Name 1: _____

Name 2: _____

Ecole Polytechnique Fédérale de Lausanne
Earthquake Engineering and Structural Dynamics Laboratory

Course: CIVIL-522, Seismic Engineering
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Assignment 2

To be submitted: 11.03.2025

The aim of this assignment is:

- Use the equivalent lateral force method for determining the internal force diagrams (shear force, bending moment) of a wall.
- Estimate the fundamental period of a building using different approaches.

Note: Neglect the effect of the accidental eccentricity.

Building and site characteristics (we consider the y-direction of the building, see Figure 1):

- Valais, Zone 3b, Soil Class B.
- Construction work class COII, Behaviour factor q=4.
- Building of 5 storeys, interstorey height 3 m.
- Structural elements that contribute to horizontal stiffness: 2 walls (length 3.1 m and thickness 0.3m). The layout of the building is symmetric in plan.
- Stiffness of cracked section = 50% of the gross sectional stiffness.
- Storey mass (the same for all storeys): M=600t.
- Concrete: C40/50 and E_c=34 GPa.
- Reinforcement: B500C (with f_{sk}=500 MPa) and E_s=205 GPa.

For the data concerning the modal analysis, check the Annex at the end of the document.

Task 1: Equivalent lateral force method (ELFM) - 12 pts

Determine the internal force diagrams (bending moment and shear) of one of the two walls using the equivalent lateral force method. Plot the shear force and bending moment diagrams. Summarize your results in the following table:

Storey	**V** [kN]	**M** [kNm]
5		
4		
3		
2		
1		

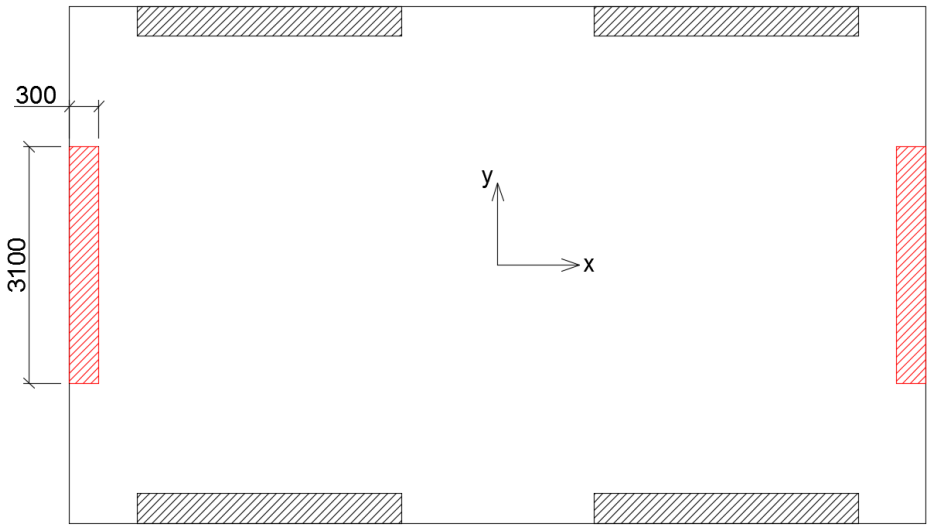


Figure 1: Plan view of the building.

Task 2: Response spectrum method (RSM) – 18 pts

Determine the internal force diagrams (M and V) of one of the two walls using the response spectrum method. Use the SRSS combination rule. Use once all modes and once only the modes for which the sum of the effective modal masses > 90% of the total mass. Add the M and V diagrams to the plots of the previous task. Summarize your results in the following table:

Storey	**V** [kN]	**M** [kNm]
5		
4		
3		
2		
1		

Compare the results of the RSM with the ones obtained using the ELFM, and comment about the differences between the two methods.

Bonus: Fundamental period – 5 pts

Estimate the fundamental period of the structure using the Rayleigh method (see also the hint at the end of this assignment).

Comment the results, and compare them to the exact solution:

For mode 1 to 5, T_1 = 1.357s ; T_2 = 0.213s ; T_3 = 0.075s ; T_4 = 0.039s ; T_5 = 0.026s

Hint:

The flexibility matrix of a cantilever with constant storey height h and constant flexural stiffness EI can be obtained using the following expression:

$$F = \left[f_{ij} \right]$$

$$f_{ij} = \frac{h^3}{6EI} i^2 \left(3j - i\right) \qquad j \geq i$$

(The shear flexibility is neglected).

```
F=zeros(n_st,n_st); % flexibility matrix
for i_st=1:n_st
    for j_st=i_st:n_st
            F(i_st,j_st)=h_st^3/(6*EI_eff)*i_st^2*(3*j_st-i_st);
            F(j_st,i_st)=F(i_st,j_st);
    end
end
K=F^-1 % stiffness matrix
```

References

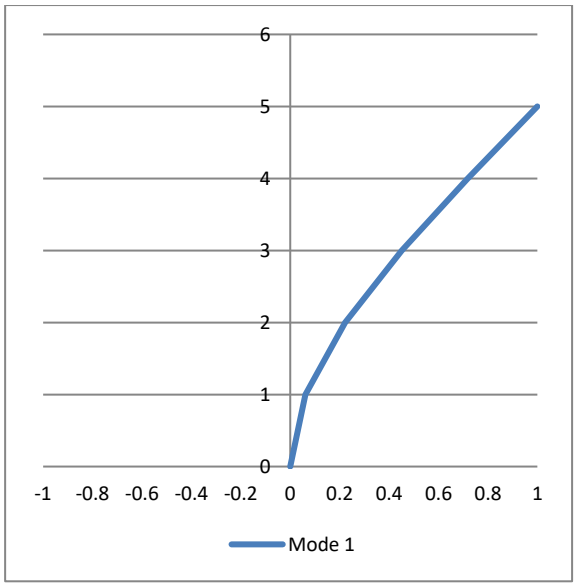
Lestuzzi, P., Smith, I.F.C.: Dynamique des structures, bases et applications pour le génie civil. PPUR, 2019, 2e édition.

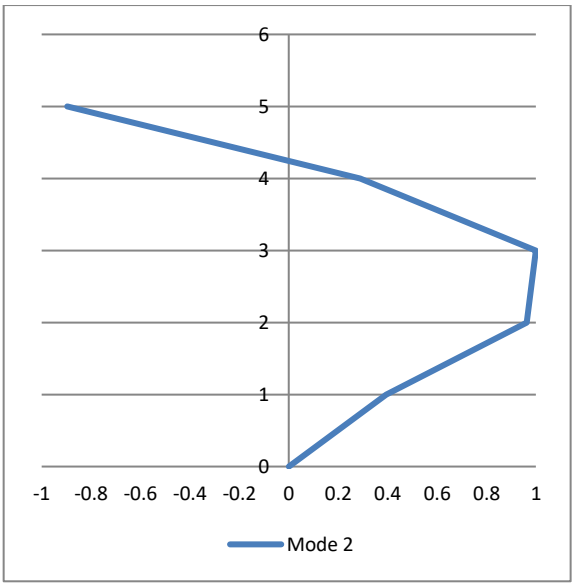
Annex

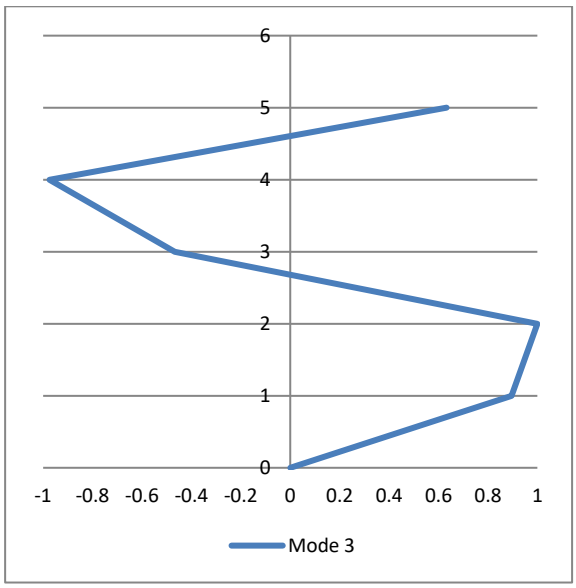
Results of modal analysis for storey mass M = 600t

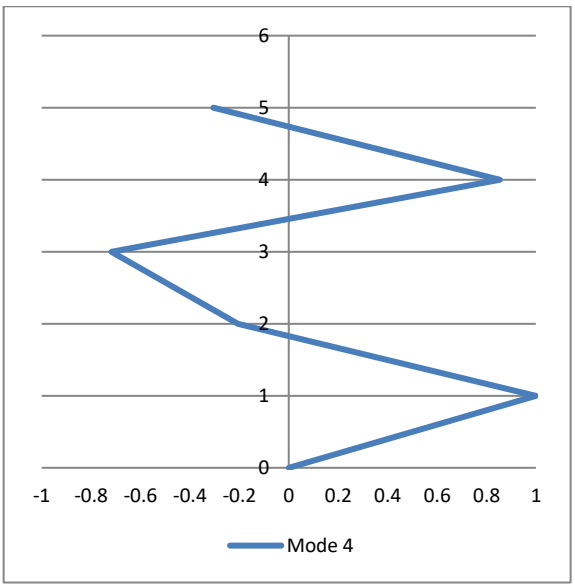
	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
Period	1.357 s	0.213 s	0.075 s	0.039 s	0.026 s

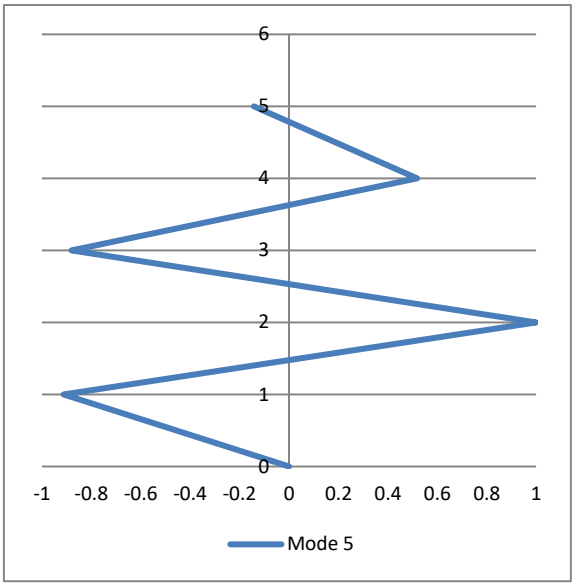
Storey	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
1	0.06	0.39	0.90	1.00	-0.91
2	0.22	0.96	1.00	-0.21	1.00
3	0.45	1.00	-0.47	-0.72	-0.88
4	0.72	0.29	-0.97	0.85	0.52
5	1.00	-0.90	0.63	-0.31	-0.14










6
5
4
3
2
1
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Mode 5