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M. Eskijian

STAFF REPORT ON THE INVESTIGATION OF PORT/HARBOR DAMAGE RESULTING FROM THE JAPAN EARTHQUAKE AND TSUNAMI OF MARCH 11, 2011

Following the earthquake and tsunami of March 11, 2011 in Japan, the American Society of Civil Engineers/Coasts, Oceans, Ports, Rivers Institute put together teams of engineers to assess coastal damage and report back to the United States. Martin Eskijian and Alex Augustin, two engineers from the Marine Facilities Division of California State Lands Commission were invited to participate.

The team consisted of practicing structural/port engineers, one geotechnical engineer, one engineering specialist for container cranes and a group from Ports, Airports Research Institute of Japan (PARI). The team was assigned the task of assessing damage to port/harbor structures north of the epicenter. The PARI engineers provided the background for each area and served as translators and facilitators for the investigation. Without help of the PARI engineers, the investigation could not have been accomplished. The leader of the Japanese team was Dr. T. Sugano, the Director of Earthquake Disaster Prevention Engineering at PARI.

The port areas that were investigated included Soma, Sendai, Kesennuma, Kamaishi, Onagawa, Otsuchi, Kuji and Hachinohe, moving from the south to the north. The south was closer to the epicenter and more earthquake damage was expected. To the north, as the team approached the port of Hachinohe, the damage was minimal.

In order to understand the magnitude of this earthquake and tsunami, some recent comparisons are relevant[1]:

Japan (March 11, 2011, 2:46 PM)	18,000 dead, 6,000 injured, 10,000 missing
Haiti (January 12, 2010, 4:53 PM)	230,000 dead
Chile (February 27, 2010, 3:34 PM)	1,000 dead

[1] Approximate Figures

Japan's March 11, 2011 earthquake is the largest earthquake in Japan's recent history, with over 800 significant aftershocks and a few foreshocks. The epicenter was 43 miles off the eastern coast of Honshu, and there was a tectonic displacement of approximately 0.6m downward (note the similarity to Sea Level Rise).

Most of the significant damage that the team observed was a result of hydrodynamic forces on port and near-shore structures. There were portions of gravity walls, with submerged weights of over 250,000 pounds that were lifted from the seafloor and dropped onto wharves. The team saw concrete multi-story buildings that had overturned completely. In many cases tsunami walls and other protective measures did not limit the destruction and loss of life.

Port and harbor structures constructed of pile supported construction performed better than expected and there was almost no apparent damage. Soil failure, tectonic displacement and hydrodynamic forces were the main contributors to the collapse of port/harbor structures. The most significant coastal damage was due to the tsunami and not the earthquake.

In conclusion, the team found that port structures in Japan are better designed for earthquake than the ones in California. The structures are relatively newer and designed elastically for earthquake loads. The damage to some of the port structures visited is mainly related to soil liquefaction. Soil liquefaction is very critical and will cause several Marine Oil Terminals in California to fail in the event of a level 2 earthquake. Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS) addresses soil liquefaction and several California Marine Oil Terminals are being scheduled for rehabilitation.

The tsunami was the major factor in Japan. Buildings and coastal structures are typically not designed for these hydrodynamic forces. Therefore, tsunami plans are crucial for coastal regions. MOTEMS requires all terminals to have a tsunami plan.

The full assessment report from the ASCE team will be available in late 2011 with lessons learned and detailed recommendations that can be applied to port structures in California. The Commission Marine Facilities Engineers will determine how the information obtained from the Japan assessment can be incorporated into future revisions of the MOTEMS in the California Building Code.