Design of innovative seismic-resistant steel-concrete hybrid coupled shear walls

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Summary

An innovative hybrid coupled shear wall (HCSW) system obtained coupling a reinforced concrete wall with two side steel columns connected by means of steel links at each floor is presented. The reinforced concrete wall is designed to undergo limited damages while the steel links connected to the wall are the only dissipative elements and can be easily replaced if damaged after a seismic event. A significant part of the overturning moment is resisted by an axial compression - tension couple developed by the two side steel columns while almost all the horizontal shear and only a fraction of the overturning moment are resisted by the wall. Such hybrid system might represent a cost- and time-effective type of construction since simple beam-to-column connections could be used for the steel frame constituting the gravity-resisting part and traditional and well-known building techniques are required for the reinforced concrete and steel components. The problems encountered in the design of the presented HCSW system are discussed and a specific performance-based design method is presented and applied to the design of a realistic case study. Incremental nonlinear dynamic analyses are performed to assess the behaviour of the proposed innovative structural system in seismic areas and validate the proposed design procedure.

Keywords: steel-concrete hybrid structures; steel structures; dissipative links; seismic design; seismic-resistant structures.

1. Introduction

Coupled shear wall systems made of reinforced concrete shear walls connected by means of reinforced concrete beams placed at the floor levels constitute efficient seismic resistant systems characterized by good lateral stiffness and dissipation capacity. Walls are subjected to bending in combination with an alternation of tension and compression axial forces as well as shear while linking beams are subjected to bending and shear. Conventional reinforced concrete coupled shear wall systems suffer from being difficult to be repaired after strong earthquakes. Structural steel coupling beams or steel-concrete composite coupling beams provide a viable alternative, facilitating repair after seismic events if damage is limited to the steel elements. A farther potential alternative is proposed in this study that illustrates some of the work developed in the European RFCS research project INNO-HYCO (INNOvative HYbrid and COmposite steel-concrete structural solutions for building in seismic area). The proposed hybrid coupled shear wall (HCSW) system is made of a reinforced concrete shear wall coupled to steel side columns by means of steel links (Figure 1). The connections between links and side columns are pinned ensuring the transmission of shear force while the side columns are subject to compression/traction with small bending moments.

The structure is conceived to limit the damage under earthquake excitation to the link elements so to obtain a seismic resistant system that is simple to repair. To this end, it is important to develop a suitable connection between the steel links and the concrete wall that ensures the easy replacement of the damaged links and, at same time, the preservation of the wall. The proposed hybrid system is effective as seismic resistant component if the yielding of a large number of links is obtained while the reinforced concrete wall is still in the elastic range. Such systems should permit to exploit both the stiffness of the reinforced concrete element, necessary to limit building damage under low-

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