National Earthquake Hazards Reduction Program
Advisory Committee on Earthquake Hazards Reduction
National Institute of Standards and Technology
Gaithersburg, Maryland
February 28, 2013

Conference Call Meeting Summary

Advisory Committee Members:

Chris Poland, Chair	Degenkolb Engineers
Norman Abrahamson	Pacific Gas & Electric Company
James Beavers	James E. Beavers Consultants
Craig Davis	Los Angeles Department of Water & Power
Richard Eisner	Retired
Robert Herrmann	Saint Louis University
John Hooper*	Magnusson Klemencic Associates
Laurie Johnson	Laurie Johnson Consulting
Michael Lindell*	Texas A&M University
Ronald Lynn*	Clark County (NV) Department of Development Services
Jack Moehle	University of California, Berkeley
Kenneth Stokoe	University of Texas at Austin
Brent Woodworth*	Emergency Preparedness Foundation
Mary Lou Zoback	Stanford University
Ralph Archuleta	Ex-officio member of ACEHR as Chair of USGS Scientific Earthquake Studies Advisory Committee

* Not in attendance

NEHRP ICC Member-Agency Representatives and NIST Support:

Shyam Sunder	NIST, Engineering Laboratory Director and ACEHR Designated Federal Official
Howard Harary	NIST, Engineering Laboratory Deputy Director
Jack Hayes	NIST, NEHRP Director
Steve McCabe	NIST, NEHRP Deputy Director
Eric Letvin	NIST, Director of Disaster and Failure Studies Program
Jason Averill	NIST, Program Coordination Office
Tina Faecke	NIST, NEHRP Secretariat
Ed Laatsch	FEMA, Chief, Building Science Branch
Dennis Wenger	NSF
Brian Garrett	BRI Consulting Group

Guests:

Heather Gordon	FEMA contractor
Paula Gordon	Consultant, researcher, and educator

Summary of Discussions

I. Review Meeting Goals and Agenda

Chris Poland, Chair of the Advisory Committee on Earthquake Hazards Reduction (ACEHR), asked Tina Faecke to call the roll of committee members and others in attendance. The Chair welcomed guest attendees to the audio portion of this teleconference. The purpose of the meeting was to review and finalize ACEHR's 2013 draft report on NEHRP effectiveness. The draft report was posted on the NEHRP web site and also displayed on a WebEx videoconferencing site accessed by the attendees for real-time editing during this discussion.

ACEHR will submit a final report, in the form of a letter, to the National Earthquake Hazards Reduction Program (NEHRP) Interagency Coordinating Committee (ICC).

II. Public Input Period

The Chair acknowledged that a member of the public, Paula Gordon, requested in advance to make a statement to the committee during the public input period, following the committee's discussion. Dr. Gordon read aloud a statement that included a question and a recommendation relating to the safety of nuclear power facilities in seismically active areas and areas vulnerable to tsunamis. A written transcript of the statement was also submitted by Dr. Gordon and is attached to this meeting summary. The Chair thanked Dr. Gordon for her input and suggested that the committee consider the statement at its next regular meeting.

IV. Adjournment

Shyam Sunder announced that the terms of two committee members, Chair Chris Poland and Rich Eisner, are coming to an end. Both individuals have served on ACEHR since 2007. Dr. Sunder thanked them for their service on behalf of NEHRP, the NEHRP agencies, and the ICC. He also thanked Chris Poland, on behalf of ICC Chair Patrick Gallagher and his predecessor, Bill Jeffries, for the dynamic and proactive leadership that Mr. Poland has provided to the committee, and for his contributions in articulating and championing the work of NEHRP. Mr. Poland thanked Dr. Sunder for his remarks and stated that his experience with ACEHR has been rewarding because the committee has been able to help move NEHRP forward. Mr. Eisner thanked the NEHRP agency representatives who have briefed the committee on their work over the years, as well as the many individuals, with Chris Poland preeminent among them, who have served on the committee since 2007.

Other members of the committee also thanked Mr. Poland and Mr. Eisner for their service, and asked how the committee will fill the "big shoes" left by the departing Chair. Dr. Sunder responded that ICC Chair Gallagher will appoint a new ACEHR chairperson in consultation with the ICC, and that the NEHRP Secretariat will confer with that individual regarding the timing of the next ACEHR meeting. The Chair then adjourned the meeting.

Statement by Paula D. Gordon, Ph.D.[i]

To the Advisory Board of the Earthquake Hazards Reduction Program

February 28, 2013

Thank you for this opportunity to make a statement at this meeting of the Advisory Committee of the Earthquake Hazards Reduction Program.

I would like to raise a question and make a recommendation. These pertain to some issues raised in a review piece of mine that some of you may have seen. The review piece was recently published in the **Journal of Physical Security** and is entitled "The Japan Earthquake and Tsunami ~ Their Implications for the U.S." [ii]

I believe that a solid case can be made and has been made that those individuals, primarily structural engineers, who set the safety standards used for building nuclear power plants in the U.S, including plants in seismically active areas, that those individuals did so without adequately taking into consideration mechanical engineering principles, specifically the implications that mechanical engineering principles have for setting the standards for the bearing clearances in rotor bearing systems in nuclear power plants, including primary fluid coolant pumps and generators and other rotor bearing systems that could become projectiles in an earthquake and damage the reactors and the facilities. If this is the case then, such nuclear power plants will not likely withstand even the magnitudes of earthquakes that they have been built to withstand, let alone earthquakes of higher magnitudes and tsunamis that could accompany those higher magnitude earthquakes.

My question and recommendation to you and to others in the executive and legislative branches of government are as follows:

Shouldn't this serious matter be addressed not only by those who have regulatory responsibility in the Nuclear Regulatory Commission (NRC), but shouldn't this matter be addressed as well, by the Earthquake Hazards Reduction Program along with the Interagency Coordinating Committee (ICC) and others with relevant responsibilities in other parts of the government? That includes those with responsibilities for prevention, mitigation, and emergency management; including preparedness, response, and recovery, responsibilities that should become a matter of concern now owing to the potential catastrophic impacts that higher magnitude earthquakes could have on nuclear power plants in seismically sensitive areas of this country and the

potential impacts that accompanying tsunamis could have on plants located in coastal areas. It does not seem likely that one agency such as the NRC could possibly undertake all the protective, remedial and other actions that are needed. Awareness of the vulnerabilities that exist and commitment to taking appropriate actions should not be limited to the NRC alone. The creation of a Federal interagency task force would seem to be in order to raise awareness regarding the mechanical engineering principles that appear to have been overlooked in the setting of standards for building nuclear power plants in the U.S. and for configuring the bearing clearances in rotor bearing systems in nuclear power plants. Such a task force is needed for consolidating knowledge and expertise on these vulnerabilities and for taking appropriate action.

Thank you for the opportunity to raise this question and share this recommendation with you.

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[i] Paula D. Gordon, Ph.D. is an educator, researcher, writer, and consultant based in Washington, D.C. Specialty areas of hers include emergency management and homeland security. Two of her websites, GordonHomeland.com and GordonPublicAdministration.com, include extensive publications, reports, and presentations on the topics of homeland security and emergency management. She is currently teaching courses on homeland security and emergency management-related topics and public administration-related topics for several universities. One of the kinds of hazards that she has long been interested has been earthquakes. During the two years that she worked for FEMA as a full time consultant and the time she served at EPA as a staff officer, she became particularly interested in nuclear power plant vulnerability to earthquakes. As a result of her previous association with the Research Applied to National Needs Program of the National Science Foundation, she heard presentation by A. H. Soni, a researcher who had a grant from the NSF Earthquake Engineering Division. On becoming informed concerning the results of that research, she expanded her interest and over the years has had discussions concerning the implications of that NSF-funded research with individuals at the NRC and other places in government, academia, NGOs, and the nuclear power industry. The viewpoint paper **in The Journal of Physical Security** provides an overview of those some of the concerns that she has had regarding the safety of nuclear power plants in seismically sensitive areas in the U.S. Contact: pgordon@starpower.net .

[ii] Paula D. Gordon, The Japan Earthquake and the Tsunami: Their Implications for the U.S**.,**
The Journal of Physical Security 6(1), 1-9 (2012), http://jps.anl.gov/ (A copy accompanies this statement.)

Journal of Physical Security 6(1), 1-9 (2012)

Viewpoint Paper

The Japan Earthquake and Tsunami: Their Implications for the U.S.

Paula D. Gordon, Ph.D.

Auburn University Center for Governmental Services and
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Department of Safety, Security & Emergency Management

What can be made of the Japanese 9.0 earthquake and tsunami that occurred in March of 2011? What can be made of the assessments of the damage done to date, of ongoing damage to nuclear reactors there, and what are the possible consequences following from that ongoing damage and the implications for the safety of nuclear power plants in the U.S? In addition, what are the implications for nuclear security in the aftermath of an earthquake of devastating proportions beyond the magnitudes that nuclear facilities have been built to withstand?

There are differences in the views of experts making assessments concerning the extent of damage and the consequences of the damage, the potential for continuing damage and the consequences and implications of the damage that can potentially occur as a result of high magnitude earthquakes. There are differing views concerning the implications of the Japan Earthquake for the safety and security of nuclear power plants around the world, particularly those nuclear power plants built in seismically active areas, such as the faults near and along the West Coast of the U.S., in New York near New York City, and the New Madrid fault in the center of the U.S.

No nuclear power plant anywhere in the world appears to have been built to withstand an 8.3 or higher magnitude earthquake. According to Japanese power plant officials, some nuclear power plants in Japan, surprisingly enough, were only built to withstand an 8.2 earthquake at most.[1] Others have quoted lower figures.[2]

Even Los Alamos National Laboratory has shown a concern for seismic safety in planning a Chemistry Metallurgy Research Replacement Facility in Northern New Mexico. That facility in all likelihood will include involvement in nuclear and plutonium research. Current plans are to build a facility that will withstand an earthquake of up to 7.3 magnitude.[3]

According to one source, the nuclear power plants in California, San Onofre and Diablo Canyon, have not been built to withstand earthquakes that exceed 7.0 or 7.5 in magnitude respectively.[4] It is said that the Indian Point power plant which is located on a fault in New York has been built to withstand only a 6.0 magnitude earthquake.[5] (To the author's knowledge no nuclear power plant anywhere in the world has been built to withstand tsunamis generated by 8.3 or higher earthquakes.)

Tsunami threats aside, it is arguable, however, whether or not California nuclear power plants could withstand an earthquake that exceeded a 6.9 magnitude. The reason why these nuclear power plants would be unlikely to withstand an earthquake of this magnitude is owing to the way the plants have been constructed and the failure, according to some cutting edge mechanical engineering researchers, of those who set the standards used in configuring nuclear reactors and building nuclear power plants. According to these mechanical engineering researchers, those setting the standards for bearing clearances in primary fluid coolant pumps and generators and other rotor bearing systems in nuclear reactors have failed

to take fully into account gyroscopic and coriolis effects on moving systems in an earthquake of significant magnitude.[6,7]

In the 1980s and 1990s, a U.S. mechanical engineering research expert, A. H. Soni, whose work had been funded by the National Science Foundation, focused on the seismic analysis of rotor bearing systems, including primary fluid coolant pumps and generators involved in the day-to-day operation of nuclear reactors. His research indicated that while gyroscopic and coriolis effects on such systems were taken into consideration by earthquake engineers in Japan, they were not being taken into consideration by those responsible for setting standards for nuclear reactors in nuclear power plants in the U.S. According to Soni, the reason for this was that the academic and professional backgrounds of Japanese nuclear power plant engineers tended to be far more cross disciplinary than the backgrounds and academic training of the structural engineers in the U.S.[8] This is important in that in the U.S., the standards for nuclear power plants have tended to be set by structural engineers. According to the same source, structural engineers have tended to be at the top of the professional "pecking order" of U.S. engineering professionals and it is the structural engineers who have played the key role in setting power plant standards for nuclear power plants built in seismically sensitive areas in the U.S. As a result of these differences in background and knowledge, the standards for the bearing clearances in rotor bearing systems including primary fluid coolant pumps and generators and other rotor bearing systems in Japanese power plants were mounted differently than those in U.S. power plants. This was done to prevent the likelihood of such pumps and generators and other rotor bearing systems becoming projectiles in an earthquake and damaging the reactor and the facility.

In the 1980s and 1990s, several individuals, including Professor Soni, attempted to raise awareness concerning these matters. He felt that the Nuclear Regulatory Commission (NRC) had not adequately understood these concerns and had not brought adequate attention to them. In an August 7, 1992 letter to this author, Soni summed up the implications of his work and his 1984 article on the seismic analysis of rotor bearing systems as these pertained to nuclear reactors[9] as follows:

> While most of the research is done to advance the fundamental understanding of the system, nothing has been done anywhere in the public domain knowledge to develop standards for the bearing clearances in the primary fluid coolant pump, the generator (..and other systems) that are involved in the day-to-day operation of a nuclear reactor. It is a very serious problem in the maintenance and upkeep of a reactor power plant. During seismic activities, this pump may have a breakdown and possible leak of the radioactive primary fluid. Such things may even happen during normal operation when proper maintenance procedures are not (followed). Hence, the problem is of a very serious nature...[10]

Soni gave briefings and spoke with individuals in major roles of responsibility in government. Other individuals shared the implications of Soni's research with others in government and industry in the U.S. These efforts apparently had little or no success in raising awareness. NRC officials as well as U.S. industry officials were not open to considering the work or the implications of the work done by Professor Soni. In fact, some NRC officials in the research development branch had expressed the view to this author that the Professor was likely an intervener.[11] In fact, the Professor had no political agenda whatsoever.[12]

The climate today seems only slightly more hospitable for ongoing efforts to raise awareness of these concerns for the safety of nuclear reactors and nuclear power plants in seismically sensitive areas in the U.S. The Japan Earthquake and Tsunami that have triggered the Fukushima nuclear power plant disaster have opened the eyes of many concerning comparable risks and vulnerabilities in the U.S. Owing to the scientific and technological complexities surrounding nuclear power plants and nuclear power plant safety, many of those in positions of responsibility in government and industry have turned to experts whom they assume understand these complexities. The following questions arise:

What is the basis of the understanding of these experts?

Are these experts equally knowledgeable concerning both structural and mechanical engineering principles?

Do they recognize that those setting the standards for the building and configuration of nuclear reactors in nuclear power plants in seismically sensitive areas in the U.S. have not tended to take into consideration seismic analysis of rotor bearing systems and mechanical engineering principles?

Do they know that there are questions concerning whether or not nuclear power plants in the U.S. can withstand earthquakes of the magnitudes that structural engineers have assumed were sufficient?

There are disasters such as the Challenger Disaster, the Kansas City Hyatt walkway collapse and the Minneapolis bridge collapse where after action reports and assessments were done to try to determine the exact reasons for the failures. Experts from various relevant disciplines

were convened. The conclusions reached by those voicing a "majority opinion" in the reports have sometimes overshadowed or even drowned out a "minority" viewpoint. In the case of the Challenger Disaster Commission deliberations, Richard Feynman, the renowned physicist, a minority of one, provided a simple explanation of the causes of failure: the failure of the O-rings owing to the frigid temperatures at the time of the launch. His assessment echoed Roger Bojoly's pre-launch warnings. Bojoly was an engineer who had vehemently warned against launching in cold conditions owing to the likely failure of the O-rings.

Professor Soni who passed away several years ago was like both Roger Bojoly and Richard Feynman with respect to their prescience and perspicacity. Warnings implicit as well as explicit in his government-funded research that should have been listened to and acted upon apparently have not been heard. One hopes that all those with responsibilities for the safety of nuclear power plants as well as other nuclear facilities will call on a wider circle of experts when determining risks and vulnerabilities and that such circles of experts will be facilitated by generalists who are not closed-minded or untutored when it comes to the pertinence of all relevant and essential areas of expertise. In the case of the safety and security of nuclear power plants, this would include the expertise of those on the cutting edge of mechanical engineering.

If it is indeed the case that there is no certainty at present that nuclear power plants built in seismically sensitive areas in the United States will even be able to withstand the magnitude of earthquake they were built to withstand, nuclear safety and nuclear security and, hence, public safety are at far greater risk than most individuals have imagined or presently imagine. Given the possibility of worst case scenarios such as the events that occurred and continue to unfold in Fukushima and given the possibility of higher, presently unplanned for, magnitudes

of earthquakes that could occur in the U.S., matters involving nuclear power plant safety and security surely need to be more seriously reviewed and rigorously reconsidered than is presently the case and actions need to follow to prevent similar worst case scenarios from occurring here.

About the Author

Dr. Gordon is an educator, researcher, writer, and consultant. Her specialty areas include emergency management and homeland security. Her websites can be found at http://GordonHomeland.com and http://GordonPublicAdministration.com. She is currently teaching courses on homeland security and emergency management-related topics for several universities.

Earthquakes have been one of her particular interests. During the time she worked for U.S. Federal Emergency Management Agency and the U.S. Environmental Protection Agency, she became particularly interested in nuclear power plant vulnerability to earthquakes. As a result of her previous association with the Research Applied to National Needs Program of the National Science Foundation (NSF), she had heard a presentation by A. H. Soni, a mechanical engineering researcher whose research had received funding from NSF's Earthquake Engineering Division. His research focused in part on the seismic analysis of rotor bearing systems, including primary fluid coolant pumps and generators involved in the day-to-day operation of nuclear reactors. He was particularly concerned with the standards for bearing clearances on systems that likely to be significantly impacted by seismic activity.

On becoming informed regarding Soni's work, the author expanded her interest and over the years has had discussions concerning the implications of Soni's research with individuals at the Nuclear Regulatory Commission as well as with individuals from other places in government, academia, non-governmental organizations, and the nuclear power industry. The vulnerabilities of nuclear reactors in the U.S., according to Soni, were not well understood by those setting the standards for nuclear reactors in the U.S. Those standards were in his view typically set by structural engineers rather than by mechanical engineers who had an understanding of seismic impacts on rotor bearing systems.

Based on her understanding of the work of Soni and his colleagues, the author concludes that there is no certainty at present that nuclear power plants built in seismically sensitive areas in the United States will be able to withstand the magnitude of earthquake they were built to withstand, and that nuclear safety and nuclear security and hence public safety are at far greater risk than most individuals have imagined or presently imagine.

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References

[1] Jacob Goodwin (2011 March 13) "Nuke plant owner in Japan didn't plan for an 8.9 magnitude earthquake," GSNMagazine.com. Retrieved August 15, 2012 at http://www.gsnmagazine.com/node/22680?c=disaster_preparedness_emergency_response .

[2] Yuka Hayashi and Mari Iwata (2011, March 13) "Japan Struggles to Control Reactors." WSJ.com. Retrieved August 15, 2012 at http://online.wsj.com/article/SB10001424052748703555404576195700301455480.html .

[3] Jeri Clausing (2011 December 18) "Quake risk eyed amid concerns about planned N.M. nuclear lab," **Washington Post**, p. A7 .

[4] Travis Madsen (2011 March 14 as updated March 16) Frontier Group.org. Retrieved August 16, 2012 at http://www.frontiergroup.org/blog/blog/how-large-of-an-earthquake-could-u.s.-plants-withstand. The following material is quoted verbatim:

According to the U.S. Nuclear Regulatory Commission, historical earthquake activity at the location of a proposed plant is an important part of reactor design standards. Commission staff determine the largest "credible" earthquake that could occur at a given site, and require engineers to design the plant to withstand that force, plus an added margin of safety.

- According to a spokesperson for Southern California Edison, the San Onofre nuclear power plant is designed to withstand a magnitude 7.0 earthquake happening 5 miles away.
- According to the Nuclear Regulatory Commission, Diablo Canyon is designed to withstand a magnitude 7.5 earthquake 3 miles away.
- A spokesperson for the Indian Point nuclear power plant in New York told Reuters that the plant was designed to survive an earthquake of magnitude 6.1 on the Richter scale.

See also: Nuclear Regulatory Commission (May 2011 Reviewed/Updated *2012 May 29)* Fact Sheet on Seismic Issues for Nuclear Power Plants. Retrieved August 15, 2012 at http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-seismic-issues.html .

[5] Ibid.

[6] V. Srinivasan and A.H. Soni, "Seismic Analysis of a Rotor-Bearing System," **Earthquake Engineering and Structural Dynamics**, Vol. 12, 287-311 (1984) L.E. Suarez, M.P. Singh, and M.S. Rohanimanesh (1992), Seismic response of rotating machines. **Earthquake Engineering & Structural Dynamics**, 21: 21–36, doi: 10.1002/eqe.4290210102. For abstract see http://onlinelibrary.wiley.com/doi/10.1002/eqe.4290210102/abstract. Abstract retrieved August 15, 2012. A quote from the abstract: "The rotational input terms in the forcing function, however, are quite important and can be ignored only when they are not very strong."

[7] L.E. Suarez, M.P. Singh, and M.S. Rohanimanesh (1992), Seismic response of rotating machines. **Earthquake Engineering & Structural Dynamics**, 21: 21–36, doi: 10.1002/eqe.4290210102. For abstract see http://onlinelibrary.wiley.com/doi/10.1002/eqe.4290210102/abstract. Abstract retrieved August 15, 2012. A quote from the abstract: "The rotational input terms in the forcing function, however, are quite important and can be ignored only when they are not very strong."

[8] A.H. Soni, personal communication, 1984.

[9] V. Srinivasan and A.H. Soni, ibid.

[10] A.H. Soni, personal communication, August 7, 1992.

[11] Personal communication with an individual in the research development branch at NRC, February 8 1993 and separately reported in a personal communication with A. H. Soni, November 1992.

[12] A.H. Soni, personal communication, November 1992.