MODELLING TRANSITION ZONES IN RAILWAY TRACKS

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MODELLING TRANSITION ZONES IN RAILWAY TRACKS

SÃO PAULO SCHOOL OF ADVANCED SCIENCES ON NONLINEAR DYNAMICS

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FAPESP

INTRODUCTION

Transition zones in railway tracks are areas with substantial variation of track properties (e.g., foundation stiffness) encountered near rigid structures such as bridges, tunnels or culverts. These zones necessitate special attention, mainly because they:

- Require frequent and expensive maintenance activities.
- Cause reduced availability of the railway track.

OBJECTIVE

The objective is to better understand the underlying degradation mechanisms in railway tracks close to transition zones by using two 1D models. To describe the degradation in the railway track model A has been used, while to describe the interaction between the vehicle and the track model B has been developed.

MODEL A

1D model of an infinite Euler-Bernoulli beam on nonlinear and inhomogeneous Winkler foundation subjected to a constant moving load.

Main characteristics

- Infinite extent of the beam-foundation system.
- Inhomogeneous foundation stiffness and damping.
- Nonlinear foundation-stiffness constitutive law.

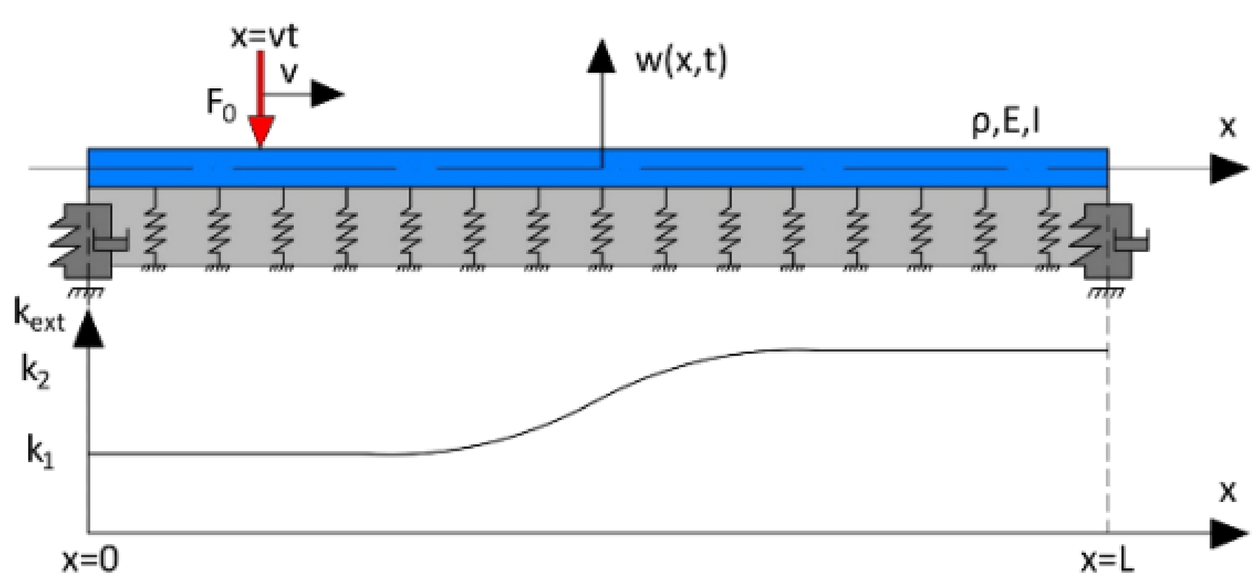

FIGURE 1 – Schematics of Model A

Solution method

The reaction of the Winkler foundation has been characterized by a piecewise-linear (in displacements) constitutive relation which accounts for permanent deformations. The foundation's piecewise-linear behaviour allows to obtain the solution by sequentially applying the Laplace transform over time. The Finite Difference Method has been used for the spatial discretization. The infinite extent of the system has been accounted for through a set of non-reflective boundary conditions, derived by replacing the semi-infinite domains by their response at the interfaces, and through the input initial conditions based on the steady-state response of a beam with homogeneous foundation subject to the moving load.

Graphical results

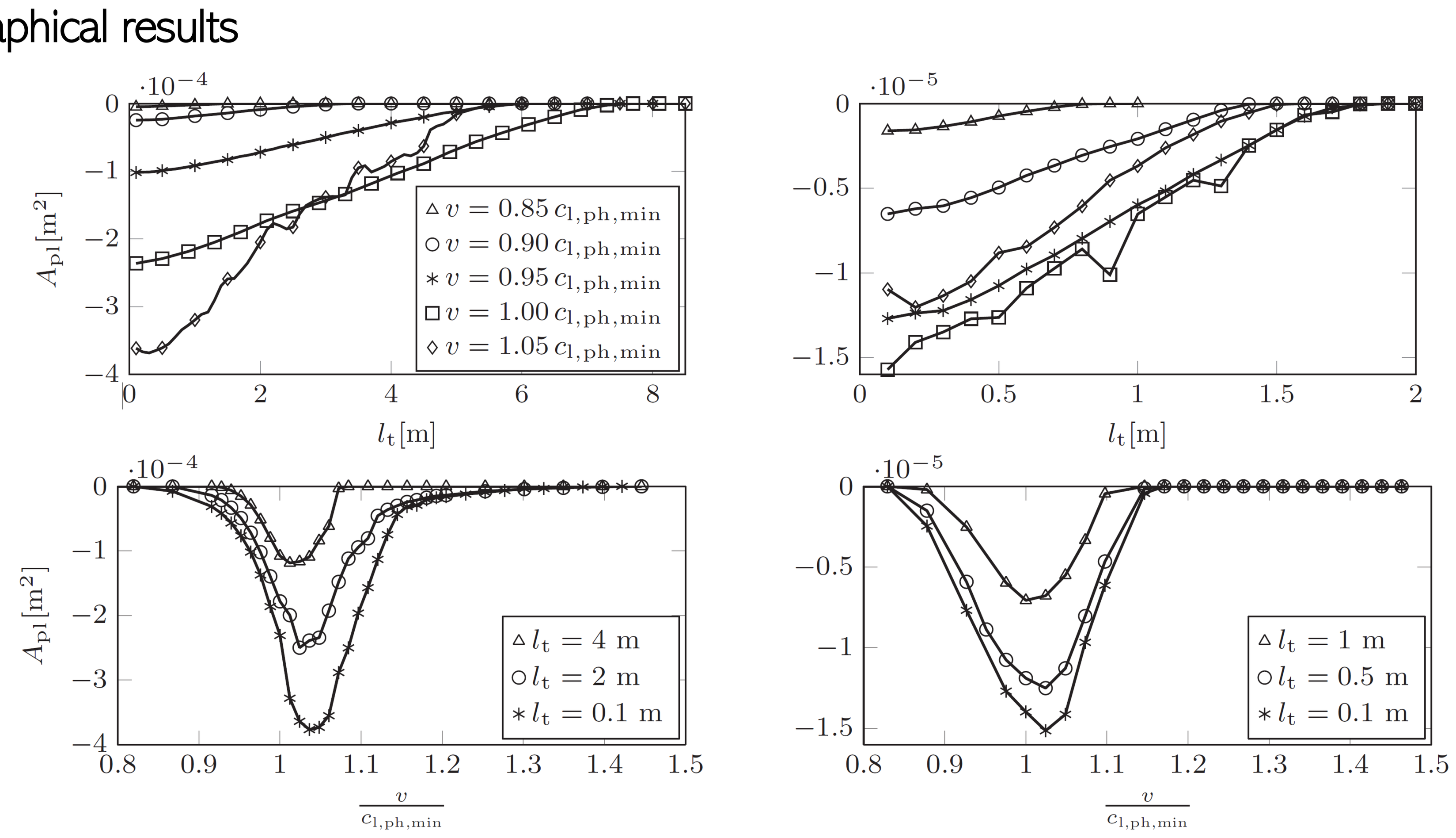

FIGURE 2 – Plastic deformation area vs. transition length (top panels) and vs. velocity (bottom panels)

MODEL B

1D model of an infinite Euler-Bernoulli beam on inhomogeneous Winkler foundation interacting with a moving mass-spring oscillator.

Main characteristics

- Infinite extent of the beam-foundation system.
- Inhomogeneous foundation stiffness and damping.
- Nonlinear contact stiffness (Hertzian contact model).

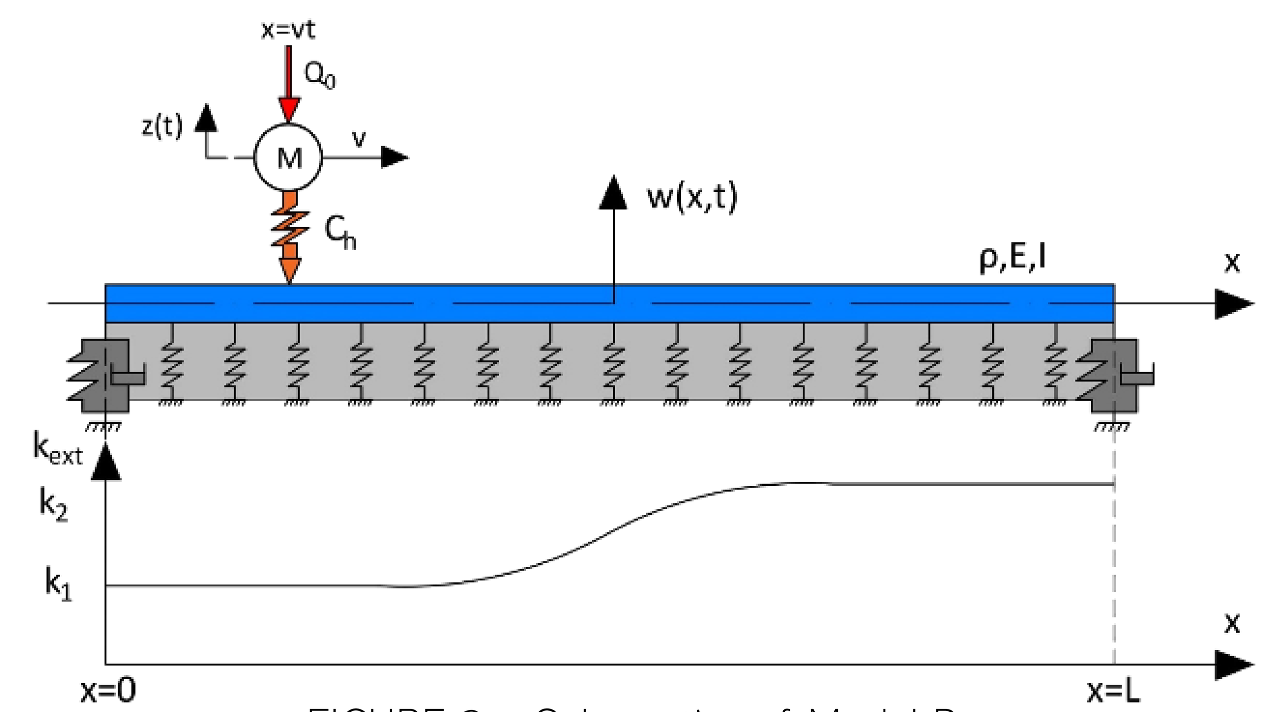

FIGURE 3 – Schematics of Model B

Solution method

The linear behaviour of the individual sub-systems, namely the moving oscillator and the supporting structure, allows to obtain the solution by means of the Green's-function approach. The Finite Difference Method has been used for the spatial discretization to accommodate the smoothly inhomogeneous foundation. The infinite extent of the system has been accounted for through a set of non-reflective boundary conditions, derived by replacing the semi-infinite domains by their response at the interfaces, and through the initial conditions based on the steady-state response of a beam with homogeneous foundation subject to a moving load.

Graphical results

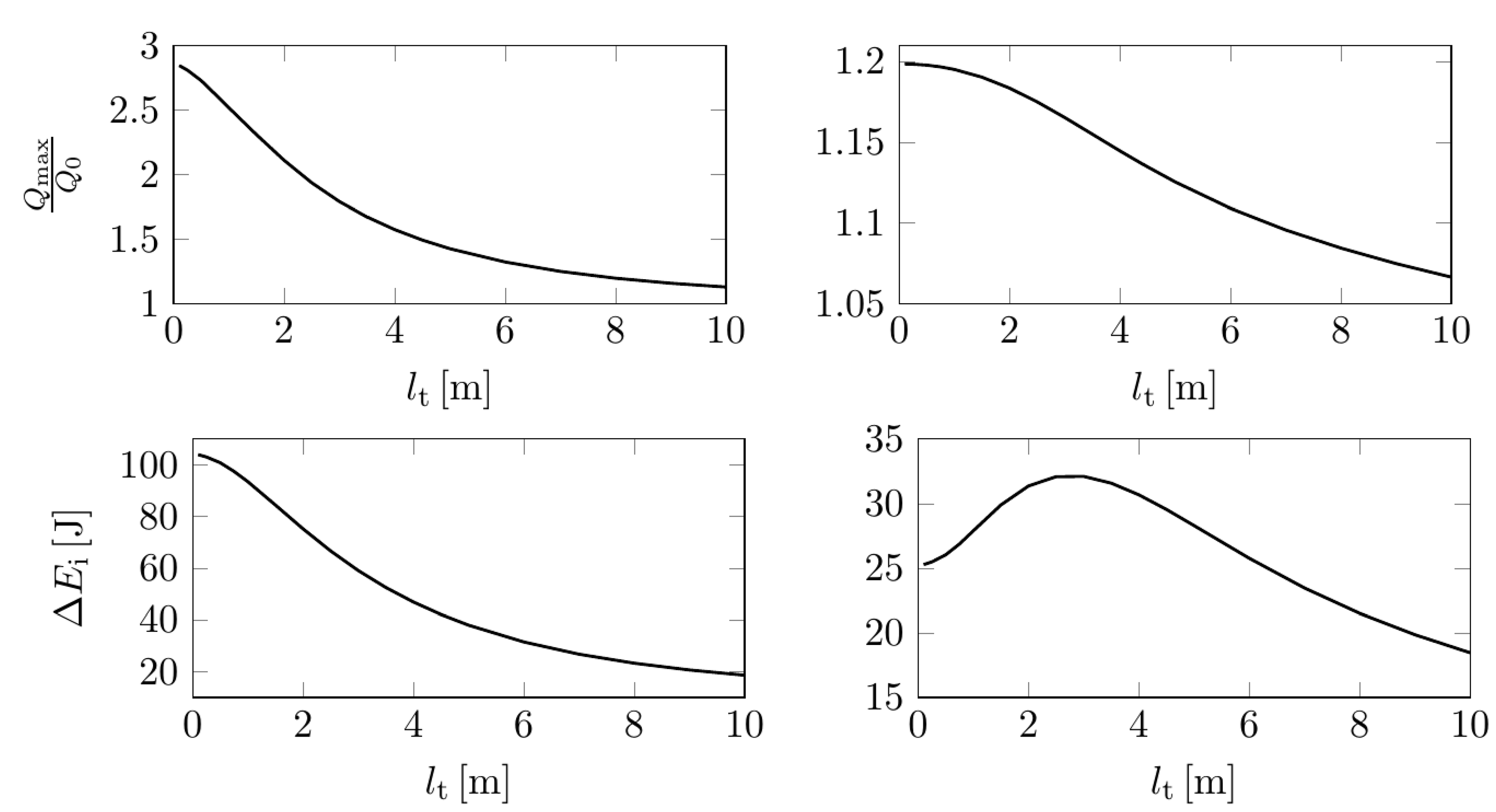

FIGURE 4 – Maximum contact force vs. transition length (top panels) and difference in energy input vs. transition length (bottom panels)

CONCLUSIONS

The models presented here can be used for preliminary designs of transition zones in railway tracks. Given the stiffness dissimilarity and the initial plastic deformation, the optimum length of the transition zone can be obtained to minimize the damage in the railway track.

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