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OPTIMAL DYNAMIC REGIMES OF VIBRATION COMPACTION EQUIPMENT

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REZUMAT. *The paper deals with the dynamics of vibrating compactors for road works. Thus, the dynamic model adopted faithfully ensures the behaviour of the vibrating equipment in the working process. For this purpose, the characteristics of the working amplitudes of the road rollers in a frequency range positioned after the last resonance of the machine were raised. The in-situ experimental results were relevant for the evaluation of the dynamic behaviour of the vibrating rollers modelled in this paper.*

Keywords: *vibrating compactor, vibrations.*

1. INTRODUCTION

The modern execution technologies of the layers of soil, stabilized soil, ballast, asphalt mixtures ensure a technical-economic efficiency corresponding to the construction works through a rational use of the vibration compaction technological equipment.

The technical challenge to this type of equipment is to meet a specific, fundamental criterion, which cumulates two contradictory aspects, namely:

- performing the working vibration parameters on the vibrating roller for compaction;
- framing the vibration parameters within the allowable limits of the attendant mechanic to the shift, in order to ensure the ergonomic parameters and observe the legislation in the field of safety and health at work and, at the same time, to maintain the characteristic parameters of the operating safety.

In order to achieve the compacting effect, the vibration amplitude of the compacted element is to be achieved, and in order to achieve the ergonomic conditions, it is aimed to diminish the vibration transmission from the vibrating roller to the machine structure.

Experimental tests have been carried out on the road works sites in Romania to determine the efficiency of the compaction as well as to establish the dynamic regime of the technological vibrations.

2. CONSTRUCTIVE ANALYSIS

The following types of equipment are used in the soil compaction process:

a) towed vibrating compactors;
b) self-propelled vibrating compactors, with single casting (non-articulated) chassis and two smooth rollers. The vibration is performed wither with a single roller or on both rollers, and the traction with a single roller, or total, with both rollers;
c) self-propelled vibrating compactors with two profiled rollers with articulated chassis. The vibration is performed on both rollers or only on one roller, while traction is performed on both rollers;

d) self-propelled vibrating compactors with two smooth rollers and articulated chassis. The vibration is performed either with a single roller (fig. 1), or on both rollers and traction on a single roller or on both;

e) mixed self-propelled vibrating compactors with articulated chassis. The vibration is done with a single roller located in front, and the traction on two or four tires located in the rear. All-wheel drive systems can also be used simultaneously on rollers and tires.

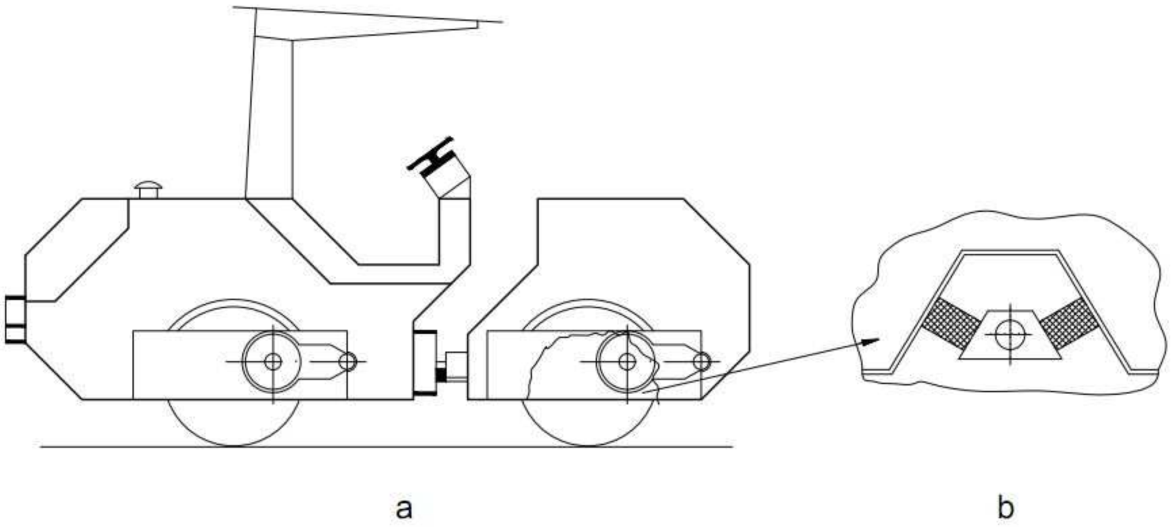

Fig. 1. Self-propelled equipment with a vibrating roller and a single dynamic isolation gear

The elastic connection roller - fore chassis is constituted as an elastic vibration isolation “gear” composed of rubber elements (fig. 1).

If the rubber anti-vibration elements are not rationally located in the machine structure, an abnormal operation of the machine may occur, accompanied by the short-term destruction of the subassemblies, as well as the transmission of vibrations at the control station.

The ability of the rubber to absorb much of the mechanical energy causes the amplitude of the vibrations to be diminished, especially when passing through resonance, in which case the rubber elements act as shock absorbers, as a result of the energy dissipation property.

The metal construction is made up of the chassis components, the weighting down box, the driving unit support, the associated ground loops and the cabin.

The construction elements are made as rigid and compact as possible so that they do not deform under the conditions of the imposed vibration regime.

The chassis consists of two parts connected by a double joint with vertical and horizontal axis.

3. DYNAMIC PARAMETERS

The calculation model for a vibrating compactor, reduced to the single-cylinder schematization is shown below, in figure 2

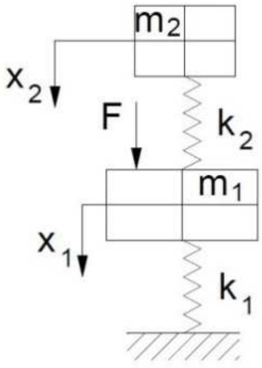

Fig. 2. Dynamic model

The differential equations of movement are as follows:

$$m_1\ddot{x}_1 + k_1x_1 + k_2(x_1 - x_2) = F(t) \qquad (1)$$

$$m_2\ddot{x}_2 - k_2(x_1 - x_2) = 0 \qquad (2)$$

where

$$F = F(t) = m_0 r\omega^2 \sin \omega t \qquad (3)$$

The function of own pulsations is given by the relation of D, thus:

$$D(\omega) = \left(k_1 - m_1\omega^2\right)\cdot\left(k_2 - m_2\omega^2\right) - m_2k_2\omega^2 \quad (4)$$

The amplitudes of the forced vibrations are given by the following relations:

$$A_1 = \frac{m_0 r\omega^2}{D}(k_2 - m_2\omega^2) \qquad (5)$$

$$A_2 = \frac{m_0 r\omega^2}{D}k_2$$

Where:

- ✓ A_1 is the amplitude of the technological vibrations of the compacting roller;
- ✓ A_2 – the amplitude of the fore chassis of the machine.

4. VARIATION OF DYNAMIC RESPONSE PARAMETERS

The working hypothesis for plotting the variation graphs of the compacting roller vibration amplitude, respectively of the chassis with the pulse ω is established based on the experimental determinations performed within ICECON.

Thus, based on case studies, significant curves can be raised for the following initial parametric data:

- ✓ m_1 is the mass of the compacting roller; $m_1 = 5000$ kg;
- ✓ m_2 - the mass of the chassis of the compaction equipment; $m_2 = 2000$ kg;
- ✓ k_1 - the stiffness coefficient of the soil; $k_1 = (5; 10; 20; 25)10^7$N/m;
- ✓ k_2- the stiffness coefficient of the elastic gear consisting of a system of elastomeric devices assembled in parallel between the vibrating roller and the fore chassis.
- ✓ $k_2 = 5\cdot 10^7$ N/m;
- ✓ m_0r - the total static moment of the inertial vibrodriver;
- ✓ $m_0r = 7{,}5 kgm$, where m_0 is the total mass of inertial imbalance elements;
- ✓ r – the coordinate of the centre of mass in relation to the axis of rotation of the inertial imbalance elements.
- ✓ ω - the pulsation of the driving force, as a current variable; $\omega = 0...500 rad/s$.

Figure 3 shows the variation of A_1 in relation to the variable ω and the discrete variable k_1 meaning the stepped compaction of the land starting with $k_1 = 5\cdot 10^7$N/m up to $k_1 = 20\cdot 10^7$N/m. Figure 4 shows the variation of A_2 in relation to current variable ω and to the discrete variable k_1, highlighting that as the degree of compaction increases the vibrations transmitted to the chassis have increasing discrete amplitude.

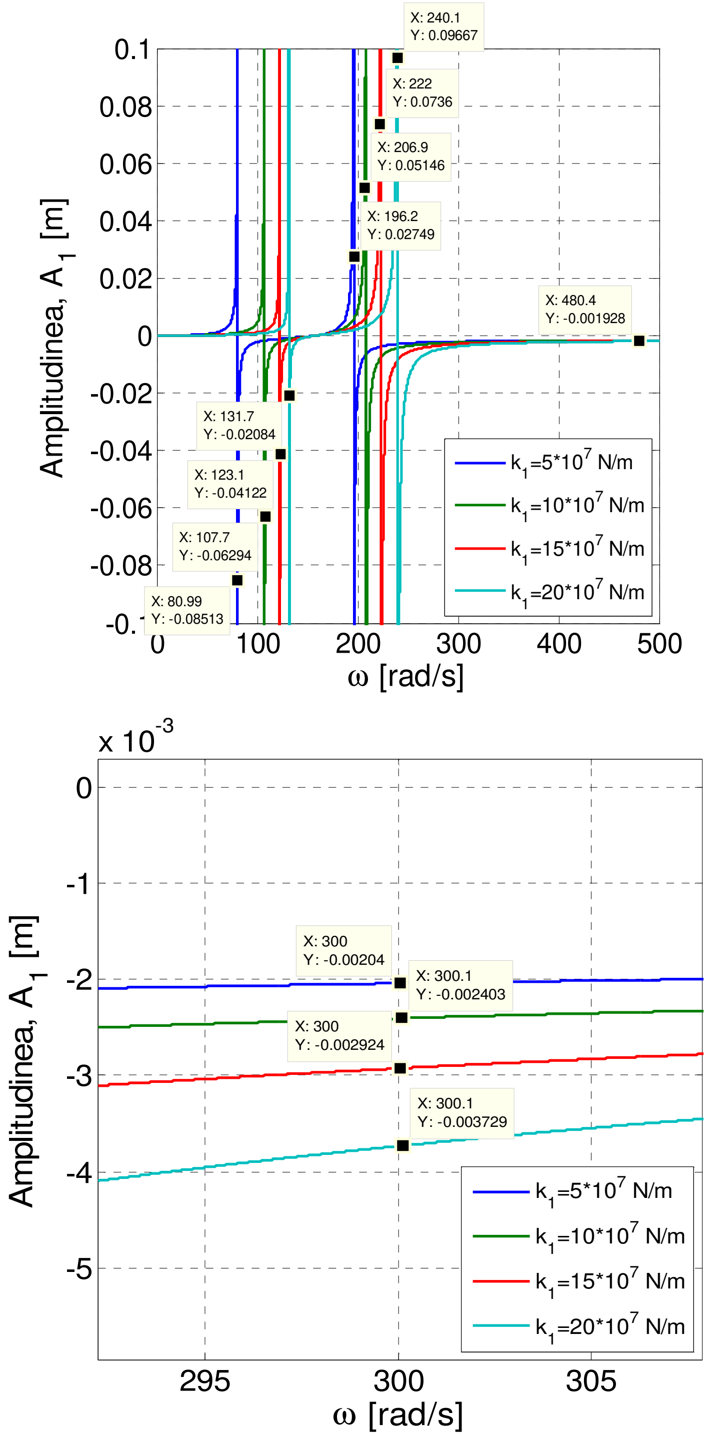

Fig.3. Variation curve of amplitude A_1 depending on the continuous variation of ω and the discrete variation of k_1

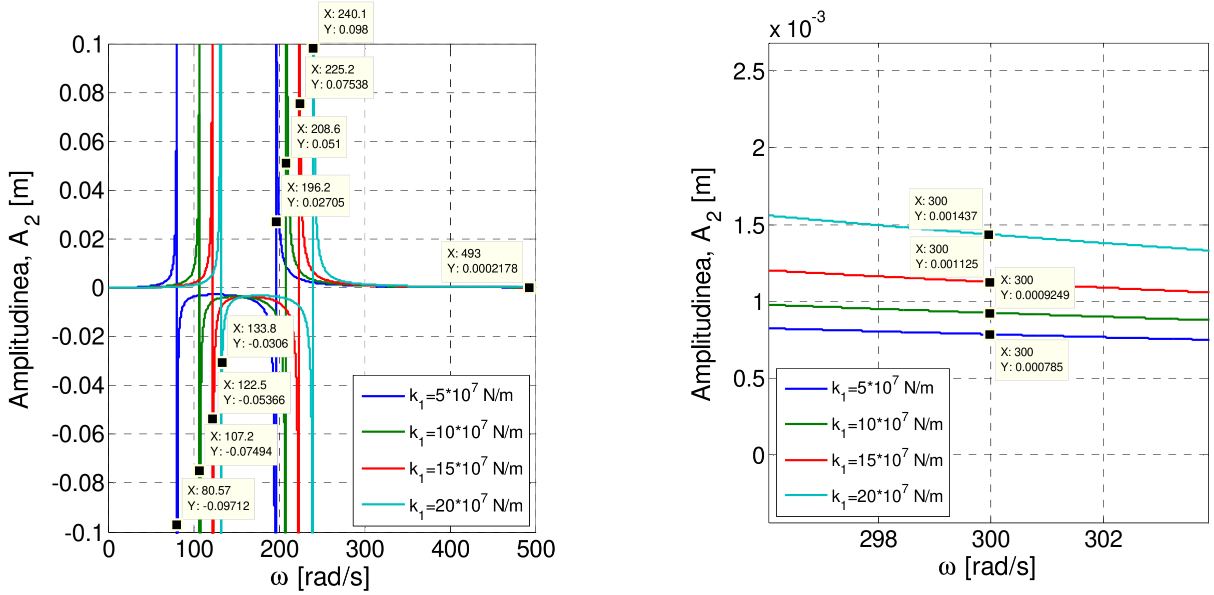

Fig.4. Variation curve of amplitude A_2 depending on the continuous variation of ω and the discrete variation of k_1

5. CONCLUSIONS

Compared to the ones presented above, the following conclusions can be summarized:

a) for the calculation model established (fig. 2) for a single cylinder vibrating compactor, the curves of variation of amplitudes A_1 and A_2 were drawn depending on the continuous variation of ω (0…500 rad/s) and the discrete variation of k_1 (5; 10; 20; 25)10^7N/m.

b) at ω = 300 rad/s the technological amplitude A_1 is kept constant for each discrete value of k_1 because the post-resonance area is stable which gives the guarantee of a uniform and constant technological process.

The parametric values of the paper were established based on the in situ experiments.

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REGIMURI DINAMICE OPTIME ALE ECHIPAMENTELOR DE COMPACTARE PRIN VIBRARE

REZUMAT. Lucrarea tratează dinamica compactoarelor vibratoare pentru lucrări de drumuri. Astfel, modelul dinamic adoptat asigură cu fidelitate comportamentul echipamentului vibrator în procesul de lucru. Pentru aceasta au fost ridicate caracteristicile amplitudinilor de lucru ale rulourilor compactoare într-un interval de frecvenţă poziţionate după ultima rezonanţă a maşinii. Rezultatele experimentale in-situ au fost relevante pentru evaluarea comportării dinamice a rulourilor vibratoare modelate în prezenta lucrare.

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