Modelling and design of rubberised asphalt for railways sub-ballast

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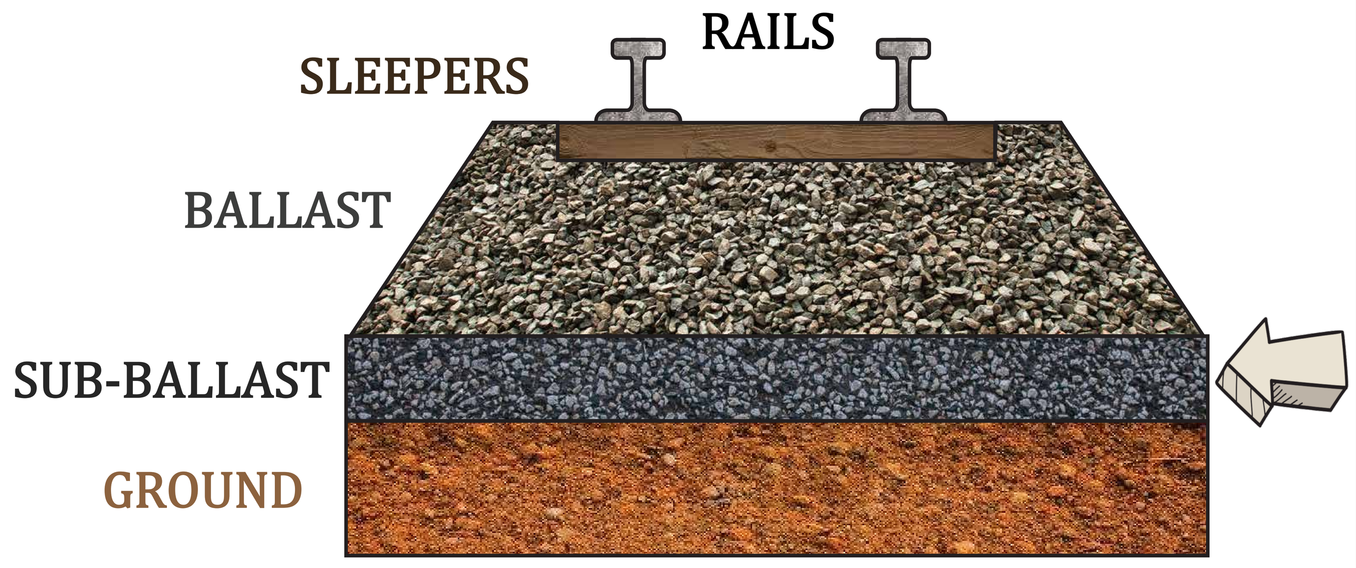
Objectives

This project is focused on the study of using rubberised asphalt as sub-ballast layer for railway superstructures.

The project aims to create a **railtrack model**, based on **fractional calculus**, to predict the **mechanical behaviour** and the **performance** of the railway infrastructure. Modelling is focused on the **sub-ballast layer** made of **rubberised asphalt**, emphasizing on the **temperature** effect.



Rubberised asphalt is a kind of asphalt that consists on regular asphalt concrete mixed with **crumb rubber** made from **wasted tires**.

Traditionally **viscoelastic materials,** as **rubberised asphalt**, have been modelled with mechanical models that consist on combination of springs and dashpots. Since almost one century, it has been demonstrated that the **creep** and the **relaxation** function are better fitted by power laws. That fact implies the introduction the **fractional operators** on the stress-strain relationship of **linear fractional viscoelasticity**. The element that represents fractional constitutive laws is called "**springpot**", in this element elastic and viscous effects are present simultaneously.

Rubberised asphalt

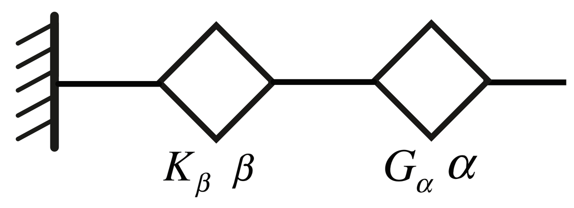
Rubberised asphalt is model by means of **3D linear fractional viscoelasticity**, that arises from a generalization of the 3D elastic constitutive law (Hooke's Law) for isotropic materials.

$$\underline{\varepsilon}(t)=\int_0^t \underline{\underline{C}}(t-\tau)\dot{\underline{\sigma}}(\tau)d\tau$$

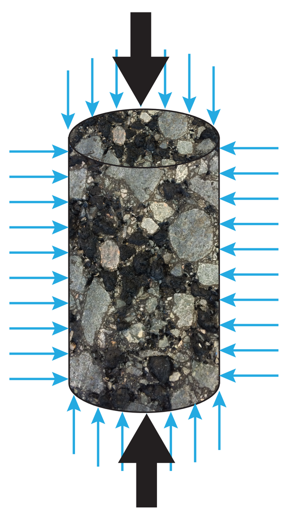
$$C_{ijkh}(t)=\underline{\underline{C}}(t)=\left(\frac{K_C(t)}{9}-\frac{G_C(t)}{6}\right)\delta_{ij}\delta_{kh}+G_C(t)\left(\delta_{ik}\delta_{jh}-\frac{\delta_{ih}\delta_{jk}}{2}\right)$$

Where $G_C(t)$ and $K_C(t)$ are the deviatoric and volumetric creep functions, that are model as springpots.

$$G_C(t)=\frac{t^{\alpha}}{G_\alpha\Gamma(1+\alpha)} \qquad K_C(t)=\frac{t^{\beta}}{K_\beta\Gamma(1+\beta)}$$

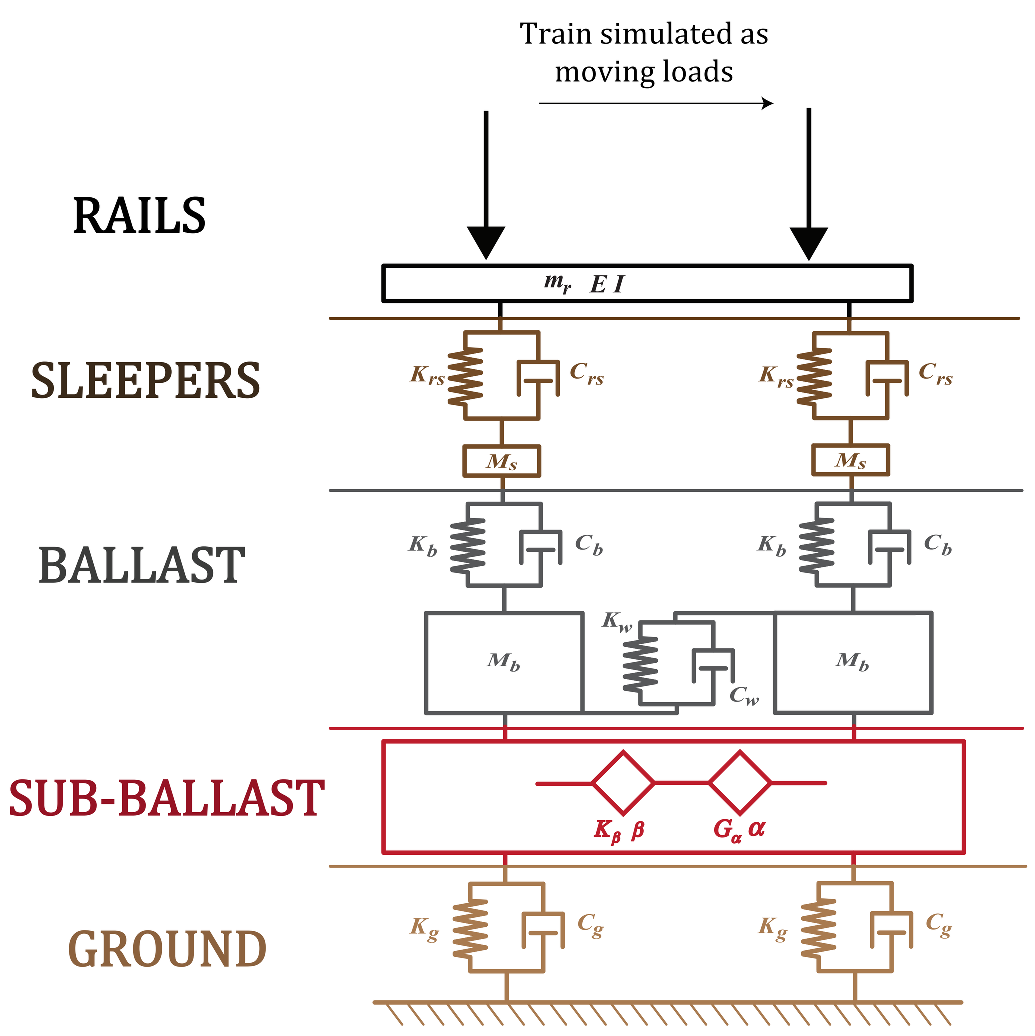


$0\le\alpha\le1$
$0\le\beta\le1$



In order to characterize the 3D linear fractional viscoelastic model, creep and cyclic tests (with different confinement conditions) are developed in a triaxial cell with longitudinal and transversal mesurements (LVDT and strain gauges).

Railway superstructure



Rubberised asphalt is used as sub-ballast layer in the railway superstructures in order to: **protect the ground** from the train loads, **reduce the vibrations, improve the performance** of the superstructure and, as a consequence, **decrease maintenance costs.**

The railtrack will be modelled as a **multilayer structure** (rails, sleepers, ballast, sub-ballast and ground) and the train will be modelled as **moving loads**.

Once the **fractional viscoelastic model** for the rubberised asphalt is obtained, it will be introduced in the railtrack model. The study of superstructure is focused in the the **sub-ballast** behaviour to obtain the **optimum** performance.

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