Project E	**Under-track crossings as a class of transition**
Part of	**Research Challenge 2, DESIGNER SWITCHES AND CROSSINGS**
Project timing	Started June 2015
More information from	Dr Louis Le Pen
Project partners	Network Rail (NR)
Associated project	EU project CAPACITY4RAIL FP7 – TRANSPORT: Grant agreement 605650 EPSRC EP/K03765X/1: Track Systems for High Speed Railways

Project aims

Together with switches and crossings (S&C), transition zones require a disproportionate amount of maintenance compared with the rest of a railway track network. Transitions are often characterised for purposes of analysis by an estimated variation in the track support stiffness. This is an oversimplification. To improve transition performance, there is a need to develop a holistic approach that takes into account both their real behaviour and the range of system interventions available to the designer. These include the sub-base depth and stiffness, under-sleeper and under-rail pads, rail geometry and material type, wheel profile and the dynamic characteristics of interacting vehicles within the train. This project aims to gather data on, and develop methods of analysis for, the behaviour of under-track crossings (UTX) as a particular class of transition, through

1. field studies, both before and after maintenance or remediation interventions
2. numerical finite element method (FEM) analysis to explore the behavioural mechanisms associated with the UTX and different types of intervention.

Progress to date

Project aim 1. Field data have been obtained from a number of problem sites on HS1 and from a site on the classic network (Fig.E1). On HS1, stiff under-track crossings (UTX) are associated with trackbed faults, both before and after maintenance and / or remediation. On the classic network, the focus is on newly-installed, shallow and relatively flexible UTX. The development of permanent settlement along the line of a flexible UTX is shown in Fig.E2. Dynamic deflection data (Fig.E3) suggest some success with managing the track system support stiffness above a hard UTX, but not as yet with the more flexible installation. It may be more effective to repack over an extended region, beyond the length of the visibly affected sleepers, to ensure continuity of support and geometry after the intervention. Despite the improvement achieved with the rigid UTX, the underlying problem remains.

Fig.E1: (a) Rigid and (b) flexible UTX and associated trackbed faults

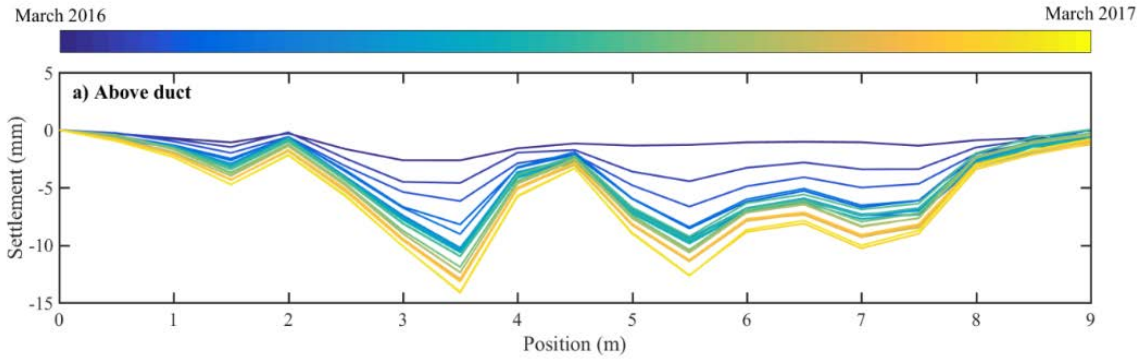

Fig.E2: Development of permanent settlement along the line of a flexible UTX

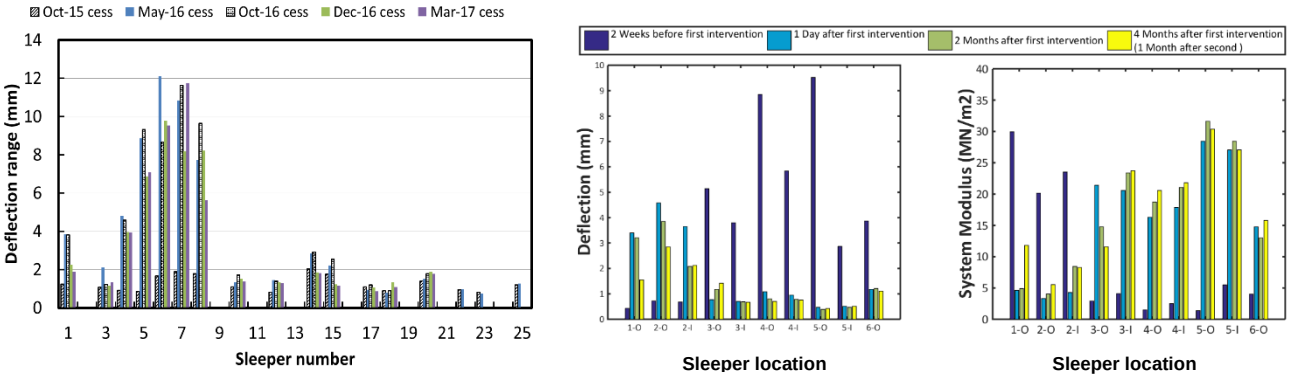

Fig.E3: Sleeper displacements before and after various maintenance interventions, (a) flexible and (b) rigid UTX

Project aim 2. Dynamic finite element models have been set up to explore vehicle-track system interaction over a shallow UTX and assess the relative benefits, with reasons, for different maintenance and remediation measures (Fig. 4). Initial analyses suggest that the difference in stiffness is not in itself a problem on a single cycle basis, but that it leads to voiding below sleepers which is the major cause of poor geometry and further deterioration [E10].

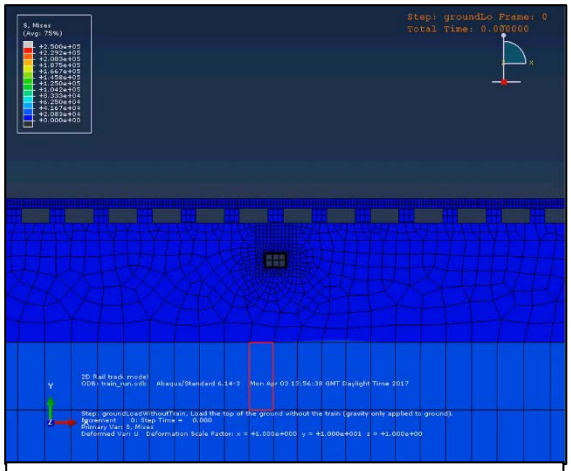

Fig.E4: Example dynamic FEA model for vehicle / track system interaction analysis

Planned further work (Programme objectives in brackets)

- further field measurements (2.1)
- further dynamic finite element and vehicle/track interaction analyses (2.2, 2.3)
- implementation of improved representations of ballast, sub-base, rail components and vehicles in further, more detailed models of the vehicle-track system dynamic interaction environment (2.4)
- validation of the further models developed with reference to field and laboratory test data (2.5)
- incorporation of results into integrated performance and maintenance models (2.6).

Journal papers

[E10] Powrie, W, Le Pen, L, Milne, D, Watson, G and Harkness, J. Effects of under-track crossings on ballasted high speed railway lines. *Transportation Geotechnics* (in review)

Related publications

Cross Industry Track Stiffness Working Group (2016) A Guide to Track Stiffness, pp29f