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Fragility Assessment of a Low-Rise Building with Plan Irregularities under Strong Seismic Motions

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Abstract

This paper is an attempt to study the fragility of a low-rise building with mass irregularities in plan with emphasis on collapse region of response. The study evaluates the fragility and collapse response of a three-dimensional 3-story reinforced concrete model with unidirectional mass eccentricities in plan equal to 0% (symmetrical), 10%, 20% and 30% using extensive nonlinear incremental dynamic analyses. Performance of each model is examined by means of calculation of collapse margin ratios (CMRs) and the associated fragility curves. Results demonstrate that substantial differences exist between behavior of torsional (irregular) and non-torsional (regular) buildings in terms of safety margin against collapse and fragility curves. Results indicate that current seismic design parameters could be non-conservative for low-rise buildings with high levels of plan eccentricity and such structures may not meet the design target performance objectives.

Keywords: fragility, irregular structures, collapse, performance-based, low-rise buildings

1. INTRODUCTION

Buildings with intensive plan irregularities have proved to respond quite differently compared with non-torsional buildings under seismic attacks [1, 2, 3]. Irregularities in plan may be attributed to large distance between the center of mass (CM) and the center of stiffness (CR) in the elastic (pre-yielding) range of response or the center of mass (CM) and the center of strength (CV) in the post-yielding range of response. Performance of such structures is basically different from regular ones; which is attributable to the coupling of transitional and torsional responses. In such structures, the distribution of seismic demands in the structure is not uniform and the displacement and ductility demands on the elements along the so-called "stiff side" are generally different from those on the "soft (flexible) side" [3, 4]. The present study is intended to evaluate the seismic fragility of a low-rise 3D reinforced concrete building with varying mass irregularities in plan and under the simultaneous effects of both horizontal components of strong ground motions.

2- METHODOLOGY

2.1. STRUCTURAL MODELS

For the purposes of this study, a 3-story RC building with typical architectural characteristics, as shown in Figure 1, is considered. The building has 3 spans in each direction. The structural system is composed of reinforced concrete moment frames in both directions conforming to ASCE/SEI 7-10 [5] design provisions. Reinforcements detailing also conforms to the ACI code [6] requirements for "special moment resisting frames". Span lengths are identical in both directions and equals to 5 meters and story heights are considered to be 3 meters. Distributed dead and live loads on floors are 5.3 KN/m^2 and 2 KN/m^2, respectively. It is assumed that the structure is located in a "high seismicity" area with the underlying soil being as "firm soil" according to ASCE/SEI 7-10 classification. 28-day concrete cylindrical specified strength and rebar strength