

# **Railway components: standard test and simulation**

By

Nitikorn Noraphaiphaksa (Ph.D.)

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# Publication





Nitikorn Noraphaiphaksa 

Mechanical Engineering, [Thammasat University](#)  
Verified email at engr.tu.ac.th - [Homepage](#)

[Fracture mechanics](#) [Fatigue](#) [Fretting fatigue and Wear](#) [Porous metal and composi..](#)  
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<input type="checkbox"/>	TITLE			CITED BY	YEAR
<input type="checkbox"/>	<a href="#">Wear characteristic of epoxy resin filled with crushed-silica particles</a> C Kanchanomai, N Noraphaiphaksa, Y Mutoh Composites. Part B, Engineering 42 (6), 1446-1452			33	2011
<input type="checkbox"/>	<a href="#">Numerical and experimental investigations on fretting fatigue: Relative slip, crack path, and fatigue life</a> N Noraphaiphaksa, C Kanchanomai, Y Mutoh Engineering Fracture Mechanics 112, 58-71			12	2013
<input type="checkbox"/>	<a href="#">The microstructure and strength of copper alloy brazing joints</a> A Hasap, N Noraphaiphaksa, C Kanchanomai Welding Journal 93 (4), 116-123			8	2014
<input type="checkbox"/>	<a href="#">Interaction of plastic zone, pores, and stress ratio with fatigue crack growth of sintered stainless steel</a> N Noraphaiphaksa, T Putta, A Manonukul, C Kanchanomai International journal of fracture 176 (1), 25-38			6	2012
<input type="checkbox"/>	<a href="#">Fretting fatigue with cylindrical-on-flat contact: Crack nucleation, crack path and fatigue life</a> N Noraphaiphaksa, A Manonukul, C Kanchanomai Materials 10 (2), 155			3	2017
<input type="checkbox"/>	<a href="#">Fretting-contact-induced crack opening/closure behaviour in fretting fatigue</a> N Noraphaiphaksa, A Manonukul, C Kanchanomai, Y Mutoh International Journal of Fatigue 88, 185-196			3	2016

<input type="checkbox"/>	TITLE			CITED BY	YEAR
<input type="checkbox"/>	<a href="#">Fretting fatigue life prediction of 316L stainless steel based on elastic-plastic fracture mechanics approach</a> N Noraphaiphaksa, A Manonukul, C Kanchanomai, Y Mutoh Tribology International 78, 84-93			3	2014
<input type="checkbox"/>	<a href="#">Torsional strength and failure of copper alloy brazing joint</a> A Hasap, N Noraphaiphaksa, C Kanchanomai Engineering Failure Analysis 48, 174-184			2	2015
<input type="checkbox"/>	<a href="#">Analysis of the fatigue performance of elastic rail clip</a> A Hasap, P Paitekul, N Noraphaiphaksa, C Kanchanomai Engineering Failure Analysis				2018
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<input type="checkbox"/>	<a href="#">Influence of toe load on the fatigue resistance of elastic rail clips</a> A Hasap, P Paitekul, N Noraphaiphaksa, C Kanchanomai Proceedings of the Institution of Mechanical Engineers, Part F: Journal of ...				2018
<input type="checkbox"/>	<a href="#">Experimental and numerical investigations to determine the modulus and fracture mechanics of tamarind seed (Tamarindus indica L.)</a> N Noraphaiphaksa, W Sochu, A Manonukul, C Kanchanomai Biosystems Engineering 151, 17-27				2016



**Total publish in international journal = 12**

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# Our partner



**TSE: Thammasat school of engineering**

Prof. Chaosuan Kanchanomai  
Topic: Basic research

- Fretting fatigue
- Fatigue testing
- Fatigue crack growth
- Tensile test
- Implant testing
- Numerical analysis
- Stress corrosion cracking
- Failure analysis
- Polymer testing



**RTTC: Railway Transportation system Testing Centre**

Anat Hasap (Ph.D.)  
Topic: Application research

- Railway
- Automotive
- Bridge
- Vibration
- Numerical analysis
- Failure analysis
- Stress analysis using strain gauge



Anchalee Manonukul (Ph.D.)  
Topic: Basic research

- Porous material
- Super alloy material
- Bi-material fuel cell
- MIM
- Numerical analysis
- 3D printing metal



Nipon Taweechan (Ph.D.)  
Topic: Basic research

- Coating technology
- Residual Stress
- Welding technology
- Numerical analysis
- Microstructural analysis



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## Design development and finite element analysis (FEA) of railways components

ออกแบบ พัฒนาและวิเคราะห์เชิงตัวเลขของ  
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# Topic

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- Overview of railway track
- Standard Test and simulation
- Advantage of simulation
- Conclusion

# Topic

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- Overview of railway track
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- Conclusion

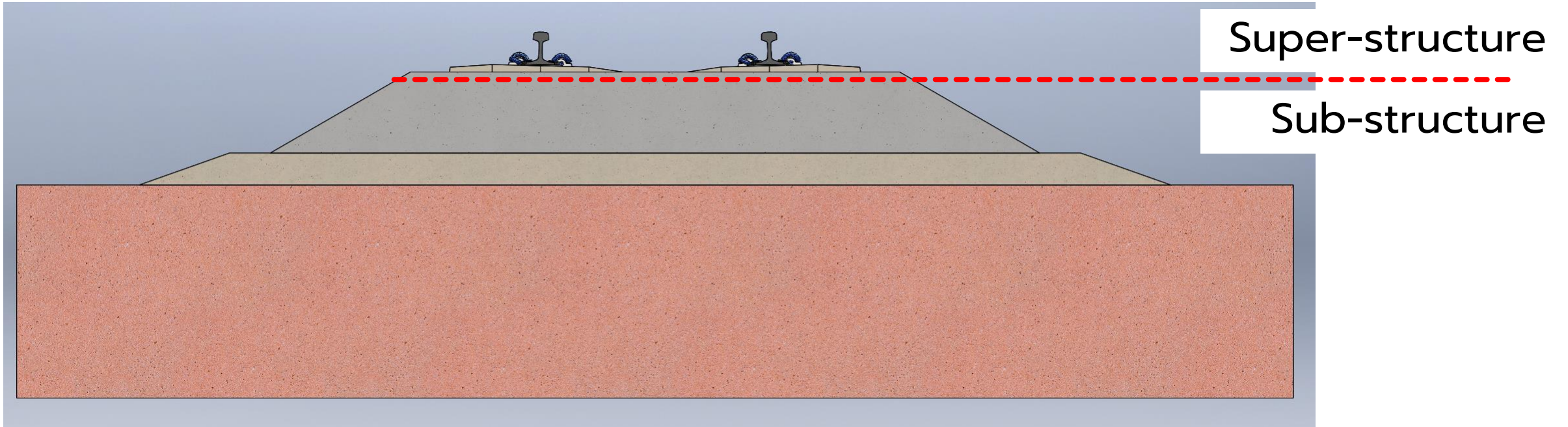
# Why do we interest in railway track?





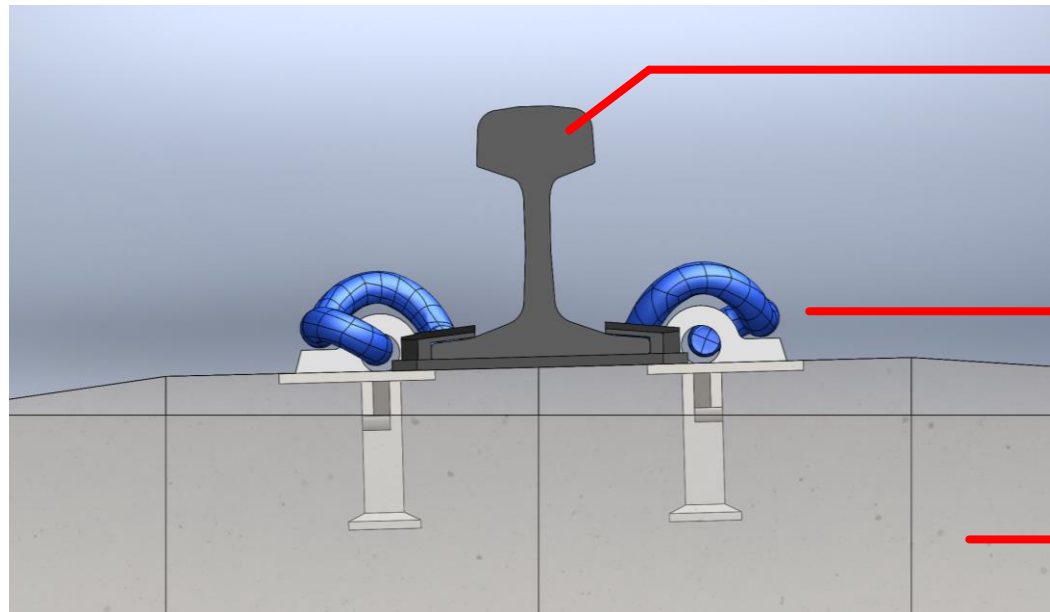
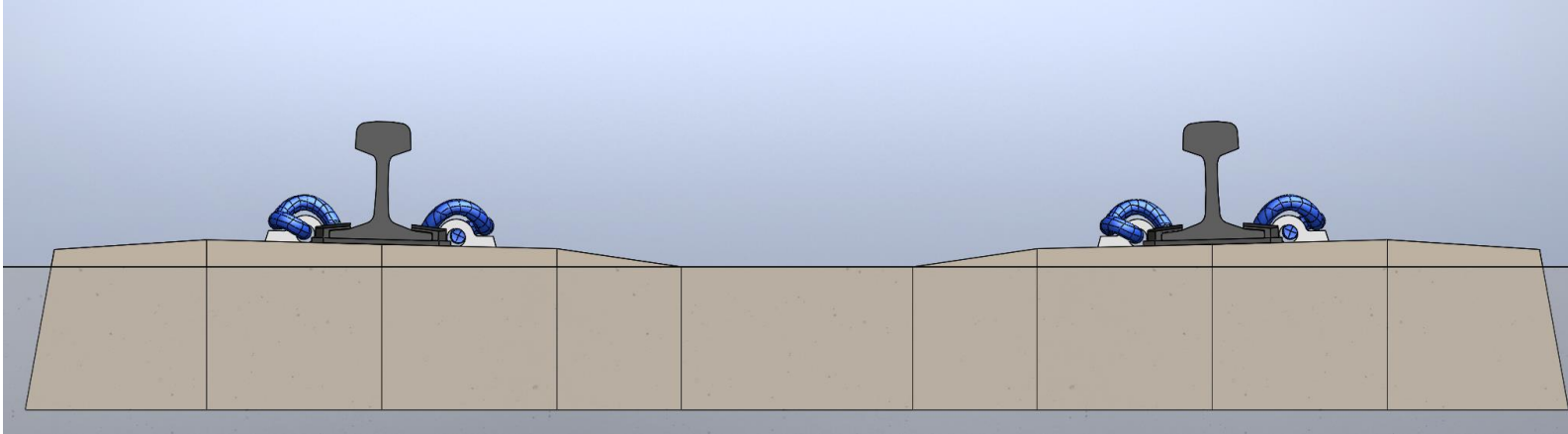
# Overview of Railway Track

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**railway track**





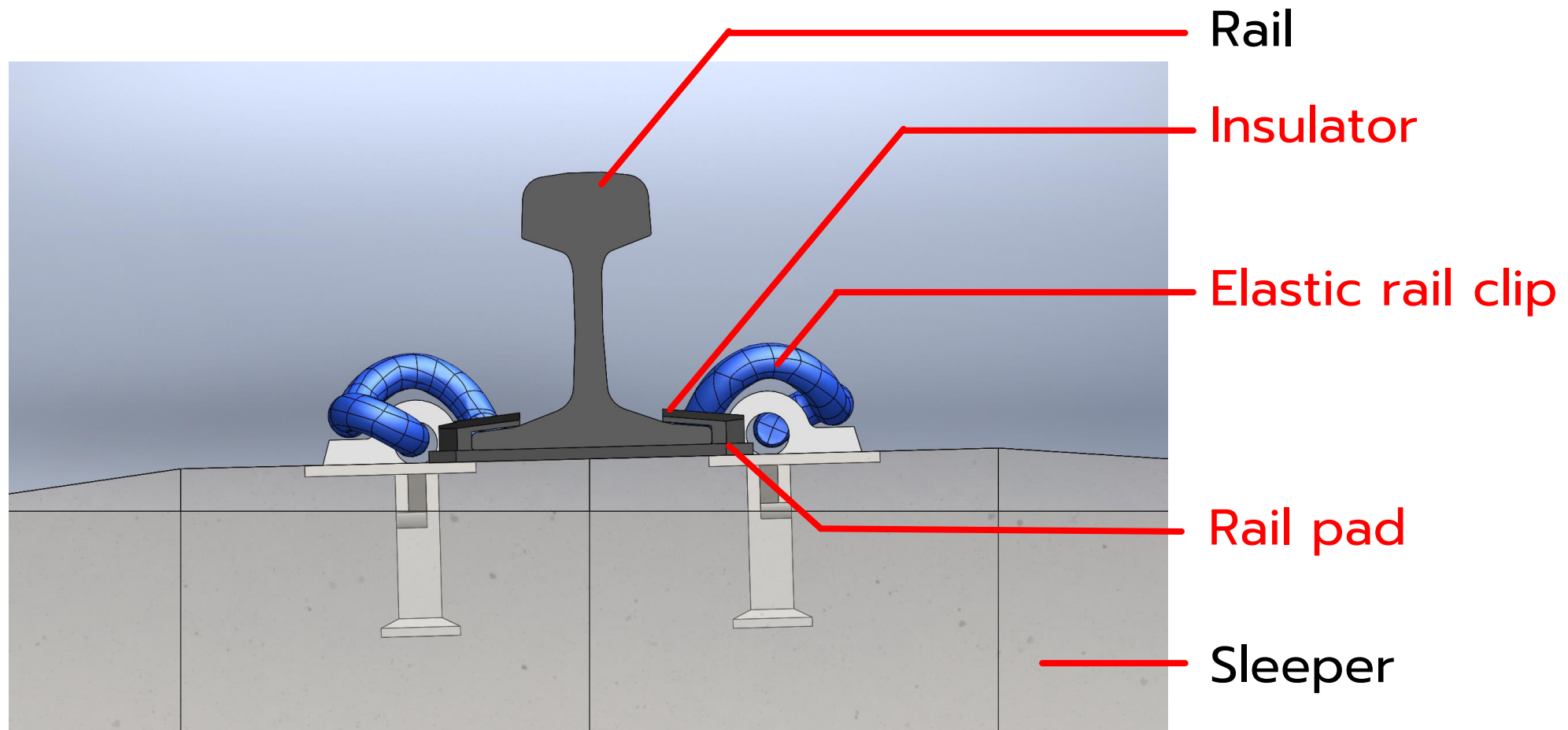
Rail

Fastening system

Sleeper

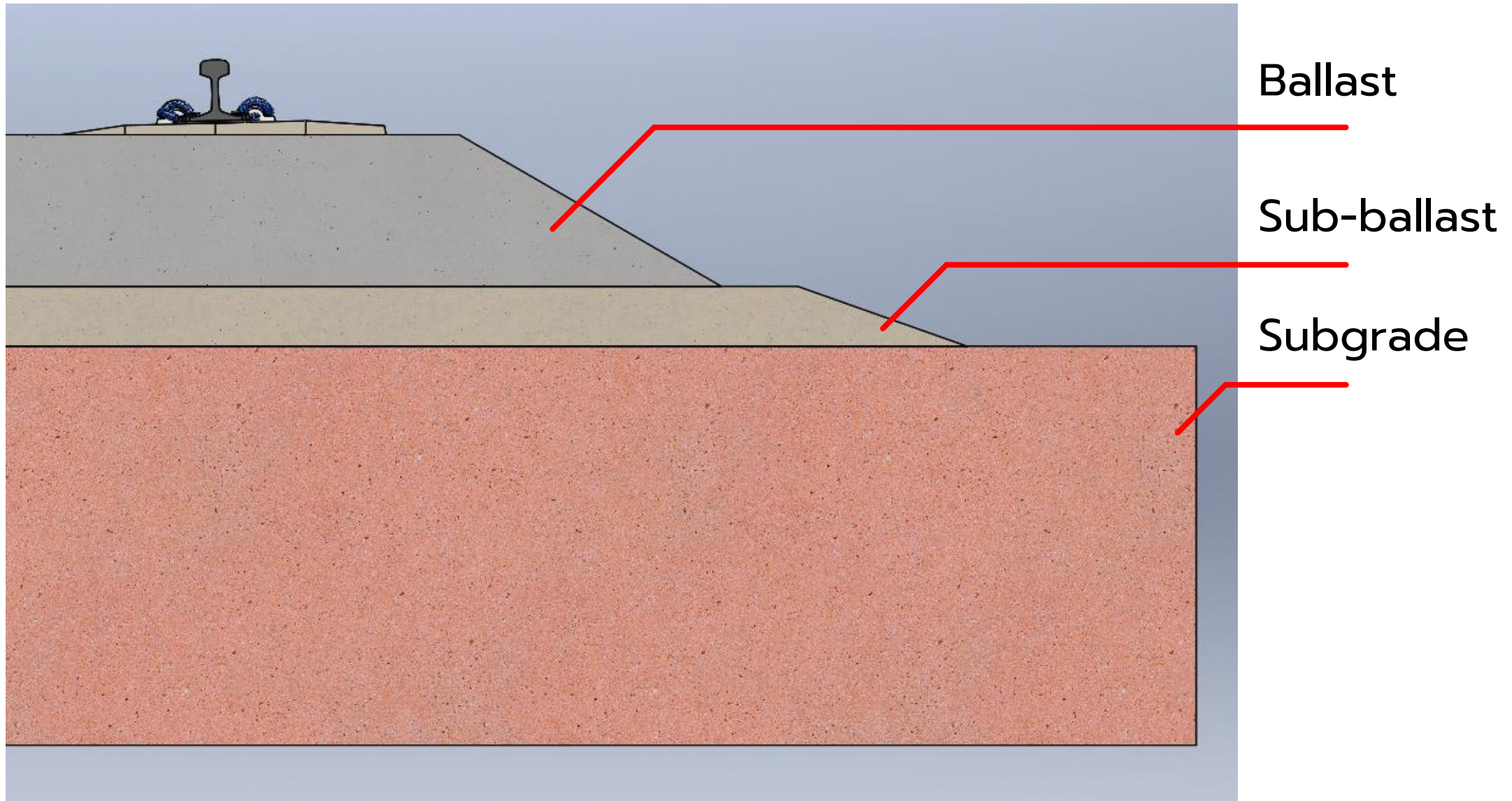
## Super-structure of railway track



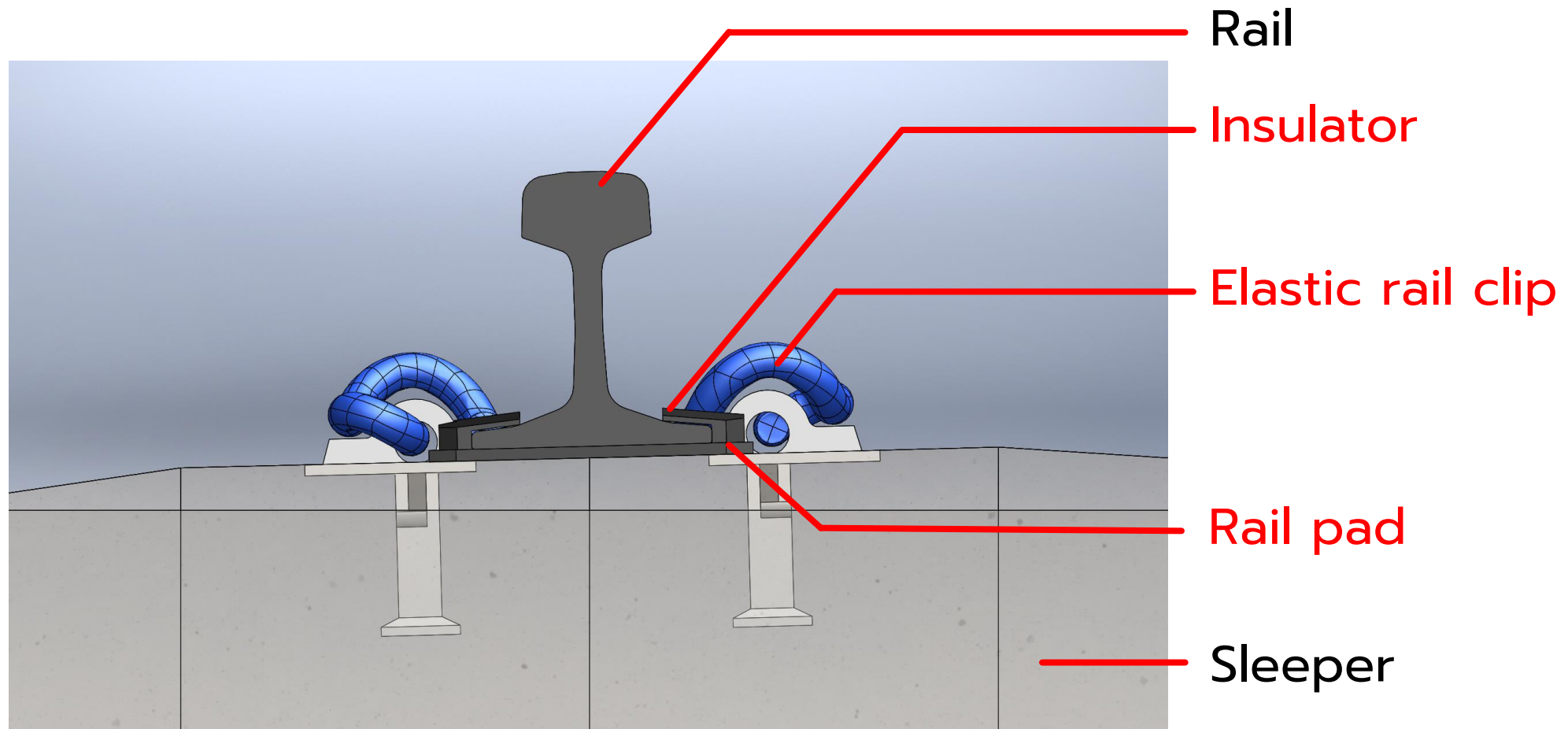


## Super-structure of railway track





## Sub-structure model of railway track



## Super-structure of railway track

# Topic

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- Overview of railway track
- Standard Test and simulation
- Advantage of simulation
- Conclusion

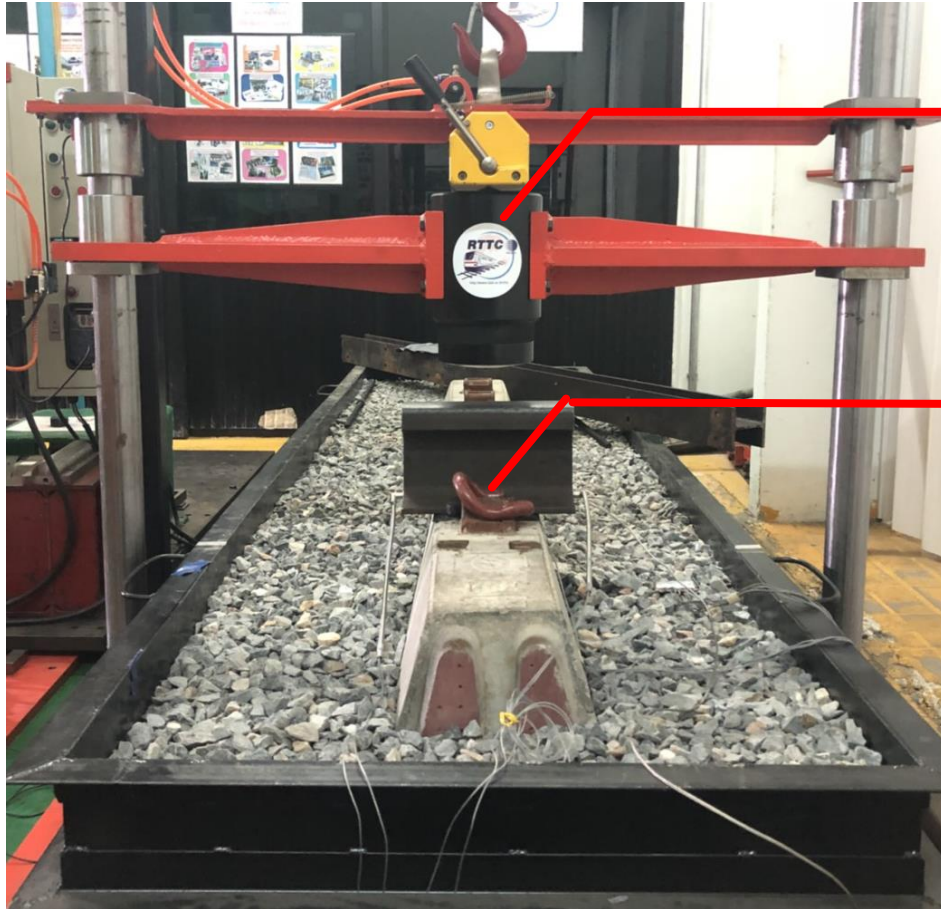
# Standard test on super-structure

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Testing	Part	Load case
<b>EN:13146-3</b>	fastening	impact
<b>EN:13146-7</b>	Elastic rail clip	static, dynamic
<b>EN:13146-9</b>	Rail pad	static, dynamic
<b>EN:13230-2</b>	Sleeper	static, dynamic
<b>EN:14587</b>	Rail	static, dynamic



# Impact testing system EN:13146-3



Impact  
header

Fastening  
system

**EN:13146**

**Railway applications –  
Track – Test methods  
for fastening systems  
Part 3: Determination  
of attenuation of  
impact loads**

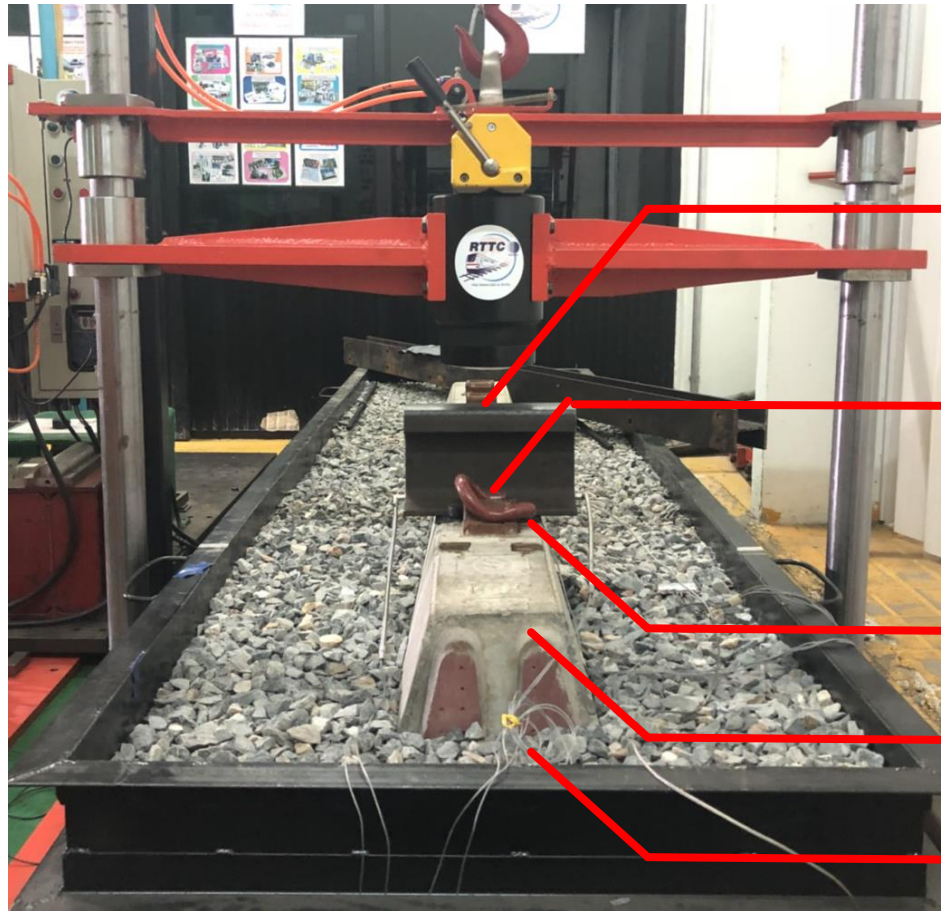
## Scope

comparing the attenuation of  
impact loads on concrete sleepers  
or bearers by different rail pads.





# Impact testing system EN:13146



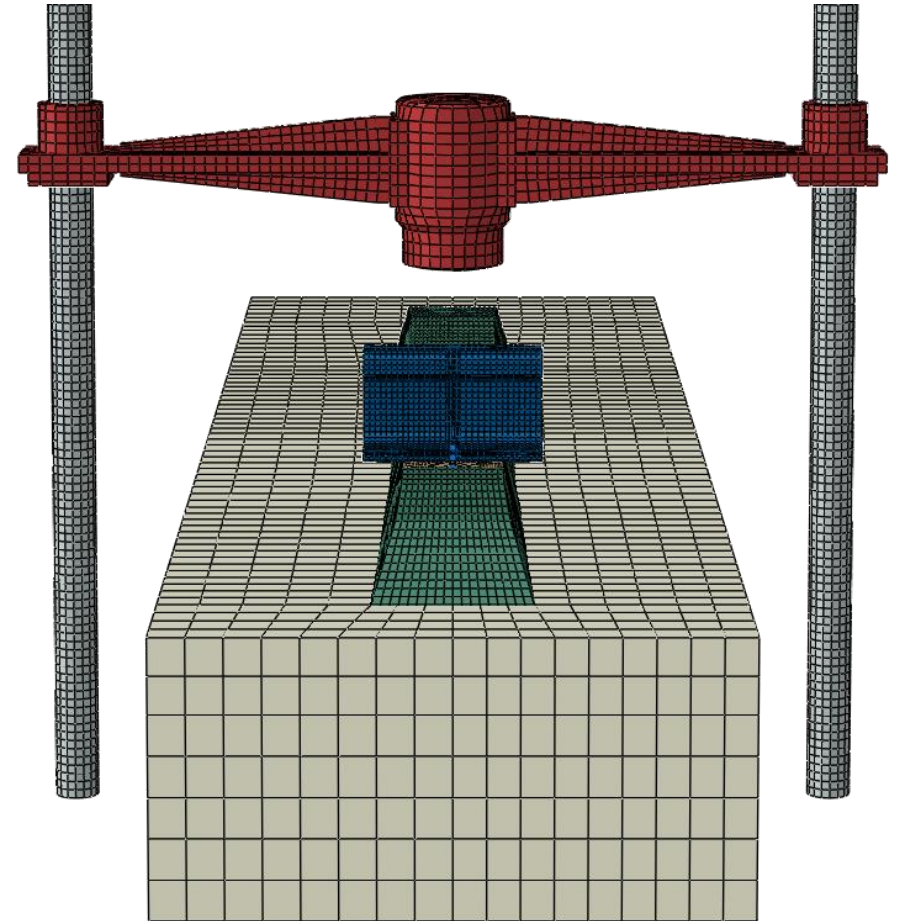
Rail

Elastic  
rail clip

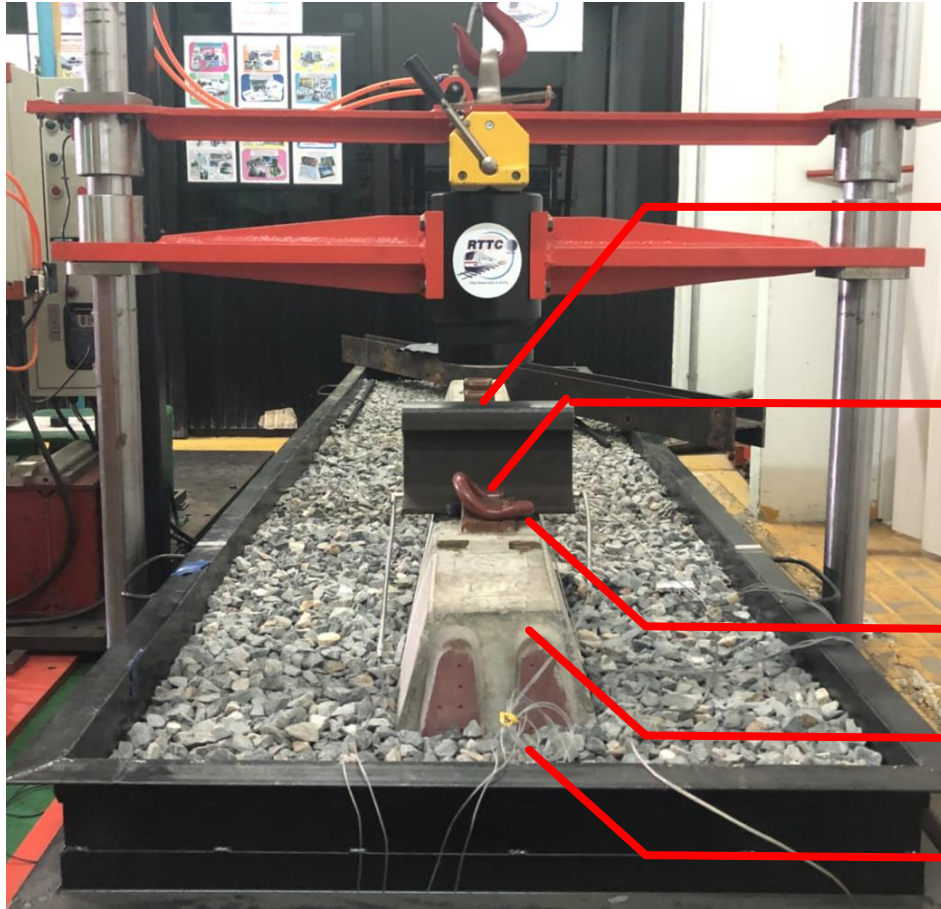
Rail pad

Sleeper

Ballast



# Railway component



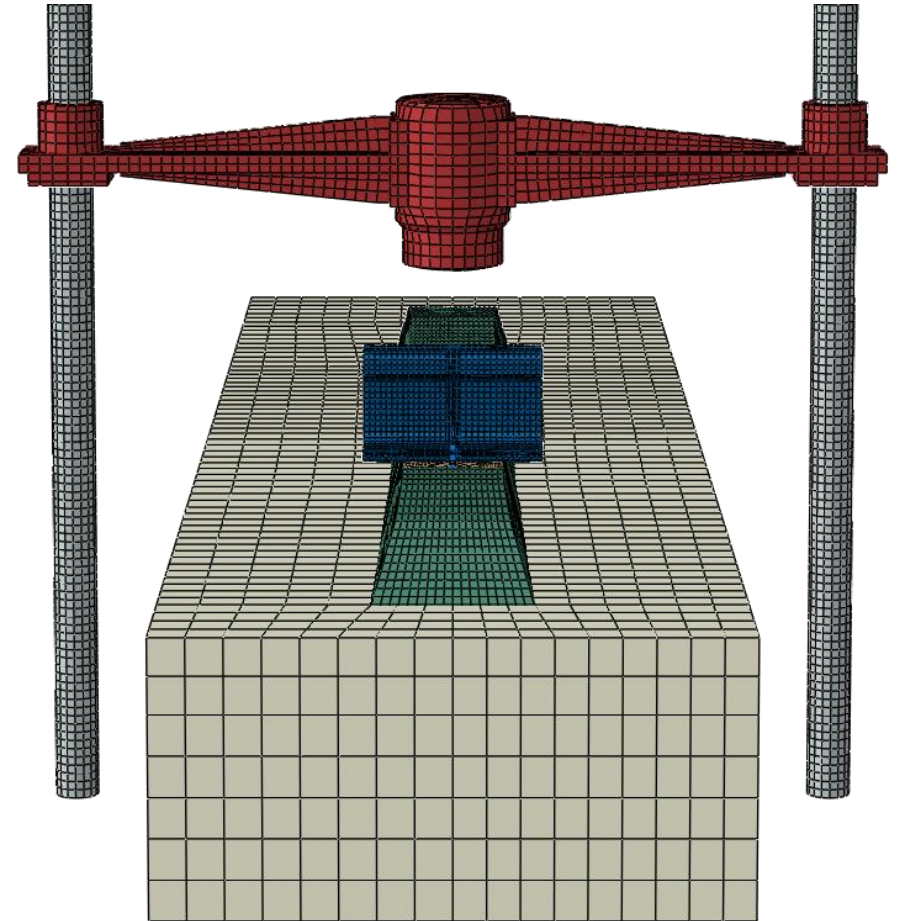
Rail

Elastic  
rail clip

Rail pad

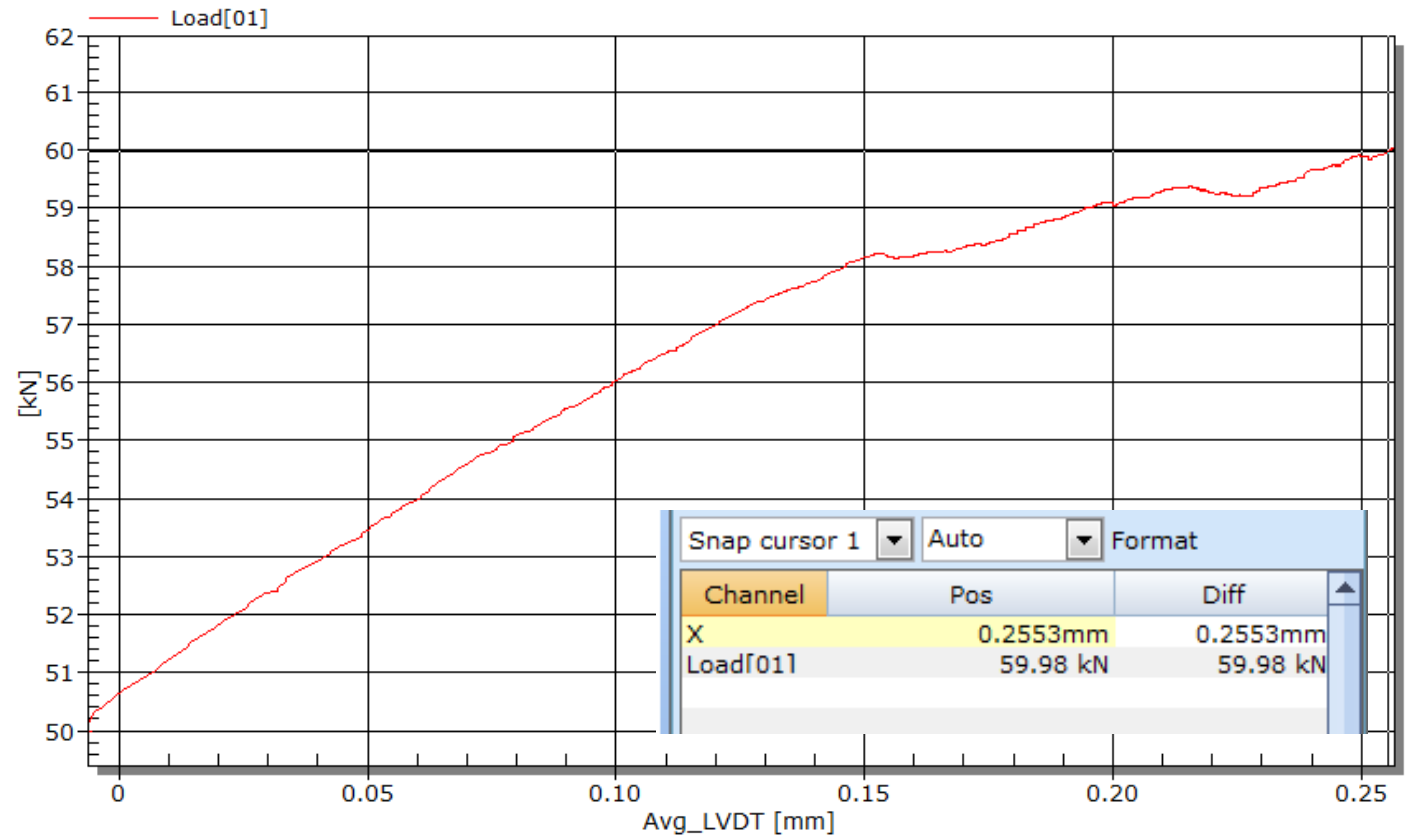
Sleeper

**Ballast**

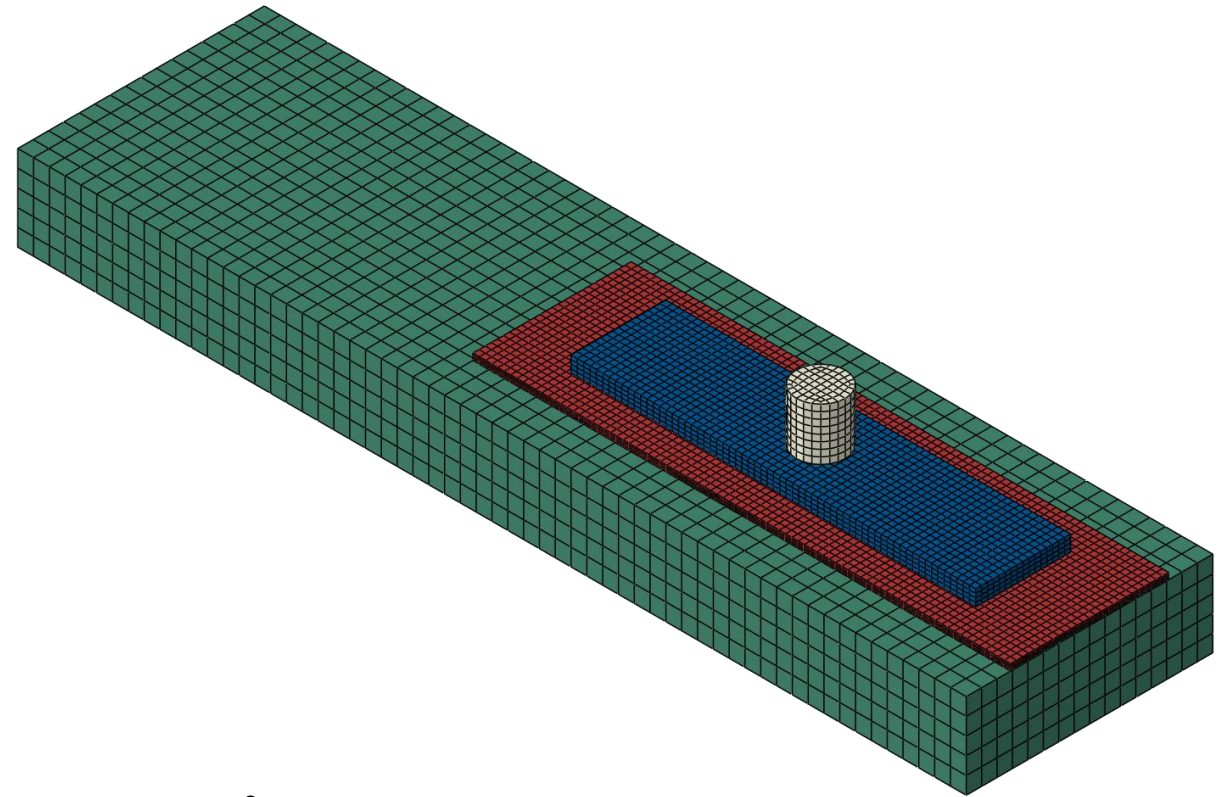
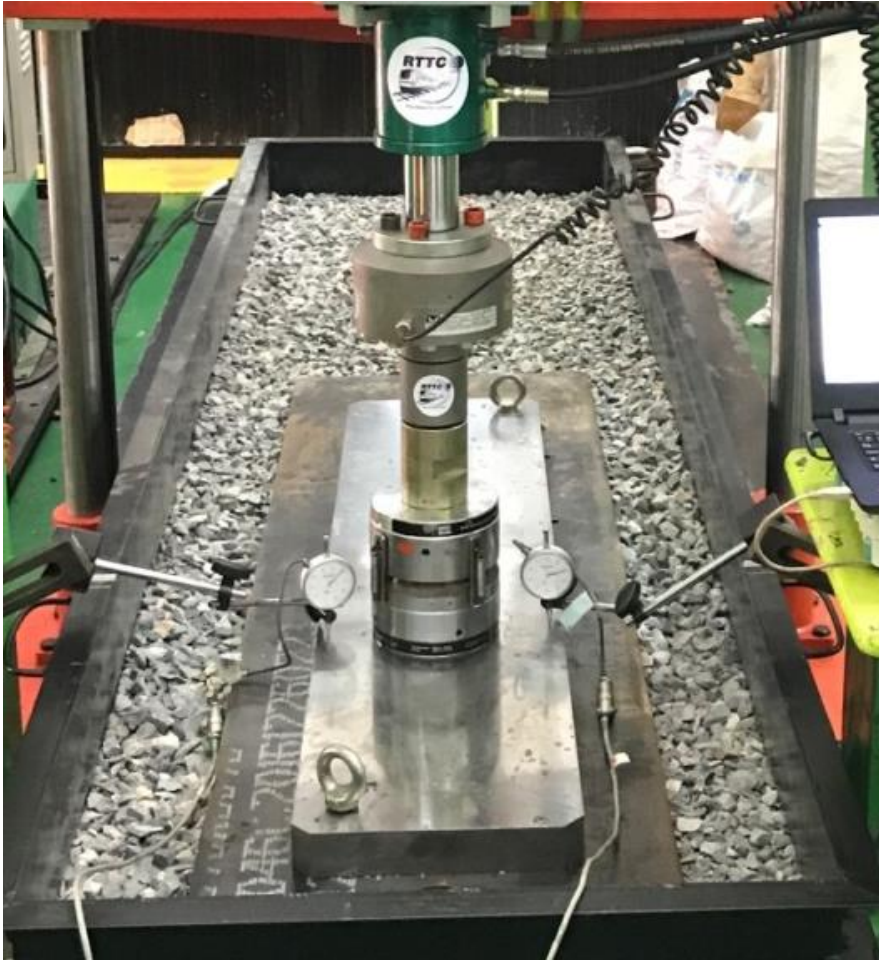




# Ballast testing



# Ballast testing

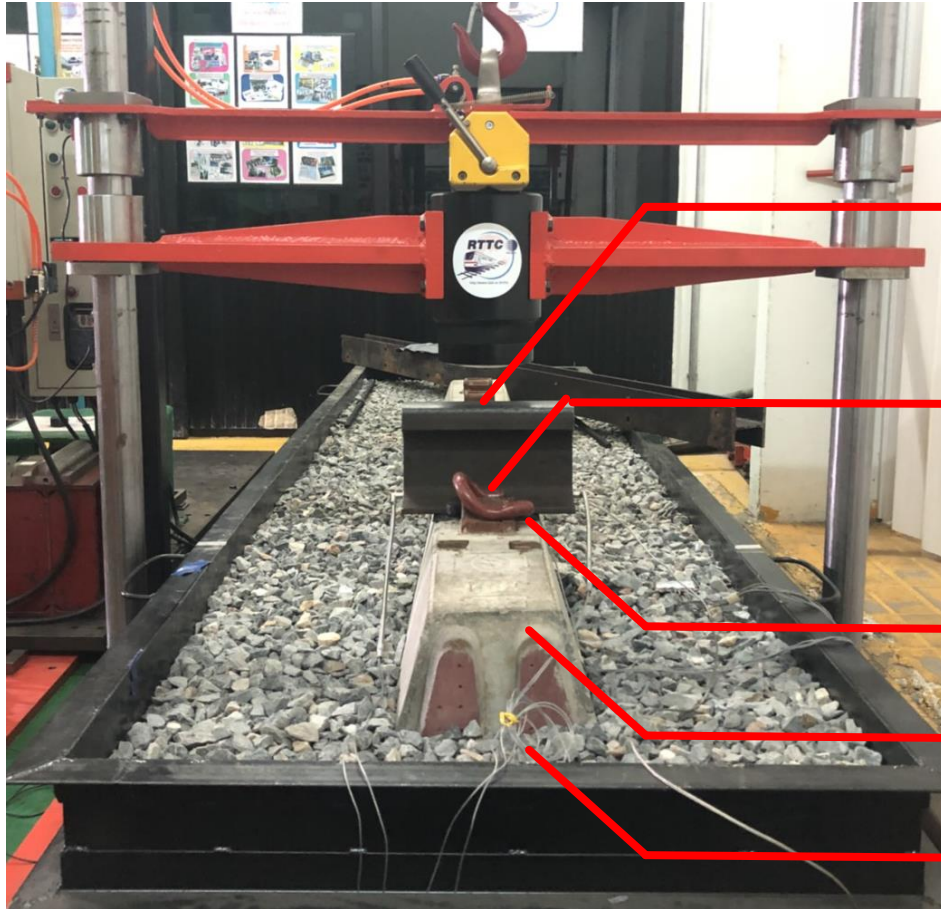


**Investigate parameter**

- Ballast (bulk) modulus



# Railway component



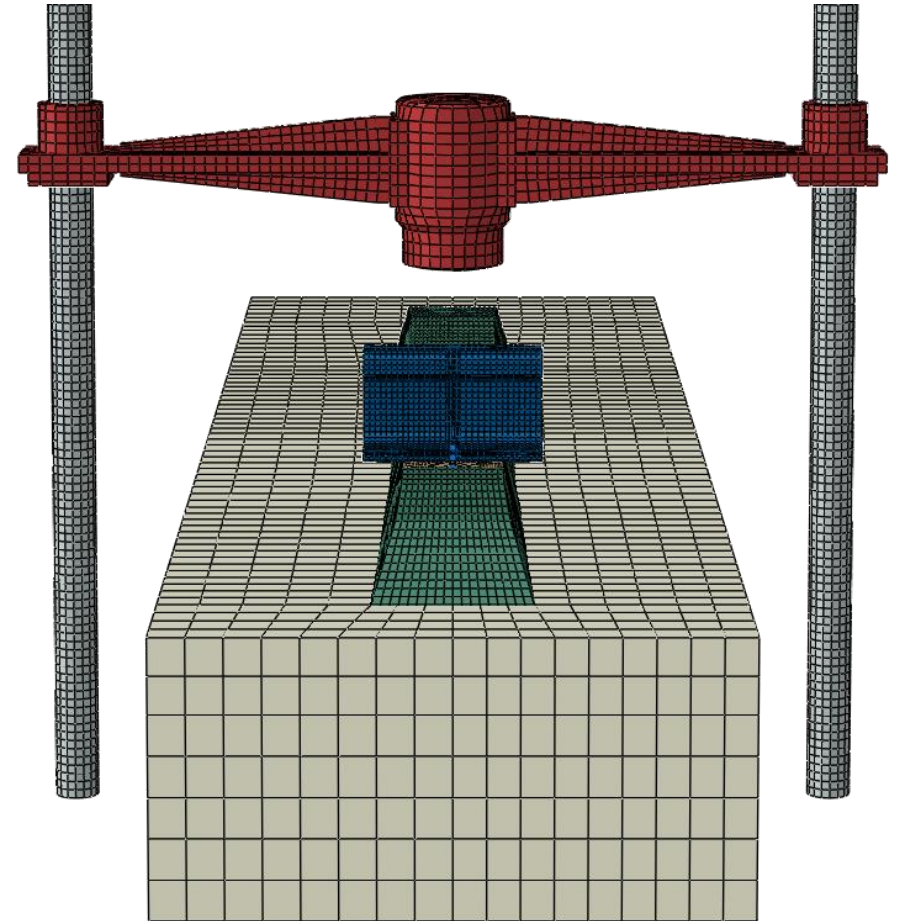
Rail

Elastic  
rail clip

Rail pad

**Sleeper**

Ballast



# Sleeper testing EN:13230-2

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## EN:13230

**Railway applications –  
Track – Concrete sleepers  
and bearers**

### **Part 2: Prestressed monoblock sleepers**

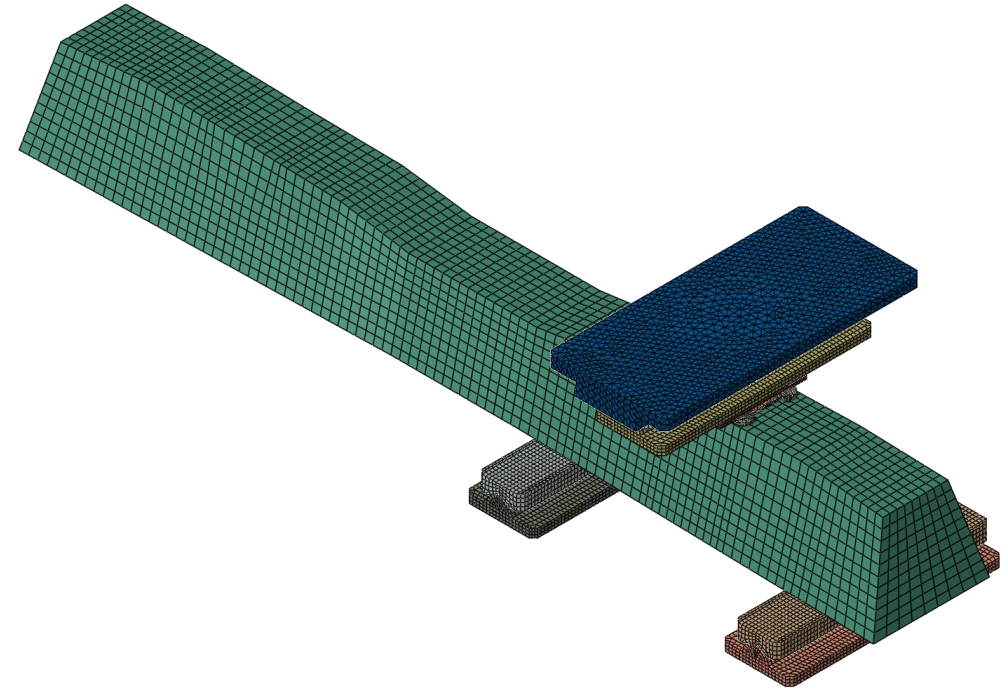
#### **Scope**

provide assurance of the capability of sleepers or bearers to resist repetitive loading and provide sufficient durability.



# Sleeper stiffness EN:13230-2

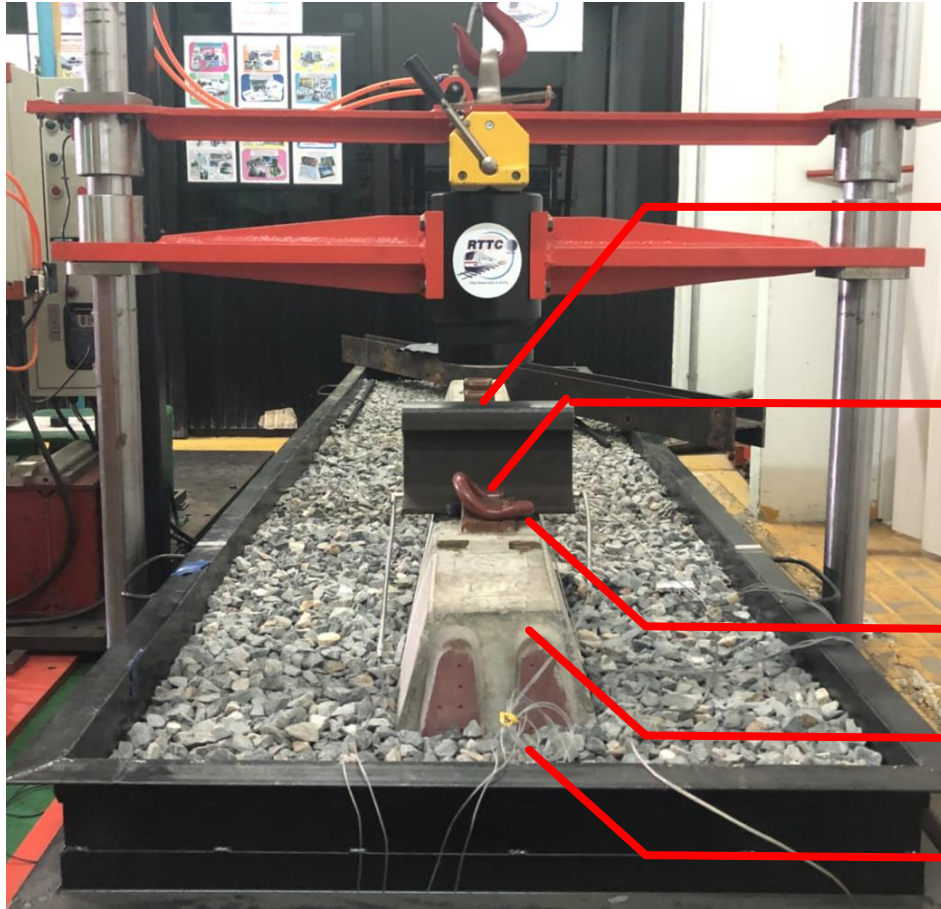
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**Investigate parameter**

- sleeper (bulk) modulus

# Railway component



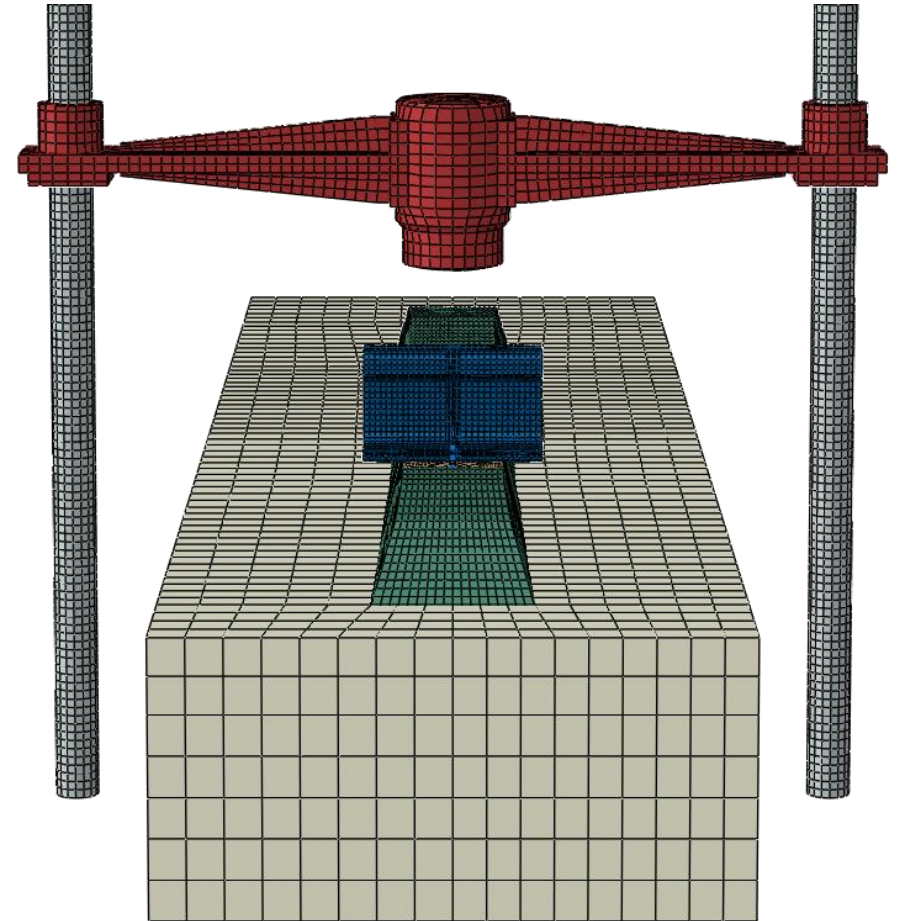
Rail

Elastic  
rail clip

**Rail pad**

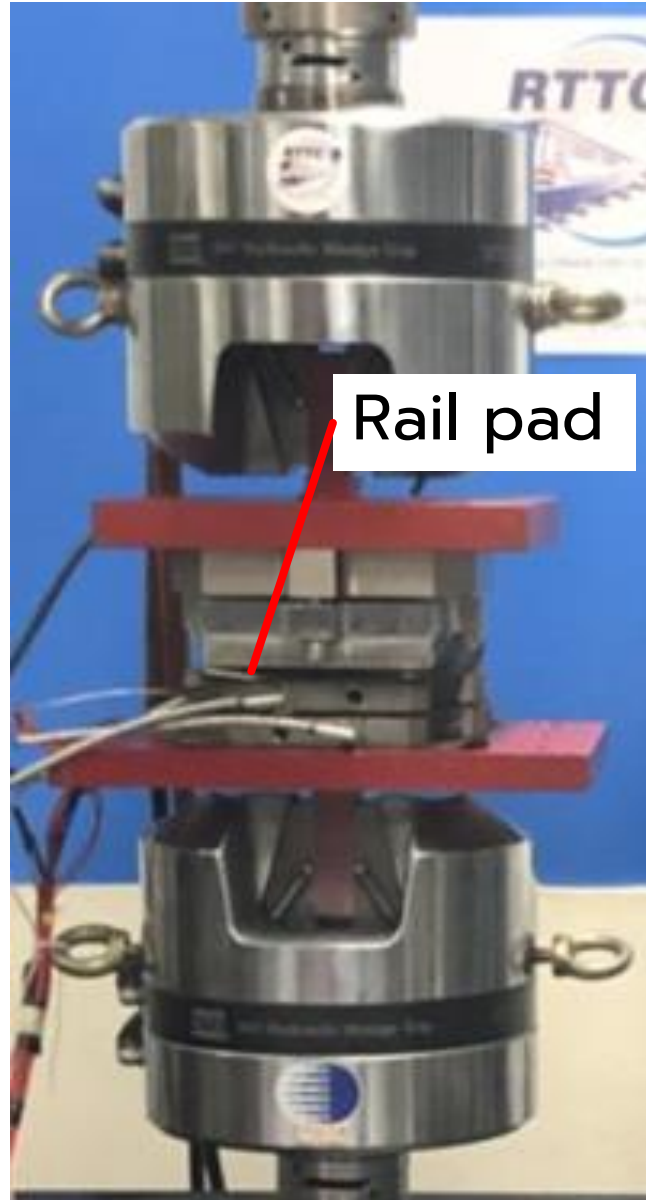
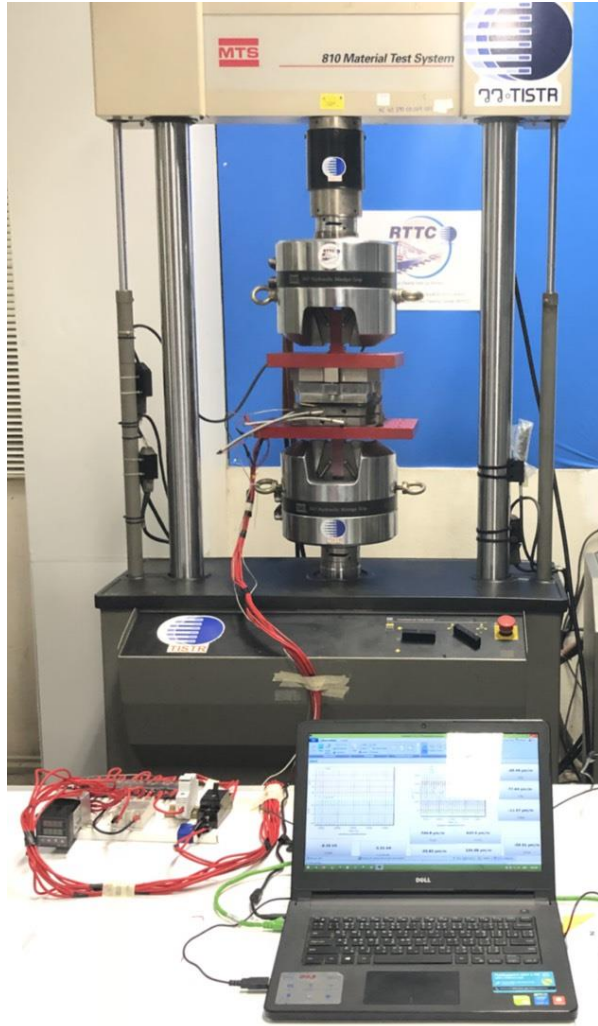
Sleeper

Ballast





# Rail pad testing EN:13146-9



## EN:13146

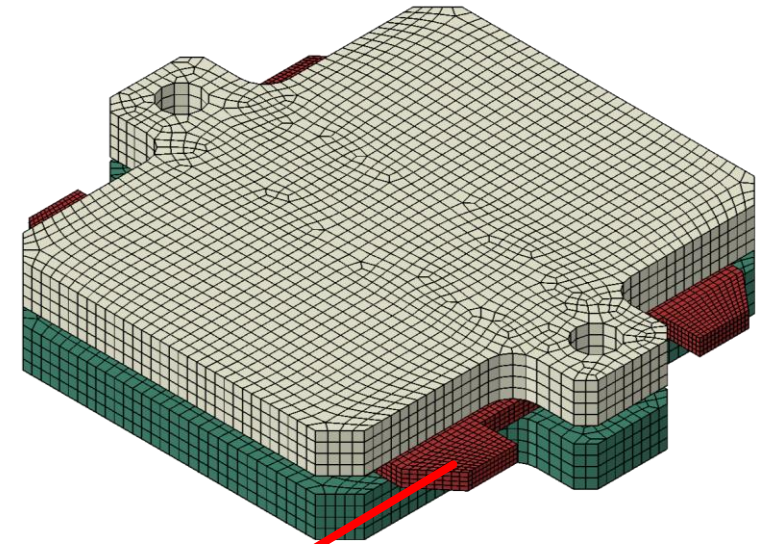
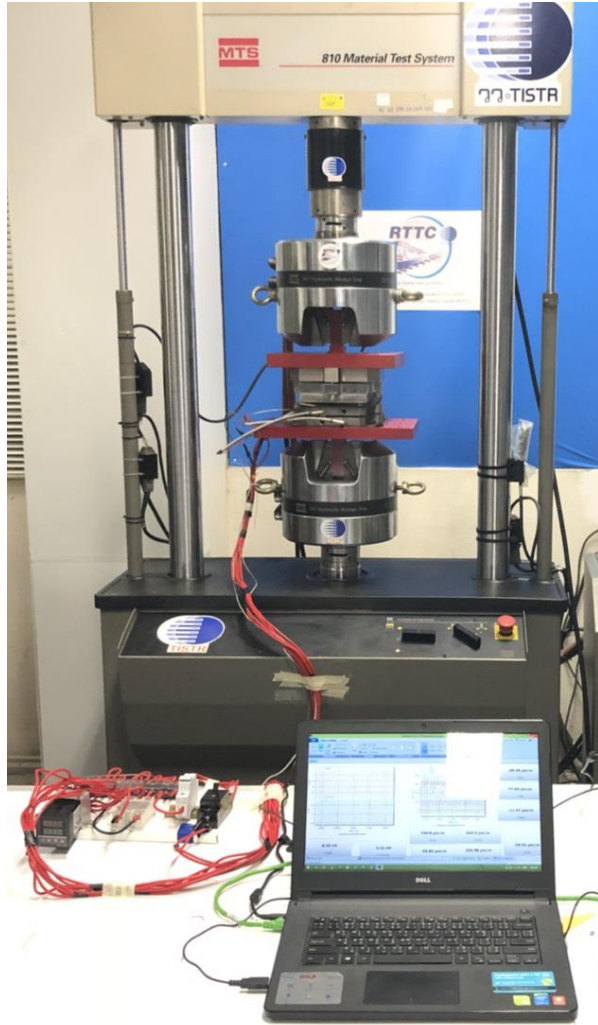
**Railway applications –  
Track – Test methods  
for fastening systems**  
**Part 9: Determination  
of stiffness**

## Scope

determine the static  
and dynamic stiffness  
of rail pads, and  
complete rail fastening  
assemblies



# Rail pad testing EN:13146

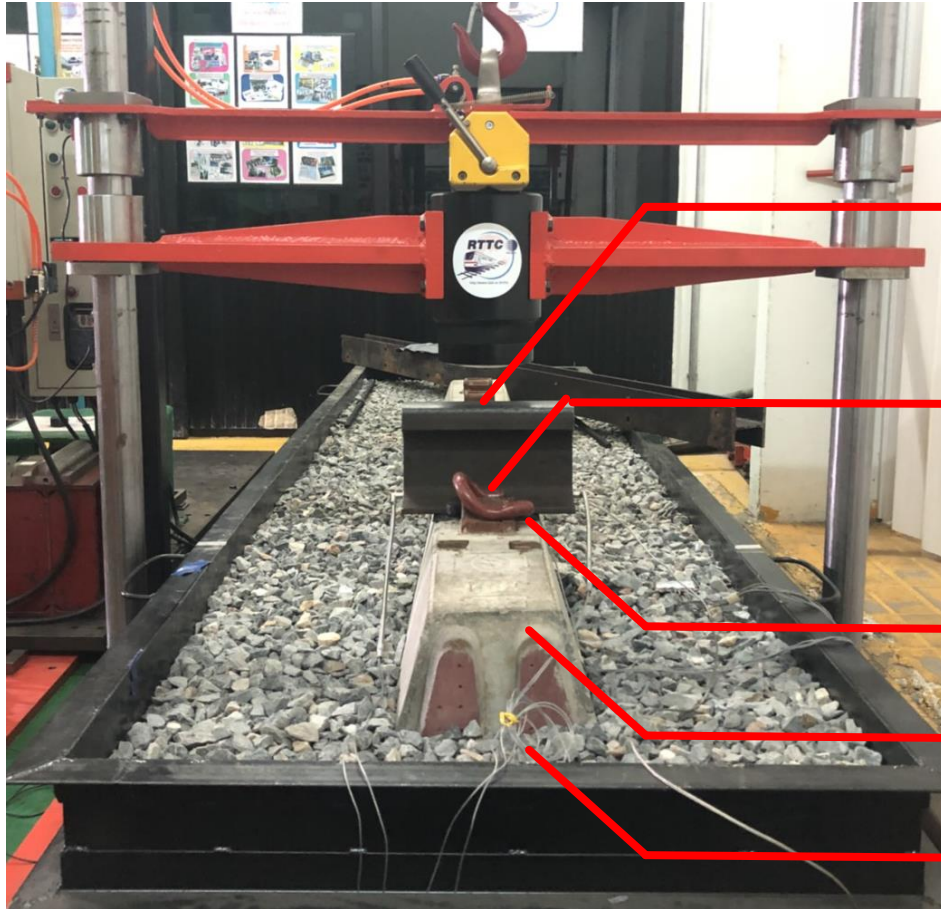


Rail pad





# Railway component



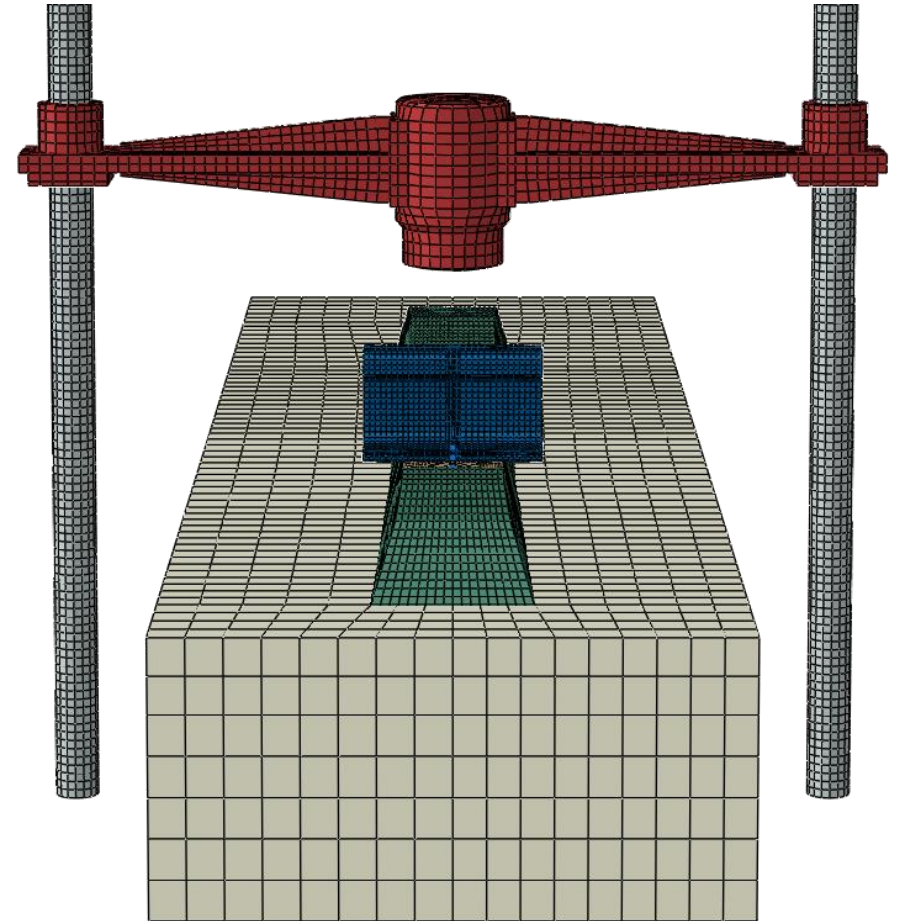
**Rail**

Elastic  
rail clip

Rail pad

Sleeper

Ballast



# Rail testing EN:14587-3

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## EN:14587

**Railway applications –  
Track – Flash butt welding  
of rails**

**Part 3: Welding in  
association with crossing  
construction**

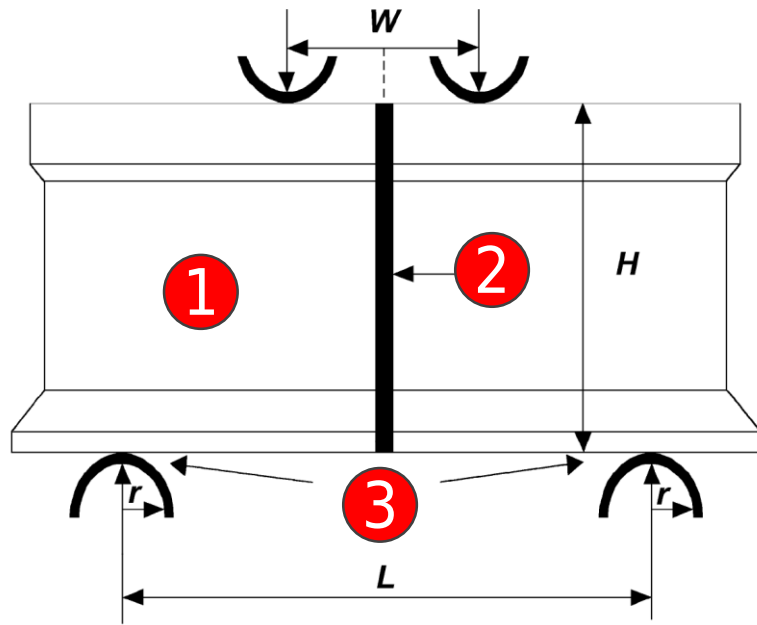
## Scope

the fatigue strength distribution of  
a weld at endurance of five million  
cycle





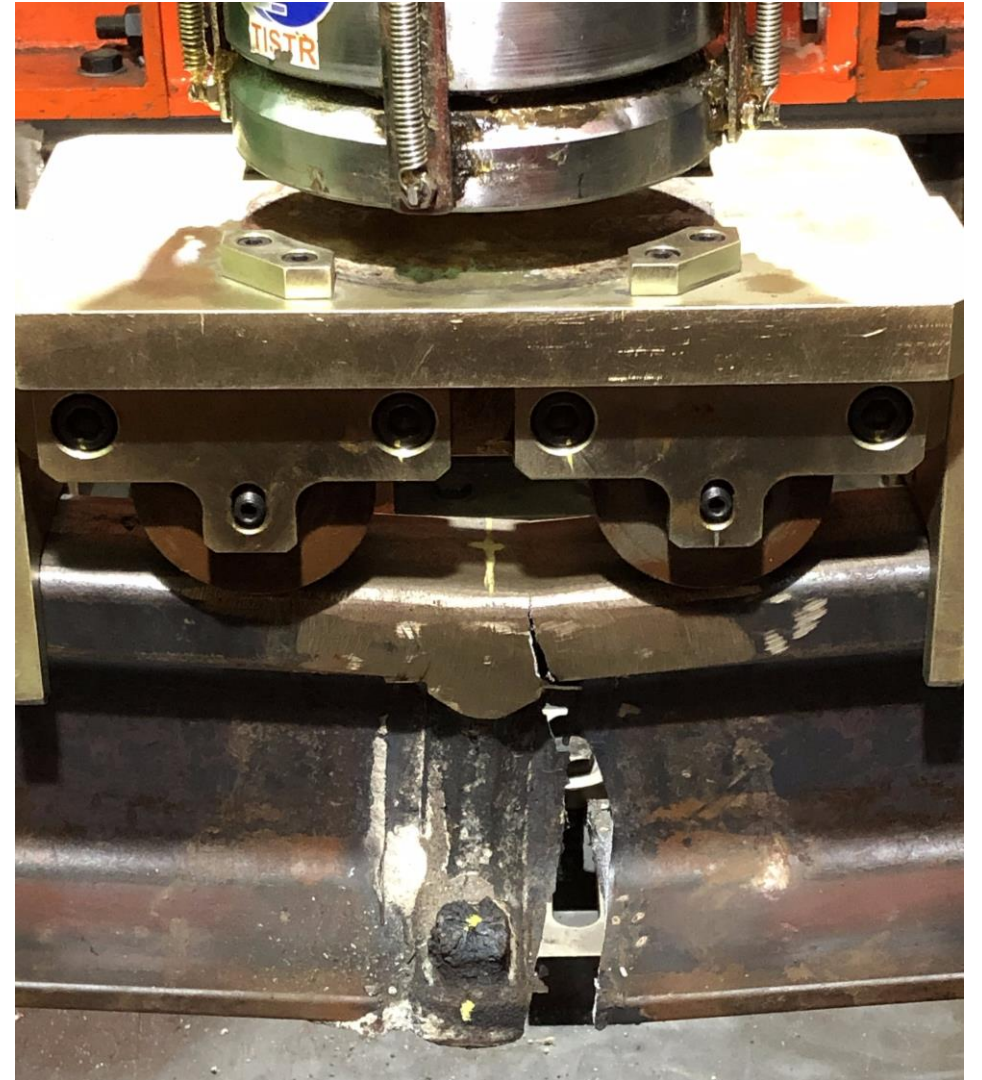
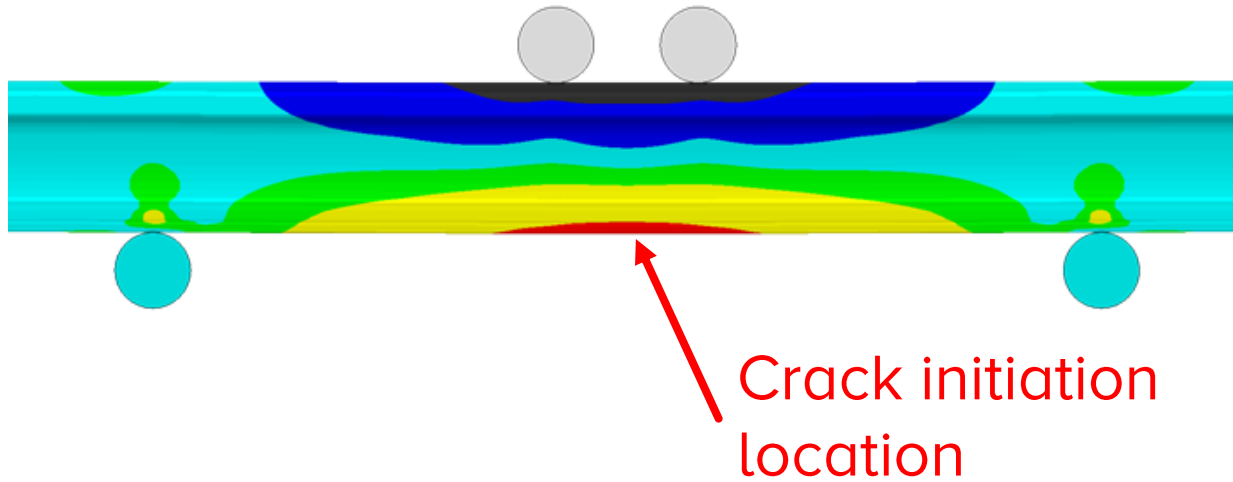
# Fatigue of flash butt welded joint of rail EN:14587



- ① Rail or casting
- ② Weld (s)
- ③ Bearers

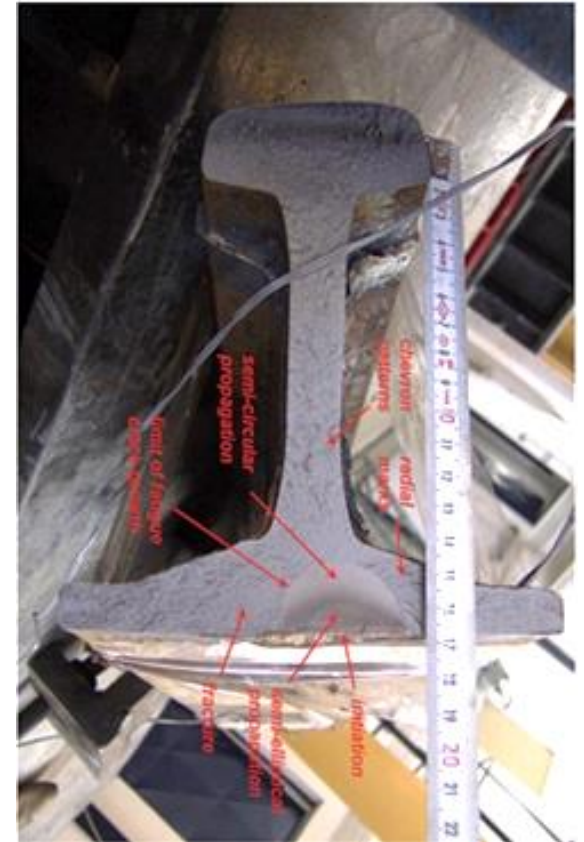
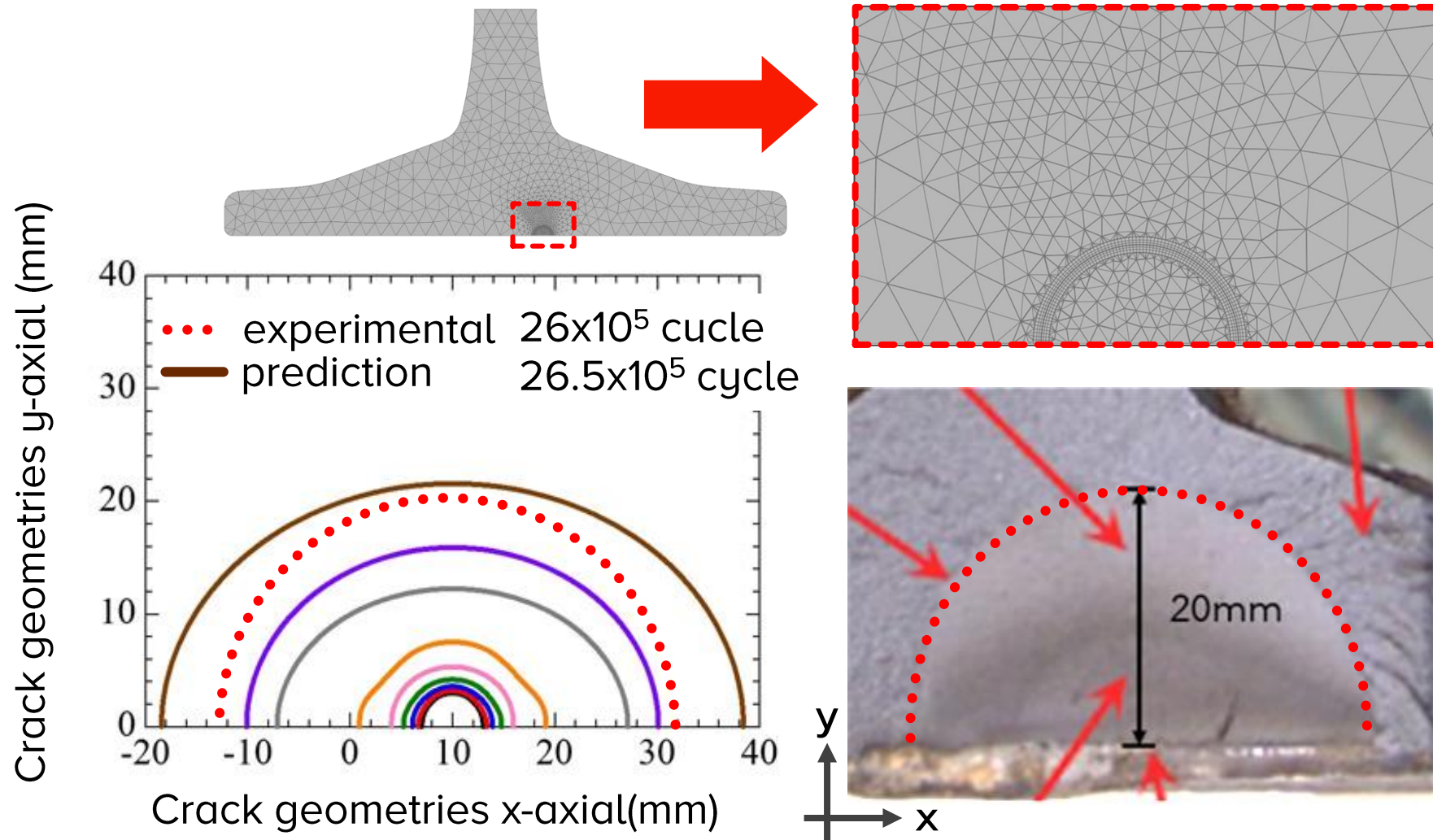


# Crack path and fatigue life prediction



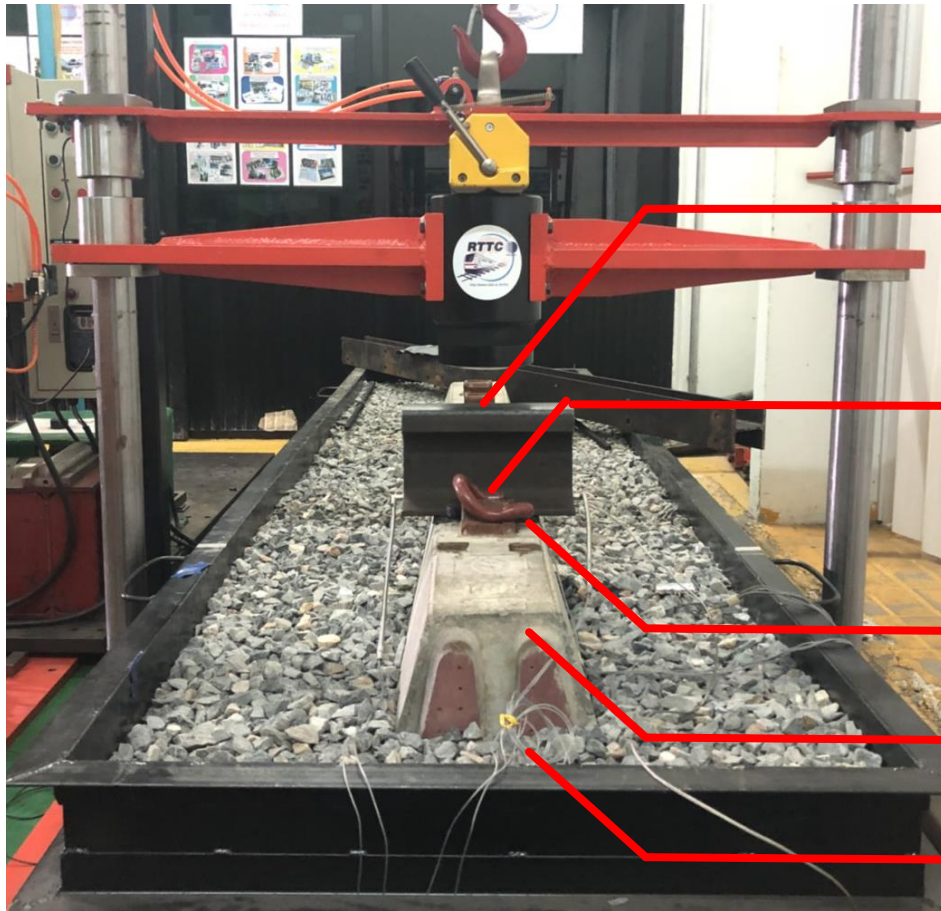


# Crack path and fatigue life prediction



**Ozakgul et al.  
(2010)**

# Railway component



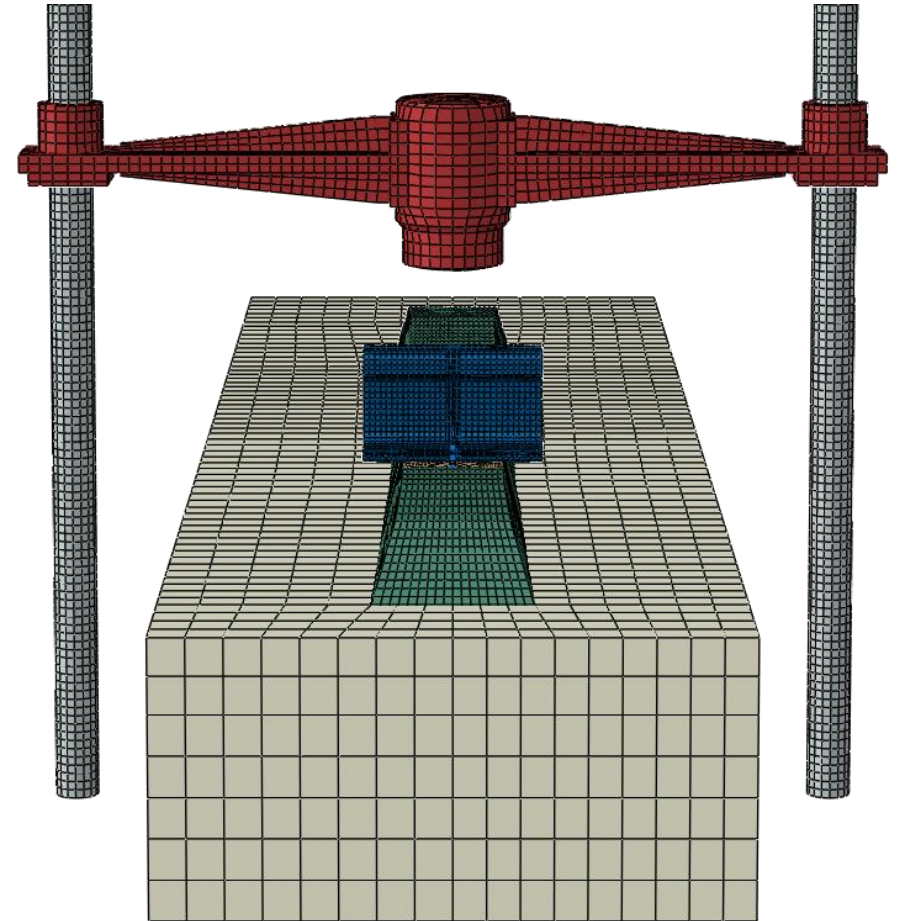
Rail

Elastic  
rail clip

Rail pad

Sleeper

Ballast





# elastic rail clip testing EN:13146-7

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## EN:13146

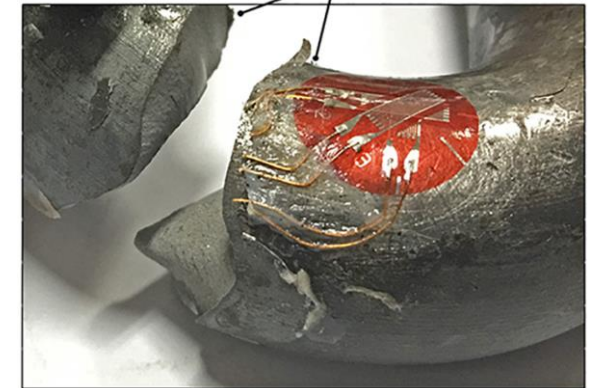
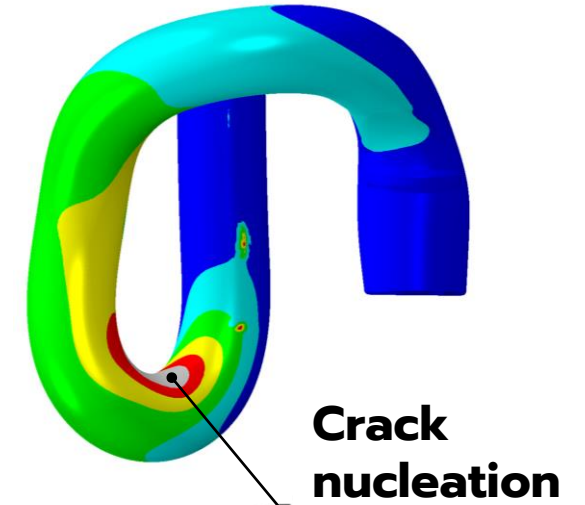
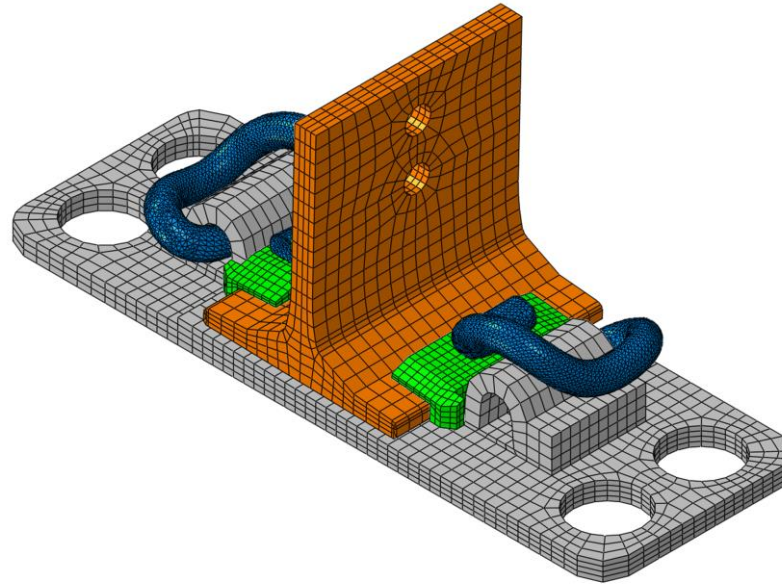
### Railway applications – Track – Test methods for fastening systems

#### Part 7: Determination of clamping force

#### Scope

measuring the clamping force  
exerted by the fastening system  
on the foot of a rail

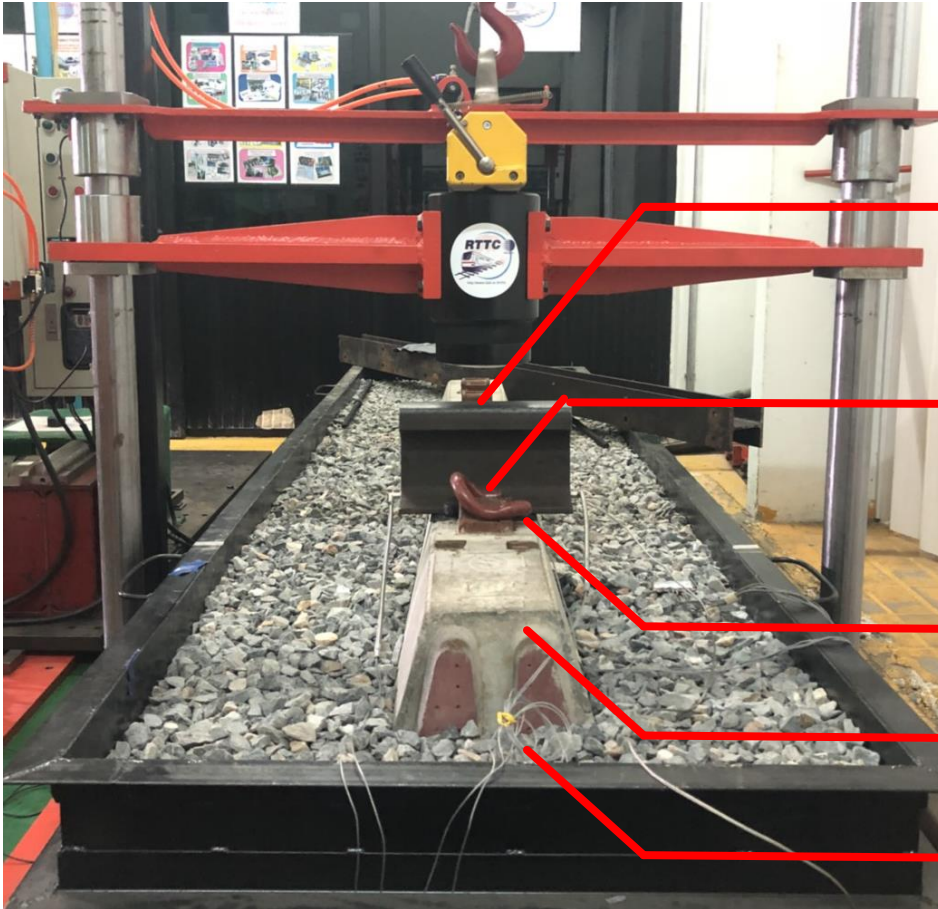
# Fatigue testing of elastic rail clip



1. Influence of toe load on the fatigue resistance of elastic rail clips, **Journal of Rail and Rapid Transit** (2018)
2. Analysis of the fatigue performance of elastic rail clip, **Engineering Failure Analysis** (2018)



# Impact testing system EN:13146



Rail



Elastic  
rail clip



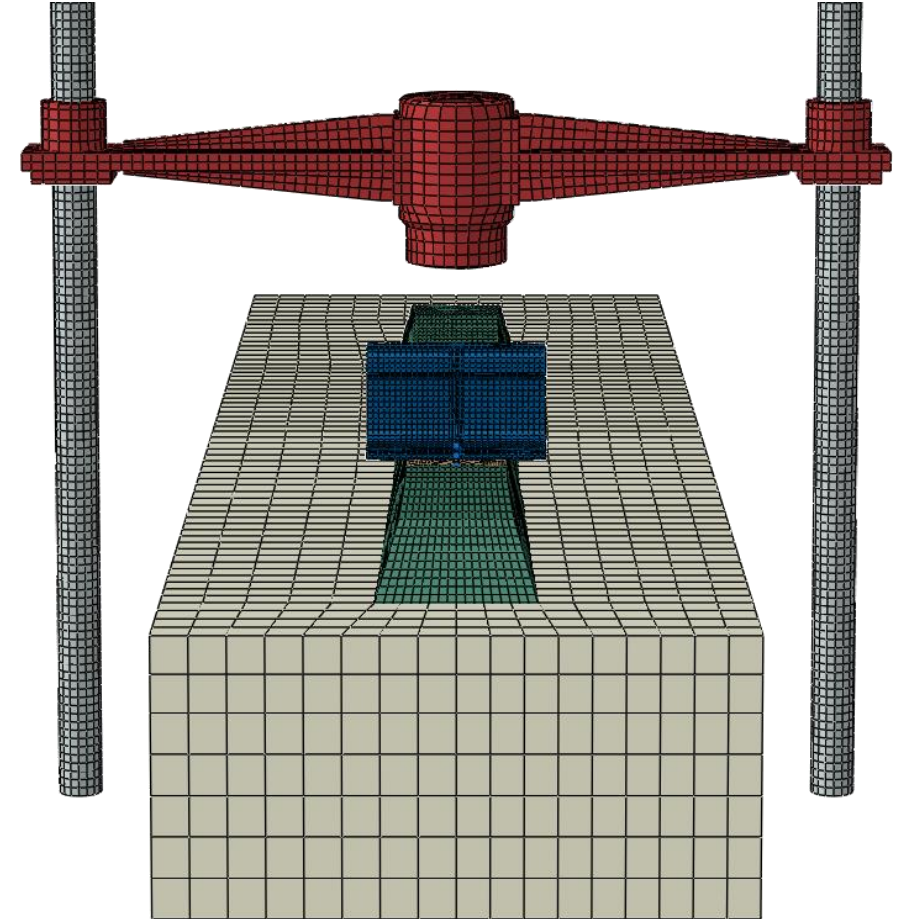
Rail pad



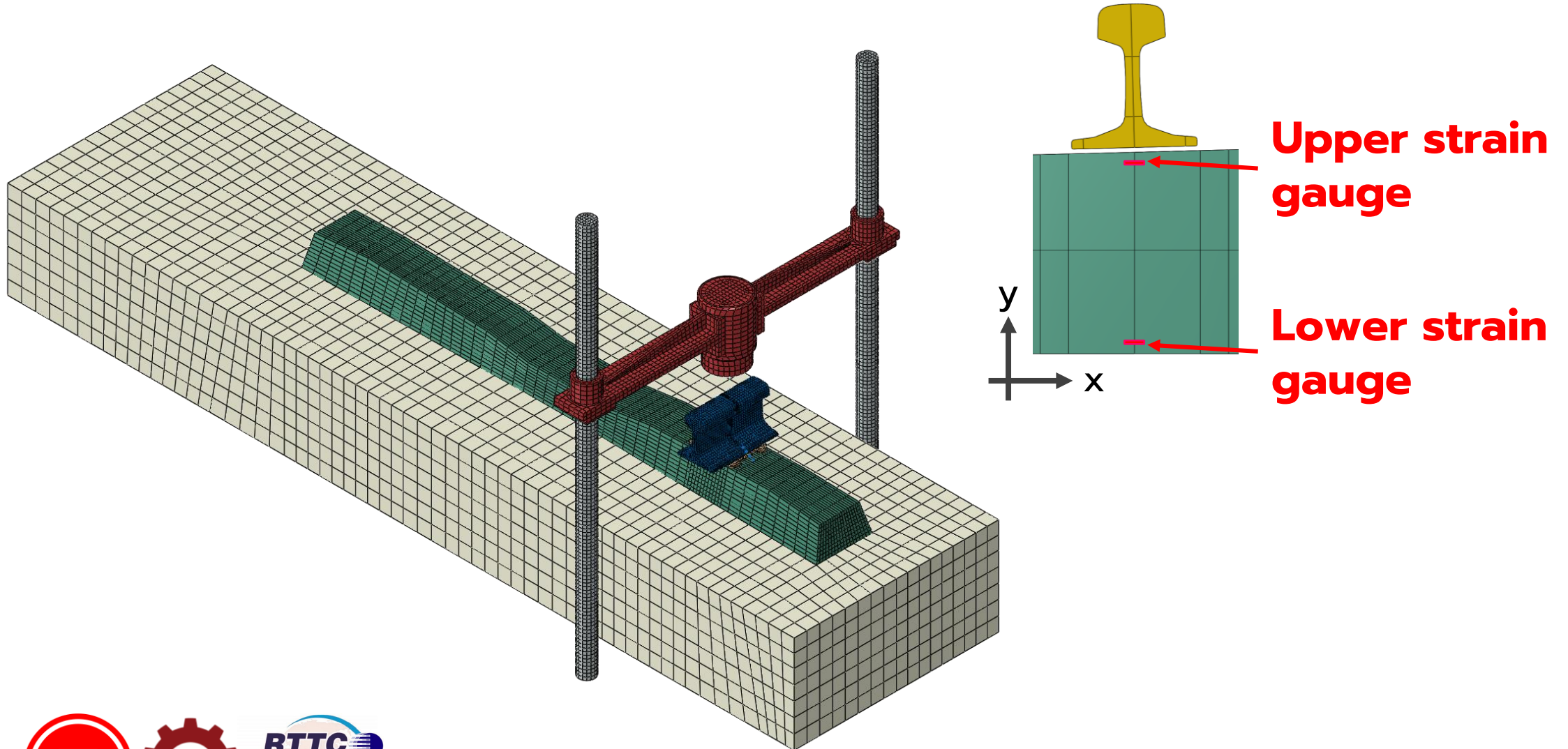
Sleeper



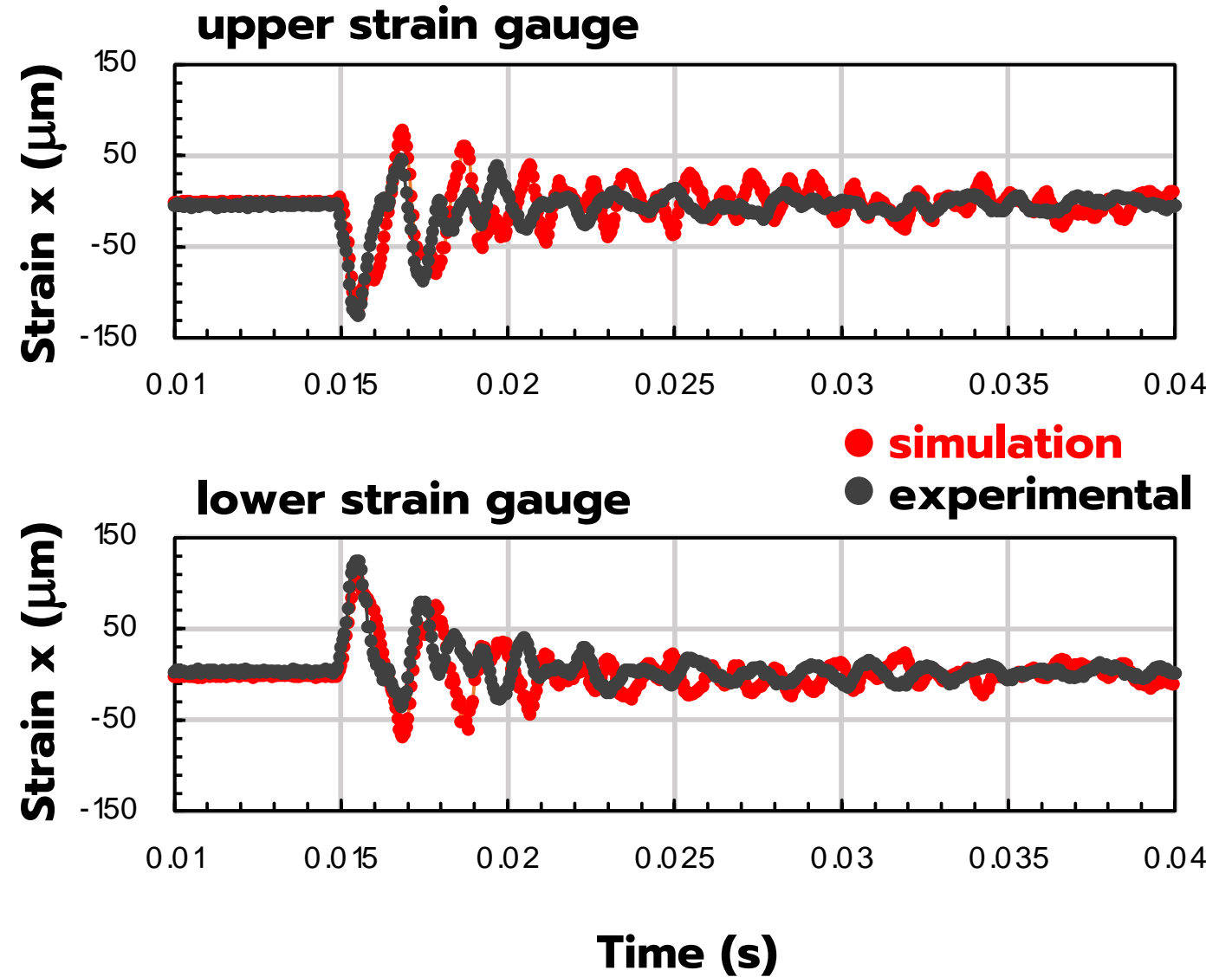
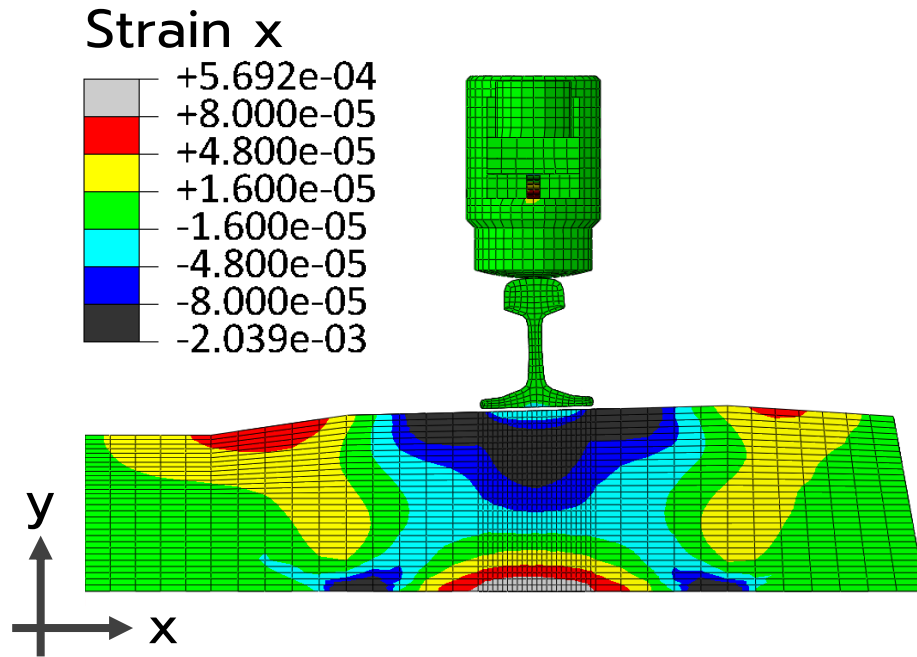
Ballast



# Impact testing system EN:13146



# Simulation result



# Topic

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- Overview of railway track
- Standard Test and simulation
- Advantage of simulation
- Conclusion



# Advantage of simulation

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- Expand testing result



- Simulation tell us why failure occur



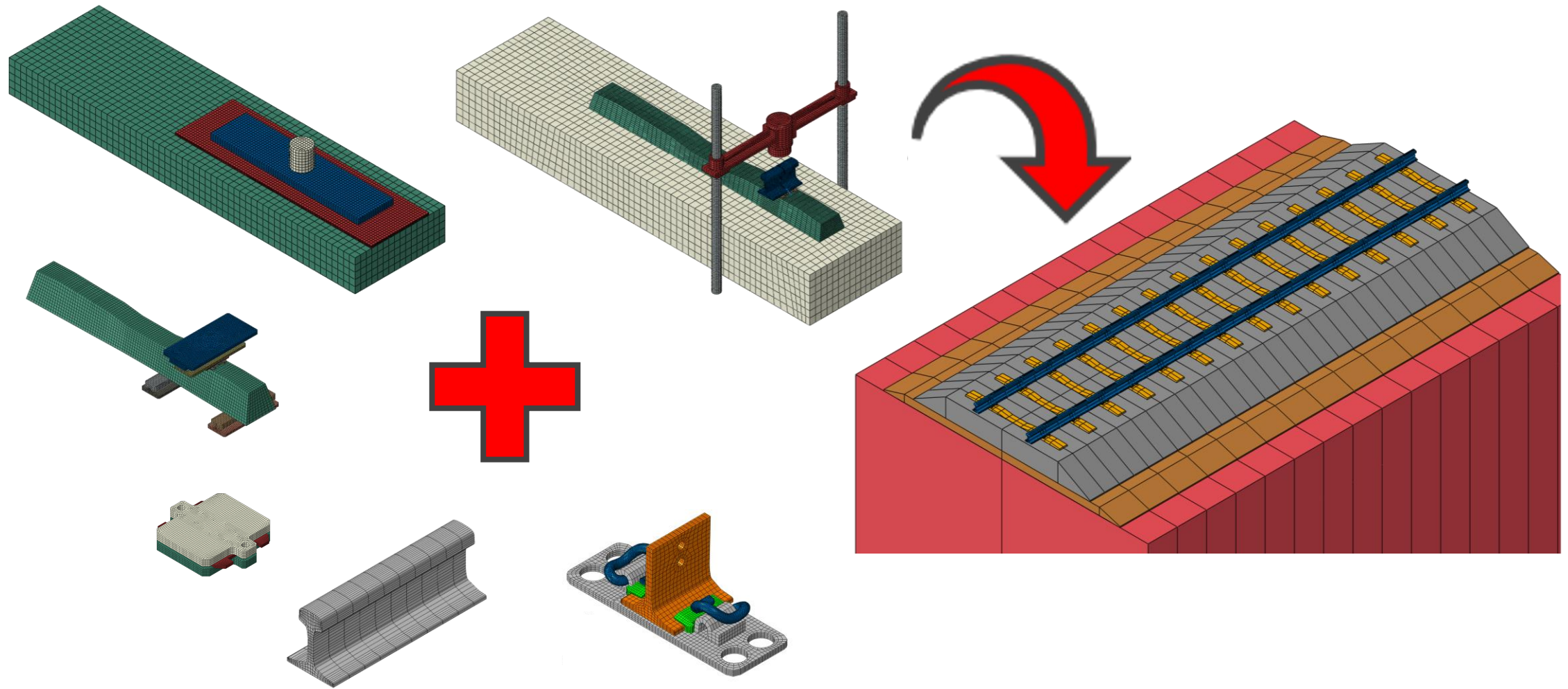
- Save time and cost of design and testing



- Simulation make us understand all perspective



# Next





# Topic

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- Overview of railway track
- Standard Test and simulation
- Advantage of simulation
- Conclusion

# Conclusion:

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- Impact of railway test system: experimental and simulation
- Ballast analysis: stiffness, damping and natural frequency by experiment and simulation
- Crack propagation and life prediction at rail weld joint
- Effect of toe-load on rail pad stiffness and damping

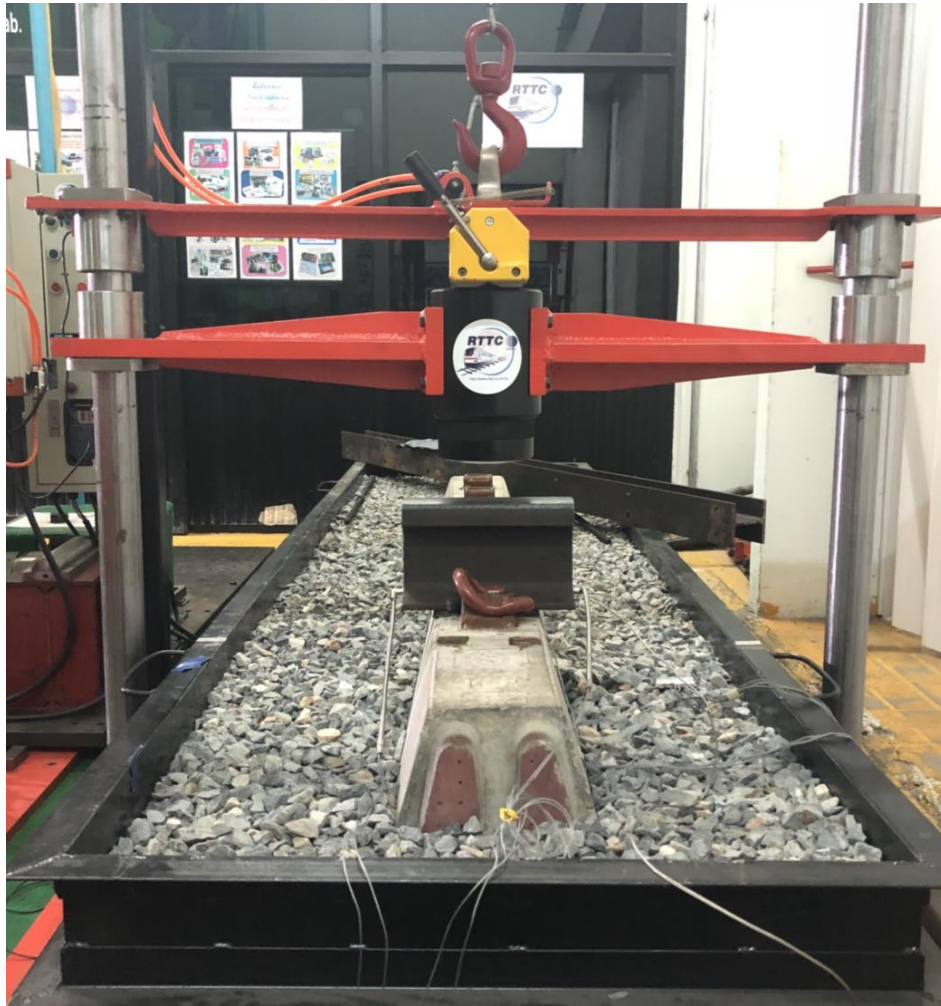


# Thank you

## Q&A



# Impact testing system EN:13146



**EN:13146**

**Railway applications – Track –  
Test methods for fastening  
systems**

**Part 3: Determination of  
attenuation of impact loads**

**attenuation = stiffness, damping**



**stiffness,  
damping**

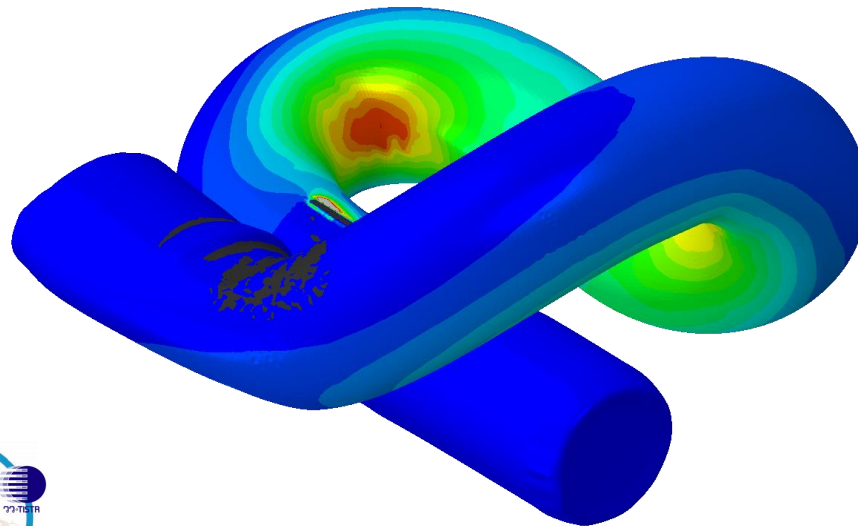
**Rail pad**

**Ballast**



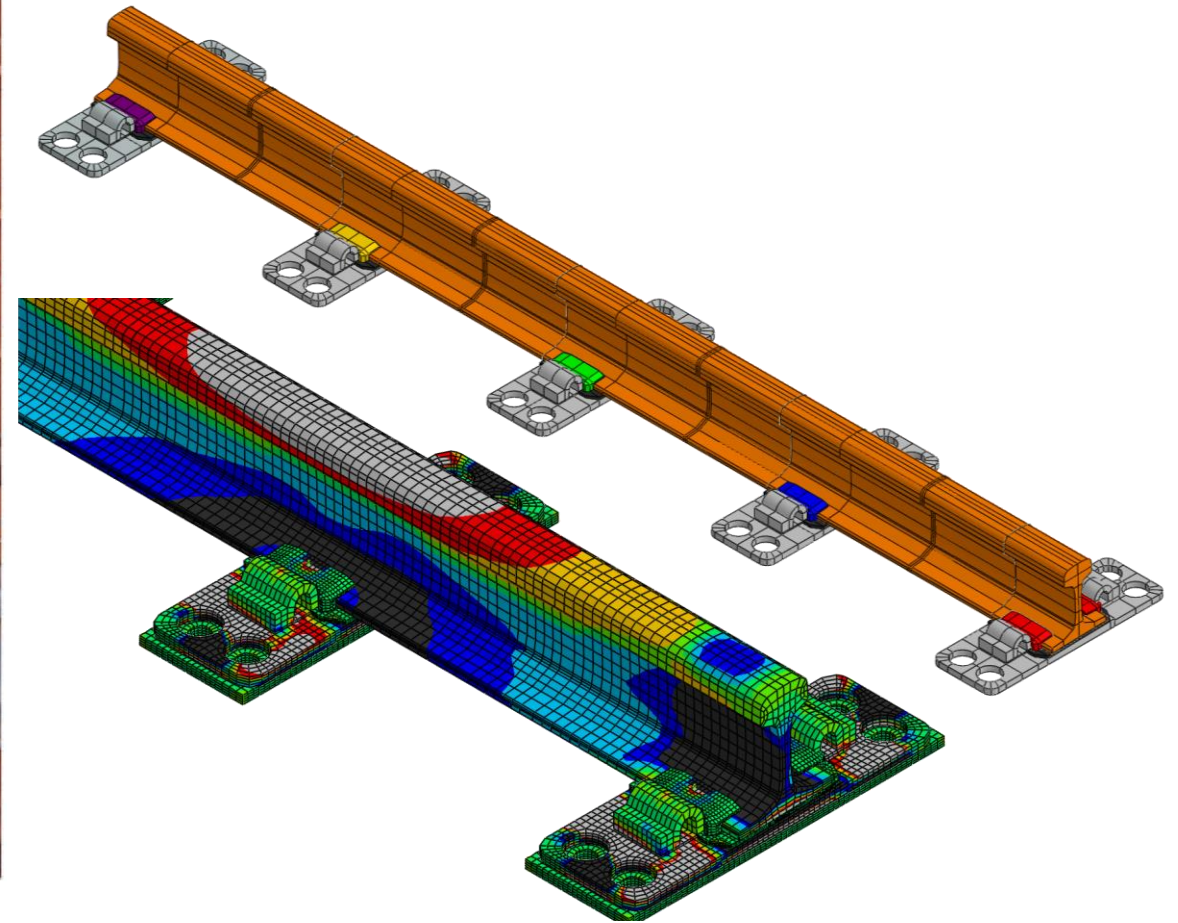
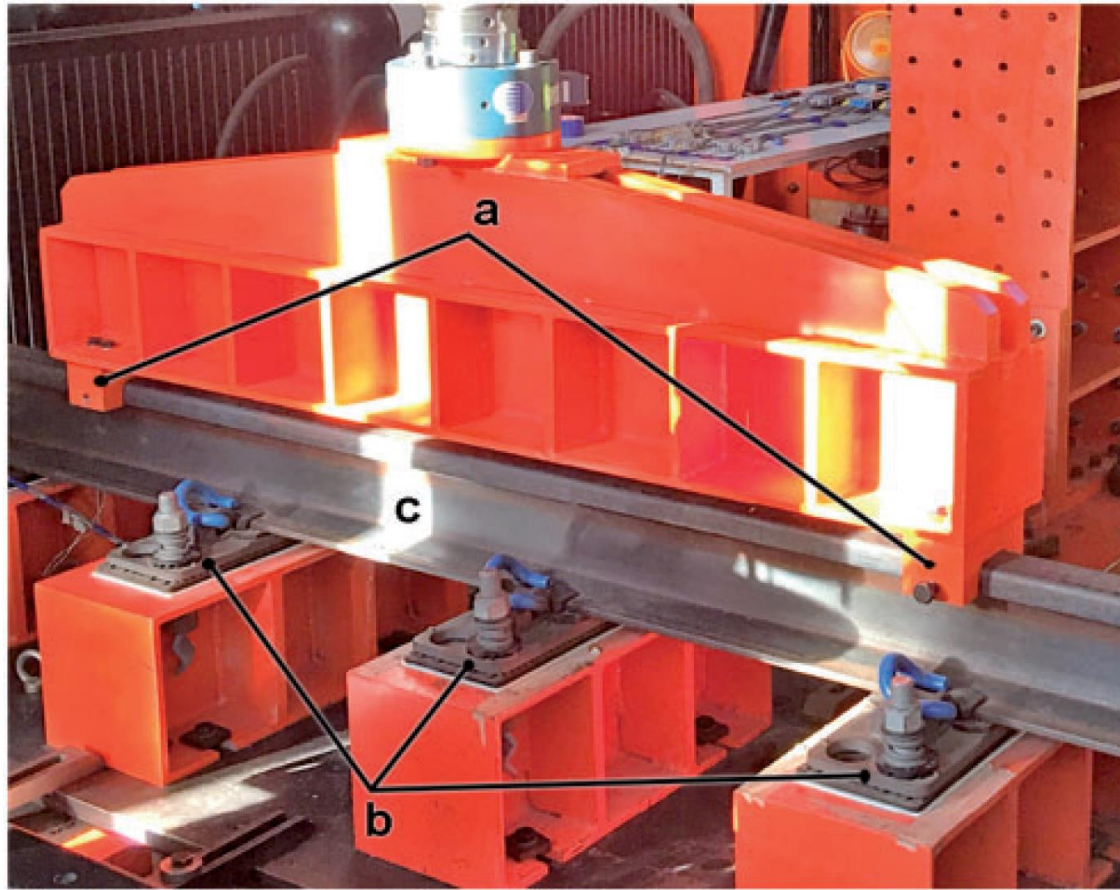


# Stress analysis of elastic rail clip





# Stress analysis on elastic rail clip



**Ref:** Influence of toe load on the fatigue resistance of elastic rail clips

A Hasap, P Paitekul, N Noraphaiphaksa, C Kanchanomai

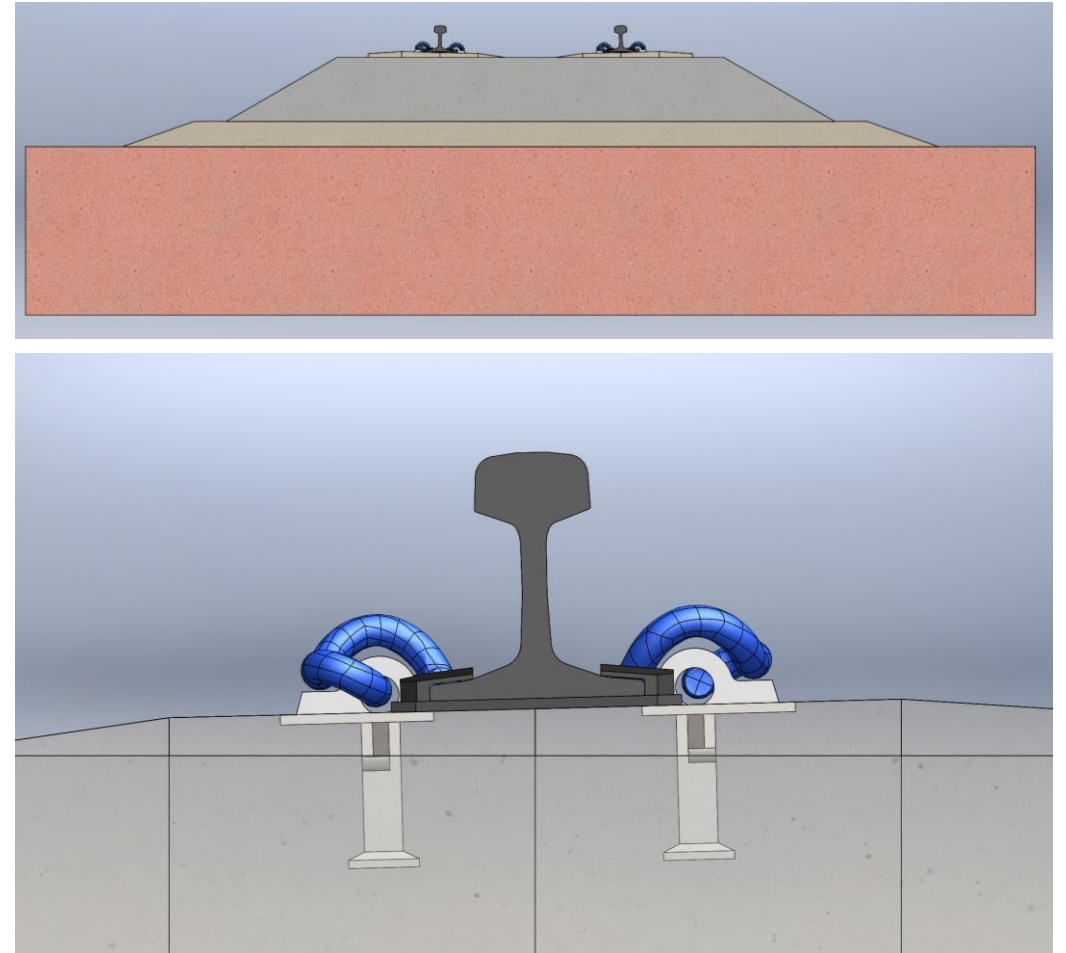
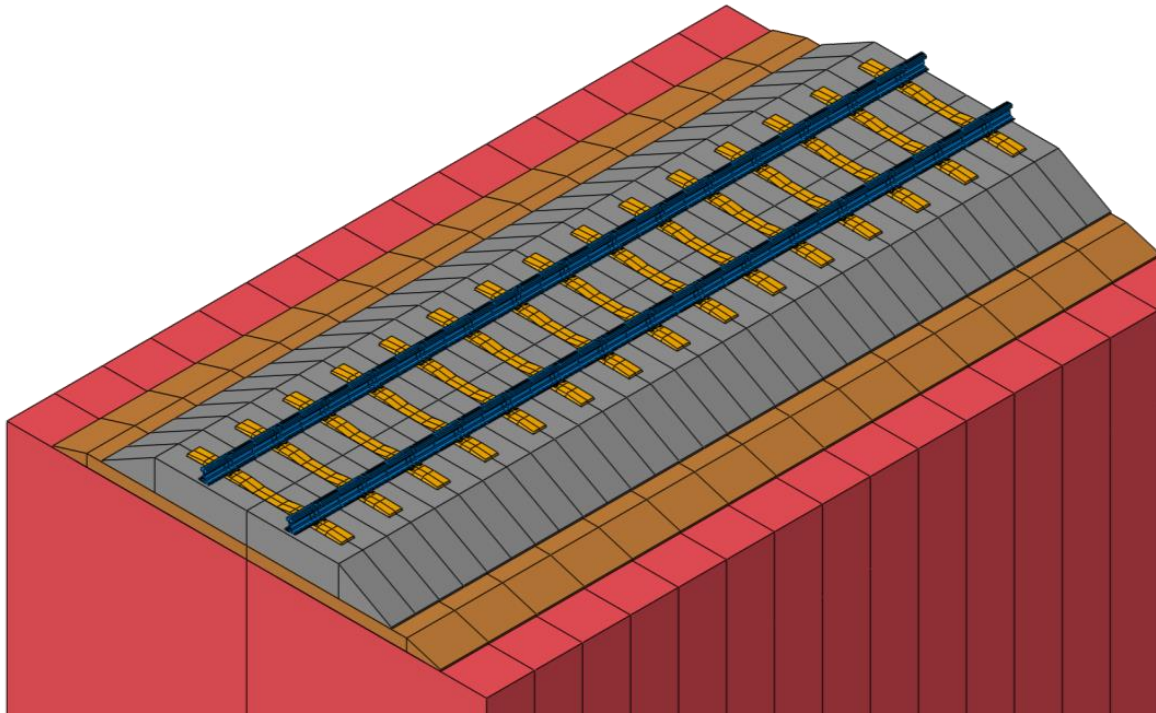
Proceedings of the Institution of Mechanical Engineers, Part F: Journal of ...





# Deformation and stress analysis on ballast railway

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Reference	Stewart and Selig (1982)	Stewart and Selig (1982)	This Study
Study	Parametric-Numerical	Representative-Numerical	Base Model-Finite Element
Program	GEOTRACK	GEOTRACK	ABAQUS
Rail E (MPa)	207,000	207,000	207,000
Rail I <sub>z</sub> (m <sup>4</sup> )	$0.395 \cdot 10^{-4}$	$0.395 \cdot 10^{-4}$	$0.132 \cdot 10^{-4}$
Sleeper E (MPa)	3,400–20,700	10,300 (wood)	10,300 (wood)
Sleeper Size (l, t, w) (m)	2.59 x - x 0.229	2.59 x - x 0.229	2.6 x 0.18 x 0.229
Sleeper I <sub>z</sub> (m <sup>4</sup> )	$1.07 \cdot 10^{-4}$	$1.07 \cdot 10^{-4}$	$1.11 \cdot 10^{-4}$
Sleeper s (m)	0.245–0.914	0.495	0.495
Ballast E (MPa)	173–689	310	290
Ballast v	0.1-0.49	0.3	0.3
Ballast t (m)	0.38-0.53	0.38	0.38
Subballast E (MPa)	31–126	N/A	100
Subballast v	0.4	0.4	0.4
Subballast t (m)	0.15 & 0	0.15	0.15
Subgrade E (MPa)	31–126	55	50
Subgrade v	0.4	0.4	0.4
Subgrade t (m)	> 0.91	> 0.91	6
Wheel Load (kN/#axels)	22–146 / 4-axel	142 / 4-axel	89-175 / 4-axel

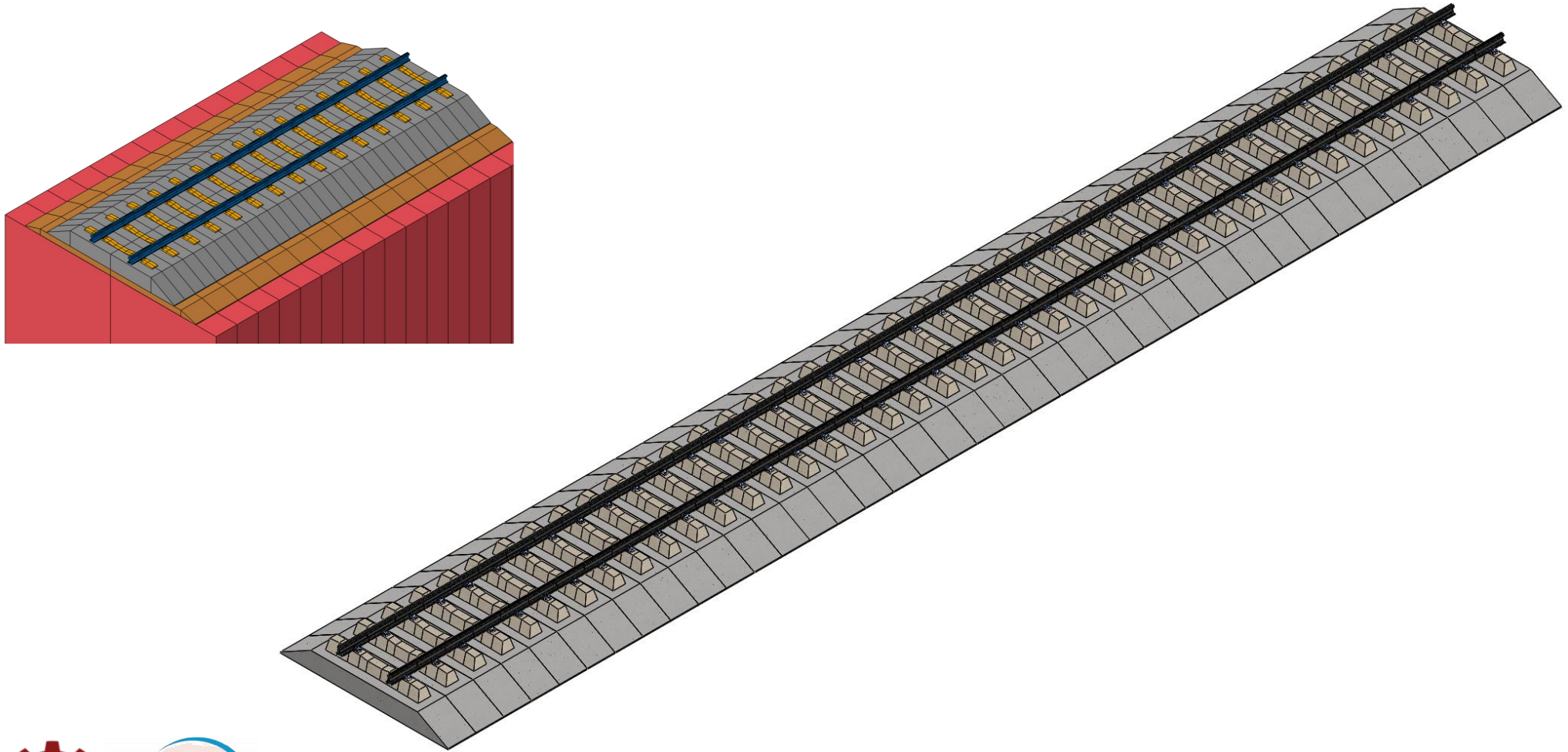
parameter	NRP, TSE, TISTR model
Study	FE-model
Program	ABAQUS
Rail E (MPa)	207000
Sleeper E (MPa)	28300
Sleeper size (m)	2 x 0.2 x 0.272
Ballast E (MPa)	290
Ballast v	0.3
Ballast t (m)	0.38
Subballast E (MPa)	100
Subballast v	0.4
Subballast t (m)	0.15
Subgrade E (MPa)	50
Subgrade v	0.4
Subgrade t (m)	6
Wheel load (kN/#axels)	200 / 4-axel



Ref

# Rail track testing 40 m

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# Multi-Body Simulation of train

