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Mutual Comparison of two Pavement Computing Models

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Abstract

Moving load effect on pavements is actual engineering problem. For the numerical simulation of moving load effect on pavements the various computing models were created. In the proposed paper two computing models of pavement are described and mutually compared. One computing model is created in the sense of the beam on elastic foundation and the second in the sense of Finite Element method. The plane computing model of vehicle is adopted.

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Keywords: Moving load; pavement; computing model; vehicle; beam on elastic foundation; Finite Element Methods.

1. Introduction

The pavements are the structures directly exposed to dynamic effect of moving vehicles. To know the stress and strain states in dynamic regime of load is necessary for assessment of many engineering problems as fatigue, life time, reliability and so on. There are two basic approaches how to obtain the required data – numerical or experimental. With regard to various constructive variants of pavements the numerical approach is very effective. There are many possibilities how to create the computing model of the pavement and computing model of the load. In this paper two computing models of the pavement are introduced and mutually compared. One model comes from the solution of equation of motion of the beam on elastic foundation and the second model is created in the sense of Finite Element Method. The results of numerical simulations in time and in frequency domain can be employed for the solution of many engineering tasks [1, 2].

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2. Vehicle computing model

The plane computing model of vehicle is adopted for the solution of this task, Fig. 1, [3]. It is discrete computing model with 8 degrees of freedom, 5 mass and 3 mass-less degrees of freedom. The mass-less degrees of freedom correspond to vertical movements of contact points of the model with the pavement.

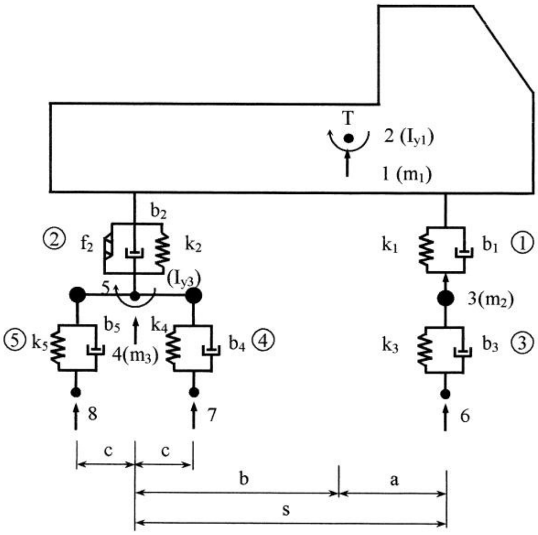

Fig. 1. Plane computing model of vehicle.

Vertical vibration of mass objects is described by 5 functions of time $r_i(t)$, (i = 1,2,3,4,5).

$$\ddot{r}_1(t) = -\{+k_1 \cdot d_1(t) + b_1 \cdot \dot{d}_1(t) + k_2 \cdot d_2(t) + b_2 \cdot \dot{d}_2(t) + f_2 \cdot \dot{d}_2(t)/\dot{d}_c\} / m_1 ,$$

$$\ddot{r}_2(t) = -\{-a \cdot k_1 \cdot d_1(t) - a \cdot b_1 \cdot \dot{d}_1(t) + b \cdot k_2 \cdot d_2(t) + b \cdot b_2 \cdot \dot{d}_2(t) + f_2 \cdot \dot{d}_2(t)/\dot{d}_c\} / I_{y_1} ,$$

$$\ddot{r}_3(t) = -\{-k_1 \cdot d_1(t) - b_1 \cdot \dot{d}_1(t) + k_3 \cdot d_3(t) + b_3 \cdot \dot{d}_3(t)\} / m_2 ,$$

$$\ddot{r}_4(t) = -\{-k_2 \cdot d_2(t) - b_2 \cdot \dot{d}_2(t) - f_2 \cdot \dot{d}_2(t)/\dot{d}_c + k_4 \cdot d_4(t) + b_4 \cdot \dot{d}_4(t) + k_5 \cdot d_5(t) + b_5 \cdot \dot{d}_5(t)\} / m_3 ,$$

$$\ddot{r}_5(t) = -\{-c \cdot k_4 \cdot d_4(t) - c \cdot b_4 \cdot \dot{d}_4(t) + c \cdot k_5 \cdot d_5(t) + c \cdot b_5 \cdot \dot{d}_5(t)\} / I_{y_3} . \tag{1}$$

The contact forces F_j(t), (j = 3,4,5) corresponds to mass-less degrees of freedom

$$F_3(t) = -G_3 + k_3 \cdot d_3(t) + b_3 \cdot \dot{d}_3(t) = -g \cdot \left(m_1 \cdot \frac{b}{s} + m_2 \right) + k_3 \cdot d_3(t) + b_3 \cdot \dot{d}_3(t) ,$$

$$F_4(t) = -G_4 + k_4 \cdot d_4(t) + b_4 \cdot \dot{d}_4(t) = -\frac{1}{2} \cdot g \cdot \left(m_1 \cdot \frac{a}{s} + m_3 \right) + k_4 \cdot d_4(t) + b_4 \cdot \dot{d}_4(t) ,$$

$$F_5(t) = -G_5 + k_5 \cdot d_5(t) + b_5 \cdot \dot{d}_5(t) = -\frac{1}{2} \cdot g \cdot \left(m_1 \cdot \frac{a}{s} + m_3 \right) + k_5 \cdot d_5(t) + b_5 \cdot \dot{d}_5(t) . \tag{2}$$