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Analytical and Finite Element Concrete Material Models - Comparison of Blast Response Analysis of One Way Slabs with Experimental Data

Editors: Ganesh Thiagarajan and Eric Williamson

SP-306

American Concrete Institute
Always advancing

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Preface

The mission of ACI-ASCE Committee 447 is to develop and report information on the application of finite element analysis methods to concrete structures. The mission of ACI 370 is to develop and report information on the design of concrete structures subjected to blast, impact, and other short-duration dynamic loads. In this Special Publication (SP) and the accompanying presentations made at the ACI Fall 2013 Convention in Phoenix, Arizona, these committees have joined efforts to report on the state of practice in determining the Behavior of Concrete Structures Subjected to Blast and Impact Loadings. Recently, the (2008-2014) National Science Foundation (NSF) funded a study by University of Missouri Kansas City (UMKC) (CMMI Award No: 0748085, PI: Ganesh Thiagarajan) to perform a series of blast resistance tests on reinforced concrete slabs. Based on these results, a Blast Blind Simulation Contest was sponsored in collaboration with American Concrete Institute (ACI) Committees 447 (Finite Element of Reinforced Concrete Structures) and 370 (Blast and Impact Load Effects) and UMKC School of Computing and Engineering. The goal of the contest was to predict the response of reinforced concrete slabs subjected to a specified blast load using a variety of simulation methods. The blast experiments were performed using a Shock Tube (Blast Loading Simulator) located at the Engineering Research and Design Center, U.S. Army Corps of Engineers at Vicksburg, Mississippi.

Over 40 entries were received from researchers and practitioners worldwide; the competition was open to methods used in both research and practice. There were four categories in the contest: 1) Advanced Modeling of slabs with Normal Strength Concrete and Normal Strength Steel, 2) Analytical or Single-Degree-of-Freedom (SDOF) Modeling of slabs with Normal Strength Concrete and Normal Strength Steel, 3) Advanced Modeling of slabs with High Strength Concrete and High Strength Steel, and 4) Analytical or SDOF Modeling of slabs with High Strength Concrete and High Strength Steel. The first- and second-place winners were invited to present their work at the Fall 2013 convention. Furthermore, all teams were invited to submit papers for this SP, and original experimental data were provided to allow the teams to compare their results with those measured. This SP is a result of all the papers that were submitted and reviewed in accordance with ACI peer review requirements. In this SP, there are three papers from academic researchers and six from industry personnel, providing a healthy cross section of the community that works in this area.

The editors gratefully acknowledge all the hard work by the authors, the reviewers, and ACI staff, especially Ms. Barbara Coleman, who have helped very enthusiastically during every stage of the process. The editors also thank members of ACI Committees 447 and 370 for their continuous support in reviewing the papers.

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PARAMETERS INFLUENCING FINITE ELEMENT RESULTS FOR CONCRETE STRUCTURES

Joseph M. Magallanes, Youcai Wu, Shengrui Lan, and John E. Crawford

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Synopsis: It is widely recognized that a competent constitutive model for concrete, and a set of calibrated parameters for it, are important to producing accurate response predictions using the finite element method (FEM). What is not obvious, without having access to a large database of test data and practical experience using and validating the FEM models, is that a host of parameters for the FEM calculation can significantly influence the results. The objective of this paper is to identify these parameters and illustrate their effect by computing the response of some simple concrete structure tests subject to transient loads. Calculations for each of these structures demonstrate that in addition to some of the more nuanced material model parameters, parameters involving boundary conditions, hourglass energy suppression, interface friction, and loading-rate effects, all have a strong effect on the response predictions. The results demonstrate that any of four concrete constitutive models considered in this paper can be used to match any one set of test data, even though they differ in their assumptions and the behaviors modeled through their formulation; however, it is difficult to match the larger set of data without carefully considering each of these parameters. Guidance is provided to produce meaningful computational results using the constitutive model developed by the authors.

Keywords: Concrete; Reinforced Concrete; Finite Element Method; Constitutive Model; Parameters; Transient Loads; Blast; Shock.

Joseph M. Magallanes, P.E., S.E. Joe Magallanes is President of Karagozian & Case, Inc. Mr. Magallanes has analyzed and designed a variety of structures subjected to extreme loads. His technical work at K&C is focused on developing and implementing physics-based models, validating them with test data, and using them to support designs, assessments, and product development. He obtained his Bachelor's and Master's degrees in Civil Engineering and Structural Mechanics from the U.C. Berkeley and is a licensed Civil and Structural Engineer in the State of California.

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Shengrui Lan, Ph.D. Dr. Shengrui Lan is a Principal Engineer at Karagozian & Case, Inc. He has 20 years' experience in structural engineering, focusing on finite element analysis of structures under static, dynamic, blast and impact loads. He was a key member of a team awarded the prestigious Defense Technology Prize by the Ministry of Defense, Singapore, 1999.

John E. Crawford, P.E. John Crawford is a Senior Principal at Karagozian & Case, Inc. He has provided engineering services related to blast and shock effects for over 40 years to a variety of government agencies, building owners, and engineering and architectural firms. This work includes designing structural and mechanical systems to resist extreme blast and impact loads; developing engineering tools and first principle finite element codes; and testing components and systems with blast and impact loads.