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Modelling transition zones in railway tracks

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Introduction

Transition zones in railway tracks are areas with significant variation of track properties (e.g., foundation stiffness) encountered near structures such as bridges and tunnels. Due to strong amplification of the response, differential settlements develop in time as depicted in Fig.1. Consequently, transition zones require frequent maintenance which cause:

- reduced availability of the track
- increased operational costs

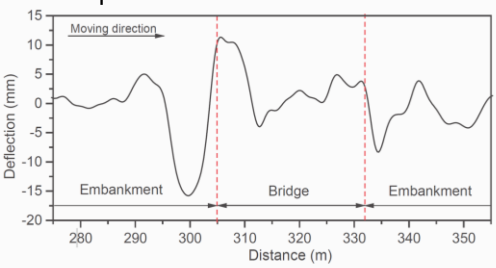
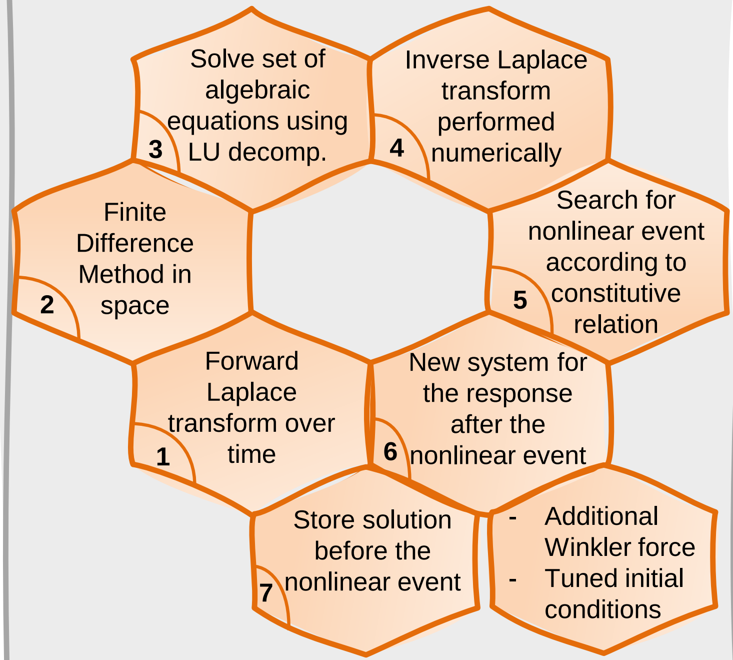


Figure 1: Measured track deflection profile [1]

The **objective** is to gain understanding by modelling the behaviour, and ultimately identify mitigation solutions.

Solution method



Model

The 1-D model consists of an infinite Euler-Bernoulli beam resting on a piecewise linear and inhomogeneous Winkler foundation, subjected to a moving constant load (Fig. 2), and is represented by the following equation of motion:

$$w'''' + \rho\,\ddot{w} + c_{\mathrm{d}}(x)\,\dot{w} + F_{\mathrm{k,W}}(x,w) = -F_0\delta(x - vt)$$

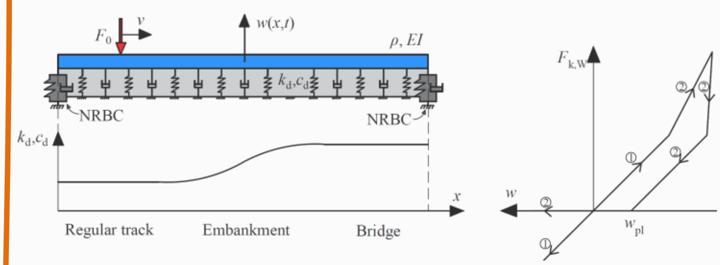


Figure 2: Model schematization (left panel), where NRBC stands for non-reflective boundary conditions, and the foundation piecewise-linear constitutive relation (right panel)

Main characteristics of the model

- Infinite extent of the beam-foundation system
- Inhomogeneous foundation stiffness and damping
- Piecewise-linear constitutive relation of the foundation stiffness (depicted in the right panel of Figure 2)

Results

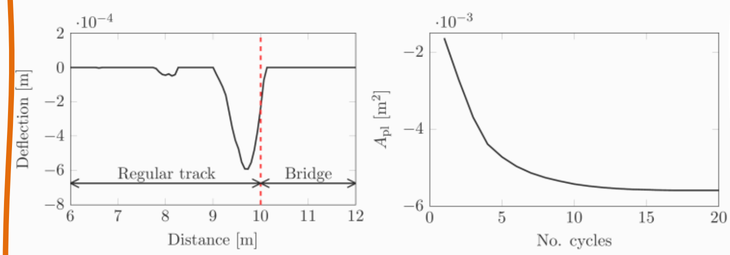


Figure 3: Track deflection after 20 load passages (left panel) and plastic deformation area versus number of train passages (right panel)

Conclusions

- The solution method is capable of handling systems which exhibit a non-smooth dynamic behaviour.
- The qualitative behaviour is well described by the model.

For more accurate quantitative results, one has to:

- Tune the unloading branch of the constitutive relation (right panel in Figure 2) to match experimental results
- Account for the vehicle-structure interaction
- Account for the non-locality of the foundation response (e.g., Pasternak foundation, 2-D/3-D continuum)

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References

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