Structural and Architectural Design of Complex-Shaped Structures in Seismic Regions: Early Stages from a Practical Perspective

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Summary

This paper attempts to fill the knowledge gap that is encountered in the structural and architectural design of complex-shaped buildings in seismic prone regions. In a combined effort between academia and practice the challenges involved in the seismic design of complex geometry structures have been analyzed through a number of complex-shaped case study structures. Several parametric studies on the seismic performance of typical complex geometry components have been performed for the design situation where the complex geometry does contribute to the lateral stability. In the case it doesn't, the principles of a previously proposed innovative design solution are shown that involves the isolation of external irregular parts of the structure from the regular interior one. The findings have been formulated as generic design recommendations, aiming to aid the early stages of comparable designs.

Keywords: complex geometry; non-regular structure; seismic design; seismic isolation.

1. Introduction

Complex geometry structures in the engineering and architectural community have become more and more prominent in recent years (see Figure 1). Several built cases have triggered this new "trend" related to the construction of free-form structures (i.e. non-straight or curved boundaries and structural elements in a non-repetitive arrangement). As a consequence, the general design procedures developed for regular structures are no longer efficient, which becomes increasingly problematic in seismic prone regions due to the difficulty to steer the structural behaviour or assess its performance intuitively. In addition, national building codes do not provide any guidelines for complex-shaped structures but simply categorise structures as regular or irregular just looking at their vertical and horizontal configuration, without any reference for the case of curved and inclined structural elements.

In addition to the design of structural elements, also the behaviour of non-structural components (e.g. glazing façade, ceilings, infill, etc.) is a major concern as these are usually related to the biggest economic losses after an earthquake event. This is especially relevant in complex-shaped buildings that usually represent a higher cost of construction than more conventional, regular building designs. As a consequence damage during an earthquake excitation needs to be reduced.

Given the above discussion, there is a concern that architecture and engineering practice do not have clear guidelines for the safe and economical design of complex-shaped buildings. To overcome this, the authors' aim is to provide design strategies for the seismic design of complex-shaped structures, both for the structural and non-structural elements.

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