

MARCH 2011, TSUNAMI DISASTER IN JAPAN

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The damage caused by the recent tsunami disaster in Japan is immeasurable and greatly influences the mental, socio-economic, political and cultural state of the country. This natural disaster results in serious disruption of the functioning of society, widespread human, material or environmental losses which exceed the ability of the affected society to cope using its own resources. Japan is an archipelago made up of many islands, of which there are four main ones namely Honshu, Shikoku, Hokkaido, and Kyushu. Japan is located in an area where several continental and oceanic plates meet which is the cause of frequent earthquakes and the presence of many active volcanoes and hot springs across the nation.

An offshore earthquake with moment magnitude of 9 struck at 05:46 UTC on March 11th 2011 (named as the Tohoku Earthquake) is the biggest to hit Japan since late 1800's as per the available records. Table 1 gives to the details of this great earthquake. It is ranked as the 5th largest earthquake in the world since 1900 and nearly 8,000 times stronger than one that devastated Christchurch (in New Zealand) in 2011 February. The quake shook dozens of cities and villages along a 2100 km stretch of coast. Figure 1 provides the MMI intensity map at different locations in Japan. When earthquake occurs below or close to the ocean it may result in causing tidal waves termed as Tsunami. Just over an hour after the earthquake, a tsunami was observed flooding Sendai Airport, which is located near the coast of Miyagi state. A 4m high tsunami hit Iwate State. Figure 2 represents the expected heights of tsunami wave as predicted by National Oceanographic and atmospheric administration (NOAA). This earthquake is followed by aftershocks around 124 detected near Japan's main island of Honshu and 111 events are with magnitude greater than or equal to 5.0. The main earthquake was preceded by a number of large foreshocks, beginning with 7.2 M_w events on 9th March 2011 approximately 40 km from the main event, and followed by another three on the same day with moment magnitude of ≥ 6 .

Japan lies on the "Ring of Fire", an arc of earthquake and volcanic zones stretching around the Pacific region where about 90% of the world's quakes occur, including the one that triggered the 26th December 2004, Indian Ocean tsunami that killed around 230,000 people in 12 countries. The epicenter of the main quake is located off Miyagi state, about 370 km northeast of

Tokyo. The earthquake occurred in the Japan Trench, where the Pacific Plate is subducting beneath the Okhotsk Plate. An earthquake of this size usually has a rupture length of at least 480 km and requires a long, relatively straight fault line. Because the plate boundary and subduction zone in this region is not very straight, earthquake magnitudes are usually expected to be up to 8 or above. The hypocentral region of this earthquake extends from offshore Iwate to offshore Ibaraki states. The earthquake released a surface energy of 1.9×10^{17} J, dissipated as shaking and tsunamic energy, which is nearly double than that of the 2004 Sumatra earthquake with 9.1 magnitude and killed 230,000 people. The total energy released is 3.9×10^{22} J, slightly less than the 2004 Sumatra earthquake. The total energy released underground is around 205,000 times that on the surface.

Table 1 Details of the 11th March, 2011 Japan Earthquake (U.S Geological Survey)

Magnitude	9.0 (M_w)
Date-Time	Friday, March 11, 2011 at 05:46:23 UTC Friday, March 11, 2011 at 02:46:23 PM at epicenter
Location	38.322°N, 142.369°E
Depth	32 km
Region	Near the east coast of Honshu, Japan
Distances	29 km E of Sendai, Honshu, Japan 177 km E of Yamagata, Honshu, Japan 177 km ENE of Fukushima, Honshu, Japan 373 km NE of Tokyo, Japan
Location Uncertainty	horizontal +/- 13.5 km

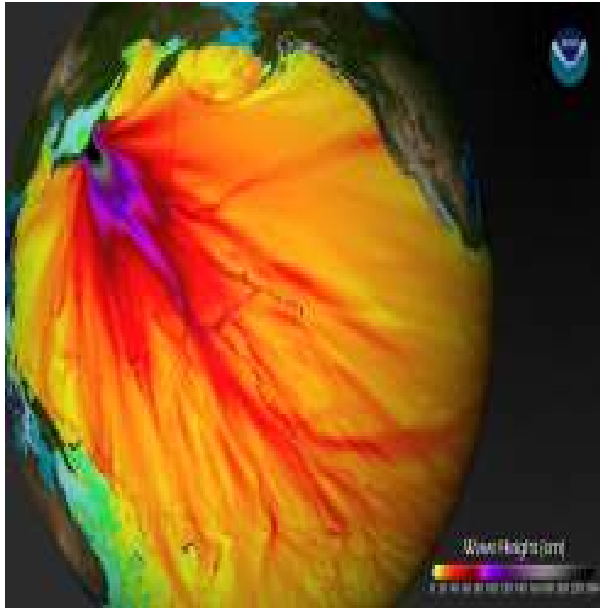


Fig.2. Height of the Tsunami waves (National Oceanographic and atmospheric administration)

Table 2 represents the observations recorded by Japan Meteorological Agency (JMA) at different stations around the coastline of Japan following the earthquake. These observations included tsunami maximum readings of over 3 m at the following locations and times on 11 March 2011, following the earthquake at 14:46 JST. Japan has an unforgettable history of experiencing the most devastating earthquakes and tidal waves in the recent past also i.e., Kanto earthquake (1923) which killed over 1 lakh people and the Kobe earthquake (1995) which killed about 6,000 and injured 415,000 people.

Table 2 Tsunami wave heights recorded at different stations along Japan coastline
(<http://www.jma.go.jp/en/quake>)

Time (JST)	Location	Wave Height (m)
15:12	Iwate Kamaishi-oki	6.8
15:15	Ofunato	3.2 or more
15:20	Ishinomaki-shi Ayukawa	3.3 or more
15:21	Miyako	4.0 or more
15:21	Kamaishi	4.1 or more
15:44	Erimo-cho Shoya	3.5
15:50	Soma	7.3 or more
16:52	Oarai	4.2

The combination of a stronger earthquake and tsunami in Japan has created extreme destruction to buildings, roads, factories, railway network, tall structures, dams, nuclear reactors and even some areas were in fires. During this 11th March 2011 earthquake 2694 people died and

7,222 persons were missing. Airport runways were deluded and shipping containers were cascaded through the city of Sendai. Buildings collapsed and landslides were reported in several communities along the 2,100 km stretch of coastline. The Tokyo port has suffered slight damage, smoke rose from the buildings in port area with part of the port being flooded. Soil liquefaction occurred in Tokyo Disneyland's carpark area. About 46,000 buildings were estimated to be damaged, out of which 5,700 were collapsed in the country.

At Tohoku Electric Power Plant, fire broke out and one third of Kesenuma city is submerged by tsunami waters. The Fujinuma irrigation dam in Sukagawa ruptured, causing flooding and destroyed 1,800 homes downstream. At Fukushima Daiichi Nuclear Power Plant No. 1 and No. 3 reactor buildings exploded (Fig. 3) on the alternative days after the Tsunami which has damaged the power supply system to the nuclear plant and further resulted in the failure of cooling system which controls the reactions in the reactors. Substantial damage was caused to the reactor building, including the upper structure being largely destroyed with the building's roof and side panels blown off. The climax of this tragic event was the melting down of two nuclear reactors, which also caused a chemical explosion that prompted immediate evacuations of the affected areas with over 200,000 people being evacuated, especially those who were within a 10km radius of the Fukushima II Nuclear Power Plant and a 20km radius of the Fukushima I Nuclear Power Plant.



Fig. 3 Fukushima Daiichi reactor before and after explosion

(<http://www.nytimes.com/interactive/2011/03/13/world/asia/satellite-photos-japan-before-and-after-tsunami.html?hp>)

The three disasters in Japan, namely earthquake, tsunami and the nuclear leak are expected to drop the economy of Japan which is now struggling to rise after falling due to the crisis and high debt. Japan's economic loss due to earthquake and tsunami is accounted to be nearly \$ 171 billion.