Recent Advances in Earthquake Resilient Structures

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Abstract

The current article introduces a new methodology for developing Earthquake Resilient Structures (ERS). This is achieved by following principles of full cycle Performance control (PC) and embracing a holistic approach to Design Led Analysis (DLA) of ERS. Collapse Prevention (CP), Post-Earthquake Realignment and Repairs (PERR) are the basic traits of ERS. Real buildings cannot be ideally re-centered unless specifically designed and detailed for CP and PERR. The proposed methodology is introduced by way of developing an earthquake resilient Rocking Core Moment Frame (RCMF), as the lateral resisting component of a gravity resisting structure that has been detailed not to develop residual effects while sustaining large lateral deformations.

Keywords: Resiliency, re-centering, collapse prevention, repairability, cost effectiveness

1. INTRODUCTION

The analysis and design of ERS demands greater analytic and detailing effort than that for code compliance only. It is more challenging since it focuses as much attention on *seismic unloading and realignment* as it does on the loading. Whereas a simple pushover plot may suffice to study the seismic response of a building, a full cycle hysteresis diagram is needed to address the CP and PERR potentials of the same structure under similar conditions. Here the authors have adopted the definition suggested by the Sustainability Committee that characterizes “resilience” as *“the ability to suffer less damage and recover more quickly from adverse events.* The current paper addresses sustainability in terms of a generalized RCMF upgraded to meet the ERS standards introduced above. The physical behavior of a seismically sustainable RCMF can best be visualized by the MF and the RRC resisting the lateral forces together until the MF becomes a stable mechanism without falling apart. The stable condition of the damaged building allows for the replacement of repairable parts without major difficulties. Earthquake resiliency is an important concept that requires a thorough understanding of the mechanics of CP and PERR. In PERR the resilience of the gravity and non-structural elements are as important as those of the lateral resisting system. For one thing, *residual deformations and P-delta effects at the end of an earthquake or at the onset of the re-alignment have the same effect as initial imperfections and P-delta moments at the beginning of the seismic event.* Damage sustained by the gravity elements is often more pervasive than that suffered by the earthquake resisting members, an issue that has often been ignored in the literature. Three basic concepts govern the development of viable ERSs;

- Understanding the full cycle or comprehensive behavior of elastoplastic systems, Fig. 2(e) as opposed to investigating the half cycle or pushover curve of the same system, Fig. 2(d). It embraces a holistic approach to the development of the kinematics of the structure, including all gravity and lateral resisting components, throughout the complete loading-unloading history of the system.
- Adopting a holistic approach to detailing and designing of all parts and components with a view to actual physical response, as opposed to assumed theoretical behavior. Simplifying assumptions or practices that ignore the effects of undesirable interactions between vital details and building parts are totally dismissed. Protecting moment-free joints and articulated supports against rotation inhibiting details can considerably improve the re-centering process.
- Following the principles of Performance Control (PC) and DLA which are purpose-centric design philosophies as opposed to investigative methods of approach. *PC employs both theoretical as well as*