ANNALS of the ORADEA UNIVERSITY.

Fascicle of Management and Technological Engineering

THE INFLUENCE OF VIBRATIONS AGAINST BUILDINGS

Eugenia SECARA
Transilvania University of Brasov

Abstract

The paper presents the influence of vibrations against buildings. Depending on vibrations speed, acceleration and frequency, their effects against buildings are different. These effects start by producing small cracks and finish by destroying the building. The paper presents both the formulae used to calculate the level of vibrations and the diagrams showing security of buildings subject to shocks and vibrations.

1. CHARACTERISTICS OF VIBRATIONS

The vibrations generated by motor vehicles and industrial equipments are transmitted to the structure of buildings. The specialty literature evaluates vibrations using the kinematics variables: moving, speed, acceleration and frequency. In order to determine the admissible limits of vibrations we define the variables which help us measure the vibrations.

The intensity of vibrations (according to Zeller):

$$Z = \frac{a_0^2}{f} = 16p^4 \cdot x_0^2 \cdot f^3 \quad (\mathrm{cm}^2/s^3) \tag{1}$$

where: a_0 represents the amplitude of acceleration

f represents the frequency

x_0 represents the amplitude of moving within a harmonical vibration

The vibrations intensity level is calculated using the formula:

$$S = 10\lg\frac{Z}{Z_0} \tag{2}$$

where Z_0 is the reference value.

S is determined using a measure unit named “vibrar”.

The intensity level can also be determined using the three kinematics variables:

$$S_x = 20\lg\frac{x}{x_0} \; ; \; S_v = 20\lg\frac{v}{v_0} \; ; \; S_a = 20\lg\frac{a}{a_0} \tag{3}$$

where: x, v, a represent the amplitudes of kinematics variables

x_0, v_0, a_0 are chosen reference values so that f = 1 Hz.

Using formula 2 we can define the vibrations level perceived by the human body:

$$P = 10\lg\frac{Z}{Z_1} \qquad [\mathrm{Pal}] \tag{4}$$

where: Z_1=0,5 [cm^2/s^2].

Replacing Z_1 within formula (4) we will have:

$$P = 10\lg 2Z \qquad \text{[Pal]} \tag{5}$$

Depending both on speed and moving the level of vibration is:

$$P = 20\lg 22{,}4 \cdot v_0 \tag{6}$$

and

$$P = 20\lg 140 x_0 f \tag{7}$$

2. THE EFECTS OF VIBRATIONS AGAINST BUILDINGS

The rigorous behavior of buildings facing vibrations, which is due both to the diversity of their shapes and the resistance structures, generates difficulties while establishing adequate analysis criteria.

The possibilities of buildings deterioration depend on the amplitude of vibrations speed and are presented in the table below:

Table no. 1

Crt. No.	Vibration speed (cm/s)	Building deterioration
1	0,5	Very little
2	1,0	Important
3	5,0	Likely
4	10,0	Very likely

Figures no. 1 and no. 2 present the effects of vibrations against buildings; the vibrations are characterized by different speed or different moving, for frequencies ranged up to 100 Hz.

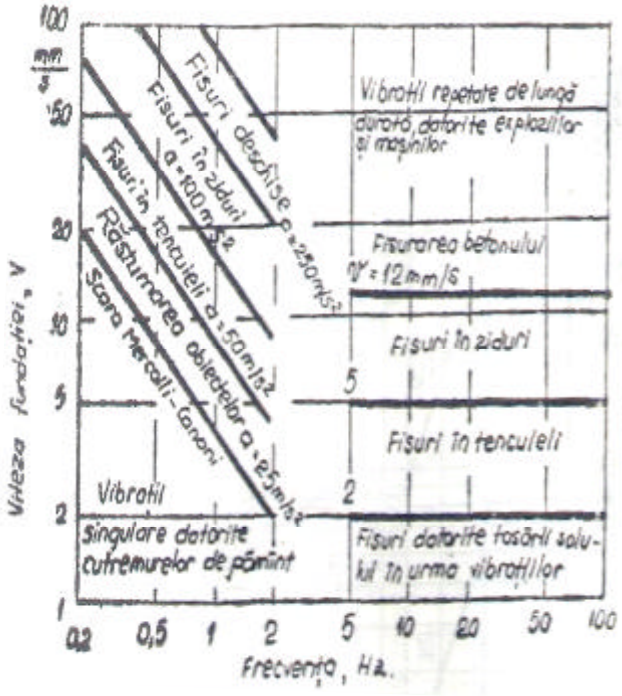

Figure no. 1
The influence of vibrations speed against buildings

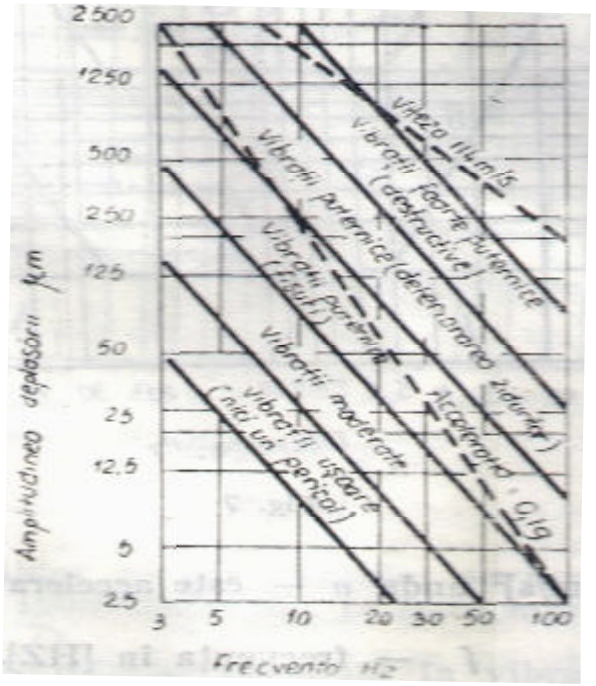

Figure no. 2
The influence of vibrations amplitude against buildings

There are many situations when the admissible vibrations limits are important to be known, such as the vibrations produced by explosions nearby the buildings. Crandal determined this limit as:

$$\frac{a^2}{f^2} = 0{,}28 \text{ (m/s}^2\text{)}$$

where: *a* represents the acceleration measured in (m/s^2)
f represents the the frequency measured in Hz

Edwards and Northwood consider that the limit is reached when the speed measures 11,5 (cm/s).

The effects of vibrations against buildings can be explained by calculating their intensity using measurements. Table no. 2 classifies vibrations according to their effects.

Table no. 2

Crt. no.	Vibrations intensity level ("vibrar")	Vibrations class	Effects against buildings
1	10 – 20	Slight vibrations	No danger
2	20 – 30	Medium vibrations	No danger
3	30 – 40	Strong vibrations	Slight deteriorations, cracks in the walls
4	40 – 50	Hard vibrations	Clefts in the relieving walls
5	50 – 60	Very hard vibrations	Buildings breakdown

As well the speed of the vibrations can show their effects against buildings.

Table no. 3

Quake intensity Mercalli-Cancani	Ground oscillation speed (cm/s)	Effects against buildings
1	0,2	Not perceived
2	0,2 – 0,4	Perceived by few people inside the buildings, especially by those living at top floors
3	0,4 – 0,8	Perceived by some people inside the buildings
4	0,8 – 1,5	Perceived by the majority of people inside the buildings Perceived by few people outside the buildings
5	1,5 – 3,0	Perceived by all people inside the buildings Perceived by the majority of people outside the buildings
6	3,0 – 6,0	Perceived by all people Slight damage caused to weak buildings
7	6,0 – 12,0	Slight damage caused to lasting buildings

		Considerable damage caused to weak buildings
8	12,0 – 24,0	Slight damage caused to anti-quake designed buildings Big damage caused to regular buildings
9	24,0 – 28,0	Considerable damage
10-12	48,0	Majority of buildings are completely destroyed

Figures no. 3 and no. 4 present the diagrams concerning the security of buildings subject to shocks and vibrations.

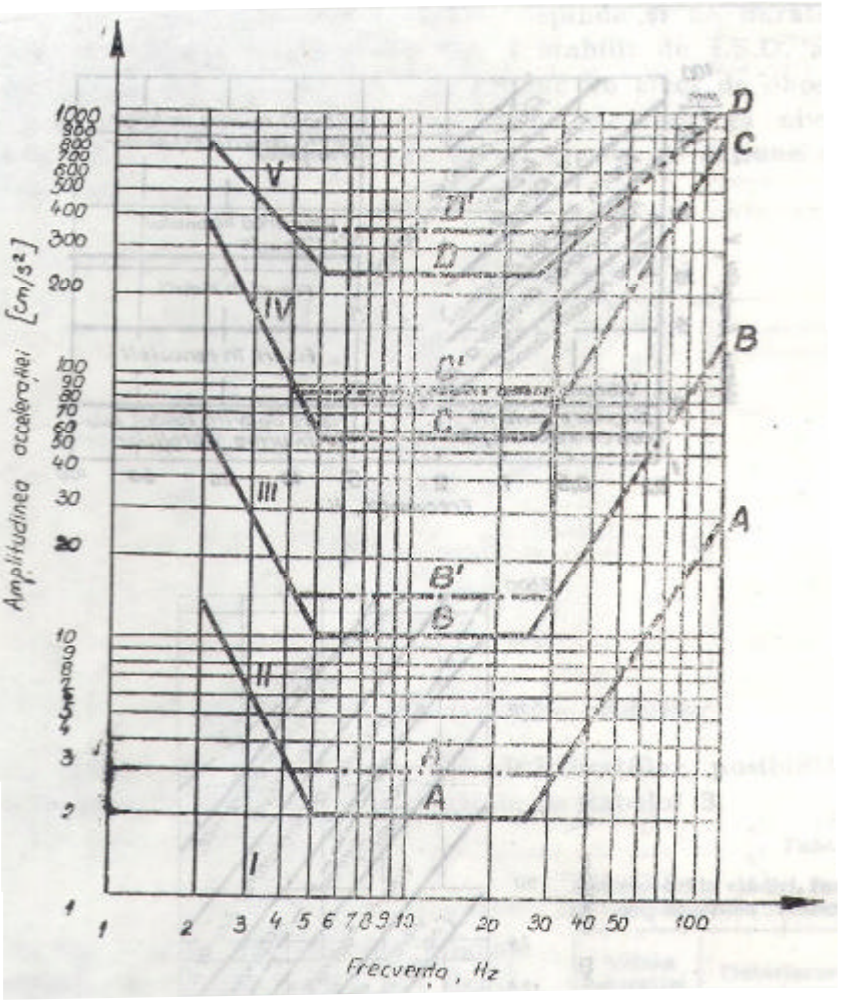

Figure no. 3
The effect of acceleration against buildings having a height/width ratio h/b = 1

Figure no. 3 refers to buildings characterized by a height/width ratio h/b = 1. Figure no. 4 refers to buildings characterized by a height/width ratio h/b = 2.

Within these figures, lines A-D correspond to certain accelerations:

A – buildings sensitivity threshold, underneath there is no danger;

B – buildings rigidity threshold, underneath which no important damage appears;

C – breakdown limit for some elements of the buildings. Over that limit appears the risk of serious damage;

D – buildings stability limit, over which the buildings are destroyed.

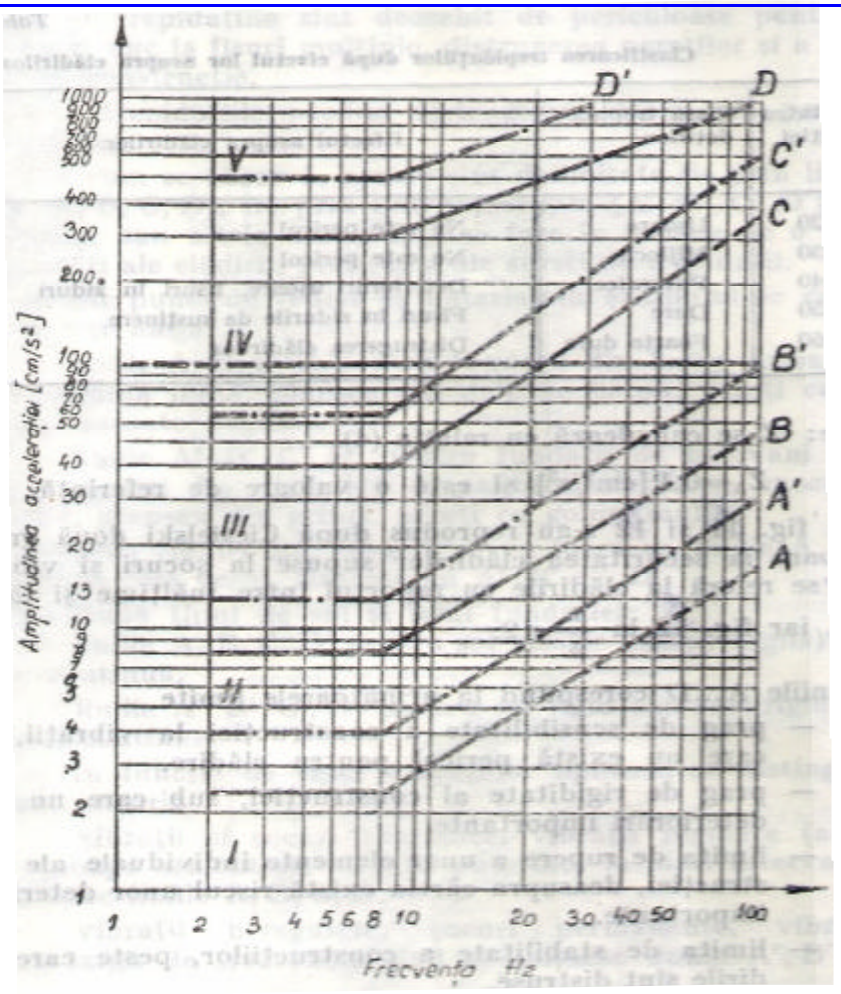

Figure no. 4
The effect of acceleration against buildings having a height/width ratio h/b = 2

There are certain zones underlined in the diagrams and they can be explained as it follows:

I – the vibrations do not influence the constructions;

II – the vibrations are perceived, but they are harmless. Very frequent reiteration of those vibrations makes the buildings grow old;

III – the vibrations deteriorate the buildings and produce cracks in walls and other constructive elements;

IV – the vibrations are very dangerous and they determine multiple cracks, they destroy walls and other constructive elements;

V – the vibrations produce total or partial building destruction.

Within figures no. 4 and no. 5, zones are marked either using continuous lines (A, B, C, D) or using interrupted lines (A', B', C', D'). Depending both on several properties of the buildings and on vibration source characteristics it is chosen the type of line:

a) regarding the material and the type of construction it will be chosen:

- lines A, B, C, D for reinforced concrete foundations, brick walls, concrete tile floors, walls with few blisters disposed regularly;

- lines A', B', C', D' for bricks or stones foundations, low quality brick walls, low quality execution, beam floors, walls with many blisters;

For new and intact buildings there will be used lines A, B, C, D; for old and cracked buildings there will be used lines A', B', C', D'.

b) Depending on the type of ground as well as on the type of foundation the limit values will be chosen as follows:

- lines A, B, C, D for elastic ground (sand, clay) and continuous foundations;
- lines A', B', C', D' for rigid or half rigid ground and for discontinuous foundations.

c) Depending on the type of applied vibrations there are different situations:

- lines A, B, C, D in the case of: rare vibrations and shocks, harmonical vibrations, strong vibrations occurred after long periods in time;
- lines A', B', C', D' in the case of: irregular vibrations, permanent shocks, wide frequency range vibrations.

Bibliografy

1. Cieselski, R., "Ocena sz kodliwosci wplywow dynamicznych w budownicwie", Arkady, Warsawa, 1973
2. Darabont A., "Masurarea zgomotului si vibratiilor în tehnica", Editura Tehnica, Bucuresti
3. Randall, R. B., "Application of Bruel & Kjaer equipment to frequency analysis"