Faculty of Civil and Environmental Engineering
Institute of Structural Engineering

Dynamics

Project exercise No. 3

Name and surname ....
Group ....
Academic year ……………………………………
Final grade ....

Date	Remarks	Signature

Vibration of frame excited by seismic forces

Conduct the dynamic analysis of chosen frame show on page 4. The frame is subjected to forces induced by the seismic or paraseismic shock. In particular you are asked to do the following:

1. calculate the natural frequencies and modes of vibration of frame without dampers;
2. using the response spectrum calculate the peak values of all displacements and chosen internal forces for frame without dampers;
3. calculate natural frequencies and nondimensional damping ratios of frame with and without dampers,
4. for a given ground accelerations function solve equations of motion using the time integration method and determine for frame with and without dampers:
   - peak values of all displacements and accelerations,
   - peak values of chosen internal forces for frame,
   - peak values of dampers forces,
5. calculate the function of dissipation energy of damper in a range of natural frequencies of vibration of the frame;
6. show results of calculation on appropriate figures.

Calculation data

Type of material: ……………………………………………………………………………..

The height of storey: ……………………………………………………………………………

The cross-section of columns ……………………………………………………………….

The cross-section of beams ………………………………………………………………….

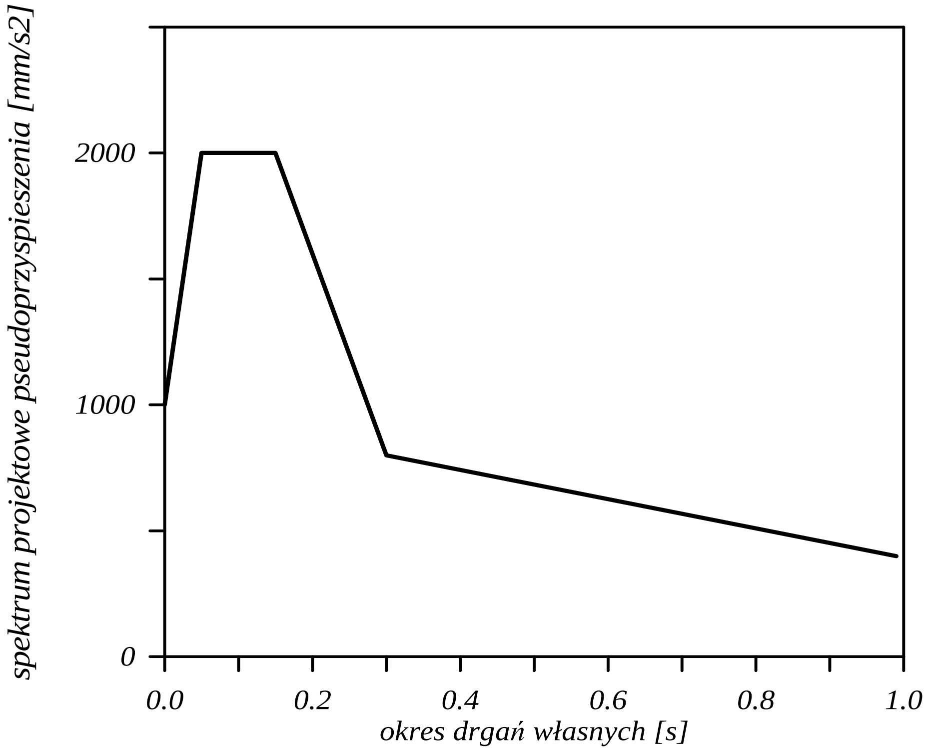
The unit mass of storey ……………………………………………………………………….

A number of floors …...………………………………………………………………………..

The dimensionless modal damping ratio of the first mode of vibration ……………….

The dimensionless modal damping ratio of the second mode of vibration …………..

The design acceleration spectrum is presented below. This spectrum is valid for all dimensionless modal damping ratios



$$S_a[mm/s^2] = \begin{cases} 20\,000T + 1000 & \text{for} \quad 0{,}00 \le T \le 0{,}05\ s \\ 2000 & \text{for} \quad 0{,}05 < T \le 0{,}15\ s \\ -8000T + 3200 & \text{for} \quad 0{,}15 < T \le 0{,}30\ s \\ (-4000T + 6800)/7 & \text{for} \quad 0{,}30 < T \le 1{,}00\ s \end{cases}$$

Calculating data for dampers

Values of stiffness factor of springs k_0 and k_1 and values of damping factors of dashpot c_0 and c_1 appearing in a model of damper must be calculated from the following formulae:

$$c_0 = \alpha_1 \sqrt{m_k k_k} \ , \qquad c_1 = \alpha_3 \sqrt{m_k k_k} \ , \qquad k_0 = \alpha_2 k_k \, , \qquad k_1 = \alpha_4 k_k \ ,$$

where m_k is the mass of storey with damper, k_k is the stiffness of storey with damper, and values of factors α_1, α_2, α_3 and α_4 are given in table 1.

Table1 Values of factors α_i

Model of damper	α_1	α_2	α_3	α_4
Viscous	0,30	0,0	–	–
	0,40	0,0	–	–
	0,60	0,0	–	–
	0,80	0,0	–	–
	1,00	0,0	–	–
Kelvin	0,30	0,40	–	–
	0,40	0,60	–	–
	0,60	1,00	–	–
	0,80	1,20	–	–
	1,00	1,40	–	–
Maxwell	0,0	0,0	0,30	0,40
	0,0	0,0	0,40	0,60
	0,0	0,0	0,60	1,00
	0,0	0,0	0,80	1,20
	0,0	0,0	1,00	1,40
Complex	0,30	0,40	0,30	0,20
	0,40	0,60	0,40	0,30
	0,60	1,00	0,60	0,35
	0,80	1,20	0,80	0,40
	1,00	1,40	0,90	0,50

The energy E_d dissipated by damper executing harmonic vibrations with the excitation frequency λ and amplitude x_0 can be determined from the following formulae:

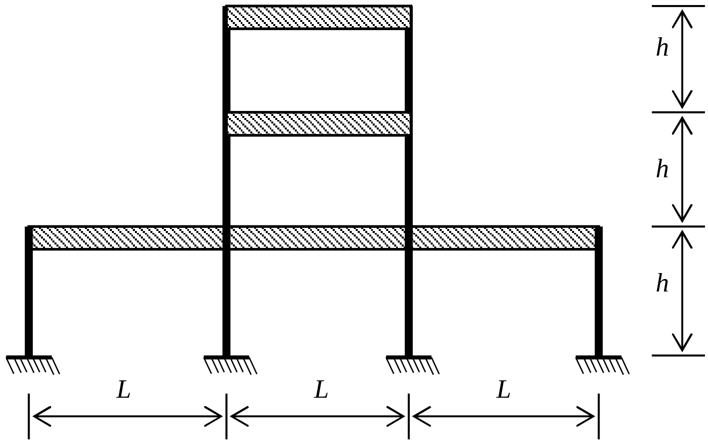
- the viscous model and the Kelvin model $\quad E_d = \pi \lambda c_0 x_0^2$,

- the Maxwell model $\quad E_d = \pi \lambda c_1 x_0^2 / (1 + \tau^2 \lambda^2)$, $\quad \tau = c_1 / k_1$,

- the complex model $\quad E_d = \pi \lambda c_0 x_0^2 + \pi \lambda c_1 x_0^2 / (1 + \tau^2 \lambda^2)$, $\quad \tau = c_1 / k_1$.

Dampers are connected with structures with a help of infinitely rigid braces and they are horizontally positioned.

1



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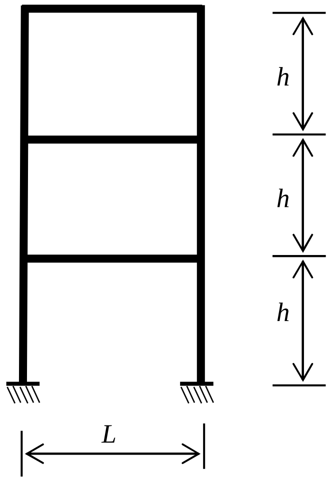

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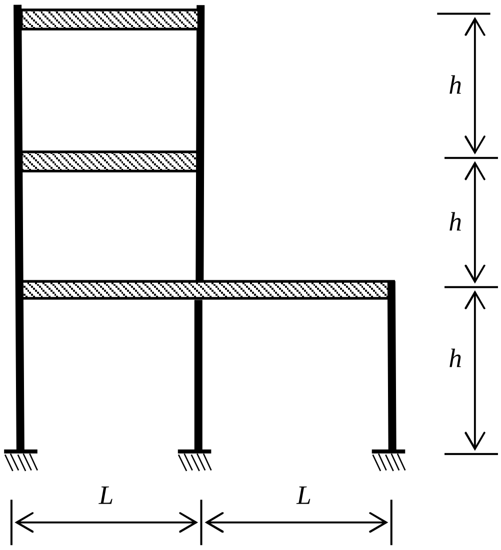

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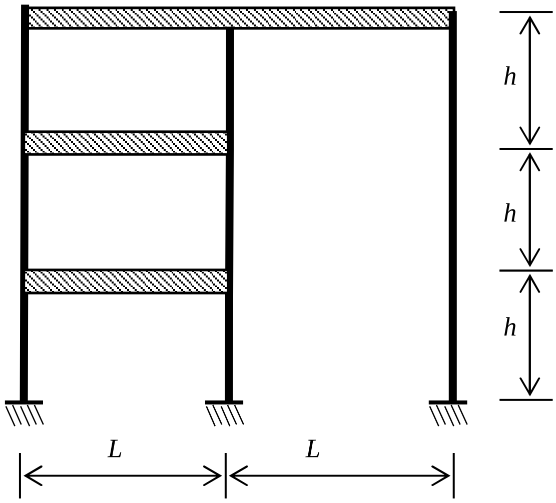

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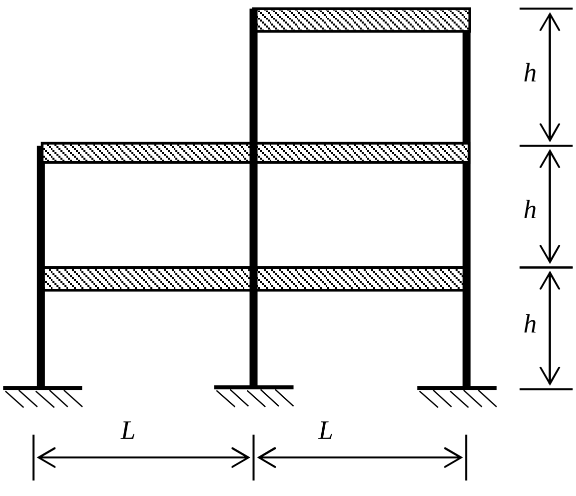

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