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AN INTRODUCTION TO SUSTAINABLE SEISMIC DESIGN

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This paper peruses two complementary purposes. First, to link Performance Based Seismic Design (PBSD) to Performance Control (PC) with a view to Post-Earthquake Realignment and Repairs (PERR), and then to discuss the applications of new technologies that help achieve Seismic Sustainability (SS) for Earthquake Resisting Structures (ERS). SS involves two facets, theoretical development and physical functionality. Post-earthquake Global Stiffness Reduction (GSR) and Restoring Force Adjustment (RFA) are innovative technologies that have been devised to achieve SS through PC. While there is abundant data on element design for ERS, such as energy absorbing devices, rocking cores, etc., there is little to no information on PERR of complete buildings equipped with such components. SS is a concept that requires a thorough understanding of the mechanics of Collapse Prevention (CP) and PERR. In PERR the resilience of the gravity and nonstructural systems are as relevant as that of the ERS and the nature of the restoring forces are as important as those generated by the earthquake. A new archetype with supporting details has been presented. Construction sustainability is concerned mainly with environmental impact of building materials and carbon footprint assessment. Regardless of the extent of carbon footprint improvements, no structure can be regarded as seismically sustainable unless it has been designed to remain serviceable with minor to moderate repairs after strong ground motion, otherwise the system would be disposable with greater damage to the carbon footprint than expected. Sustainability in the present context also implies the ability to prevent actual collapse, to overcome residual stresses and strains, the $P\delta$ effects and to lend the system well to PERR, Gilmore (2012) and Grigorian et al. (2017). The earlier International and United States codes related seismic performance to structural strength rather than to system response. The realization that increasing strength alone may not prevent collapse nor preserve functionality, led to the evolution of PBSD as practiced today Priestley (2000). Since then PBSD has been the subject of many studies that have advanced its applications to more dependable performance levels, use of innovative energy dissipating devices and methods of computation Goel et al. (2010) and Naeim et al. (2016). The current article discusses a transition from PBSD to PC with a view to extending the currently expected performance levels from Life-Safety and Incipient collapse to cost effective SS by means of GSR and RFA. The pioneering efforts in implementation of Rigid Rocking Core-Moment Frames (RCMF), amongst others, is due to Wada et al. (2012). PC is a newly introduced methodology Grigorian et al. (2012) that aims to provide insight into the response of a particular structure to seismic events with a view to greater reliability and economic construction. It is based largely on estimation of hazard, evaluation of the consequences and appraisal of anticipated repairs. PC is a purpose specific methodology with applications to drift reduction, minimum weight design and SS. In PBSD the expected response is relied upon the natural behavior of a given systems, whereas in PC the desired response is imposed upon a purpose specific structure. PC is achieved through Design Led Analysis (DLA), which in turn is influenced by controlled behavior of purpose specific design objectives. Currently, PBSD objectives neither address PERR nor consider reconstruction costs. In order to emphasize the importance of the proposed concepts and technologies rather than mathematical formulations, resort has been made to simple diagrammatic analysis that reduce the task of otherwise cumbersome computations to simple combinations of idealized response curves. Diagrammatic analysis allows the inclusion of the $P\delta$ effects, influences of supplementary devices as well as restoring forces. The use of replaceable earthquake resisting devices and parts can be effective if the structure is free from unaccounted stiffnesses and residual effects, is designed to sustain anticipated damage and to realign itself after major earthquakes, otherwise no meaningful repairs can take place Grigorian et al. (2018).

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