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2004 Indian Ocean Tsunami on the Madras Nuclear Power Plant, India

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1. Introduction

In On December 26 00:58(UTC), 06:28 (Local time, India), a great earthquake occurred off the coast of north Sumatra, Indonesia. The magnitude of this earthquake was 9.0 and it was the fourth largest earthquake in the world since 1900. The tsunami, 2004 Indian Ocean tsunami, accompanied with this earthquake propagated in the entire Indian Ocean, and caused significant damage. The tsunami attacked not only the coast of Indonesia and Thailand, close to the source of earthquake, but also the coast of India, Sri Lanka, and the Maldives and even the east coast of Africa, thousands of kilo meters away from the epicenter.

In India, Tamil Nadu State is the most damaged area by this tsunami. Unfortunately, there are many nuclear facilities in Kalpakkam City, Tamil Nadu State.

In the present study, the tsunami effects on the Madras nuclear power plant (MAPS), one of the nuclear facilities located in Kalpakkam City, are reviewed, and preliminary numerical simulation results of 2004 Indian Ocean tsunami are discussed.

2. Tsunami Effects

At Kalpakkam site, there are two nuclear power plants, one fast breeder test reactor, fast reactor fuel reprocessing plant, central waste management facility, etc. The 2004 Indian Ocean tsunami affected the operation of MAPS Units. At the time of the incident, MAPS Unit-2 was operating at 215 MWe. Unit-1 of MAPS was under long shutdown for en-masse coolant channel replacement and safety upgradation, since August 2003.

Following the Tsunami, the water level in the seawater pump house of the plant had risen causing tripping of condenser cooling water pumps. The operator manually tripped the turbine-generator, noticing the unavailability of these pumps. Following this, the reactor tripped automatically. Subsequently, the reactor was brought to cold shutdown state by following the emergency operating procedure.

The increase in water level in pump house during tsunami made all the seawater pumps located in this area unavailable except for one process seawater pump, which was utilized for cooling the stations loads in the initial period following reactor shutdown. Subsequently, this pump also became unavailable due to choking of the traveling water screen in the seawater pump house due to heavy ingress of debris caused by the tsunami. Further, the cooling of the reactor of MAPS Unit-2 and different loads were achieved by using the firewater system. Though the offsite power remained available throughout the event, emergency diesel generators were started and kept running as a precautionary measure. The plant declared an emergency alert at 10:25 on December 26, which was lifted at 21:43 on December 27.

The tsunami did not affect the activities in MAPS Unit-1, which was under shutdown. And there was no loss of human life or any significant loss of property at MAPS site due to the tsunami.

An inspection team of Atomic Energy Regulatory Board (AERB) visited MAPS and other Indira Gandhi Centre for Atomic Research (IGCAR) facilities at Kalpakkam on December 29 to ascertain the impact of the tsunami. After detailed review of the impact of the tsunami, AERB permitted restart and operation of MAPS Unit 2. And it was restarted on January 1, 2005.

3. Numerical Simulation

3.1 Fault Parameters

The fault parameters used to compute the sea bottom deformation are based on the Koshimura's model, as shown in Table 1.

Table 1. Fault parameters to compute the initial sea surface profile of the tsunami

	1st segment	2nd segment
Latitude(˚)	94.8E	92.3E
Longitude(˚)	2.5N	6.5N
Length(km)	500	400
Width(km)	150	150
Dislocation(m)	11.0	13.9
Strike angle(˚)	329	358
Dip angle(˚)	15	15
Slip angle(˚)	90	90
Depth(km)	10	10

3.2 Numerical Conditions

The numerical modeling of the 2004 Indian Ocean tsunami is performed using TSUNAMI code by Tohoku

University, Japan. The model is based on the linear shallow water equations of a spherical co-ordinate system. The leap-frog finite difference method is used for numerical scheme. It is used the 2 arc-minute grids of bathymetry of ETOPO2, provided by the National Geophysical Data Center.

The spatial grid step of numerical computation is 2 min, and the time step of numerical integration is set to 5 sec. In this computational grid condition, 8 hours of tsunami propagation is simulated. At open boundaries, absorbing sponge layers are applied at the edge of numerical domain with several dummy meshes because reflected high frequency waves are trapped within the domain. On the other hand, wall boundary condition is applied at the shore side, and run-up effect is not considered.

3.3 Simulation Results

Figure 1 shows the snapshot of tsunami propagation 162 minutes after the earthquake. The tsunami reaches to the east coast of India. We compared simulated time history with measured water level at the Chennai port. The result shows that calculated tsunami reaches earlier than the measured one. This may be because Bathymetry data of 2 minute grid spatial length used in this computation has poor resolution to describe the detailed geographical features. Also the lack of knowledge on the detailed source mechanisms may contribute to the error. For these reasons, while the maximum runup at MAPS is about 4.5 meters above the MSL, the simulation results are smaller than 2 meters. A more elaborate analysis using the detailed source mechanisms and the fine grid data with nonlinearity and runup is required in the future work.

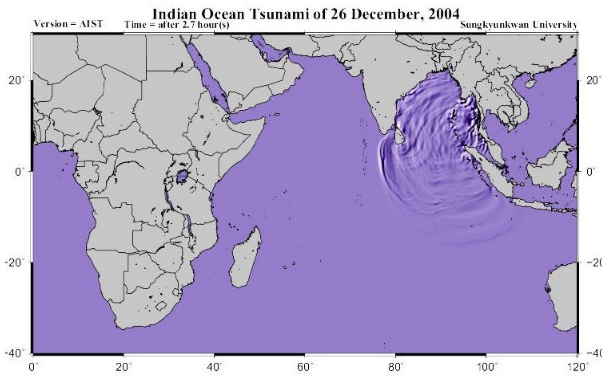

Figure 1. Snapshot of modeled tsunami propagation 2.7 hours after the earthquake

4. Conclusion

MAPS Unit 2 operated normally during the year, was shut down on December 26, 2004, due to the tsunami hitting the Kalpakkam coast. Flooding occurred in the sea water pumphouse of the plant due to the surge on sea water level on account of the tsunami. Apart from this, there was no damage to the plant due to the incident. An AERB inspection team inspected the Unit after the event. After review, AERB gave clearance for restart and the unit was brought back to operation on January 2, 2005.

From the preliminary numerical model runs, we attempted to understand the propagation characteristics of the 2004 Indian Ocean tsunami. The model results are qualitatively consistent with the reported damage. However, due to the lack of detailed source mechanism and nearshore bathymetry data in India, simulation results have some differences from measured data.

REFERENCES

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