

# Title: **Seismic design of x-braced frames for light-weight steel structures**

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## **Abstract**

The construction of residential buildings with light-weight cold-formed steel structures has largely increased in the last years. Some of the reasons are a reduction of the costs, a good quality, the versatility of the structure, being able to create different configurations of the building with few number of structural elements, and the absence of obstacles for the installations. But the most important factor in its development has been the quickness in the construction.

From the structural point of view, lightness is the main characteristic of this kind of buildings, since all the elements are made from steel sheets of about 1mm thickness. As a result, beams with very low cross-sectional area and moment of inertia are used; thus, high slenderness is also a common characteristic in all light-weight steel structures. Moreover, these sections have low ductility, due to local buckling phenomena, which has to be solved by the addition of shear walls or x-braced frames.

These characteristics yield to a different dynamic behaviour of the light-weight structure when compared with the most common residential buildings, which are made with more usual technologies. Consequently, since the seismic actions can not be neglected in the structural analysis, a detailed study of this response is justified. This study is performed by means of the finite element method (FEM), which has been proved to be a powerful technique in the numerical simulation of many physical problems. In this thesis work the seismic analysis has been focused in the linear elastic calculation of the structure, using the response spectrum analysis. It is a method only used in the seismic design of structures, which leads to a computation time much lower than any other numerical procedure, since just the maximum displacements and stresses are calculated. Therefore, it has become the most widely accepted method in the seismic design.

The study of the light-weight steel structure begins with the dynamic calculation of a simple structural member, a cantilever. The aim is to show the common characteristics in all dynamic analyses, especially in the seismic design. Some examples are the eigenmodes of vibration, the influence of the material and geometrical properties of the structure or the variation in the dynamic behaviour due to different seismic excitations acting on the structure.

Next, the dynamic actions are applied on a frame, restraining the study to 2D. Regarding this new structural system, the influence of the damping properties is analysed, but the main objective is to reach the first conclusions in the FEM model to use and in the configuration of the structure. As an example, it is proved that the mass of the roof can not be neglected in the calculation of the frame and that the best stabilisation system, when horizontal ground motions act on the base, is the x-bracing with straps. Then, the 2D analysis is extended to a whole façade, in order to check the results from the frame and to obtain some new ones. In this particular case it is seen that the dependence of the dynamic response on the boundary conditions is negligible. Besides, it is shown that the position of the x-braced frames in the façade and the existence of openings, i.e. removal of columns, have no influence in the seismic design. Therefore, the designer will not be too restricted in the configuration of the façades.

Finally the complete structure is analysed, so it has to be done in 3D. First of all, like in the case of the frame, a representative model is created. Once this model is achieved, it is applied in the design of the x-bracing elements for a realistic loading case. With these calculations it is shown that, when acting two perpendicular ground motions simultaneously, it is not possible to reduce the design of the structure into a 2D analysis.