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Seismic Performance of RC Frame with Low Strength Concrete: Experimental and Numerical Study

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Abstract. Experimental and numerical studies have been conducted on low rise reinforce concrete frames having low strength concrete i.e. possesses concrete with strength less than the design specified strength, typically found in developing countries. The experimental study involved the shake table testing of two 1:3 reduced scaled two storey frame, including a code confirming SMRF model and a noncompliant model of similar characteristics but built in low strength concrete i.e. 2000 psi (14 MPa), which is about 33% less than the design specified strength. The models were subjected to linearly scaled accelerogram of 1994 Northridge earthquake to deformed the models from elastic to inelastic and subsequent incipient collapse stage in order to understand the damage mechanism of the models and retrieve the structural response parameters. An FE based numerical model was prepared in SeismoStruct for inelastic modeling of the considered reinforced concrete frame incorporating beam bar-slip and joint panel damage mechanisms as observed during shake table testing. Seismic performance assessments of the considered frames were carried out using incremental dynamic analysis with a suit of spectrum compatible accelerogram, to evaluate the force reduction factor (response modification factor R) for critical comparison.

Keywords: SMRF, response modification factor, shake table testing, nonlinear modeling, IDA

1. Introduction

Recent field surveys in developing countries (Badrashi et al. 2010) have shown number of construction deficiencies including the use of substandard quality of materials and poor detailing practices. Among these, the use of low strength concrete less than the design specified is very common (Badrashi et al. 2010). Furthermore, recent experimental studies conducted on deficient RC frame built in low strength concrete have shown significant flexural cracking in beam-column members and severe joint panel damageability under lateral loads well-below the design level demands (Ahmad et al., 2017). Such joint damage can result in brittle shear hinging at local level and soft-storey mechanism at global level (Pampanin et al., 2002; Sharma et al., 2012). Reinforced concrete structures if not built properly can result in catastrophic failure and subsequent human and economic losses, upon subjecting to earthquake induced strong ground motions (Ruiz-Pinilla et al., 2016, Erdil 2016, Ates et al. 2013, Rossetto and Peiris 2009, Arslan and Korkmaz 2007; Inel and Meral, 2016). The above facts make it essential to assess the performance of the existing building stock, taking into account the structural- and regional-specific deficiencies, for seismic safety evaluation under various hazard levels, which will aware the public about the potential risk of their buildings.

The present paper presents experimental and numerical investigation carried out on two reinforced concrete special moment resisting frames (SMRFs) that included a codeconfirming model designed to the seismic building code and a non-compliant model SMRF with a construction defect of having low strength concrete of 2000 psi (14 MPa), typically found in developing countries. Shake table tests were carried out on 1:3 reduced scale representative models, which were excited using natural acceleration time history of 1994 Northridge earthquake with

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