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Faculty of Transport

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suspended monorail, crew, dynamic load, deformation, mathematical model

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RESEARCH OF PROCESS OF RUNNING WHEEL WITH SUSPENDED MONORAIL

Summary. In the article there have been regarded the movement of the single crew on the suspended monorail having irregularities on the joints. It is formed the mathematical model of vertical oscillations taking into account the crew suspended part and running wheel oscillations during the movement on the elastic monorail. There have been determined the amplitudes of crew oscillations at the arrival on the joints with elevations.

ИССЛЕДОВАНИЕ ПРОЦЕССА ВЗАИМОДЕЙСТВИЯ ХОДОВОГО КОЛЕСА С ПОДВЕСНЫМ МОНОРЕЛЬСОМ

Аннотация. В статье рассмотрено движение одиночного экипажа по подвесному монорельсовому пути, имеющему неровности в стыках. Составлена математическая модель, учитывающая вертикальные колебания подвесной части экипажа и ходового колеса во время движения по упругому монорельсу. Установлены амплитуды колебаний экипажа при наезде на стыки с превышениями.

1. INTRODUCTION

During the movement of the crew on the suspended monorail in the places of running wheels contact there have inevitably emerged oscillating loads which has probabilistic nature changing in the space and time. The main sources of disturbances are running wheels and monorail which have irregularities and also elastic deformations occurring during the movement.

In addition monorail has joints and junctions permitting spacing and wraps in different planes. For these reasons during the movement there appear additional dynamic loads which are transferred onto monorail suspension decreasing its stability. That's why the research of process of interaction of running wheel with suspended monorail is actual objective.

To the researches of dynamic processes occurring in the system " wheel – rail" and in particular in zone of the rail joint there has been devoted a number of scientific works [1, 2, 3, 4]. In the works [5, 6, 7] it is considered the mode of deformation of crew elements. The research of mode of deformation of wheel is given in [8, 9].

This work is the continuation of mentioned researches. The goal of the article is to determine the interaction between parameters of suspended monorail and crew during the movement of its running wheels on the joints.

2. RESERCH AND RESULTS

During the movement of single crew on the joints of suspended monorail sections of which are connected between each other and have spacing and elevations δ (fig.1), there appear impulse strikes, caused by changing of driving direction of speed of running wheel mass centre. These strikes cause the unspring mass oscillations and are transferred to monorail crew and are disturbances.

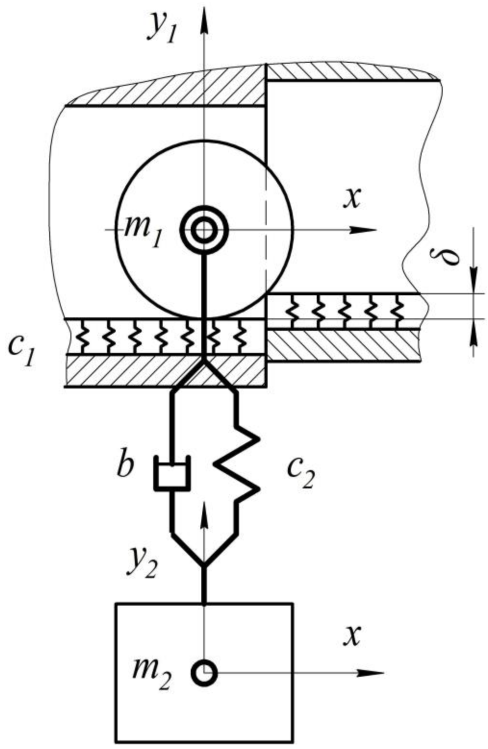


Fig. 1. The scheme of movement of suspended crew on the suspended monorail
Рис. 1. Схема движения подвесного экипажа по подвесному монорельсу

Let's examine the model of vertical oscillations which is represented in the form of twomass system taking into account the oscillations of running wheel on the elastic monorail and oscillations of the crew suspended part. Let's introduce the following symbols: m_1 – reduced running wheels mass; m_2 – reduced crew suspended part mass; c_1 – coefficient of monorail stiffness on the joint; c_2 – coefficient of crew suspension stiffness; b – coefficient of crew suspension damping; y_1 , y_2 –generalised coordinates of motion of mass centres of running wheels and crew suspended part accordingly.

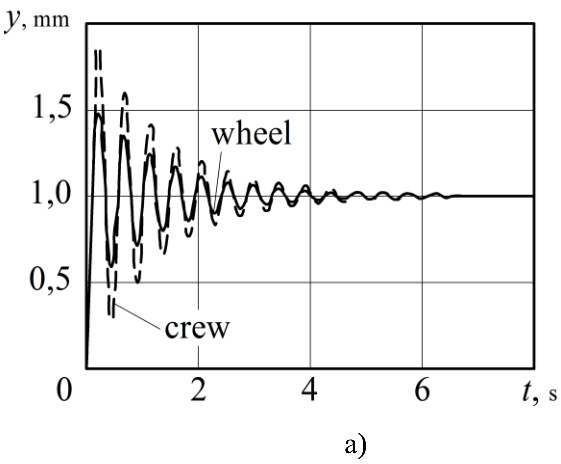
Generalised force which influences the given system is impulse of impact force appearing during the running wheels movement on the monorail

$$Q = \eta(t). \tag{1}$$

Let's examine the oscillations occurring in the vertical plane. Corresponding motion equations are

$$m_1\ddot{y}_1 + b(\dot{y}_1 - \dot{y}_2) + c_1 y_1 + c_2(y_1 - y_2) = \eta(t);$$
$$m_2\ddot{y}_2 + b(\dot{y}_2 - \dot{y}_1) + c_2(y_2 - y_1) = 0. \quad (2)$$

During the crew movement on the single joint having the elevation δ, there emerges the single disturbance causing the oscillations showed in fig. 2.The graphic solution given in this figure is received for the following symbols of coming parameters of suspended crew and monorail: m_1 = 200 kg; m_2 = 6000 kg; c_1 = 2x10^3 kN/m; c_2 = 2,5x10^3 kN/m; δ = 1 mm; b = 50 kN·s/m.



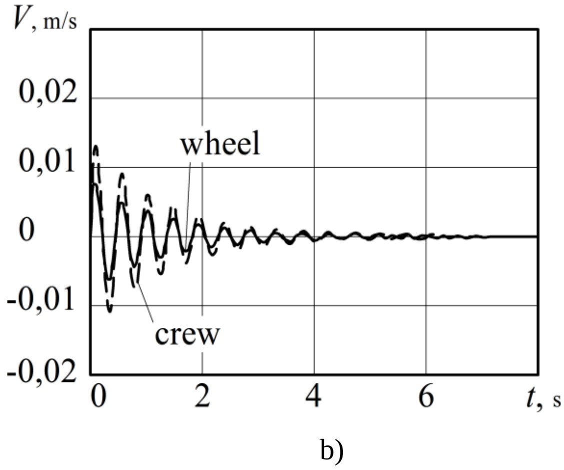


Fig. 2. Dependencies: a) – of amplitudes on motion from the time; b) – of speed during the movement on the joint
Рис. 2. Зависимости: a) – амплитуд перемещений от времени; b) – скоростей при наезде на стык

With the increase of elevation δ from 0,1 till 5,0 mm the maximal amplitude of wheel oscillations practically in proportion increases from 0,19 till 9,3 mm, and crew one increases from 0,15 till 7,5 mm. With the decrease of the crew mass till 2000 kg the maximal amplitude of wheel and crew oscillations decrease insignificantly, but with this oscillations frequency increases more than by twice. With the increase of crew suspension stiffness coefficient by 10 times the amplitude and the oscillations frequencies practically don`t change, but time of oscillations damping increases more than by 20 times.

Operating during the crew movement on the joints of the suspended monorail consisting of the segments L_i, of disturbing in the vertical plane can be described by the function

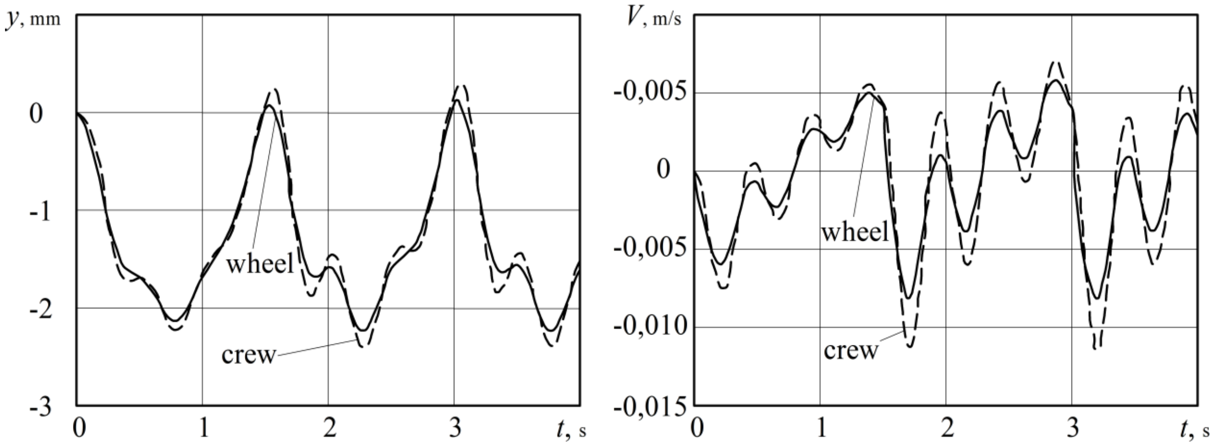
$$\eta(t) = -|\delta_i \sin \omega t|, \quad (3)$$

where: δ_i – amplitude of monorail irregularity half-wave;
ω – frequency of irregularity half-wave is equal to

$$\omega = \frac{\pi V}{L_i}. \quad (4)$$

where: V – crew motion speed.

The solution of the equations (2) taking into account disturbances effect is given in the fig. 3.



a) b)

Fig. 3 Graphic of dependence on the motion on the determined surface: a) – $y= f(t)$; b) – $V=f(t)$
Рис. 3. Графические зависимости движения по детерминированной поверхности: a) – $y= f(t)$; b) – $V=f(t)$

Particular solution of equations (2) and the amplitude value taking into account forced oscillations (3) can be found as [10]

$$f = \frac{h\gamma + (\gamma - d)^2}{h\gamma(\gamma + a - 1)^2 + [ad\gamma + (\gamma - 1)(\gamma - d)]^2}, \quad (5)$$

where: $h = \frac{b^2 m_1}{c_1 m_2^2}$; $\gamma = \left(\frac{\omega}{\omega_1}\right)^2$; $a = \frac{m_2}{m_1}$; $d = \left(\frac{\omega_2}{\omega_1}\right)^2$;

$$\omega_1 = \sqrt{\frac{c_1}{m_1}};\ \omega_2 = \sqrt{\frac{c_2}{m_2}}.$$

For modern monorails the coefficients a and d, taking into account the proportion of the reduced masses and circular frequencies of the crew suspended part and running wheel are set constructively. More often there are a =0,03, and d = 1, 0.

The dependence of oscillations amplitude from the coefficient γ for different values of coefficient h, is given in the fig. 4.

From the fig. 4 one can see that with the increase of coefficient γ from 0 till 0,6…0,8, the oscillations amplitudes decrease to the lower-range value and with the further increase of this coefficient they increase. And for values γ more than 1,5 it is observed directly proportional amplitude increase.

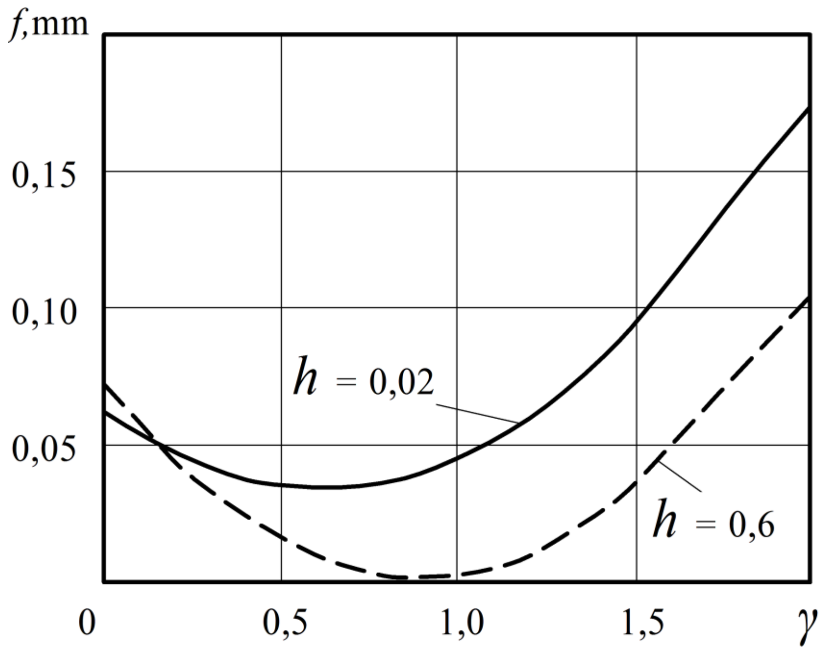


Fig. 4.The dependence of oscillations amplitude on the coefficient γ

Рис. 4. Зависимость амплитуды колебаний от коэффициента γ

It should be mentioned that for γ less than 0.2 the coefficient change h practically doesn't influence oscillation amplitudes. If not the increase h causes the oscillation amplitude increase which one should take into account during the choosing of damping device parameters.

3. CONCLUSIONS

The received dependences determining the interaction between parameters of monorail and crew during the movement of its running wheels on the joints will be used for the well-grounded choosing of monorail parameters. In future it is planned to carry out theoretical researches taking into account the monorail oscillations caused by its suspension flexibility.

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