Deterioration Factors for Feasible Rail Track Solutions

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Introduction

Combined rail track solutions (CTS) consisting of ballasted track and ballastless track can meet today's requirements for increased availability and reliability while maintaining cost efficiency by reducing life cycle costs. This goal can be achieved by ensuring a minimum deterioration of the track structure in CTS.

Analysis

Using a comprehensive literature review, this study firstly identifies and discusses deterioration factors impairing the track structure and its long-term behaviour in the single-track form solutions, i.e., the ballasted track and ballastless track solution. Then, the difference in the track response in CTS compared to that in single track form solutions analyses. Finally, the review found that deterioration factors for the feasible track solutions can be classified into four groups correlating with different deterioration source domains. These groups are: train/track interaction, interaction between track components, track/environment interaction, and interaction of track with track support structure. In addition, some of the deterioration factors presented in previous studies need to be adjusted for CTS conditions. This article proposes a new comprehensive system of deterioration factors relevant for modelling combined track solutions. These new factors can be derived by (i) adapting existing deterioration factors to CTS peculiarities (ii) including additional factors. The adaptation is related to the interaction of track with track support structure and emphasises the modulus of elasticity of the subgrade and the amplitude and the wavelength of differential settlement in the subgrade. This is required due to a different dynamic response of the track forms in CTS compared to that in a single-track form solution. The additional factors related to track component interaction are (i) the design of the track forms, (ii) the location, design and quantity of track transitions, and (iii) the mechanical property of constituting track components (i.e., ballast or track slab).

Conclusions

The output of this study will contribute towards accurate prediction of the condition of different track solutions, quantification of maintenance needs, and development of reliable decision support models, e.g., LCC and LCA.

References

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Plus, another 104 references.

Determination of the moment of inertia for different types of superstructures for track stability considerations

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Introduction

The theoretical moment of inertia (I_{TH}) of a track grid is a specific value, with which the lateral stiffness of the track grid itself is described. The experimental determination is based on the relation of a pin-ended simple beam with a centrally arranged single load. Transferred to a track grid, the I_{TH} can be determined by the knowledge of the lateral track-grid bending and the required force.

Analysis

In the presented research, the I_{TH} of different types of superstructures were determined in dependence of the track grid length and deflection. The considerations also include newly developed fastening components with higher torsional resistance and their influence on the I_{TH} compared to conventional systems. Concerning the lateral track stability, comparative calculations can be carried out using Meier's Theory to determine the critical temperature increase.

Conclusions

It can be stated that the investigated rail fastening systems with higher torsional resistance lead to an increase in the theoretical moment of inertia I_{TH} of a track grid compared to a conventional fastening systems.
This results in higher lateral track stability and therefore also a higher resistance against track buckling.

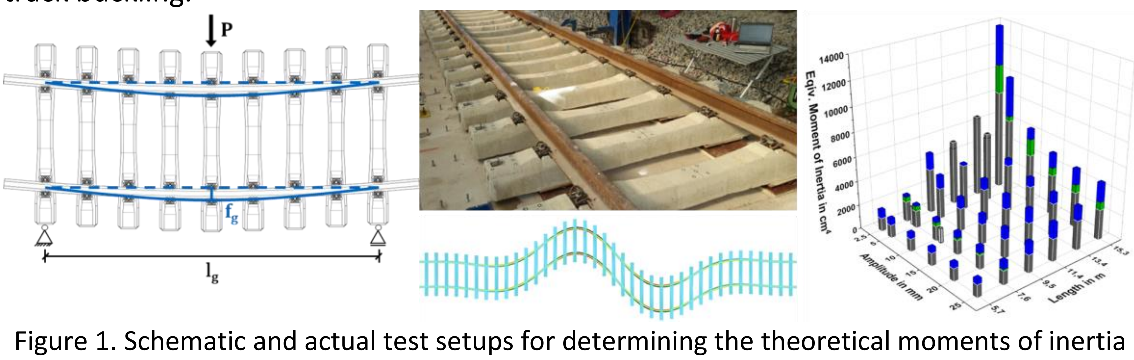

Figure 1. Schematic and actual test setups for determining the theoretical moments of inertia of a track grid for different lengths and types of superstructures.

References

Wastlhuber, Timo; Freudenstein, Stephan; Iliev, Dimitre; Bösterling, Winfried: Preventing rail buckling in extreme heat. In: IRJ (International Railway Journal) December 2023 Volume 63 (Issue 12), 41a-41c.

Whole System Modelling of Switches & Crossings

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A so-called Whole System Model (WSM) for railway switches and crossings (S&Cs, turnouts) has been under development throughout the In2Track-projects in the EU-sponsored Shift2Rail research programme. The objective is that this type of model should allow for holistic simulation-based assessment of S&C designs. In the WSM, dynamic interaction between S&C and passing vehicles is considered along with the loading and deterioration of S&C components over time. An iterative approach is applied where damage increments are computed and accumulated in the model for increments of traffic loading.

Given the vast differences in length and time scales involved in dynamic vehicle-track interaction compared to long-term track deterioration, it is not feasible for a single model to capture all relevant aspects of long-term S&C performance. The WSM is therefore a framework that integrates several state-of-the-art simulation tools and techniques. One example of the WSM that accounts for crossing running surface deterioration and ballast settlement as well as the evolution of bending moments in rails and sleepers is given in Figure **1**.

This presentation will give an overview of the WSM developments performed in the In2track3 project at Chalmers. This includes model calibration to comprehensive field measurements, an empirical model for crossing geometry deterioration and predictions of long-term deterioration in S&C compared to field measurements.

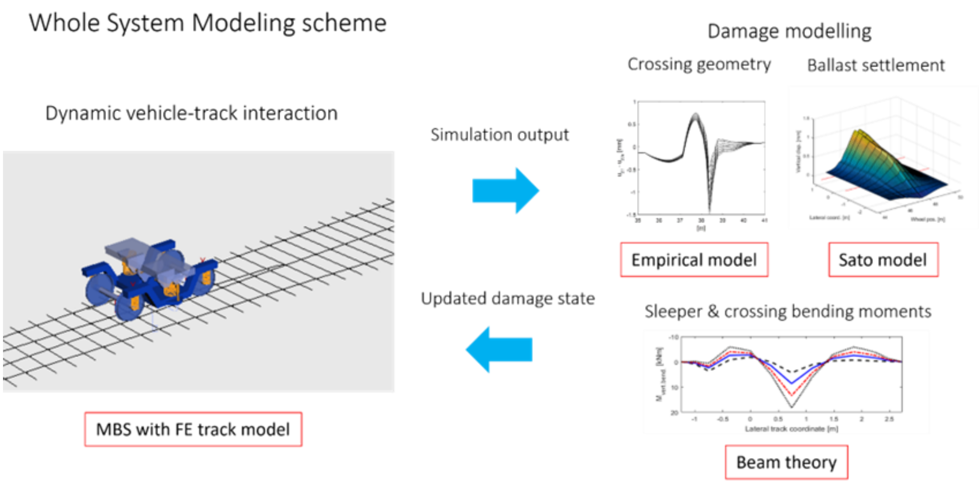

Figure 1. Illustration of Whole System modelling scheme. Simulation of dynamic vehicle-track interaction using multibody simulation with a finite element track model give input for damage modelling that in turn provides damage increments for crossing geometry and ballast settlement before the next iteration.

Effect of FFU and UPS sleepers on low frequency vibration in soft soil areas

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Introduction

Rail transport generates broad-band vibration to the track environment. The vibration travels along the surface of the ground into the buildings. In Finland the low-frequency vibration (under 6 Hz) from certain types of heavy freight wagons causes a lot of resident feedback on vibration nuisance especially in soft soil areas.

Analysis

Study was made to test composite sleepers and USP-sleepers effect on low-frequency vibration. Test track of several kilometres was built in western Finland with three different width FFU-sleepers, five different USP types and reference concrete sleeper sections. Test wagons with three-piece bogies with a lot unsprung mass was brought from Russia.

The measured characteristics included soil vibration beside the track, sleeper deflection, embankment deflection in three depths and soil pressure in embankment in two depths. The study aimed to find if and how the FFU-sleepers or USPs dampens low frequency vibration.

Conclusions

The subsoil is the biggest factor in the low-frequency vibrations transmission from track to the track environment. According to the measurements the USPs could dampen the track induced vibration in the suitable conditions. In the measured conditions the USPs dampens the low frequency vibration as much as lowering the train speed from 70 km/h to 50 km/h. The FFU35/16 sleeper dampened the low frequency vibration in all directions. Other FFU sleepers increase the low frequency vibration.

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Risk of derailment due to entrapped foreign objects in railway switches

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The aim of this study is to reduce traffic disturbances by improving the reliability of switch rail control measures while maintaining safety against derailment. The focus is on foreign objects (e.g., ballast stones) that are trapped between switch rail and stock rail. These situations will lead to a rail gauge reduction that may cause a derailment and must therefore be detected to ensure safety. In Sweden the switch rail position is currently monitored by the point machines and switch rail control sensors (Tungkontrollkontakt, TKK). However, sensor alarms lead to traffic disruptions. It is therefore important that they only indicate faults when there is a real derailment risk. The main research topics in this study have been explored in an effort to quantify the value of the TKK sensors for traffic safety; 1) which object locations and sizes can be detected with TKKs installed, and 2) what is the derailment risk due to gauge narrowing from trapped objects, in particular ballast stones.

The additional object detection capability of the TKKs was investigated with a finite element (FE) model including both switch rails and their connecting links. The model has been validated against field measurements. It was confirmed that the TKKs are necessary if objects causing gauge narrowing exceeding 13 mm should be detected. In the next step, dynamic vehicle–switch interaction including a trapped foreign object was analysed using multibody simulations. Simulations were performed for trapped objects of different types. Results in the studied cases show that the derailment risk is minimal as ballast stones will be crushed.

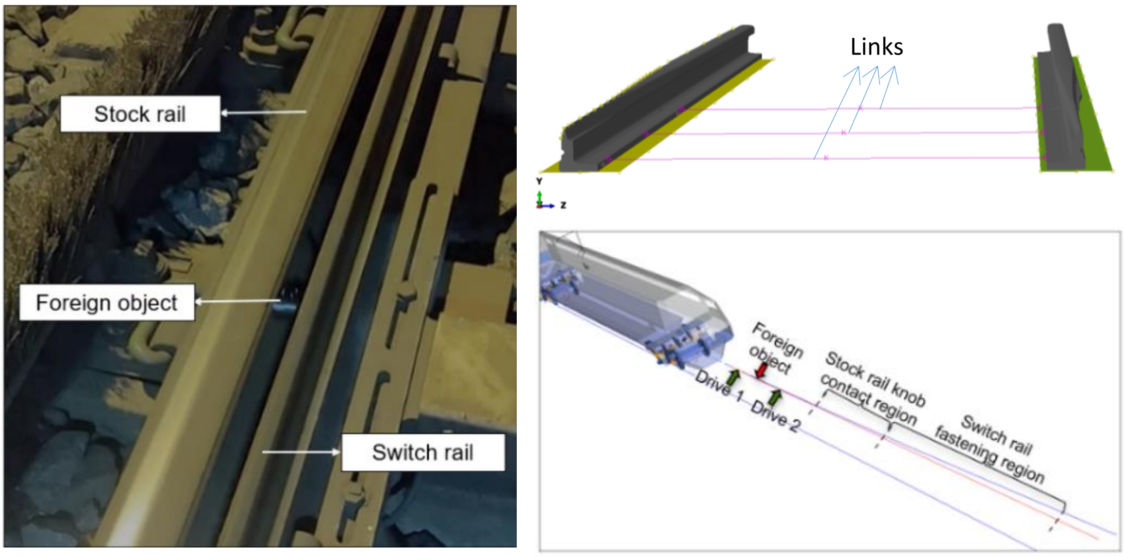

Figure 1: Picture on the left is from a field test conducted in Vätteryd, Sweden (September 2022). The top right picture shows the setup of the FE model of the switch rail in ABAQUS. Bottom right picture is the setup of the multibody simulation model in Simpack to capture the wheel–switch interaction.