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Determining the Effective Length of Railway Tracks in Earthquake Excitation Using a 3D Numerical Model

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Abstract

Seismic stability of infrastructures against earthquake is one of the most important engineering challenges in railway transportation systems. Reviewing the present literature shows that there are many considerable technical shortages in this matter. As the ballasted railway track is a long line structure, one of the major questions about their seismic behavior relates to the efficient excited length of the track during the earthquake. For this purpose the current study tries to find the answer through accomplishing a series of dynamic analysis using finite element method. Therefore at first, a track model with considering the longitudinal and lateral resistance of the railway tracks was developed, in continue seismic analysis was performed by imposing the acceleration components of the Kobe earthquake. Consequently, through comparing the results for various track lengths, it was observed that a length around 40m could be selected as a representative length for railway track in dynamic analysis which this length leads to the worst condition for track components.

Keywords: Effective excited length, Seismic analysis, Railway track, 3D numerical model

1. INTRODUCTION

The Railway transportation networks are one of the most significant infrastructures in each country that should perform their tasks in the best way. They should be fast, safe, comfortable and stable under traffic loads, environmental condition and natural events. As regard, safety passing of the train on the railway tracks is very sensitive to track geometrical parameters such as gauge, twist, cant, vertical and horizontal leveling, they will be protected against traffic loads and natural disaster e.g. earthquakes. The past experiences have represented occurrence of the earthquake on the railway locations deviates the track geometry parameters from the standard position and causes to disrupt the operation of the track.

For example during the great Tangshan earthquake that was occurred with a 7.8 magnitude on July 1976 and the its death toll had been to over 255,000, the China railway network was completely disrupted. In this event, 28 freight trains and 7 passenger trains were travelling on the railway in total; 7 freight trains and 2 passenger trains were turned over and derailed. The ground surface deformed during the earthquake causing the rail to bend seriously both in profile and in plan. Only on the Beijing to Shanhaiguan railway line and on the Tongxian to Tuozitou line more than 63 kilometers of line was seriously damaged. In this matter various embankment damage mode including sinking, cracking, slope sliding and cave-in were observed and, so for the restoration of these embankments over 100,000 m^3 of stone ballast and rubble was used. [1]

As Iran country has located on Eurasia seismic zone and a large portion of its railway tracks endangered by earthquake risk. Therefore its necessary preserved the railway structures versus quakes and ground motions. Four categories of the railway structures which must be protected against earthquake damage are as following:

- Railway buildings such as terminals, stations, offices, ticket halls, platforms, and etc.
- Railway bridges,
- Railway Tunnels,
- Railway track structures including of super and substructures including the embankments and trenches.

Although a lot of investigations and researches on retrofitting of the first three categories's structures have been thoroughly accomplished, a few studies have been performed about the earthquake effects on railway tracks up to now.

Reviewing the related literature in this matter shows that Senkine et al. (2005) has accomplished an experimental study to examine the deformation properties of ballasted track during earthquake. A series of shaking table tests were performed for two types of single size crushed stone [2]. Nakamura et al. (2010)