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Structural and Physical Aspects of Construction Engineering

Experimental and Sensitivity Analysis of the Vibration Impact to the Human Comfort

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Abstract

This paper presents the problem of the vibration analysis of the high building structures and the human comfort in the point view of the national standard, ISO standard and Eurocode requirements. There are presented the results from the experimental measurement of the observed vibration in the administrative building in Bratislava. The plate vibrations of building were look on in the point view of human comfort in accordance with STN ISO 2631. The sensitivity analysis of the influence of the structural model and dynamic load uncertainties give us the effective tools to the optimal design process. The numerical simulations of the vibrations were realized with software ANSYS.

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Keywords: Seismicity; Safety; Sensitivity; Experimental test; Simulation; FEM; ANSYS

1. Introduction

The seismic load impacts to the building structures and technology as well as to the human comfort [1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 14, 16, 17, 24 - 27]. These influences on the building structures is designed in accordance with the standards STN 73 0032 [20], STN 73 0032 [21] and STN EN 1998-1-1 [22]. The requirements for the human comfort are described in the standard STN ISO 2631-1, 2 [19]. The building structure design under the vibration of the machines is required in the two levels of the limit state loading in concern with the requirements of the Eurocodes [22]. In the case of the real structures the negative vibration effects from the environments to the building structures and human health is verified experimentally [1, 2, 3, 4, 8, 11, 12, 16, 17, 18, 24 - 27].

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The design tasks are defined as follow:

- I. level – Ultimate limit state – there shall be verified where they are relevant: the loss of equilibrium of the structure or any part of it, considered as a rigid body; the failure by excessive deformation, transformation of the structure or any part of it into a mechanism, rupture, loss of stability of the structure or any part of it, including supports and foundations; the failure caused by fatigue or other time-dependent effects,
- II. level - Serviceable limit state – there shall be verified the serviceability of the structure from the point of view of the limit deformations and vibrations or the cause damage to finishes or non-structural members.

The Eurocode require three base type of the design

- Influence of the vibration on the building structures
- Influence of the vibration on the human comfort and the operation (mechanical, acoustic, optical)
- Influence of the vibration on the technological process (investor requirements).

The building structures have been designed using the strength criterions for the forces and moments, or stresses and the deformation criterions using the displacement, velocity or acceleration amplitudes of the vibration.

In the case of the strength criterions it's necessary to consider the influences of the cyclic loading to the degradation of the material strength. For example the strength of the concrete is reduced by factor κ_b, which depends on the maximum and minimum stress in the form

$$\rho_b = \frac{\sigma_{b,\min}}{\sigma_{b,\max}} \tag{1}$$

Factor κ_b has the values in the interval from 0.75 (for $\rho_b \leq 0.1$) to 1.00 (for $\rho_b \geq 0.6$).

Tab.1. Limit values of the machine vibration by STN 73 0032 [21].

Sensitivity class of the machine	Sensitivity class characteristic	Limit values	
		Acceleration for frequency up to 10Hz [mm.s^{-2}]	Velocity for frequency over 10Hz [mm.s^{-1}]
I	High	6.3	0.1
II	Medium	63.0	1.0
III	Low	250.0	4.0
IV	None	>250.0	>4.0

2. Vibration massiveness

The influences of the vibration on the structures and humans have been considered using the vibration massiveness by the requirements of the actual standards [21 and 22]. The machines and structures are sort out in the sensitivity classes in compliance with the vibration massiveness.

The class of the machine vibration massiveness depends on the dimension and mass of the oscillated corps, boundary conditions, machine parameters and its utilizations.

The vibration massiveness of the machine is considered using the effective value of the vibration velocity in the frequency interval 10 to 1000Hz

$$v_{ef} = \sqrt{\frac{1}{T}\int_0^T v^2(t).dt} \tag{2}$$

where $v(t)$ is the prompt value of the velocity during the period T.