Discussion Forum

Concrete Structures of Nuclear Power Plants

Dear Sir,

This has reference to the paper titled 'Concrete Structures of Nuclear Power Plants' by Shylamoni P. and Basu P.C., published in the Indian Concrete Journal, Vol. 85, No.4, April 2011, pp. 9-27.

The recent nuclear melt down of at least three nuclear reactors of Fukushima Daiichi Nuclear Power Plant at Japan on March 11, made some European countries back away from nukes altogether. Germany announced plans in May 2011 to shut down its 17 nuclear power plants by 2022, with plans to replace atomic power with renewable energy sources. Switzerland and Italy followed suite and announced to forgo building new plants. However, India's Atomic Energy Commission chairman S. Banerjee, recently informed that India is planning a major expansion of nuclear energy in the coming decades, from the current level of 4,780 MW to a level of 20,000 MW by 2020 and a project growth to about 60,000 MW in the early 2030s. Nuclear power is the fourth-largest source of electricity in India after thermal, hydroelectric and renewable sources of electricity. As of 2010, India has 20 nuclear reactors in operation in six nuclear power plants, generating 4,780 MW while 5 other plants are under construction and are expected to generate an additional 2,720 MW. In this scenario, the paper by the authors which explains the safety aspects of design, construction and maintenance of concrete structures of Nuclear Power Plants (NPP), assumes importance. Normally, structures connected with NPP are designed only by a few privileged engineers who work with Nuclear Power Corporation of India Ltd. or Atomic Energy Regulatory Board (AERB). Hence the information contained in the paper are quite useful.

However, nuclear safety should encompass the entire spectrum of activities, including the site, design, construction, commissioning, operation and periodic up gradation. The recent nuclear melt down at Japan, which resulted in irradiating the entire nation and forcing thousands to evacuate, was not due to the earthquake of magnitude 9.0. It was due to the Tsunami, which flooded the emergency generators that are supposed to run the control electronics and water pumps needed to cool the reactors. (The plant was protected by a sea-wall designed to withstand a 5.7 m tsunami but not the 14 m maximum wave which arrived 41–60 minutes after the earthquake). The batteries that were provided had a life of about 8 to 10 hours (the battery life in US power plants is up to 5-6 hours only). Can the authors throw some light regarding these safety aspects of our NPP?

The Nuclear power plants that were affected in Japan are quite old: Fukushima I Nuclear Power Plant Unit 1 is a 439 MWe type reactor constructed in July 1967. It commenced commercial electrical production on March 26, 1971, and was scheduled for shutdown in March 2011. It was designed for a peak ground acceleration of 0.18 g and a response spectrum based on the 1952 Kern County earthquake. Units 2 and 3 are both 784 MW type reactors, Unit 2 commenced operating in July 1974 and Unit 3 in March 1976. The 1, 2, and 3 are all "boiling water reactors," made by General Electric in the early- to mid-1970s. A boiling water reactor, or BWR-Generation II, is the second-most-common reactor type in the world. (The NRC database of nuclear power plants shows that 23 of the 104 nuclear plants in the U.S. are GE boiling-water reactors with GE's Mark I systems for containing radioactivity, the same containment system used by the reactors in trouble at the Fukushima Dai-ichi plant). Pressurized Water Reactor (PWR) is the most common type, with over 230 in use for power generation and several hundreds more employed for naval propulsion. Pressurized Heavy Water Reactor (PHWR) is used in India, Canada and other countries. Most of the current

Generation III+ reactors have layers of passive safety elements designed to stave off meltdown, even in the event of power loss. But the discusser believes that the difficulties encountered by Japan's Dai-ichi plant due to tsunami, will be similar in Indian PHWR also. Soon after the disaster people living around the plant to a radius of 50 miles were evacuated. Should such a scenario happen in Indian plant, do we have enough resources to evacuate people quickly to safe shelters? I am afraid that temporary shelters which will house people in case of emergencies are lacking around Indian NPPs.

The current climatic changes happening in many parts of the world have introduced many risky situations such as forest fires, floods, etc., which might not have been considered during their design of NPPs. For example, recently, Fort Calhoun nuclear station in Nebraska was surrounded by flood water from the Missouri river and wild fire near New Mexico's Los Alamos nuclear lab (where the first atomic bomb used during World War II was developed and tested; thousands of outdoor drums of plutonium-contaminated waste is also stored) threatened to damage this facility, raising concerns of radiation.

A single NPP may provide the energy equivalent of 1200 windmills or 50 square kilometers of solar panels, and produces no carbon emissions. However, the main concern with regard to NPP is the storage of nuclear waste. Till now no reliable technology has been developed to dispose nuclear waste. Nuclear waste may remain dangerous for 250,000 years! Currently there are 75 U.S. power plant sites, scattered among 33 states, where nuclear fuel is kept in temporary storage, typically in pools of water that cool radioactive material. Such a storage system is not foolproof, as seen in the recent accident at the Fukushima Daiichi nuclear plant in Japan, where spent fuel pools allowed radiation to leak into the environment. A tunnel 7.6 m wide and 8 km long was drilled in Yucca Mountain, Nevada, to serve as a permanent grave for 70,000 tons of nuclear waste at an expense of $15 billion. The mountain turned out to be wetter than expected. Scientists discovered that plutonium from the atomic bomb tests had migrated into the groundwater, indicating that the mountain was not as geologically isolated as hoped. Hence the current Obama administration is shelving the project. Also due to the "not in my backyard" approach adopted by every state, it may be difficult to store these wastes-which will remain forever as a danger to mankind.

Moreover, in India there is not enough transparency regarding radiation near NPPs. It has been reported in USA that radioactive tritium has leaked from three quarters of US nuclear power plants and affected the health of people living around NPPs. With all the safety measures stated in the paper, there is no guarantee that such a leak can not occur. Moreover India's domestic uranium reserves are small and the country is dependent on uranium imports to fuel its nuclear power industry.

The solution to the above problems may be in the form of thorium- powered molten-salt reactors (MSR).[15,16] In an MSR, liquid thorium would replace the solid uranium fuel used in today's plants, which may eliminate melt downs. MSR has two primary safety advantages: (1) its liquid fuel remains at much lower pressures than the solid fuel in light water plants. This greatly reduces the likelihood of hydrogen explosions, similar to that occurred in Fukushima. (2) In the event of a power outage, the frozen salt plug within the reactor will melt making the liquid fuel passively drain into tanks where it solidifies, thus stopping the fission reaction. Moreover, thorium is four times as abundant as uranium (fortunately, India has much greater reserves of thorium). It has lower radioactivity and exponentially efficient than uranium, and hence produce far less waste than today's plants; these wastes will remain radioactive only for a few hundred years. MSRs can be much smaller than present day NPPs and many not require large cooling towers. Perhaps we may enjoy these benefits of thorium based technology when the prototype reactor under construction at the Kalpakkam Atomic Power Station, starts functioning in a couple of years (KAMINI, CIRUS, and DHRUVA research reactors in BARC are already using this technology).

Warm regards,

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References

15. MacKay, D. J. C., *Sustainable Energy - without the hot air*, UIT Cambridge Ltd., Cambridge, England Version 3.5.2., November 3, 2009, 383 pp. (http://www.withouthotair.com/about.html).
16. Thorium fuel cycle — Potential benefits and challenges, IAEA-TECDOC-1450, International Atomic Energy Agency, Vienna, Austria, 2005, 113pp.

The author replies

Dear Sir,

1. It is nice to learn from the reader that the information contained in the paper is useful. It's not only the engineers of NPCIL or AERB are involved with the engineering safety of the concrete structures of nuclear power plants, the engineers of DAE units like BARC, IGCAR; consulting engineering organisations such as DCPL, TCE, STUP; and Construction firm Like ECC of L&T, HCC, GIL are also involved.

2. Huge tsunami having height of 15 m or more, like the one following the Great East Japan Earthquake of March 2011, is generally generated from a large earthquake originated in subduction zone of plate boundary. Indian NPP coastal site is not within the near distance of such fault and has potential of not being inundated by large tsunami generated from such earthquake within short time. This is also true in case of possible tsunami from Makran fault. Recent studies shows that Indian NPP site will get more time (minimum as 90 minutes) as compared to Fukusima Dai-ichi NPP of Japan; and thus will have more time for onsite emergency management. In addition, there is well established methodology in engineering of NPP involving multiple defence–in depth for safety NPP against tsunami. From these considerations, Indian NPP and Fukushim Dai-ichi NPP may not be compared.

3. There is well proven methodology to ensure safety of operating plant of old vintage. World experience is positive in this direction. The Fukushima Dai-ichi NPP accident is not because of the plant is old, but due to tsunami. There is multi-level defence-in-depth for safety of NPP and protection of public and environment against an NPP accident. Evacuation of people is last resort. The safety and protection of people and environment shall be ensured through the defence-in-depth of design and operation. The report of IAEA International Fact Finding Expert Mission of the Fukushima Dai-ichi NPP Accident Following the Great East Japan Earthquake and Tsunami does not indicate that the Fukushima Dai-ichi NPP accident challenged the present state of knowledge and practice of nuclear technology concerning design, engineering, operation and ultimately safety. The cause may lie in the area of implementation of technology and appropriate regulation. The complete IAEA report is available in the website http://www-pub.iaea.org/MTCD/meetings/PDFplus/2011/cn200/documentation/cn200_Final-Fukushima-Mission_Report.pdf.

4. The design basis for NPP against external events like flood, fire, ground motion is based on maximum possible scenario with low probability exceedence. If engineered properly with rational conservative approach within the present state of knowledge and practice of nuclear technology, it is very unlikely that NPP safety will be breached.

5. Quantity of nuclear waste is very low compared to the waste of any other heavy industries. Research on ultimate repository of nuclear waste is in advanced state. There exists very robust technology to store nuclear waste safely for a long time till the research is concluded.

6. The discussion in the last but one paragraph is out of the scope of the paper, or is not related to the paper.

7. Author has no good knowledge on molten-salt reactor, which is in the conceptual stage of research.

The above is the personal opinion of the senior author of the paper to address the queries raised by the reader.

Thanks and regards,

Sincerely yours,

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