PROTECT PEOPLE FROM TSUNAMI HAZARD

MUSTAFA KAYA

Aksaray University Civil Engineering Department, Aksaray, Turkey
E-mail: kaya261174@hotmail.com

Abstract- Tsunami is a naturally occurring series of waves that can result when there is a rapid, large-scale disturbance of a body of water. The most common triggering events are earthquakes below or near the ocean floor, but a tsunami can also be created by volcanic activity, landslides, undersea slumps, and impacts of extra-terrestrial objects. The waves created by this disturbance propagate away from the source. Upon reaching the shoreline the waves can have hazardous, height and force, penetrating inland, damaging structures, and flooding normally dry areas. Also, this wave can cause very severe currents. These currents can turn out to be an earthquake, typhoon, avalanche, fire or flood. The tsunami in Japan caused nuclear accidents, in the Fukushima Daiichi Nuclear Power Plant complex, and the associated evacuation zones affecting hundreds of thousands of residents. Residents within a 20 km radius of the Fukushima Daiichi Nuclear Power Plant and a 10 km radius of the Fukushima Daini Nuclear Power Plant were evacuated. In addition, the U.S. recommended that its citizens evacuate everyone within up to 80 km of the plant.

Keywords- Japan, tsunami, Construction Damaged by Tsunami

I. INTRODUCTION

TA tsunami is a naturally occurring series of waves that can result when there is a rapid, large-scale disturbance of a body of water. The most common triggering events are earthquakes below or near the ocean floor, but a tsunami can also be created by volcanic activity, landslides, undersea slumps, and impacts of extra-terrestrial objects. The waves created by this disturbance propagate away from the source. Upon reaching the shoreline the waves can have hazardous, height and force, penetrating inland, damaging structures, and flooding normally dry areas. Also, this wave can cause very severe currents. These currents can turn out to be an earthquake, typhoon, avalanche, fire or flood. The tsunami in Japan caused nuclear accidents, primarily the level 7 meltdowns at three reactors in the Fukushima Daiichi Nuclear power plant complex, and the associated evacuation zones affecting hundreds of thousands of residents, and at Least three nuclear reactors suffered explosions due to hydrogen gas that had built up within their outer containment buildings after a cooling system failure resulting from the loss of electrical power. Residents within a 20 km radius of the Fukushima Daiichi Nuclear Power Plant and a 10 km radius of the Fukushima Daini Nuclear Power Plant were evacuated. In addition, the U.S. recommended that its citizens evacuate everyone within up to 80 km of the plant.

II. BEHAVIORS AND CHARACTERISTICS OF TSUNAMIS

Information from historic tsunami events indicates that tsunami behaviors and characteristics are quite distinct from other coastal hazards, and cannot be inferred from common knowledge or intuition. The primary reason for this distinction is the unique time scale associated with tsunami phenomena. Unlike typical wind-generated water waves with periods between 5 and 20 Sec, tsunamis can have wave periods ranging from a few minutes to over 1 hour [1-3]. There is significant uncertainty in the prediction of hydrodynamic characteristics of tsunamis because they are highly influenced by the tsunami wave form and the surrounding topography and bathymetry.

Although there are exceptions, previous research and field surveys indicate that tsunamis have the following general characteristics [3].

A tsunami can propagate more than several thousand kilometers without losing energy.

Tsunami energy propagation has strong directivity. The majority of its energy will be emitted in a direction normal to the major axis of the tsunami source. The more elongated the tsunami source, the stronger the directivity. Direction of approach can affect tsunami characteristics at the shoreline, because of the sheltering or amplification effects of other land masses and offshore bathymetry [3].

At the source, a tsunami wave form contains a wide range of wave components, from short to long wavelengths. Long wave components propagate faster than short wave components; therefore, a trans oceanic tsunami is usually characterized by long-period waves. Shorter wave components are left behind and attenuated by radiation and dispersion.

For a locally generated tsunami, the first leading wave is often a receding water level followed by an advancing positive heave. This may not be the case if the coastal ground subsides by co-seismic displacement. For far-source-generated tsunamis, the leading wave is often an elevation wave

Tsunamis are highly reflective at the shore, and capable of sustaining their motion for several hours without dissipating energy. Typically, several tsunami waves attack a coastal area, and the first wave is not necessarily the largest sensitive instrumentation can detect tsunami activity for several days.

TABLE 1.
COMPARISON OF RELATIVE TIME AND LOADING SCALES FOR VARIOUS COASTAL HAZARD PHENOMENA

	Loading duration	Water heigh	Warning time
Wind-generated Waves	Tens of seconds	1 to 2 meters	Days
Tsunami run-up	Tens of minutes to an hour	1 to 10 meters	Several minutes to hours
Hurricane storm surge	Several hours	1 to 10 meters	Several hours to a few days
Earthquake shaking	Seconds	N/A	Seconds to none

Tsunami run up height varies significantly in neighboring areas. The configuration of the continental shelf and shoreline affect tsunami impacts at the shoreline through wave reflection, refraction, and shoaling. Variations in offshore bathymetry and shore line irregularities can focus or disperse the tsunami wave energy along certain shore line reaches, increasing or decreasing tsunami impacts [3].

These broken waves (or bores) are considered relatively short wave forms (although still longer than wind-generated waves) riding on a much longer main heave of the tsunami.

After a bore reaches the shore, the tsunami rushes upon dry land in the formation of a surge.

In some cases, especially when a long wavelength, leading-elevation, and far-source-generated tsunami attacks land on a steep slope.

III. HISTORIC TSUNAMI ACTIVITY

The first tsunami occurred in the Kavarna coastal in the North of the Varna in 1 century BC. [4]. The tsunami waves caused by the explosion of a volcano in Santorini in Greece in 1630 BC caused large losses in Cretan island. In 1700 AC a severe earthquake occurred on the North West Pacific coast of America (Cascadia) continental in 1700 AC and this earthquake caused tsunami waves. Some historians believe that the tsunami caused the dispersion of the Minoan civilization. The Lisbon earthquake occurred in the 1755 caused tsunami. This tsunami wave could pass Atlantic ocean from one point to another point and caused major damage. Japan's northeast of the tsunami occurred in 1896 in Sanrikuda caused to lose their lives of more than 20.000 people. The tsunami occurred on ALEUT islands of Alaska in 1946 reached within five hours the Hawaiian shores and caused major damage. This event accelerated the development of the Pacific Ocean tsunami warning system. A magnitude 9.5 earthquake occurred in Chile in 1960, and this earthquake created 11m high tsunami waves in the Great Ocean. This disaster that caused loss of life of 2200 people. This hazard showed the importance of the need to more educated the public against tsunami danger. In this tsunami, one thousand people in Sile and 61 people in Hawaii lost their life. Tsunami waves, reached the shores of Japan quickly 750 kilometers per hour and hit the coast and demolished everything. Tsunami went to approximately 17,000 km distance between Chile and Japan. A 8,9 magnitude earthquake occurred in northern Japan in March of 2011, and this earthquake caused huge tsunami waves. In the earthquake and tsunami disaster more than 20,000 people died. Immediately after the earthquake and tsunami disaster in this country, people saw Fukishima nuclear power plant accident. This accident occurring in the plants caused nuclear leaks into the air and ocean water. Environmental pollution caused the deaths of fish, etc. Living in the ocean. and the people living in that area exposure to radiation.

IV. TYPE OF CONSTRUCTION DAMAGED BY TSUNAMI

In the previous parts historical large tsunamis given in the literature, and their loss is roughly described. In this part information was given about the types of construction damage examples by the tsunami were given in Fig. 1-4.



Fig. 1. A church building erected by tsunami waves



Fig. 2. A steel structure erected by tsunami waves



Fig. 3. A wooden building was dragged along by tsunami waves

V. STRUCTURE TYPES PROTECT FROM TSUNAMI

It can be concluded that the impact may cause devastating damage to critical structural members of the building, according to the mass of waterborne objects and the structural system. Failure of a column due to a very large impact load cannot be avoided and it would be costly to design a building for such impact loads.



Fig. 4. A Liquid storage tank tilts over by tsunami waves

However, there are certain mitigation measures that could be adopted to protect critical buildings that can be used for tsunami evacuation purposes. One of the impact mitigation strategies for buildings with an open first - story is the inclusion of redundancies in the open first-story to avoid collapse of the building due to failure of one or two columns. Tsunami resistant buildings where the lower level is elevated by means of RC columns to allow the free flow of tsunami waves, have been recently constructed in some countries [1]. An example of the tsunami resistant buildings is tsunami evacuation buildings (Fig. 5.).



Fig. 5. Typical TEB Conceptual Design

These buildings can be an important element to ensure that schools, essential facilities, and government buildings are able to meet their everyday purposes, and continue to function after the earthquake and tsunami. People who cannot safely evacuate the tsunami inundation zone should be able to evacuate to a TEB. TEBs must be able to withstand prolonged strong shaking and may be reinforced concrete structures with deep scour-resistant foundations and a minimum of two stories. The lowest story should be open space on the ground floor to allow for water and debris passage [2]. Or, the lowest floor may be designed to be sacrificial, such as with breakaway walls. The elevation of the bottom of the second story should be higher than the anticipated tsunami inundation elevation. The roof may be designed for general purposes, such as for parking or recreation space. It may also be designed for emergency purposes, such as for evacuees, heliport, emergency storage of food or medical supplies, emergency generator, emergency vehicles and so on. Energy dissipation or deflection structures may be designed to protect the TEB by reducing the tsunami force and scour effects. In addition, TEB design should accommodate rapid ingress by foot traffic during tsunamis and be readily identifiable to evacuees. Accommodation must also be made for wheelchair access. TEBs should allow for a minimum area per evacuee depending on its purpose [2].

Another impact mitigation strategy is the construction of impact resisting barriers or walls, which absorb and dissipate most of the impact energy to protect critical buildings [1].

A.Seawalls

Seawalls, bulkheads and revetments are coastal structures that are used to protect shoreline land from tsunami due to rising sea levels and waves. Reinforced concrete seawalls can withstand higher wave forces than soil revetments and stone bulkheads. They are designed to absorb breaking wave energy or reflect waves seaward or upward.

In order to design a tsunami dissipation wall that reduces the tsunami actions the TEB, we adopt the foregoing design concept of seawalls. These destructive waves can carry debris, such as logs, creating high impact loads and cause extensive damage to wood and unreinforced masonry structures. To dissipate some of this tsunami energy, the vertical tsunami evacuation building will have two reinforced concrete seawalls along the west and east sides of the buildings. The primary objective of the tsunami dissipation walls is to reduce some of the tsunami energy and debris forces by wave front upward deflection and debris damming. The more wave and debris energy that can be absorbed or dissipated by the wall prior to reaching the building, the less robust the building will need to be. The seawall is not intended to completely prevent tsunami inundation, but merely to dissipate some of the tsunami energy.

Seawalls will have two pile supported reinforced concrete walls (Fig. 8.). The ocean side wall is a combination stepped and curved face and the landward wall is a curved facade only.

The curved face of the wall will reflect the wave energy upward, causing the tsunami to reflect some of its destructive energy before reaching the building. The wall will absorb impact and damming debris forces. The west wall will dissipate wave energy from the run-up and the east wall will dissipate wave energy from the drawdown.

To design and build an effective and efficient seawall, more information is needed about the expected tsunami wave and the soil types below the walls. The design tsunami wave shape, velocity, height and frequency will govern the forces needed to design the seawalls. Local soil classification is needed to determine pile depths and the width of the wall. There are several structural systems protecting structures from hydrodynamic loads of the tsunami. Post-tensioned concrete frames or a combination of concrete frames with concrete shear walls parallel to the direction of anticipated tsunami flow are more suitable for the TEB.

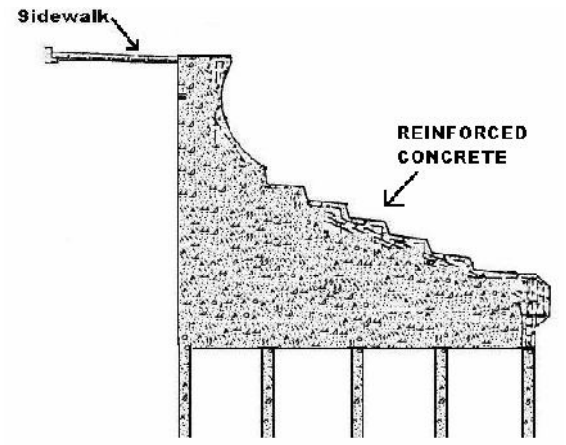


Fig. 6: Combination stepped and curved face pile support seawall, modified from

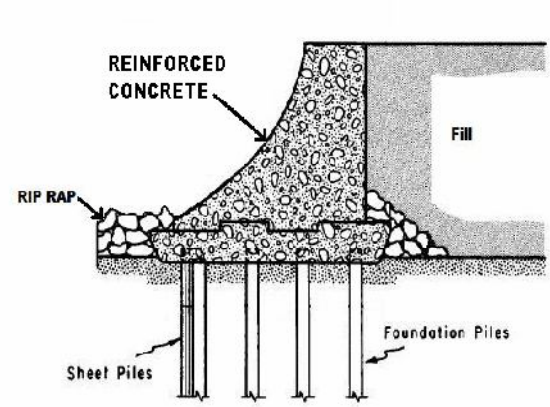
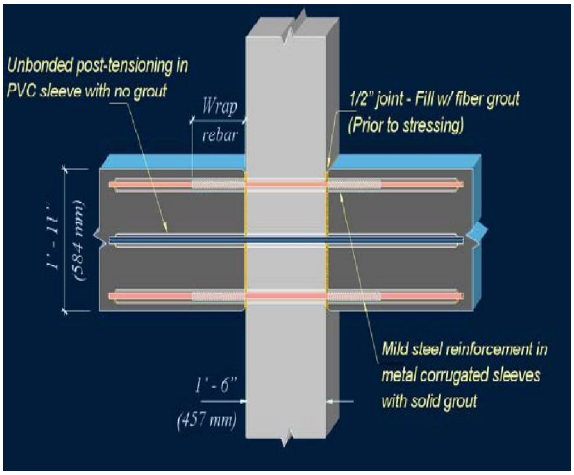


Fig. 7: Pile supported, reinforced concrete, curved face seawall, modified form



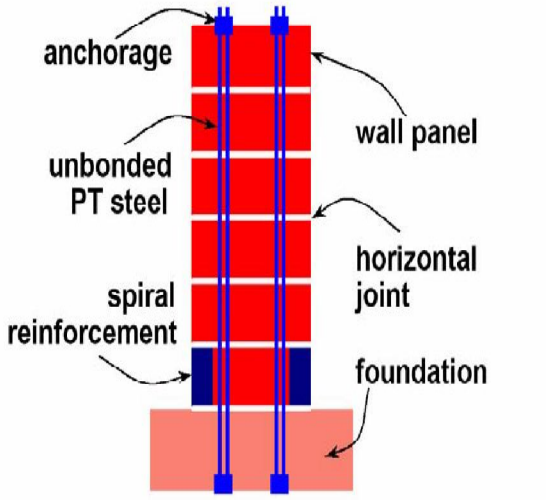


Fig. 8 Lateral-force Resistance Systems (b) Post-tensioning concrete shear wall

Fig. 9 shows a conceptual layout of lateral-force resistance system for the beam TEB. It is expected that the site would likely experience liquefaction during the seismic shaking, which could result in differential settlement of ground soil. Also, significant scouring due to tsunami is likely to occur at the site. To minimize the undesirable effects of liquefaction induced differential settlement and scoring on the structural system, pile foundation is

recommended as shown in Fig. 8 support the columns of both seismic and gravity frames. Pile caps are interconnected with grade beams and ground slab to ensure lateral forces can be distributed to all the piles.

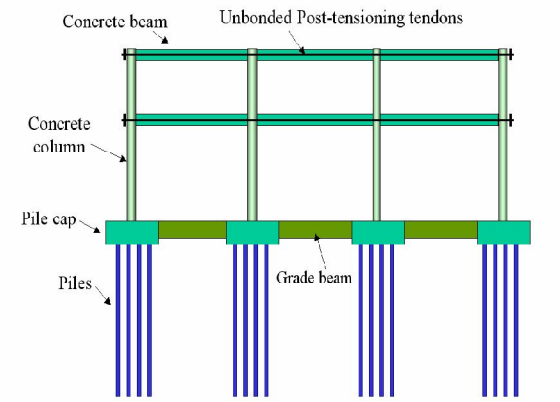


Fig. 9. Typical Post-tensioning Concrete Frame Elevation

CONCLISIONS

The concrete columns in the lower level are designed with circular cross-sections to minimize hydrodynamic loads and impact loads associated with waterborne debris. At the city hall site, the tsunami inundation depth is estimated to range from 6 feet at the most likely tsunami to 15 feet to 30 feet in rare events. Both the second level and a roof terrace are planned for refuge. Given the uncertainty involved in the tsunami modeling and estimate, if the first story height is set unconservatively low, the water run-up could potentially exceed the first story height, wash away the contents in the second story, and pose buoyancy and hydrodynamic uplift force on the 2nd floor concrete slab, as well as the excess moments on the column structures Thus, the design team must exercise care to properly set the story height of the first story. The concrete floor framing and slab at the 2nd and the roof levels will be designed to accommodate refuge live load. The slab to beam connection at the ground and the 2nd floor levels need to be strong enough to resist any potential buoyancy and hydrodynamic uplift forces on the slab. In case that “break away” wood stud walls are used in the building, we will detail the connections with a fuse at the top and sides to minimize the hydrodynamic loads on the building structure [7]. Due to the uncertainties involved in the estimate of impact forces associated with waterborne debris, the TEB design will incorporate considerations of the “tie force” strategy and the “miss column” strategy in the design to reduce the potential for progressive collapse if one column is severely damaged [1].

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