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Sensitivity study of a model for the stability analysis of continuous welded rail

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Summary

In 1992÷1999 period the International Union of Railways (UIC) commissioned a research program from European Rail Research Institute (ERRI) about improving the knowledge of continuous welded rail (CWR) track, including switches [2]. This research was necessary for revision and update of Leaflet UIC 720 which regulate the problems concerning the laying and maintenance of CWR track, which was from January 1986 [3]. In the new Leaflet UIC 720 [4], which was from March 2005, was introduced concepts and criteria for the CWR buckling safety assessment and it were shown cases studies which appeal to the two analysis of CWR stability software, one developed at TU Delft (Holland) for ERRI – software called initially CWERRI, and nowadays LONGSTAB – and the other developed at Foster&Miller company for Federal Rail Administration of United States of America (FRA) – software called CWR-BUCKLE [1, 2]. In this context, at Civil Engineering Faculty from Brasov was developed a software for simulation of lost of track stability using a non-linear discrete model for CWR buckling analysis, in presence of thermal and vehicle loads, model called SCFJ [5, 8]. A presentation of SCFJ model can be found in [5].

In this paper is presented a comparison of numerical experiment results which were achieved with SCFJ and CWERRI software.

KEYWORDS: Continuous welded rail, Non-linear stability analysis, Temperature loading, Sensitivity analysis.

1. INPUTS

For this analysis which used the same inputs like in comparative studies of CWERRI and CWR-BUCKLE software presented in [6, 7, 9].

Hereby, it was considered a sector of $L=47,5\ m$ in the central zone of a CWR track located in a curve with $R=400\ m$, which has in the middle a misalignment characterized by a half sine wave with a length of λ = 9,144 m and an amplitude of δ = 0,0381 m (fig. 1). These values are characteristic for USA railway [6, 7, 9]. The track is composed from AREA 136 type rails and reinforced concrete sleepers

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laying at 0,61 m spacing. For the fastenings it was considered a linear-elastic behavior with a torsional resistance of the fastenings R_t = 11250 N/rad per meter track. The vertical behavior of railway track is supposed to be linear-elastic with a stiffness of R_z = 68900 kN/m per meter track. The longitudinal resistance is supposed to be linear-elastic. The lateral resistance is tri-linear with o pick value F_p which corresponds to W_p displacement and a limit value F_l for W_l displacement. It was supposed that the values of lateral resistance are in function of the vertical force between the sleeper and ballast (fig. 2) generated by the vertical loads on train axle. The model is vertically loaded by a hooper wagon with two bogies, represented by four vertical axle forces of F_z= 293 kN each (fig. 3). The centre spacing between bogies is 12,85 m. The space between the axle in a bogie is 1,78 m. The vehicle is placed on track in such a way that the middle of center spacing between bogies is coincident with the centre of the misalignment. Ori: The vehicle is centered on the misalignment. The value of the friction coefficient between sleepers and ballast is *tan Φ* = 0,86 – this being an average value for reinforced concrete sleepers.

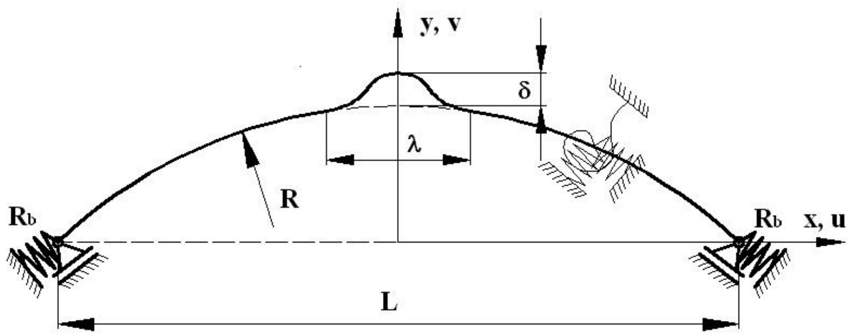

Fig. 1. Plan view of CWR track model

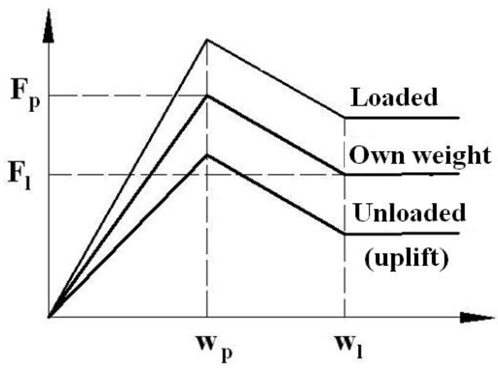

Fig. 2. The lateral behavior of ballast including the corrected value due to vertical loads

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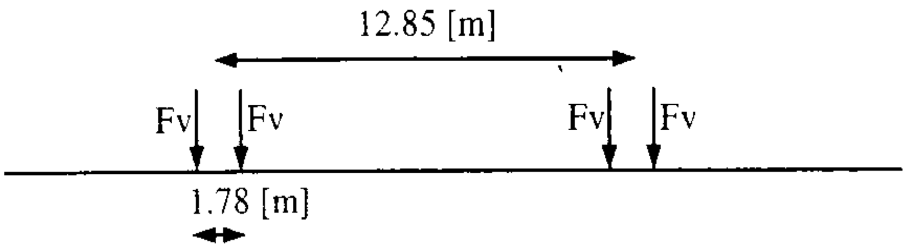

Fig. 3. Vertical axle loads on track

2. THE COMPARISON OF THE RESULTS

In the sensitivity study the quantities of interests are the increases of the superior critical temperature T_{max}, respectively inferior T_{min}, which result from the lateral displacement curve for the middle of the CWR model in function of the increase of the temperature (fig. 4). These were obtained through variation of each parameter in an interval, while the other parameters are remaining constants, as shown in Table 1. It was considered that in the initial position the track is strain free.

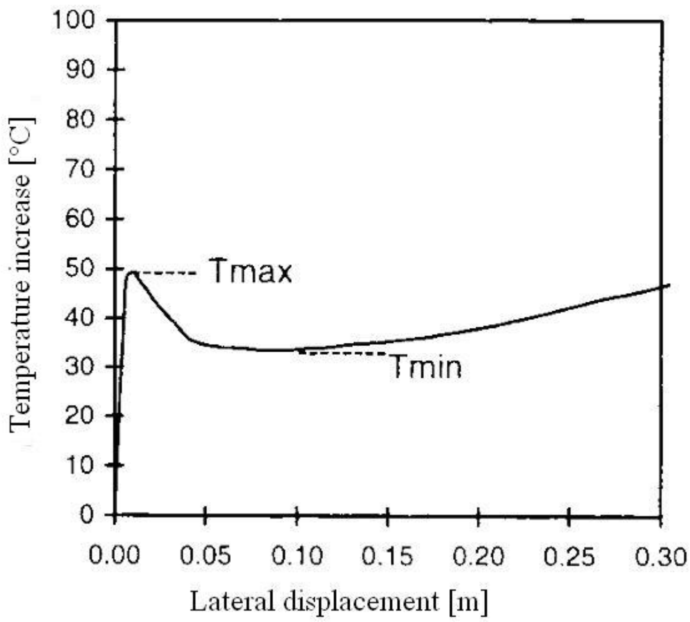

Fig. 4. Lateral displacement at the middle of CWR model versus temperature increasing

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Table 1. The parameters of the model for the sensitivity analysis

Parameter	Reference value	Range
Radius (R) [m]	400	100 ÷ ∞
Lateral peak resistance (F_p) [N/m track]	17508	8754 ÷ 26262
Lateral limit resistance (F_l) [N/m track]	9630	4815 ÷ 14445
Longitudinal resistance (R_x) [N/m/m track]	$1{,}378 \cdot 10^6$	$1{,}0 \cdot 10^5 \div 1{,}0 \cdot 10^7$
Torsional resistance (R_t) [Nm/rad/m track]	$1{,}1125 \cdot 10^5$	$0{,}0 \div 3{,}0 \cdot 10^6$
Misalignment amplitude (δ) [m]	0,0381	0,008 ÷ 0,05
Wave length of misalignment (λ) [m]	9,144	1,2 ÷ 9,6

It is observed that for the critical temperature increases in function of radius (fig. 5), the difference between SCFJ and CWERRI results is maximum 7%, and the biggest differences are for the smallest radius values.

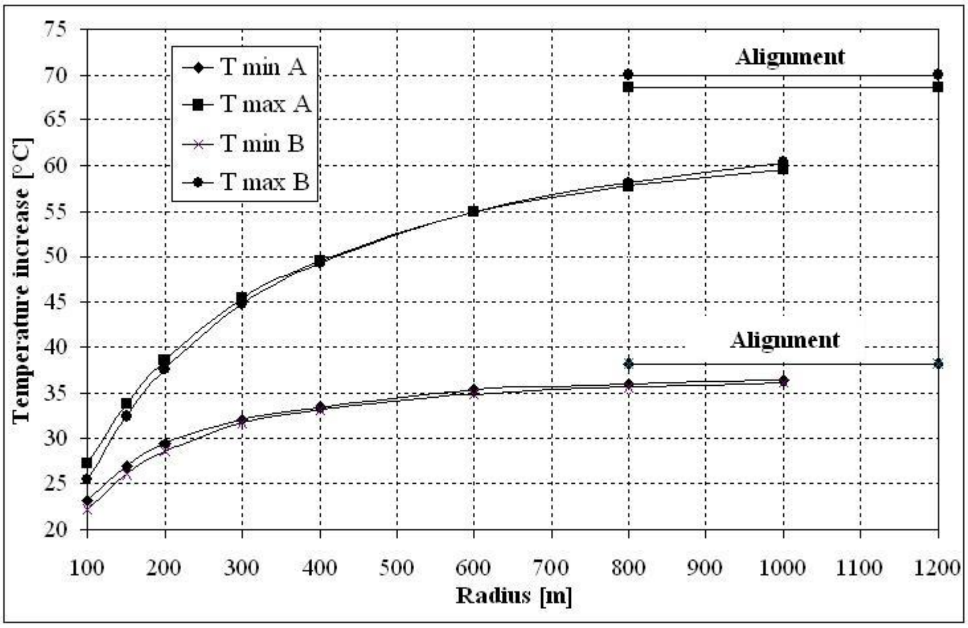

Fig. 5. The critical temperature increasing versus radius

The differences between SCFJ and CWERRI for the critical temperature increasing in function of the lateral peak resistance (fig. 6) are maximum 2,6% when the track is loaded only with thermal loads, therefore in absence of vehicle vertical loads.

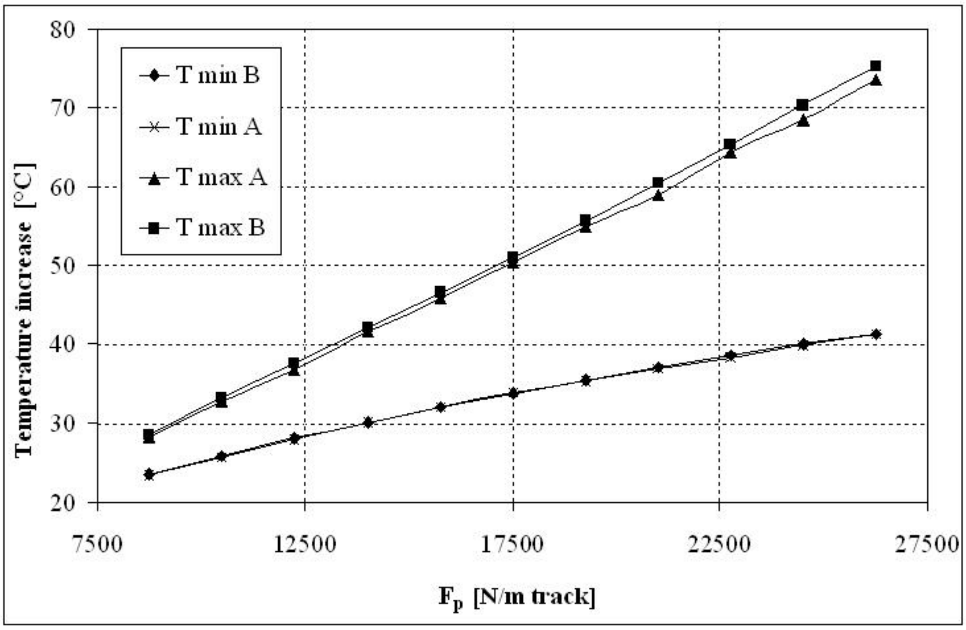

Fig. 6. The critical temperature increasing versus lateral peak resistance (without vertical loads)

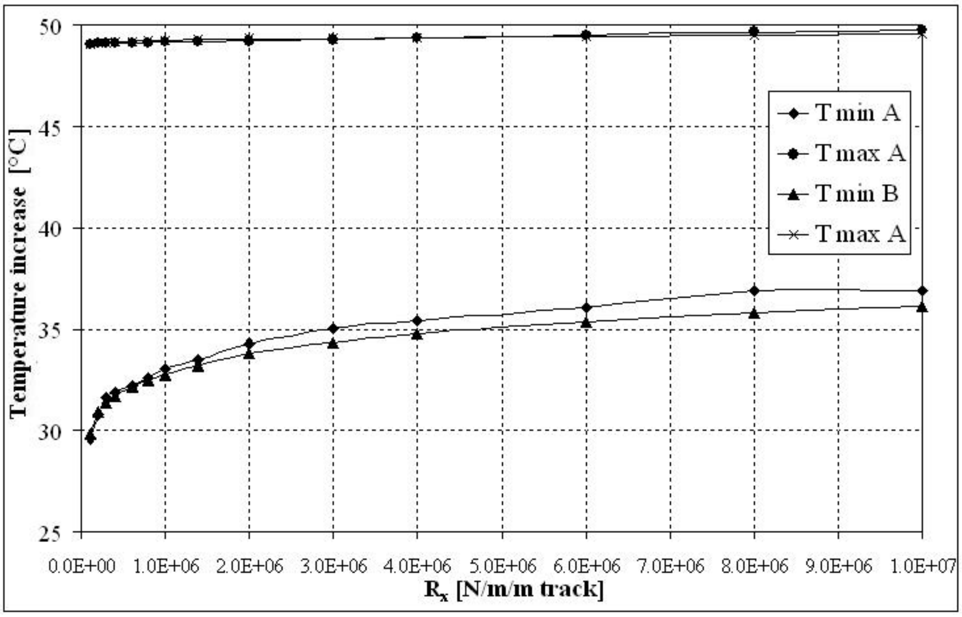

Fig. 7. The critical temperature increasing versus longitudinal resistance

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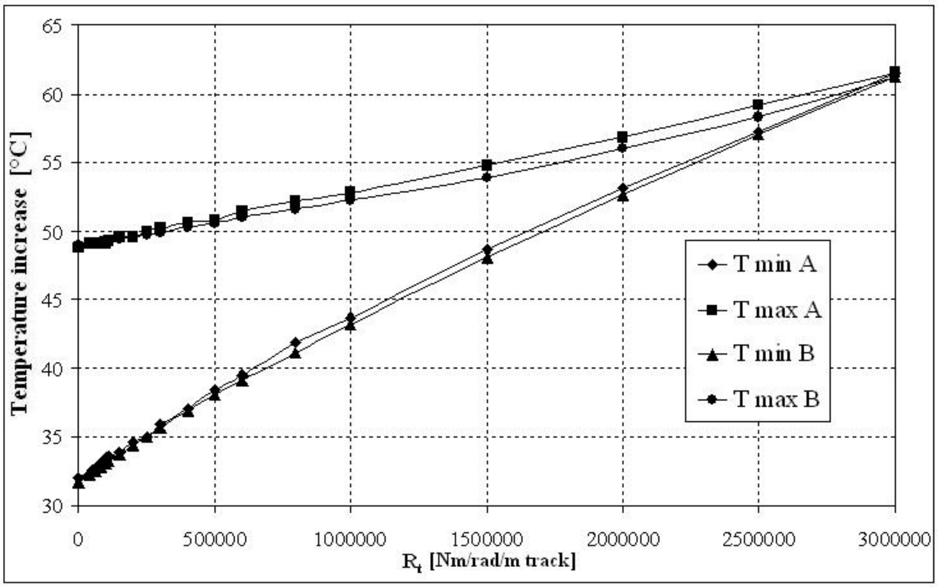

Fig. 8. The critical temperature increasing versus torsional resistance of the fastenings

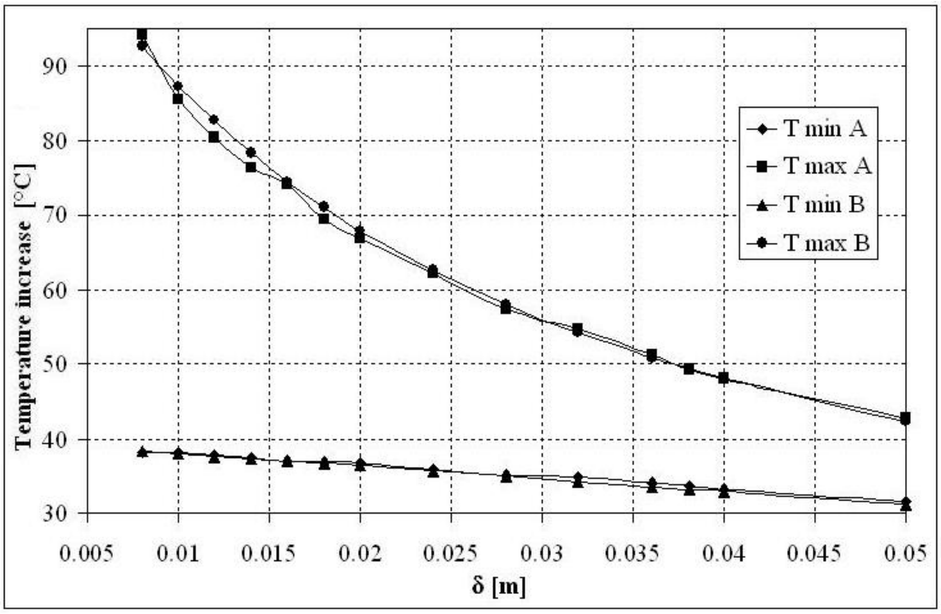

Fig. 9. The critical temperature increasing versus the amplitude of the misalignment

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For critical temperature increasing in function of lateral resistance (fig. 7) resulted 3% maximum differences between SCFJ and CWERRI results.

There were analyzed the differences between SCFJ and CWERRI results for critical temperature increasing in function of torsional resistance of the fastenings (fig. 8). It results a maximum difference of 1,7%.

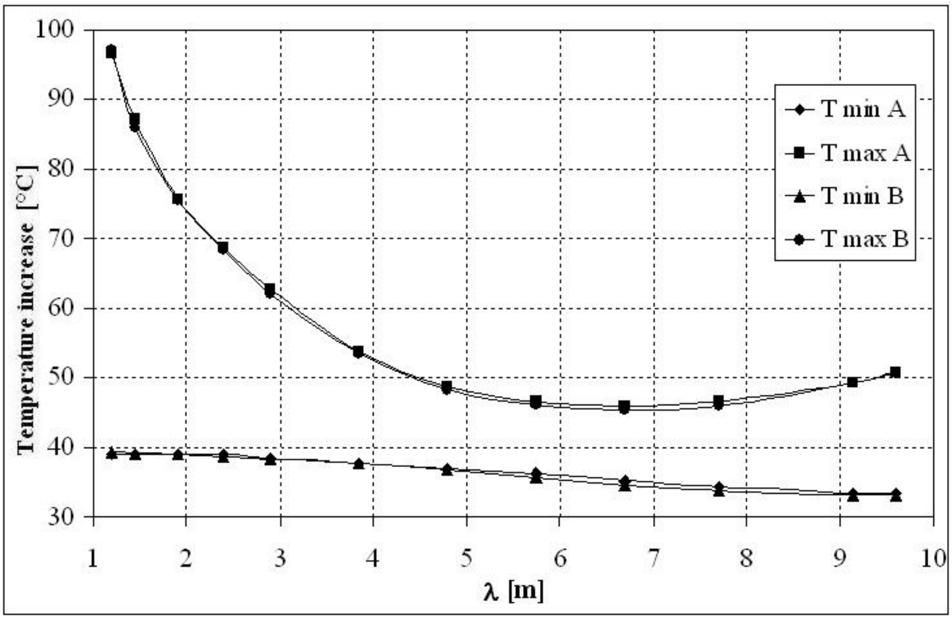

Fig. 10. The critical temperature increasing versus the amplitude of the misalignment

With regards to the amplitude of the misalignment, the differences between SCFJ and CWERRI results for critical temperature increasing (fig. 9), it results a maximum difference of 2,7%.

Finally, it was observed that for the critical temperature increasing in function of the length of initial misalignment (fig. 10), the differences between SCFJ and CWERRI results were maximum 1,9%, if the amplitude is 1/240 of the length of initial misalignment.

In conclusion, it was observed a good correspondence between the results of the two models, therefore the SCFJ model can be used for implementation of Leaflet UIC 720R regulation in Romania or in stability of CWR track analysis with a precision of the results closed to those developed by others.

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