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Assessing Tsunami Hazards and Developing Strategies to Minimize Risk

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Geology & Earth Science

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INTRODUCTION

A tsunami is often referred to as a 'wall of water'. An average wave can be as high as 30 feet and can be as fast as 30 miles per hour when it hits the land. Tsunamis come after earthquakes that, on their own, have the potential to level cities. The infrastructure must withstand an earthquake then it also has to be able to survive the many forces from a tsunami. The damage from a tsunami is not as simple as the water hitting something. The water can lift infrastructure from its foundation or liquify the soil and that can lead to houses and roads being undermined and carried away. Mitigating this kind of damage is also not easy. Tsunami's in the last ten years have destroyed buildings previously thought to be indestructible to tsunamis and tested warning systems meant to prevent the loss of human lives. New ways of lessening the damage are being thought up and tested so events like what happened during the 2004 Indian Ocean, 2010 Chile, 2011 Japan events aren't as catastrophic as they were. This poster is going to look at mostly the damage from the 2011 Japan event since is more prevalent to the pacific northwest and any future event that may occur.

Tsunami wave from 2011 Japan Tsunami

Typical Forms of Damage from a Tsunami

There are multiple forms of damage from multiple forms of force from a tsunami. Arguably most of the damage comes from hydrodynamic force, or the force caused by the wave moving horizontally. This can effect buildings, bridges, trees, or powerlines can be hit and then get picked up by the tsunami and add to force of the waves. Another form of force is buoyancy force, or the upward force. This is what allows the martials to float and be carried by the tsunami. Objects like ships and larger buildings are more likely be damaged by the by buoyancy force than the hydrodynamic force since they will be picked up and collide with other objects in the tsunami. Larger scale tsunamis are expensive to clean up and repair, costing countries billions of dollars. Another cost comes in the form of human lives. Anyone in the way of a tsunami is almost guaranteed to not survive it. Anyone not in the vicinity of the tsunami that got to a safe zone would have to live with possibly contaminated water supplies and sewage all around the effect area.

Damage from the 2011 Japan Tsunami

Reinforce concrete (RC) buildings were thought to be invulnerable to tsunamis and experienced many forms of failure. Many RC buildings failed by being overturned by the waves of the tsunami. The buildings themselves were not broken, however. The failure is hypothesized to be from the buildings being submerged and if the waves were fast enough, caused the buildings to flip over. It is also important to mention that entrapped air within the buildings made the buildings easier to float. Debris impact and soil instability also played a role in RC building failure. Another form of failure came from foundation failures. Many seawalls had complete sections undermined. Sections showed evidence of scouring and components were taken off and were found on the beaches. Roads and building foundations also suffered damage, such as "severe undermining damage in the road and scour under the building foundation" (Yeh et al., 2012, p. 9).

These are examples of damage just to buildings designed to specifically withstand tsunamis. The figures are over 22,000 people died and about 2,600 people are missing (Figure 1). Much of this could be attributed to Japan's warning system at the time. They only broadcast 9 minutes after the earthquake hit and gave people only 15 minutes to do anything. Japan has had tens of billions of dollars in damage, including over 190,000 buildings were destroyed or damaged from both the earthquake and tsunami. The infamous Fukushima meltdown resulted in radiation levels being eight times the normal levels. This meltdown caused radioactive iodine to be detected in tap water and radioactive iodine and strontium to be detected in soils.

	Personal damages			Property damaged	Damaged roads	Damaged bridges	Landslides	Break of dikes	Damaged railways
	Killed	Injured	Missing						
Total	15,899	6,157	2,529	1,206,394	4,198	116	207	45	29

Figure 1 Data from the National Police Agency of Japan

Mitigation Strategies

While the RC buildings in Japan had many failures, possible effective mitigation techniques were observed. Some buildings that stay standing had breakaway walls and holes, such as windows and doors, that were aligned with the flow direction of the tsunami. This allowed water to enter and let entrapped air escape, making it less susceptible to being overturned. Sturdy buildings, like one built with reinforced concrete, altered the path of the tsunami flows. This protected less stable building immediately behind them, but possibly strengthened the stream and destroying more building past the shadow zone. Some seawall designs were able to stay upright and prevent more damage. A seawall in Hakozaki, Japan had concrete flanges on the front and rear toes, protecting a critical failure point of the seawalls seen in Japan. Another way reduce the damage from a tsunami is coastal vegetation. The presence of coastal vegetation can reduce tsunami energy (Figure 6) and lower the damage in terms of economics and the environment. The amount of reduction of damage depends on the type of vegetation, arrangement, and the actual conditions of the tsunami. A combination of at least two kind of vegetation are "recommended as a vegetation bioshield to protect coastal areas from tsunami hazard" (Thuy, et al., 2011, p. 11). A way to test these strategies in real time was developed that could test a grid of 10 meters in under 20 minutes (Musa, et al., 2018). One potential problem is that a supercomputer is needed for simulation and the areas at the time of publication were limited to limited in Japan.

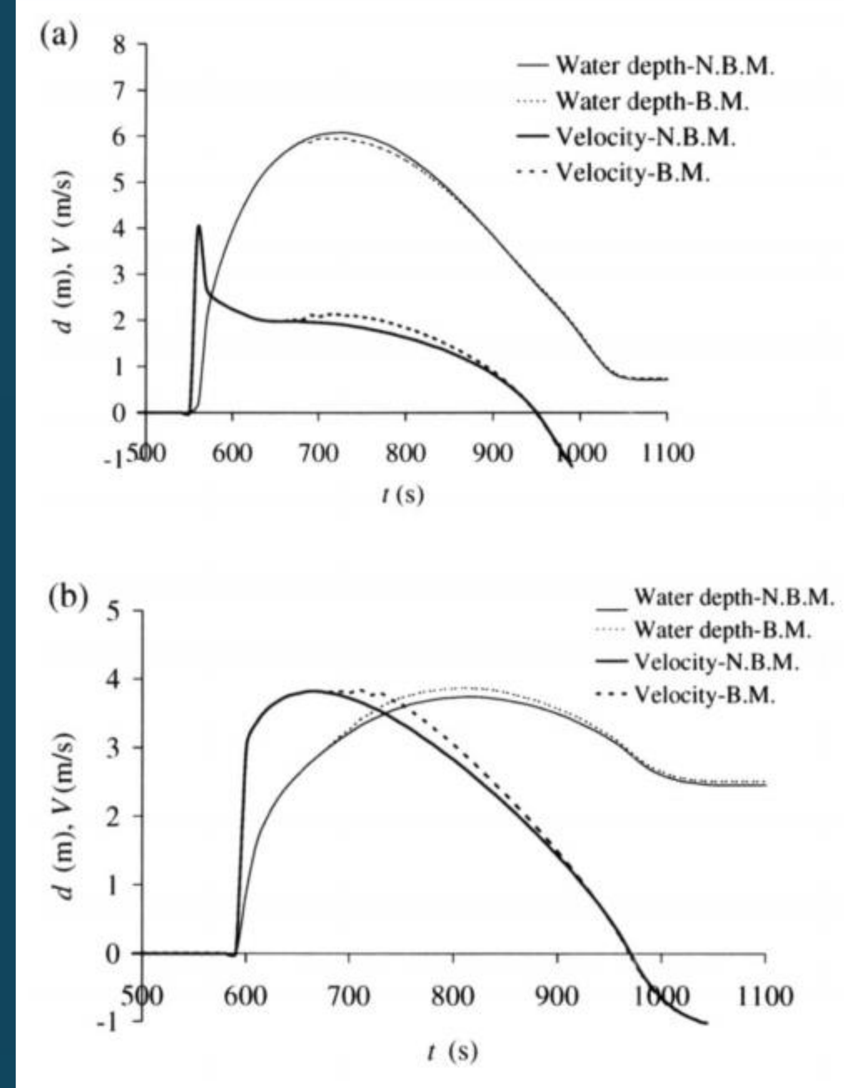

Fig. 6 Time profiles of water depth and velocity **a** at front of and **b** at behind the coastal forest

Figure 6 (Thuy et al., 2011, p. 7)

Conclusions

Preparing for a tsunami is difficult. Buildings thought to be invincible in the face of a tsunami are taken right off their foundation. Seawalls designed to keep water on the other side of a town are completely overrun and then undermined with pieces being ripped off and carried back to the beach. Japan was one of the most prepared countries in terms of a tsunami and many of its structures were decimated. Oregon on the other hand, is not so well prepared even nine years after the Japan event. Since the event, Japan is putting in place more land use regulations and planning its land use. Since the event, Oregon has built more hospitals, police stations, schools, and firehouses in the expected inundation zone (Schulz, 2019). There is no way to really test some thing build for these large-scale tsunami events other than seeing the aftermath of a real tsunami. Scientists are still developing and producing ways that may help in the future of another large tsunami, but one must question if it will really be enough. This does not mean that people should just standby and do nothing while the probability of another large-scale event increases every year there is not one.

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