DYNAMICS OF MECHANICAL SYSTEMS

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1 Introduction

The project contained in this repository deals with the study of the dynamic behavior of a harbor crane. The first part has been developed by using a software given by the professor and which allows to apply the Finite Element Method to the structure. In the Matlab code, instead contained the instruction to make the same analysis using the modal superimposition approach instead.

2 Structure and discretization

The structure studied is the following one:

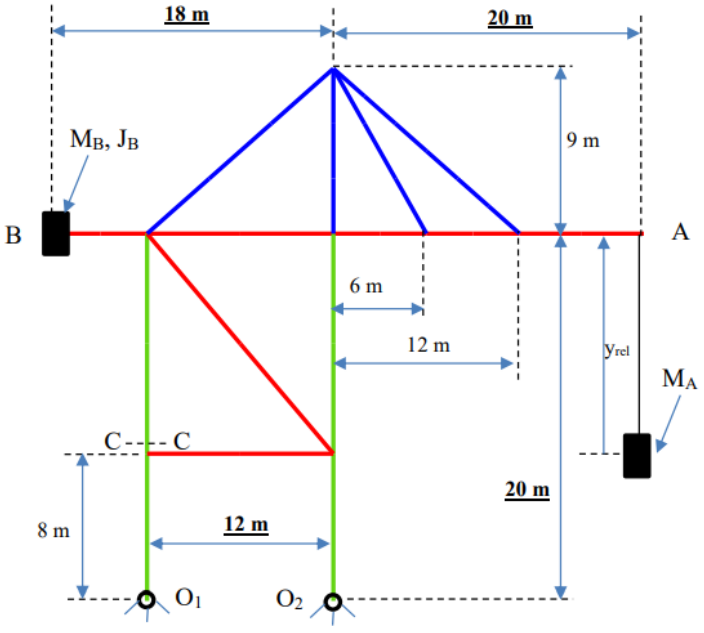

Figura 1: Structure

All beams are made of steel ($E = 2.06e11 N/m^2$, $\rho = 7800 kg/m^3$). Beams in blue have IPE240 ($A = 3.912e-3m^2$, $I = 3.892e-5m^4$) cross section, beams in red have IPE300 cross section ($A = 5.381e-3m^2$, $I = 8.356e-5m^4$) and beams in green have IPE550 cross section ($A = 1.344e-2m^2$, $I = 6.712e-4m^4$). A rigid body having mass $M_B = 2000kg$ and mass moment of inertia $J_B = 80kg\ m^2$ is rigidly attached to the red horizontal beam at point B. Damping is defined according to the "proportional damping" assumption: $[C] = \alpha[M] + \beta[K]$, with $\alpha = 0.2s^{-1}$ and $\beta = 4e-4s$.

As far as discretization, 24 nodes have been used, which correspond to 72 variables. Due to the presence of two hinges, the total number of degrees of freedom is 68.

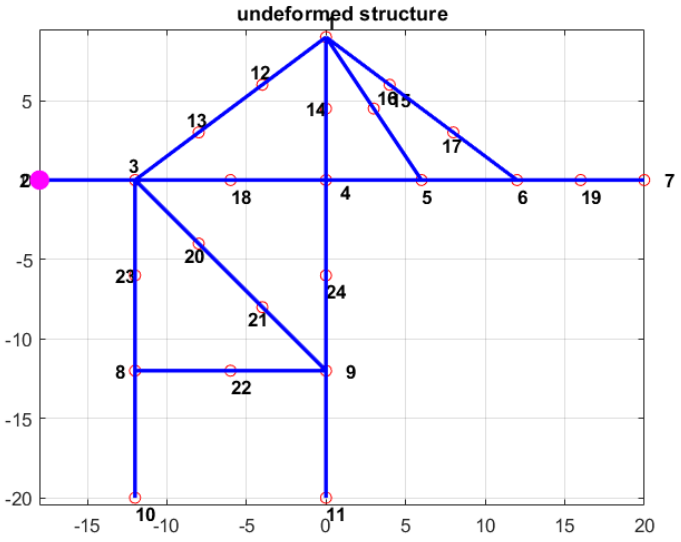

Figura 2: Undeformed structure

3 Analysis

1. Compute the natural frequencies of the damped system (unloaded crane without mass M_A) up to 10 Hz and the related non-dimensional damping ratios.

2. For the unloaded crane (i.e. without mass MA), develop a model in modal coordinates limited to the first four modes and plot the Bode diagrams (in linear scales) of the following frequency response functions (FRF) in the frequency range $0 \div 10$ Hz with step 0.01 Hz:

   - Input: vertical force at point A; output: vertical displacement of point A;
   - Input: horizontal force at point A; output: horizontal displacement of point B;

- Input: vertical force at point A; output: vertical acceleration of point A;

3. For the unloaded crane (i.e. without mass M_A), plot the Bode diagrams (in linear scales) of the following frequency response functions (FRF) in the frequency range $0 \div 10$ Hz with step 0.01 Hz.

   - Input: vertical force at point A; output: vertical component of the constraint force in the hinge O1;
   - Input: horizontal force at point A; output: vertical component of the constraint force in the hinge O2.

4. For the unloaded crane (i.e. without mass M_A), plot the Bode diagram (in linear scales) of the following frequency response function (FRF) in the frequency range $0 \div 10$ Hz with step 0.01 Hz. Input: horizontal force at point A; output: bending moment at section C-C, belonging to the vertical green beam and located just above the connection with the red transverse beam