



Vertical geometric irregularity assessment of steel frames on robustness and disproportionate collapse

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ABSTRACT

Disproportionate collapse of building structures can be defined as the partial or total failure of a building as a consequence of an initial local damaging event which develops throughout the structural system of the building. Various building structural systems depending on their level of available ductility and redundancy can perform better or worse to disproportionate collapse events; their resistance to the phenomenon is a function of many parameters including their regularity or not. This paper presents an extensive parametric study on the response of irregular steel frames in case of initial damage, expressed by the total removal of their columns, one in turn. The study regards a set of 15 steel frames designed according to the Eurocodes and the Greek codes. Morphologically, the frames include vertical geometric irregularity leading to useful conclusions regarding the influence of such a property in their resistance to disproportionate collapse. At the end of the paper, the results of the analyses are presented for their limit analysis, their elastic limit and their respective robustness measures. Special attention is given to the influence of vertical geometric irregularity through comparative results.

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1. Introduction

Many building structures are designed today with various irregularities for serviceability, aesthetic or economical reasons. Vertical irregularities appear through sudden changes in stiffness, strength or mass between consecutive floors. The sudden changes in stiffness and strength are expressed through changes in the structural system along the height of the building, through changes in the height of the floors, changes in plan along the height of the building, changes in the material etc. Many buildings have suffered significant and unexpected damages due to their irregularities and in that way, irregularities could be an aggravating parameter regarding disproportionate collapse resistance or robustness.

So far, current regulations have already taken care of including separate clauses defining irregular buildings, since in many cases its design requires specific and special steps.

In that framework, Eurocode 8 [1,2] includes criteria for the characterization of regular or irregular buildings in plan and in elevation. An irregular building is defined as the building for which the difference appearing in any of the properties such as stiffness, strength or mass between two consecutive floors is above a specified limit. In order for a building to be considered as regular, all the lateral

structural systems of the building such as walls, frames, cores should be continuous throughout the whole height of the building from foundation to the top of the building. Among many, the most important points that should be met are presented below:

- The lateral stiffness and mass of every floor remain constant or are gradually decreased, without sudden changes from the base to the top of the building,
- In framed structures, the ratio of the real floor strength to the strength required by the analysis should not be disproportionately different between consecutive floors,
- In case of recessions, the recessions must be stepped and in any case the recession should not exceed the 20% of the parallel plan dimension along the recession.

On the other hand, the International Building Code [3] applies a more categorized aspect of irregular buildings which is in accordance to ASCE 7 [4]. The various types of irregularities can be summarized as follows:

- Stiffness-soft story irregularity,
- stiffness-extreme soft story irregularity,
- weight (mass) irregularity,
- vertical geometric irregularity,
- in-plane discontinuity in vertical lateral force-resisting elements irregularity,

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