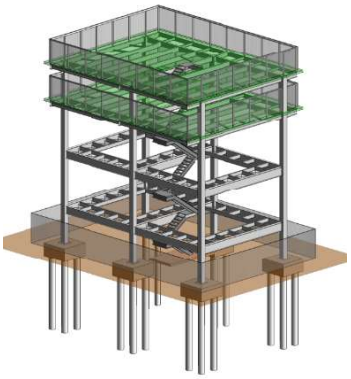
Tsunami Evacuation Tower Project History



Conceptual Design
November 8, 2017

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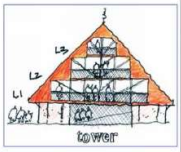
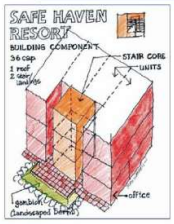
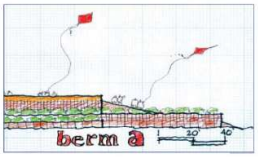
Project Safe Haven –Vertical Evacuation Refuge Structure Planning

PROJECT SAFE HAVEN:

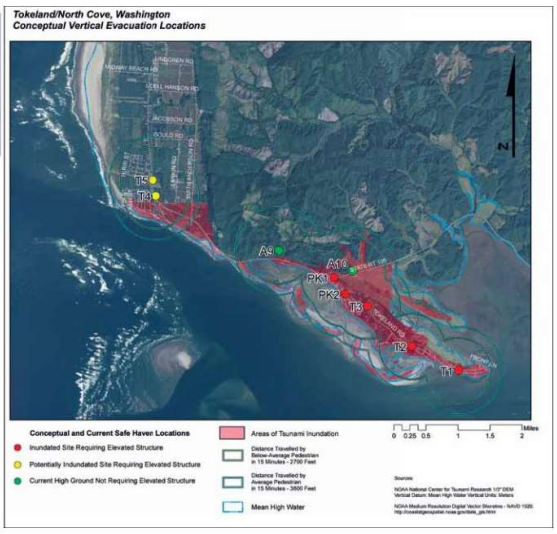
TSUNAMI VERTICAL EVACUATION ON THE WASHINGTON COAST







Pacific County



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2017 Conceptual Design

- Conceptual design began – October 11, 2017
- PDM Grant Application Due – November 14, 2017
- Tribe funded conceptual design; team included:
  - Goettel & Associates (Benefit-Cost Analysis)
  - Degenkolb Engineers (Structural)
  - Cumming (Cost Estimator)
  - UW (Tsunami Modeling)
  - WA EMD
  - WA DNR

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Aerial View

Project Location

Tokeland Tsunami Tower Choosing the Location

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2018 FEMA Grant Award

- $1.98m Construction Cost Estimate (Q2, 2019 dollars)
- $2.2m FEMA funding awarded
  - 90% Federal cost share
- Believed to be first FEMA-funded tsunami safe refuge project

FEMA Approves $2.5 Million for Shoalwater Bay Indian Tribe Tsunami Vertical Evacuation Tower

English

Release Date	Release Number
June 26, 2018	10

Release Date: June 26, 2018

BOTHELL, Wash. – The Shoalwater Bay Indian Tribe will receive $2.2 million from the Federal Emergency Management Agency (FEMA) for construction of a vertical evacuation shelter for protecting the population from tsunamis. That amount

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Tower Design Process

- Design began June 25, 2019
- Project goals:
  - 50’ safe refuge elevation assumed
  - 400 Person Occupancy
  - 4,000 sf
- Tower should be secured but with 24/7 emergency access
- Backup power and emergency supplies for 12-24 hours occupancy
- Project intended to be largely funded via PDM Grant

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Geotechnical Investigations

- Geotechnical borings were conducted in August 2019
- Initial findings were available in late-September 2019 indicating lateral spreading of soils were possible
- Revised foundation system was required:
  - Conceptual design assumed 24-inch diameter auger cast piles to meet liquefaction hazard
  - 5-foot diameter drilled shafts were required to resist lateral spreading
  - Significant construction cost difference between pile types ($300k+)

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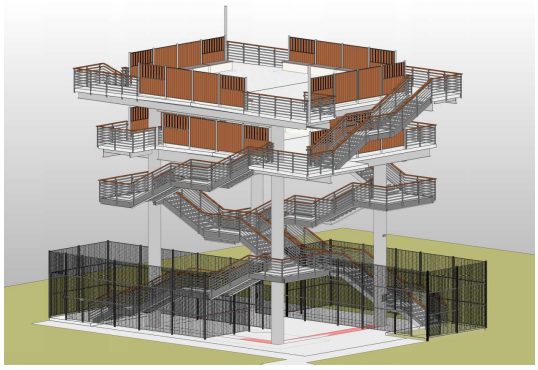
Redesign due to Geotech

- Although design was nearly 50% complete, redesign was completed from six- to four-column layout to account for liquefaction issues.



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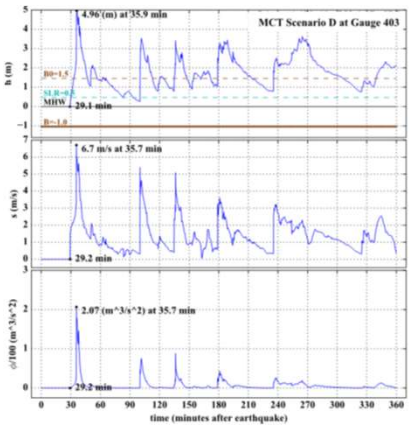
Getting around the problem

Inundation Modeling -University of Washington

Maximum Considered Tsunami (MCT) Scenario

Key Hazard Parameters

- Maximum Inundation Height (h): 20.2 feet
- Maximum Tsunami Flow Velocity (s): 22 ft/sec
- Arrival times of the first wave: 30 minutes
- High waves throughout the first 6-hours



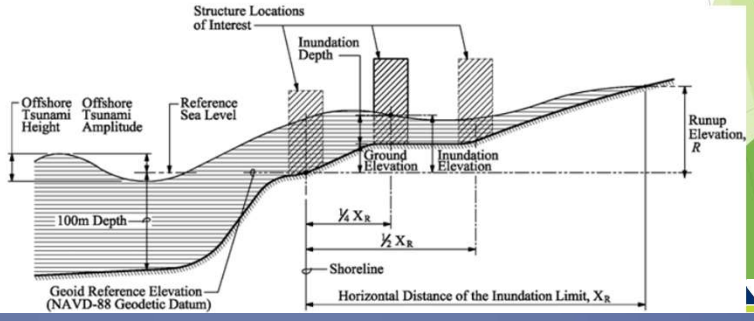
Modeled time series of h, s, ϕ at Gauge 403.

Hydrodynamic Drag

- Inflow & outflow of tsunami waves
- Global hydrodynamic drag Debris accumulation
- Component hydrodynamic drag

$F_{dx} = 1/2\rho_s I_{tsu} C_d C_{cx} B(hu^2)$ (Eqn. 6.10-2)

ρ_s = Fluid Mass Density
C_d = Drag Coefficient
C_{cx} = Closure Coefficient
B = Building Width
h = Inundation Height
u = Flow Velocity



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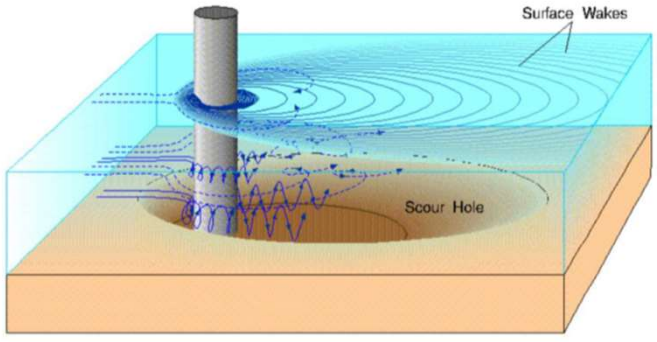
Ground Scour



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Debris Impact Loads

- ASCE 7-16 §6.11
- Logs, shipping containers, boats
- Simplified debris impact static load (Eq 6.11-1): 134 kips

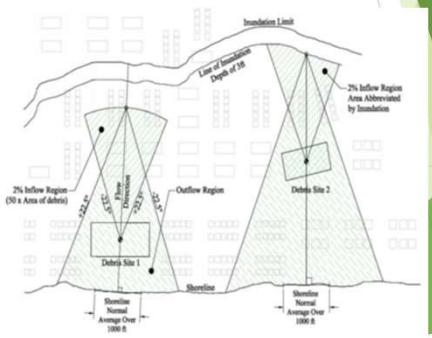

Figure 6.11-1 Illustration of Determination of Floating Debris Impact Hazard Region

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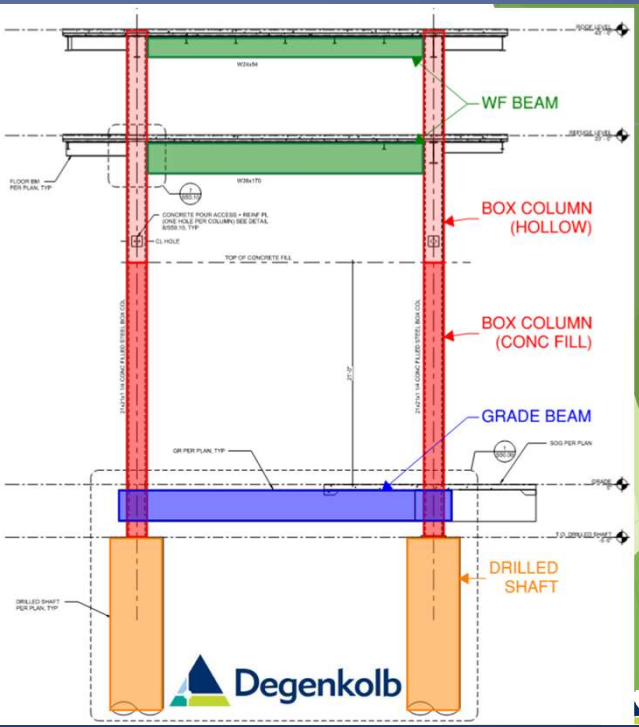
Structural Re-design

- First refuge level is at 33' above grade.
- Steel columns are 21" square and filled with concrete.
- Foundations are 5 feet in diameter and extend 55 feet below ground.



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Stair Design

Special considerations

- Designed for ingress in emergency –lower rise/run, wider
- One stair on leeward side of tower to protect from tsunami
- Designed with slip connections sized for Cascadia-level ground shaking
- Slab supported by grade beams to preserve during earthquake and tsunami

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Project Budget Impacts

- Foundation redesign required additional rounds of design revision and peer review, delaying permit submittal to March 2020
- Permitting was delayed due to pandemic restrictions on holding public hearings
- Project initially bid in November 2020. Low bid of $2.28m, bidder withdrew bid due to rising steel costs.
- Project re-bid in April 2021. Low bid of $2.67m by Rognlins, who was awarded contract and built the project.

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FEMA Outreach

- Team began outreach to WA EMD in April 2020 to explain project challenges and explore other grant funding options (e.g. HMGP or BRIC)
- WA EMD helped engage FEMA in May 2020
- Tribe met with FEMA in July 2020
- Given project circumstances, FEMA was open to increasing grant award budget
- Confirmation received from FEMA in November 2020
  - After Additional Funds awarded: $2.8m
- Project was able to move forward into constructio phase

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Design Challenges & Survival Needs

- Saltwater exposure
- Wetlands – Concessions and Credits
- Security
- Needs to be accessible to Community

Break Glass to Release Doors

Security Fencing at each Stair Entrance

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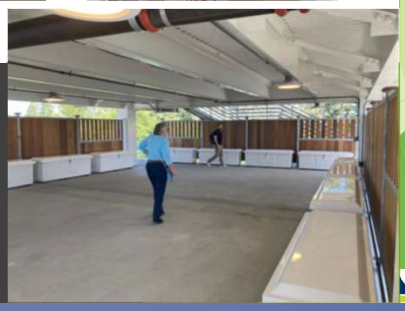
24 DCV Electrical Power

Emergency Supplies Storage

- MRE's
- Water
- Public Service Radios
- Heaters
- Blankets
- First Aid
- Sanitary needs



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Project Success

- Groundbreaking ceremony – May 17, 2021

Shoalwater Bay Tribe Builds Evacuation Tower to Provide Tsunami Safety for Community

English Español

Release Date
Wed, 06/30/2021 - 14:57

FEMA Region 10 Earthquake Program Manager Amanda Siok shares how the people of the Shoalwater Bay Tribe are proactively taking steps to protect their community from an earthquake and tsunami.

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Project Success

- Dedication ceremony – August 5, 2022

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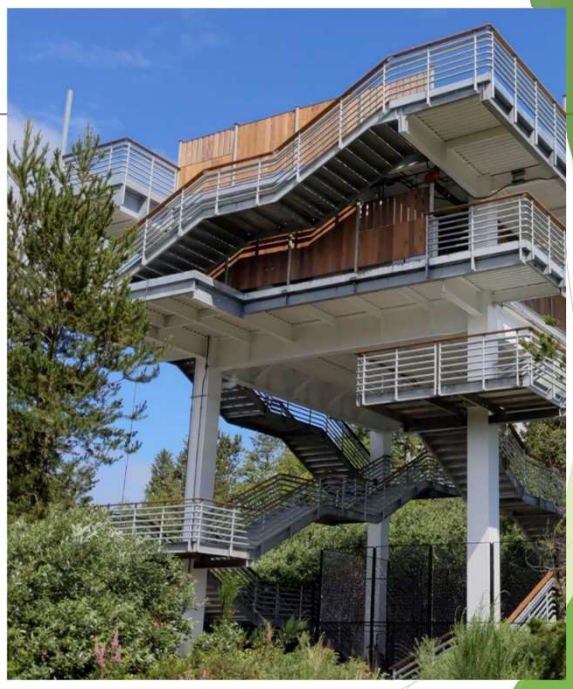
Completed Project July 2022



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Project Statistics

- Designed for ~400-person occupancy at 10 SF / person
- Designed per FEMA P646 and ASCE 7-16
- Design inundation depth of 20.2 feet, design velocity of 22.0 feet/second
- Refuge levels are at 33’ and 43’ above grade
- Drilled shaft foundations are 5’ diameter, 55’ deep
- Steel columns are 21” square box columns with 1 ¼” thick steel plate walls and concrete filled to resist debris impact
- Peer reviewed by both practicing engineers and university faculty involved with tsunami research
- Provides 24/7 accessibility with backup batteries and emergency communications equipment

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Project Lessons Learned

- An evacuation tower is unique in terms of building code requirements (e.g. accessibility, zoning/permitting)
- Project budgets should factor in timeline to finalize grant award
- Construction cost escalation over past 2-3 years have impacted many projects
- Advance Assistance HMGP funding could have allowed geotechnical investigations to be completed earlier in the project
- FEMA grant funding was essential to the success of the project

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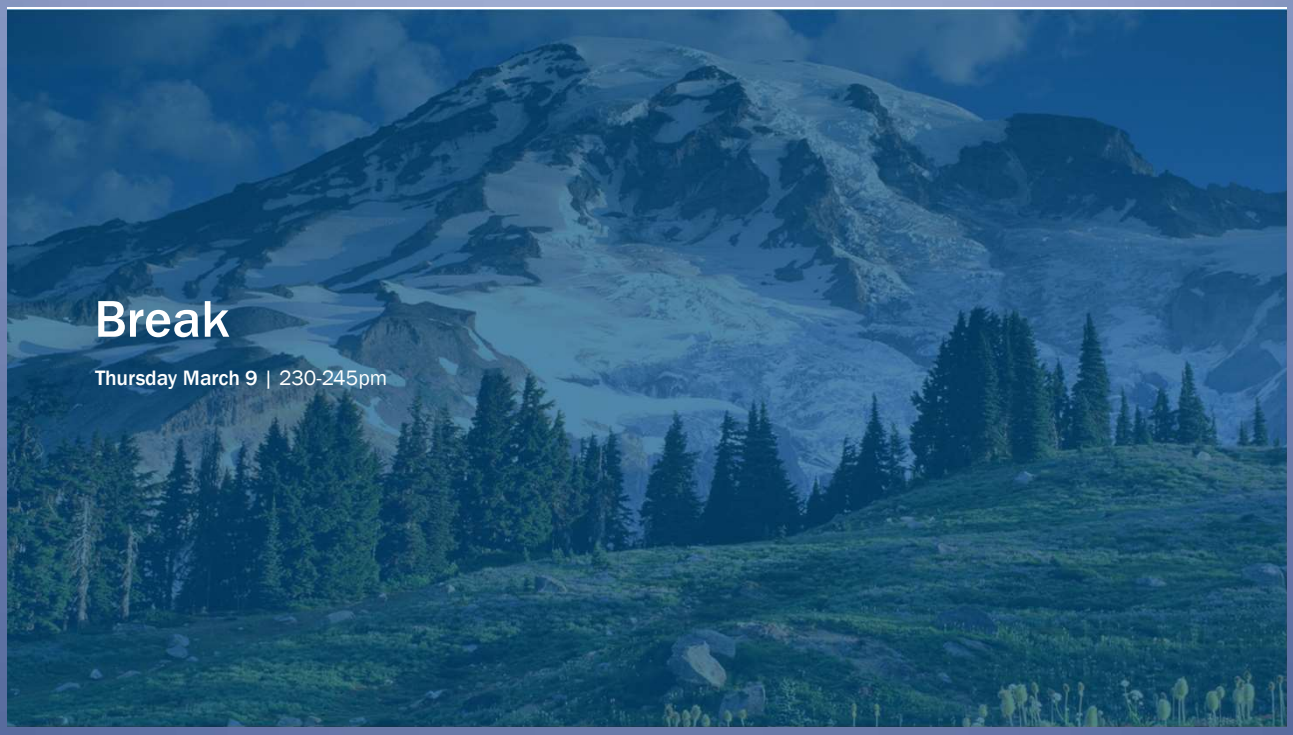
Break
Thursday March 9 | 230-245pm