University of Cyprus
Department of Civil and Environmental Engineering

PhD Dissertation Defense

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with title:

Modeling the Behavior of RC Columns Under Lateral Loads

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Abstract

Existing reinforced concrete buildings constructed before the development of modern seismic design provisions represent one of the largest seismic safety concerns worldwide. Such buildings are vulnerable to significant damage and even collapse when subjected to strong ground shaking. Collapse of reinforced concrete buildings has resulted in many of the fatalities in past earthquakes. Since 1980 after the capacity design concept was introduced in the seismic design code provisions, the seismic safety gap between the newly designed seismic resistant buildings and those constructed before 1980 is widened causing worldwide concern. The crucial issue that was evident after the earthquakes in 1999 in Athens (Partnitha) and in Turkey (Kocaeli) and was underlined by the destructive earthquake of L'Aquila (2009) in Italy is the need to improve assessment and retrofit procedures for existing reinforced concrete buildings.

Columns play a very important role in the structural performance. Therefore, it was essential to apply a suitable analytical tool to estimate their structural behavior considering all failure mechanisms such as axial, shear, and flexural failures. In the present thesis a fiber beam-column element accounting for shear effects and the effect of tension stiffening through reinforcement-to-concrete bond was developed, in order to provide an analytical test-bed for simulation and improved understanding of experimental cases where testing of reinforced concrete columns actually led to collapse. Emphasis was particularly on lightly reinforced columns.

For the definition of deformability of such columns, the definition of plastic hinge length was reassessed through consideration of yield penetration effects. The required confined zone in critical regions of columns and piers undergoing lateral sway during earthquakes is related to the plastic hinge length where inelastic deformation and damage develops. The exact definition of the plastic hinge length stumbles upon several uncertainties, the most critical being that the extent of the inelastic region evolves and spreads with the intensity of lateral displacements. Design codes quantify a reference value for the plastic hinge length, through calibrated empirical relationships that account primarily for the length of the shear span and the diameter of primary reinforcing bars. The latter term reflects the effects of bar yielding penetration in the support of columns. Here a consistent definition of plastic hinge length was pursued analytically with reference to the actual strain state of the reinforcement. Finally, the column's structural behavior was assessed by considering all mechanisms of behavior involved, namely flexure with or without the presence of axial load, shear and anchorage. The peculiar characteristics of lightly reinforced concrete columns are the outcome of the shear – flexure interaction mechanism which was studied based on the Modified Compression Field Theory and the significant contribution of the tensile reinforcement pullout from its anchorage to the total column's lateral drift. These features are embedded in the stand-alone Windows program named "Phaethon" -with user's interface written in C++ programming language code- aiming to facilitate engineers in executing such analyses both for rectangular and circular substandard reinforced concrete columns.

Confining wraps or jackets to rehabilitate and strengthen existing substandard RC columns such as those described in the present thesis has proven to be an efficient technique for seismic retrofit of structures. A new constitutive material law was developed and was added to the source code of OpenSees as a uniaxial material, i.e. the 'FRPConfinedConcrete' material. In order to evaluate the relevance and accuracy of the

proposed material model, its performance was corroborated through simulation of a series of cyclic loading tests performed on jacketed columns with a rectangular cross section.

Short Biography:

Konstantinos G. Megalooikonomou is a Structural Engineer graduated from Democritus University of Thrace of Greece (M.Eng., 2005). He holds a Master of Science (M.Sc.) in Earthquake Engineering from ROSE School of the University of Pavia of Italy (2007). He has worked as a Research Engineer at the University of Rome – Sapienza, Italy (2006-2008), at the University of Rome – Roma Tre, Italy (2008-2011), at the University of California Berkeley, USA (2010) as well as at the GFZ German Research Centre for Geosciences in Potsdam, Germany (2016-2018) with the financial support by the research programs Marie Curie ITN ENCORE, RELUIS and DESTRESS (H2020). His Ph.D. studies at the University of Cyprus were funded with a triennial scholarship (2012-2016) by the Alexander S. Onassis Public Benefit Foundation. His research field is concentrated generally on Earthquake Engineering and more specific on seismic assessment of reinforced concrete and masonry structures, on seismic retrofit of reinforced concrete structures with Fiber Reinforced Polymers (FRPs) and finally on seismic risk assessment of structures with the development of suitable fragility curves. He is member of the Technical Chamber of Greece (TCG), of the Hellenic Society of Earthquake Engineering (HSEE) and of the German Society of Earthquake Engineering and Structural Dynamics (DGEB). He speaks English (Proficiency). Italian (postgraduate studies in Italy) and German (Mittelstufe –C1). Finally, he has published 13 peer-reviewed international conferences' papers and 7 peer-reviewed high impact journal papers.