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Seismic Evaluation of FRP Strengthened RC Buildings Subjected to Near-Fault Ground Motions using Artificial Neural Networks

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ABSTRACT

Recordings from recent earthquakes have provided evidence that ground motions in the near field of a rupturing fault differ from ordinary ground motions, as they can contain a large energy, or "directivity" pulse. This pulse can cause considerable damage during an earthquake, especially to structures with natural periods close to those of the pulse. Failures of modern engineered structures observed within the near-fault region in recent earthquakes have revealed the vulnerability of existing RC buildings against pulse-type ground motions. This may be due to the fact that these modern structures had been designed primarily using the design spectra of available standards, which have been developed using stochastic processes with relatively long duration that characterizes more distant ground motions. Many recently designed and constructed buildings may therefore require strengthening in order to perform well when subjected to near-fault ground motions. Fibre Reinforced Polymers are considered to be a viable alternative, due to their relatively easy and quick installation, low life cycle costs and zero maintenance requirements. The objective of this paper is to investigate the adequacy of Artificial Neural Networks (ANN) to determine the three dimensional dynamic response of FRP strengthened RC buildings under the near-fault ground motions. For this purpose, one ANN model is proposed to estimate the base shear force, base bending moments and roof displacement of buildings in two directions. A training set of 168 and a validation set of 21 buildings are produced from FEA analysis results of the dynamic response of RC buildings under the near-fault earthquakes. It is demonstrated that the neural network based approach is highly successful in determining the response.

Key Words: Seismic evaluation, FRP, neural network, near-fault ground motion.

1 INTRODUCTION

Impulsive type motions can cause considerable damage during an earthquake, especially to structures with natural periods close to those of the pulse. Near-fault effects can be broken down into three types depending on the pulses, i.e. whether they are of acceleration, velocity, or displacement type. The velocity pulse motion, sometimes referred to as "fling," represents the cumulative effect of almost all of the seismic radiation from the fault [1]. From a seismological perspective, the velocity pulse is more commonly found in earthquake records than are acceleration or displacement pulses. Although, from an engineer's perspective, the velocity pulse is a better indicator of damage than the acceleration pulse, the damage potential is also dependent on the peak displacement during the pulse [2].

The displacement pulse without the high velocity pulse does not have a high damage potential because the structure has time to react to the displacements. After the 1971 San Fernando earthquake, engineers and seismologists realized the potential damage that may occur due to the effects of near-fault ground motions on structures. The damage observed during the 1994 Northridge, California, the 1995 Kobe, Japan, the 1999 Izmit, Turkey, and the 2003 Bam, Iran earthquakes proved the engineer's hypothesis that structures located within the near-fault area