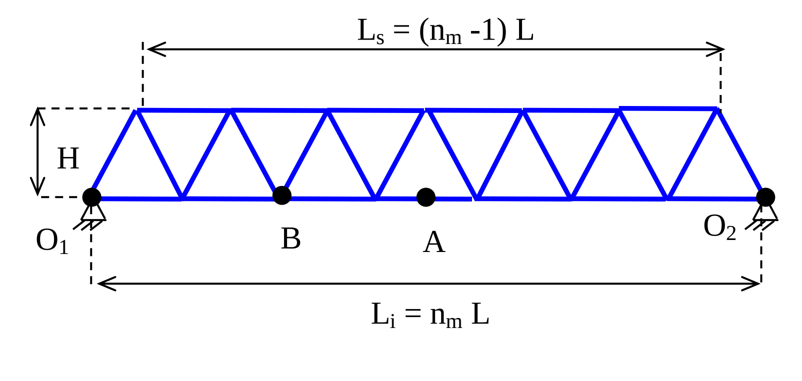
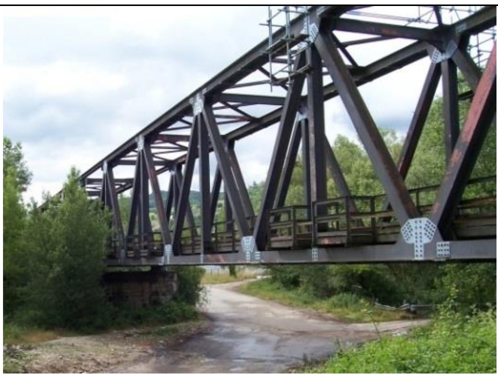
Single span metallic truss bridge

The figure below on the left shows a plane model of a single-span metallic truss bridge, like that shown on the right.





The bridge constraints are a hinge in O_1 and a cart in O_2. Structural damping is to be accounted for according to the proportional damping assumption, $[R]=\alpha[M]+\beta[K]$, with values α and β assigned in the input data table.

The students are asked to:

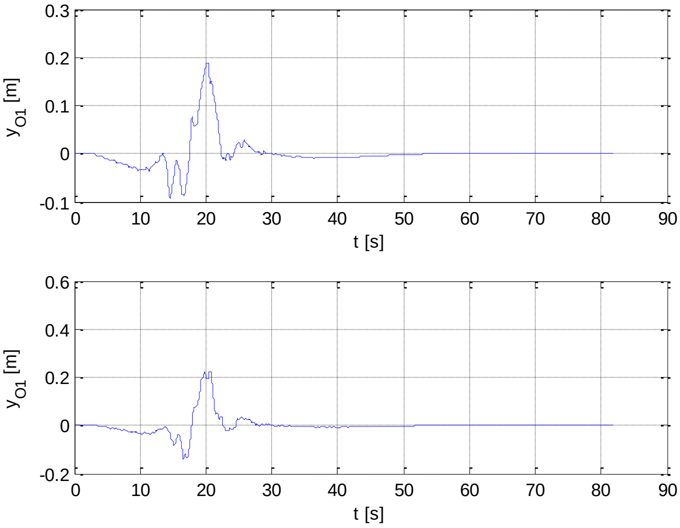
1) Define a finite element model valid in the frequency range 0÷15 Hz

2) Compute the system's natural frequencies and related modes of vibration in the frequency range 0÷15 Hz

3) Compute the following frequency response functions (FRF) in the frequency range 0 ÷ 15 Hz with step 0.01 Hz:
    - vertical displacement of point A produced by a vertical force on point A
    - vertical displacement of point B produced by a vertical force on point A
    - vertical acceleration of point A produced by a vertical force on point B
    - vertical acceleration of point B produced by a vertical force on point B

    Point A is at mid-span, while the distance between point B and O_1 is 2L.

4) Compute the bridge response due to a seismic motion of the ground, represented as a vertical displacement of points O_1 e O_2 shown on the figure below:



The time histories of point O_1 and O_2 are given in the *seismic_displ.txt* file available in beep. The file has three columns reporting the time, the O_1 displacement and the O_2 displacement respectively.

The students are requested to plot:

- The spectrum of the input displacements y_{O1}, $y_{O2;}$
- The spectrum of the vertical displacements of points A and B;
- The time histories of the vertical displacements of points A and B;
- The spectrum and the time histories of the vertical accelerations of points A and B.

5) Considering the passage with constant speed V of a sequence of moving concentrated loads with distance of 26 m one to the other, discuss the possibility of producing a resonance condition in the bridge for specified values of train speed V. To this end, consider an infinite sequence of moving load (approximation of a long train). The groups are advised to use the modal superposition approach to answer this question.

6a) Define a structural change that allows for a 20% increase of the first natural frequency of the bridge. To this aim, the total bridge mass must not increase more than 3%. It's not allowed to change the span length, to change the material, to add constraints. In case of variation of the beams cross-section, all of the inertial and elastic parameters (m, EA, EJ) must change according to the new cross-section dimension and shape, which has to be chosen among the standard metallic section provided in the tables of standardised geometric properties for beam sections made available on BeeP.

or, alternatively,

6b) Define a structural change of the bridge constrains that allows for a 15% reduction of the maximum amplitude of vibration evaluated at point A when the bridge is subjected to the seismic excitation described at point 4).

INPUT DATA:

Geometric data:

Length of base for one module L	[m]	10
Modules number n_m		7
Bottom chord total length L_i	[m]	70
Top chord total length L_s	[m]	60
Bridge height H	[m]	2.8

Inertial and elastic properties of the bottom chord

Cross section type		IPE400
A	[cm^2]	84.46
J	[cm^4]	23130

Inertial and elastic properties of the top chord

Cross section type		IPE400
A	[cm^2]	84.46
J	[cm^4]	23130

Inertial and elastic properties of the diagonal beans

Cross section type		HEA160
A	[cm^2]	38.77
J	[cm^4]	1673

Material: steel - Coefficients for the structural damping evaluation

ρ	[km/m^3]	7800
E	[N/m^2]	2.06E11
α	[s]	0.2
β	[s^{-1}]	1e-4