PARSONS

Earth Covered Magazines
Vertical Seismic Ground Motion Effects

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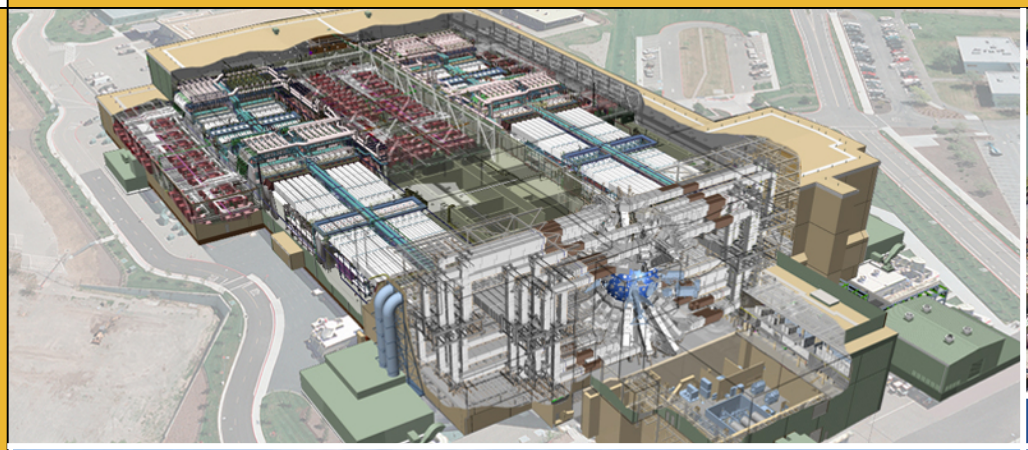


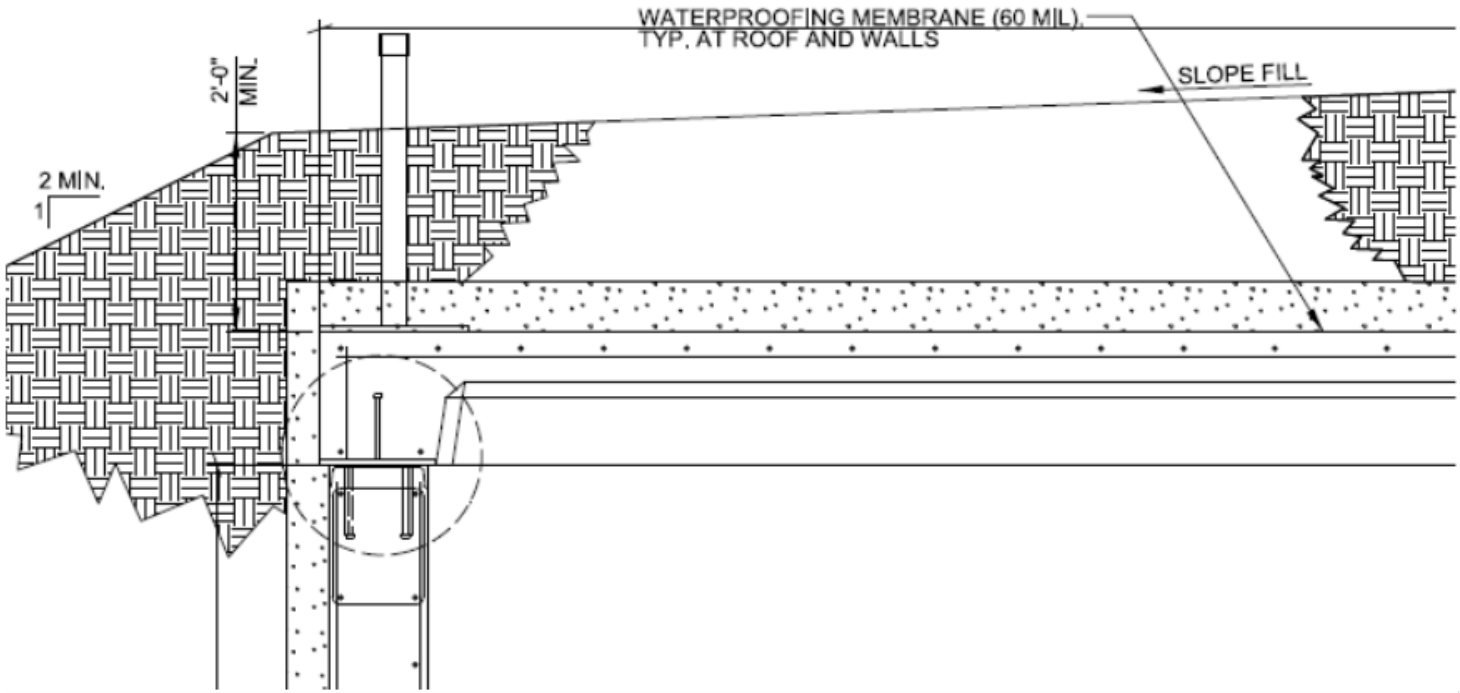
Vertical Seismic Ground Motion Design

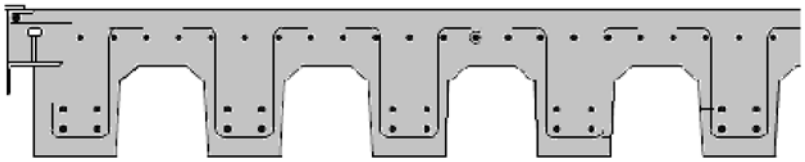
- ECM historic focus on avoidance of blast safety and sympathetic detonation
- USACE EM CX provides site adaptation
- Industries with history of characterizing vertical seismic effects
  - American Petroleum Institute and American Water Works Association
  - Nuclear pwr. and weapons other construction under DOE
  - RC V facilities per UFC 3-310-04

Vertical Seismic Ground Motion Design

- RC III & RC IV do not address vertical seismic because ASCE 7 did not until ASCE 7-16
- Correction cannot happen until IBC 2018 is adopted which adopts the ASCE 7-16 by reference
- Option for short term – Bring vertical seismic into UFC 3-301-01 and UFC 3-310-04 using RC V as a model

Vertical Seismic Ground Motion Design





Roof Wall Connection MSS Box Type Std. 421-80-08

Vertical Seismic Ground Motion Design

UFC 3-301-01
1 June 2013
Change 3, 12 September 2016

Table E-3

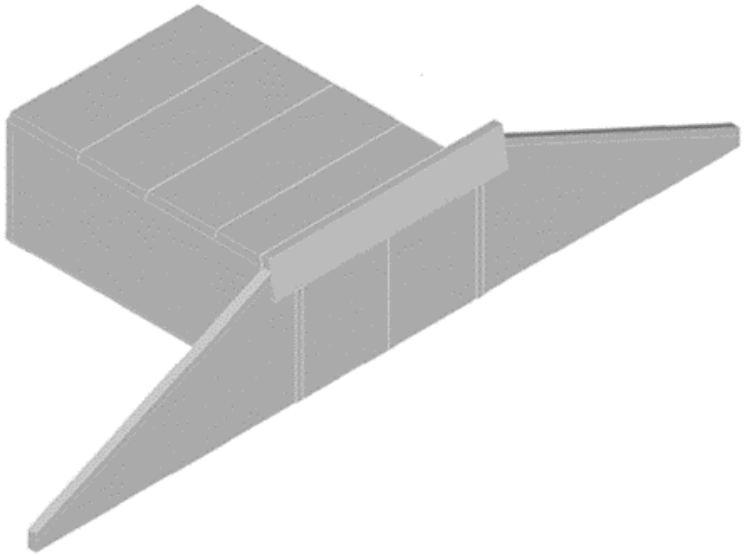
Base / City	Seismic Data (Site Class B)								
	PGA (%g)	S_S (%g)	S_1 (%g)	$S_{S,5/50}$ (%g)	$S_{1,5/50}$ (%g)	$S_{S,10/50}$ (%g)	$S_{1,10/50}$ (%g)	$S_{S,20/50}$ (%g)	$S_{1,20/50}$ (%g)
Guam (b)	90	279	68	208	51	151	37	105	25

Effect of fault proximity – Within 10 km of the fault

Event	Station (Mw)	Hor1 (g)	Hor2(g)	Ver(g)	V/H
Gazli, Uzbekistan 1996	Karakyr (6.8)	0.71	0.63	1.34	1.89
Imperial Valley, USA 1970	El Centro array 6 (6.5)	0.41	0.44	1.66	3.77
Nahhani, Canada 1985	Site1(6.8)	0.98	1.10	2.09	1.90
Mprgan Hill, USA 1984	Gilroy array#7(6.2)	0.11	0.19	0.43	2.25
Loma-prieta, USA 1989	LGPC(6.9	0.56	0.61	0.89	1.47
Northridge, USA 1994	Arleta fire sta(6.7)	0.34	0.31	0.55	1.61
Kobe, Japan 1995	Port Island(6.9)	0.31	0.28	0.56	1.79
Chi Chi, Taiwan 1999	TCU 076	0.11	0.12	0.26	2.07

Vertical Seismic Ground Motion Design

- Lessons from RC V and Missile Defense
  - Pseudo static is not applicable to vertical
  - No real basis for 2/3 (i.e. Design Basis Earthquake for vertical response
  - Consequences:
    - Shear failure
    - Earthquake ground motion very wide area
    - Same design / same response



Design Lessons from MDA RC V

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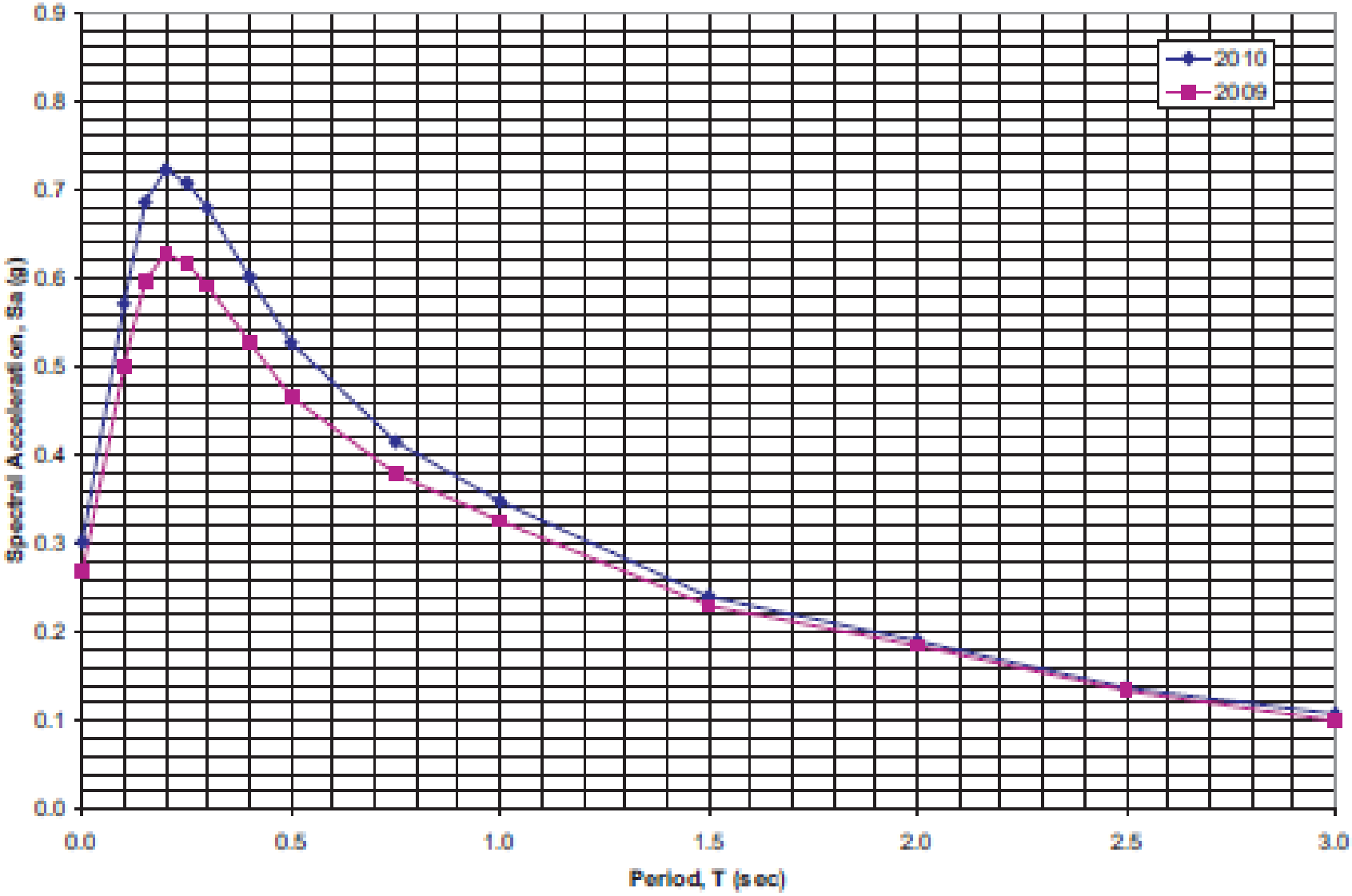
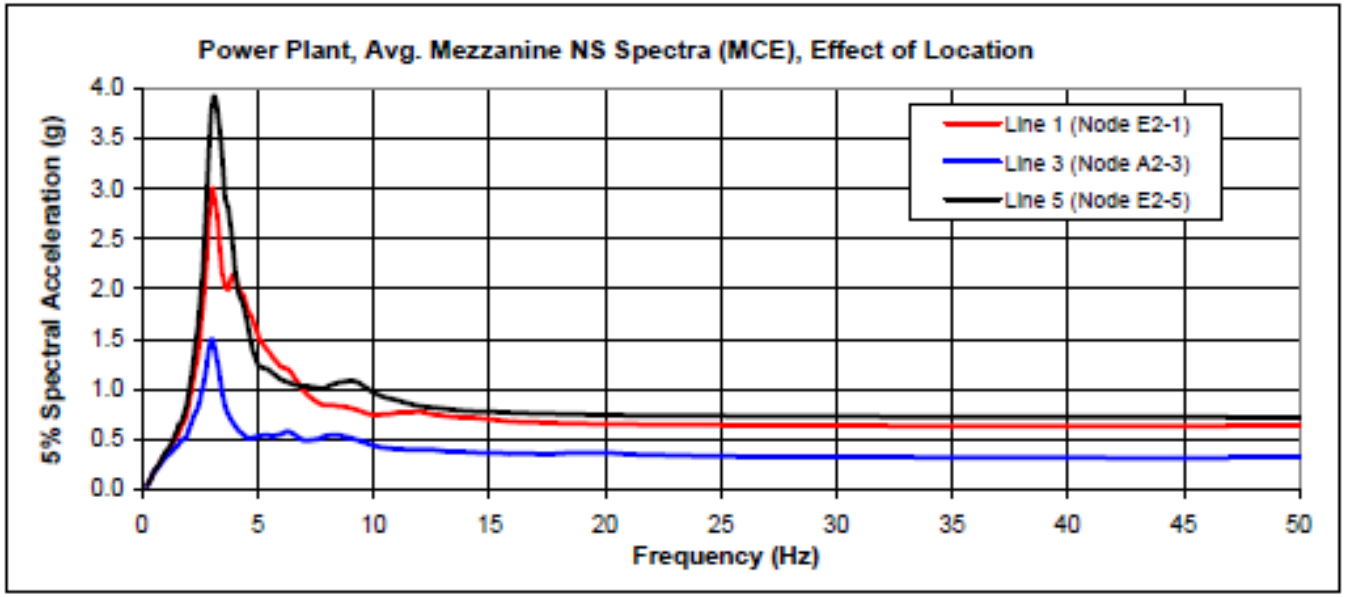
ECM Contained costs

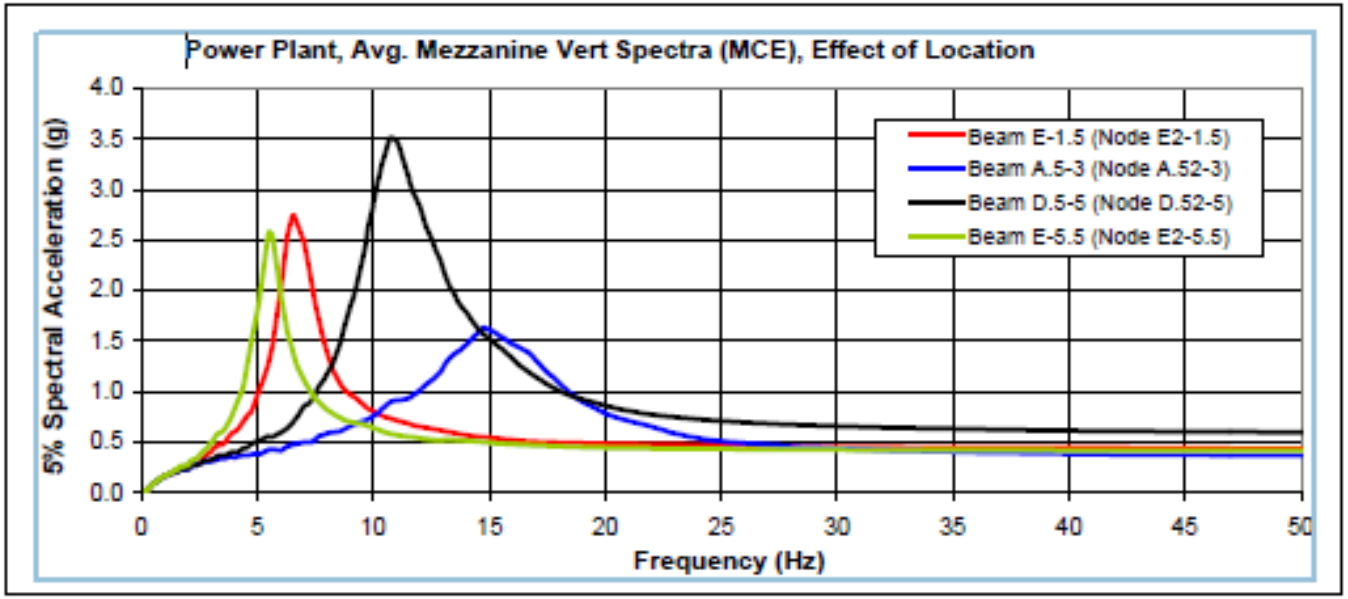
- Weapons costs
  - AGM 114 Hellfire – Unit cost $117,000
  - FGM 148 Javelin – Unit cost $126,000
  - GBU-15 infrared (IR) – Unit cost $300,000
  - B61 – Unit cost $25 million
- Assume GBU-15 IR of 100 units in one ECM
  - MSS Box-Type Std. 421-80-08 (500,000 pounds)
  - 100 - GBU-15 IR 100,000 pounds NEW
  - Potential dollar loss $30 million in one ECM
  - Loss of 10 ECM's would be a $300 million loss potential

EQ Free Field Horizontal Response Spectra



In-Structure Seismic Demand





Conclusions

- The DBE = 2/3 MCE_R was predicated on non-linear lateral analysis and collapse
- Pseudo static analysis used for most seismic design will not work for ECMs
- Dynamic analysis indicates very large in-structure responses form 3.5 to 12 times vertical free field accelerations
- The problem is potentially pervasive

Conclusions

Recommendations

- Modify the UFC 3-301-01 and UFC 3-310-04 as necessary
- Use the MCE_R as opposed to the DBE
- Use RC V unless more rigorous analyses are performed based on performance
- Perform a series of dynamic response history analyses (SAP) using a scaled EQ at Guam
- Analyze multiple ECM types due to varying responses