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Estimating clamping force of rail fastener system by experimental and numerical methods

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Abstract

Higher demand on security of passenger railway nowadays leads to a trend of field testing method tried on the existing lines. Features of rail fastener are important parameters relevant to safety of railway track structure. Numerical model calculated to predict lateral features of rail fastening system investigates the relation between applied load and displacement of rail in order to provide a new idea of experiment design. The displacement of rail caused by torsional deformation is also considered. Nonlinear relationship of displacement response and load excitation discovered from experimental validation of a numerical model mainly lies in rail bending due to the dynamic response hardening (DRH). Consequently, clamping force which is only measured in the laboratory can be evaluated by both numerical and experimental analysis in this paper. Displacement distribution in longitudinal direction is also mentioned.

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Keywords: clamping force, numerical model, rail fastening system, nonlinearity

1. Introduction

Growing axle loads of train and increasing high speed has placed significantly demand on rail infrastructure in China, especially on rail security. Structural safety is of paramount importance in rail transport industry thus there have been continuing efforts in design and testing of rail structure. Rail fastening system fixes rail to sleeper by tensioning rail through spring-actuation as a result of the long elastic spring deflection of the tension clamp. The

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tension clamps combine exceptional clamping force, superior dynamic fatigue strength and stable creep resistance all in one. Clamping force of rail fastener is an essential parameter relevant to the safety of railway track structure but also is hard to test on site.

Though field testing of clamping force in the existing line has not done before, some laboratory tests have performed by manufacturers and other researchers. In Europe, experimentalists measure clamping force of fastening system according to the standard of EN 13146-7-2002 which is applicable to complete fastening systems assembly. In the test procedure, an increasing tensile load is applied to rail until rail pad can just be moved, then remove pad and decrease load until the average of displacement transducers is zero. Clamping force is the value at d=0 read off from load-displacement diagram, whereas rail fastening system installed on the existing railway is impractical to evaluate its clamping force by means mentioned above while the reliability and security of rail could not be ensured enough.

Some basic numerical methods have gradually been developed as guidance to carry experiments on the field test. Discrepancy of lateral force in aspect of direction and magnitude on two rails results in a numerical method utilized on lateral mechanical behaviour of two rails set up by D. Tong(1988). In addition, Y. Zhang and S. Lian (1997) considered the twist of rail when analysing lateral displacement due to non-ignorable torsion deformation on the top of rail. B. Tesfa et al. (2012) proposed a means of automatically measuring the clamping force of bolted joint independently on railway track joints and points.

In order to determine clamping force of fastener above-mentioned in the practical use which are continuous distributed and hardly obtained, a set of experimental tests is designed and carried out on the base of static lateral mechanical model of rail structural system in Suzhou city, China in this present study. Fastener properties observed from testing results are studied and explained through numerical model analysis conducted by Matlab, which is used to evaluate lateral stiffness of rail fastening system from the calculated relationship between applied load input and lateral displacement response of track. Analysing results of both numerical simulation and experiments are believed to indicate an approximate value of clamping force, to reduce lateral displacement of rail and to enhance security of rail structural system.

2. Numerical Model

Aiming at defining the clamping force of fastening system accurately by numerical method, mechanical model must be established in lateral direction since lateral stiffness of rail is much larger than vertical in all types on account of geometry properties. Displacement range of rail in lateral direction is also wider enough to distinguish evidently. As a result, static lateral mechanical model of rail is finally selected for estimating clamping force of rail fastening system, see Fig.1.

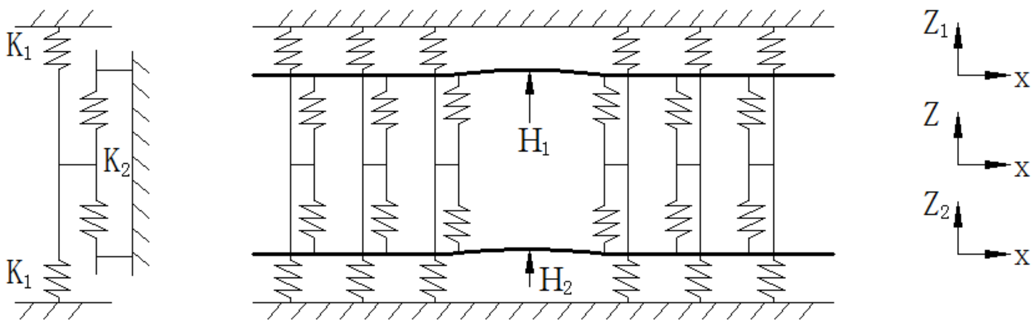

Fig.1. static lateral mechanical model of rail

In this present study, the two rails are modelled as Winkler beams with a bending stiffness EJ_y. The rail displacements resulted from bending are denoted as Z_1 and Z_2. The rail fastening systems are modelled as continuous