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ESTABLISHING THE SIGNIFICANT PARAMETERS FOR APPRECIATING THE SEVERITY OF TRANSMITTED VIBRATION TO BUILDINGS

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***Abstract**: It is already known that vibration and shock can cause harmful effects on people, equipment, machinery, installations and buildings of any kind, from unpleasant to dangerous (which may destroy, damage). What is passed after the occurrence of vibration and shock, it can be measured and appreciated if you can identify a number of characteristic parameters.*
Through this study, the author seeks to establish, as accurately, the main parameters which must be considered when is desired the assessing of the severity of vibration transmitted to the buildings. It will be analyzed cinematic usual sizes (displacement, velocity and acceleration), the temporal size (frequency, respectively pulsation or period) and criteria for assessing the effects of vibration (efficient velocity, intensity of the vibration, the perception degree of vibration).
***Keywords**: vibration severity in structures, transmitted vibration to building*

1. INTRODUCTION

Sizes that can be determined when measuring mechanical vibrations are displacements, velocities, accelerations, frequency, phases and deformations. For the essential sizes can be measured instantaneous values, values of the amplitudes, maximum values or limits average values.
Free vibrations of an elastic system is the dynamic response given by a system as arising from a brief initial actions (impulse, shock). This answer is given after the disappearance of the action, provided that the system be removed from the repose [1].
A mechanical system parameters, being in a state of equilibrium - motion or rest - (but no situations to change his status and to modify parameters) will be considered reference parameters.
Generally, the vibrations are completely defined at the time when are known:
- The vibration source (where dynamic force is generated);
- Path propagation (how energy is transmitted);
- Vibration receptors (how much noise or vibration can be tolerated).

Determining the severity of vibration in buildings and establish a connection between it and the visible effects on the structure involves the comparing of the cinematic sizes and the temporal magnitude with their reference values.
Depending on the severity of vibration can highlight the following categories of vibration [2]:
- Vibrations that are not perceived by occupants;
- Vibrations are perceived, but does not affect normal comfort of occupants
- Vibrations affecting comfort and normal use of the building
- Vibration of which severity can lead to damage the health of occupants.

2. THE SIGNIFICANT PARAMETERS FOR APPRECIATING THE SEVERITY OF TRANSMITTED VIBRATION TO BUILDINGS

Vibrations transmitted to buildings can be caused by the following causes: explosions in quarries, earthquakes, wind action, the movement of vehicles, machinery operation, dynamic actions of equipment incorporated (embedded) in construction. [1]
According to duration, registered vibrations in buildings are divided into two main groups:

- transitory vibration, which are depreciated quickly after having peaked, like the vibration of a heavy object falling;
- Continuous or intermittent vibration occurs continuously over a long period or by periods that are separated does not occur, such as vibrations caused by moving groups of people.

For more objective assessment of the effects of vibration transmitted to the buildings and people, and for establishing admissible limits were formulated concepts and were adopted criteria for quantitative evaluation of vibration.

2.1. Magnitudes used in the vibration study. Definitions and relations

Vibration severity is defined as a simple and comprehensive magnitude and it is used to describe the state of vibration of machinery, buildings or people. It is used as a basis for classification and, based on theoretical considerations and practical experience, the root mean square value of vibration velocity was chosen as a unit of measurement for indicating the severity of vibration. The term "Vibration Severity" is a generic term that designates a value such as a maximum, medium or another significant numerical value descriptive of a vibration. Thus, the severity of the vibration of a car is defined as the maximum effective value of the vibration velocity measured at the significant point of a machine, such as a bearing point of the installation. The severity of transmitted vibration to buildings is called the level of strength.

In order to assess the severity of vibration it can determine the following magnitudes:

a) own pulsations - used in the interpretation of a resonance threat
b) vibration amplitudes (displacement, expressed in µm; vibration velocity in mm/s; the acceleration expressed in m/s^2) - used in the interpretation of the effect on the environment or oscillating system.

To express the strength (severity) S based on kinematic parameters x, v and a shall be established corresponding reference values [1].

$$Z_0 = \frac{a_0^2}{f_0} \tag{2.1.1}$$

- the reference value for the maximum displacement (amplitude displacement) is x_0 and is determined based on the relation:

$$x_0 = \frac{v_0}{2\pi f_0} \tag{2.1.2}$$

- the reference value for the maximum velocity (amplitude velocity) is v_0 and is determined based on the relation:

$$v_0 = 2\pi f_0 \, x_0 \tag{2.1.3}$$

- the reference value for the maximum acceleration (amplitude acceleration) is a_0 and is determined based on the relation:

$$a_0 = 4\pi^2 f_0^2 \, x_0 \tag{2.1.4}$$

where:
$Z_0 = 0{,}1$ cm^2/s^3
$f_0 = 1$ Hz
$x_0 = 0{,}008$ cm
$v_0 = 0{,}05$ cm/s
$a_0 = 0{,}316$ cm/s^2

Table 2.1.1: Magnitudes used in the vibration study

Magnitude type	Designation / notation	Measuring unit	Formula	Observations
Common cinematic sizes	Displacement (amplitude) / x_0	µm	$x = x_0 \cdot \sin(\omega t + \varphi)$ $x_0 = \frac{v_0}{\omega}$ [illegible]	x – the elongation at a certain moment x_0 - amplitude φ – phase at time origin Z – intensity Z_0 – the reference intensity S^x, S^v, S^a – severity based on kinematic parameters x, v and a
	Velocity / v_0	mm/s	[illegible]	
	Acceleration / a_0	m/s^2	[illegible]	
Temporal sizes	Frequency / [illegible]	Hz	$\nu = \frac{1}{T} =$ [illegible]	
	Pulsation / [illegible]	rad/s	$\omega = \frac{2\pi}{T} = 2\pi f$	
	Period / T	s	$T = \frac{2\pi}{\omega} = \frac{1}{f}$	

Appreciative magnitudes		cm^2/s^3	$Z = \frac{a_0^2}{f} = 16\pi^4 x_0 f^3$	v_0 velocity amplitude
	Intensity level (strength level - severity) / Z or S	vibrar	$S = 10\lg\frac{Z}{Z_0}$ $S^x = 20\lg\frac{x}{x_0} + 30\lg f$ $S^v = 20\lg\frac{v}{v_0} + 10\lg f$ $S^a = 20\lg\frac{a}{a_0} - 10\lg f$	
	Efficient velocity / v_{ef}	mm/s	$v_{ef} = \sqrt{\frac{1}{T}\int_0^T v^2(t)dt}$ $v_{ef} = v_0/\sqrt{2}$	
	The degree of perception / P	Pal	$P = 10\lg\frac{Z}{Z_0}$	

2.2. Values of magnitudes which characterize the vibrations

Parameters of the vibration transmitted to the natural and built environment, established according the rules, constitutes the objective basis for assessing the level of vibration and impacts of the degradation, damage or comfort in buildings.

Table 2.2.1: Ranges of structural response for various sources [15]

Vibration source	Frequency range Hz	Amplitude range μm	Velocity range mm/s	Acceleration range m/s^2
Traffic road, rail, ground-borne	1 to 100	1 to 200	0,2 to 50	0,02 to 1
Blasting vibration ground-borne	1 to 300	100 to 2500	0,2 to 100	0,02 to 50
Air over pressure	1 to 40	1 to 30	0,2 to 3	0,02 to 0,5
Pile driving ground-borne	1 to 100	10 to 50	0,2 to 100	0,02 to 2
Machinery outside ground-borne	1 to 100	10 to 1000	0,2 to 100	0,02 to 1
Machinery inside	1 to 300	1 to 100	0,2 to 30	0,02 to 1
Human activities inside	0,1 to 30	5 to 500	0,2 to 20	0,02 to 0,2
Earthquakes	0,1 to 30	10 to 10^5	0,2 to 400	0,02 to 20
Wind	0,1 to 10	10 to 10^5	-	-
Acoustic (inside)	5 to 500	-	-	-

Table 2.2.2: Trepidations classification according to their effect on buildings [5]

The intensity of the trepidations (Vibratings)	**The category of the trepidations**	**The effect on building**
10 – 20	Low trepidations	Not dangerous
20 – 30	Medium trepidations	Not dangerous
30 – 40	Strong trepidations	Slight deterioration, cracks in walls
40 – 50	Heavy trepidations	Cracks in the main walls
50 - 60	Heaviest trepidations	The destruction of buildings

Tabel 2.2.3: Admissible vibration limits indoors [3]

Room destination	**The admissible amplitude of the displacement**
Laboratories with precision machinery	10...30
Workshops with precision machines	20...40

Steam turbine power plants	20
Foundries	30...50
Offices and homes	50...70

3. CONCLUSION

To display the spectrum of vibration is preferable to choose the parameter with the uniform level of the entire frequency range considered.

It can be concluded that expression of vibration in terms of displacement is more suitable low frequencies, while expressing in terms of acceleration is better suited for high frequencies. At the vibrations with frequency higher than 15 Hz and amplitudes up to 0.02 mm, speed vibration has a decisive effect.

Exceeding the admissible level of vibration as intensity and duration of exposure causes organic perturbations with physiological and psychosensorial effect.

Curves of human perception are shown in figure 3.1 based on the relation between amplitude and frequency.

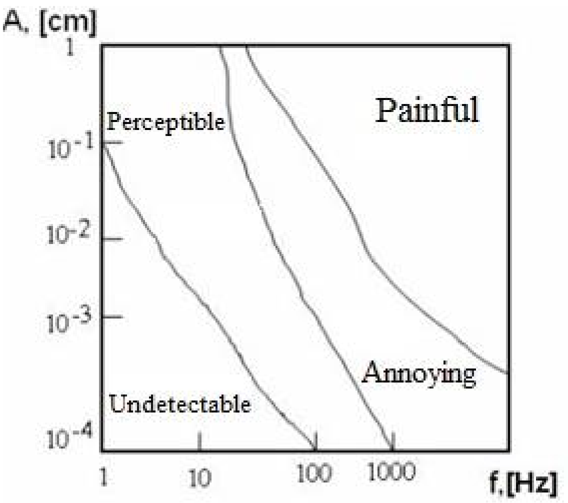

Figure 3.1: Perception effect

Experience has shown that the overall RMS value of vibration velocity measured over the range 10 to 1000 Hz gives the best indication of a vibration's severity.

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