Semnan University
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Reliability Analysis of Reinforced Concrete Frames Strengthened by FRP Sheets

A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Science in Civil Engineering

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Abstract

Many existing Reinforced Concrete (RC) structures require strengthening due to several reasons such as unsatisfactory of ductility, design just based on gravity load. The use of FRP composites is one of the most common methods for strengthening concrete structures. These composites has some advantages such as increase in ductility, lateral strength, minimum weight and dimensions added to the structure. In this study, the reliability of three RC frames, 5, 10 and 15-story represent low-, medium- and high-rise frames in two cases including original and strengthened with FRP is presented. The limit state function defined to perform reliability analyzes based on the maximum drift ratio inter-story. The seismic behavior of frames was assessed by nonlinear time history analysis (NTHA) with finite element program OpenSees in life safety performance (LS) under the seven far-field records earthquake from fault. Four random variables represented the variation in compressive strength of concrete, yield strength of steel, live load, and elasticity modulus of FRP materials are defined. The results of the 5-story frame reliability analysis showed that have relative safety, but the frames of 10- and 15-story are in the range of failure. By increasing the system of FRP composites, the existing frame has a significant increase in the reliability index and has reached a value above 3. Reliability analysis was performed by two precise methods of Monte Carlo with samples of 100, 1000, 10000, 100000, and 1000000, and the Hasofer-Lind approximation method. The results of the Monte Carlo method reliability analysis with simulated samples showed that with increasing the number of random variables, the volume of operations for convergence results in greater. In strengthened frames, due to the increase in the number of variables, more samples are needed for convergence than existing frames. The results of the reliability analysis methods were compared, and the results showed that in the existing frames due to the number of variables, the Hausfer-Lind approximation method had a good estimate of the reliability of the system. By increasing the number of variables, the error in the Hasofer-Lind method increases with Monte Carlo method. Sensitivity analysis in order to investigate the importance of random variables on reliability index, in strengthened frames with increasing height of frames, the effect of random variable of compressive strength of concrete and elastic modulus of FRP increases and compressive strength of steel decreases. In existed frames, with increasing height of frames, the effect of random variable of compressive strength of the concrete decreases and compressive strength of steel increases. The live load, despite the uncertainty that exists in the amount and location of its effect, is reduced due to the decreasing coefficient applied to it.

Keywords: Concrete frame; FRP composite; Reliability analysis; Monte Carlo simulation method; Hasofer-Lind method.

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