Prud’homme’s Criterion and its Relevance for the Modern Railway Track

Karin Metnitzer, Ferdinand Pospischil and Roman Schmid

Institute of Railway Infrastructure Design

Prud’homme’s Criterion, devised in 1967, now evaluates railway safety. This study contrasts its original intent with its current use in European standards, emphasizing the impact of sleeper resistance and vehicle crossings on lateral track stability. No definitive link with sudden track buckling is identified.

Research Question

Prud’homme’s Criterion limits the sum of the guiding forces (∑Y) of a wheelset as a function of the vertical wheelset force. This limit is based on research by Prud’homme in 1967, which was not concerned with sudden track buckling but with the occurrence of incremental lateral displacements of the track. Nevertheless, it is now used in as an assessment parameter for running safety in the European Standard 14363[1], which regulates the testing and simulations for the acceptance of running characteristics of railway vehicles.

Fig.1: Track Buckling (US Department of Transportation 2015)

In this work, Prud’homme’s studies and the changes in the use of his formula are contrasted with the main parameters influencing horizontal track stability. This leads to the question of the correct classification of the formula in the currently valid standard.

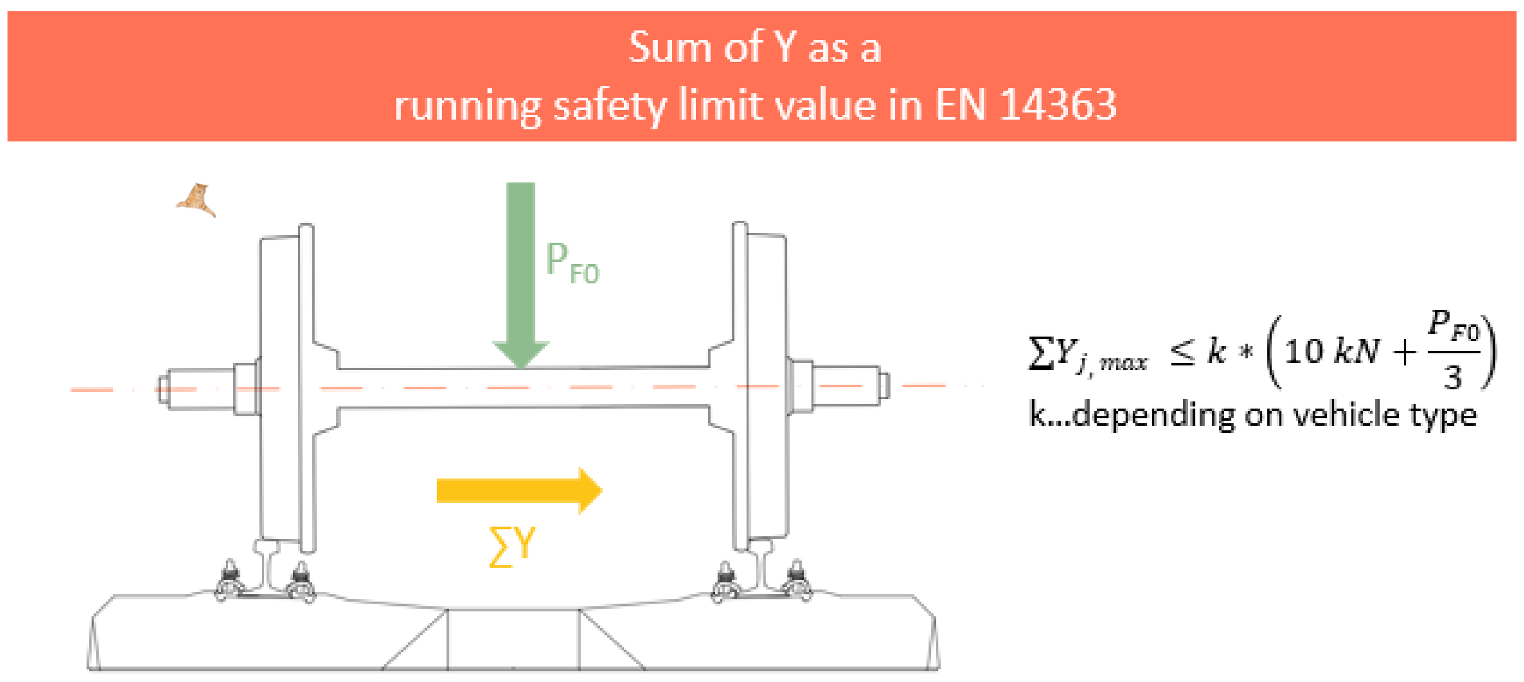

Fig.2: Running safety limit in the standard

Influence of the vehicle on track stability

The most important factor influencing the track stability is the lateral resistance of the track which is not only different for each sleeper, but is also influenced by the vehicle crossings. The lateral resistance is made up of 3 parts: friction on the sleeper sides, pressure at the sleeper shoulders and friction at the bottom between sleeper and ballast. The last part is reduced in the area of the uplift (red in figure 3) due to the lower contact between sleeper and ballast.

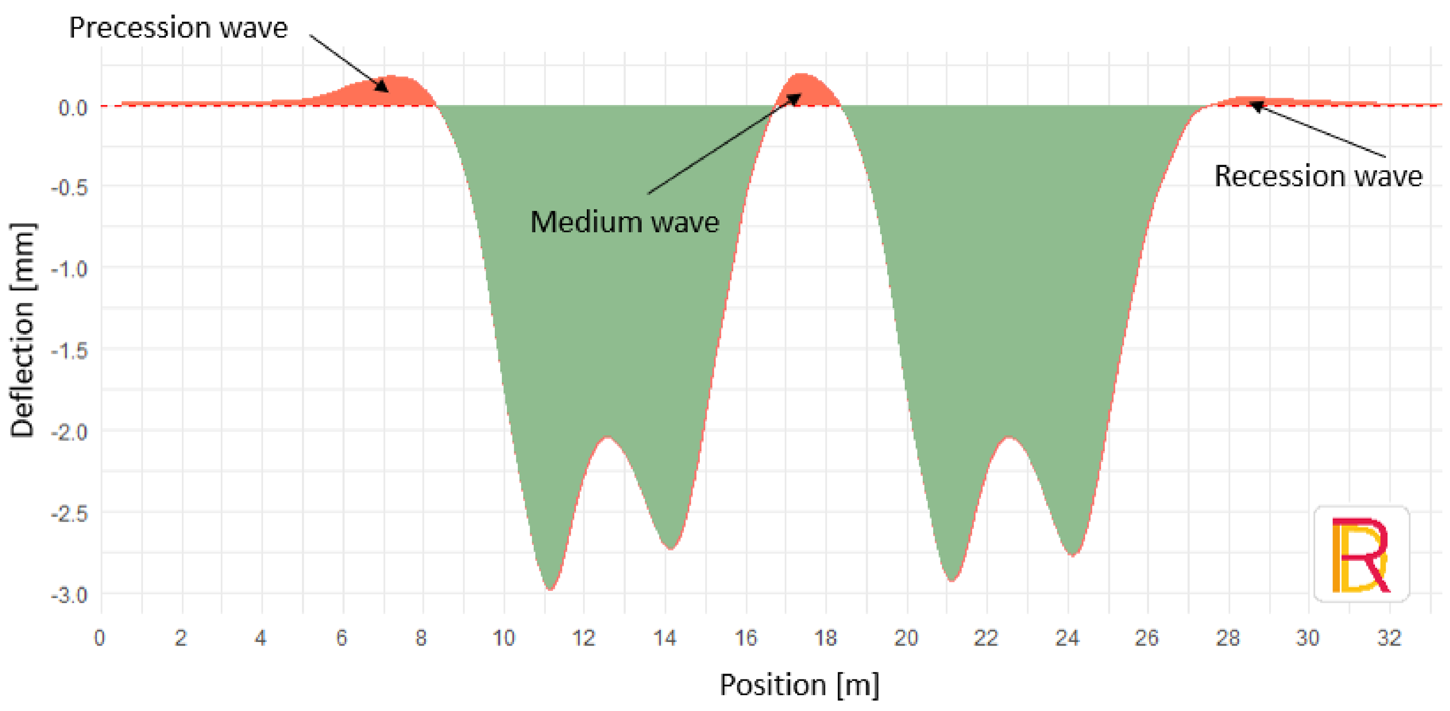

Fig.3: Vertical movement of the rail during a vehicle crossing

This uplift occurs shortly after or between the axles and can vary depending on the superstructure properties and vehicle type (especially bogie spacing).

In order to investigate the influence of the vehicle crossing on the stability of the track position, two measurements were carried out. The first measurement, carried out by Institute of Railway Infrastructure Design, investigated the simultaneity of the uplift and the maximum lateral force. The **horizontal displacement** of the rail head was considered as a quantitative value for the **lateral force**. The **maximum lateral force** occurs in the area of wheel-rail contact. In the area of the 'weakened' superstructure (uplift-area) hardly any lateral force occurs.

The data was overlaid with data from a loaded lateral resistance measurement carried out by the University of Innsbruck. The goal was to determine the relationship between the vertical load of the vehicle and the lateral resistance.

From the superposition of these measurements, there were two main findings to be made:

1. **No significant lateral force occurs in the area of the uplift.**
2. **In the area of maximum lateral force (wheel-rail contact point), the lateral resistance is many times higher than in the unloaded state due to the vertical vehicle load.**

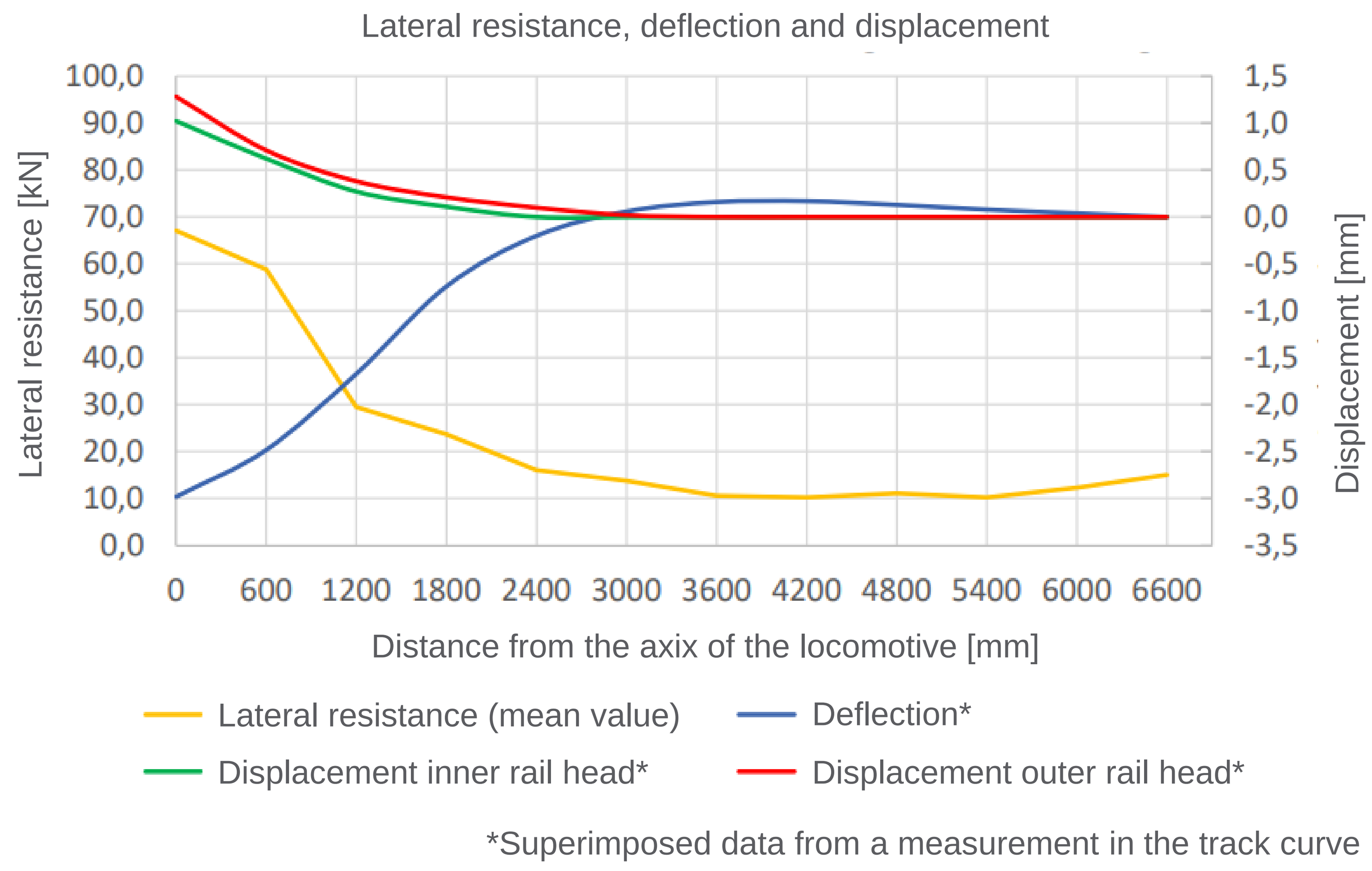

Fig.4: Superimposition of data from track curve and transverse displacement resistance measurement

Based on the investigations conducted to date, there is no discernible relationship between Sum Y and sudden, safety-relevant track buckling. In the next step, the Institute of Structural Durability and Railway Technology will develop a simulative approach to the problem in order to identify and evaluate the main factors influencing the buckling of the track.

References

[1] ÖNORM EN 14363: Bahnanwendungen - Versuche und Simulationen für die Zulassung der fahrtechnischen Eigenschaften von Eisenbahnfahrzeugen - Fahrverhalten und stationäre Versuche. Austrian Standards International, Wien Jänner 2023.

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TU Graz – Institute of Railway Infrastructure Design
8010 Graz, Inffeldgasse 25E/II, Austria, Tel.: +43 316 873-35081
rid@tugraz.at, rid.tugraz.at