October 13, 2013

An Important note from the Principal Investigator Abolhassan ASTANEH-ASL, on the document that follows:

Following document is a report I wrote on my testimony before the Committee on Science of House of Representatives at its World Trade Center Hearings held on March 6, 2002. I wrote the report after testifying on March 6, 2002 and returning from Washington D.C. to Bay Area.

Respectfully,

Abolhassan ASTANEH-ASL, Ph.D., P.E.

Professor and P.I. for the NSF Funded UC Berkeley WTC Project

An Executive Summary Report on

"Congressional Hearing on World Trade Center, March 6, 2002"

By UCB Faculty Participant:

Abolhassan Astaneh-Asl, Professor,
Department of Civil and Environmental Engineering
College of Engineering, University of California, Berkeley
(Astaneh@ce.berkeley.edu)

On March 6, 2002, the Committee on Science of the U.S. House of Representative held a hearing on: "Lessons Learned from Ground Zero" (www.house.gov/science). The 3.5 hours hearing was held on the investigation into the collapse of the World Trade Center (WTC). The witnesses who testified at the hearing (including the author) were: Mr. Robert Shea, Acting Administrator Federal Insurance and Mitigation Administration, Mr. Craig Wingo, Director of Division of Engineering Science and Technology, Federal Emergency Management Administration, Dr. W. Gene Corley, P.E., S.E., American Society of Civil Engineers, Professor Glenn Corbett, Assistant Professor of Fire Science at John Jay College, New York City, Professor Abolhassan Astaneh-Asl, Ph.D., P.E., Professor, Department of Civil and Environmental Engineering University of California, Berkeley and Dr. Arden Bement, Director, National Institute of Standards and Technology.

A. Astaneh (2nd from right) Testifying Before Committee on Science

Congressman Boehlert (right), Chair and Congressman Hall, Ranking member of the Committee on Science, U.S. House of Representatives

The witnesses were asked to submit a written testimony answering specific questions asked by the Committee on Science and summarized the written statement at the beginning of the hearing with question and answer to follow. The entire hearing was web-cast live on www.house.gov/science. The hearing charter, written testimonies of the witnesses and a video recording of the entire hearing can be found at www.house.gov/science. The author's written testimony is attached to this report as Appendix.

This document is part of the **"World Trade Center Post-Disaster Reconnaissance and Perishable Structural Engineering Data Collection"**, a research project funded by the U.S. National Science Foundation at the Univ. of California Berkeley with Prof. Abolhassan ASTANEH-ASL (http://www.ce.berkeley.edu/~astaneh) as the Principal Investigator. Duration of the project was from 10/2001 to 9/2002. Further Information and project archives are at http://lib.berkeley.edu/ENGI/WTC.

According to the hearing charter released before the hearing (www.house.gov/science): *"The Committee plans to explore several overarching questions raised by the collapse and the ensuing investigation:*

1. *What have we learned about how the federal government investigates catastrophic building collapses, and are any changes warranted?*

2. *What have we learned about the collapse of the World Trade Center, including which structural elements failed first, and why?*

3. *How will we know what changes, if any, are warranted in building and fire codes as a result of lessons learned from the World Trade Center's collapse?*

4. *Has the World Trade Center disaster exposed any gaps in our understanding of buildings and fire, and are changes needed in the federal government's research agenda? "*

In the aftermath of 9/11 tragedy, there were two groups of investigators studying the collapsed WTC structures. The author, funded by the National Science Foundation started his field investigation of the structure just one week after the collapse. The second team to start field investigation was ASCE team funded by the FEMA which first visited the site in early October . Following is an excerpt from the hearing charter (www.house.gov/science) on NSF-funded research projects including author's work on structural aspects of theWTC collapse.

"Researchers supported by the National Science Foundation are used to mobilizing rapidly after an earthquake and arriving on scene soon after the event to begin collecting data. Recognizing the similarities between the WTC disaster and earthquakes, NSF program managers awarded nearly $300,000 to experienced earthquake researchers, including engineers and social scientists, to begin an analysis of the 9/11 terrorist attacks within 72 hours of the events. In an effort to quickly deploy researchers to the site, awards were made through the Small Grants for Exploratory Research Program, a supplemental award program that enables NSF program managers to award additional support to currently-funded investigators through an abbreviated internal review process (see Appendix A for a list of awards).

The efforts of NSF-funded researchers were impeded by the same obstacles the BPAT team encountered: an inability to examine the steel, either removed from the site during the early search and rescue work or shipped to recycling plants, and the denial of access to building design, construction and maintenance documents. Interestingly, it was an NSF-funded researcher*[A. Astaneh*] *who ultimately negotiated the arrangements by which he and others investigating the disaster were provided access to the remaining pieces of steel at the recycling plant.

To date,*[March 6, 2002] *the NSF-funded researchers continue to face problems. They continue to be denied access to important building diagrams and blueprints, and so are unable to complete their analyses or develop the computer models necessary to better understand the failure of the buildings structural elements. Perhaps more importantly,

without these computer models, engineering researchers will be unable to develop effective mitigation strategies (Excerpt from the Hearing Charter of Committee on Science Hearing on WTC, 3/6/02) "

Two of the issues that surfaced at the hearings were (a) the fact that in order to obtain the building blue prints, the ASCE/FEMA Building Performance Assessment Team had signed an agreement not to testify against the Port Authority of New York and New Jersey (PANYNJ), the original owners and builder of the World Trade Center and (b) the confidential nature of the ASCE/FEMA team's studies. The ASCE/FEMA team was strongly criticized for both undertakings by the Committee on Science. To preserve the objectivity of my investigations into the collapse of WTC, I had refused to sign such agreements. As a result, I was denied the drawings. However, after the hearings, thanks to the efforts of FEMA and PANYNJ, in mid-April I received the blueprints without any restriction placed on their use or release of our research results. Currently, our team is in the process of building a realistic non-linear computer model of the north tower of the World Trade Center and a Boeing 767 airplane to subject the realistic model to the impact of the 767 plane and the ensuing fire. The final objectives are to understand what happened on 9/11 and why? In addition and more importantly, we want to learn lessons from the collapse of WTC to apply to other structures to prevent such tragedies from happening in the future.

In the analysis, first, we will subject the WTC tower in its "as-was" condition to the impact of 767 and ensuing fire. After being successful in simulating the impact, the ensuing fire and the collapse, we will alter the structure and use more robust systems and subject the improved structure to the impact of 767 and ensuing fire. The robust systems will include adding more fireproofing, replacing the walls around the core, which were gypsum walls with reinforced concrete, steel plate and composite shear walls. The idea is to see if with relatively minor changes in fireproofing and protection of egress routes the collapse of the towers could be prevented and more people could be saved.

Acknowledgements: The efforts of Program Directors at the National Science Foundation in particular Dr. Priscilla Nelson, Dr. Peter Chang and Dr. Richard. Fragaszy in immediately processing, reviewing and funding the author's proposal to collect perishable data and to study WTC is sincerely appreciated. Also, the efforts of staff of the Institute of Transportation Studies, Engineering Library and Sponsored Project Office of the University of California, Berkeley, in particular Susan Gardener and Jean McKenzie in assisting the author in preparation of the proposal and its submittal in a very short time was essential to starting the investigation in time and before the valuable data was lost.

A. Astaneh Testifying Before the Committee on Science

Appendix

From: www.house.gov/science

Testimony of
Dr. Abolhassan Astaneh-Asl
Professor
Department of Civil and Environmental Engineering
University of California, Berkeley

Before the Committee on Science of the U.S. House of Representatives

March 6, 202 Hearing on

"Learning from 9/11: Understanding the Collapse of the World Trade Center"

It is a great honor for me to testify here today and address specific questions listed in your letter (in *Italic below)* regarding my involvement in the post disaster investigation of the World Trade Center.

- *What role did you play in the investigating the collapse of the WTC buildings and what do you expect to produce from your effort? How did you arrange NSF funding for your work, and how was that arranged so quickly?*

My involvement in the investigation of the collapse of the World Trade Center is to conduct a reconnaissance of the collapsed and damaged WTC buildings and to collect the perishable data. The main objectives of the reconnaissance are to learn as much as possible from the actual collapsed structures and to document the failure modes and performance of the members and connections as well as quality of the construction. The purpose of collecting the perishable data is to collect material samples, photographs, videotapes, drawings and data on design, construction and collapse. Using the information collected and by conducting the necessary analyses and research, we try to establish probable causes of the collapse and most likely scenario for such collapse.

Our project was funded by the Directorate of Engineering of the National Science Foundation as one of the eight Quick Response Research Awards in the aftermath of the WTC collapse. These projects focus on structural engineering (our project at UC-Berkeley), fire engineering, social aspects and response and recovery. More information on these projects can be found at www.nsf.gov. We prepared and submitted our proposal to the National Science Foundation three days after the 9/11 events and it was reviewed and funded by the end of the

week. The credit for such a fast preparation, submittal, review and funding of these research projects should be given equally to the staff at the universities involved as well as the Program Directors and staff of the National Science Foundation. The use of "Fastlane" electronic submittal process of the NSF also expedited the process tremendously.

So far, I have made three trips to NYC and spent a total of about 25 days there conducting field investigation and collecting data. Upon arrival to NYC on September 19, and after visiting Ground Zero and paying my respects and prayers to the victims, I started my reconnaissance and collection of the perishable data. I have collected some data on design and construction of the WTC and have met and discussed the case with the structural engineers who have designed the WTC Buildings. Thanks to cooperation of the HSNE recycling plant, I have been able to study the steel from the WTC before recycling. I have identified and saved some components of the structures that appear to have been subjected to intense fire or impact of fast moving objects. Figures 1 through 4 show examples of inspected structures. These critical pieces are saved as perishable data and can be used in future research.

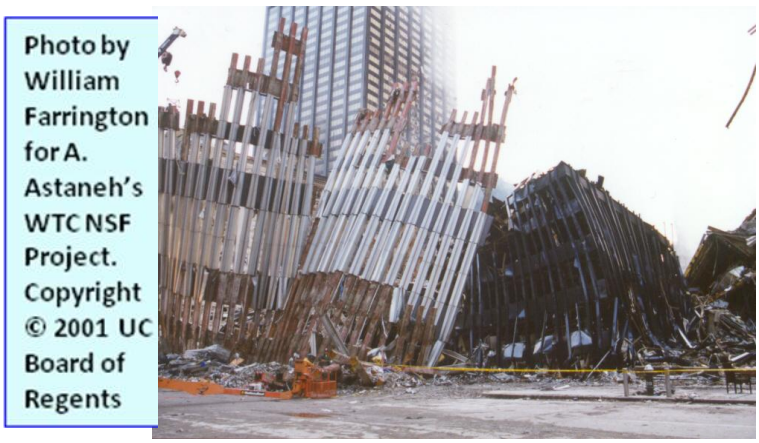

Photo by W. Farrington for A. Astaneh's NSF Report

Fig. 1. Collapsed exterior walls of WTC towers

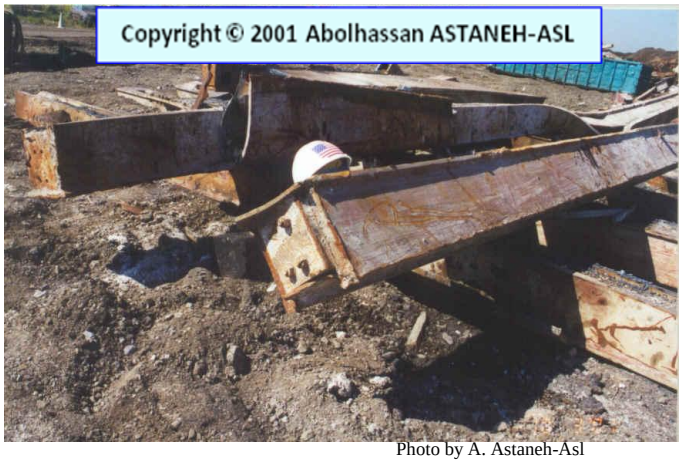

Photo by A. Astaneh-Asl

Fig. 2. A critical connection of exterior columns of WTC

Photo: A. Astaneh-Asl

Fig. 3. Exterior columns of WTC towers probably buckled after being subjected to intense heat.

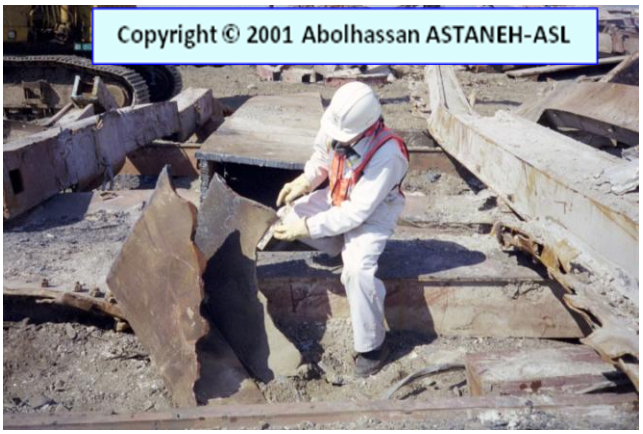

Photo: HNSE

Fig. 4. A. Astaneh inspecting an internal column of WTC which has been hit with a round object

- *Please describe the impediments that you encountered during the investigation of the collapse of the WTC buildings, such as the loss of material from the WTC site and any effects of such impediments on your work.*

I wish I had more time to inspect steel structure and save more pieces before the steel was recycled. However, given the fact that other teams such as NIST, SEAONY and FEMA-BPAT have also done inspection and have collected the perishable data, it seems to me that collectively we may have been able to collect sufficient data. The main impediments to my work were and still are:

1. Not having a copy of the engineering drawings and design and construction documents.
2. Not having copies of the photographs and videotapes that various agencies might have taken during and immediately after the collapse.

Such data has already been made available to ASCE Building Performance Assessment Team. If those are also available to us, we will be able to proceed further with our research. Figure 5 shows an example of analysis of performance of generic steel high-rise structure subjected to the impact of a 747 jetliner and the ensuing fire. The example demonstrates the power of advanced technology developed in aerospace and mechanical engineering that can be brought to bear on this problem. We plan to use the drawings and the data and the software used in the example to build a computer based realistic model of the World Trade Center towers and analyze their response to simulated impact of the 767 planes that crashed into them on 9/11 and the ensuing fire.

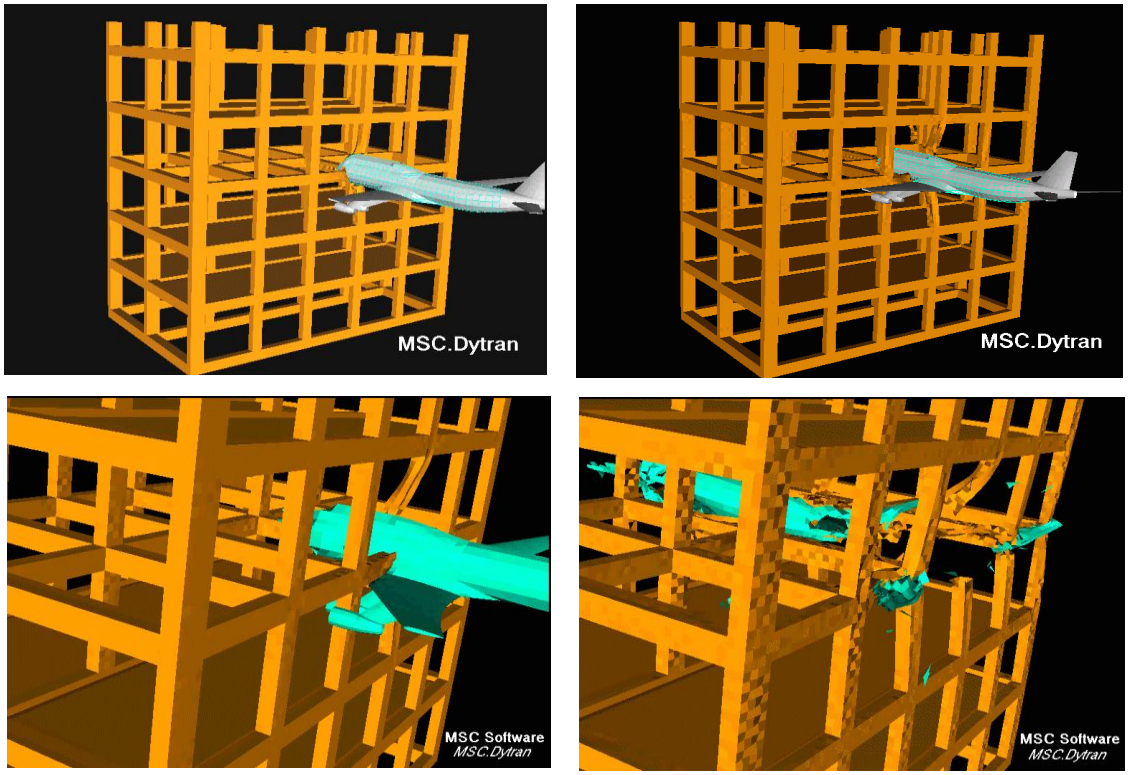

Fig. 5. Results of simulation analysis of impact of a 747 jetliner crashing into a steel structure. Notice fracture of the steel column and breaking of the plane due to dynamic stresses
(Graphics and analysis by MSC Software Corporation)

- *should the Federal Emergency Management Agency (FEMA) and/or Congress develops a more comprehensive protocol for how to conduct investigations in response to natural disasters and/or terrorist attacks?*

The earthquake engineering community has conducted post disaster investigations very successfully and systematically within the Earthquake Engineering Research Institute and funded by NSF and FEMA for several decades. As a result of such post-disaster investigations, the lessons learned and the continued research and technology developments, great advances have been made in mitigating earthquake hazard. The approach taken in earthquake engineering can equally be applied to investigation of damage due to terrorist attacks as well as to minimizing consequences of such attacks. Due to criminal nature of terrorist attacks and higher priority placed on criminal investigation over engineering investigation, it appears that there is a need for a protocol to govern the availability of information and access to the site as well as interaction of the crime investigators and researchers investigating the scientific and engineering aspects of the terrorist attacks.

- *what areas of research into the WTC collapse still need to be addressed, and what is the most appropriate way to handle these needs?*

There are short term and long-term research needs into the WTC collapse. In short term, there is a need for a comprehensive, in-depth and research-oriented study of the WTC buildings from the time of plane impact, through the ensuing fire and the final collapse. Such studies not only should focus on structural and fire engineering aspects, but also social and human aspects of the tragedy as well. A broad based team of researchers and engineers from academia, government agencies and private sector, with expertise in various aspects of the problem need to be assembled to conduct such studies. In my opinion, such studies need to be directed by federal entities such as National Science Foundation (NSF) and/or National Institute of Standards and Technology (NIST) that are involved in directing and conducting scientific and engineering research. In December, the National Science Foundation sponsored a workshops organized by the Institute for Civil Infrastructure Systems of the New York University to identify research needs for future research related to WTC. A list of workshop recommendations can be found at www.nsf.gov. I participated at the workshop and feel that funding research in those areas will result in learning many valuable lessons from this tragedy and will result in significant improvements in the structural design, construction, fire protection, evacuation, fire fighting, rescue and recovery efforts, debris removal and many other aspects of protection of buildings and occupants against terrorist attacks.

In the long term, there is a need for major and sustained funding to conduct basic and applied research on various aspects of terrorist attacks. Such research activities can result in development of scientific methods and technologies to assure life safety, prevent catastrophic collapses and massive loss of lives and minimize the impact of such attacks on the national economy and security. Last months, NIST held a workshop to identify research needs related to evaluation of performance and protection of buildings during intense fires. I also participated at this workshop and feel that the research areas identified at the workshop are very important in providing engineers and architects with the technologies to protect tall buildings, their occupants and firefighter and rescuers against catastrophic fires and resulting collapse.

In the aftermath of 9/11 tragedy and the hazard posed by terrorist attacks to public safety and the economical well being of the U.S. is not much different than the hazard posed by other "extreme

events' such as major earthquakes three or four decades ago. In the case of seismic hazard mitigation, Congress, by providing sufficient funding to the National Science Foundation and other agencies involved, has enabled research and engineering community to develop efficient and economical technologies to mitigate seismic hazard and to prevent catastrophic loss of lives. To prevent catastrophic consequences of terrorist attacks, we need to develop and fund a long-term plan of research, perhaps modeled after seismic research programs developed and supported over the years by NSF and FEMA, and in the field of protection of built environment against terrorist attacks.

- *has the confidential nature of the FEMA's Building Performance Assessment Team investigation made it more difficult to gain access to materials that might be useful, such as private videotapes?*

I have not been provided with the information made available to the FEMA Building Performance Assessment Team. This includes videotapes and photographs taken on 9/11and the following days and copies of the engineering drawings. At this time, having the videotapes, photographs and copies of the drawings not only is useful, but also is *essential* in enabling us to conduct any analysis of the collapse and to formulate conclusions from our effort.

I have been the Principal Investigator in conducting research on damage and collapse of several major buildings and bridges in the aftermath of earthquakes. I understand and respect the concerns of owners, designers, builders and those who are responsible for safe operation of these structures for possible legal ramifications of findings of our research investigations. However, the main objective of our research is to understand how the WTC buildings failed and learn lessons that can be used to prevent such collapses in the future. Never before my research results have been used in any legal proceedings. However, to allay any concerns that any findings of our research project might increase the liabilities of the City, Port Authority or Silverstein, the data on these structures could be provided to the Principal Investigator (myself) on a propriety basis. The Principal Investigator would keep the data and provide the other members of the research team with the information on a need-to-know basis. I have followed similar procedures to the satisfaction of parties involved in conducting research on major buildings and bridges subjected to earthquakes and blasts due to terrorist attacks.

I would like to take this opportunity and thank Chairman Boehlert and members of the Committee on Science for inviting me to testify. I would like now to welcome any questions that you may have.

(End of A. Astaneh's statement)