Awarded Contracts for External Experts to Support the NIST World Trade Center (WTC) Disaster Investigation

Contract No.	Awarded to	Date Awarded
SB1341-06-8-0539	Applied Research Associates	8/22/2006

WTC 7 STRUCTURAL ANALYSIS AND COLLAPSE HYPOTHESES, CONTRACT MODIFICATIONS FOR STRUCTURAL AND BLAST ANALYSES

Under GSA Contract number GS23F0278M, NIST Order No. SB1341-06-8-0539, as a firm fixed price effort, has been awarded to APPLIED RESEARCH ASSOCIATES, INC. (ARA) of Albuquerque, New Mexico, to append the following tasks to the original contract awarded on March 31, 2006. Under the appended tasks, the ARA (1) shall conduct analyses of impact damage and fire effects to provide candidate initiating events which may lead to structural failures and global collapse, and (2) shall determine if there is any scenario of a hypothetical blast event or events that could have occurred in WTC 7 on September 11, 2001.

As part of determining likely modes of failure in WTC 7, impact by falling debris from WTC 1, fire events, and hypothetical blast events are being considered for their contribution to the collapse of WTC 7. NIST has documented debris damage and fire growth and spread in WTC 7, based on available evidence. NIST is analyzing scenarios for the event that initiated the collapse of the building. As a part of this work, NIST is considering whether hypothetical blast events could have played a role in initiating the collapse. While NIST has found no evidence of a blast or controlled demolition event, NIST would like to determine the magnitude of hypothetical blast scenarios that could have led to the structural failure of one or more critical elements as a result of blast.

ARA is an engineering firm founded in 1979 that performs research and design studies for complex defense, security, environmental, transportation, and readiness problems. This study will be managed from the Silicon Valley Office of ARA that specializes in finite element analysis and nonlinear structural dynamics under blast and impact loading, impact and penetration mechanics, failure analysis, and blast effects and the analysis of progressive collapse in buildings. ARA is partnering with Simpson Gumpertz & Heger Inc. (SGH) of Waltham, Massachusetts, to conduct the appended tasks, and with Loizeaux Group International (LGI), the consulting services branch of Controlled Demolition Incorporated (CDI) of Phoenix, Maryland.

SGH is an engineering firm that specializes in design, investigation and retrofit of buildings and structures of all types. SGH has expertise in building structures, materials, and investigations and conducted the thermal-structural response analyses of each WTC tower, as part of their contract for the WTC towers investigation.

Loizeaux Group International (LGI) has expertise in a wide range of demolition, explosion and explosives-associated technology. This includes explosive processes and their direct and collateral effects of blast and resulting vibration, projectiles, and overpressure. They have conducted investigations involving commercial explosives, terrorist devices, commercial gas, and industrial accidents involving dusts, hot metals, and combustion processes.

The specific tasks that ARA will perform with SGH (task 1) and LGI (task 2) include:

1. Identify and analyze hypothetical blast scenarios in three phases, with the results from each phase being used to decide if the analyses in the next phase is required:
    A. Identify hypothetical blast scenarios, using analysis and/or experience, to determine conditions that would fail specified column sections by direct attachment of explosive materials.
    B. Analyze the overpressure produced by the blast load and determine if the overpressure would have failed windows in WTC 7.
    C. Determine if the overpressure would result in sound levels transmitted through intact WTC 7 windows that could be heard outside the building.
2. Conduct the following analyses using a three-dimensional ANSYS model (provided by NIST) of the lower 16 floors of WTC 7:
    A. Review the ANSYS model provided by NIST for conducting structural analysis of damage to components and the effect of time-varying temperatures. Identify possible revisions/improvements to the ANSYS model that may improve efficiency, accuracy and/or capture of critical failure modes.
    B. Work with NIST staff to incorporate agreed upon changes to the ANSYS model.
    C. Determine the structural response of WTC 7 for up to six scenarios of structural damage from debris impact and temperature histories provided by NIST. NIST will conduct analyses of other scenarios in parallel. Work with NIST to identify the structural response and failure modes for each analysis.

The ARA team has expertise and experience in failure analysis, nonlinear structural analysis, damage of steel and concrete structures, progressive collapse analyses, nonlinear constitutive and damage modeling, analysis of structures subjected to thermal loads, and blast effects on structures. The team will be led by Dr. Steven W. Kirkpatrick. Select experience of key project personnel is summarized below:

- Dr. Steven W. Kirkpatrick is the program manager for this project. Dr. Kirkpatrick is a Principal Engineer with 21 years of experience in structural dynamics, failure analysis, finite element analysis, impact and blast/penetration mechanics, and vehicle crashworthiness. He has more than 40 publications in these areas. His research experience includes a wide range of government and commercial projects for rail, highway, civil, military, and aerospace applications. He has been a program leader for many studies requiring close collaboration between experimental and computational efforts with emphasis on model validation. Dr. Kirkpatrick was previously the PI for the ARA participation in the NIST WTC investigation in performing the aircraft impact analyses. Dr. Kirkpatrick has a doctorate in mechanical engineering from Stanford University.
- Mr. Charles Needham is a Principal Engineer for the Southwest Division of ARA. He has experience with numerical hydrodynamics, shock, fireball and thermal effects modeling, conventional explosives and munitions effects and structure interaction, explosive safety and storage. He has 14 years specific experience with SHAMRC, a state-of-the-art hydrodynamic code for two- and three-dimensional fluid dynamics problems with applications for conventional munitions. Mr. Needham has a master's degree in astrophysics from the University of New Mexico.
- Mr. Joseph Crepeau is a Principal Computer Scientist for the Southwest Division of ARA. His responsibilities include the maintenance and development of features for SHAMRC, as well as training for its applications. Mr. Crepeau has a master's degree in computer science from the University of New Mexico.
- Ms. Lee Ann Young is a Principal Engineer I for the Southwest Division of ARA. She has spent the last 14 years at ARA working in the areas of human vulnerability to explosions, penetration mechanics, and conventional weapon effects. Ms. Young has a master's degree in applied statistics from the University of New Mexico.

- Dr. Mehdi Zharghamee is a Principal and Head of the Engineering Mechanics and Infrastructure Division at SGH and has 30 years of engineering experience in analysis and design of precision structures. He has been responsible for analysis, design, and failure investigation of complex structural and mechanical systems. Dr. Zarghamee has a doctorate in structural engineering from the University of Illinois and his S.M. in Mathematics from the Massachusetts Institute of Technology.
- Dr. Omer Erbay is a Senior Engineer with SGH and has experience with the analysis of the structural response of the WTC towers to impact damage and fire conditions and structural analysis of buildings and bridge piers. Dr. Erbay has a doctorate in structural engineering from the University of Illinois.
- Frank Kan, a Senior Project Manager, has been with SGH for 16 years. He has been involved in structural and seismic analysis, design, and investigation of buildings, bridges and special structures. Mr. Kan received his M.S. in Civil Engineering from the Massachusetts Institute of Technology.
- Mr. Mark Loizeaux is CEO of LGI and President of CDI, and has been responsible for the design and performance of CDI's projects since 1976, including the felling of major steel industrial, commercial and office buildings across the United States and internationally. Several of these buildings were major structures up to 439 ft tall, with column flanges ranging from 6 in. thick (laminated steel flanges) to 4 in. thick (hot-rolled flanges). His experience with steel structures includes the demolition of major steel bridges and construction and communication towers as tall as 1,200 ft. He is responsible for all aspects of CDI explosives demolition design and control of related consequences, including control of fly of debris, air overpressure, vibration and debris impact on surrounding structures. He has been recognized as an expert in demolition and explosives operations in U.S. Federal Court and the Courts of Australia.