Fukushima Daiichi Nuclear Power Plant Accident Impact on Okuma Japan and Assessment of Ethics, Risk Analysis, and Mitigation

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Abstract

The Fukushima nuclear power plant is an inoperative power plant in Okuma, Fukushima Japan, that was operated by the Tokyo Electric Power Company. The Fukushima nuclear disaster occurred following a significant earthquake in which a 15-meter tsunami disabled the power supply on March 11, 2011. The nuclear accident caused high radioactive releases that were eight times higher than the average level, and several reactors were damaged. This single event caused the fatalities of several people and the evacuation of over 100,000 people from their homes as a result of environmental radiation pollution. The economic impact of this nuclear power plant accident estimation was at approximately 25 trillion yen ($300 billion). The engineers accountable for the design of the plant-based on the risk analysis violated several National Society of Professional Engineers (NSPE) Code of ethics as the safety, health, and welfare of the general public was not of utmost priority as at the time of engineering design and construction. Also, the Tokyo Electric Power Company management team did not predict a possible tsunami disaster. It, therefore, failed to take necessary precautionary measures, which are the types of risk analysis that needed to have been examined critically during the design phase of the engineering technology project. This disaster was a result of poor management from the operators of the power plant. And this research paper will explore the ethical engineering issues that caused this disaster and provide the best management practices for the successful operation of future nuclear power plants to prevent future disaster occurrences.

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1. 0. Introduction

The Fukushima Daiichi Nuclear Power Plant had six bubbling water reactors (BWR) that were built in the 1960s and first charged in the year 1971. It is right now a broken power plant situated at Okuma in Fukushima Prefecture at the Tōhoku area of Japan. The organizations that worked on the plant are General Electric and Tokyo Electric Power companies (TEPCO) (World Nuclear, 2018). The plant site was on an 860-acre of land and comprised of a Mark I regulation outline which involved the drywell, concealment chamber, interconnecting vent network, and the auxiliary control (World Nuclear, 2018). The drywell encompasses the reactor vessels and distribution circles while the concealment chambers stores an extensive waterway. The interconnecting vent network installed between the drywell and the concealment chamber. The optional regulation encompasses the essential control (drywell and concealment chamber), and it likewise incorporated the spent fuel pool and the crisis center cooling systems (Nuclearstreet, 2017).

FNPP Mark I Containment

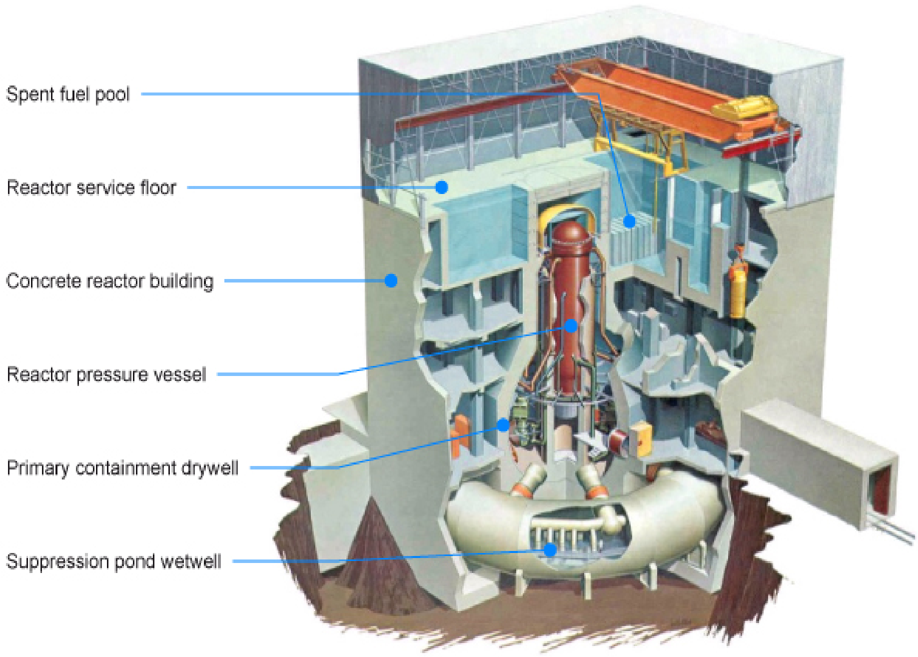

Figure 1:(source Nuclearstreet, 2017).

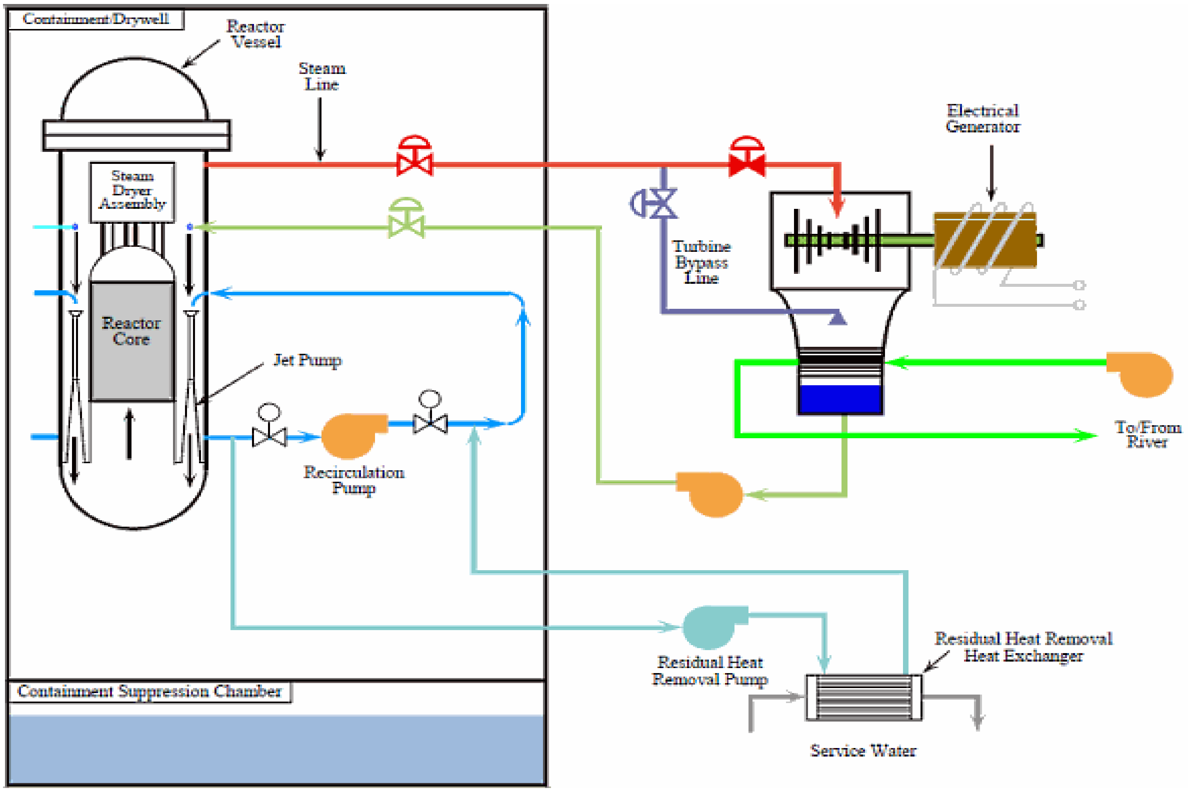

Figure 2: (Source: World Nuclear, 2018). Components of FNPP

2. 0. The Earthquake that Caused Tsunami

The earthquake at a 9.1 magnitude occurred 231 miles northeast of Tokyo at a depth of 15.2 miles at 2:46 pm on March 11, 2011. This earthquake caused a tsunami with 30-foot waves that damaged the Fukushima nuclear power plant reactors. The environmental and material damages from the earthquake and tsunami estimation were at approximately 25 trillion yen ($300 billion). The earthquake and tsunami caused a nuclear emergency at 5:00 am on March 12, 2011, since the accident cut off the plants, the tsunami disabled electrical power, and the backup generators. The radiation emitted from the Fukushima nuclear power plant was eight times higher than the average level (Nuclear and Industrial Safety Agency (NISA).

2.1. Exact Event at the Fukushima Nuclear Power Plant

Following a noteworthy earthquake, a 15-meter tsunami handicapped the power supply and cooling of three Fukushima Daiichi reactors, causing an atomic mishap on 11 March 2011. Every one of the three centers, to a great extent, dissolved in the initial three days. The mischance was appraised seven on the INES scale, because of high radioactive discharges over days 4 to 6, in the long run, a sum of somewhere in the range of 940 Petabecquerel (PBq) and iodine-131 equivalent (I-131 eq). Four reactors were composed off because of harm in the mishap, which is about 2719MWe (megawatts electrical) net capacity. Following two weeks, the three reactors (units 1-3) were steady with water expansion, and by July, are cooled with reused water from the new treatment plant. Official 'icy shutdown condition' was reported in mid-December. Aside from cooling, the major progressing undertaking was to avert the arrival of radioactive materials, especially in defiled water spilled from the three units. This errand ended up newsworthy in August 2013. There have been no passings or instances of radiation ailment from the atomic mischance. However, more than 100,000 individuals were cleared from their homes to guarantee this. Government apprehension defers the arrival of many. Official figures demonstrate that there have been well more than 1000 passings from keeping up the departure, rather than little hazard from radiation if the early return had been permitted (world nuclear association).

3.0 Table 1: * According to the 2012 MAAP analysis

Occasion succession following an earthquake (timing from it: 14:46, 11 March)

	Unit 1	Unit 2	Unit 3
Loss of AC power	+ 51 min	+ 54 min	+ 52 min
Loss of cooling	+ 1 hour	+ 70 hours	+ 36 hours
Water level down to top of fuel*	+ 3 hours	+ 74 hours	+ 42 hours
Core damage starts*	+ 4 hours	+ 77 hours	+ 44 hours
Reactor pressure vessel damage*	+11 hours	uncertain	uncertain
Fire pumps with fresh water	+ 15 hours		+ 43 hours
Hydrogen explosion (not confirmed for unit 2)	+ 25 hours service floor	+ 87 hours suppression chamber	+ 68 hours service floor
Fire pumps with seawater	+ 28 hours	+ 77 hours	+ 46 hours
Off-site electrical supply	+ 11-15 days		
Fresh water cooling	+ 14-15 days		

3.1. Government Response and Engineering Ethics

The Japanese response to the Fukushima Plant disaster was the relocation of over 100,000 residents to safe distances from the plant. Due to the deadly radiation that leaked into the atmosphere, the health of citizens was at high risk. Although the relocation of these citizens protected their health, today, a lot of these citizens face unforeseen financial hardships as government assistance, and financial subsidies are depleting. According to Justin McCurry, the author of the Fukushima evacuee face 'forced' return as subsidies withdrawn, "those who will have their subsidies withdrawn at the end of this month, forcing them to a near-impossible choice. And move back to homes they believe are unsafe or face financial hardship as they struggle on living in nuclear limbo" (McCurry, 2017). In other words, when these citizens have relocated, they did not benefit financially, and their well-being was compromised. They have the option of either struggling financially or moving back into unsafe conditions. The engineers responsible for the design of the plant as well the risk analysis and mitigation violated several National Society of Professional Engineers (NSPE) Code of ethics, specifically I.1 and II.1. These reads

3.1.1 Fundamental Canons

Hold paramount the safety, health, and welfare of the public (NSPE, 2017)

3.1.2 Rules of Practice

Engineers shall hold paramount the safety, health, and welfare of the public (NSPE, 2017)

Although these two sections say the same thing, they are under two different categories, which I believe are essential as well as reiterates how important the safety and welfare of the public is when it comes to engineering design and build. According to a 2011 article titled, Fukushima accident: disaster response failed to report, "Tokyo Electric Power did not take prudent measures in anticipation that a severe accident caused by (a) tsunami such as the one that hit" (BBC, 2011). Also, this is a critical analysis that the engineers should have taken into consideration that the probability of a tsunami striking the island of Japan after an earthquake is 30% (Japan Times, 2011). Risk consideration is necessary when designing and building such a powerful and potentially dangerous piece of engineering technology. Author and researcher, William E. Kastenberg focused on this issue in his article, Ethics, risk, and safety culture: a reflection on Fukushima and beyond. Kastenberg describes that the following risk as analysis questions have to be addressed:

- What are the risks imposed by technology and natural phenomena on society and the environment?
- Are these risks acceptable?
- What are the options for reducing these risks?
- On what basis should we choose among these options?

These are fundamental questions because uncertainty comes with the safety culture of people's well-being. These threats have to be quantified to ensure they are ethically reasonable but also with risks is uncertainty, as Kastenberg describes, "the most dominant emotions regarding technological risk are fear-based and uncertainty (fear of the unknown)" (Kastenberg, 2015). Reflecting on the incident at Fukushima, Kastenberg focuses on how the politics of risk may have impacted the response to Fukushima. Specifically, those on the scene should have the capability to make rationale in-the-moment decisions rather than waiting for permission from higher ranks. He says, "when operators faced situations beyond the scope of procedures and guidelines, they should make decisions at the level appropriate to act. That is, operators should have the authority to make decisions appropriate to the activities they need to perform" (Kastenberg, 2015).

4.0 Best Management Practices

4.1 Disaster Mitigation in the Future

There are several ways to reduce damages from future nuclear disaster, which includes the use of detectors and recorders.

4.1.1 Tsunami Detection System

The stringent tsunami detection system needed an installation that will signal a high sea wave. A detector that can identify a genuine tidal wave adrift effectively is necessary to prevent future disasters. The tsunami detection buoys system is an enhanced and reliable deep-water sensor that could meet emerging international requirements. The tsunami detection buoy system gauges little changes in the depth of the deep ocean caused by tsunami waves as they distribute past the sensor. The difference in measurement is by using a sensitive bottom pressure sensor to measure minimal pressure changes as the waves move past the buoy structure. The base pressure sensor component includes a processor with algorithms that recognize these characteristics. *It then immediately alerts* a tsunami warning center through the communications buoy when the processor senses one of these waves.

4.1.2 Installation of Strong Earthquake Motion Recorders

The standard atomic controls require that Nuclear Power Plants should have the capacity to relieve the potential impacts of seismic tremors. The monitor can utilize instrumentation for checking the seismic tremor ground movements and the reaction of the plant highlights to these movements (GeoSIG, 2018). The instrument used for this reason is called Seismic Monitoring system (SMS), and the parts of the SMS are: to recognizes any massive quake at plant area and give information records of increasing speed at characterized areas. Perform OBE/SSE exceedance assessment and provide an answer to the plant administrator after an occasion, and Periodical individual test execution. Accelerometers can assist with recording the substantial ground movement.

5.0. Risk Analysis

The risk analysis involves the recommended safety guide in an acceptable way to design a nuclear power plant so that an earthquake motion at the site will not jeopardize the safety of the plant. The primary source of risk is from external events such as earthquakes, and engineers have adequate knowledge that the use of nuclear energy involves potential risks associated with accidents (Aladesote et al., 2018). Nuclear power plant design should be against external events such as earthquakes, but the focus of most engineer design is on the prevention of internal component failure (IAEA, 2018).

5.1. Design against External Hazards such as Earthquakes

The construction and design of nuclear power plants are imperative in system security. The primary factor that added to the seriousness of the Fukushima nuclear power plant's entire debacle is the lack of contingency planning and underestimation of plan wave stature (IAEA, 2018).

6.0. Conclusion

In conclusion, the Fukushima Daiichi Power Plant incident is a great example that demonstrates the importance of engineering ethics. After the earthquake that rocked Okuma, Fukushima Japan resulting in a terrorizing tsunami, hundreds of thousands of citizens were put at risk by human technology. The lack of proper protocols and prevention methods are to blame for the power plant not being designed to withstand such natural disasters. Due to this, the well-being of the public and citizens were greatly affected financially. And also, along with health concerns, which is a violation of several ethics codes from the NSPE. This paper then describes proper Best Management Practices (BMP) that can proactively function to prevent such an incident from occurring again. These include a Tsunami Detection System and Installation of Strong Earthquake Motion Recorders.

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