Seismic safety of the Hamaoka nuclear power plant in Shizuoka Prefecture, Japan

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The Chubu Electric Power’s Hamaoka nuclear power plant in Omaezaki city, Shizuoka Prefecture, on the Pacific coast of central Japan, is situated directly above the interplate megathrust between the subducting Philippine Sea plate and the overriding lithosphere of the Tokai district. On this plate interface the M 8-class Tokai earthquake or the M 9-class Nankai trough earthquake including the Tokai event are anticipated to occur in the near future. However, when the Hamaoka NPP was first established in 1970, plate tectonics and the fault-origin theory of earthquakes were not applied in this region, and therefore, Chubu Electric Power did not imagine a great earthquake originated just beneath Hamaoka at all. When I proposed in 1976 a hypothetical fault model of the Tokai earthquake extending beneath Shizuoka Prefecture and its offing, Hamaoka NPP’s Unit 1 had just started commercial operation and Unit 2 was under construction, whose design basis earthquake ground motion (DBGM) was 450 Gal (horizontal peak acceleration) for both units. After they knew that the Hamaoka site was completely within the source region of a probable great earthquake, Chubu Electric Power continued construction of Units 3, 4 and 5, though their DBGM was slightly increased to 600 Gal. In 2007, following the revision of the Nuclear Safety Commission’s Regulatory Guide for Reviewing Seismic Design of NPPs, Chubu Electric Power increased the DBGM to 800 Gal. As for Units 1 and 2, they were permanently shut down in 2009 by reason that the cost of their reinforcement was unprofitable. After the catastrophic Fukushima nuclear accident in 2011, in order to meet the New Regulatory Requirements of the Nuclear Regulation Authority, Chubu Electric Power formulated the Standard Seismic Motion (same as DBGM) with horizontal peak acceleration of 1200 Gal for ordinary ground condition in Hamaoka site. In the end of 2015 they completed a 1.6 km-long tsunami protection wall as high as 22 m above sea level on the supposition that the maximum tsunami height would be 21.1 m. They are also preparing other various countermeasures against huge tsunami and emergent severe accidents. The anticipated Tokai or Nankai trough earthquakes will bring about long-lasting short-period and long-period strong ground motions, large-scale vertical crustal deformation, huge tsunami, successive large aftershocks to the Hamaoka NPP for a few days or more. It is not guaranteed that the maximum ground motion is less than 1200 Gal nor the height of tsunami is lower than 22 m. Strong ground motion of longer duration than the DBGM and a large-scale coseismic crustal uplift may well destroy the tsunami protection wall. The combination of sea bed uplift and large amount of backwash of tsunami may cause loss of function of sea-water intake towers distinctive in Hamaoka NPP, which can lead to a severe accident. To begin with, it is doubtful that the reactor facilities originary designed and constructed for DBGM of 600 Gal can be completely reinforced against 1200 Gal seismic motion. Thus, it is merely a dangerous optimism that the Chubu Electric Power’s countermeasures against an underfoot great earthquake and severe accidents are reliable and enough to prevent serious nuclear disaster. Still, Hamaoka NPP is producing a great fear of “Genpatsu Shinsai” (earthquake-nuclear combined disaster) which I have been warning since 1997.

Keywords: Hamaoka NPP, Tokai earthquake, Nankai trough earthquake, seismic safety, tsunami

New insights into the middle and late Holocene coastal movements and tsunamis in the Shizuoka Prefecture

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Geological evidences of coastal movements and paleotsunamis relating to the Nankai Trough earthquakes are gradually increasing in Shizuoka region. I summarize the latest achievements in this study field based on the results of sediment core analyses obtained from the coastal lowlands along the western Suruga Bay and Enshu-nada. Comparing these data with the predicted coastal movements by the “Tokai earthquake model”, I make reference to the variety of occurrence mode of the Nankai Trough earthquakes.
Historical documents reported the coastal uplift and subsidence during the 1854 Ansei-Tokai earthquake in the Shizuoka region; eastern Shizuoka region close to the Suruga Trough axis (e.g., around the Cape Omaezaki and western Suruga Bay coast) was remarkably uplifted (1.0-1.5 m), and the western region distance from the trough axis such as around Lake Hamana was subsided at tens of centimeters. Opposite phase of coastal deformation, subsidence in eastern region and uplift in the western region has been shown by the leveling during this interseismic period. This reversal of coastal deformation trend has been interpreted as the deformation of upper plate in response to the subduction of the Philippine Sea Plate; plate coupling and release of accumulated strain along the plate boundary. To explain this phenomenon, current fault model for the Tokai earthquake is approximated by single large slip surface on the plate boundary.
However, centennial-scale coastal deformation predicted by the Tokai earthquake model does not always correspond to the millennium-scale coastal movements suggested by the geological evidences. Southern coast of the Omaezaki area (Shirowa area) solely shows remarkable uplift rate; up to 1.5 m/1000 y. Along the Suruga Trough axis, uplift rate rapidly decreases in short distance from the Shirowa area. Average uplift rates are ~0.7 m/ 1000 y. and ~0 m/ 1000 y. at the sites of ca. 2 km and ca. 10 km north of Shirowa area, respectively.
Coastal uplift rate also decreasing in the trench-normal direction (westward from the Shirowa area) changes to subsidence after that. At the Kikukawa lowland, about 10 km west of the Shirowa area, average uplift rate in the last 7000 years is estimated to be ~0.4 m/1000 y (Kashima et al. 1985). The Otagawa lowland, about 15 km west from the Kikukawa lowland shows a rapid subsidence rate of ~1.0 m/ 1000 y (Fujiwara et al., 2015). About the same subsidence rate is estimated in the western Hamamatsu Plain, about 20 km west from the The Otagawa lowland (Fujiwara et al., 2014).
It is unreasonable to explain the local uplift around the Shirowa area by the Tokai earthquake model with a large single fault plain, which produces coastal deformation having a long wavelength with 100 km-order. Possible cause of the local uplift around the Shirowa area is a subsidiary fault in the upper plate. Large subsidence rate in western Shizuoka region is also difficult to explain by using the Tokai earthquake model.
While the number of reported tsunami deposits and possible tsunami deposits has been increasing in the Shizuoka region, quality and quantity of these data are not adequate to reconstruct the wave height and inundation area of each paleotsunami. Fujiwara et al. (2013) traced the landward extent of some tsunami deposits from the contemporary shoreline in the western Hamamatsu Plain. The result suggests that unusually large tsunamis, so called “the maximum possible tsunami” supposed by the Cabinet Office, Government of Japan has not occurred in the last 4000 year.
As mentioned above, results of recent paleoearthquake researches in the Shizuoka region make us to change our understanding about the Tokai earthquake. These data would help to explain the

variability of the occurrence mode of the Nankai Trough earthquakes.

Keywords: Nankai Trough, Paleoearthquake, Shizuoka, Paleotsunami

Upper plate crustal faults and earthquakes in and around the Hamaoka Nuclear Power Plant

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This paper aims at examination of the evaluation on seismic risks from upper plate faults and earthquakes on the Hamaoka Power Plant of the Chubu Electric Power Company, based on the reports submitted by the Chubu Electric Power Company to the Nuclear Regulation Authority, former Nuclear Safety Committee, and former Nuclear and Industrial Safety Agency. The upper plate onshore and offshore crustal faults and earthquakes are roughly classified into three categories. They are (1) specific sources of earthquake ground shaking in the seismogenic zone of the upper plate to be evaluated for the design of the reactor facilities, (2) Onshore active faults and lineaments that are not to be taken in to account for seismic safety design, and (3) faults next to and under critical facilities. (1) The specific sources are late Quaternary active faults that are capable of earthquakes in the future. A longer fault with larger magnitude at a shorter distance tends to induce stronger ground motion a the site. The nearest active faults on shore are about 30 km away and less than 10 km long. These faults and longer but farther away faults on shore generates much less ground motion than the off-shore faults that extend within 20 km from the site. In addition to 72.6 km long East of Omaezaki Spur fault zone, recent survey revealed a shorter but more proximal source of the 46.9 km long West of Omaezaki Spur fault zone. This newly found fault zone and the 173.7 km long Enshu fault system are recently taken into the evaluation of the design basis ground motion. (2) The short N-S trending lineaments on the Omaezaki upland are not regarded as seismogenic active faults. The lineaments are interpreted as secondary superficial faults associated with the NW-SE trending anticline along the north shore of the Omaezaki peninsular. Seismic profiles do not show any down-dip structures offset Miocene layers below. (3) The H fault system are a swarm of E-W trending south-dipping normal faults in the Hamaoka site. The Nuclear and Industry Safety Agency and the Nuclear Regulation Authority did not conduct reviews of the H fault zone as a fracture zone in nuclear power plant site after the 2011 Tohoku Earthquake and Tsunami. In the review meetings on conformity to the new regulatory requirements the capability of the H fault system as sources of fault displacement is being examined. The Chubu Electric Power Company reported the H fault systems had been generated before the consolidation of the Miocene sediments and there had been no evidence of activities in Late Quaternary.

Keywords: active fault, fault displacement, nuclear power plant

Nuclear Utilization and Role of (Geo-)Scientists: Perspectives of Science and Technology Studies

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It has been one of the most important topics of public discussion that the risk and its management of nuclear facilities caused by natural disasters, such as earthquake and tsunami, since the Fukushima Nuclear Accident on March, 2011. Our relevant scientific knowledge on those phenomena and the role of scientists have also been re-examined as an inevitable consequence of that.
In this presentation, some perspectives of science and technology studies (STS) on this topic will be introduced to widen and deepen our scope of discussion. Concretely, the relationship among natural science, engineering, policy- and decision-making and civil society will be illustrated and examined. Which part of those interactions is the key of the problem? What kind of role is expected desirable to geo-scientists and their community? Furthermore, how about is the possible idea of engagement of and collaboration with STS researchers and other social scientists on this issue? These questions will be discussed taking the case of Hamaoka Nuclear Power Station.

Keywords: Science and Technology Studies (STS), Natural Science and Engineering, Role of (Geo-)Scientists

Summary of the session and introduction to the panel discussion

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In the panel discussion, focusing on the Hamaoka plant, we shall discuss about the state of the art earth science researches associated with the plant, historical assessments of the relationship between earth science and the plant hitherto, and possible future relationship. In this talk, we briefly summarize the previous sessions we convened in the last 3 years to discuss about the issue of nuclear power plants and earth science. We also raise a few earth scince problems associated with the hazard mitigation of the plants, which we believe important to dicuss, following the invited talks in this session.

Keywords: Hamaoka nuclear power plant, Earth science research community, mega-thrust earthquake

