

Effects of Severe Accident Conditions on Integrity of RPV Pedestal of Fukushima Daiichi Nuclear Power Plant

Osamu Kontani^{1*}, Takashi Okayasu², Keishi Kawasumi³, Shunsuke Ishikawa³, Hiroshi Masaki⁴, Norihiko Tanaka⁵, Yasuyuki Goto⁶ and Shinichi Ishioka⁷

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Abstract

The Fukushima Daiichi Nuclear Power Plant lost its core cooling function due to the massive tsunami generated by the 2011 off the Pacific coast of Tohoku Earthquake, which caused core meltdown, resulting in high temperature inside the containment vessel and exposing the RPV pedestal, a reinforced concrete structure, to an unusually high temperature environment. After the earthquake, water was poured into the containment vessel to cool the molten core, and the concrete structure was gradually cooled in the process. Since it will take at least 40 years to remove the fuel from the core, the integrity of the RPV pedestal is a major concern for the decommissioning of the Fukushima Daiichi Nuclear Power Plant. In order to assess the long-term integrity of the RPV pedestal, a horizontal loading test was conducted using a 1/6 scaled model of the RPV pedestal of Unit 1 considering the effect of the high temperature heating and subsequent wet conditions. And then, the static stress analysis of the RPV pedestal was performed considering the degradation phenomena revealed by the experiments. As a result, it was confirmed that the RPV pedestal of Unit 1 would be structurally sound for 40 years against the current design basis earthquake even if the material degradation due to severe accident and aging was considered.

1. Introduction

The Fukushima Daiichi Nuclear Power Plant (FD-NPP) was hit by a large earthquake ground motion caused by the 2011 off the Pacific coast of Tohoku Earthquake. FD-NPP has six power units, and Units 1 through 3 were in normal operation according to TEPCO (2011a). All the control rods of the operated units were auto-

matically inserted following detection of the large seismic ground motion, and the reactor was safely shut down. However, a huge tsunami generated by the earthquake then hit the plant, causing the loss of power supply and, more importantly, the loss of the core cooling function, leading to core meltdown.

As a result, the inside of the primary containment vessel (PCV) reached high temperature and high pressure, the containment vessel function was impaired, and the pedestal of the reactor pressure vessel (RPV pedestal), which is a reinforced concrete structure, was exposed to an unusually high temperature environment. As an emergency measure to cool the molten core, seawater was initially injected, but this was later switched to fresh water and then to water treated in the stagnant water purification system. In these processes, the temperature and the chloride ion concentration were greatly reduced. Since it will take at least 40 years from the time of the earthquake to remove the fuel from the core, however, the effects of high temperature and aging on the integrity of the RPV pedestal are a major concern for the decommissioning of FD-NPP. The RPV, PCV, and the RPV pedestal are illustrated in Fig. 1 according to Tanaka *et al.* (2021).

Currently, it is almost impossible to repair the RPV pedestal because access to the containment vessel is very difficult due to the radiation conditions. It is necessary to evaluate the integrity of the RPV pedestal in its current and long-term states considering the influence of severe accidents, subsequent environmental conditions, and aging. Therefore, the International Research Institute for Nuclear Decommissioning (IRID) has conducted various experimental studies to evaluate

¹Principal Engineer, Nuclear Power Department, Kajima Corporation, Tokyo, Japan.

*Corresponding author, E-mail: kontani@kajima.com

²Chief Research Engineer, Kajima Technical Research Institute, Tokyo, Japan.

³Deputy Manager, Nuclear Power Department, Kajima Corporation, Tokyo, Japan.

⁴Manager, Systems Design & Engineering Department, Toshiba Energy Systems & Solutions Corporation, Yokohama, Japan, and International Research Institute for Nuclear Decommissioning, Tokyo, Japan.

⁵Expert, Mechanical Systems Design & Engineering Department, Toshiba Energy Systems & Solutions Corporation, Yokohama, Japan, and International Research Institute for Nuclear Decommissioning, Tokyo, Japan.

⁶Unit Manager, Nuclear Equipment Design Department, Hitachi-GE Nuclear Energy, Ltd., Hitachi, Japan, and International Research Institute for Nuclear Decommissioning, Tokyo, Japan.

⁷Engineer, Nuclear Plant Engineering Department, Hitachi-GE Nuclear Energy, Ltd., Hitachi, Japan, and International Research Institute for Nuclear Decommissioning, Tokyo, Japan.

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TMI 2 Chernobyl and Fukushima An extensive discussion of nuclear waste disposal is provided as part of the decision tree for energy selection The context for the future of nuclear power as a viable energy source is illuminated by the current battle between economic growth and the harm created by burning fossil fuels The status of the world's climate and projections for the disruptive effects of global warming on future populations migration economics and world strife are debated against the backdrop of an increasing world population and the drive by developing nations to achieve economic parity with the industrialized nations Within the context of increased world strife the quest by nations to obtain nuclear weapons is also discussed The steps taken by the world to limit nuclear weapons proliferation are examined with emphasis on potential links between nuclear power generation and access to nuclear weapons The final chapter discusses the moral responsibility of current generations with respect to future generations specifically the applicability of intergenerational equity in political and social decision making regarding the actions that add to global warming and those risk averse actions that can be taken to minimize global warming

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