EXPERIMENTAL INVESTIGATION OF BORE INDUCED LOCAL SCOUR

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Introduction

The 2004 Great Sumatra Andaman Tsunami and 2011 Tōhoku Tsunami resulted in a substantial loss of life resulting in a massive economic burden on their respective regions of incidences. These disasters have generated significant interest in research and design of onshore infrastructures. The study is of great significance to western Canada because of the active fault lines located in the Cascadia Subduction Zone along the eastern side of Vancouver Island.

The objective of the research was to study the relationship between hydraulic bores in the form of broken tsunami waves capable of propagating over land and water as well as local scour in the form of erosion of the bedrock or foundation at the base of an infrastructure. The main focus of this research is the investigation of local scour depth and shape produced by land-propagating bores, which are generally induced by tsunami waves and flash flood waves. The characteristics of the scour are related to the measured characteristics of the generated hydraulic bores. The results of the experiment will help the development of varying design guidelines as well as improve future coastal protections systems.

Figure 1: Tohoku Tsunami, Japan 2011
http://theaviationist.com/2011/03/11/sendai

Figure 2: Aluminum False Floor

Figure 3: Plexiglas structure and sand bed set-up

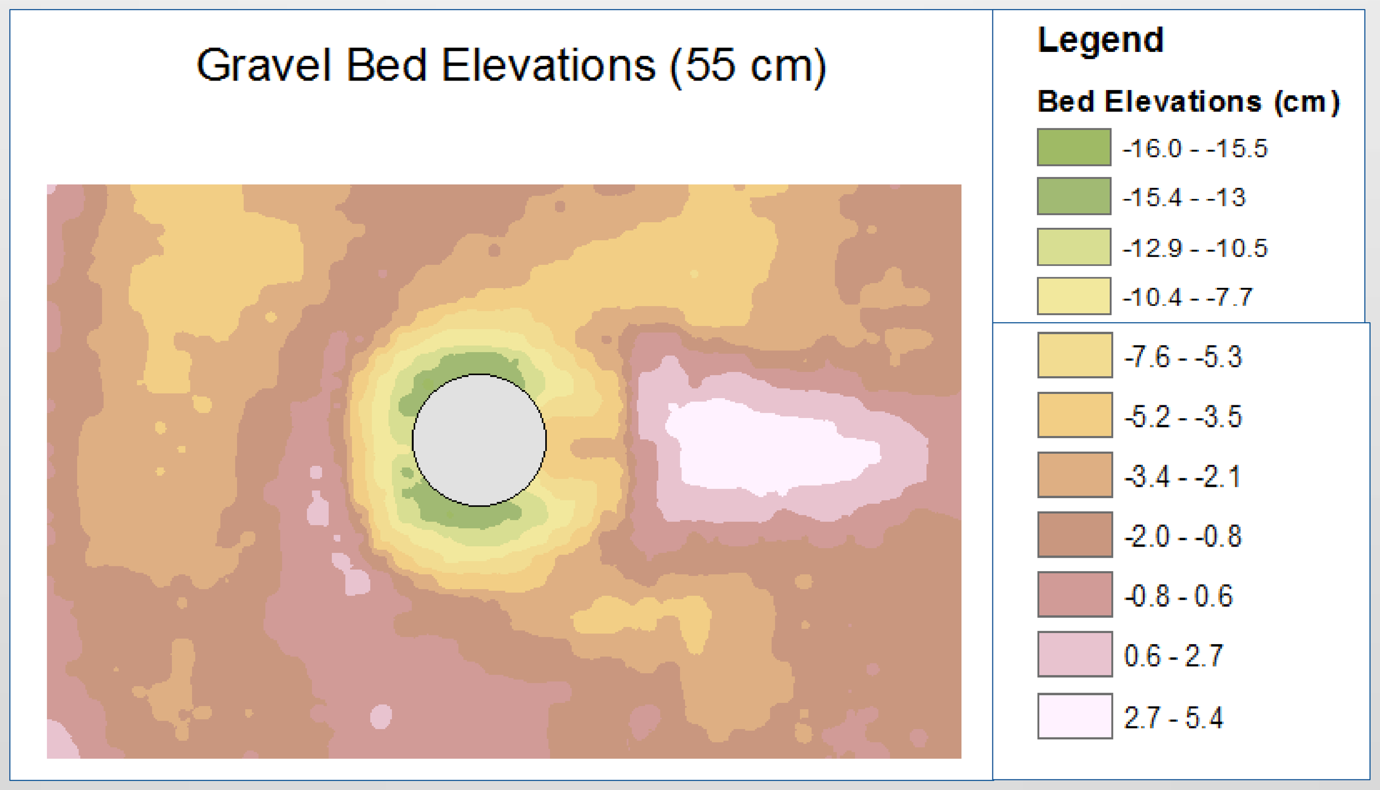

Figure 4: Local scour around cylinder

Methodology

To determine the impact of certain parameters, tests were performed in the High Discharge Flume of the Hydraulics Laboratory located at the University of Ottawa. The flume was 30 metres long, 1.5 metres wide and 70 cm tall. A steel and wooden framed swinging gate was built to allow for impoundment of water in the reservoir. A 4.0 metre long sand covered aluminum false floor was installed and a hydraulic bore was generated when the water was released by the hinged gate. The false floor was covered with a painted 20cm x 20cm grid. As shown in Figure 3, a cylindrical Plexiglas structure was placed in a bed of gravel or sand which simulated a structure impacted by the water of the tsunami-induced bore.

The final topography of the sediment bed was measured using a Leica Disto D8 Laser altimeter and then mapped out using the ArcGIS software. This allowed for the visualization and detailed measurements of the scour around the structure. Three wave gauges were used to measure the water surface elevation and the depth of the hydraulic bores during the experimental tests. Bores were recorded using an overhead high speed digital camera and a regular video camera to aid in flow velocity measurements by tracking Stryofoam particles and observing the scouring process.

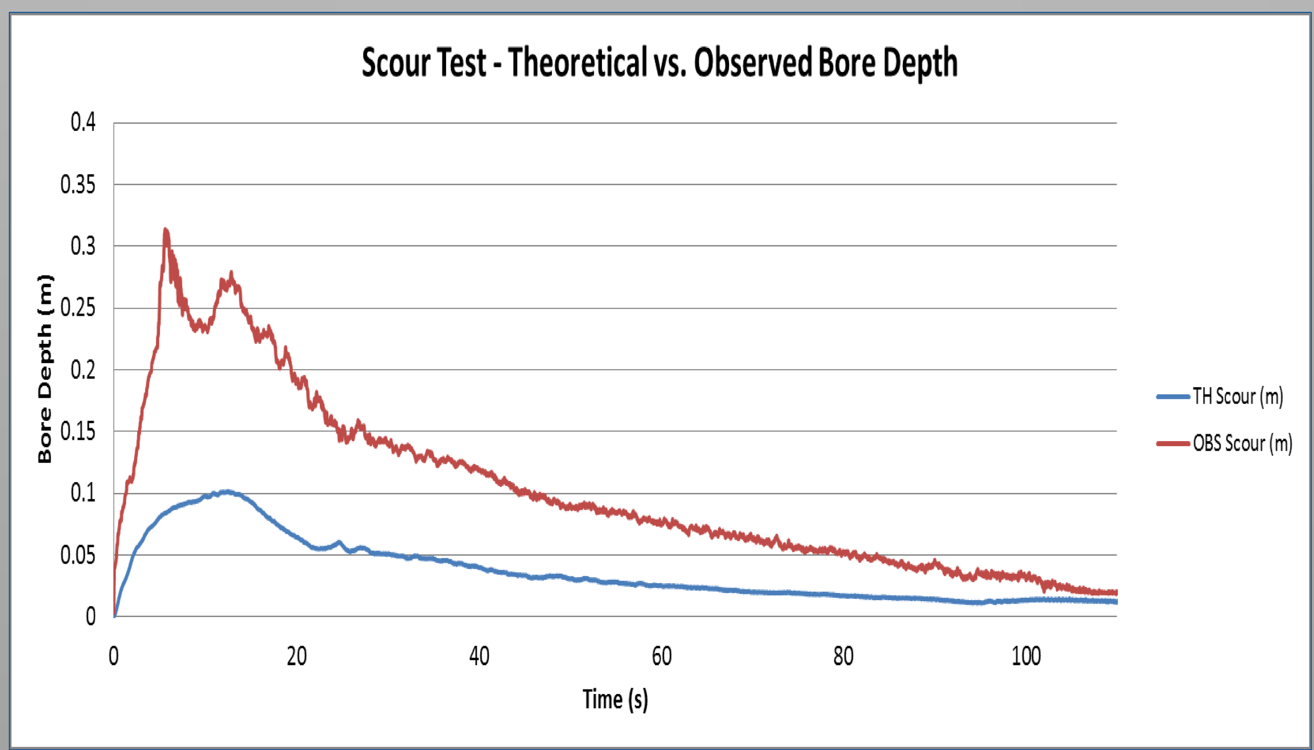

Figure 5: Bore depth over time

Results/ Discussion

Using the wave gauge recordings, Stoker's equation was used to calculate the depth of the hydraulic bore and was further compared with the recorded data based on the experimental values and recorded data. It was found that the measured hydraulic bore depth was significantly larger than the values obtained through the equations. Both the tracking of the bore front and the tracking of the particles are still underway.

Bore propagation was tracked along the longitudinal lines of the painted grid on the false floor and the sediment bed. The analysis performed showed that the bore front velocities decreased over time. Also, it indicated that there was a difference in the time history of the velocity as the bore front travelled through different surfaces. Using and tracking four (4) Styrofoam balls for each flow test allowed for the measurements of flow velocities. As a result, the tracking depicted a decrease in the magnitude of the flow velocities over time. Although both methods were used to track the velocity of the bore, the velocity of the bore front greatly differs from the velocity of the bore flow. A strong correlation was found between the bore front velocities and the bore depths.

Using ArcGIS, Figure 4 shows the scour profile of gravel around the cylinder. Most of the time, there is a scour hole immediately around the structure and large deposition of gravel behind the structure.

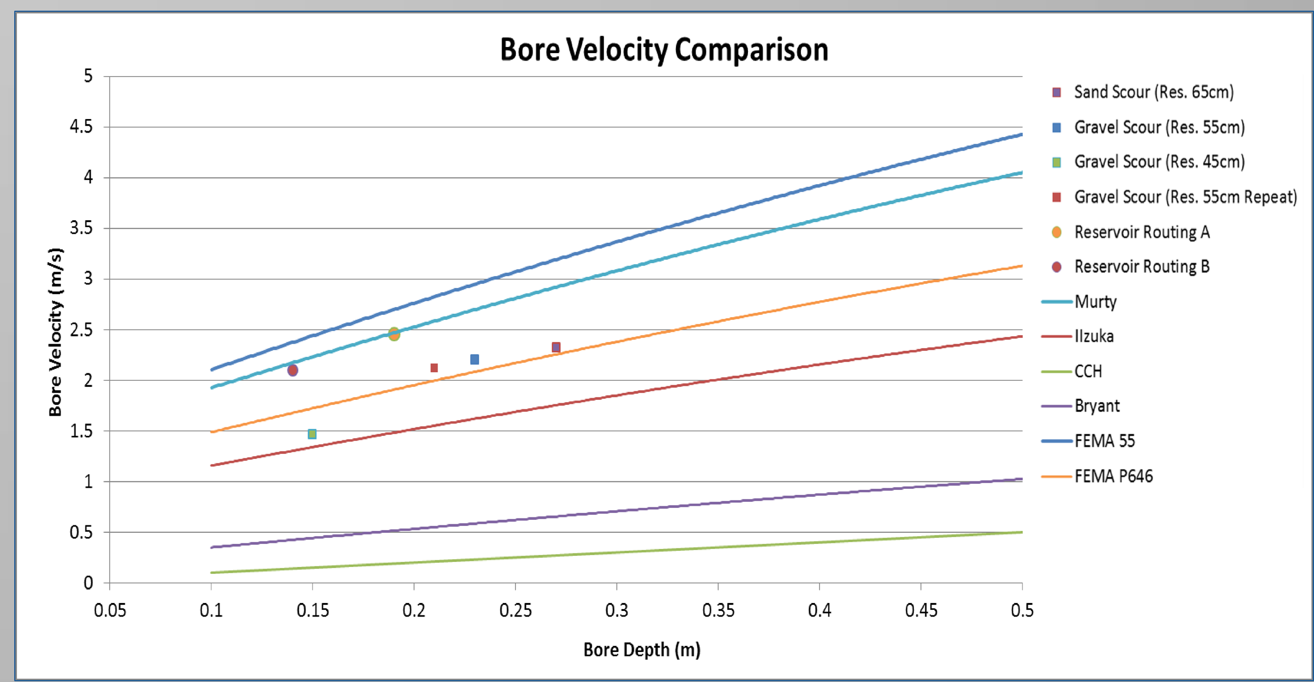

Figure 6: Bore Velocity Comparisons

Conclusions

The main outcome of the experiment is the discovery of a relationship between bore depth and bore velocities. From the results of the experiment, this relationship best correlates with the equation proposed by FEMA P646. For tests with measurements based entirely on the characteristics of the bore, the results were best fitting by the Murty equation (1977), as shown in Figure 6.

Future work will focus on in-depth analysis of the data to determine the impact that bore velocities and bore depths have on local scour depth. Furthermore, the effects of the gravel and sand particles on the scour characteristics will be studied.

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