SEISMIC VIBRATION OF THE MULTISTORIED STRUCTURES WITH THE STIFF CORE

Emília Juhásová [I]

Optimalization of building structures, the purpose of effective using of the bearing structural elements are problems, which can be said are in the middle of the interest of the structural engineering. It is well known that at the choosing of the bearing structural system the architectural requests must be taken into account and in this way the choice of the bearing system of the structure need not be always optimal. Let us consider a structural system of the tall building as a stiff core combined with the steel or reinforced concrete skeleton. The stiff core is assumed to retain horizontal load and the effect of horizontal loading on columns is supposed to be negligible. When symmetrical structural systems are considered, it is possible to agree with such assumtion. At the asymmetrical disposition of the vertical structural elements there arises a problem of the effect of the torsional overloading of those vertical structural elements, which are situated at larger distance from the centre of the rigidity of the structure.

From the results of the experimental investigation on full scale structures with the stiff core only a small difference between torsional and transversal natural frequencies is evident /Table 1./. Considering sets of structural disposition solutions at which the request of the same betrieb of bearing materials and the request of constant eccentricity are fulfilled we can obtain set of curves expressing for different eccentricities the dependence between torsional and transversal natural frequencies of the one mass asymmetrical systems /Fig. 1./. At the harmonic seismic motion loading expressive differencies between relative displacements of the symmetrical system and the asymmetrical one can be obtained. It is namely the frequency shift of the maximal responses, decrease of the resonant amplitude of the central bearing elements and increasing of the displacements of the edge vertical bearing elements /Fig.2./. The maximal resonance strains of different vertical elements of the symmetrical and asymmetrical steel models in dependence from the amplitude of the shaking table B_o are plotted in figure 3. From these experimental results follows that at the symmetrical model in the first order the bearing capacity of the stiffer central elements is exhausted. At the asymmetrical system the strains of the edge weaker elements are increasing and the strains of the central bearing elements are decreasing. For this reason the bearing capacity of the stiffer central elements cannot be fully utilised.

Building structures with the stiff core are usually characterised by the remarkable differencies between dimensions of the bearing vertical elements in different stories. Thickness of vertical elements is larger in lower stories and smaller in upper stories. Consequently it is convinient to prefere discrete dynamic theoretical computation model to continuous one and the consideration of the shear deformation component must be taken into account at the computation of the stiffness matrix. The shear deformations have significant effect on the values of higher natural frequencies of the structure. In the direction of the tranversal frames it is suitable to account the interaction of the frames and the stiff core including only the effect of the axial forces in frame columns. Comparing of the computed values of the natural frequencies to the measured ones is shown in table 2.

4-storied steel model was tested on the vibration shaking table with the harmonic seismic motion. The core of the model was of the asymmetrical [- shape, the edge columns were of the round section. After excitation of the model by the shaking table After excitation of the model by the shaking table the overloading of the edge round columns was evident /Fig.4./. When the amplitude of the shaking table B_o=1 mm, the failure of the round edge elements became by the crack of the most strained sections. The columns situated at the larger distances from the centre of the rigidity /tensometer T_1/ have the largest strains ε and their failure occurs immediately after a few cycles of loading.

It can be concluded from the presented results that the strains of the central stiff core which was proposed for retaining to the horizontal forces are due to asymmetrical disposition negligible comparing to the strains of the edge columns. The same effect was appeared like at the torsional resonancy and also at the transversal resonancy. In both cases excited torsional movement is anfavourable in the first order for the edge bearing elements. Neglection of their torsional loading leads to the underestimation of their actual seismic stresses.

I Scientific research worker, Candidate of Technical Sciences, Institute of Construction and Architecture of the Slovak Academy of Sciences, 885 46 Bratislava, Czechoslovakia

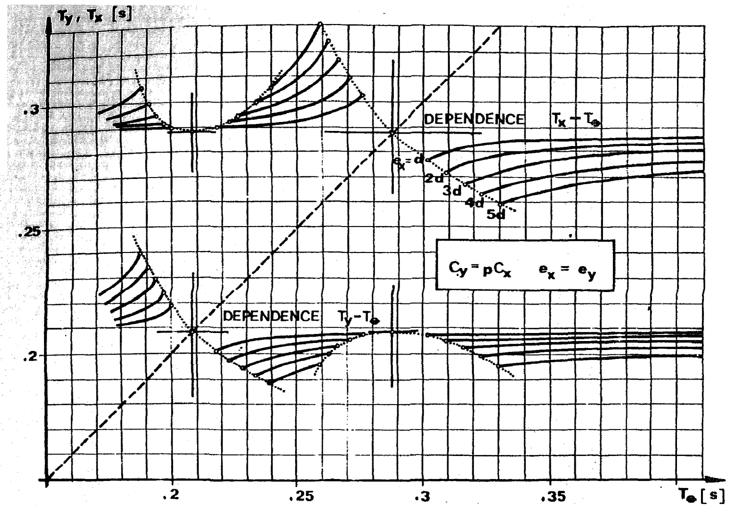

Figure 1.

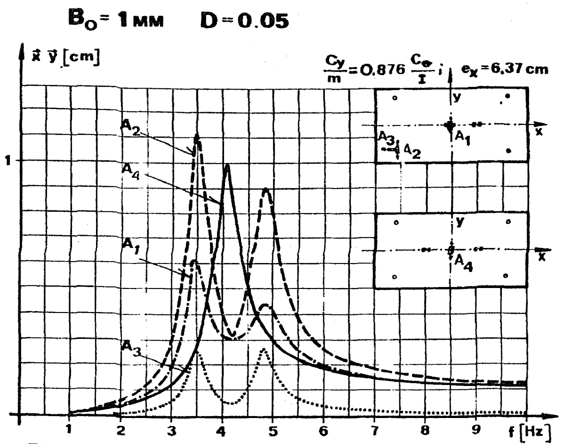

Figure 2.

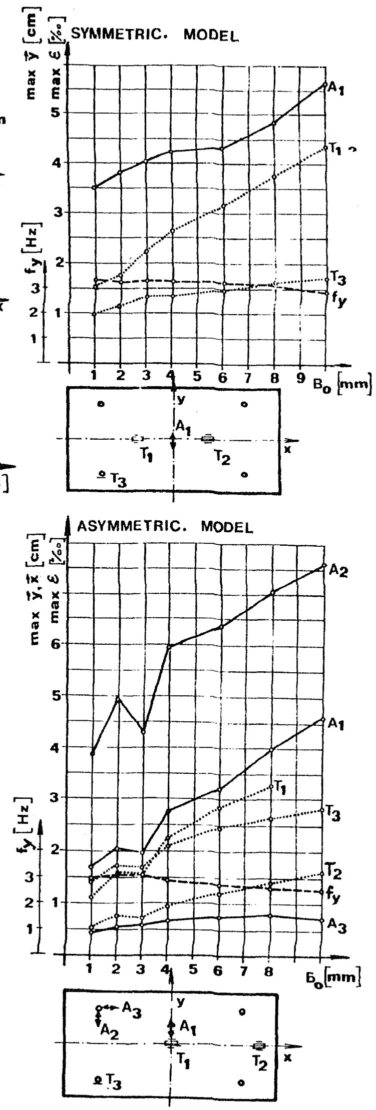

Figure 3.

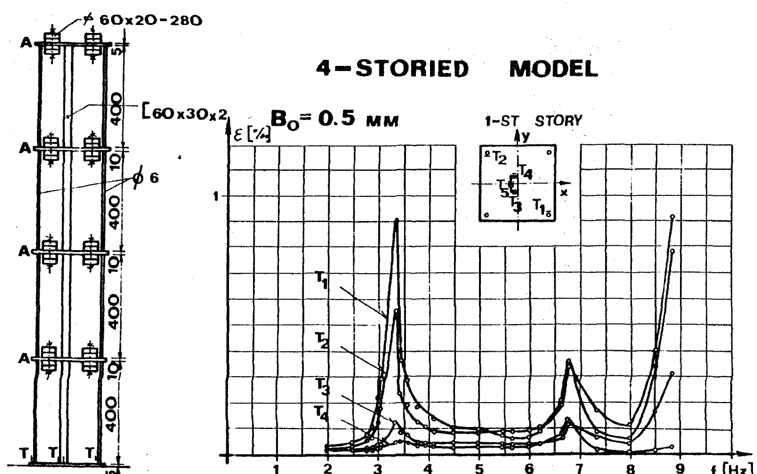

Figure 4.

Table 1.

Measured periods of buildings with the stiff core [sec]			
Nb. st.	T_{1x}	T_{1y}	$T_{1\theta}$
14	0.646	0.755	0.588
13	0.667	0.760	0.548
15	1.440	1.410	1.450
16	0.730	0.862	0.818

Table 2.

Theoretical and experimental natural frequency [Hz]				
Mode cons dered	f_{1x}	f_{2x}	f_{1y}	f_{2y}
bending only	2.25	12.35	1.08	5.78
bending+shear	1.71	5.75	0.96	3.76
experiment	1.50	5.21	1.32	4.81