INTERNATIONAL UNION
OF RAILWAYS

STABLETRACK - IRS 70720

Laying and Maintenance of Tracks with CWR

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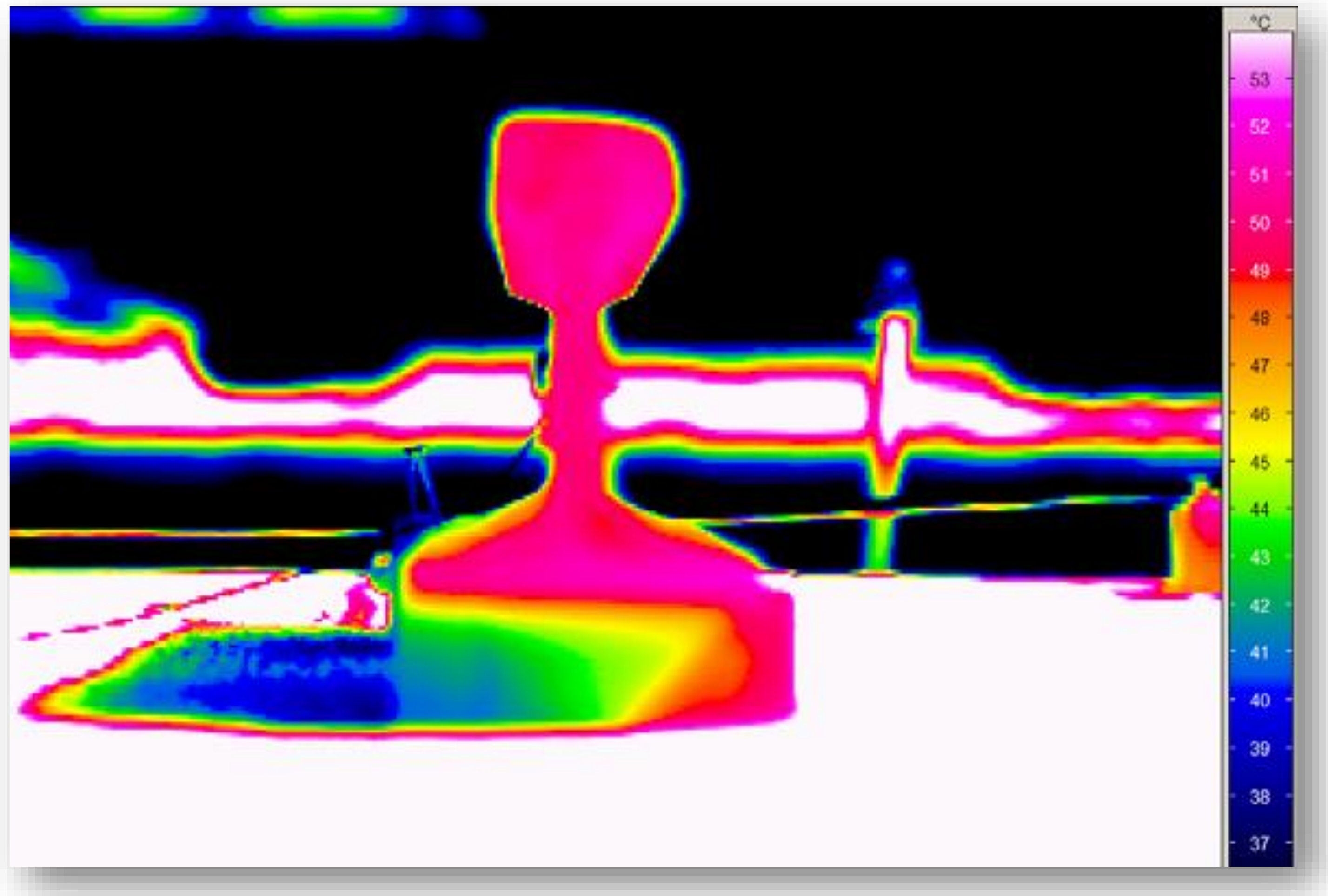
Increasing Capacity and Availability: Technology – Efficiency - Environment

24th International Convention of the Working Committee on Railway Technology - ÖVG

Stabletrack - Project

Change in world climate

high rail temperatures



track buckling

Revision of **IRS 70720** Laying and Maintenance of Tracks with CWR

Finnish Transport Infrastructure Agency

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ÖBB INFRA

SBB CFF FFS

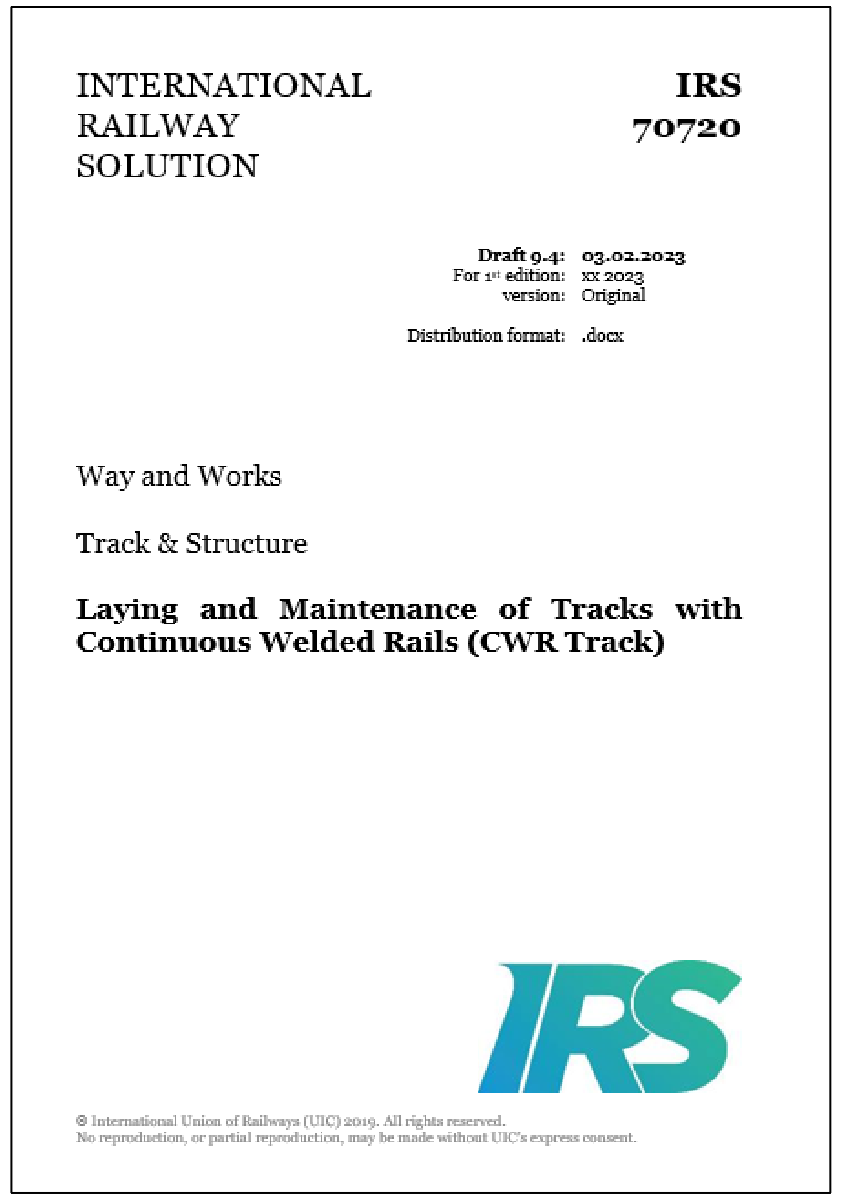
INFRABEL Right On Track

SNCF

BANE NOR

ProRail

Application of IRS 70720


INTERNATIONAL RAILWAY SOLUTION

IRS 70720

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Way and Works

Track & Structure

Laying and Maintenance of Tracks with Continuous Welded Rails (CWR Track)

A consensus document, applied on a voluntary basis, intended to facilitate and harmonise railroad operations…

- …replacing the UIC leaflets
- …do not have the force of law, but is technical approved
- …full technical legitimacy in the railroad sector

<u>This IRS 70720</u>

……contains **guidelines for the design** and **installation** of **ballasted tracks with continuously welded rails (CWR)** and for their **maintenance** (1435mm)….

It remains the **sole responsibility** of the **Infrastructure Manager (IM)** to determine the **appropriate track design**, as well as to establish internal regulations for the installation and monitoring of stable tracks **based on the specifics** of each IM's <u>own infrastructure</u>, the <u>existing temperatures</u> in the rails, and its own <u>maintenance policy</u>.

Application of IRS 70720

What is a CWR track?

- Track, in which the **expansion and contraction of the rails** are constrained
- **Longitudinal forces** are induced in the rails **due to temperature change**
- The “**breathing length**” depends on the rail profile, the sleeper type, the fastening system and the longitudinal and lateral resistance of the ballast

Managing CWR track can only be provided, if the **key-parameters** are well known, monitored and proper maintained over the entire service life of the track.

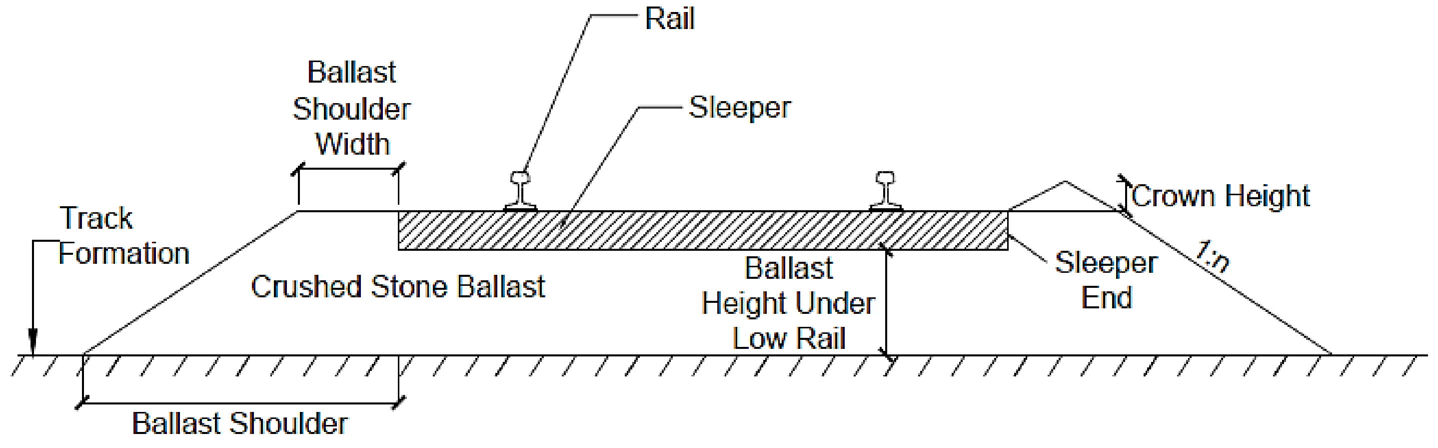
Key parameters influencing LTR and LTS

Track Panel

- Rail profiles (cross-section), fastenings, sleepers

Ballast

- profile, shoulder, degree of ballast filling in the crib, thickness, quality, stone material, shape and size, fraction, contamination level, degree of compaction/consolidation



Track Geometry

- Track alignment, curve radius, track geometry defects/ misalignment, gauge variation, gradients/slopes

Temperatures in track

- Neutral temperature and critical (buckling) temperature $T_{b,min}$ and $T_{b,max}$

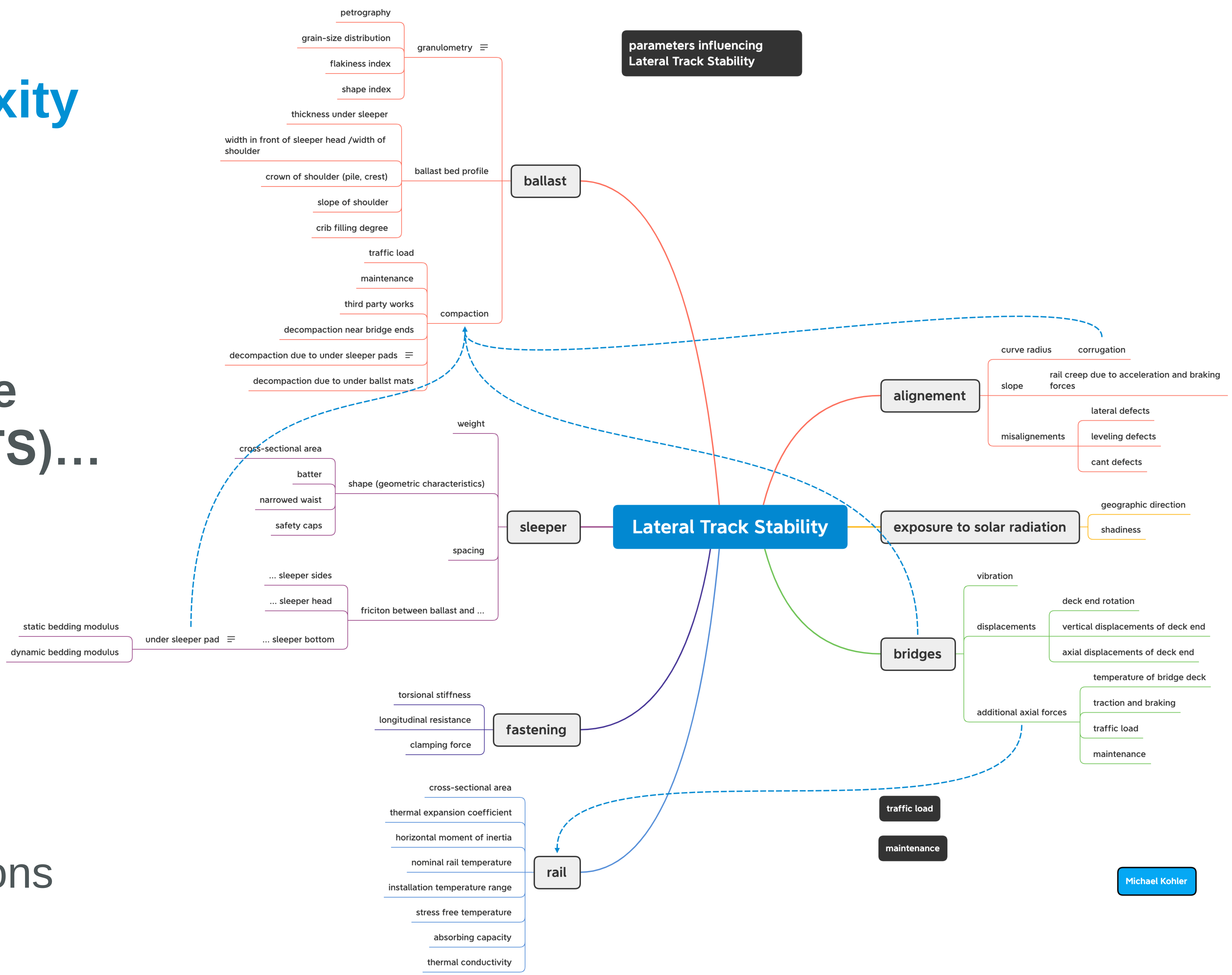
Complexity of Stable Tracks

Overview over the complexity of CWR Track:

It gives **first indication** on the possible measures to influence **the Lateral Track Stability (LTS)…**

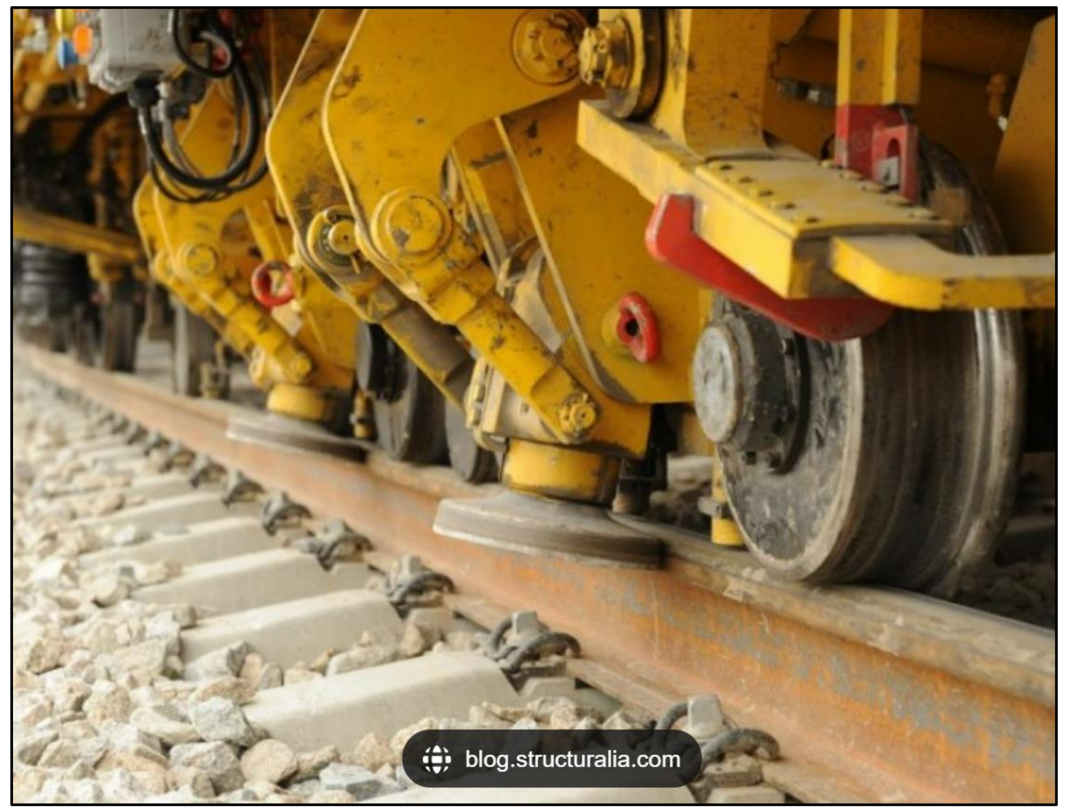
The **chart is based on**:

- the track components,
- their physical parameters and
- the external boundary conditions



Design of CWR tracks

IM'S GOAL: designing stable tracks



Ballast compaction

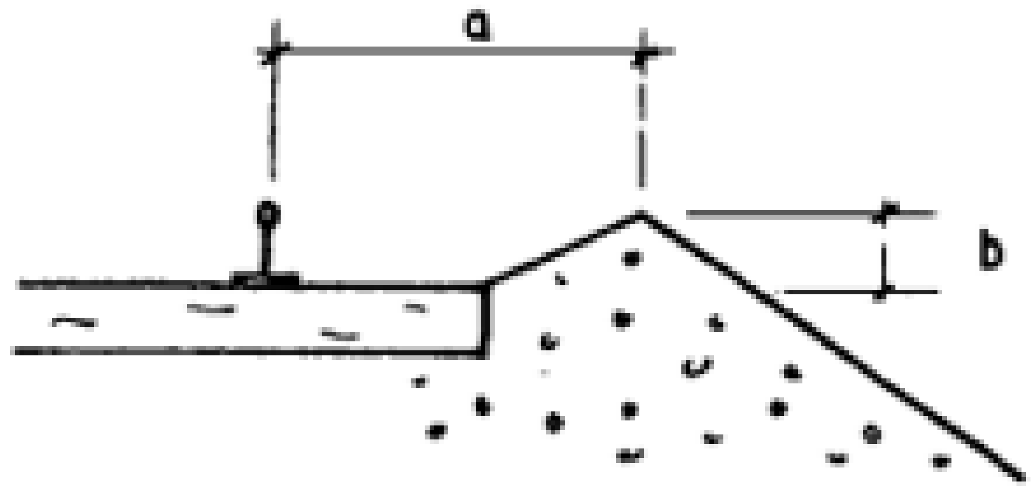
Technical requirements for design & installation

- From 60 m length

Adequate subgrade

Track geometry quality & rail wear

Rail fastenings: longitudinal & torsional resistance

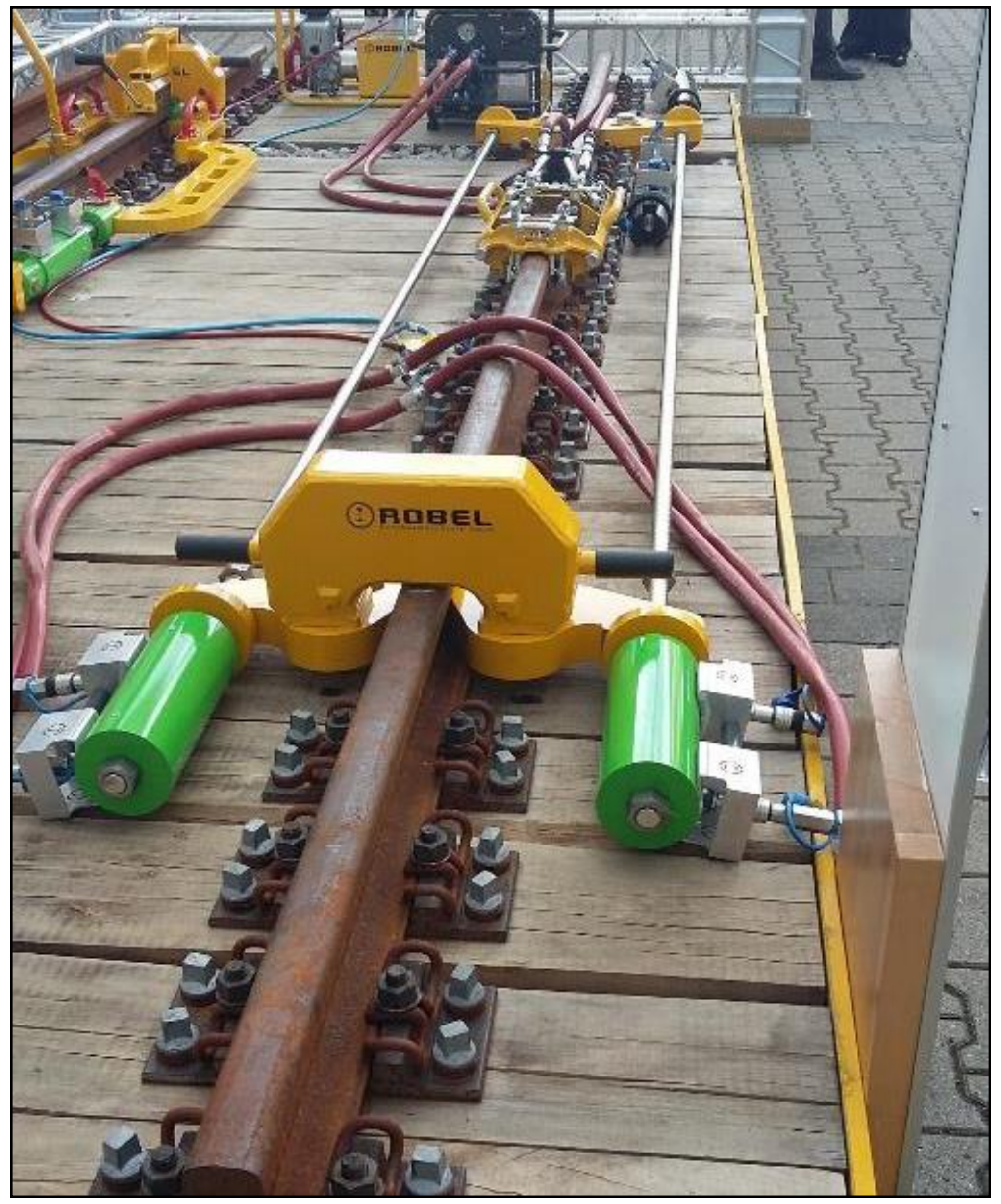


Ballast thickness & profile

Design of CWR tracks

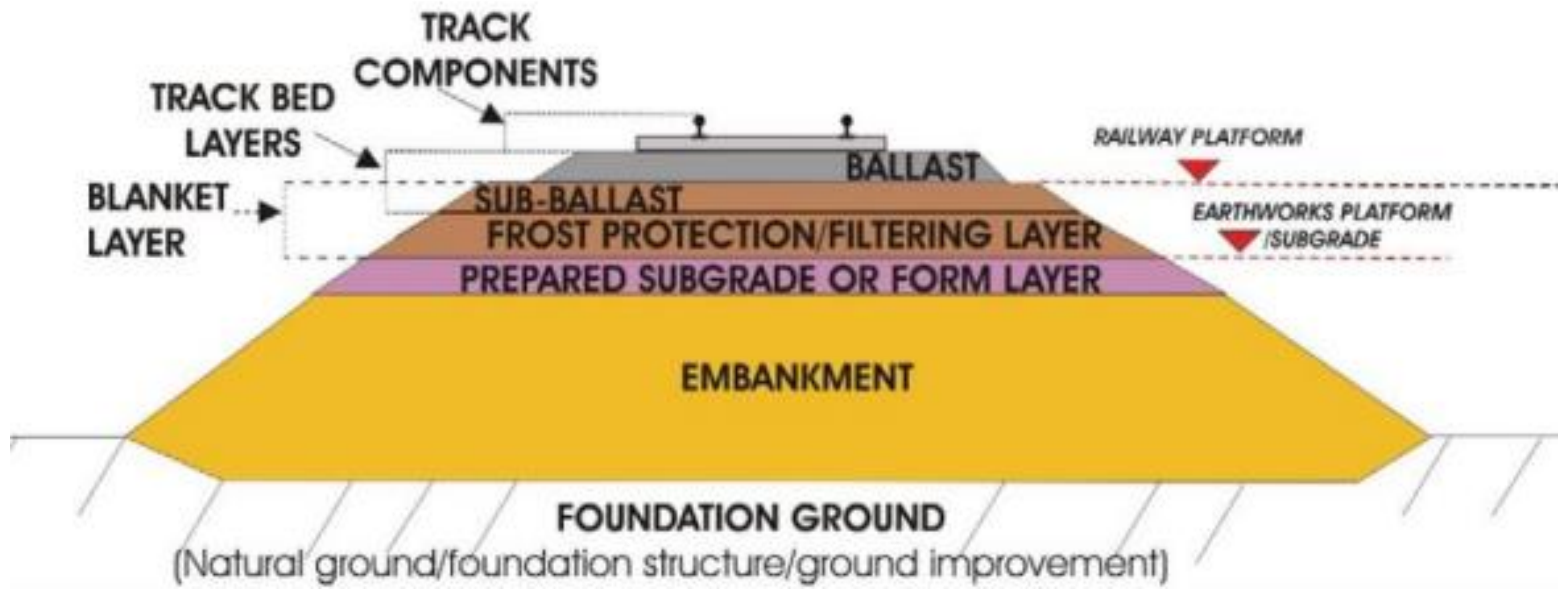
Neutralisation

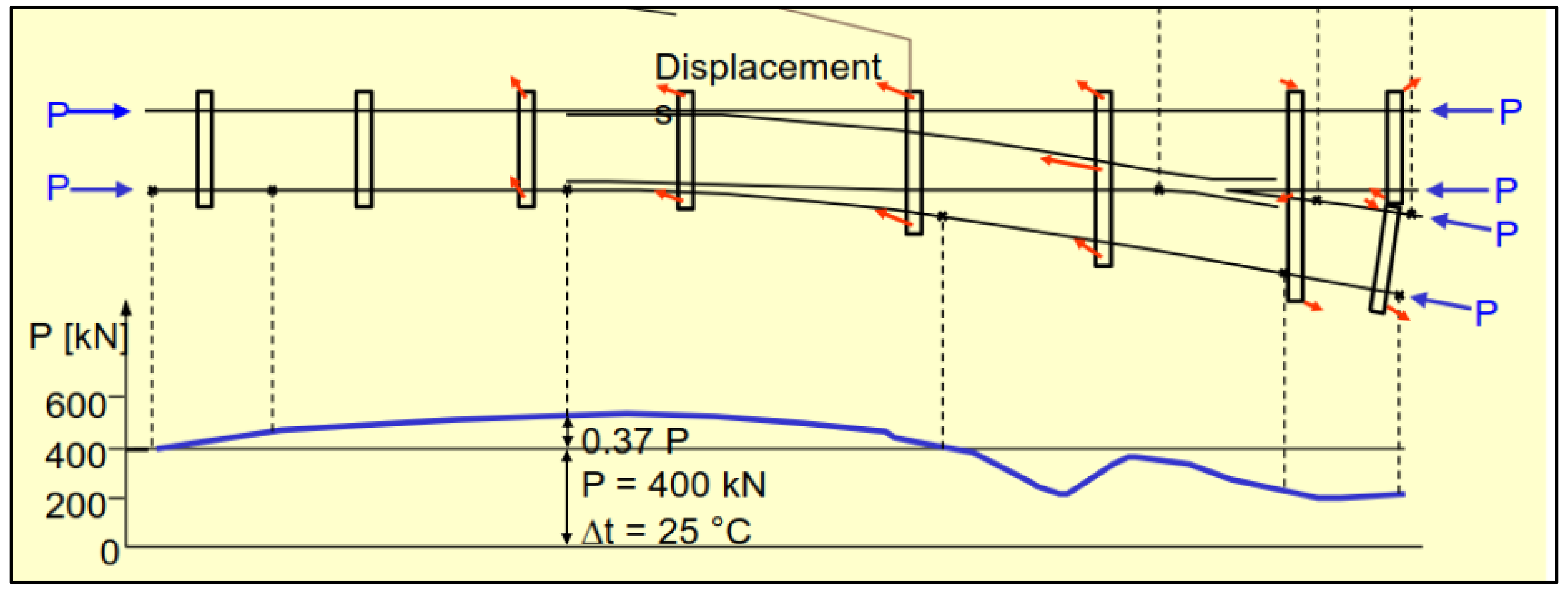
- **Crucial operation for stable CWR tracks**
- Installation at T_n (no thermal rail stresses)
- Rail stretching & welding
- Monitored and documented process



Design of CWR tracks

Singular points: changes in forces/stresses/lateral track resistance





Substructure

- Stability
- Bearing capacity
- Drainage

Switches & Crossings

- Different stiffness
- Additional stresses (additional rails)
- Faster destabilization (impact loads)

Tunnels

- Small impact inside the tunnel (uniform temperature)
- Stresses at tunnel boundaries

Design of CWR tracks

Singular points: changes in forces/stresses/lateral track resistance

Transition areas

- Fix vertical/lateral point
- Concentration of forces
- Multiple scenarios

(ballasted/non ballasted track, level crossings, change of sleeper / fastening / rail cross section…)

Bridges

- Ballasted/open deck
- Influence of the structure expansion
- Presence of expansion devices

Vehicles

- Dynamic effects
- Influencing features: axle load/spacing & speed

Maintenance of CWR Track

IM'S GOAL: keep/restore the track to perform the designed functions

CONFLICTING POINT

Maintenance works → affect compaction → reduce LTR

MAINTENANCE WORKS

- Ballast cleaning

- Tamping
- Ballast profiling
- Digging in or close to the track

Maintenance of CWR Track

NON DESTRUCTIVE TESTING DEVICES: to determine the stress-free temperature

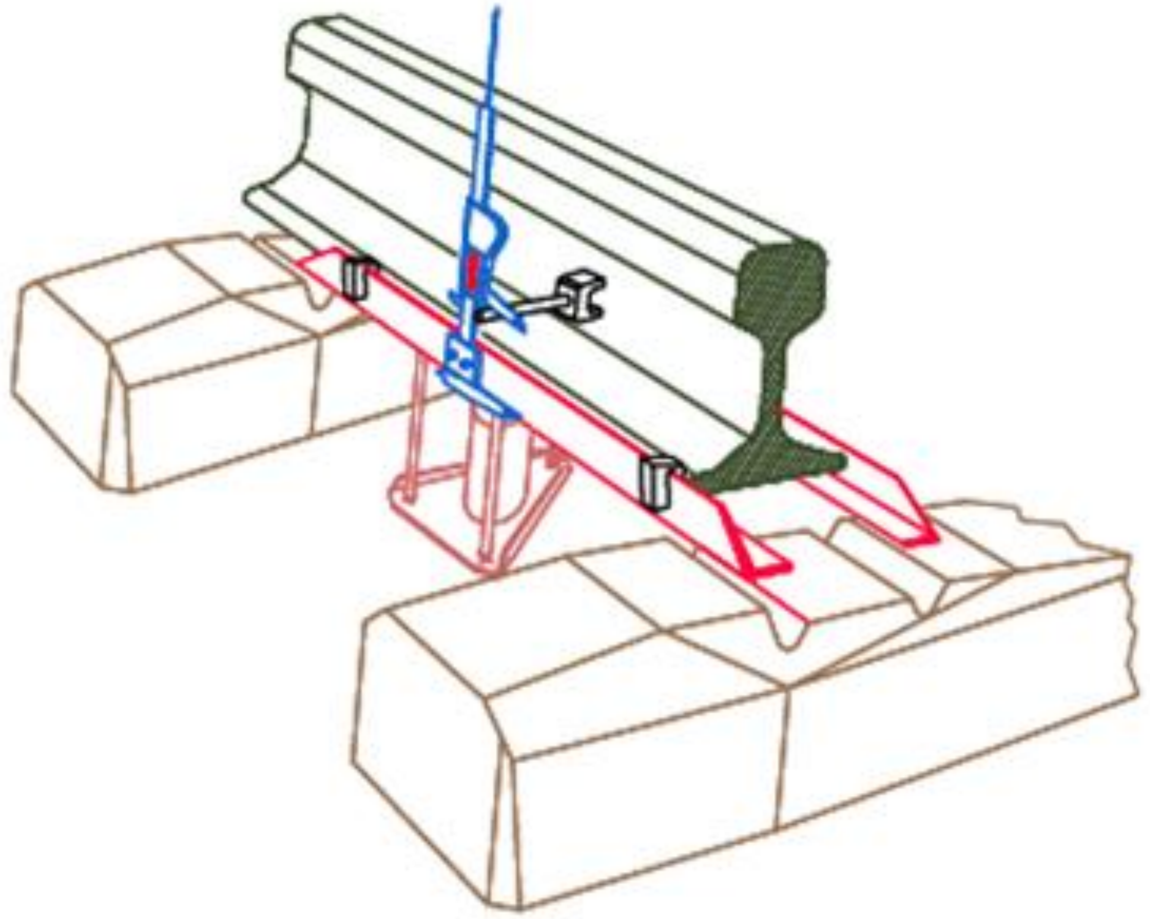
During operation/installation

Railscan

- Magnetic Barkhausen effect
- Robust/accurate
- No radius limitations
- Long time needed

Verse

- Beam theory on axial stresses
- Radius limitations
- Need for calibration
- Short time needed



Flexrail

- Similar to Verse
- More simple technology
- Adif development

Track stability calculation and assessment

Calculation methods for thermal buckling studied:

- **Meier +**
- **Prud`homme, Janin**
- **CWERRI + CW Safe –** reference calculation program for UIC Leaflet 720
- **Finite element methods** (GP Pucillo and RFI, SOFISTIK, ANSYS)

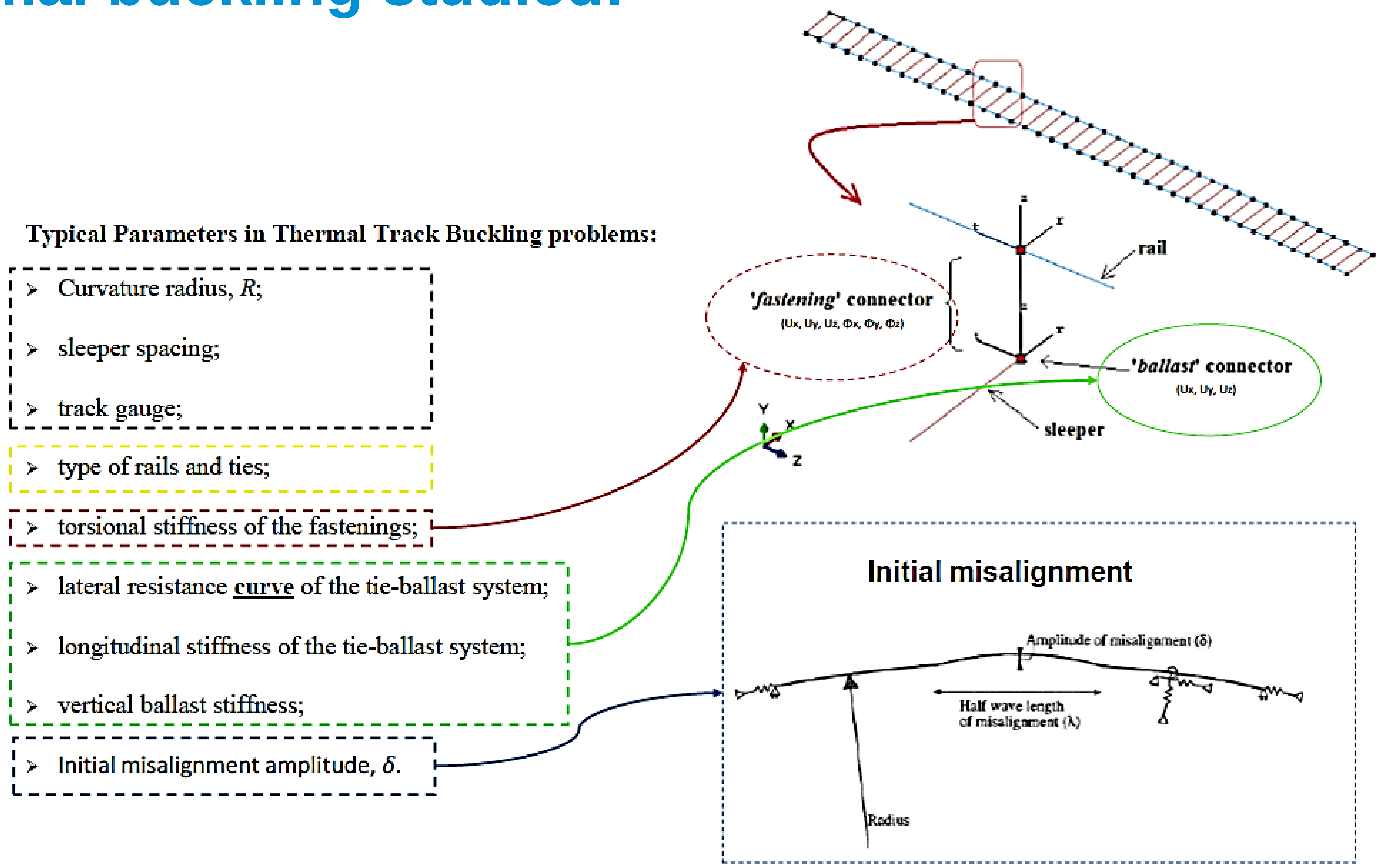


Figure 1 – Typical input parameters for buckling models.

Track stability calculation and assessment

Parameter comparison in the calculation of track stability:

		Prud` homme, Janin	CWERRI + CWR Safe	GP Pucillo and RFI	Meier +	Finite Element (use of Sofistik, Ansys)
	Input parameters					
X	Rail geometrical and mechanical parameters (*A*, *I*, *E*, *α*)	YES	YES	YES	YES	YES
X	Track gauge	NO	YES	YES	NO	YES
X	Curve radius	YES	YES	YES	YES	YES
X	Fastenings' torsional stiffness	YES	YES	YES	YES	YES
X	Sleeper-ballast longitudinal stiffness/resistance	NO	YES	YES	NO	YES
X	Sleeper-ballast lateral resistance curve (at least stiffness and peak resistance)	YES (bilinear)	YES (trilinear)	YES (whichever)	NO (constant)	YES (multilinear)
X	Peak lateral resistance	YES	YES	YES	YES	YES
X	Limit lateral resistance	NO	YES	YES	NO	NO
X	Lateral misalignment	YES	YES	YES	YES	YES
	Hypotheses on the initial shape of the defected geometry of the track	YES	YES	NO	YES	YES
	Initial defected geometry extended for the whole track	YES	NO	NO	YES	NO
	More than one existing alignment defect	NO	NO	YES	NO	NO
	Vehicle parameters (axle load, axle spacing, truck center distance)	NO	YES	YES	NO	NO
	More than one existing alignment defect and vehicle parameters	NO	NO	YES	NO	NO

		Prud` homme, Janin	CWERRI + CWR Safe	GP Pucillo and RFI	Meier +	Finite Element (use of Sofistik, Ansys)
	Output Parameters					
	Hypotheses on the shape of the buckled geometry of the track	YES	YES	NO	YES	NO
	Buckled geometry extended for the whole track	YES	NO	NO	YES	NO
X	ΔT_{min}	NO	YES	YES	NO	NO
X	ΔT_{max}	YES	YES	YES	YES	YES
X	ΔT_{min} and ΔT_{max} dependency on ballast compaction level	NO	YES	YES	NO	NO
X	Axial stress relaxation during buckling	NO	YES	YES	NO	NO
	ΔT_{min} and ΔT_{max} dependency on vehicle parameters	NO	YES	YES	NO	NO
	ΔT_{min} and ΔT_{max} dependency on multiple misalignment presence	NO	NO	YES	NO	NO

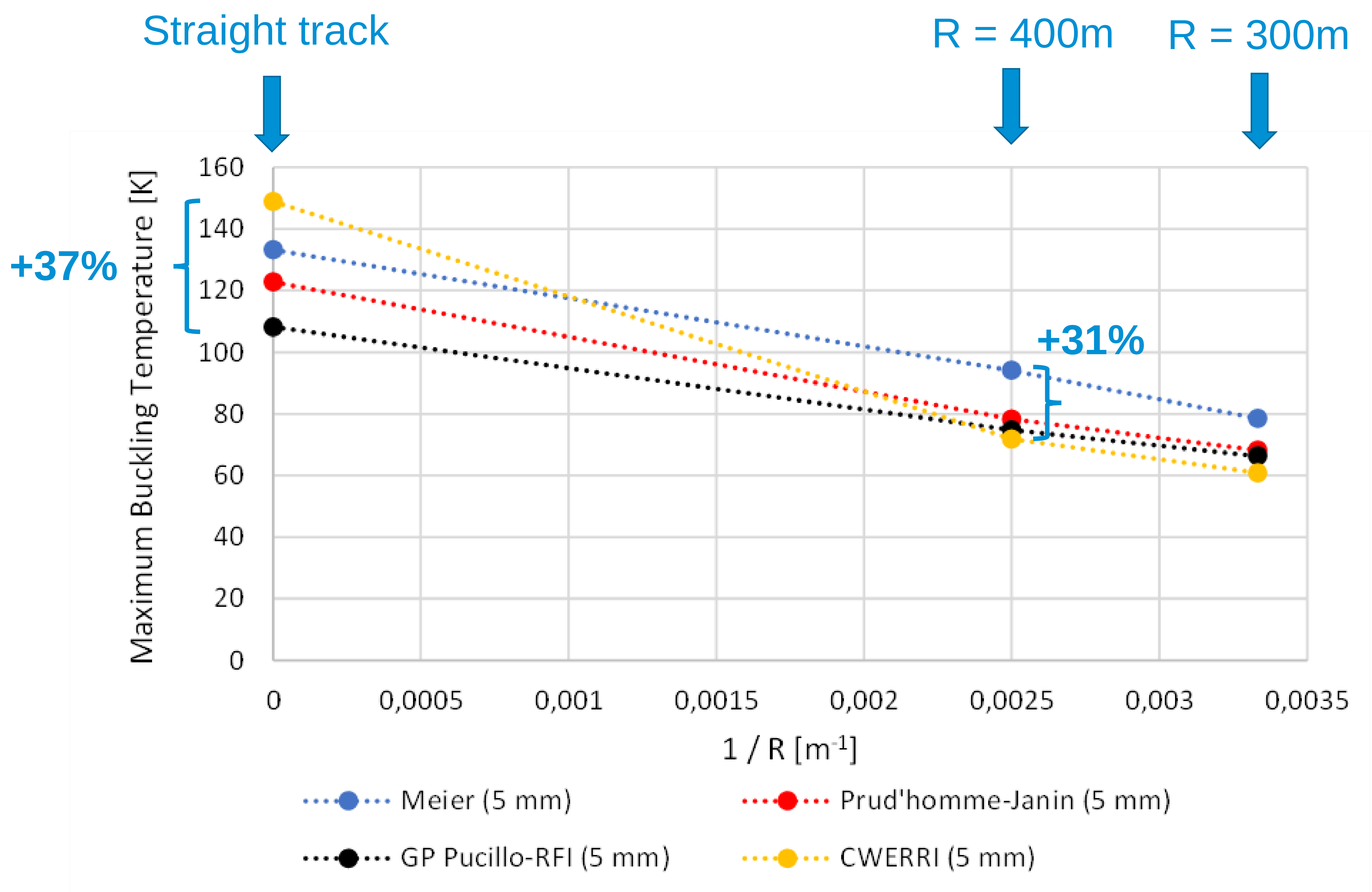
„X“ ….necessary Input/Output Parameters

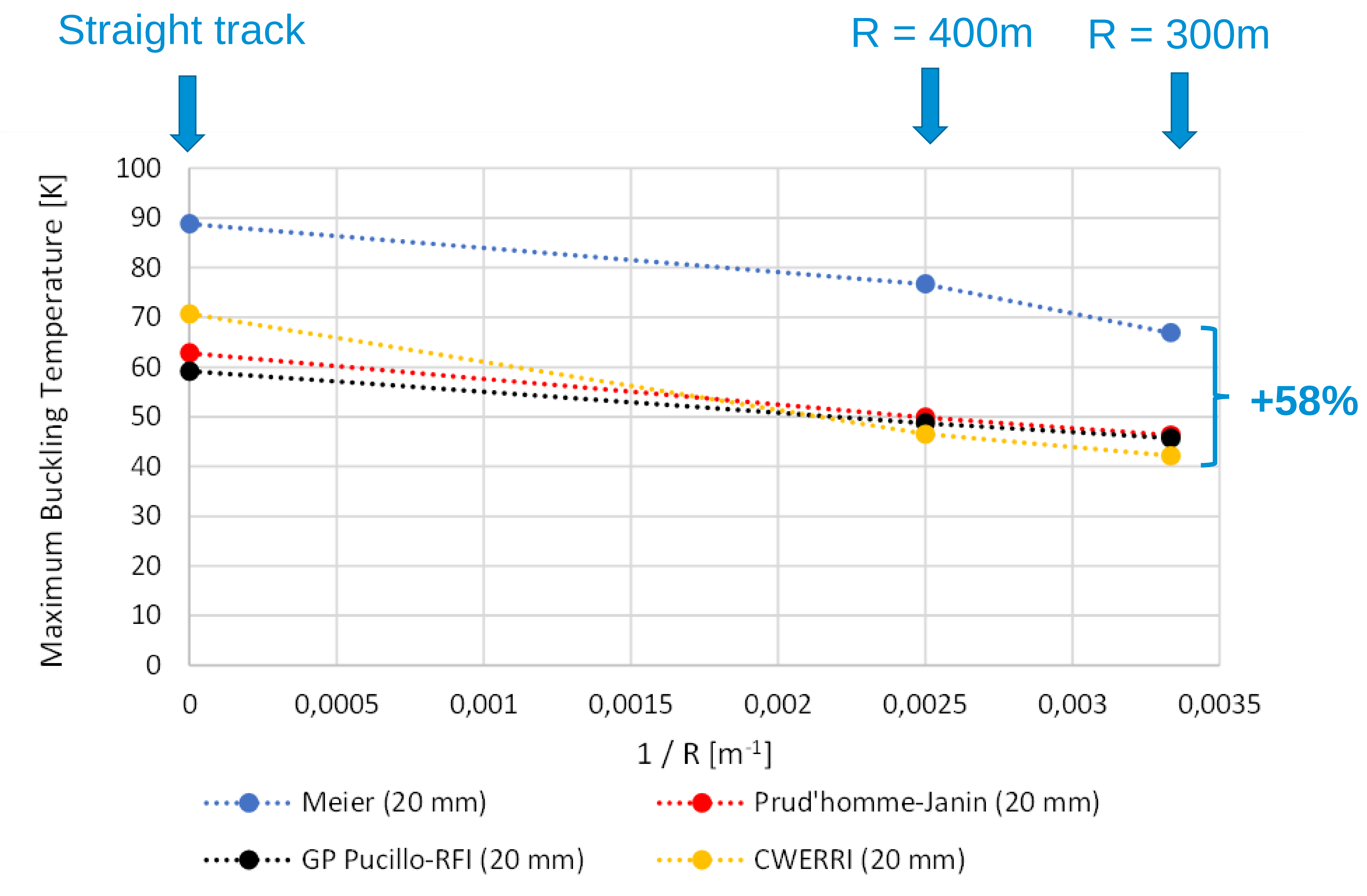
The “**Pros**” and “**Cons**” of the various calculation methods are highlightend → qualitativ comparison possible!

Track stability calculation and assessment

Case studies for buckling temperature evaluation:

Input parameters: curvature, concrete sleepers, initial misalignment (5mm, 20mm)

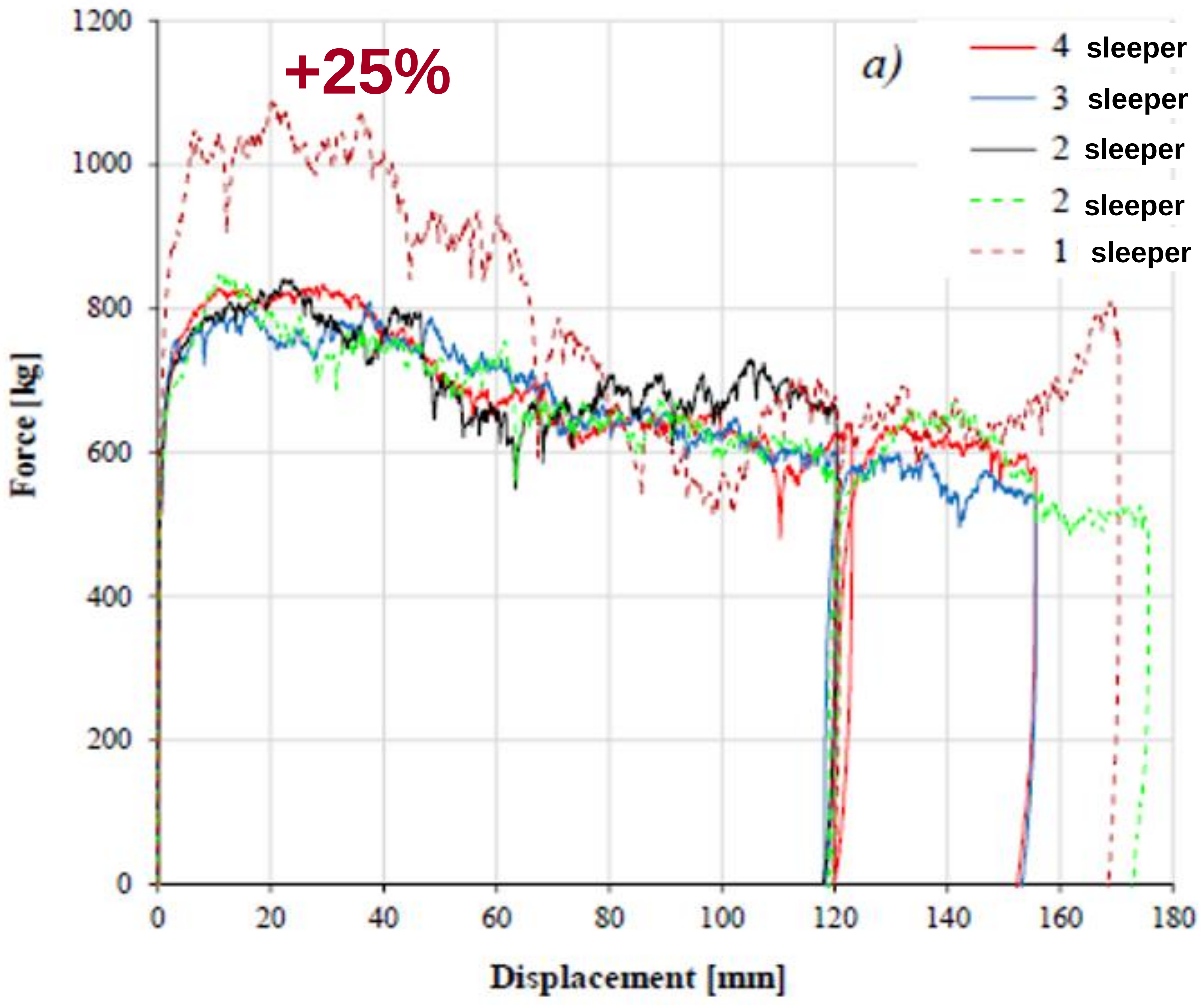




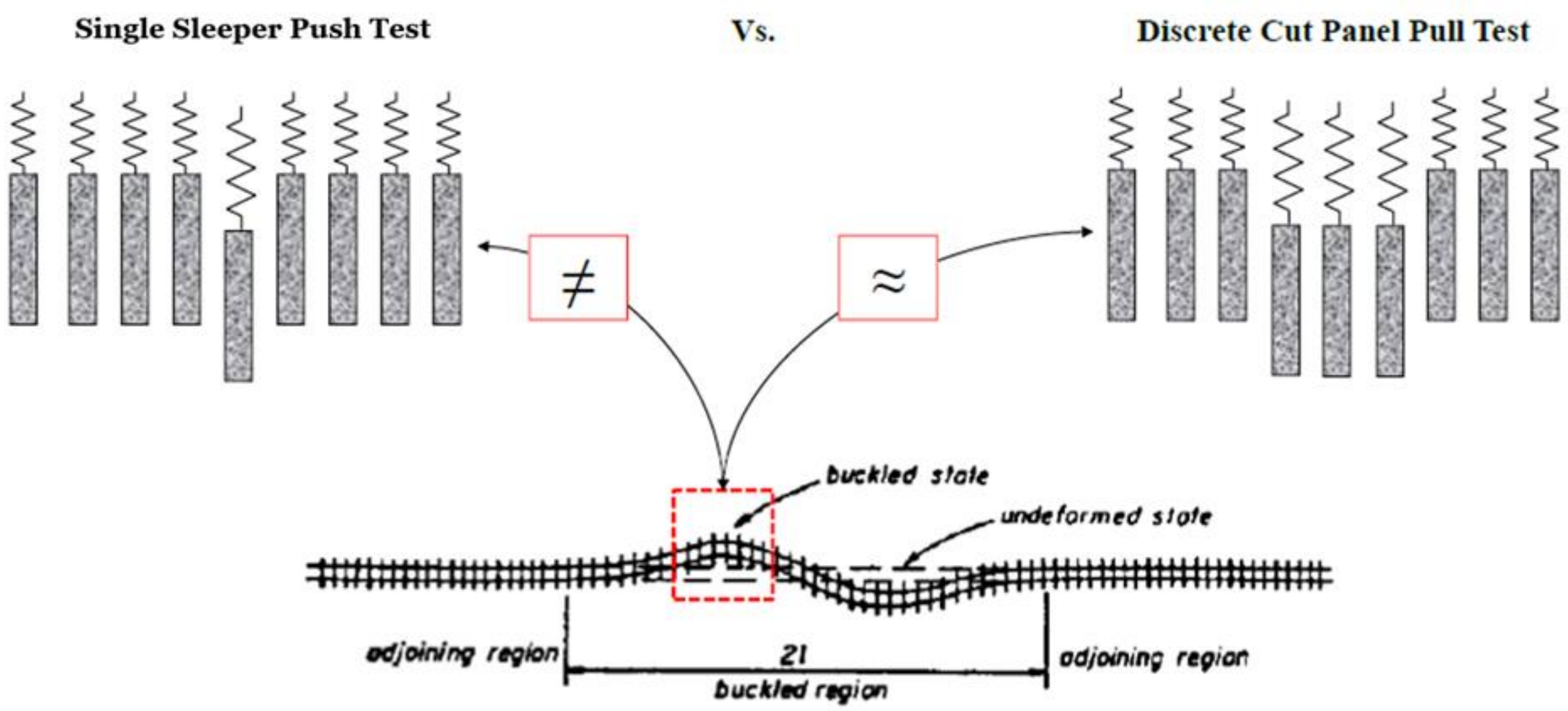
Experimental techniques for LRSB

Techniques for evaluating LRSB:

- Single Sleeper Push Test (SSPT)
- Discrete Cut Panel Pull Test (DCPPT)



Lateral resistance curves obtained by pulling different numbers of sleepers in compacted ballast conditions

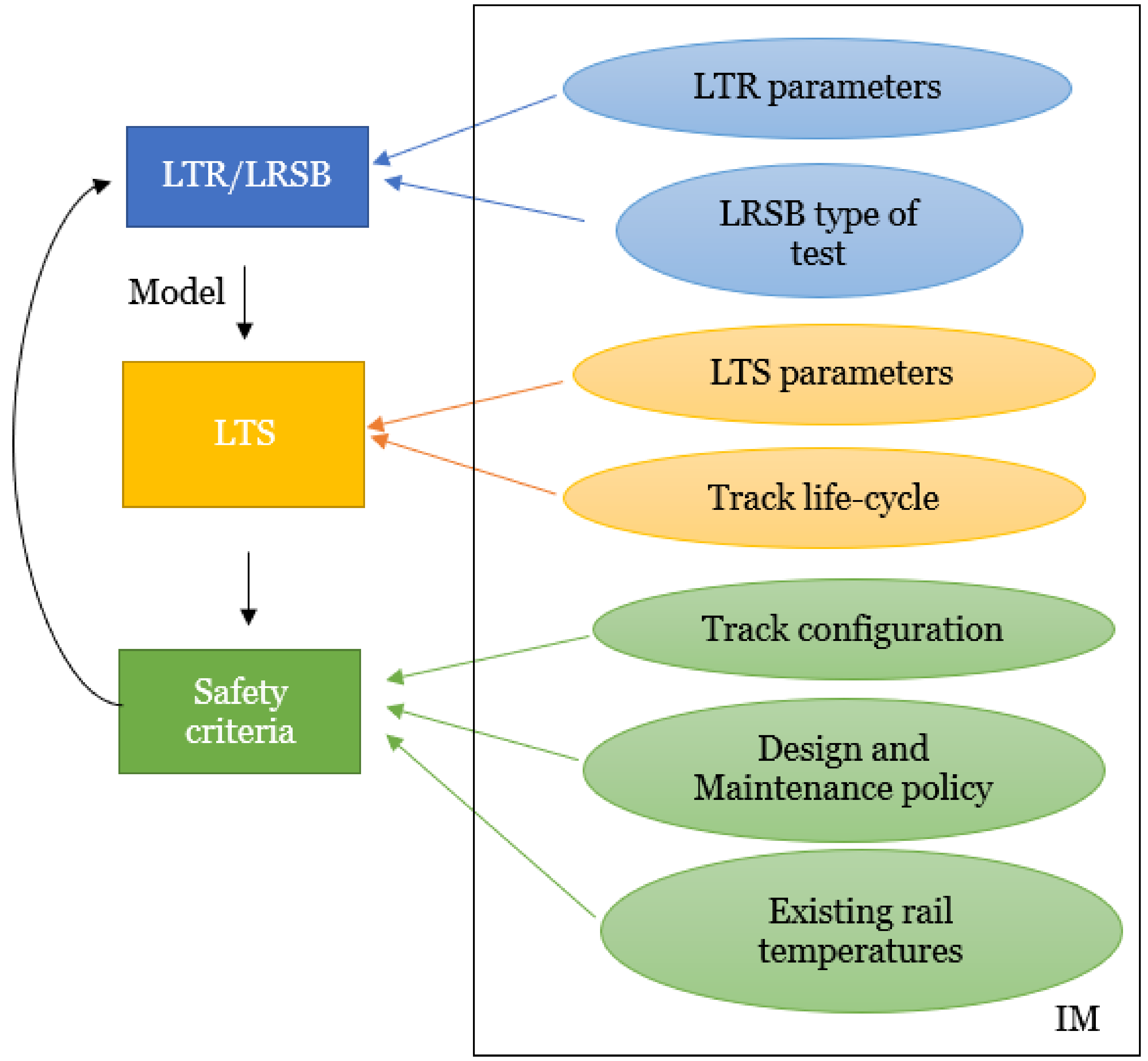


Safety philosophy and management of CWR Tracks

Premises for CWR buckling safety assurance:

- CWR **track system / component characterisation** and **external influences**
- **Perform LTR/LRSB measurements** as a main input (key) parameter
- Conduct **buckling/stability analyses** → choice of stability model for calculation
- **Establish** and **apply safety criteria**
- **Perform safety evaluation** → determination of ΔT_{all}

CWR managing



Allowable temperature (ΔT_{all}):

rail temperature above stress-free temperature (T_{sf}), **which provides** a **margin against a predicted likelihood of track buckling** depending on the defined safety criteria.

Safety management of CWR Track

Lateral track stability (LTS)

- The **thermal equilibrium curve** for LTS or at least the $T_{b,\,max}$ is calculated by every model for a given LTR value and a specific track configuration
- The typical thermal equilibrium curve provides the **two critical temperatures** expressed by $T_{b,\,max}$ and $T_{b,\,min}$

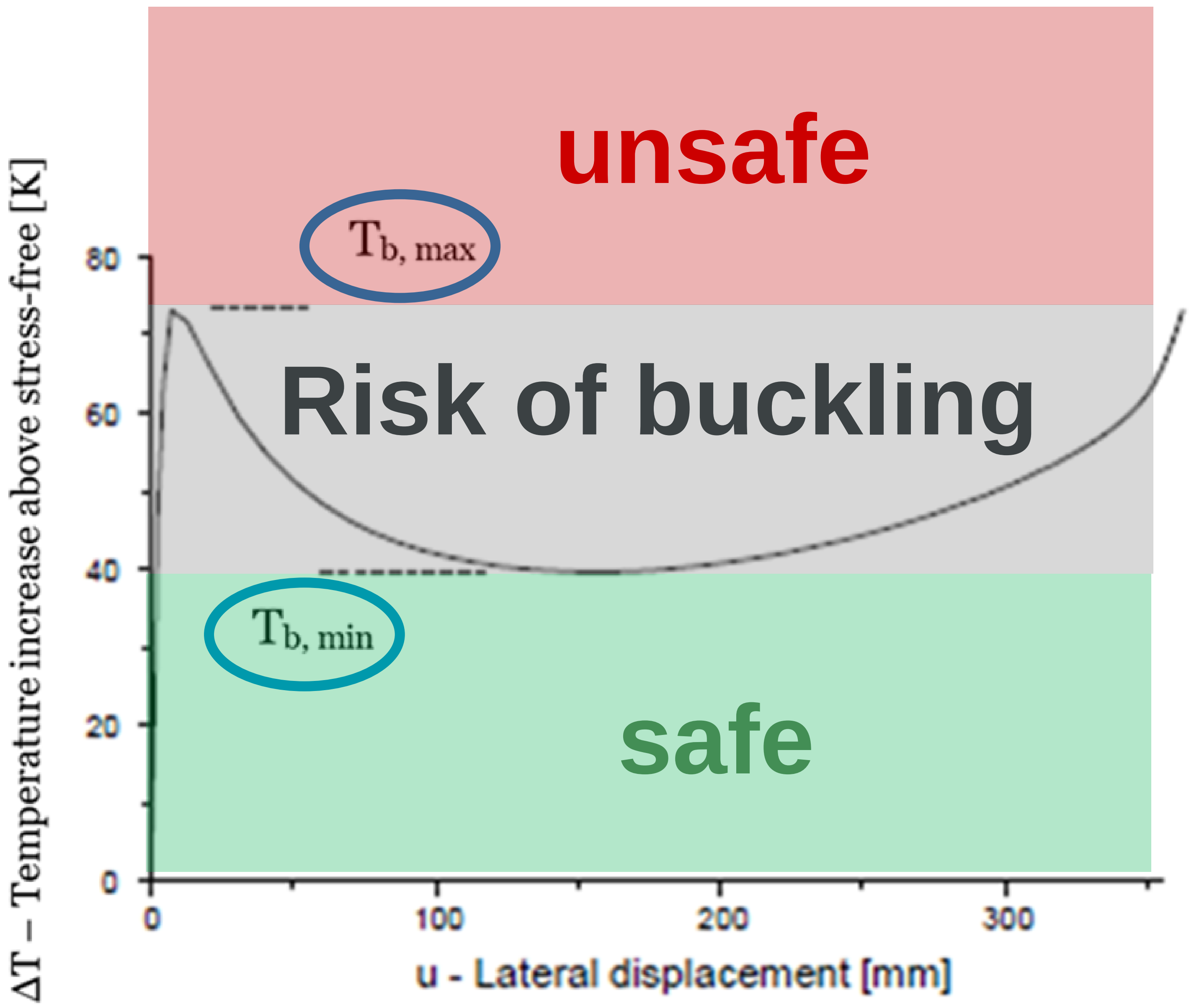


Figure 17: Thermal equilibrium curve for LTS

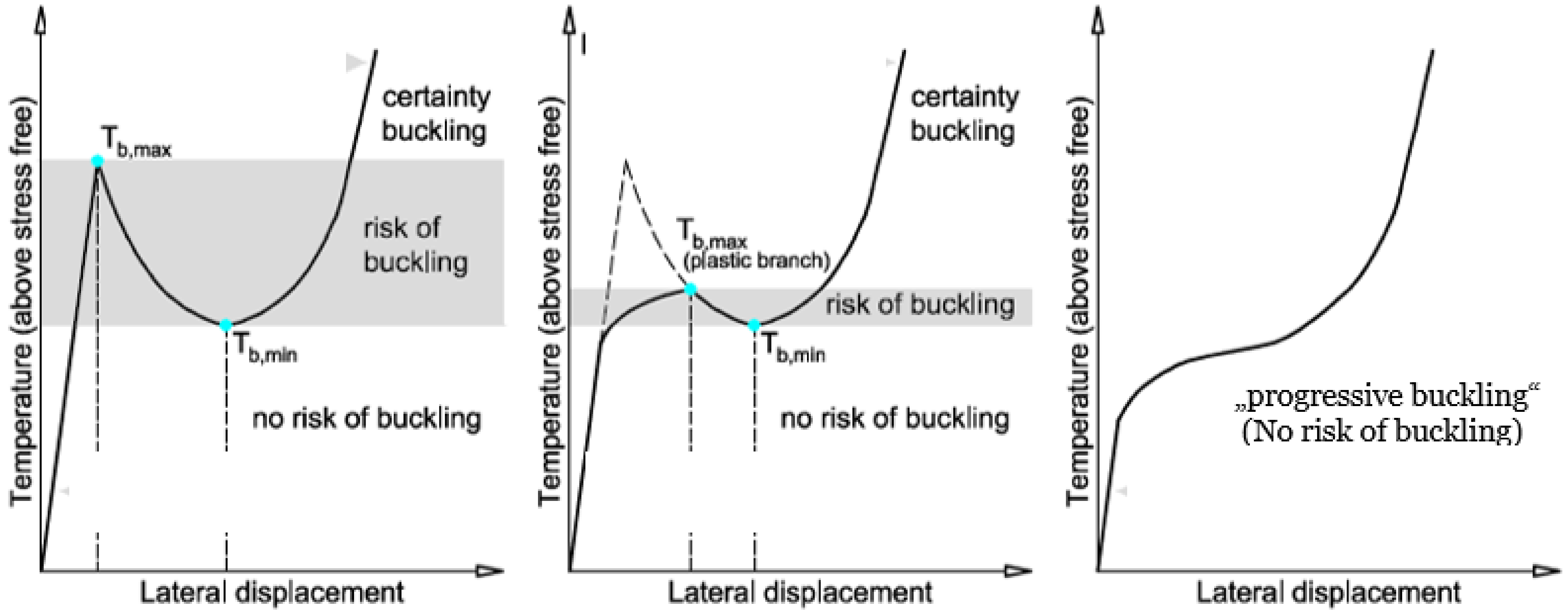


Figure 18: Temperature vs. lateral displacement for good ballast (left) and poor ballast (centre)

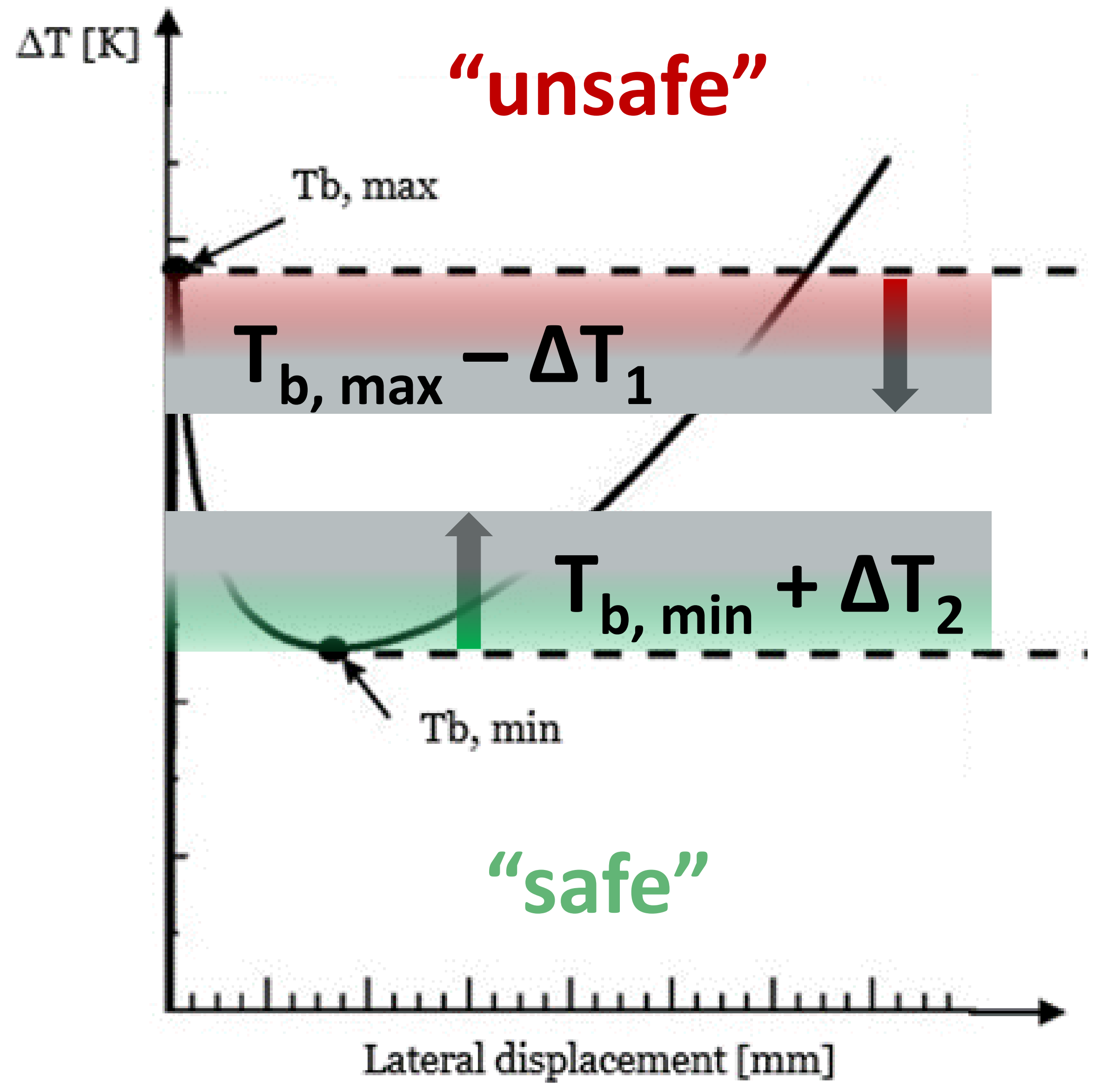
Safety management of CWR Track

Safety criteria - applicable safety levels:

- **Safety level** based on **$T_{b, max}$ – ΔT_1**
- **Safety level** based on **$T_{b, min}$ + ΔT_2**

  A well-established value is a recommendation of old *UIC Leaflet 720*: $\Delta T_2 = 0{,}25 \cdot (\Delta T_{b, max} - \Delta T_{b, min})$
- **Safety level based on the Energy criterion** (percentage of buckling energy temperature)

➡ **Result = T_{all}**



Conclusion

IRS 70720 – Laying and Maintenance of Tracks with CWR

- Well designed CWR track in **well-consolidated ballast** are **basically stable**
- But **be careful**: any maintenance activity that **loosens the consolidated ballast** may massively harm **track stability**
- The **new IRS 70720** provides information how to **design, install and maintain CWR track** in order to remain stable and **ensure a safe train operation** even in hot weather conditions
- **Stability calculation programs** in Europe provide similar results, but always keep in mind the **different maintenance strategies** and the **change of the stress-free-temperature** during service life of the track
- **Suggestion** for future **research work:**
  - development of a more appropriate non-destructive measurement device for determining the forces in the rails
  - harmonising stability calculation methods
  - providing a valid, publicly accessible computer program for calculating track stability

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