PREDICTION MODELS FOR RAIL TEMPERATURES VALIDATED WITH EXPERIMENTAL MEASUREMENTS

Verão com Ciência

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Abstract

Rail temperatures play an important role when understanding and predicting rail track instabilities. A rail temperature energy balance model was used, validated with FEA analysis, and compared with field-collected data. Both solution methods are in good agreement. Compared with the collected data, the model reaches an R^2 of 0.83. Boundary conditions improvements may be required.

Fig.1 New railway (Tua Express).

Goals

1. Understand the heat balance in railway profiles exposed to weather conditions;
2. Collect field data;
3. Simulate rail temperatures in Mirandela ("Tua Express" Fig. 1);
4. Compare Finite Element Model with simplified model;
5. Compare and evaluate the performance of the other models;
6. Study the effect of thermal loads on the structural elements of the railway (critical temperature).

Methodology

The first step of the project was the installation of thermocouples in a railway segment located in Mirandela - Portugal. A weather station was installed near the rail track to collect solar radiation, wind velocity and ambient temperature data.

The data was analysed and proceeded to the coding of the simplified model in Python language using SciPy tools. The model was proposed by Hong (2019) and considers the effect of solar radiation, wind velocity, ambient temperature, radiation emissions and the variation of sun elevation and azimuth.

Later the FEA model was built to validate the simplified model. The finite elements PLANE55 and COMBIN39 were used in Ansys to construct the model (fig. 2) . A full transient analysis was performed from 6:00 to 23:00 (61200 s), with a time step of 60 s. The rail profile utilised was UIC54.

BEAM181 was used for the nonlinear bucking analysis.

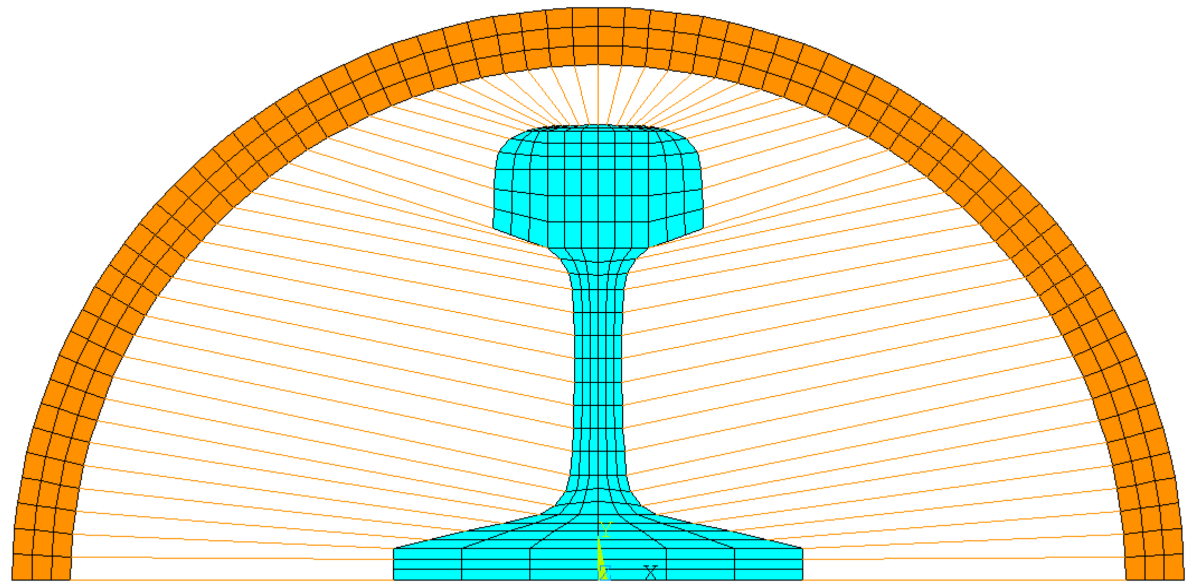

Fig.2 – Finite element mesh

An example of the weather data for the simulation is shown in fig. 3, obtained on 22/07/2020.

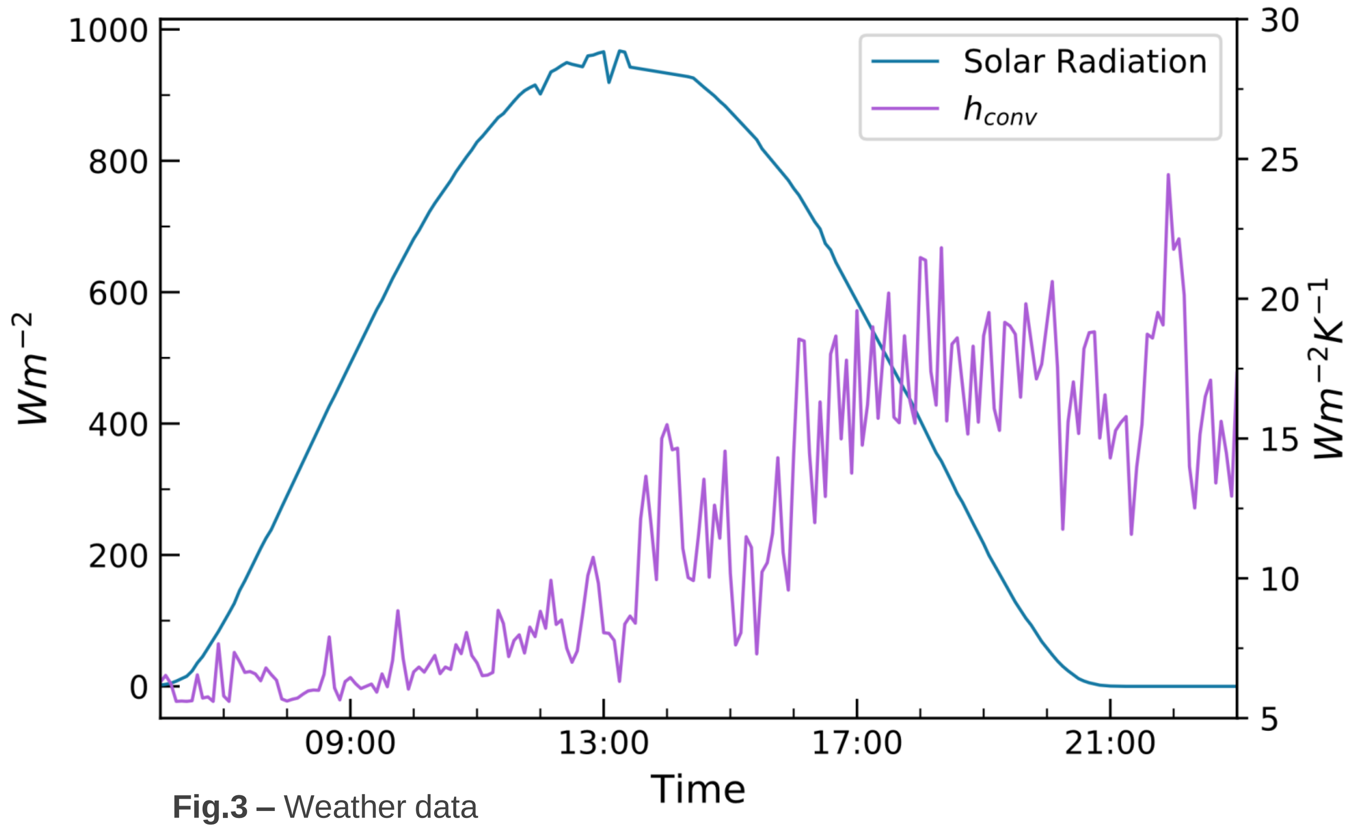

Fig.3 – Weather data

Results

Both simplified and FEA models are in good agreement, thus, simplified models can be used to perform such predictions. Comparing to experimental data, the models performs well. The results are shown in fig. 4. From this simulation is possible to use the results in mechanical simulations to study the instabilities of the railway (Fig. 5).

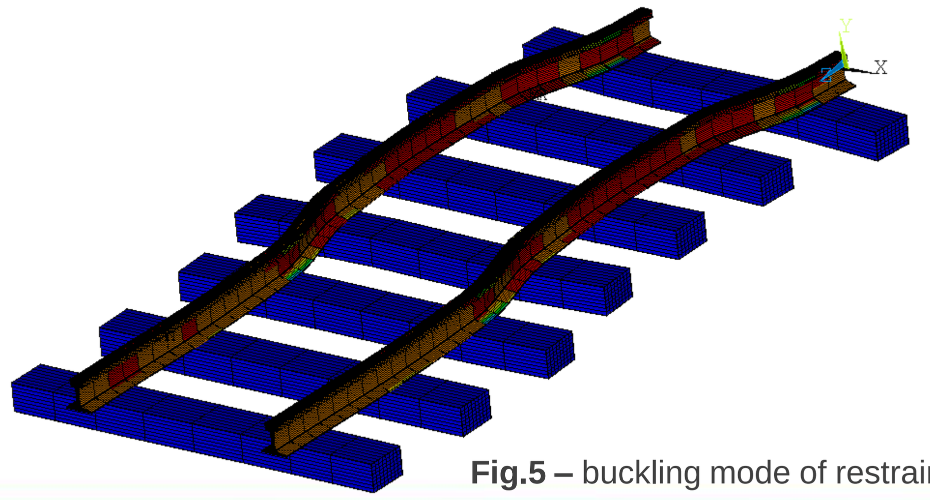

Fig.5 – buckling mode of restrained railway.

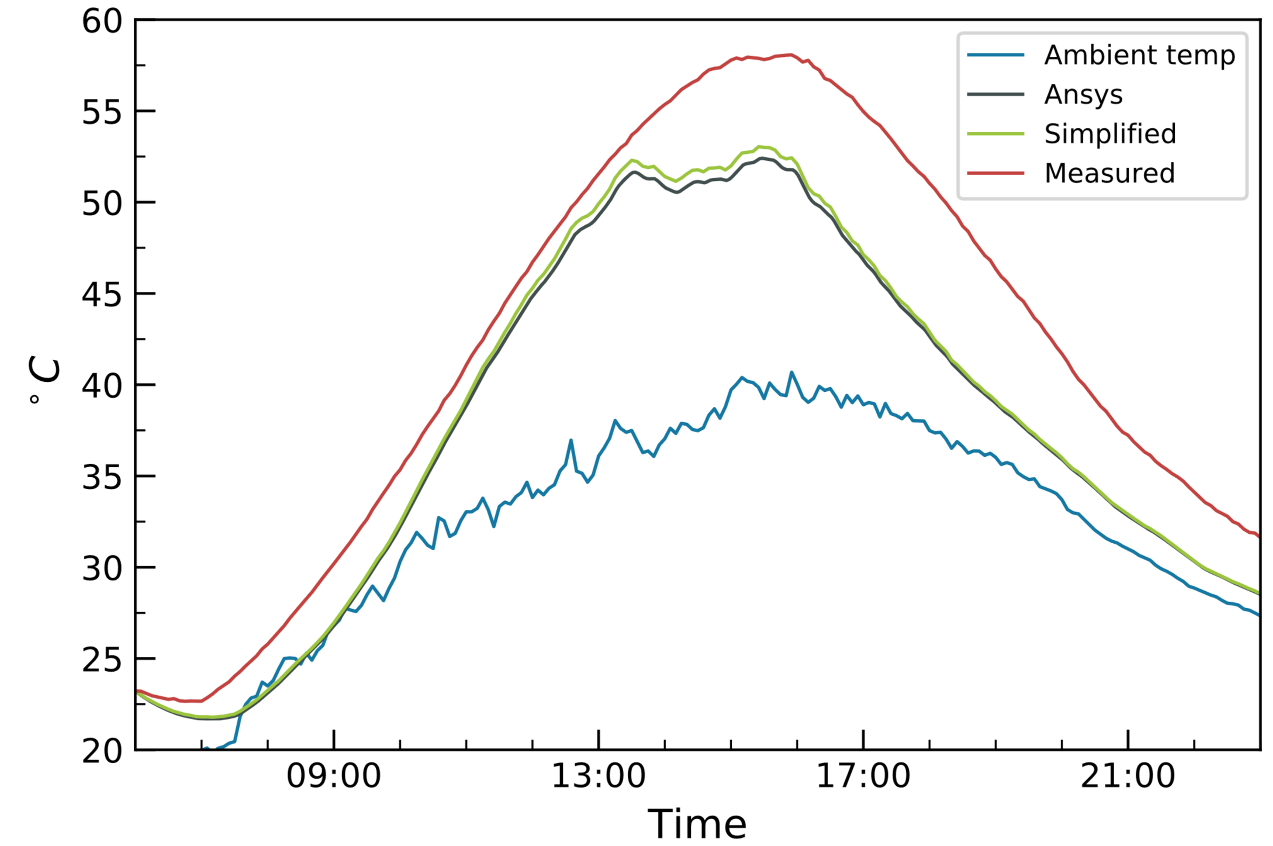

Fig.4 – Simulation results for temperature prediction at railway.

Conclusions

The study shows that simplified models can easily be used as a tool since it's more practical than FEA models. In comparison with measured temperature, the model performs with a R^2 of 0.83 but improvements on the boundary conditions are needed, mainly regarding the heat exchange areas.

All the results were submitted to the approval of CNME congress.

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