STIPENDIENBERICHT

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The objective of the research project entitled ‘Numerical simulation of track–bridge interaction with respect to reduced horizontal stiffness value of the system’ was the analysis of admissible stress in continuous welded rails due to interaction with bridge. A nonlinear finite element method model of the L110 Bridge in Austria connecting St. Pölten to Vienna has been developed in order to investigate rail–bridge interaction and predict longitudinal stresses occurring in rails due to temperature loading. The whole system of the three-spans reinforced concrete bridge supporting structure–rail supports–rail fastenings–rails has been modelled in ATENA software with consideration given to material nonlinearity.

At first, a simplified model of the clamp–rail system was calibrated with respect to experimental measurements and code specifications. Several models with different clamp geometries and different material models were tested to capture the horizontal (shear) and vertical (compressive) stiffness of the track–rail system. A rail clamp for track supported on pre-stressed concrete sleepers laid on gravel ballast (ballasted track) was calibrated at the same time as the calibration of rail clamps for non-ballasted track was taking place.

The next step in modelling was the calibration of rail boundary conditions. Different boundary conditions were tested. The rail and the supporting structure in the finite element method model were loaded by temperatures, which represent the difference between the maximum and minimum temperature value obtained over the course of 1 day/24 hours in the appropriate season via measurements taken from the rail and structure respectively. The rail strain and bridge horizontal displacement caused by the temperature loading were analysed and compared with measurements taken from the real structure. The results of in-situ measurements taken during one particular day in spring were used for the calibration while measurements gained during the other three seasons (summer, autumn and winter) were used for validation of the calibrated model.

A numerical study was carried out using the now-calibrated model in order to determine the effect of bridge temperature loading on stress induced in a rail due to track–bridge interaction. The effect of various bridge free expansion lengths for both non-ballasted as well as ballasted track was studied. All non-linear analyses showed good agreement with the monitored longitudinal forces in the rails. The results for non-ballasted as well as ballasted track confirmed that for all studied cases, i.e. for different temperatures and bridge free expansion lengths, the admissible stress was not exceeded neither in tension nor in compression; the thresholds of admissible stress caused by the structural movement due to temperature effects stated in the UIC rail specification for unloaded track were not exceeded even for a free expansion length of 150 meters

At the transitions between the bridge and the abutments attention has been paid to the longitudinal displacements of the bridge. The continuous welded rail profiles span this transition region; the rail fastenings have a defined reduced yielding resistance and the rails are free to slide along them when the relative movement of the bridge requires it. The rail profiles are welded in sections positioned on the abutments and are elastically supported through the track supporting layer by the track. Thus, the rails, through their fastening system, connect the bridge to the abutment in the longitudinal direction. Since there was a doubt in the stiffness of the fastening system at the transition between the bridge and the abutments, the horizontal stiffness of the clamp system was reduced to 60 %. The variants with four and eight blocks with reduced stiffness at the transition region were analysed with the negligible effect of bridge temperature loading on stress induced in a rail.

Finally, the joint paper to scientific journal presenting some of results was prepared.