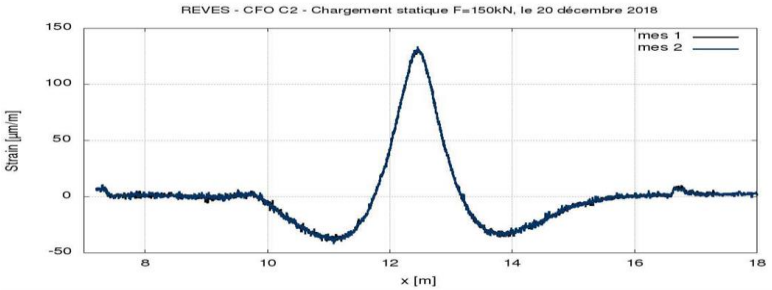
First full scale test after 1 year of set up

The French National Project REVES: SySIFe

(Sistemo de solicitacões para infrastruturas ferroviarias)

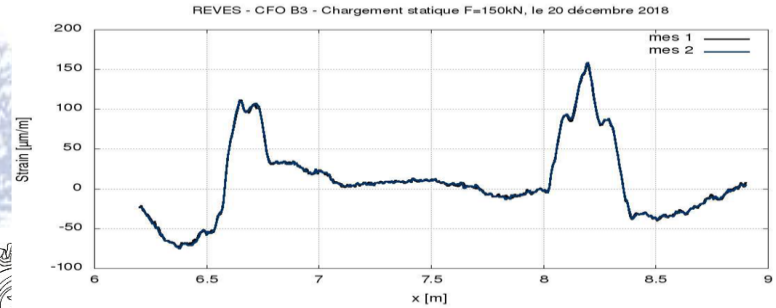
Instrumentation & First results



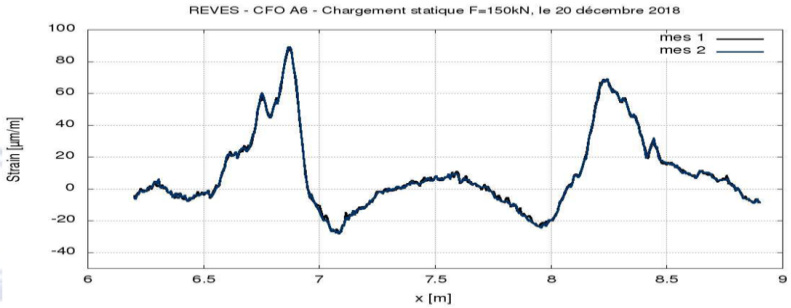


Déformation Longitudinale rail

Static loading:
1st optical fibres measurements



Déformation transversale milieu enrobé

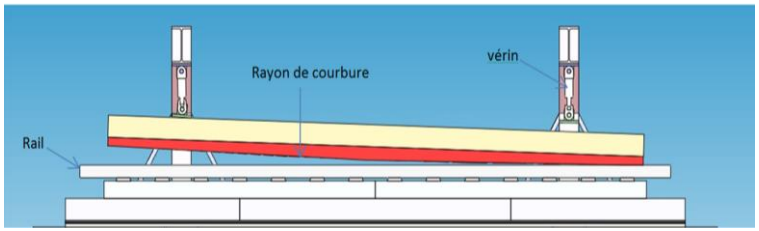


Déformation transversale base enrobé

The French National Project REVES: SySIFe

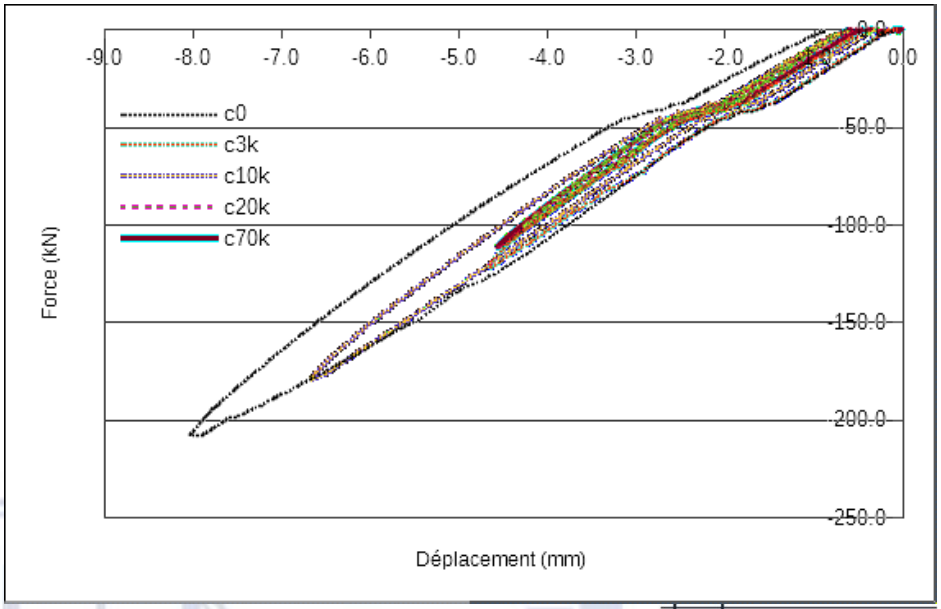
(Sistemo de solicitacões para infrastruturas ferroviarias)

Instrumentation & First results



Static loadings after 70000 cycles:
Stiffness evolution:

➔ No fatigue …



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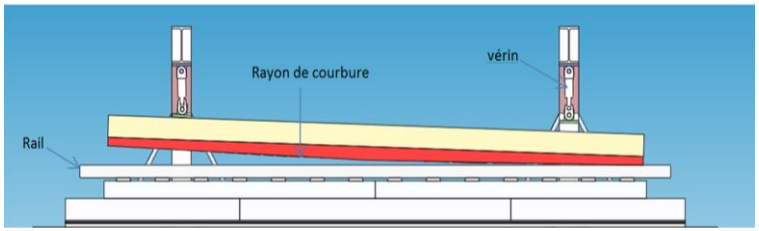
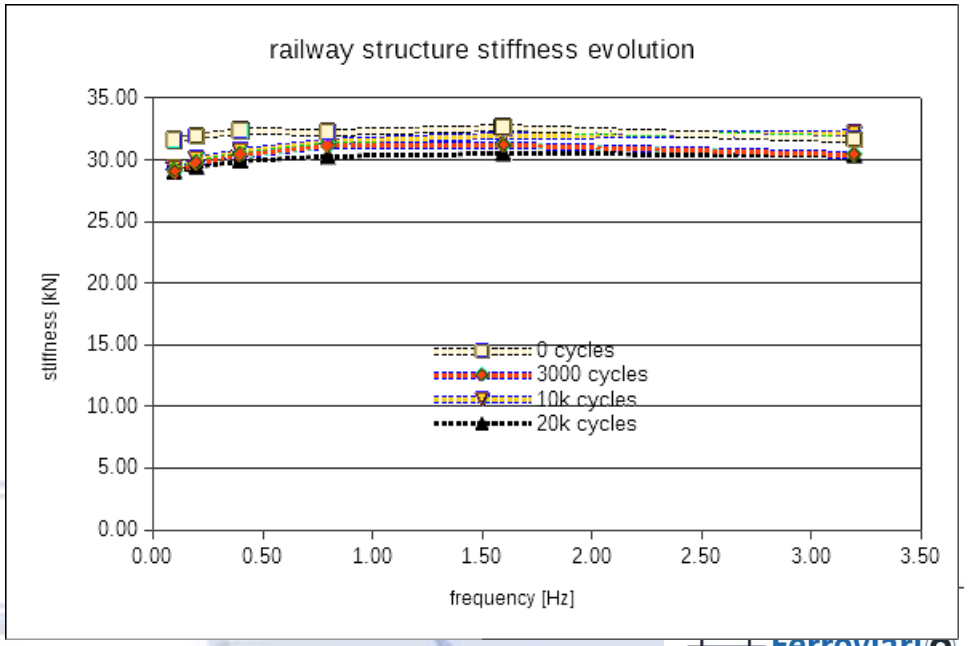
(Sistemo de solicitacões para infrastruturas ferroviarias)

Instrumentation & First results



dynamic loadings after 20000 cycles: Stiffness evolution

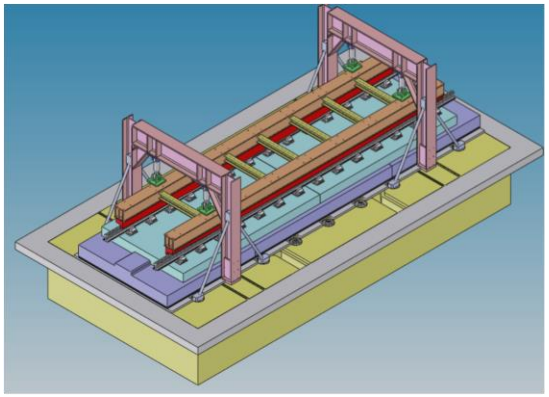
➔ No big evolution, a small trend.



The French National Project REVES: SySIFe

(Sistemo de solicitacões para infrastruturas ferroviarias)

CAD design



First full scale tests after 1 year of set up

Thank you for your attention,
Obligado dela vosso atençao !