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A PROCEDURE TO DETERMINE THE CRITICAL SPEED OF RAILWAY TRACKS BASED ON THE WINKLER'S HYPOTHESIS AND STATIC FEM SIMULATIONS

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Trains may encounter a critical speed at which the soil experiences great deformations due to large dynamic amplification of the vertical motion during train passage. In this work, we develop two procedures, based on the theory of an elastic beam on a viscoelastic half space ("beam model") [1], to estimate the critical speed of a rail/embankment/ground system: a) the first one is based on the Dynamic Amplification Factor (DAF) curves; and b) the second one is based on analytical expressions that need three track features: (i) rail bending stiffness; (ii) effective moving mass per unit length, whose value is quantified from data of the testing cases; and (iii) track stiffness. When no real measure of track stiffness is available, we take advantage of static FEM simulations to obtain this parameter.

The developed procedures have been tested and applied using data of different types: (i) measured in real tracks (Ledsgard and TGV-Paris [2]), (ii) obtained in 1:1 scale model tests (CTB, [3]), and (iii) derived from 3D FEM dynamic calculations.

The main conclusions that can be drawn from the analysis carried out are:

- The theoretical DAF curves provide a reliable value for the critical speed when they are used to fit measured data of rail deflection vs. train speed. Unfortunately, this procedure requires measurements in a wide range of train speeds, which are usually not available.
- In the analysed cases, the procedure based on analytical expressions has been proved to be a simple but powerful tool to estimate the critical speed of railway tracks. By applying it, we have corroborated the following Fortin's suggestions: (i) the rail is the only element that provides the bending stiffness of the beam; and (ii) the only elements that contribute to the effective track mass are the rail, the sleeper, and a specific region of the ballast layer that has been quantified in our procedure. In this regard, it is worth noting that the real value of the effective track mass is hard to determine, so the dependency of the "beam model" on this parameter complicates its implementation.

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