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Vertical vibration of two axle railway vehicle

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Abstract

The vertical vibration of the two axle vehicle has been solved analytically using the model of rigid rectangular plate with asymmetrically load distribution related to geometrical symmetry axes of central plane. Vertical displacements are solved for various cases of asymmetry, under kinematic excitation of the system with three degrees of freedom. The displacement of the centre of gravity and rotations to central axes are solved. The elastic support of the plate is combined with parallel viscous dumper. The task of vibration analysis is defined generally (and solved analytically) and for further solution (or extended) SYMPACT, ADAMS or MEDINA etc. software are possible to use.

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Keywords oscillation; rail vehicle; vertical displacemnet; rotation;

1. Introduction

Every mechanical system which serves for public transportation including rail vehicles has to be certified. International standards prescribe demanded dynamic tests to determine dynamic behavior of the vehicle during certification procedure. To save the necessary time of investigation, the analytical, numerical or more often experimental techniques are applied to assess the dynamic characteristic of the system. These methods are also applied during design of the new vehicle. Information about research investigated in the similar field of study can be found in [1, 3, 5, 6, 8-10].

In the present work, an analytical method for obtaining the vertical dynamic response of complex mechanical systems is proposed. Experimental tests are performed on a real railway freight wagon to validate the theoretical model.

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2. Analytical model

The vertical displacement of two axle railway vehicle has been investigated. The vehicle can be modelled by simple rigid rectangular plate with respect to certain assumptions [2]. The load is asymmetrically distributed on the vehicle related to the geometrical axes of symmetry of mid-plane. The plate is spatially supported on four springs. Investigation of vertical displacement of plate for various cases of asymmetry of kinematic excited system with 3 DOF (degree of freedom) which corresponds to vertical displacement of gravity center w and rotation φ_x and φ_y around central inertia axes of plate was presented in [11, 7].

In the article the vertical displacement of two axle rail vehicle represented as rigid plate with effect of energy dissipation under oscillation was investigated. The elastic support of plate which is combined with viscous dumping is presented in the Fig. 1.

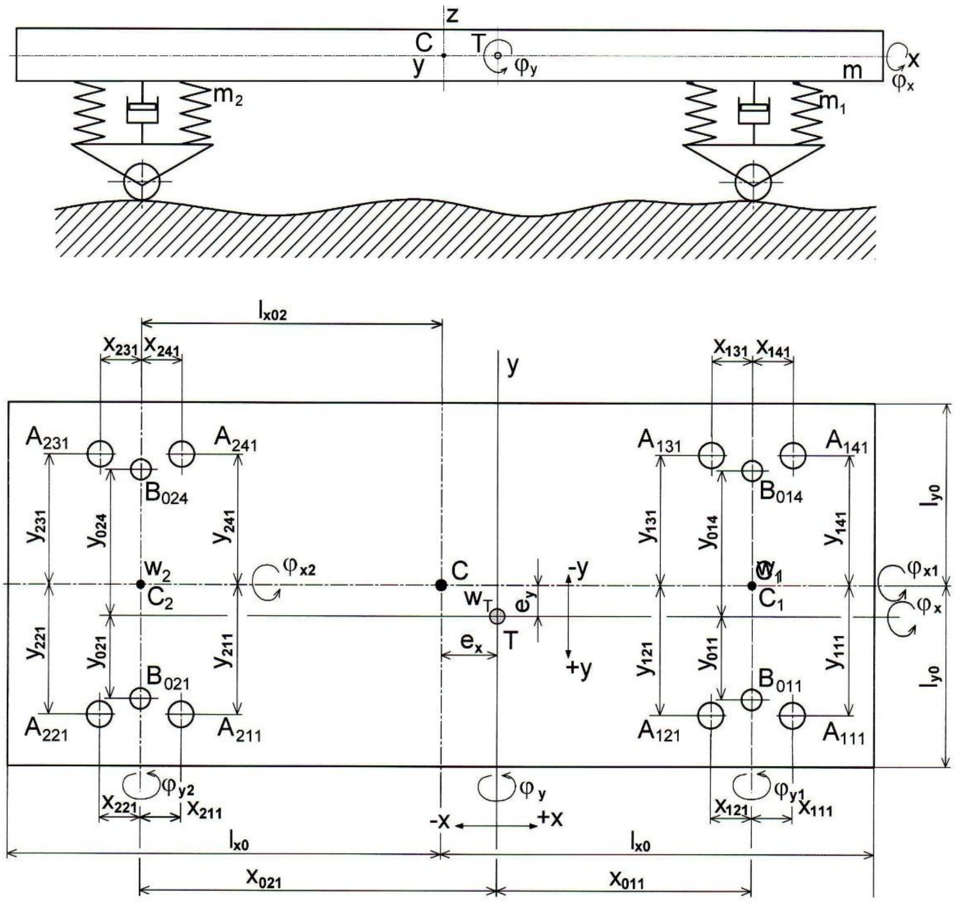

Fig. 1 Scheme of investigated model.

In case of spatial support of plate, the motion equation is written in form

$$\begin{vmatrix} m & 0 & 0 \\ 0 & J_x & -D_{xy} \\ 0 & -D_{xy} & J_y \end{vmatrix} \cdot \begin{vmatrix} \ddot{w} \\ \ddot{\varphi}_x \\ \ddot{\varphi}_y \end{vmatrix} + \begin{vmatrix} \mu_{11} & \mu_{12} & \mu_{13} \\ \mu_{21} & \mu_{22} & \mu_{23} \\ \mu_{31} & \mu_{32} & \mu_{33} \end{vmatrix} \cdot \begin{vmatrix} \dot{w} \\ \dot{\varphi}_x \\ \dot{\varphi}_y \end{vmatrix} + \begin{vmatrix} \kappa_{11} & \kappa_{12} & \kappa_{13} \\ \kappa_{21} & \kappa_{22} & \kappa_{23} \\ \kappa_{31} & \kappa_{32} & \kappa_{33} \end{vmatrix} \cdot \begin{vmatrix} w \\ \varphi_x \\ \varphi_y \end{vmatrix} = \begin{vmatrix} F_z(t) \\ F_x(t) \\ F_y(t) \end{vmatrix} \quad (1)$$