Project description

The main goal of the master thesis is to perform a stochastic simulation of train/track dynamic interaction at railway turnouts. The stochastic analysis is based on a numerical model of the train-track system (properly calibrated by using experimental results from an impacts test and or more complete FEM models).

The study takes into account not only the dynamic interaction between the train and the track but also the random features of several factors with a big impact in the dynamic response such as the speed of the train, stiffness and damping properties of the ballast layer and stiffness and damping properties of the railpads.

Dynamic effects induced in the system are analyzed in terms of vertical and horizontal accelerations on the train axles and/or horizontal and vertical contact forces in the wheel/rail interface. These parameters could be taken as sort of maintenance performance indicator (MPI) in our numerical works developed at WP3 (outputs of the stochastic analysis).

Lopez Pita, 2006 in his work '*Deterioration in geometric track quality on high-speed lines*' analyses deterioration in geometric track quality on the Seville-Madrid high-speed line during the first 10 years following its commercial launch. The author points out that dynamic track inspection with a measurement car may provide useful results about track degradation. He came up with the idea of linking the magnitude of acceleration measured at different locations of the measurement train with different maintenance actions.

Acceleration intervals (m/s^2)								**Recommended action**
a_{lb}		a_{vc}		a_{tv}		a_{vv}		
0.0	2.0	0	30	0.0	1.5	0.0	1.0	Normal control level
2.0	4.0	30	50	1.5	2.0	1.0	2.0	Internal control level
4.0	6.0	50	70	2.0	2.5	2.0	2.5	Schedules checking and correction
> 6.0		> 70		> 2.5		> 2.5		Immediate checking and correction

Table 1. Acceleration levels in dynamic inspection of the AVE Madrid -Seville line. Source; RENFE

The study will be focused on two distinct parts of the railway turnouts, the switch panel and the crossing panel. These two sections were proved to present a higher degradation rate than other regular track sections.

In the first part of the project an assessment of the importance index will be done. This method is called differential analysis and it consist in taking the derivative of the output parameter with respect to the predefined variations of the input parameters which are varied one at a time.

This methodology will be applied at two different locations of the railway turnout: the switch panel and the crossing panel. Two different routes will be considered in the simulations: the main route and the diverging route, so a total number of 4 cases will be evaluated by using the differential analysis:

1. SWITCH PANEL – MAIN ROUTE
2. SWITCH PANEL – DIVERGING ROUTE
3. CROSSING PANEL – MAIN ROUTE
4. CROSSING PANEL – DIVERGING ROUTE

A table with the different variables to be analyzed is created to perform the differential analysis.

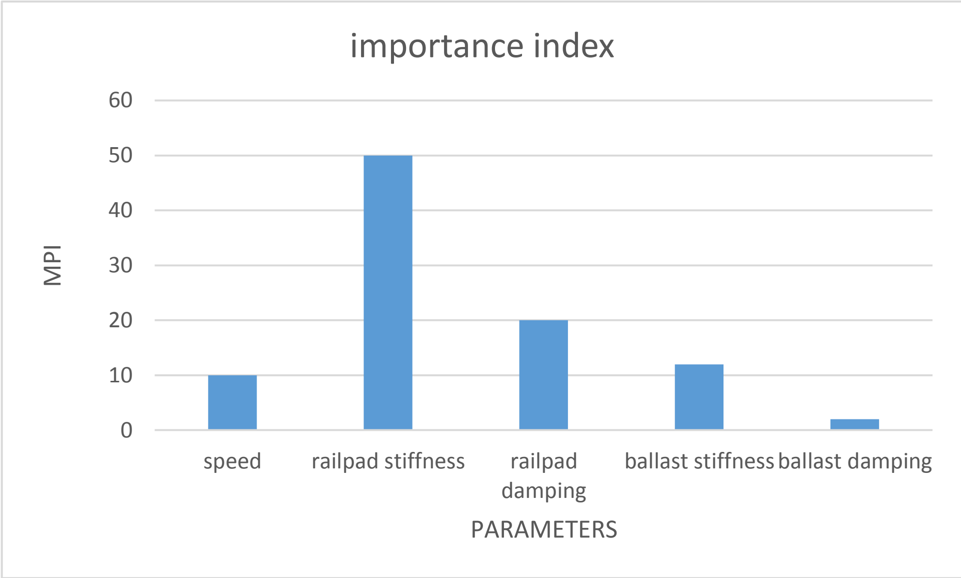
Parameter	**Index**	**Unit**	**Minimum**	**Maximum**	**Nominal Value**
Speed	1	Km/h	- (BDK)	(BDK)	Normal disstribution
Rail pad stiffness	2	N/m	-(BDK)	(BDK)	Normal disstribution
Railpad damping	3	Ns/m	-(BDK)	(BDK)	Normal disstribution
Ballast stiffness	4	N/m	-(BDK)	(BDK)	Normal disstribution
Ballast damping	5	Ns/m	-(BDK)	(BDK)	Normal disstribution

From the previous information, the differential analysis is performed according to the procedure described in the table below:

Parameter	Nominal value	Δ1	Δ2	Δ3	Δ4	Δ5
V	1	1+x%	1	1	1	1
K_r	2	2	2+x%	2	2	2
D_r	3	3	3	3+x%	3	3
K_b	4	4	4	4	4+x%	4
d_b	5	5	5	5	5	5+x%
IMPORTANCE INDEX	**Pn**	**P1**	**P2**	**P3**	**P4**	**P5**

Where the importance index P is defined as $P = \frac{MPI(nom) - MPI(\Delta param)}{\Delta param}$

Obtaining the weight or the importance index of each individual parameter with respect the selected output. In our particular case, the chosen output is the MPI indicator. See the example below:



After performing the differential analysis, an uncertainty analysis is made by applying the Monte Carlo methodology. This takes into account a great number of evaluations using different configurations over the parameter space. Once the simulations are done the mean and standard deviation of the evaluations is used to obtain the uncertainty in the model predictions and the input variables that generate the mentioned uncertainty.