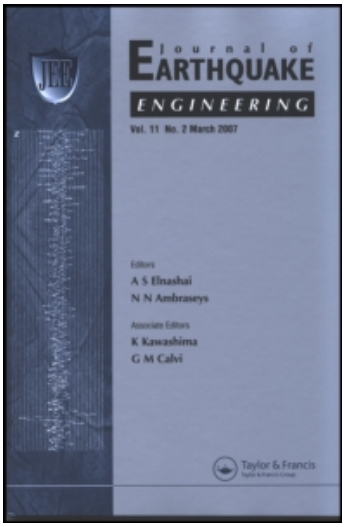

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Displacement-Based Earthquake Loss Assessment of Masonry Buildings in Mansehra City, Pakistan

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Displacement-Based Earthquake Loss Assessment of Masonry Buildings in Mansehra City, Pakistan

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A simplified nonlinear displacement-based approach is presented herein for earthquake loss estimation of structures. The methodology compares the displacement capacity of the structural systems with the displacement demand at the characteristic vibration periods of the systems taking into account their energy dissipation and the inherent variability in the seismic demand besides the variability in the geometric and material properties of the structural systems. To calibrate the methodology for Pakistani urban masonry buildings, 3D nonlinear dynamic time-history analysis of masonry buildings is performed, using a simplified formulation proposed herein, in order to obtain their vibration periods. Further calibration of the method is performed by analyzing experimental data on masonry shear walls. Deformation limit states of the masonry shear walls at different performance levels are presented. The energy dissipation characteristics of the masonry shear walls are quantified and presented in a simplified analytical form. A case study application is performed for the estimation of direct socio-economic losses in the urban area of Mansehra City for scenario earthquakes.

Keywords Displacement-Based; Seismic Losses; Unreinforced Brick Masonry; Pakistan

1. Introduction

Most of the urban and rural population in the seismic-prone areas of Pakistan use masonry as a common construction material. Despite the fact that the usual practice of construction will vary greatly from urban to rural areas, almost all of the construction practices do not use any horizontal and/or vertical reinforcement in the masonry shear wall systems. It is this type of masonry buildings that are found in abundance in the major seismically active cities of Pakistan. Unreinforced masonry building systems are often avoided in high-seismicity areas because of an assumed inherent high vulnerability of the masonry material due to its low ductility level and high brittleness. This opinion is supported by many seismic events in which the masonry building systems performed very poorly and led to huge socio-economic losses. One of the many examples is the recent 2005 Kashmir earthquake, which killed more than 80,000 people and had an overall economic impact of about US$5.8 billion dollars [ADB and WB, 2005]. Most of the damages were due to the stone masonry buildings, constructed in cement, clay, and/or dry form, and unreinforced concrete block masonry [Naeem *et al*., 2005; Naseer

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