Rail Stability

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Rail Stability

Rail Cant

Rail Seat Deterioration (RSD)

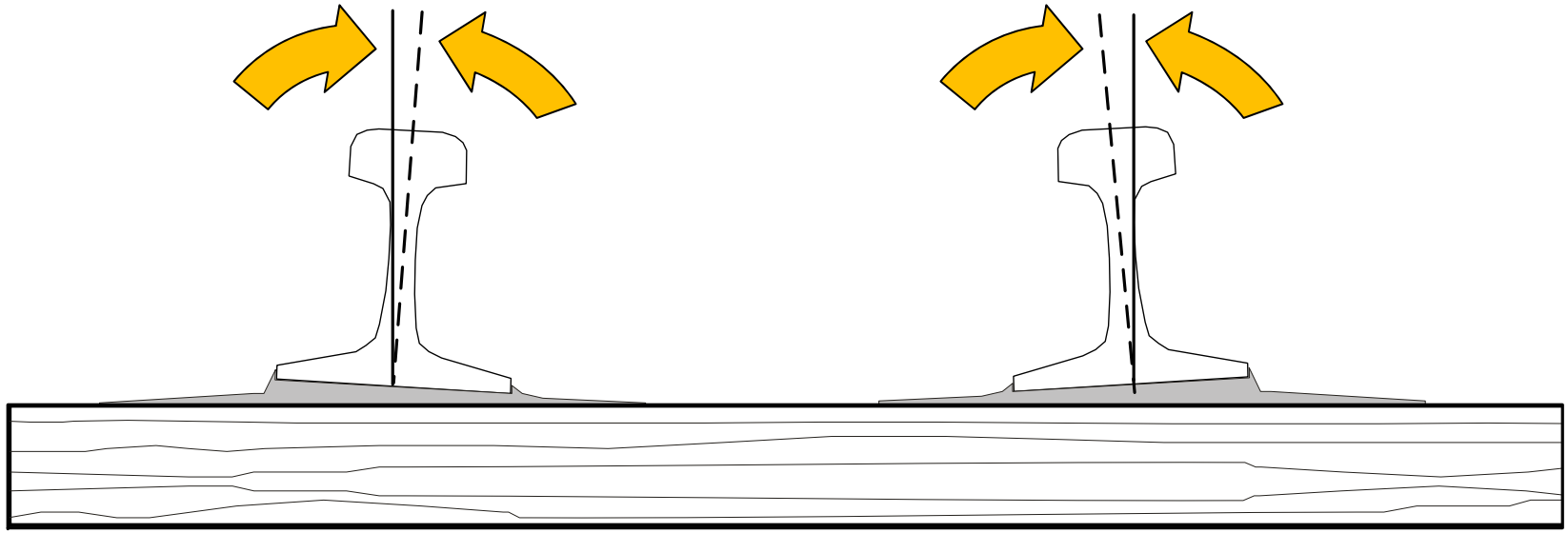
Rail Rollover

Maintenance

Rail Cant

Simple Definition:

Rail Roll Angle



Ref 1

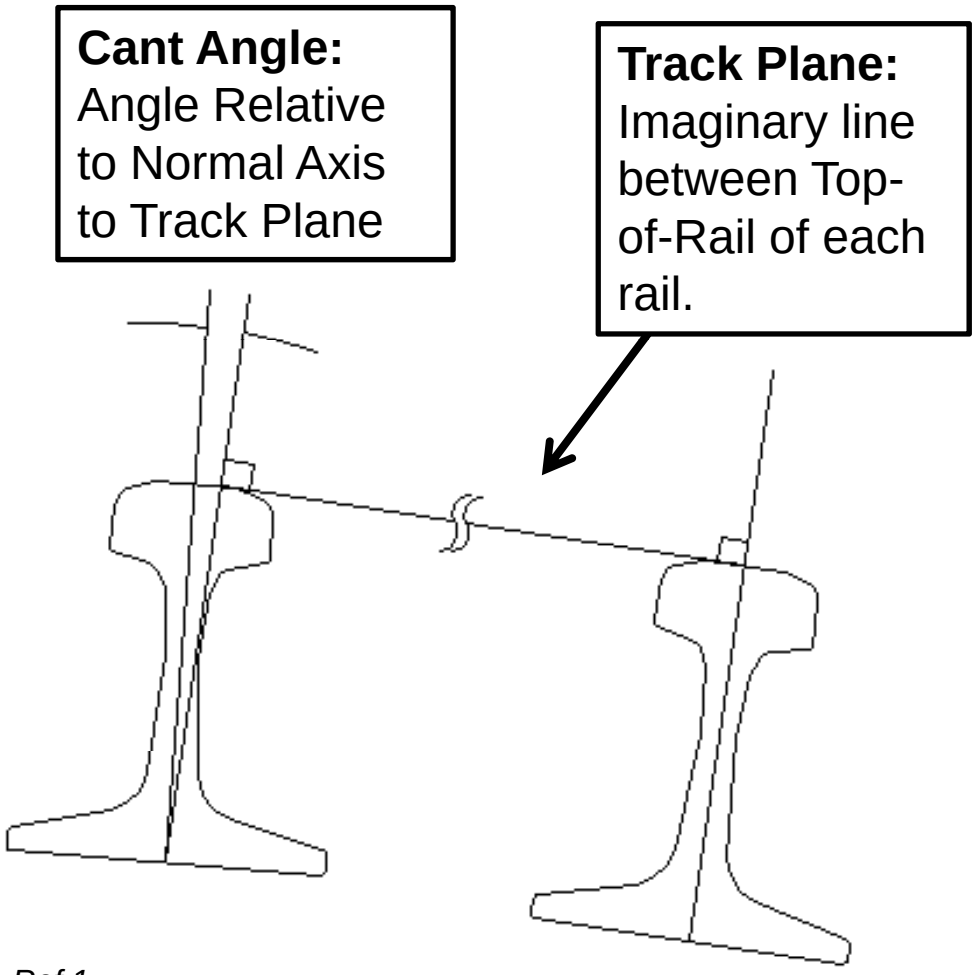
Rail Cant

Detailed Definition:

- Currently No Formal Industry Standard
- AREMA Recommended Practice in progress

<u>Common Definition</u>

- Roll angle relative to track plane.



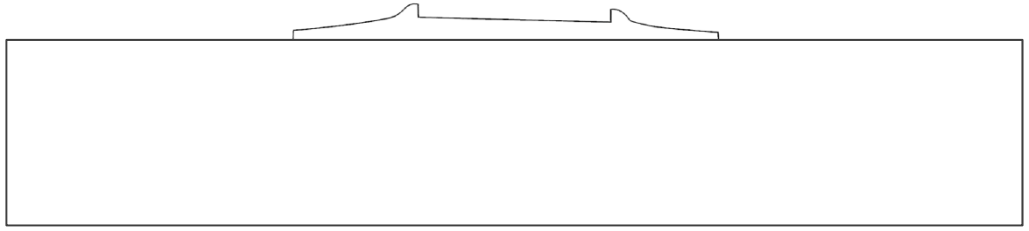
Ref 1

Design Rail Cant

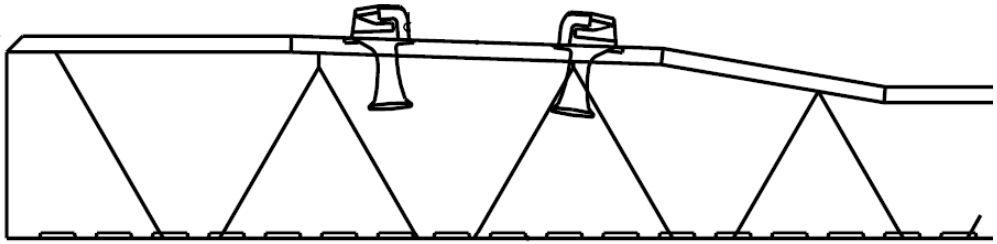
Most common design Rail Cant is “1:40”

- “1:40” refers to the “rise over run”, so 1:40 equals 1.43 Degrees
- Some railroads use 1:30 or 1:20

Wood ties use a “Tie Plate” which has the Cant angle incorporated into it.

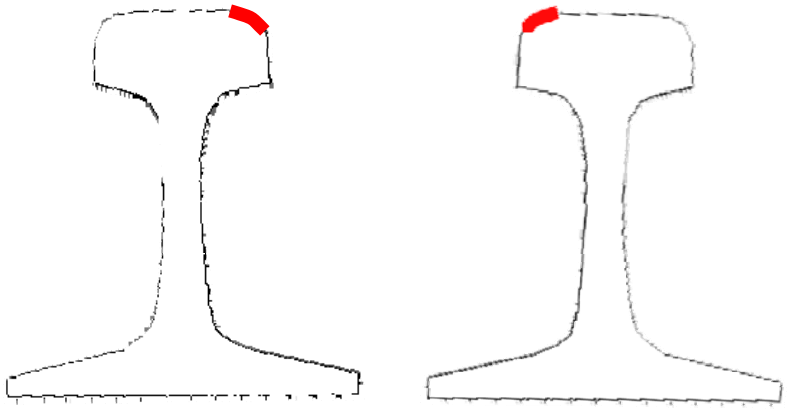


Concrete ties have the Cant angle cast into the rail base area.

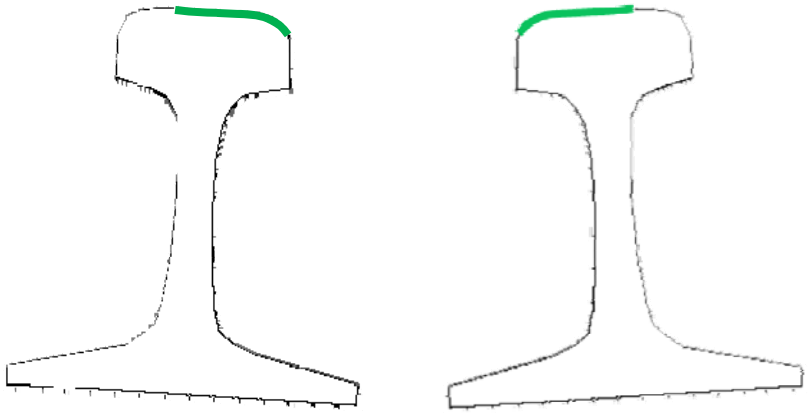


Why do you want rail cant?

No rail cant concentrates rail wear at the gage corner.



Inward cant more evenly distributes the rail wear across the crown and gage corner.

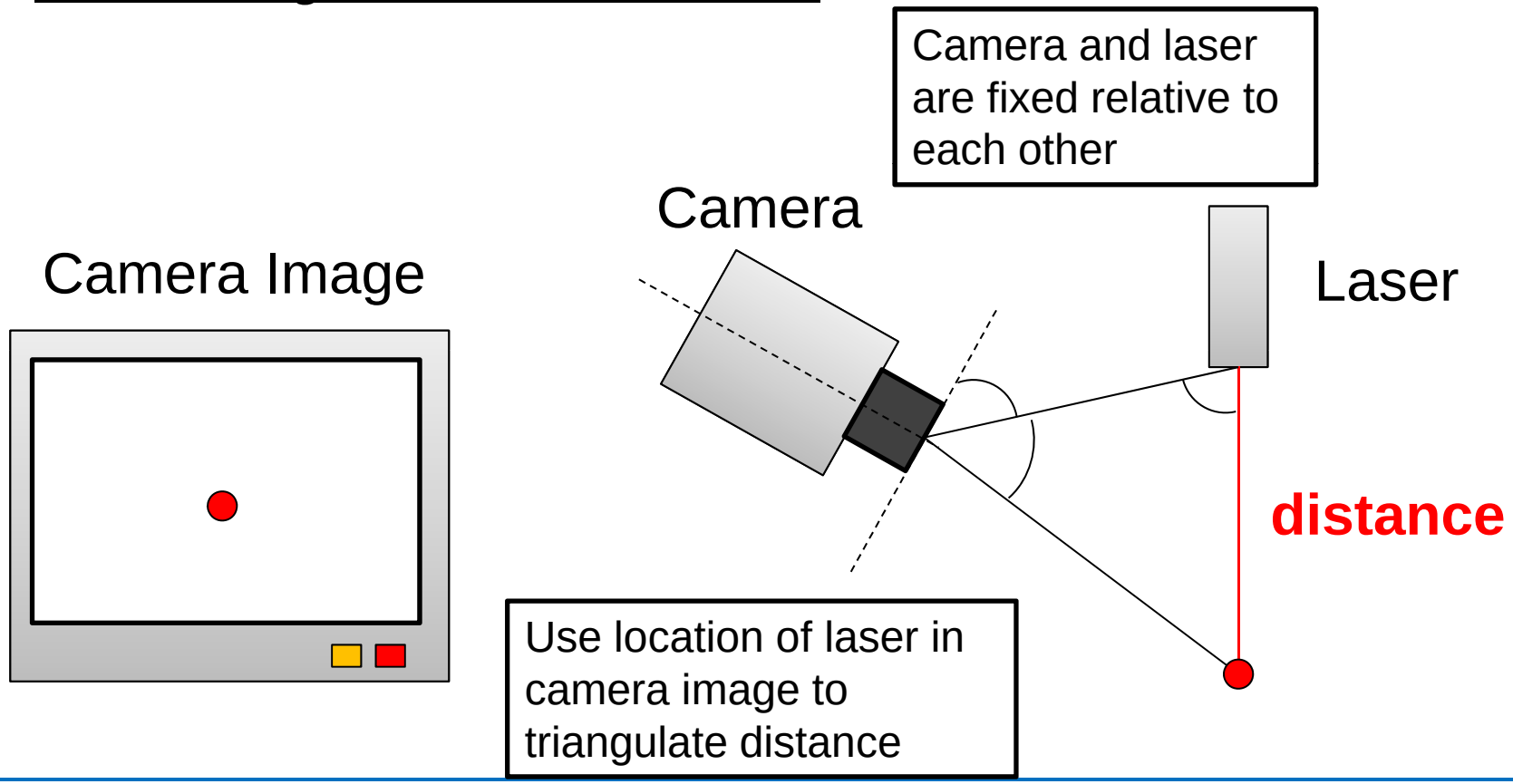


- This is the case with tapered wheel profiles.
- Cylindrical wheel profiles typically have no cant in rail.

Measurement of Rail Cant

Rail Cant measurement is a relatively new thing

- First established in the last 10~15 years with the advent of non-contact ***Laser Triangulation Measurement.***



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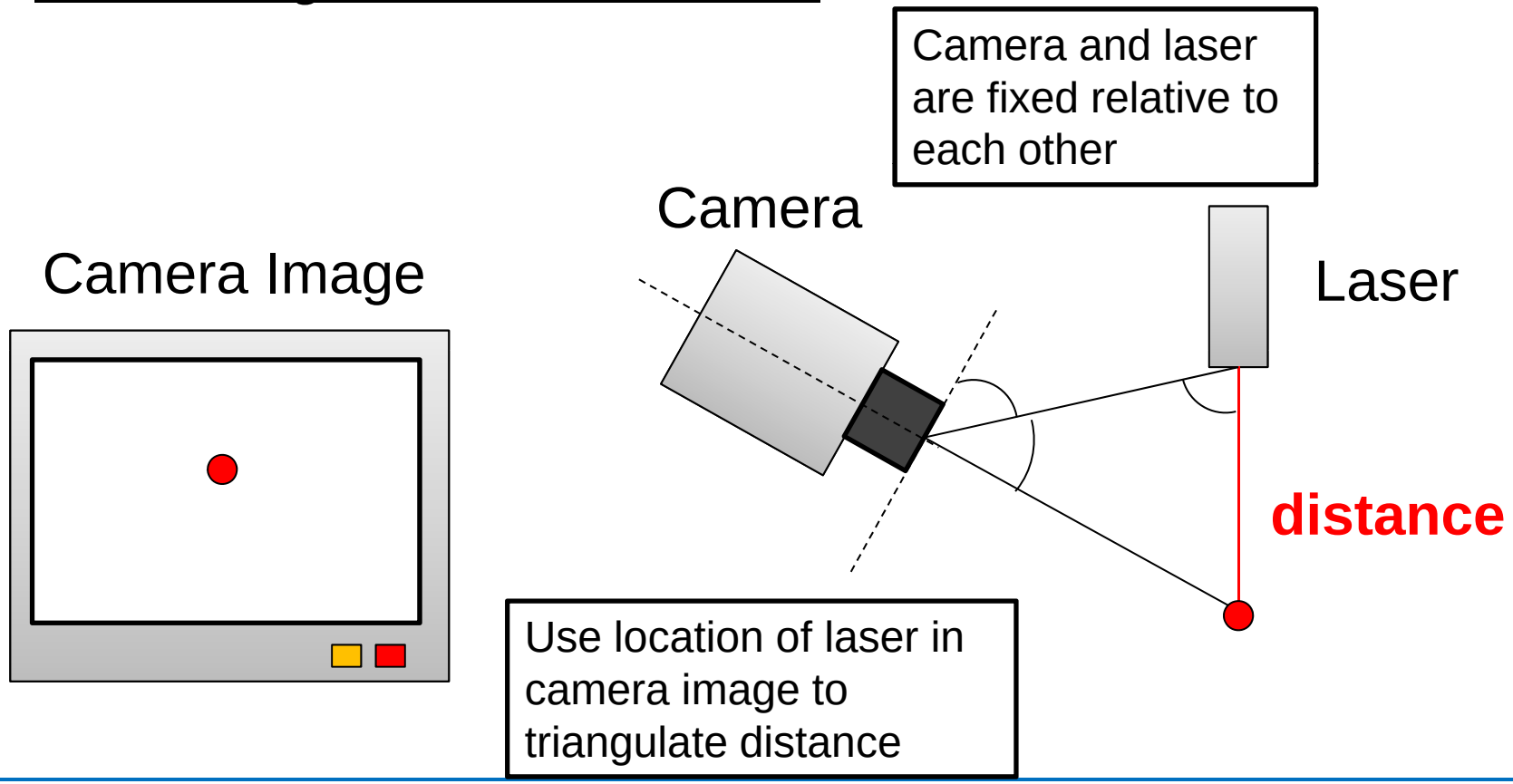

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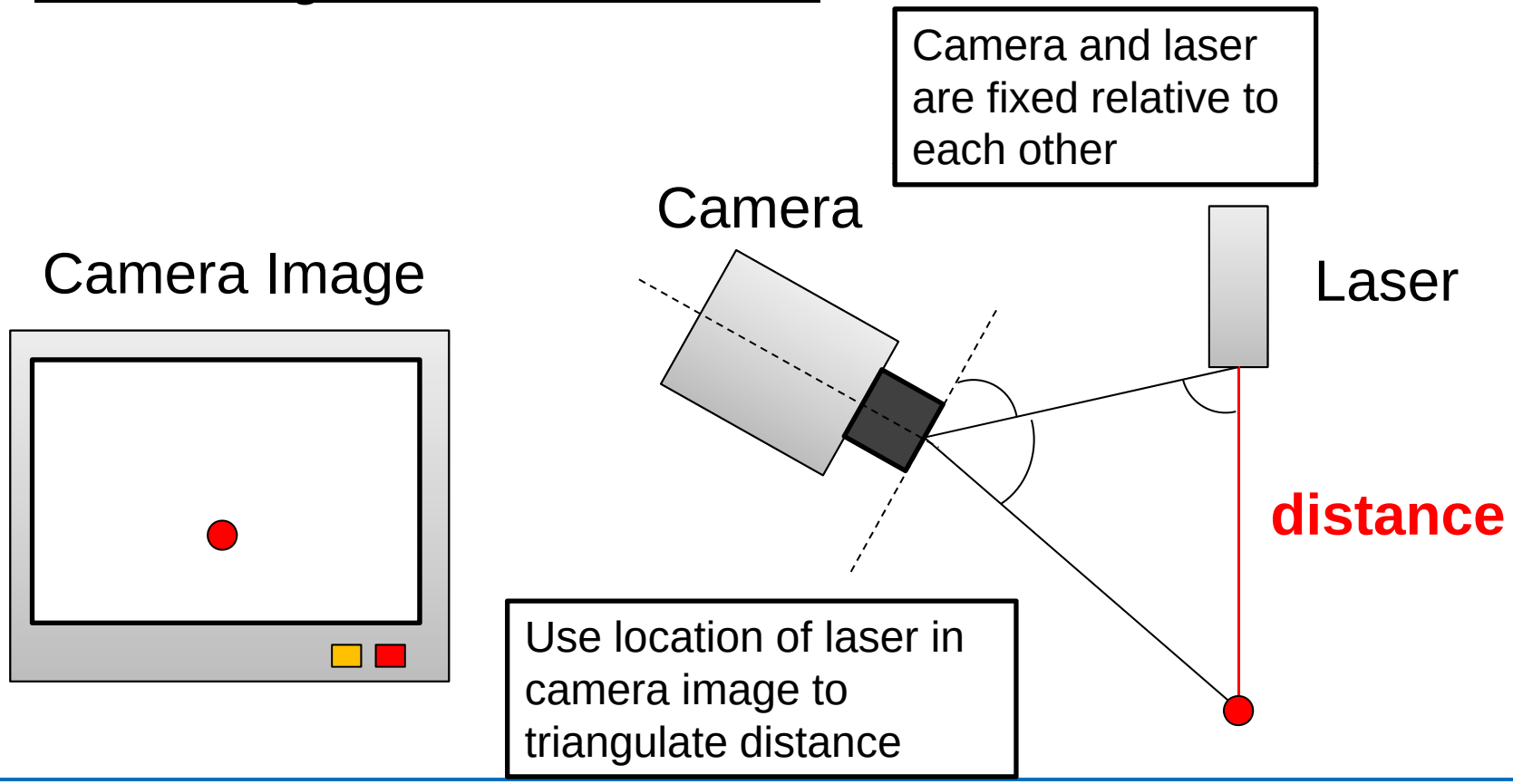

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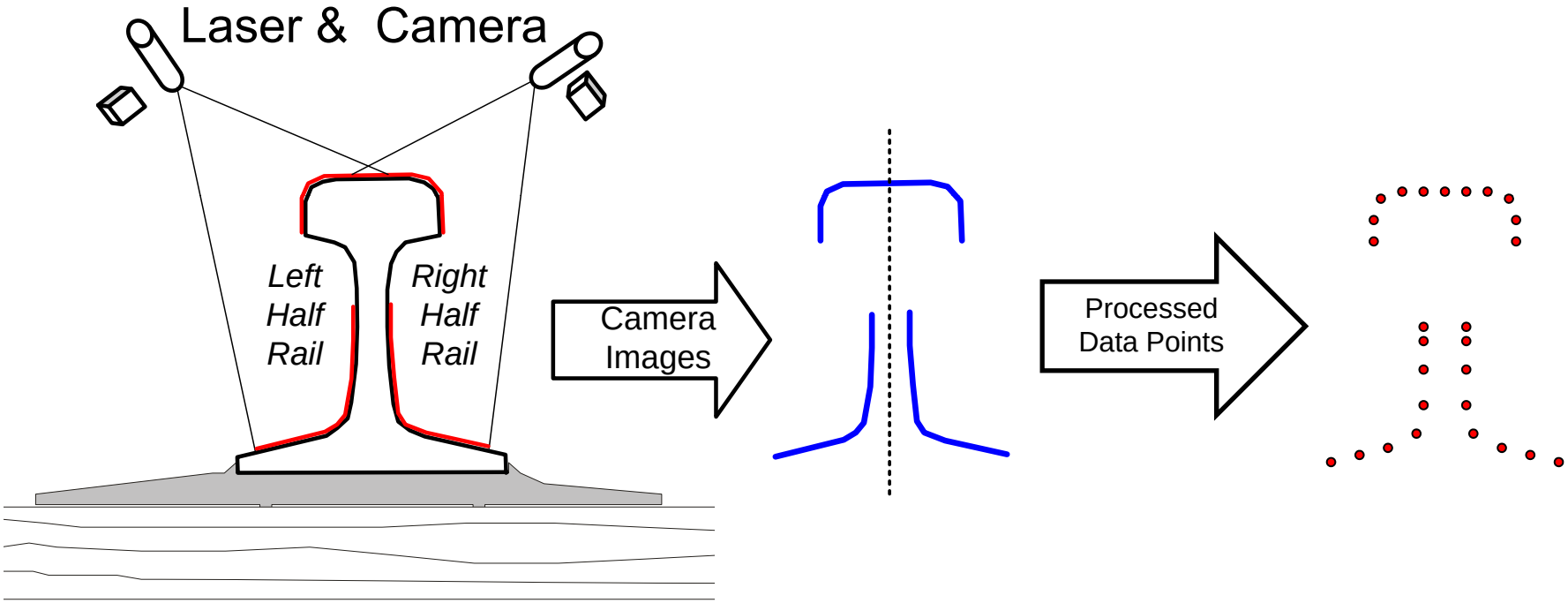
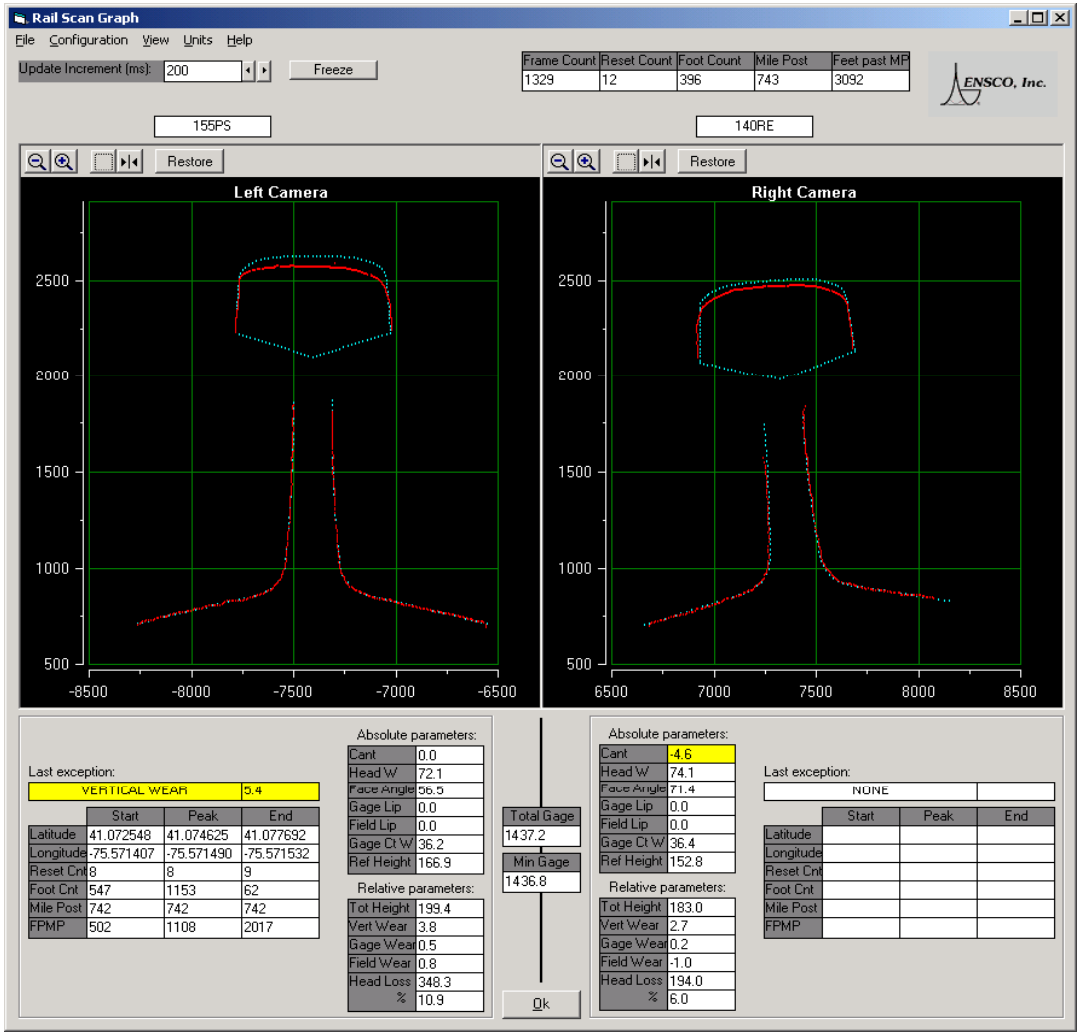


Ref 1

Measurement of Rail Cant

Example
Measured Profile



Measurement of Rail Cant: Sign Convention

- Some measurement systems considers **(+) Cant** to be towards the *field side*.
- Some measurement systems considers **(+) Cant** to be towards the *gage side*.

- Some measurement systems considers **"0" Degree Cant** to be *straight up*.
- Some measurement systems considers **"0" Degree Cant** to be the *"Design Cant" (i.e. 1:40)*

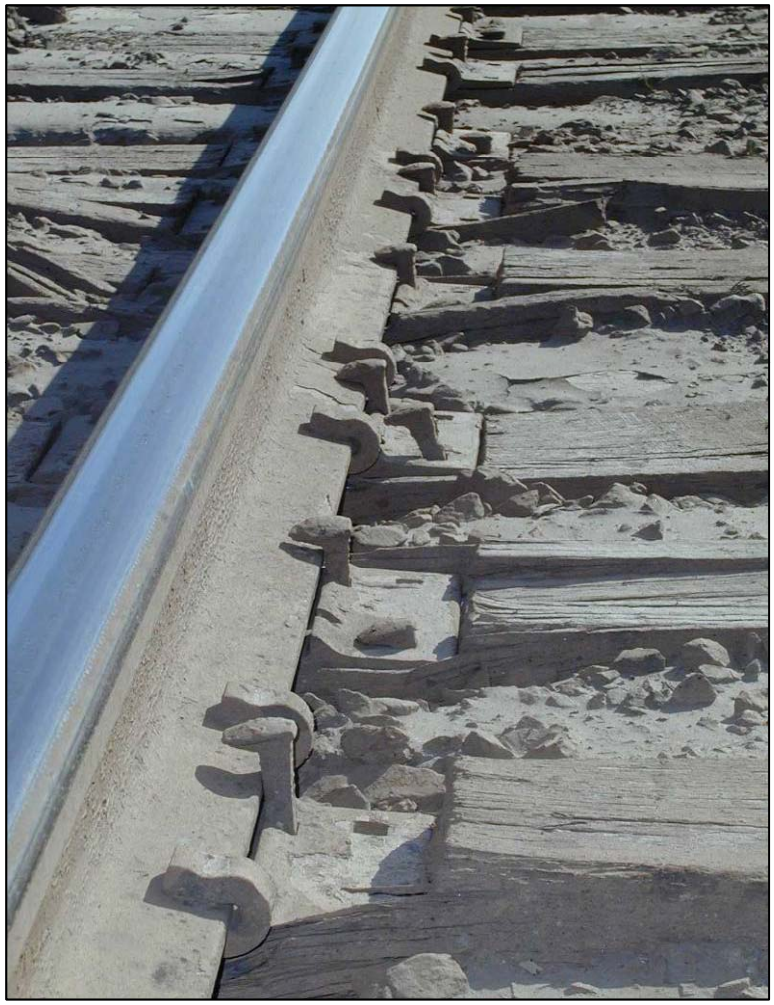
Hand Measurement of Rail Cant

Generally used for calibration/validation of laser system.

Ref 1

Cause of Cant Change: Plate Cutting

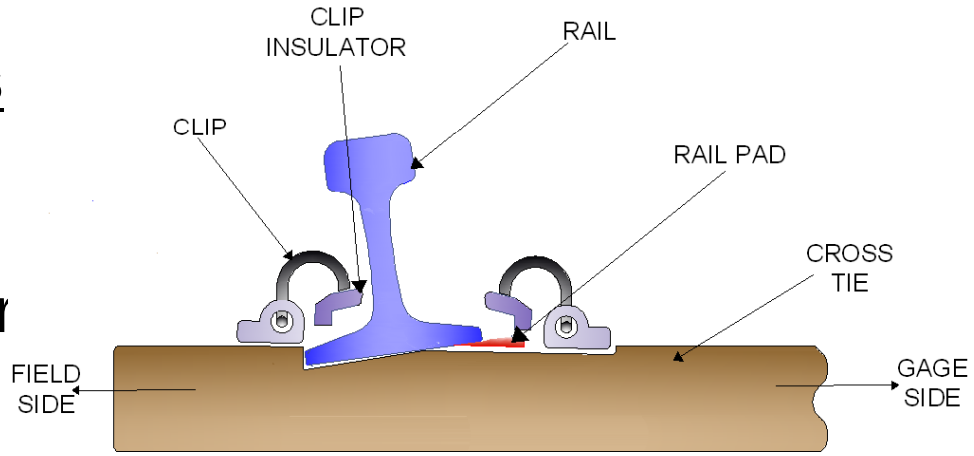
- Occurs with **<u>Wood Ties</u>**
- Wood tie wears under tie plate.



Ref 1

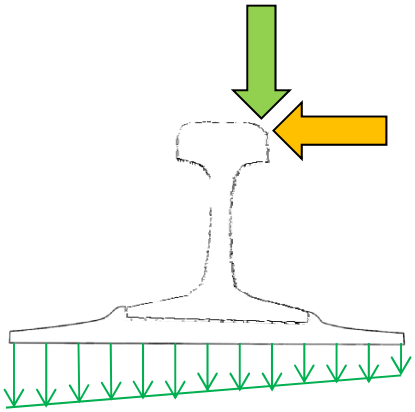
Cause of Cant Change: Rail Seat Deterioration (RSD)

- Occurs with **<u>Concrete Ties</u>**
- Rail Seat Deterioration (RSD) is made of five major causes:
  - Abrasion
  - Crushing
  - Freeze-Thaw Cracking
  - Hydraulic-Pressure Cracking
  - Hydro-Abrasive Erosion

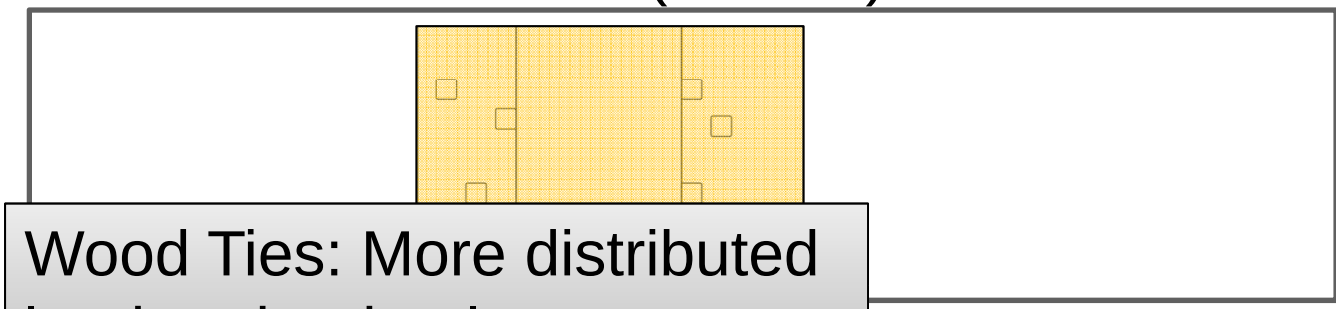


Ref 1

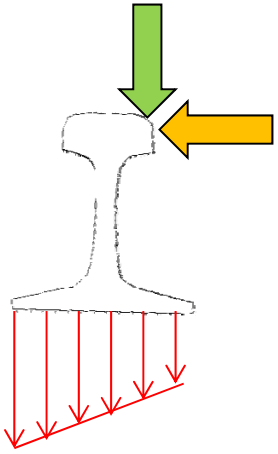
Rail Seat Pressure



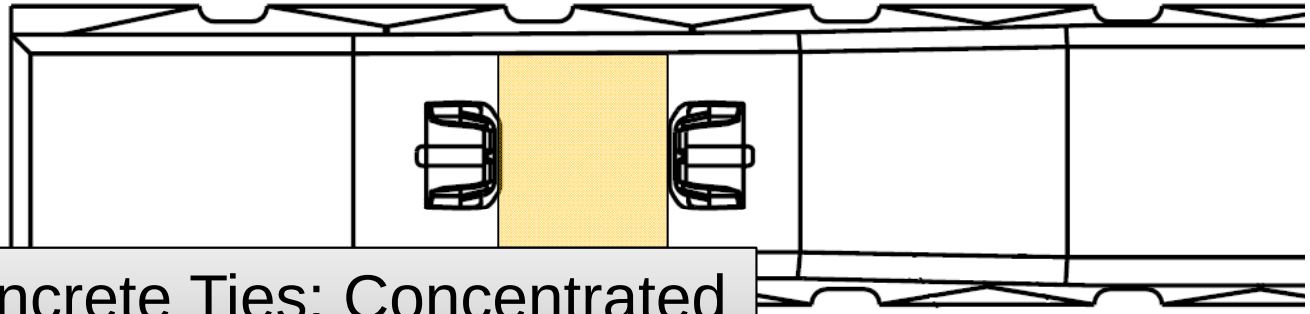
8.75” x 16” (140 in^2)



Wood Ties: More distributed load under tie plate.



6” x 6.5” (39 in^2)



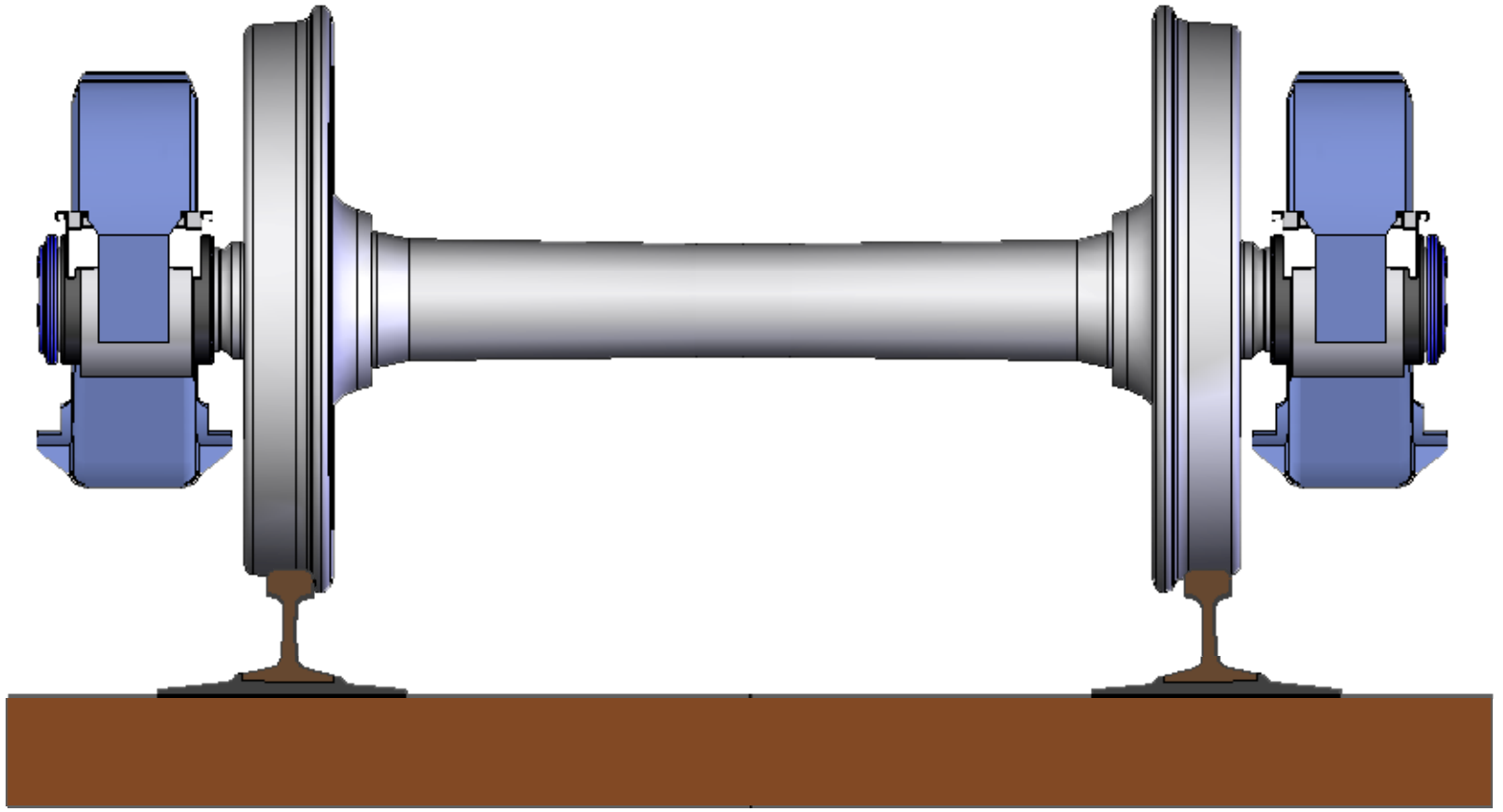
Concrete Ties: Concentrated load under rail base.

Rail Rollover

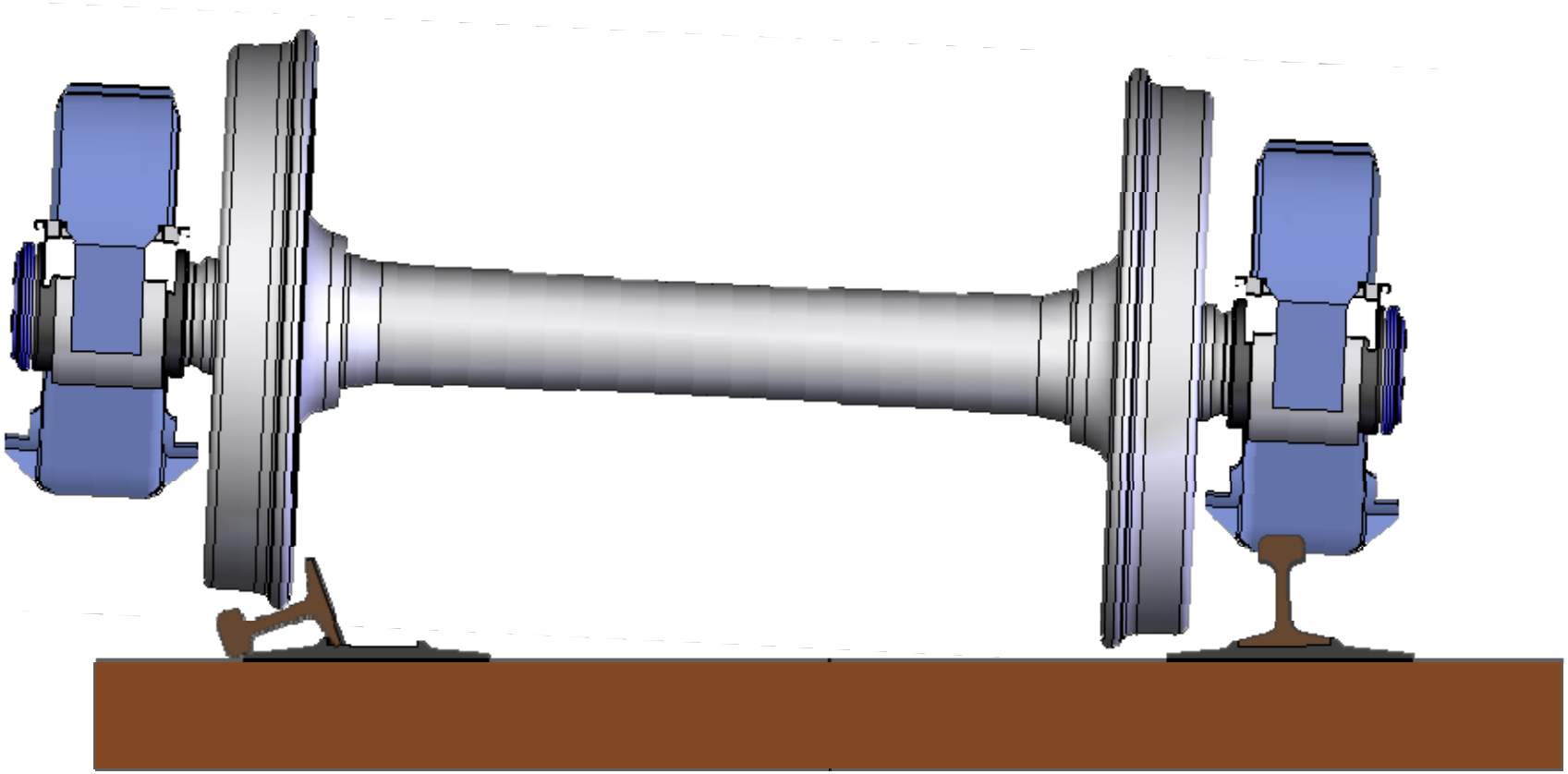
- Generally results in derailment
- Rail rolls over and wheel falls into web of rail
- Opposite wheel drops into the gage.

Ref 2

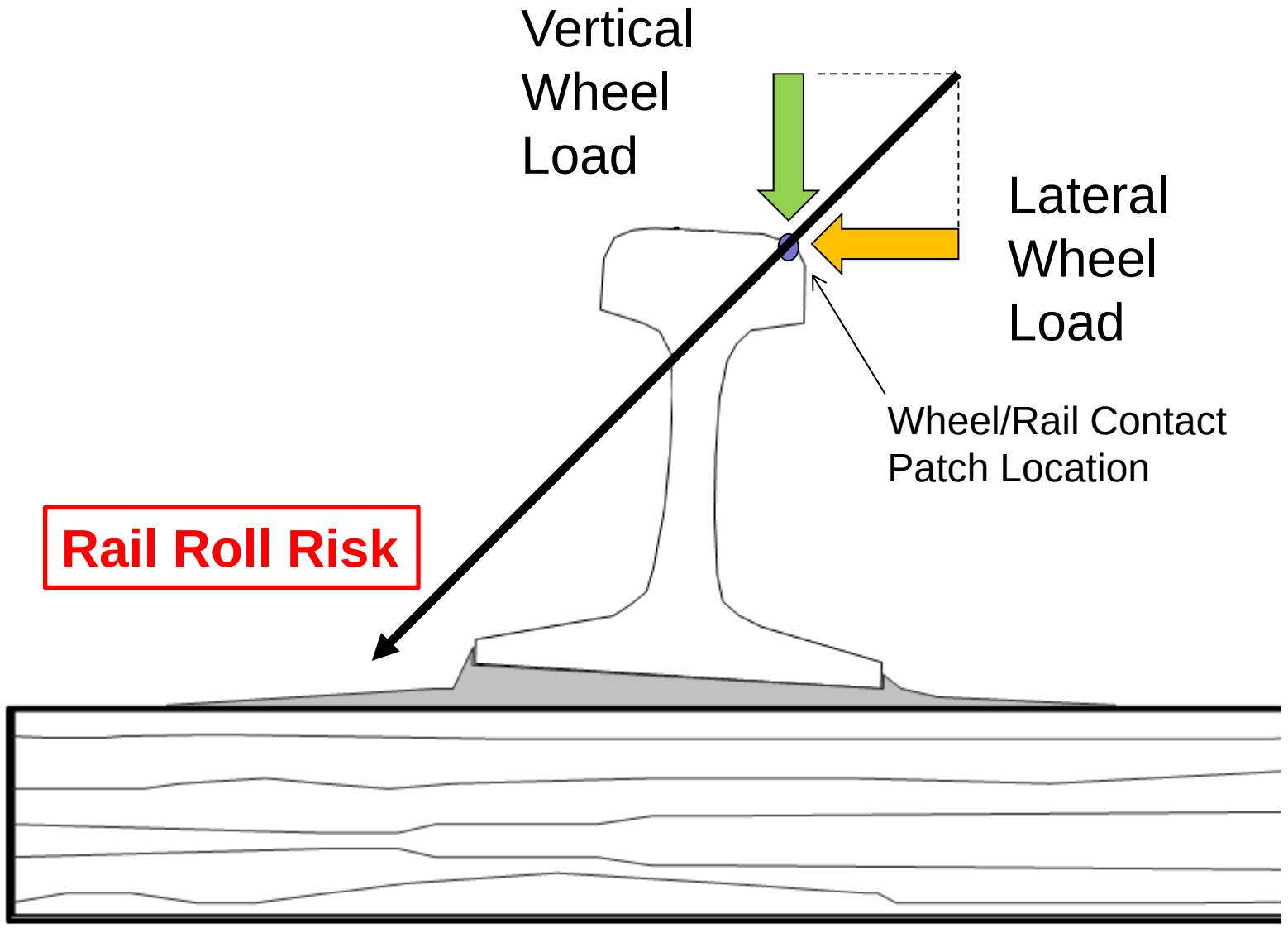
Rail Rollover



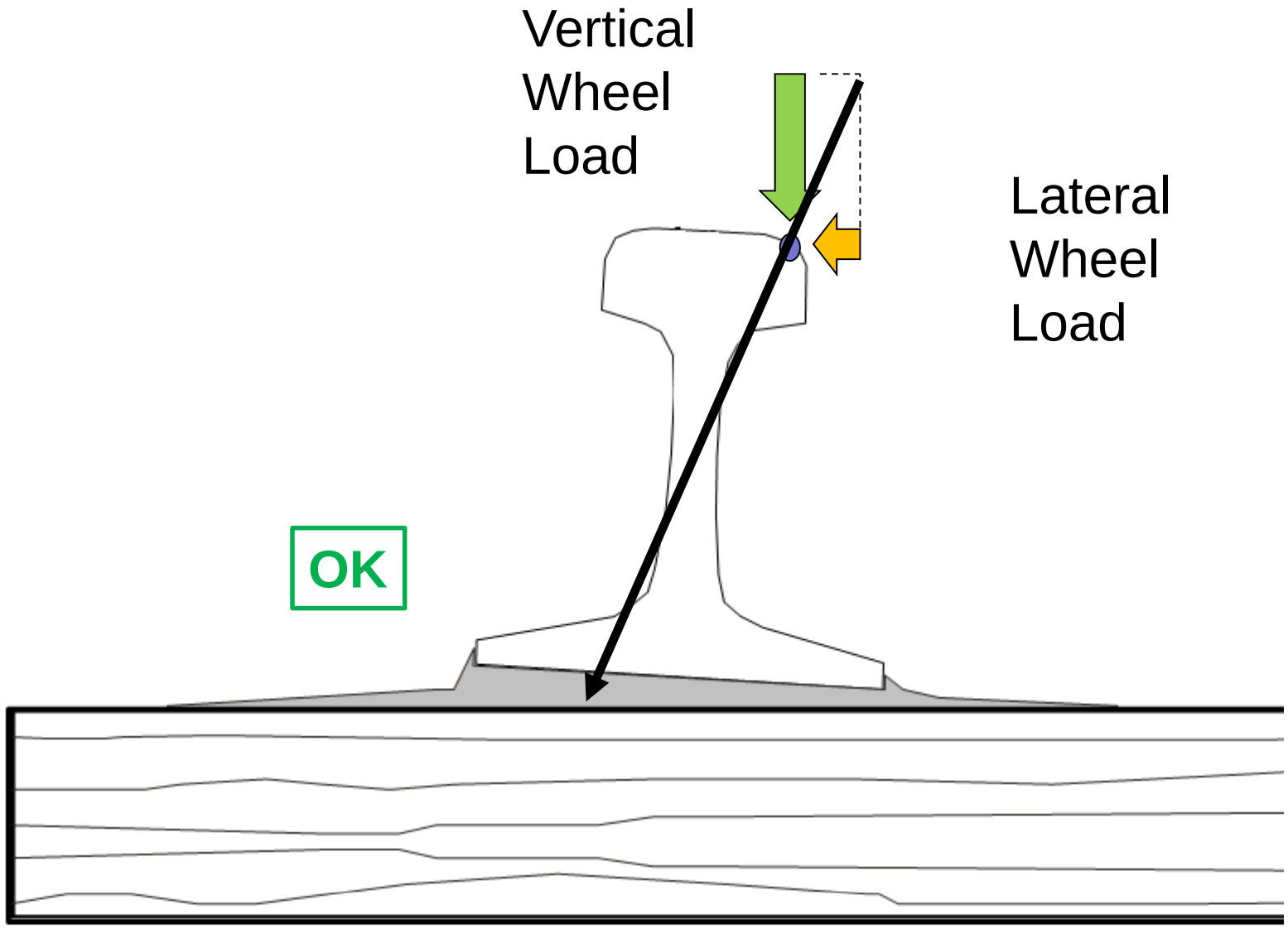
Rail Rollover



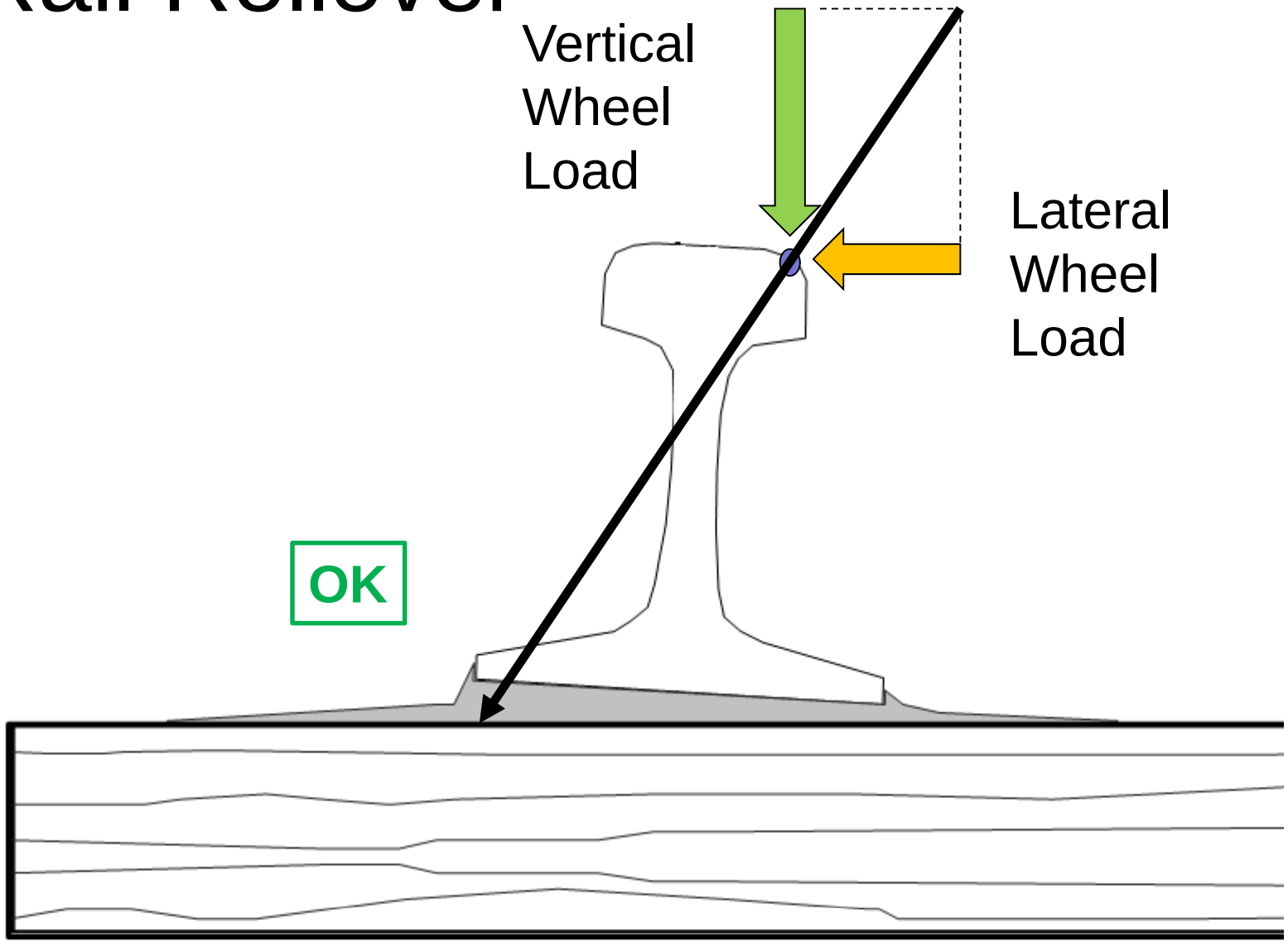
Rail Rollover



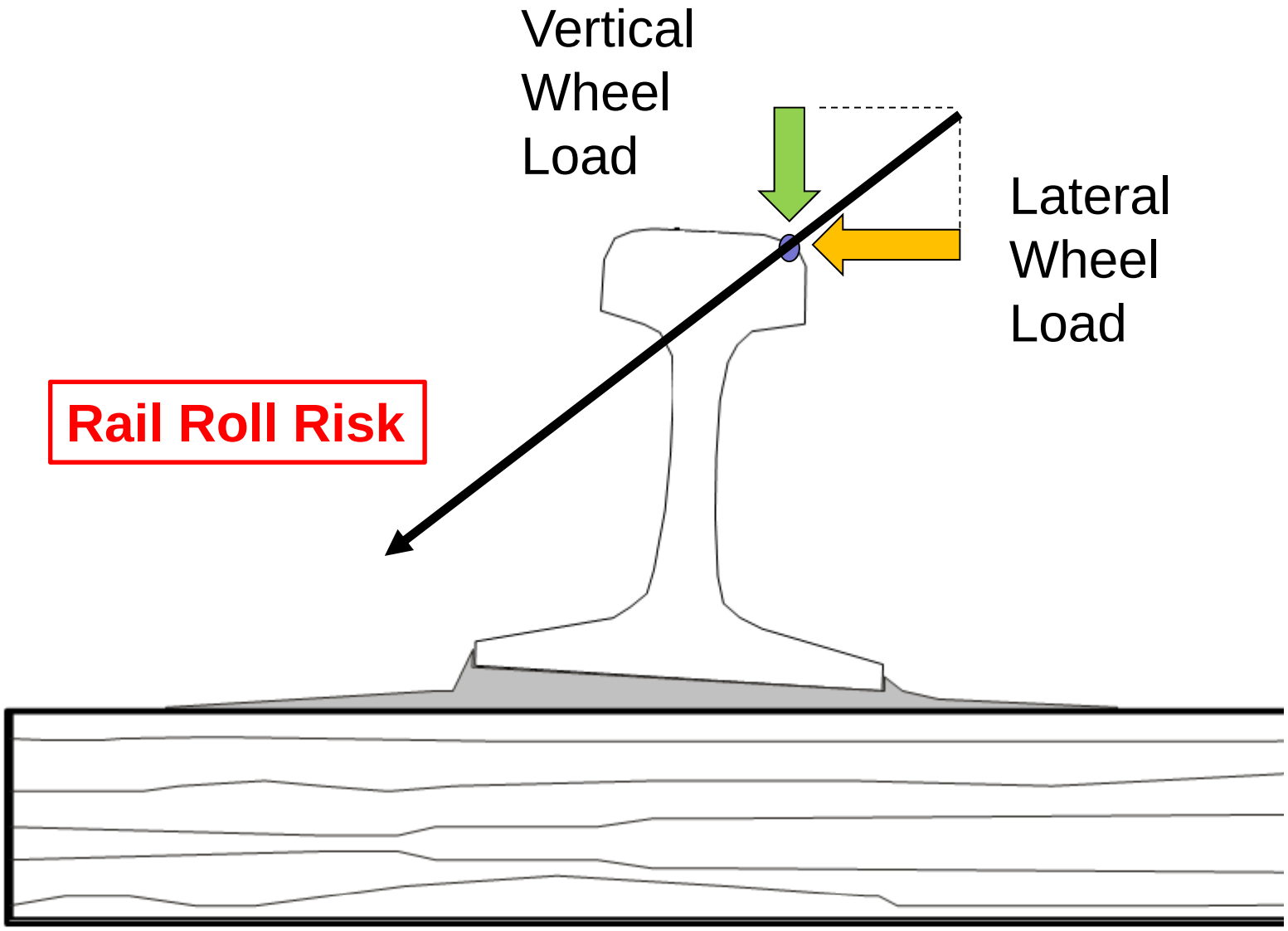
Rail Rollover



Rail Rollover



Rail Rollover



Truckside L/V Ratio

Truckside L/V Ratio =

$$\frac{\text{Sum of } \textbf{Lateral} \text{ Wheel Forces on One Side of Truck}}{\text{Sum of } \textbf{Vertical} \text{ Wheel Forces on One Side of Truck}}$$

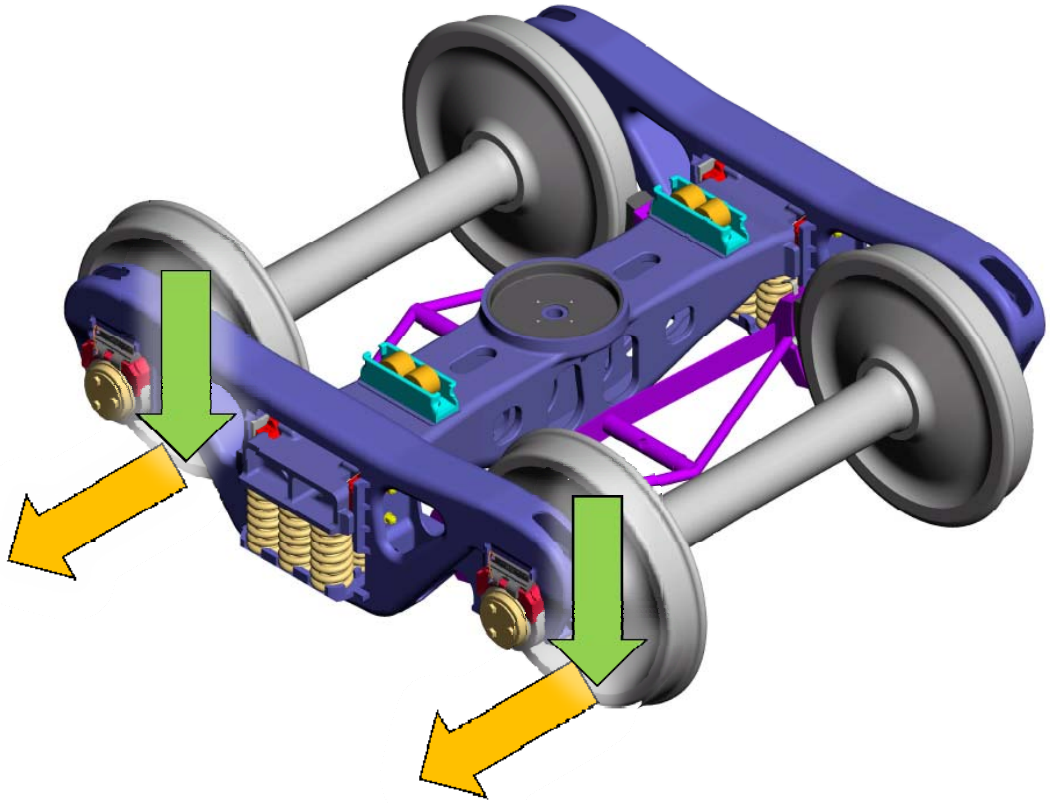
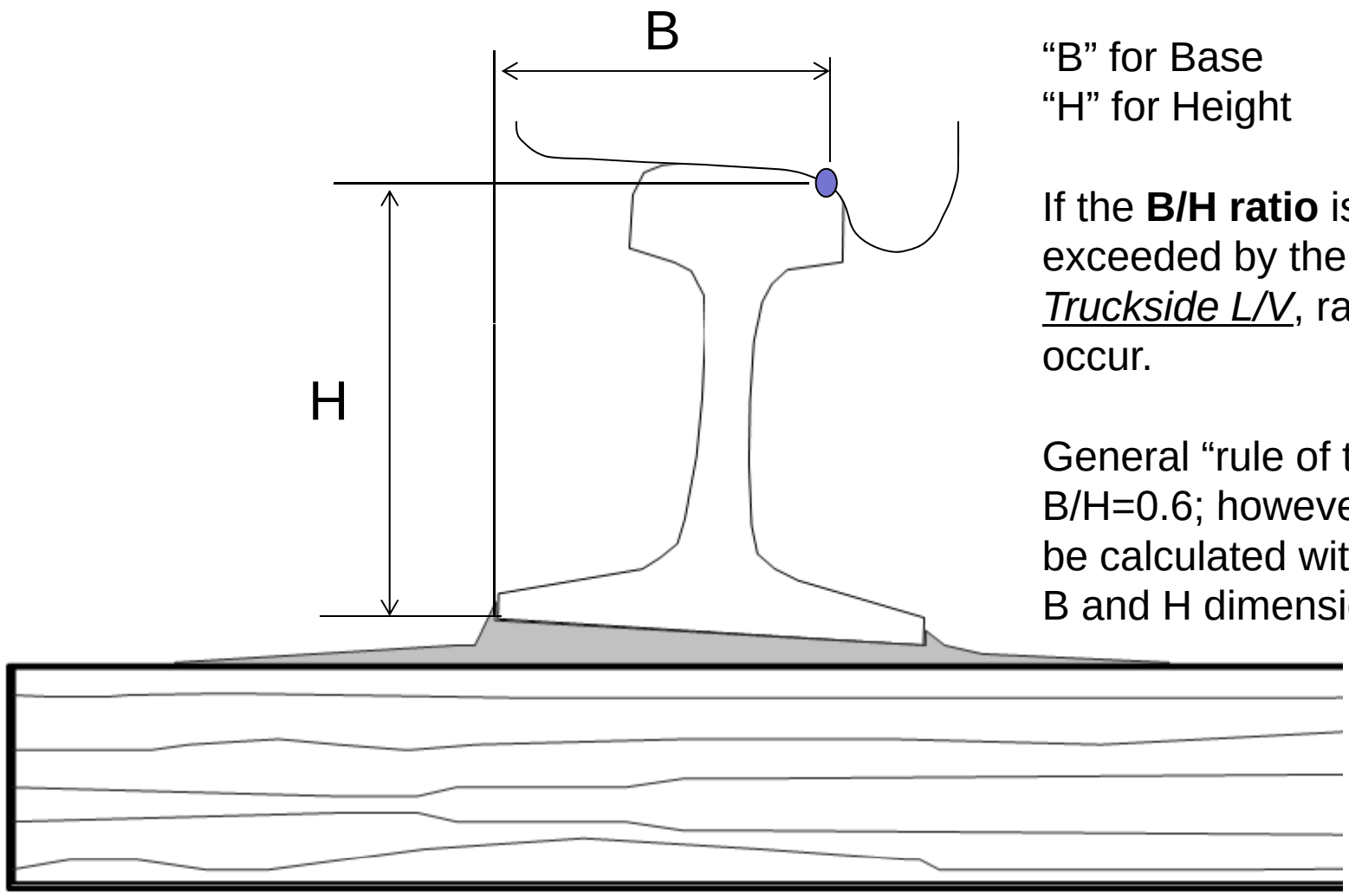


Image from Standard Car and Truck Maintenance Manual
http://www.sctco.com/pdf/Section1.pdf

B/H Ratio

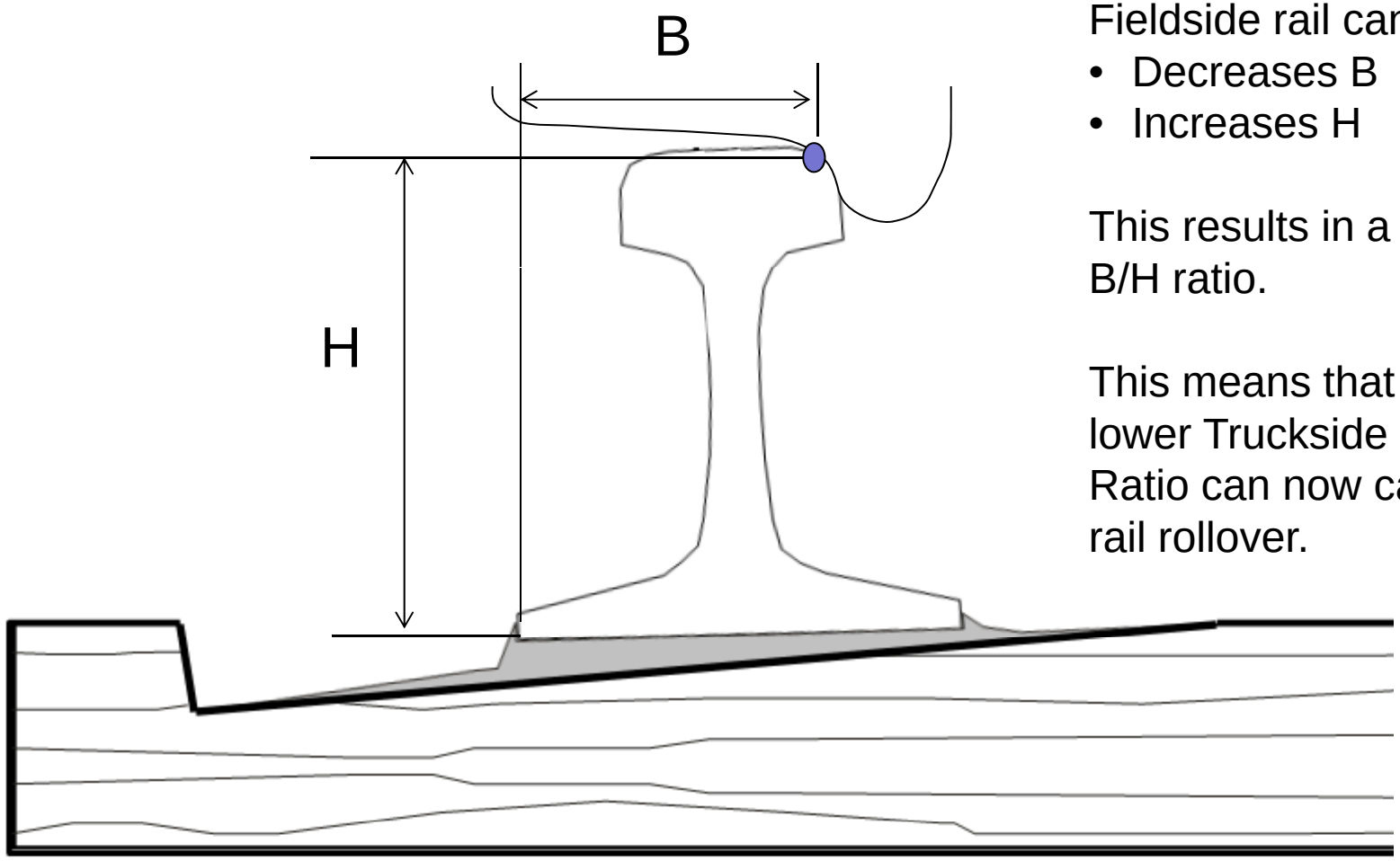


"B" for Base
"H" for Height

If the **B/H ratio** is exceeded by the *Truckside L/V*, rail roll can occur.

General "rule of thumb" is B/H=0.6; however it can be calculated with actual B and H dimensions.

B/H Ratio with Rail Cant



Fieldside rail cant:

- Decreases B
- Increases H

This results in a lower B/H ratio.

This means that a lower Truckside L/V Ratio can now cause rail rollover.

Considerations in Rail Rollover

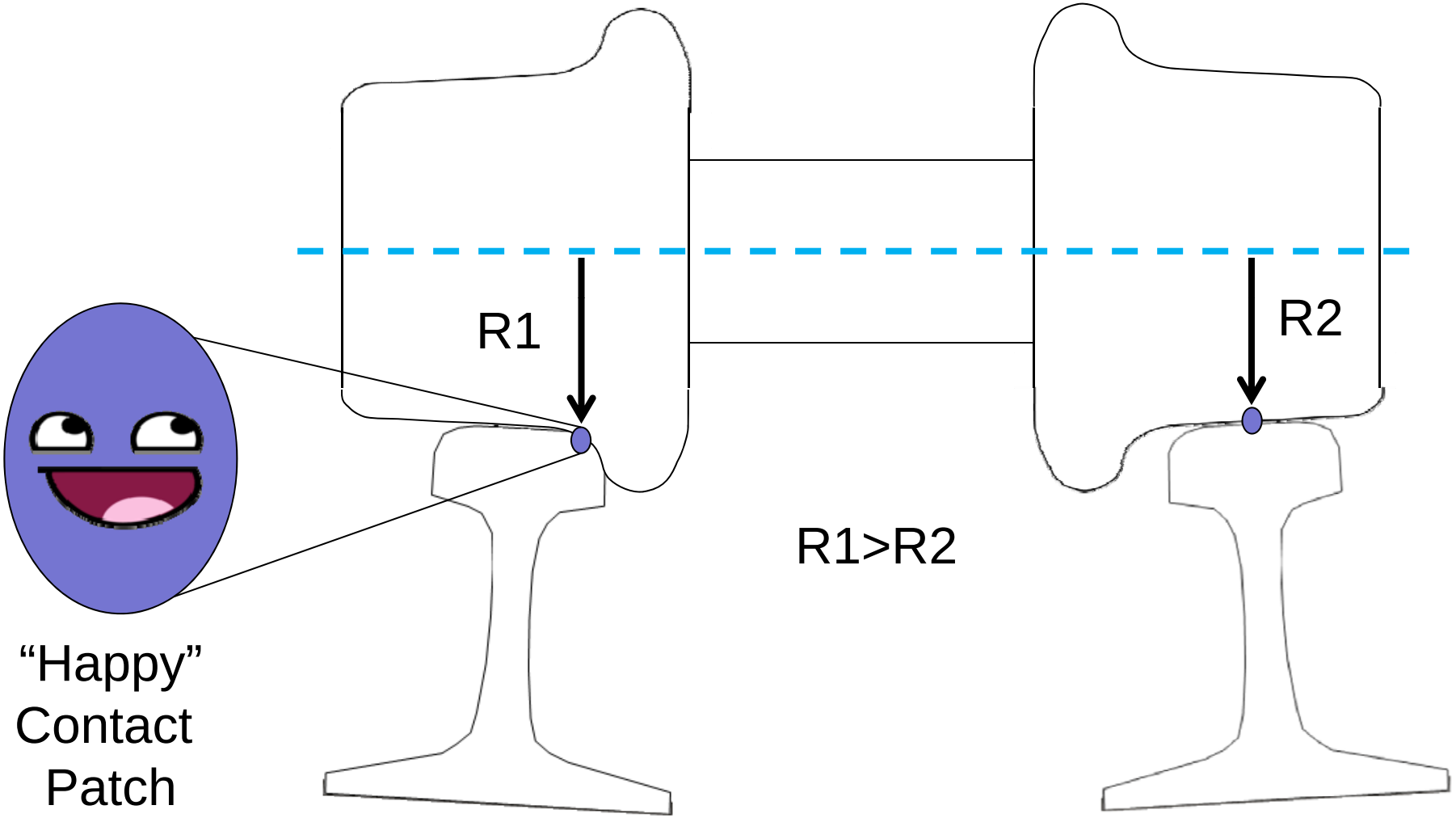
Rail Rollover is a 3-Dimensional Event.

Examples:

- The rail is physically harder to roll over if it is bending around a tight curve, as compared to a more shallow curve.
- To physically roll a rail over, it takes multiple lateral loads distributed along the curve. (i.e. multiple cars with elevated Truckside L/V ratio).
- Fasteners have a small, but sizeable contribution to preventing rail rollover.
- The Truckside L/V must be sustained for a certain time or distance..

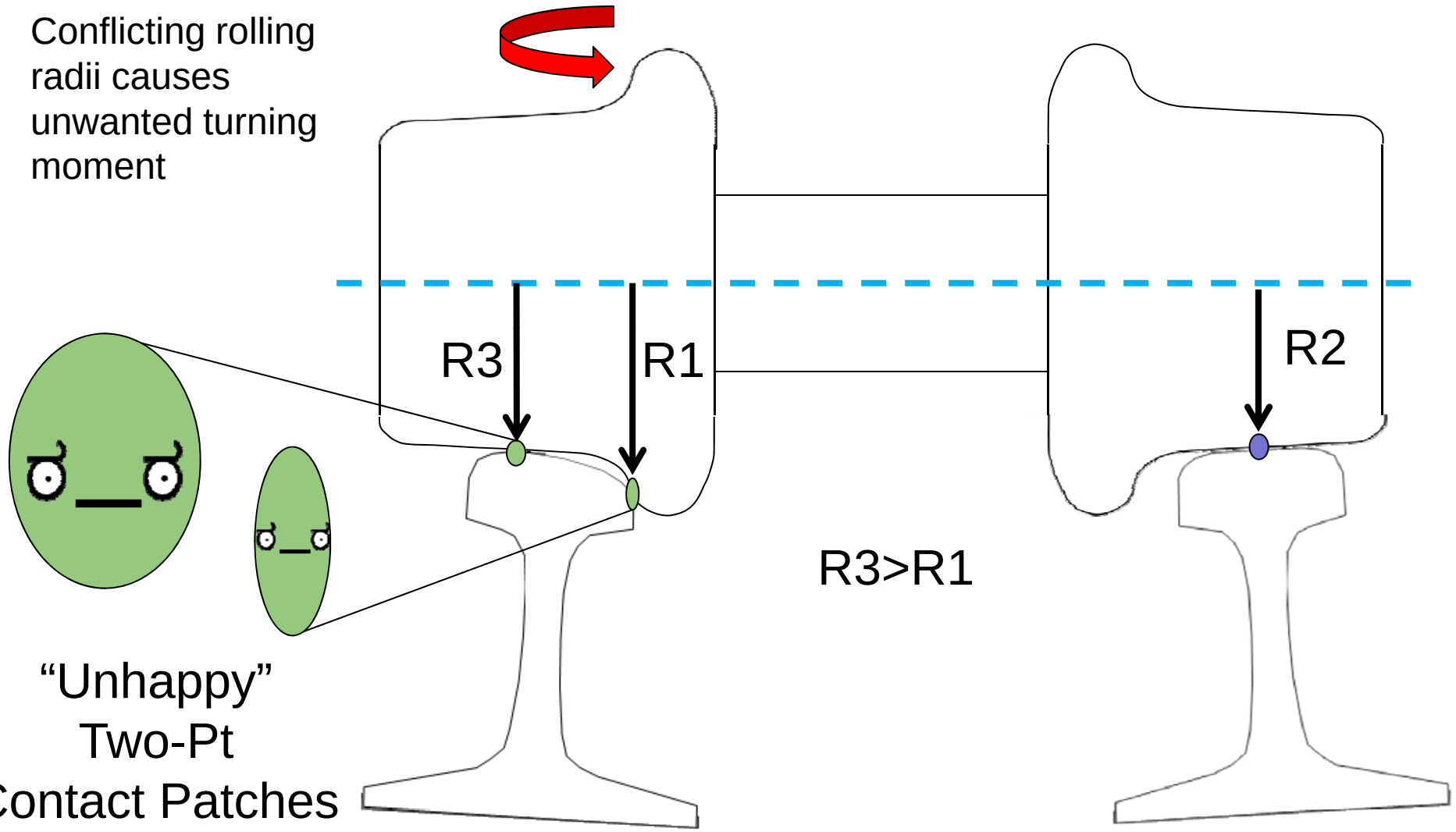
Why is Two-Point Contact So Bad for Rail Rollover?

Single Point Contact



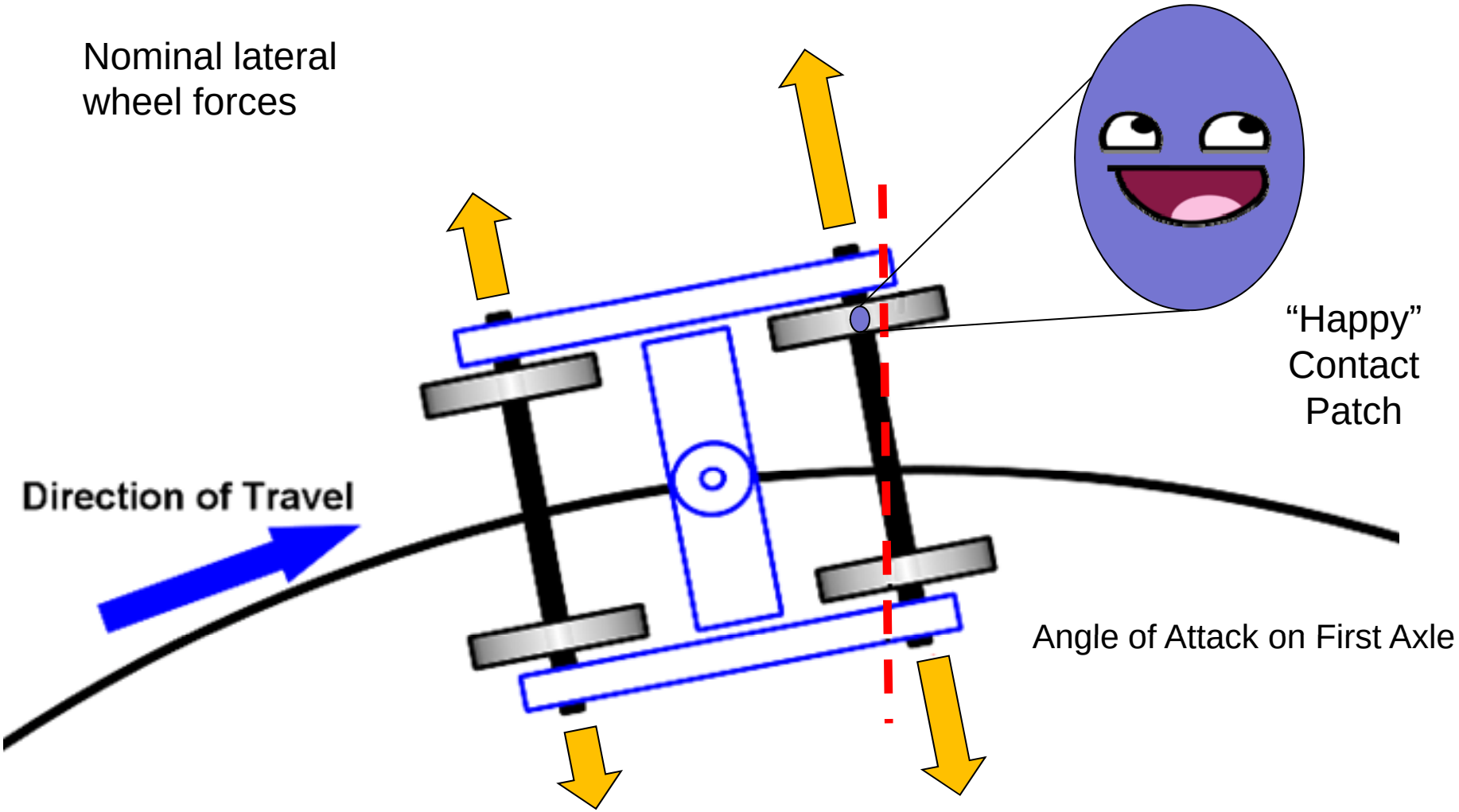
Two-Point Contact

Conflicting rolling radii causes unwanted turning moment



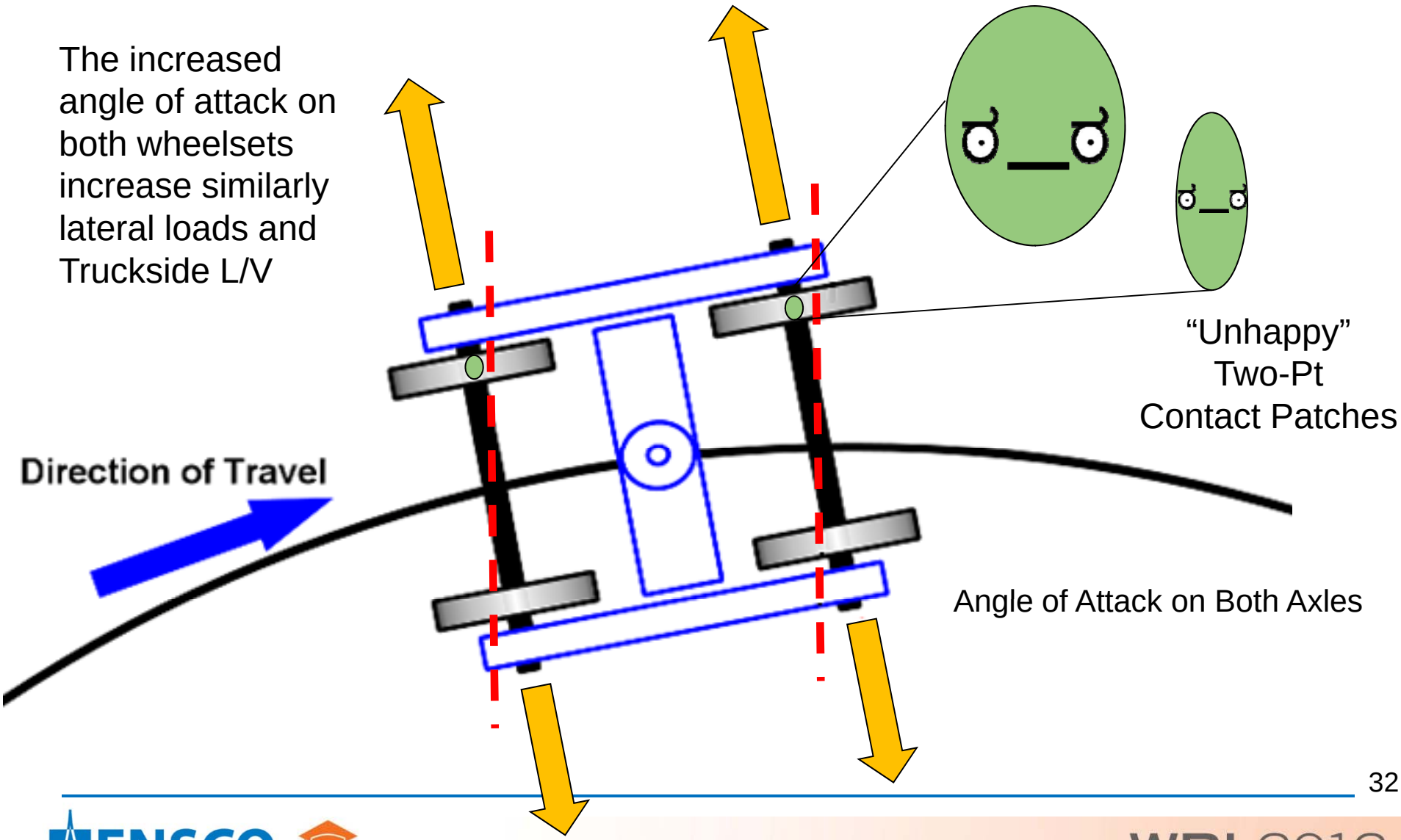
"Unhappy" Two-Pt Contact Patches

Single Point Contact Steering



Two Point Contact Steering

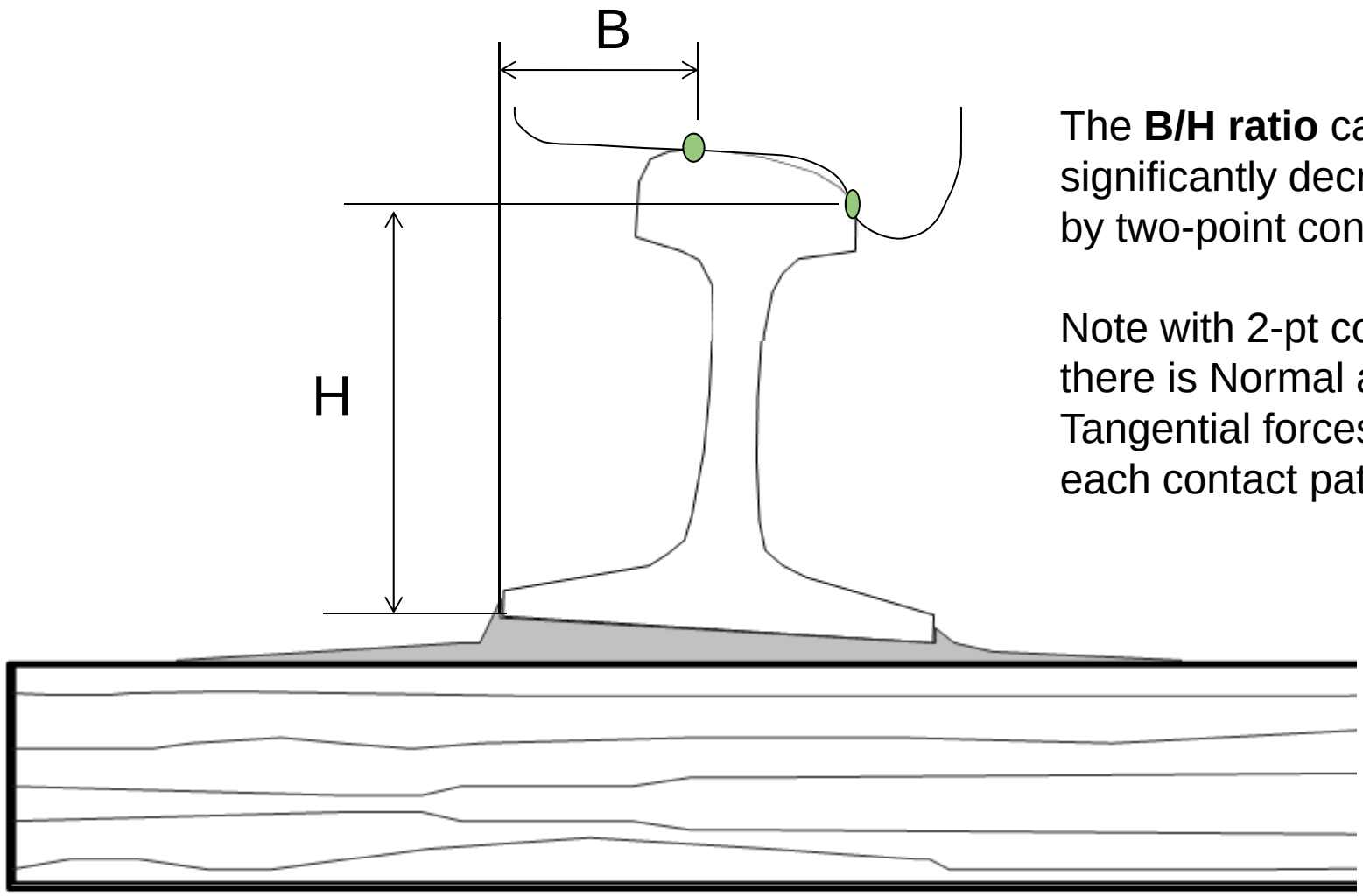
The increased angle of attack on both wheelsets increase similarly lateral loads and Truckside L/V



"Unhappy" Two-Pt Contact Patches

Angle of Attack on Both Axles

B/H Ratio with 2-pt Contact



The **B/H ratio** can be significantly decreased by two-point contact.

Note with 2-pt contact, there is Normal and Tangential forces at each contact patch.

Why is Two-Point Contact So Bad for Rail Rollover?

It increases the Truckside L/V.

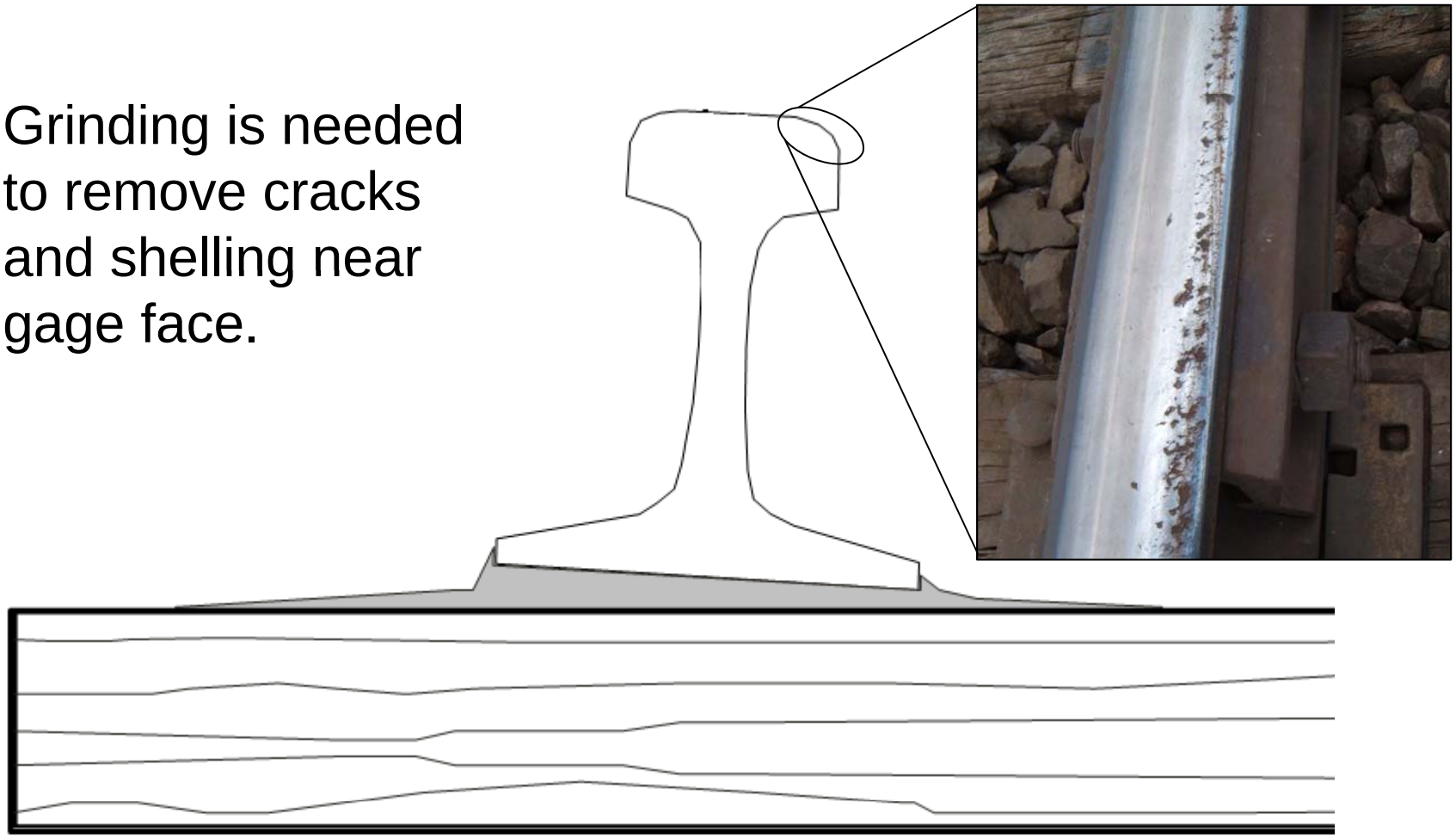
It decreases the B/H ratio.

It is a “double-whammy”.

Special Considerations with Gage Face Grinding and Tie Replacement

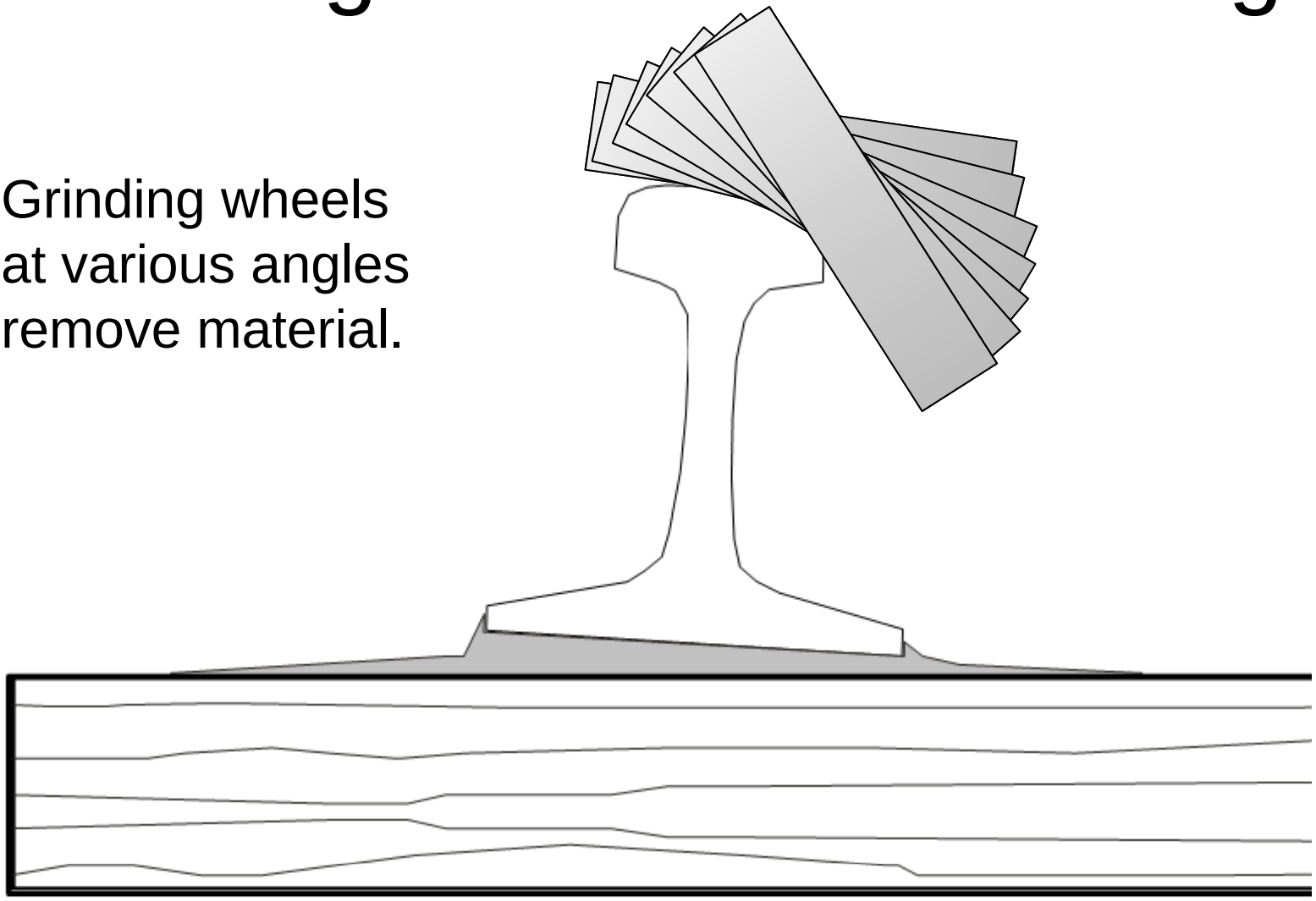
Gage Face Rail Grinding

Grinding is needed to remove cracks and shelling near gage face.

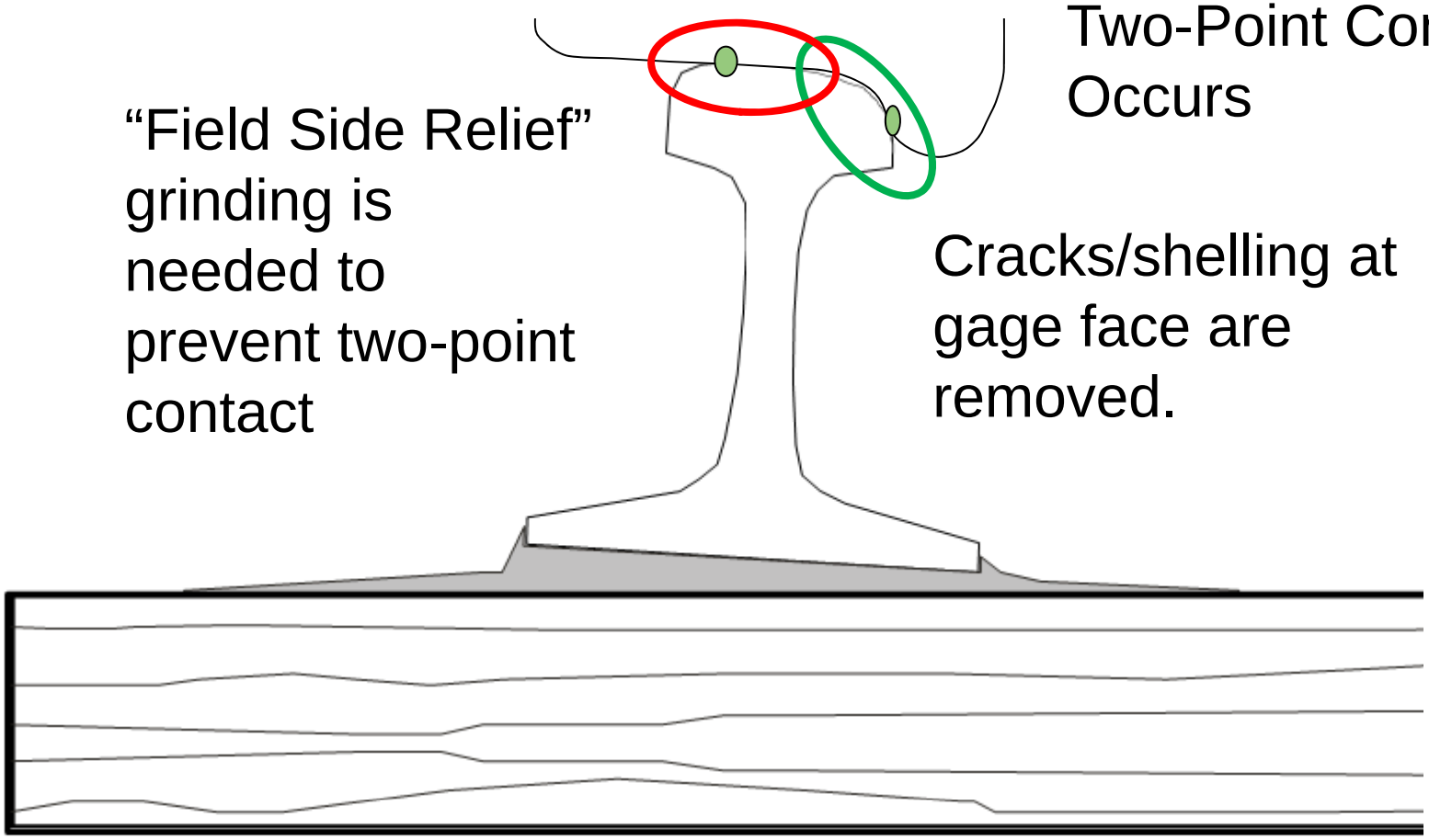


Gage Face Rail Grinding

Grinding wheels at various angles remove material.

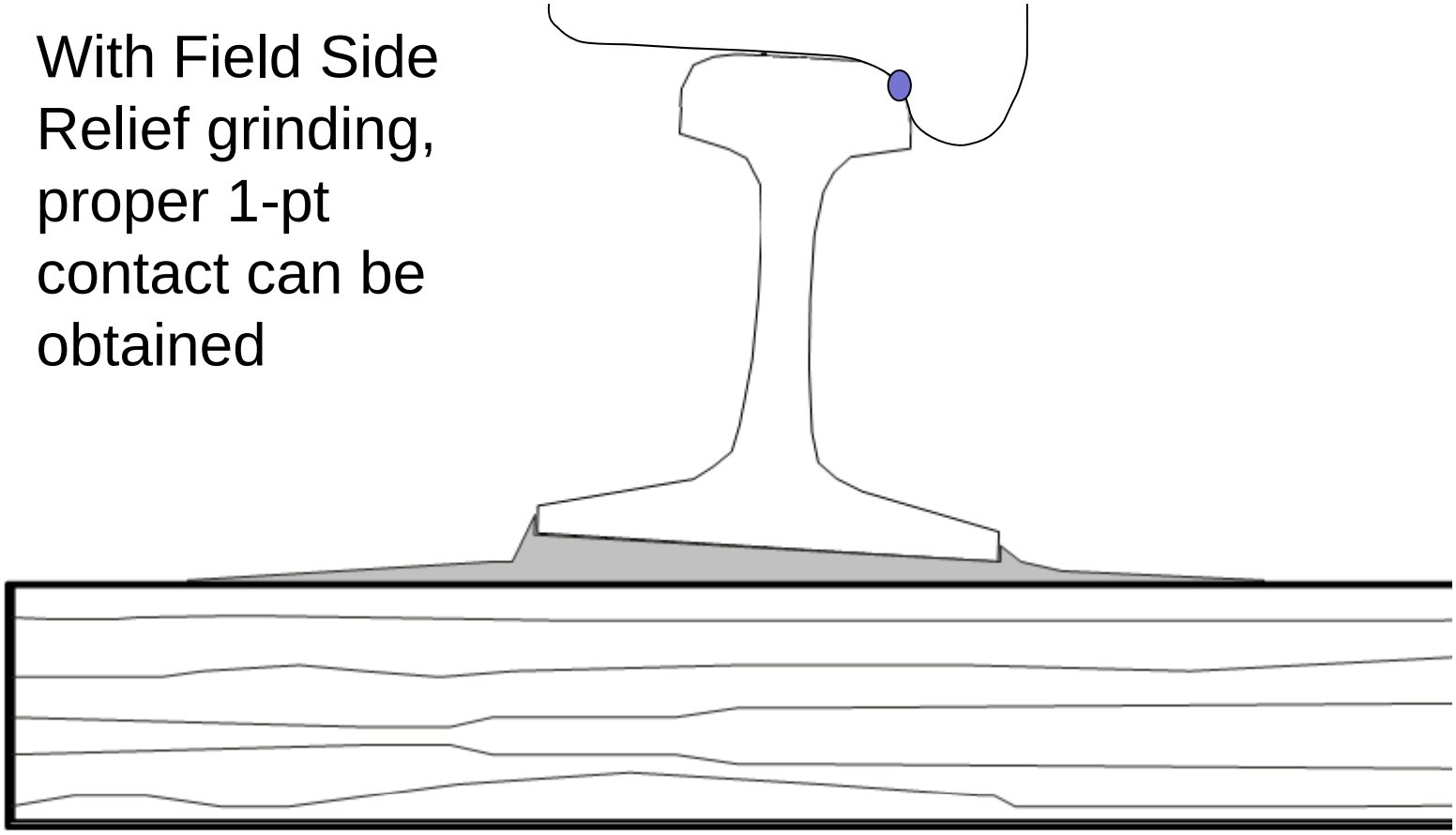


Gage Face Rail Grinding



Gage Face Rail Grinding

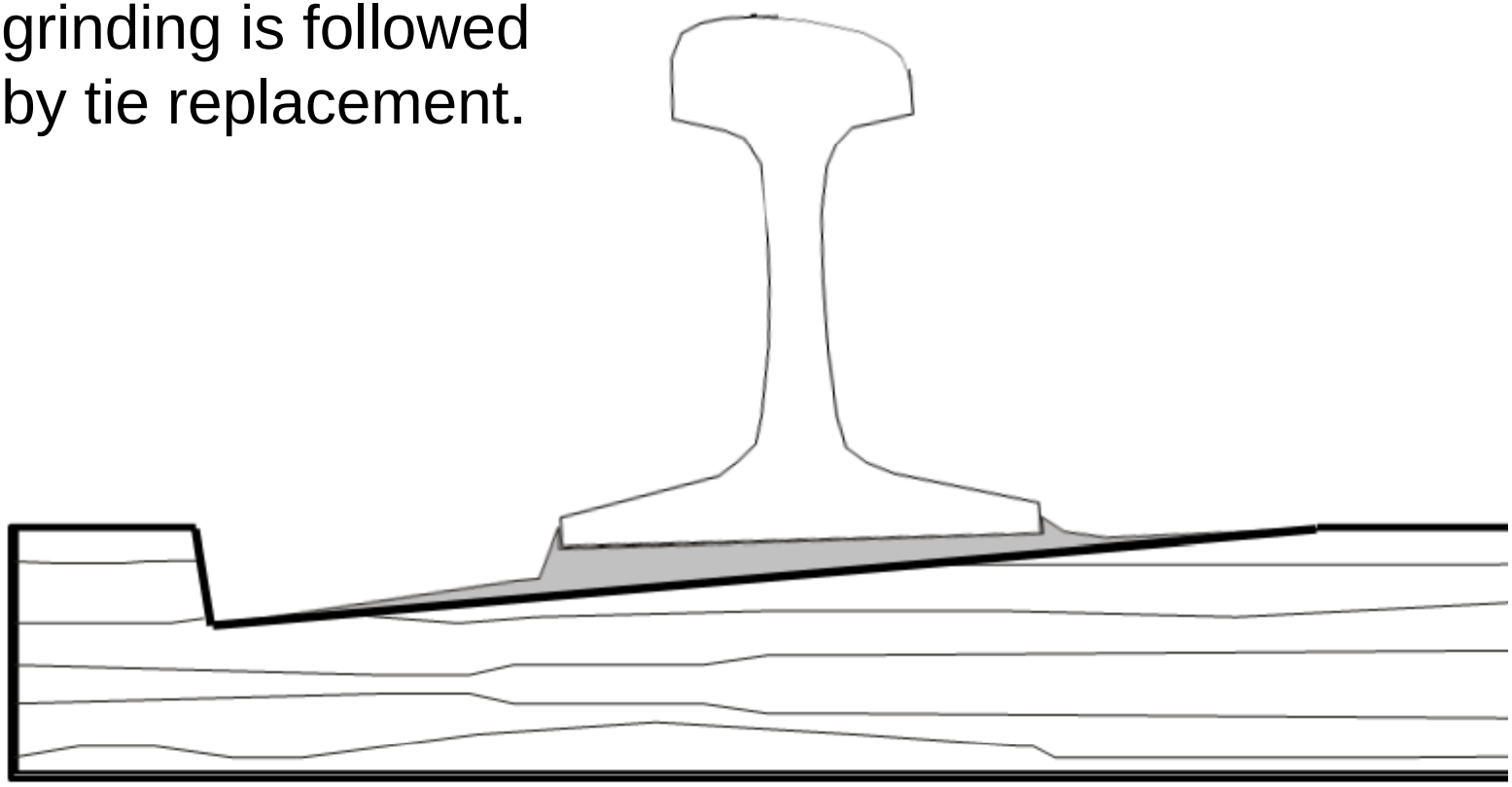
With Field Side Relief grinding, proper 1-pt contact can be obtained



Grinding with Rail Cant

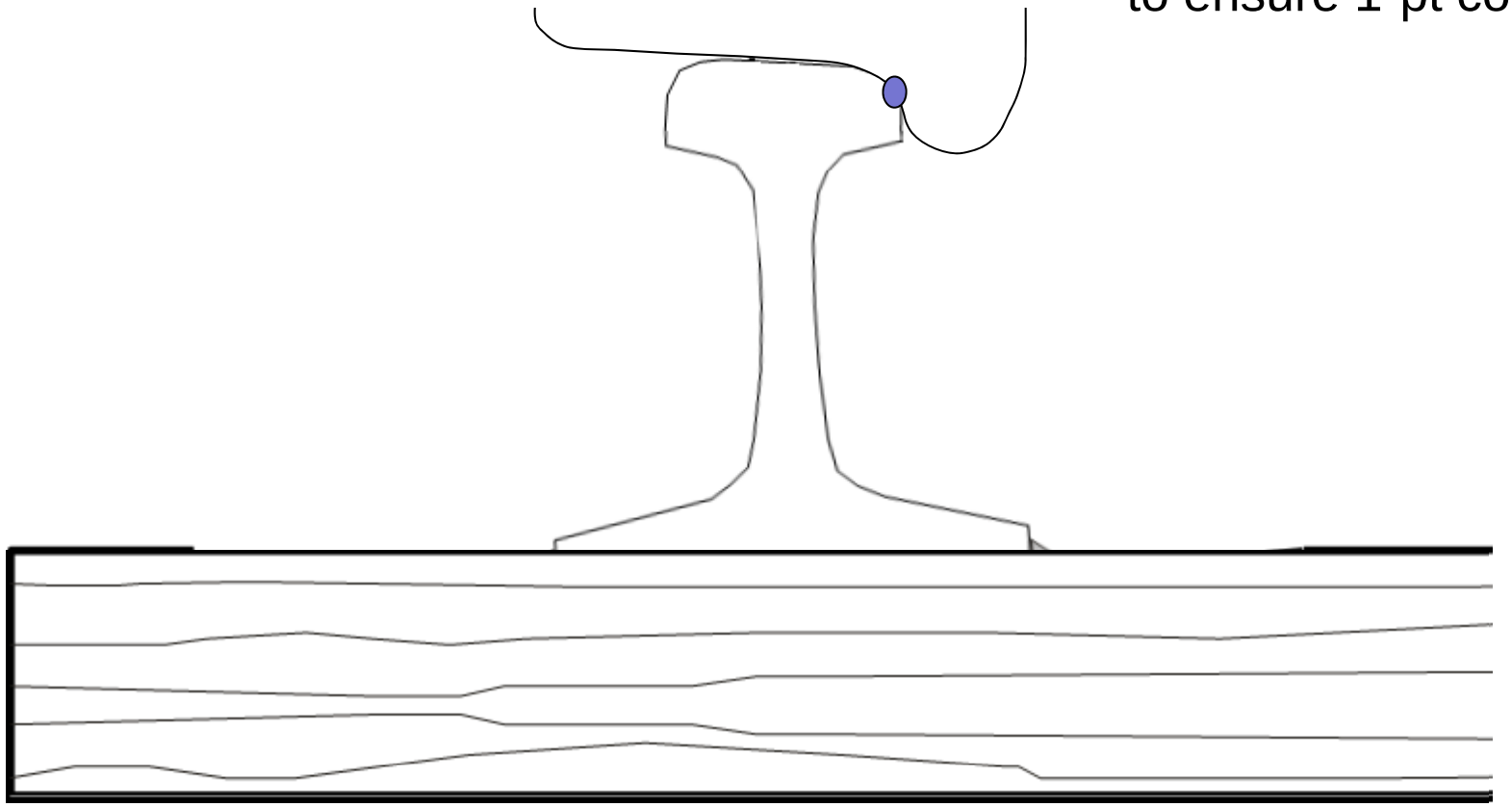
Gage Face Grinding with Rail Cant

Complications can occur when proper grinding is followed by tie replacement.



Gage Face Grinding with Rail Cant

Proper grinding occurs to ensure 1-pt contact.

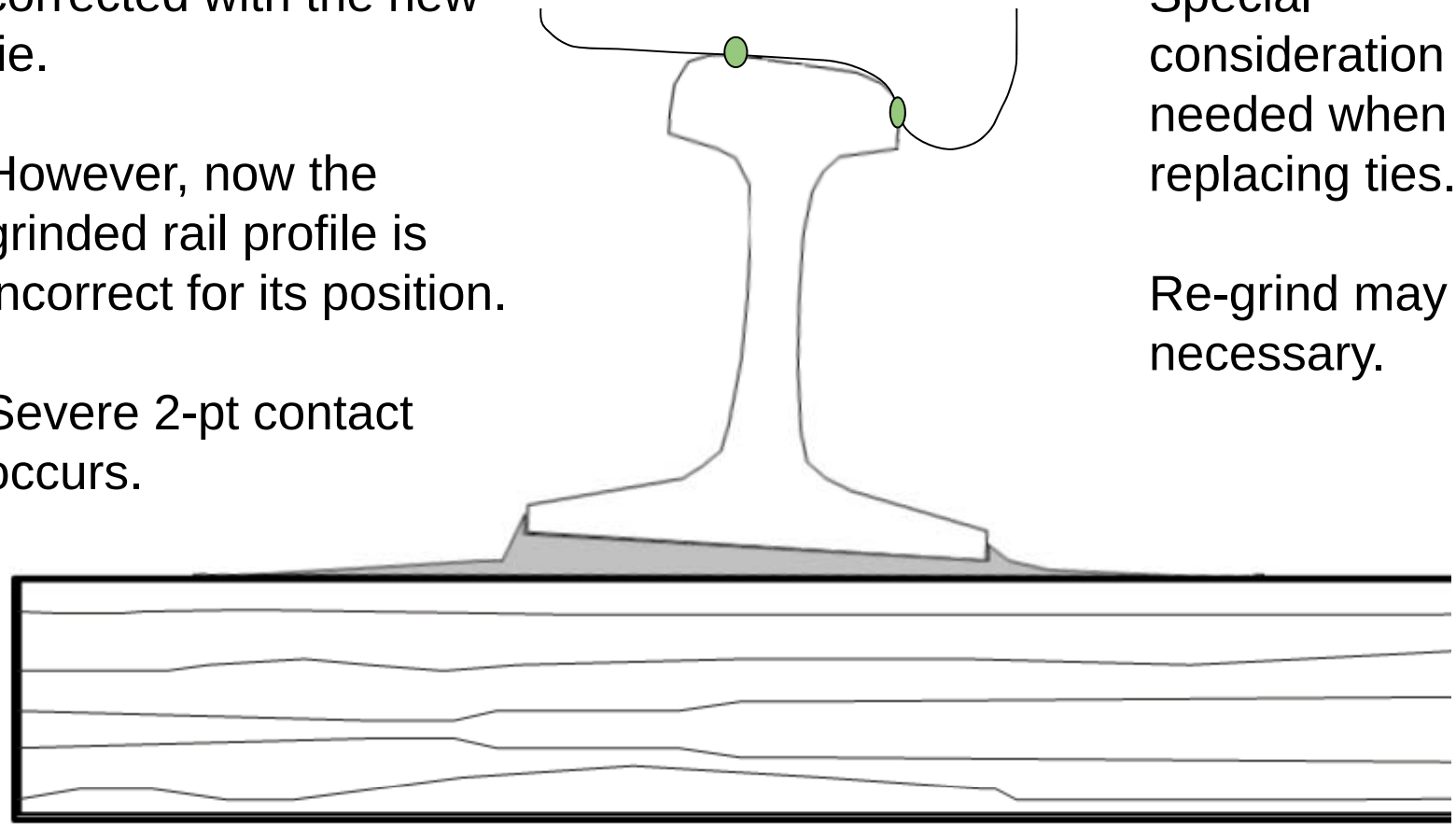


Gage Face Grinding with Rail Cant

Rail Cant has been corrected with the new tie.

However, now the grinded rail profile is incorrect for its position.

Severe 2-pt contact occurs.



Special consideration is needed when replacing ties.

Re-grind may be necessary.

References and Acknowledgements

Ref 1: "Practical Track Measurement Techniques and Tools Workshop," provided by AREMA Committee 2, Minneapolis, MN, September 18, 2011

Ref 2: Marquis, B. P., Muhlanger, M., Jeong, D. Y., *"Effect of Wheel/Rail Loads on Concrete Tie Stresses and Rail Rollover",* Proceedings of the 2011 ASME Rail Transportation Division Fall Technical Conference, 2011

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