CALCULATION OF THE FIRS OWN PULSATION FOR THE SYSTEM WITH A DEGREE OF FREEDOM FOR AN ABOVE-GROUND PARKING

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ABSTRACT: In the event of an earthquake, the energy radiates outward as seismic waves. The inner waves (longitudinal and transversal) move from the hypocenter to the outside, and the superficial waves move to the surface of the earth, those resulting from the inner waves that reach the surface of the soil.The P and S type of internal longitudinal and transversal seismic waves represent disruptive forces for any system. We propose to evaluate the own pulsation in case of the free vibrations of an overground parking. it is necessary that the wave pulsation to be different from the own pulsation of the system to be researched in order to avoid the phenomenon of resonance that is leading to the destruction of the system. We will consider the System Model with a degree of freedom for which we will determine its own pulsation and frequency.

Key words: seismic waves, own pulsation

1. INTRODUCTION

In the event of an earthquake, the energy radiates outward as seismic waves. The inner waves (longitudinal and transversal) move from the hypocenter to the outside, and the superficial waves move to the surface of the earth, those resulting from the inner waves that reach the surface of the soil. [1]

When evaluating the reaction of a mechanical system under the action of seismic waves, two elements related to the complexity of the studied phenomenon must be taken into account:

a) the permanent existence of random seismic waves
b) the complexity of the mechanical systems to be analyzed - for example a metal structure on a concrete support - fig. 1 and a metal support frame- fig. 2 [2]

In order to assess the behavior during an earthquake of a system of a parking composed of a parking and a lifting mechanism, a model is used and this way are determined the system's own pulsations [3] and its interactions with the seismic waves.

The vibration protection is based on the principles of their insulation and damping.

In order to achieve an effective vibration damping, it is necessary to appropriately adopt the mass and elastic constant characteristic of the studied system so as to avoid the resonant operation and the transmission of vibrations to the foundation to have subunitary values.[4]

At ω/ ωn =1 , when the disturbance oscillation pulse coincides with the system's own pulsation, the amplitude becomes infinite (because the system is unamortised). This phenomenon is called "resonance," and its own pulse is sometimes called "resonance pulse".

By various methods, the system's own pulses are evaluated (using the Dunkerley method, using the Veresceaghin method, the continuous system model). [5] In order to avoid the resonance leading to destruction, it is possible to optimize the design of the respective structures and to confirm the assumptions made by the designer regarding the plastic failure mechanism.

Further, the own pulsations of the studied system will be determined by the simplest method. .[5]

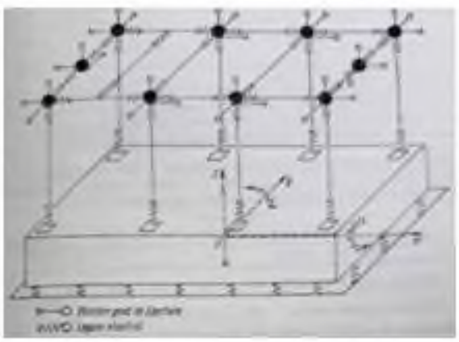

Fig 1. Metal structure on a concrete support

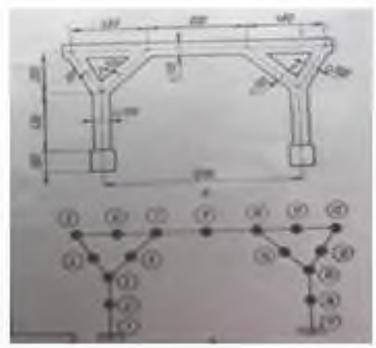

Fig 2. Metal support frame

2. CALCULATION OF THE FIRST OWN PULSATION FOR THE SYSTEM WITH A DEGREE OF FREEDOM

It is considered an elevator model as that presented in Figure 3, which includes the elevator itself, the dynamic brake, the traction engine and the counterweight. Based on this, the calculation model in Figure 4 is taken into account and the system's own pulsation can be determined by the simplest method in the event of a sudden stopping of the system. This model is typically used in situations where it is desirable to quickly assess the resonance potential of a system. It is chosen the model. 6. It should be considered that when starting and stopping the vehicles repeatedly the pulse of the exciting force varies in proportion to the speed of its rotors. In order to avoid the resonance phenomenon, in this case the oscillator is added a viscous shock absorber or a plastic damper.

a) The system is formed only by vehicle and cable, without taking into account the rest of the elements, the mass being in this case m= 3000 kg
b) The system consists of a total mass body (elevator and vehicle) of total mass m_{tot}= M+m = 20000 kg ,

Consider the system in two situations:

In both cases, the elasticity modulus of the connecting cable E = 2* 10^{11} N/m^2, the length of the connecting cable L = 10 m, the cable section A= 0,25 m^2

a) For the weight force equal to the elastic force G= kx results the deformation under the static load G is x= GL/ (EA) = 30000*10/ 2* 10^{11}* 0,25 = 0,000006 m (1)

Own pulsation

ω= $(k/m_{tot})^{0,5}$= $(g/x)^{0,5}$= $(9,81/0,000006)^{0,5}$= 1290 rad/s (2)

Own frequency

$\nu = \frac{\omega}{2\pi} \approx 205$ Hz (3)

Own period T= 0,01 s (4)

b) In the second case the deformation is

x= GL/ (EA) = 200000/ 2* 10^{11}* 0,25 = 0,000004 m (5)

Own pulsation

ω= $(k/m_{tot})^{0,5}$= $(g/x)^{0,5}$= $((9,81/0,000004)^{0,5}$= 1581 rad/s (6)

Own frequency

$\nu = \frac{\omega}{2\pi} \approx 252$ Hz (7)

Own period

T= 0,04 s (8)

It is noticeable that the lower mass decreases its own frequency. If mounted between cab and cable and a spring, the more flexible suspension further decreases its own frequency.

The chart in Figure 5 shows the values of their own frequencies in the analyzed situations

- when considering only the mechanical system used for the vehicle elevator, its own frequency is 205 Hz
- when considering the mechanical system of the studied unit the own frequency is 252 Hz

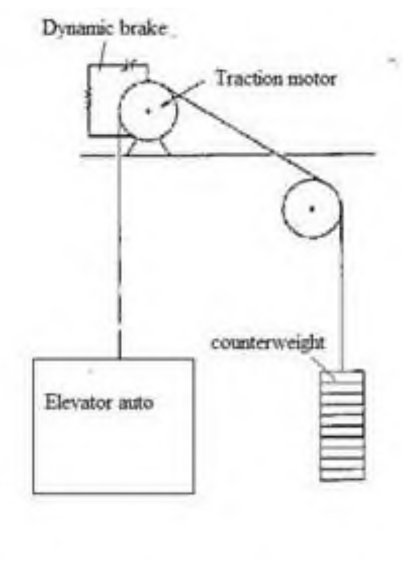

Fig. 3 Elevator model

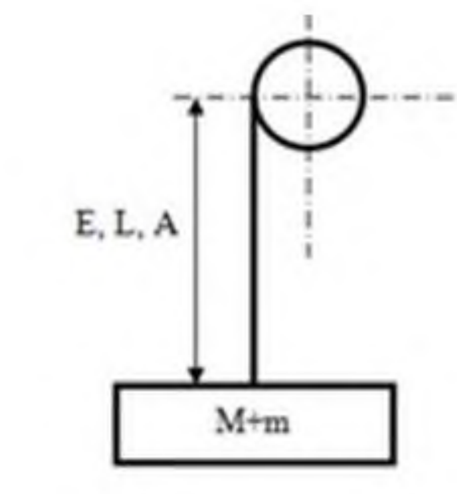

Fig.4 Calculation model

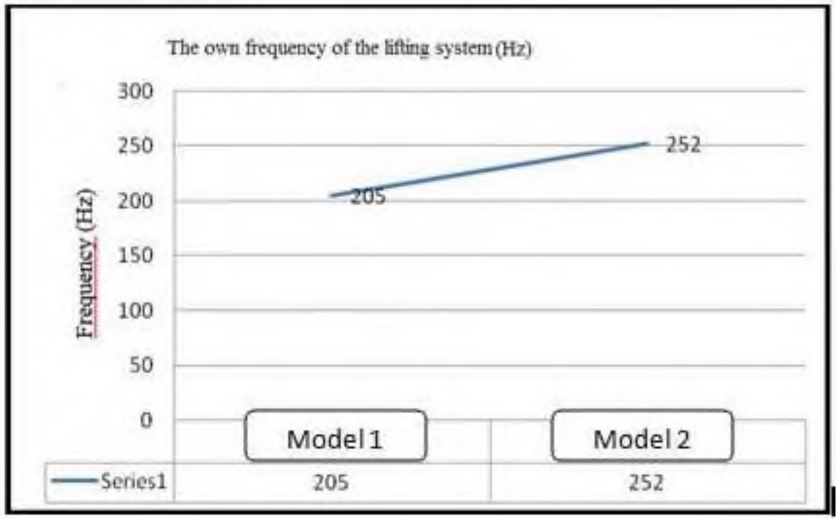

Fig.5 Own frequencies of the analyzed systems

3. THE BEHAVIOR OF THE PARKING UNDER THE ACTION OF AN EXTERNAL FORCE OF NON-PERIODIC CHARACTER.[7]

Generally, when any disturbance occurs on a linear system with invariant parameters, the resulting vibration is the sum of two distinct components: forced vibration, described by a function similar to the excitation function and its own vibration, dependent only on the dynamic characteristics of the system. In case of a stationary harmonic or random disturbance, the vibration itself is amortized immediately after the beginning of the movement, remaining only the forced vibration, which under certain conditions can produce resonance. If a system is operated by a periodic external force, the frequency of which is equal to one of the system's own frequencies, the vibration produced has relatively large amplitudes even for relatively small amplitudes of disturbing force. The system is said to be in a resonant state. At resonance, a constant amplitude force produces a maximum response, or a minimum force is required to maintain a constant amplitude response. Resonance means large amplitudes of motion at certain points or parts of the vibration system, accompanied by considerable stresses and tensions or considerable relative movements that can lead to noise and even destruction.[7]. For example, for a system similar to the previous one, for a force disturbing

$F_0 = 2 * 10^8$ N,

$\omega_0 = 1290$ rad/s (first calculation),

$k = m\omega_0^2 = 3000 * 1290^2 = 5 * 10^9$ si t< 4 s (9)

according to the relationship

$$y(t) = \left(\frac{1}{m\omega_0}\right) * \int_0^t \left(F_0\left(1 - \frac{\tau}{t_0}\right)\right) \sin \omega_0(t_0 - \tau)) \, d\tau = \\ = \left(\frac{F_0}{m\omega_0^2}\right)\left(1 - \frac{t}{t_0} - \cos \omega_0 t + \frac{\sin \omega_0 t}{\omega_0 t_0}\right) \quad (10)$$

approximate displacement results

$$y(t) = 0,04 - 0,01t - 0,04 \cos 1290t \qquad (11)$$

whose chart is represented in figure 6

According to the Seismic Design Code - Part III-2018, a calculation assessment formula can be used which takes into account the height of the building measured above the theoretical embankment (in meters) and a coefficient which is according to the material from which the structure is built.[8]

According to the seismic design code P100-1 / 2013, innovative solutions will be made in order to reduce the amplitude of the seismic response of buildings, a solution that gives good results for surface earthquakes where the wavelengths of the waves are T < 0.5s, and for the intermediate earthquakes of Vrancea T = 0.7- 1.6s.

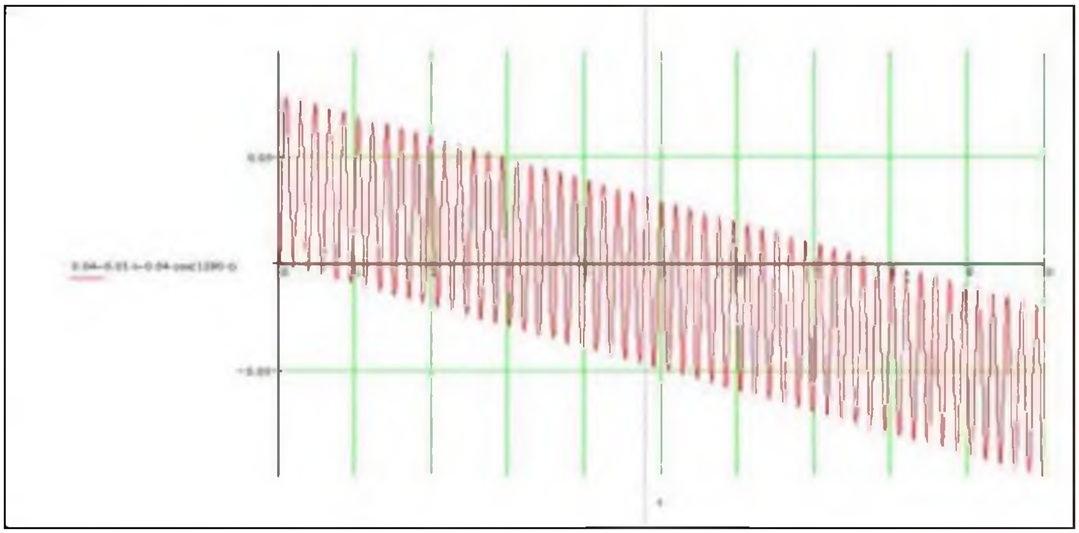

Fig. 6. Movement y(t) of the system under a disturbing force

4. CONCLUSIONS

The following conclusions may be drawn by assessing the previously obtained results:

- The own determined pulsations are strongly influenced by the model adopted for the system
- For the first two modellings which are similar, approximately equal solutions are obtained for the first own pulsation, having different values of about 6% one comparing to each other.
- These methods provide approximately double results of the first own frequency comparing to the one close to the reality, determined by the continuous environment method
- For the determination of a high number of own pulsations, specific to a continuous environment and the closest to reality, the use of the continuous system method is necessary.

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