Seismic Performance Criteria PAMP

January 10, 2023

Seismic Design Event

Earthquake magnitude [M]	Energy [erg]	Energy [tons TNT]	No. Hiroshima nuclear bombs
4.0	6.3×10^{17}	15	0.001
4.5	3.6×10^{18}	85	0.006
5.0	2.0×10^{19}	480	0.03
5.5	1.1×10^{20}	2,630	0.2
6.0	6.3×10^{20}	15,000	1
6.5	3.6×10^{21}	86,000	6
7.0	2.0×10^{22}	478,000	30
7.5	1.1×10^{23}	2,640,000	200
8.0	6.3×10^{23}	15,000,000	1,000
8.5	3.6×10^{24}	86,000,000	6,000
9.0	2.0×10^{25}	480,000,000	30,000

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Seismic Design Event

Return Period	72 years	475 years	975 years
Prob of Exceedance	50%	10%	5%

Seismic Design Event

- Very large (nuclear weapon sized) event
- Relatively small probability of occurring in design life of structure.

Seismic Risk

- Modern codes and standards acknowledge risk and try to deal with it rationally and economically.
- There is NO requirement to try to eliminate risk.

ASCE 61 -14 Performance Requirements (Code)

DESIGN CLASSIFICATION	SEISMIC HAZARD LEVEL AND PERFORMANCE LEVEL					
	Operating Level Earthquake (OLE)		Contingency Level Earthquake (CLE)		Design Earthquake (DE)	
	Ground Motion Probability of Exceedance	Performance Level	Ground Motion Probability of Exceedance	Performance Level	Seismic Hazard Level	Performance Level
HIGH	50% in 50 years (72-year return period)	Minimal Damage	10% in 50 years (475-year return period)	Controlled and Repairable Damage	as per ASCE 7	Life-Safety Protection
MODERATE	n/a	n/a	20% in 50 years (224-year return period)	Controlled and Repairable Damage	as per ASCE 7	Life-Safety Protection
LOW*	n/a	n/a	n/a	n/a	as per ASCE 7	Life-Safety Protection

Current Code

- Reasonable and responsible modern design used across the country.
- Provides “seismic resiliency”.
- Could be applied to the Port of Alaska with no modifications.
- Includes some risk of damage at extreme event (considered acceptable by national standards.)

ASCE 61-14 Performance Criteria

- 3 design classifications (Importance)
- 3 performance levels
- 3 hazard levels (OLE, CLE, DE)

Performance levels:

- Life Safety Protection
- Controlled and Repairable Damage
- Minimal Damage

2.4.1 Life Safety Protection A structure shall be classified as providing "life safety protection" when (a) the post-earthquake damage state is such that the structure continues to support gravity loads, (b) damage that does occur does not prevent egress, and (c) there is no loss of containment of materials in a manner that would pose a public hazard.

2.4.2 Controlled and Repairable Damage A structure shall be classified as having achieved "controlled and repairable damage" when (a) the structure responds in a controlled and ductile manner, experiencing limited inelastic deformations at locations where repair is possible; (b) the required repairs result in a loss of serviceability for no more than several months; and (c) there is no loss of containment of materials in a manner that would pose a public hazard.

2.4.3 Minimal Damage A structure shall be classified as having achieved "minimal damage" when (a) it exhibits near-elastic structural response with minor or no residual deformation, (b) there is no loss of serviceability of the structure, and (c) there is no loss of containment of materials in a manner that would pose a public hazard.

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Recommendations and GAC Role

From September 23, 2014 GAC letter:

We agree with the Port that, at a minimum, one container dock and one POL dock should be designed for "minimal damage" at the CLE ground motions (rather than "controlled and repairable damage" as the CLE motions referenced in the code), and "controlled and repairable damage" at the DE ground motions. These structures will be referred to as the "seismic berths" in this letter.

Recommendations and GAC Role

From September 23, 2014 GAC letter:

"Controlled and Repairable Damage" by definition implies there could be loss of serviceability for "several months". That time frame is likely to be too long to supply 80% to 90% of the goods for the entire State, particularly in winter conditions. The commission advises that the definition of "controlled and repairable damage" should be adjusted to mean damage which is feasibly repairable within several days to one week of the seismic event. We advise that contingencies, plans, and materials be included in the design for repairs in the event of a Design Earthquake to reduce response time.

Comment: The interpretation of this is not in line with the intent of the ASCE 61 committee. The intent of the "Controlled and Repairable Damage" state is to maintain some level of serviceability.

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Current GAC Recommended Performance Requirements Minimal Damage in 2/3 MCE (Mandated?)

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MODERATE	n/a	n/a	20% in 50 years (224-year return period)	Controlled and Repairable Damage	as per ASCE 7	Life-Safety Protection
LOW*	n/a	n/a	n/a	n/a	as per ASCE 7	Life-Safety Protection

effective

2014 GAC Interpretation of ASCE 61 results in suggested modifications for POA

- GAC suggestion of the facility being in service within a week following a maximum design event (D.E.) has been interpreted as minimal damage state in D.E.
- This greatly exceeds the ASCE 61 requirements. It is two full steps above requirements.
- It is likely that POA is the only facility in the nation that is using these criteria.
- Cost increase may be measured not in percent but by some factor or multiplier.
- The MOA / POA is free to exceed any standard if they so wish.

POA Costs

Performance Level in DE	Life Safety	Controlled and Repairable Damage	Minimal Damage
Cost per Square Foot	$500	?	$3,000
Notes	Typical US West Coast Cost	No Data	One Data Point: PCT

POA Costs

- POA has several unique conditions; Ice , Tides, Short Season, Beluga Whales. These contribute to a high cost.
- There are lots of data points for modern industrial docks designed to ASCE 61 seismic standards.
- The only dock that I am aware of that has been designed to a higher seismic standard is POA PCT. Therefore, there is little or no cost data.

The Politicization of Seismic Design

- We need and greatly appreciate political support. We are also not trying to usurp anyone's authority. That said politicians should not be encouraged to practice engineering.
- From MOA Assembly member: *"I would like to see a full analysis of the GAC recommendation and the rationale from varying from the recommendations since the GAC has been the entity we have been relying on for the subject matter expertise to provide us a standard."*
- From MOA Assembly member: (from previous discussion) "it became apparent that the reduction in seismic resilience only provided limited value in context of cost savings."

The Politicization of Seismic Design

- The ASCE 61-14 design standard is the result of years of work. Using the un-modified version of this is not a “reduced standard” and should not be interpreted or represented this way.
- The GAC should be aware of the risks of politization and should be providing recommendations and not “policy”.

ASCE 61-14 Performance Criteria

Controlled and Repairable Damage. The below statement from ASCE 61-14 is what the GAC was concerned with:

- "The required repairs result in a loss of serviceablity of no more than several months."

What does this mean?

ASCE 61-14 What it IS and is NOT
Controlled and Repairable Damage – Repair Time

- Repair time IS a performance goal

- Is NOT based on estimated repair times.
- Is NOT based on engineering analysis.
- Is NOT based on any studies or case histories.

ASCE 61 - Revisions

- The 2015 GAC interpretation of ASCE 61-14 is not in line with what the authors of the standard intended.
- Controlled and repairable damage by definition retains the capacity to handle service loads.
- Clarifying language has been proposed for the revised standard due to be published in 2023.

ASCE 61-23 Suggested Language- Code

Performance is classified as “controlled and repairable damage” when (a) the structure responds in a controlled and ductile manner, experiencing limited inelastic deformations to an extent such that structural repair is possible, (b) the deck does not experience significant damage and pile damage is limited to an extent that no local collapses occur, (c) the structure may experience a temporary reduction in serviceability until inspection, evaluation, and/or repairs are performed, but maintains some level of serviceability, (d) damage to ancillary structures does not cause significant risk to life safety, and (e) there is no loss of containment of materials in a manner that would pose an immediate and direct public hazard.

ASCE 61-23 Suggested Language-Commentary

It is important to recognize damage in this performance category typically will not result in a complete loss of service. For example, spalling of the concrete cover at the pile to deck or pile to cap interface is expected. This loss of concrete cover may expose the underlying steel reinforcing to the elements. This results in the risk of corrosion over time. Repair is therefore required. However, this does not equate to an immediate complete loss of serviceability to the facility.

Suggestions

- Using “controlled and repairable damage” state for D.E. has a reasonable expectation of meeting the serviceabilty goal and is above national standards.
- Risk is a part of modern seismic design and there is no requirement to try and eliminate it.
- Every berth at the port is a lifeline and the above recommendations should apply equally to all.
- The Port needs to consider design standards, expected performance, risk, and costs in order to make an informed decision.
- The Port has a responsibility to facilitate efficient use of public and private funds.

Suggested Performance Requirements (ASCE 61-23)

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