ASCE 7 DEVELOPMENT OF TSUNAMI STRUCTURAL DESIGN PROVISIONS FOR THE U.S.

Gary Chock October 2013

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ASCE is Developing a Tsunami-Resilient Design Code

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- **A national standard for engineering design for tsunami effects written in mandatory language does not exist. As a result, tsunami risk to coastal zone construction is not explicitly and comprehensively addressed in design.**
- **The Tsunami Loads and Effects Subcommittee of the ASCE/SEI 7 Standards Committee is developing a new Chapter 6 - Tsunami Loads and Effects for the ASCE 7-16 Standard.**
- **ASCE 7-16 to be published by March 2016**
- **Probabilistic Tsunami Design Maps needed are being produced to accompany this new standard**

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Meetings with Alaska Stakeholders

- July 30-31, 2013
  - University of Alaska Fairbanks Geophysical Institute and AEIC [Dmitry Nicolsky and Elena Suleimani]
  - Ervin Petty, Tsunami Program Manager, DMVA
  - Cindi Preller, NWS Tsunami Program Manager for the Alaska Region and Tsunami Warning Center
  - Peter Haeussler, USGS AK
  - Charles Mueller, USGS CO (Seismic Hazard Model for Alaska)
  - Structural Engineers Association of Alaska
- Upcoming Opportunities:
- April 30- May 2, 2014
  - Seismological Society of America
- July 21-25, 2014
  - 10th National Conference on Earthquake Engineering

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Special Alaska considerations

- Near-Field Seismic Sources and detailed slip deformation modeling at the plate interface
- Subsidence within the plate rupture zone
- Digital Elevation Model high-resolution accuracy
- Co-seismic underwater Rockfall/Landslides in fjords leads to numerous local tsunami there as well as the regional tsunami
- USGS Earthquake Hazards Science Center to update Alaska seismic models and seismic maps in 2014
- Collaboration with USGS and ASCE seismologists and tsunami modelers to develop appropriate Hazard-Consistent Tsunami scenarios

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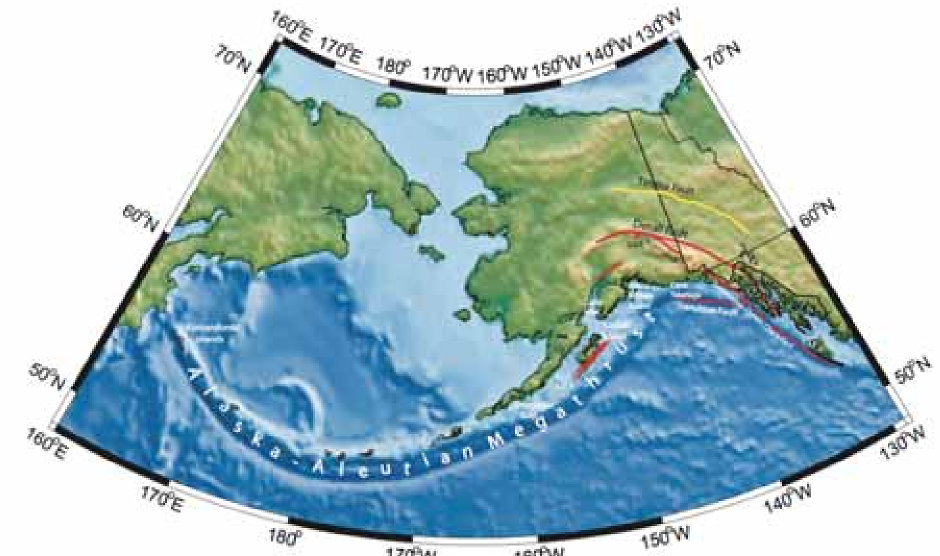

(Wesson and others, USGS OFR 2007-1043)

Physiographic features and crustal faults used in the hazard calculations (red).

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Large Historical Earthquakes

(Wesson and others, USGS OFR 2007-1043)

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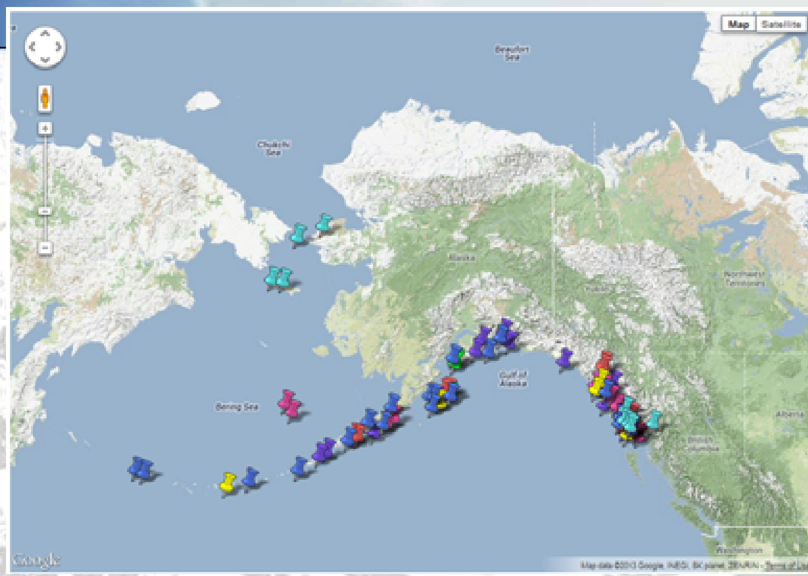
Tsunami threatened communities



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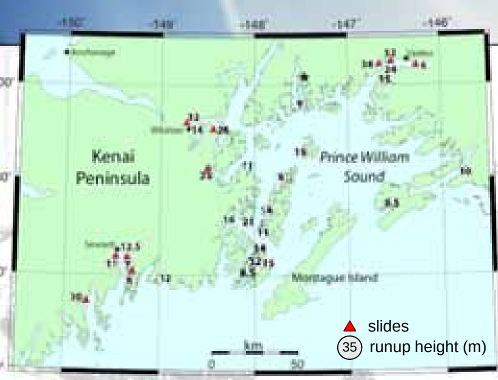
Sources of local waves in 1964



Locations of known and probable large underwater slides triggered by the 1964 earthquake, and maximum observed runup heights in meters (from *Plafker et al., 1969*)
Approach will be to use composite maps

Landslide tsunamis

Location	Max runup (m)	Deaths
Aialik Bay	30	
Blackstone Bay	24	
Homer	6	
Jack Bay	12	
Kenai Lake	10	
Chenega	21	23
Seward	12.5	12
Valdez	52	31
Whittier	32	13

Total volume of slide material: Seward: 0.2 km^3
Valdez: 1 km^3

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Code and Standard Development

Experience from Design Practice and Post-Disaster Surveys – Evaluation of Performance

Research & Development

Codes and Standards

Stakeholders
Users
Producers
General Interest

Building Officials and Authorities having jurisdiction

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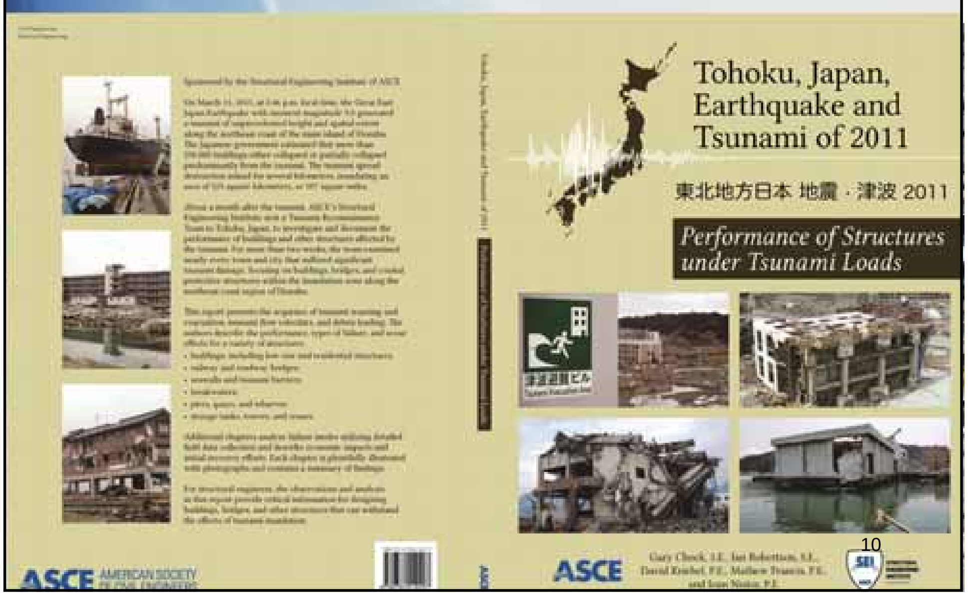
東北地方津波 Tohoku Tsunami



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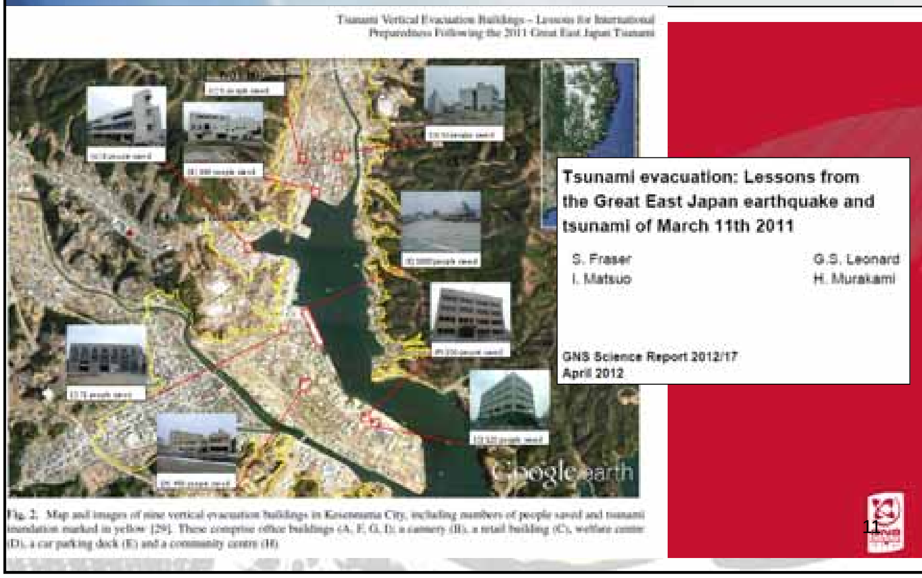
Report on Performance of Evacuation Structures in Japan



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Lessons from the Tohoku, Chile, and Sumatra Tsunamis

- Recorded history has NOT provided a sufficient measure of the potential heights of great tsunamis.
- Engineering design must always consider the occurrence of possible events greater than in the historical record
- Therefore, Probabilistic Tsunami Hazard Analysis should be performed in addition to historical event scenarios, so that the uncertainty of scientific estimation is explicitly considered
- This is consistent with the ASCE approach for probabilistic seismic hazard analysis
- This approach is inherently more precautionary with lives and property than deterministic scenario assumptions based on historical records.

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Tsunami-Resilient Design Strategy

- Select a site appropriate and necessary for the structure
- Select an appropriate structural system and perform seismic design first
- Determine flow depth and velocities at the site based on a probabilistic tsunami hazard analysis
- Check robustness of expected strength within the inundation height to resist hydrodynamic forces
- Check resistance of lower elements for hydrodynamic pressures and debris impacts to avoid progressive collapse
- Foundations to resist scour
- Elevate critical equipment as necessary

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Scope of the ASCE Tsunami Design Provisions
2016 edition of the ASCE 7 Standard, Minimum Design Loads for Buildings and Other Structures

6.1	General Requirements
6.2	Definitions
6.3	Symbols and Notation
6.4	Tsunami Risk Categories
6.5	Hazard Level of the Maximum Considered Tsunami
6.6	Flow Parameters Based on Runup
6.7	Site-Specific Probabilistic Tsunami Hazard Analysis
6.8	Structural Design Procedure for Tsunami Effects
6.9	Hydrostatic Loads
6.10	Hydrodynamic Loads
6.11	Debris Impact Loads
6.12	Foundation Design
6.13	Structural countermeasures for reduced loading on buildings
6.14	Special Occupancy Structures
6.15	Designated Nonstructural Systems (Stairs, Life Safety MEP)
6.16	Non-building critical facility structures
C6	Commentary and References

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Critical Facilities and Lifelines are Essential for Community Resilience

- **Critical Facilities**
  - Maintain the public's health and safety
  - e.g., hospitals, police, fire, and emergency medical services buildings, essential government buildings, ports, airports, water supply, wastewater treatment plants, power generating stations
- **Lifelines**
  - Power, transportation systems, and storage, treatment, and distribution systems of water and fuel, IT services and communications, and sewage systems

Visual 2.15 15

Consequence Guidance on Risk Categories of Buildings Per ASCE 7

Risk Category I	**Up to 2 persons affected** **(e.g., agricultural and minor storage facilities, etc.)**
Risk Category II	**Approximately 3 to 300 persons affected** **(e.g., Office buildings, condominiums, hotels, etc.)**
Risk Category III	**Approximately 300 to 5,000+ affected** **(e.g., Public assembly halls, arenas, high occupancy educational facilities, public utility facilities, etc.)**
Risk Category IV	**Over 5,000 persons affected** **(e.g., hospitals and emergency shelters, emergency operations centers, first responder facilities, air traffic control, toxic material storage, etc.)**

Visual 2.16 16

Tsunami Risk Category Design Criteria

- Not applicable to any buildings within the scope of the International Residential Code; Not applicable to light-frame residential construction
- Not applicable to any Risk Category I buildings
- Not applicable to any Risk Category II structures up to ~65 feet in height
- Applicable to all Risk Category III and IV buildings and structures, and only Risk Category II buildings greater than ~65 ft height
- Economic impact is anticipated to be very nominal to western states since most buildings subject to these requirements will be designed to Seismic Design Category D or greater (design for inelastic ductility).

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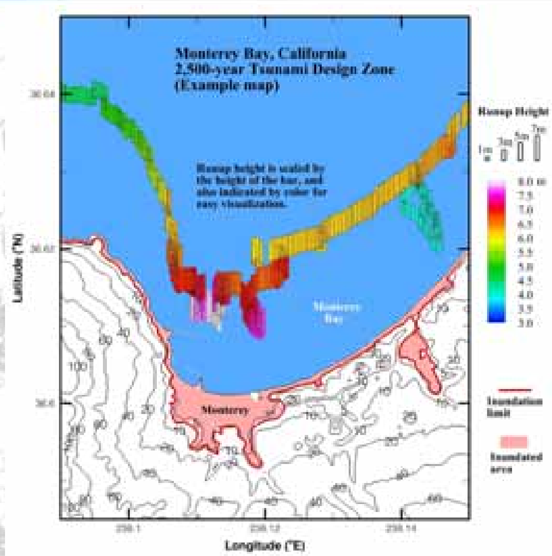
Example Illustration of a Local Design Map at a Reference Site



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Tsunami Disaster Resilience by Design

- Establish maps in the ASCE 7 design standard that are based on engineering reliability, rather than leaving local planners to use arbitrary deterministic maps
- Application to design and community planning and resilience before a tsunami event.
- After a tsunami, it will have even more significance as means to plan and evaluate what is appropriate in reconstruction, and to enable FEMA funding of Building Back Better.
- A new accomplishment that will directly improve the leadership position of the US to effectively influence international codes and standards related to community resilience and sustainable infrastructure.

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Strategy for Two-Stages of Map Development

- A new generation of tsunami inundation hazard maps for the *design* of critical structures is required
- ASCE has a role in rectifying consistency with criteria for other extreme loading, and establishing the probabilistic inundation hazard maps (and standardization of map style and format).
  [1 year ending in 2014]
- Later development of consistent local probabilistic inundation maps would then follow by the states under the federal National Tsunami Hazard Mitigation Program (NTHMP) or other programs available to the states
  [Five years leading up to 2019]

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Mapping Tasks funded by ASCE

- ASCE SEI and COPRI have supported the Tsunami Committee work since 2/2011 and is now involved in the national map development. By the end of 2014 it is estimated that over $300,000 will have been invested by ASCE
- Probabilistic Tsunami Hazard Analysis of Offshore Wave Height
- Probabilistic design maps for major populated/ regions
- The effort to develop the offshore probabilistic tsunami parameters and governing hazard-consistent tsunami scenarios for each community's regional analysis is a key linchpin to enable the local code adoption of the tsunami design provisions.

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Request for Sponsorship of Local State Maps developed with ASCE review

- 2014 Local Map -2015 Benchmarking per Probabilistic Criteria

Development of higher resolution 10-meter probabilistic design maps for PMEL reference sites. This effort establishes reference benchmarking for the later development of consistent local probabilistic inundation maps. This will also provide verification that the map formats that comply with the ASCE 7 Standard.

a. California 11 reference sites
b. Oregon 5 reference sites
c. Washington 5 reference sites
d. Hawaii 8 reference sites
e. Alaska 4 reference sites

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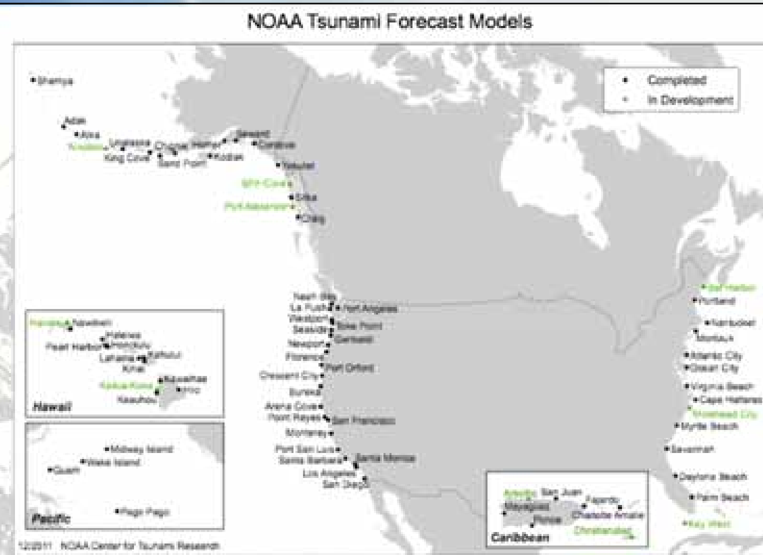
Funding needed: Federal Planning Grants are one means of funding

PMEL Reference Sites Locations



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Locally “complete” state tsunami design maps by 2019

- **Individual states would develop additional high resolution inundation maps for other coastal areas as needed in accordance with the procedure of the ASCE 7 Standard.**
- **Local adoption during the 2018-2019 timeframe when the IBC 2018 is adopted by the states and local county jurisdictions with map amendments.**
- **That subsequent effort would be performed by tsunami modelers selected by the states under the National Tsunami Hazard Mitigation Program.**

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Summary

- ASCE is completing tsunami design provisions for critical facilities, to be incorporated in ASCE 7-16
- This Standard would be referenced by the IBC 2018 reqts
- Design criteria is probabilistic and consistent with seismic provisions, and embodied in tsunami design zone maps
- Development and adoption of maps takes several stages
  - ASCE 7-16 overall maps (by ASCE) to be completed by the end of 2014
  - Local Reference Site Maps needed to benchmark state model compliance with ASCE criteria by 2015 –
    funding consideration for Alaska project implementation
  - "Complete" (as necessary) coastline tsunami design zone maps in accordance with ASCE criteria by 2019, to be managed by states

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The ASCE Tsunami Loads and Effects Subcommittee

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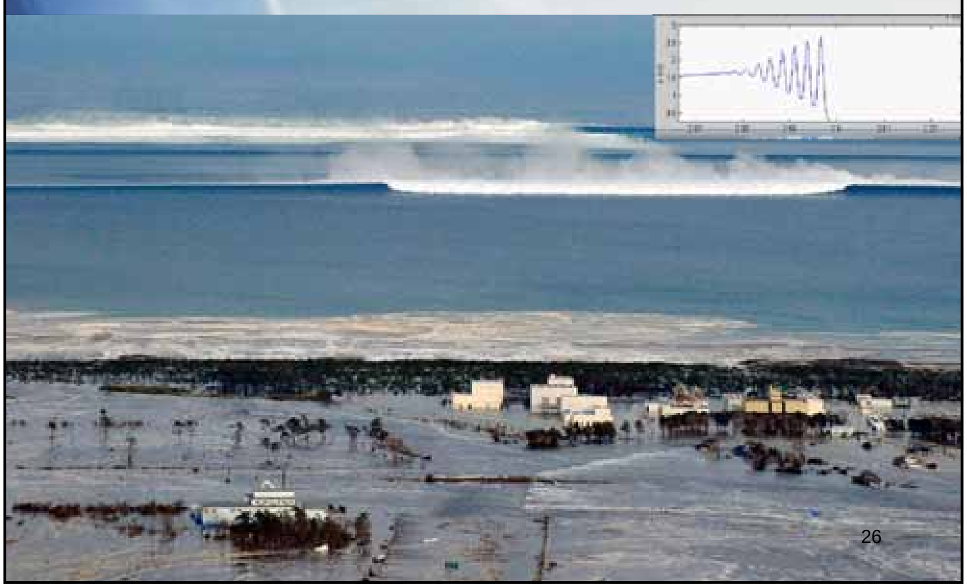

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