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Analysis of the influence of support positions in transition zones. A numerical analysis

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HIGHLIGHTS

- Numerical study of track support position in track transitions.
- No previous studies. Novelty of the study.
- Revision of current problems in these areas.
- Vertical stresses and vertical displacements under supports considered in the analysis.
- Recommendations for future track designs. Acceptable solutions.

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ABSTRACT

The recent development and use of new rail track models due to the evolution of the railway, especially with high speed and freight, has meant the introduction of slab track models with an associated variety of transition zones (between ballast and slab track) across railway networks worldwide. However, there are no studies about how the position of the supports could influence the track performance in general and track transitions in particular, how much bigger or smaller the gap must be between slab track and ballasted track. This study tries to find the optimal distance between the supports while maintaining good track performance which is assessed in terms of sleeper vertical displacements and stresses on ballast. Reducing these movements and stresses will increase track life and means less maintenance work.

The aim of this paper is to study these effects and try to provide an optimal and low cost solution for existing and future track designs.

1. Introduction

The main aim of this study is to develop a simple and inexpensive solution that could be applied not only on a national scale but globally. It consists of finding the optimal separation between supports in the locations around installations of slab track (Fig. 1).

Numerical simulation is used on a series of track model configurations and finite elements modelling software allowed the track to be studied dynamically. The specific goals of the study are:

- To find the optimal layout of the supports and transition sleepers, finding the designs which are more likely to deteriorate sooner and those which are suitable for possible installation by evaluating how the distance between supports affects the stresses and vertical displacements under the sleepers.
- To study the transitions in both directions. Compare the results obtained and discuss the most critical direction of train movement (if any).
- To look for possible simpler and cheaper solutions and the ways of implementing them.

Several case studies considering different track configurations (see Fig. 2) have been proposed. The results found designs which were unacceptable for installation on a functioning rail network, while other solutions may be suitable.

2. State of the art

Sleeper separation can have an effect on rail corrugation [1]. However, there are no references in the literature about how this

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Fig. 1. Track separation in slab track (left) and ballast track (right) in a track transition.

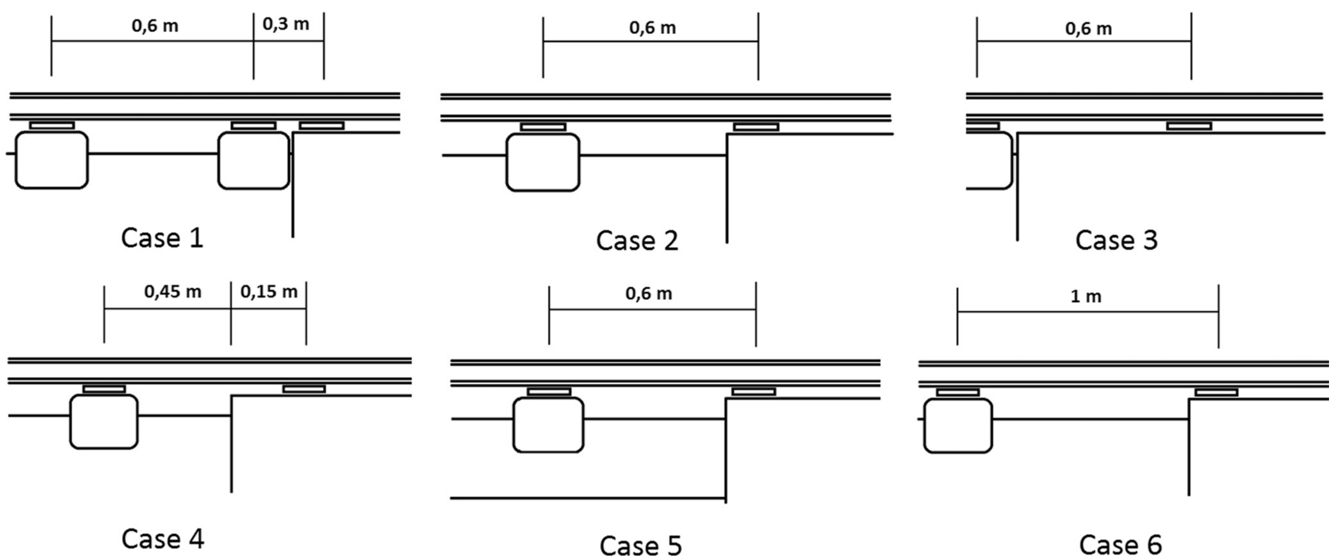

Fig. 2. Study cases of different support configurations.

gap affects track performance. Railway administrations around the world use particular separations based on their experience. The most commonly used value in European countries is 0.6 m between sleeper axles. USA recommendations for railroad construction (taken from design manuals for industrial track projects) depend on the ballast section and sleeper materials, separation between sleepers can vary between 0.546 m (wood sleepers in a 0.152 m ballast section), 0.711 m (concrete sleepers in a 0.203 m ballast section, where continuous welded rail is recommended) or 0.61 m (steel sleepers in a 0.203 m ballast section).

A reduction in the distance between sleepers causes an increase in track stiffness. The effect is similar to that of increasing the sleeper's size [2] and higher stiffness is not always desirable because it can produce accelerated wear, fatigue and cracking problems [3]. There are other common problems such as differential settlements, or loss of ballast which may result in hanging sleepers [4].

The following important structural problems can be found:

- High track displacements can produce significant jumps in the rolling contact between wheel and rail which is always detrimental to the rail, as well as being dangerous. There are thresholds that must be respected to maintain the safety and comfort required for the optimal operation of the track (avoid unsupported dancing sleepers).
- Vertical stresses produced in the transition zone can be very high and may result in the cracking or breaking of the slab and the sleepers, among other damage. These values must be below a certain threshold to allow for safe movement without the risk of SLS (Serviceability Limit State) situations occurring.
- High vertical accelerations can have a negative effect on passenger/staff comfort and track stability. For example, Spanish Standards state that the body of the train cannot support accelerations greater than 0.22 m/s^2.

The problems mentioned above may have consequences that can affect the track (track structure), the vehicle (materials) and customer comfort. The most important are the following:

- Track structural degradation (breakage and fatigue of rails, sleepers, ballast, slab track, etc.).
- Wear on rolling stock and track structure caused by altering the vertical deformability of the track.
- Loss of track geometry (levelling and alignment).

All of them mean loss in passenger comfort and will cause an increase in maintenance works involving longer service disruptions (if there are no alternatives available) and, thus greater maintenance costs.