Application of a modified concrete for vibration attenuation in railway infrastructures

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Propagation of railway-induced vibrations through the soil and its transmission to surrounding structures is a matter of major concern, since the operation of sensitive equipment and even human comfort may be affected [1]. Therefore, a significant amount of research has been carried out in recent years regarding mitigation of train-induced vibrations at some point of the emission-transmission path: i) at the source, by preventing the vibration generation; ii) along the ground, by avoiding its transmission; and iii) in the vicinity of the receiver.

In this regard, measures adopted to interrupt the transmission path have the advantage that no intervention on the track is needed and multiple buildings can be benefited, if this measure is performed close enough to the track. Among the existing alternatives, wave barriers may be highlighted, given that they can be implemented in any moment of the railway lifespan without interfering in its operation. Nevertheless, restrictions imposed by the track environment (*e.g.*, roads, buildings) usually exist and may considerably affect the barrier design. Hence, if the barrier geometry and position is restricted, the election of an appropriate in-fill material may be of utmost importance to ensure a satisfactory performance of the mitigation measure.

On the other hand, the recycling of scrap tyres has become a viable option for sustainable construction in the past years by means of using recycled waste tyre rubber as an aggregate substitute in concrete [2]. In this sense, the addition of such particles to the concrete leads to a considerable reduction of its compressive and tensile strength, as well as an increase of its elasticity, deformability and damping. Hence, due to its excellent properties for vibration attenuation, such modified concretes arise as an excellent option for wave barrier in-fill material. Moreover, the decrease in resistance (both compressive and tensile) can be compensated if a certain amount polypropylene fibres is added to the mixture, thus reducing the main drawbacks of the new material.

The purpose of this research project is to analyse the vibration attenuation efficiency of a modified concrete (i.e., with added polypropylene fibres and scrap tyres aggregate) acting as a wave barrier in-fill material. To this aim, a 3D FEM numerical model has been developed within ANSYS LS-DYNA V.14 commercial software. Moreover, it has been later calibrated and validated with real data gathered in the Alicante tramway line 1, as detailed in [3]. The problem can be solved by means of the equation of motion expressed by eq.(1).

$$[M]\{\ddot{\boldsymbol{u}}\}+[C]\{\dot{\boldsymbol{u}}\}+[K]\{\boldsymbol{u}\}=\{\boldsymbol{F}^{\alpha}(\boldsymbol{t})\} \tag{1}$$

Where [*M*], [*C*] and [*K*] are the global mass, damping and stiffness matrices, respectively; $\ddot{\boldsymbol{u}}, \dot{\boldsymbol{u}}$ *and* $\boldsymbol{u}$ are the acceleration, velocity and displacement vectors; and $\boldsymbol{F}^{\alpha}(\boldsymbol{t})$ contains the time-dependent forces, which are introduced as harmonic forces. For the sake of simplicity, it can be considered without a significant reduction of accuracy that the damping matrix only contains the stiffness term [3, 4], as shown in eq.(2).

$$[C] = \beta[K] \quad (2)$$

Where the global damping coefficient (β) is *a priori* unknown and should be estimated through the calibration process. Moreover, absorbing boundary conditions have been used in order to avoid undesired reflection effects.

References

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