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Viewpoint Paper

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

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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?
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> Are these experts equally knowledgeable concerning both structural and mechanical engineering principles?
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> 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?
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> 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 are 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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[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."

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[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.