Estimated Damage to Washington Army National Guard Armories in a 7.2 Seattle Fault Earthquake Scenario

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PURPOSE:

The Washington Army National Guard (WAARNG) has 41 armories throughout Washington State. One purpose of these armories is to support the citizens and communities of Washington State in the event of natural disasters. It is important for these installations, specifically the armory buildings to remain in functional condition when they are needed most. The purpose of this project is to determine which armories would sustain the most damage in the event of an earthquake. The data derived from this project can be used as a basis for requesting seismic retro-fits for the armories to limit the potential impact of an earthquake.

OBJECTIVE:

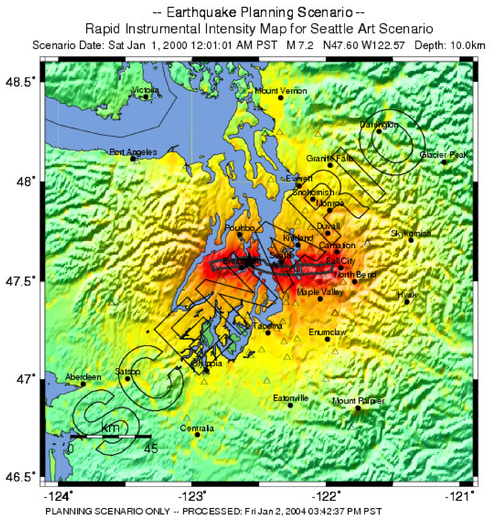
The study region for this project consists of the armories that are in close proximity to the Seattle Fault. The goal of this project was to determine which armories will be most affected in the event of a Seattle Fault earthquake.

METHODS:

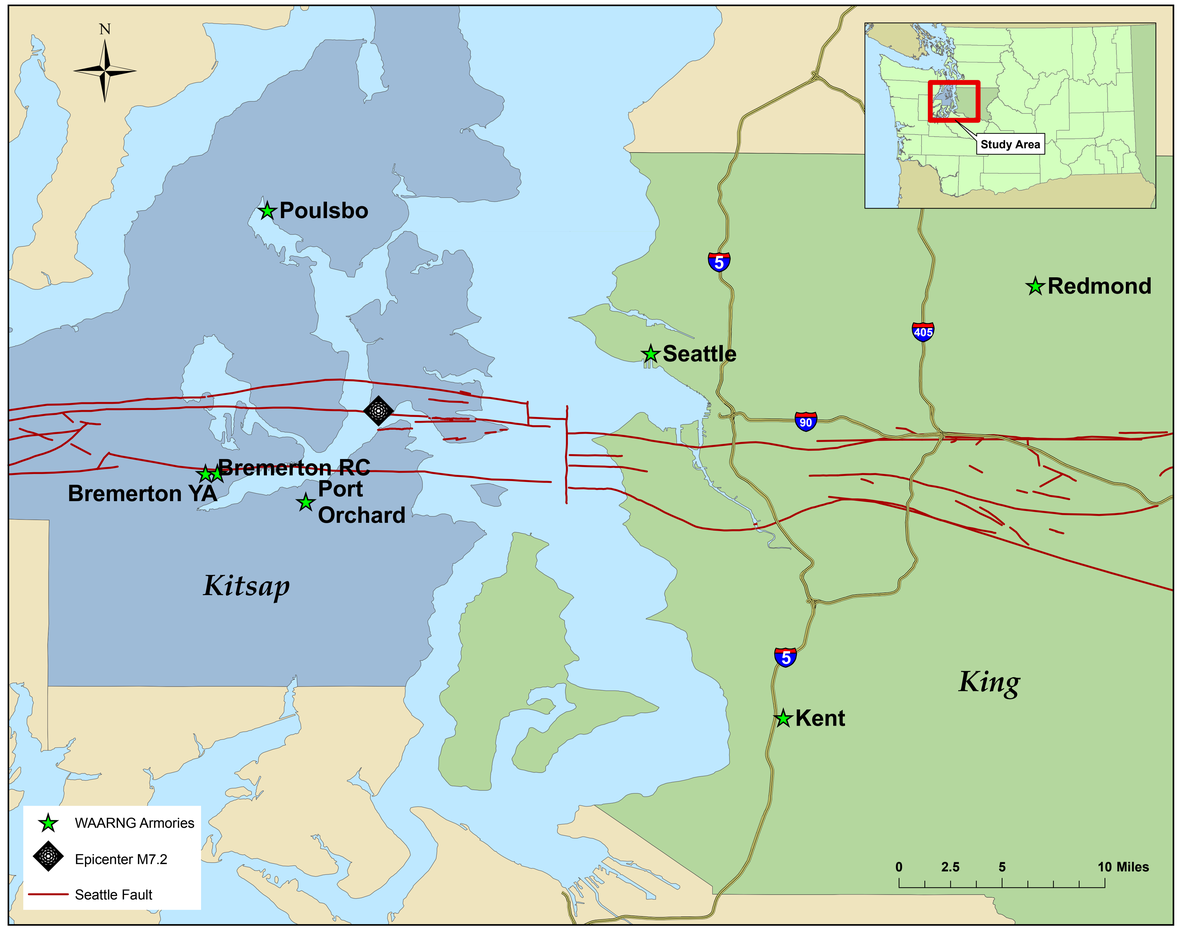
HAZUS-MH was used to conduct the analysis on the WAARNG armories which is a loss estimation and modeling software program that functions as an extension to the ArcGIS Desktop interface and allows an analyst to model or simulate the effects of an earthquake on a specified study area given specific parameters of the hazard set by the user. Census tracts that contain the armories were used as the study area for running the analysis. Soil and liquifaction feature classes were input into the HAZUS model to increase the accuracy of the analysis.

To receive building specific results from the analysis, building specific data for the armories were input into the Advanced Engineering Building Module (AEBM) Inventory. Data was gathered for each armory which included Latitude/Longitude, year built, square footage, building type, and design level.

The earthquake parameters were determined by a ShakeMap scenario obtained from USGS. A Shake Map is a geographic representation of the ground shaking produced by an earthquake. This data was imported into HAZUS to increase the accuracy of the model. Below is the ShakeMap scenario for the Seattle Fault magnitude (M) 7.2 earthquake used for this analysis.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+



RESULTS:

Once the hazard scenario was run, reports were extracted from the Advance Engineering Building Model (AEBM) in HAZUS for each armory. Figures 1 and 2 show the results. Damage state probablilities were calculated for none, slight, moderate, extensive and complete damage states. The damage state probabilities are broke out into three categories: Structural, Non-Structural Drift and Non-Structural Acceleration. Structural damage includes things that are responsible for holding up the building such as walls, columns, beams and floor systems. Building components such as the mechanical or electrical systems and architectural components such as partition walls, ceilings, windows and exterior cladding that are not designed as a part of the building load carrying system are categorized as non-structural. Non-structural components are further categorized as either drift sensitive or acceleration sensitive. Drift-sensitive non-structural damage is damage that occurs to components such as partition walls and windows, that when the floors of the building move past each other during an earthquake, may crack or tear apart. Acceleration-sensitive non-structural damage is damage that occurs to other components such as mechanical equipment that may have fallen over or was torn from their supports due to the acceleration of the building. Non-structural components can fall into both categories, but for the analysis produced by HAZUS, it is classified as one or the other.

Economic loss from the HAZUS AEBM – Individual Building Reports has three different loss categories which include Building-Structural, Building-Nonstructural and contents. The contents portion was not used in this analysis due to the lack of input data for the model. The structural and non-structural are defined the same as in the building damage portion of the report. The “Building Exposure & Economic Loss” portion of the output table includes exposure, loss, and damage ratio. The dollar amounts in this table are in thousands. The exposure refers to the replacement cost of the armories. Both structural and non-structural is combined for the exposure. The loss column shows the estimated economic loss for both structural and non-structural damage. The damage ratios are calculated by dividing the losses by the exposure. This gives a number to compare the armories against each other that takes into consideration the actual building replacement cost.

Building Damage Table - Figure 1

Redmond Armory

Damage State	Damage State Probabilities (%)		
	Structural	Non-Structural Drift	Non-Structural Acceleration
None	12.0	15.0	24.0
Slight	9.0	18.0	34
Moderate	28.0	35.0	22
Extensive	36.0	18.0	6
Complete	15.0	15.0	12

Seattle Armory

Damage State	Damage State Probabilities (%)		
	Structural	Non-Structural Drift	Non-Structural Acceleration
None	4.0	6.0	16.0
Slight	5.0	9.0	27
Moderate	22.0	31.0	21
Extensive	37.0	22.0	13
Complete	32.0	32.0	23

Kent Armory

Damage State	Damage State Probabilities (%)		
	Structural	Non-Structural Drift	Non-Structural Acceleration
None	47.0	47.0	34.0
Slight	21.0	25.0	33
Moderate	23.0	22.0	22
Extensive	8.0	5.0	6
Complete	0.0	1.0	0

Port Orchard Armory

Damage State	Damage State Probabilities (%)		
	Structural	Non-Structural Drift	Non-Structural Acceleration
None	2.0	5.0	8.0
Slight	8.0	8.0	16
Moderate	19.0	25.0	20
Extensive	27.0	18.0	18
Complete	46.0	46.0	30

Bremerton Readiness Center

Damage State	Damage State Probabilities (%)		
	Structural	Non-Structural Drift	Non-Structural Acceleration
None	8.0	10.0	14.0
Slight	14.0	18.0	31
Moderate	38.0	40.0	33
Extensive	32.0	21.0	15
Complete	9.0	12.0	8

Bremerton Youth Academy

Damage State	Damage State Probabilities (%)		
	Structural	Non-Structural Drift	Non-Structural Acceleration
None	7.0	9.0	15.0
Slight	27.0	19.0	34
Moderate	44.0	43.0	34
Extensive	17.0	21.0	12
Complete	4.0	8.0	7

Poulsbo Armory

Damage State	Damage State Probabilities (%)		
	Structural	Non-Structural Drift	Non-Structural Acceleration
None	12.0	20.0	31.0
Slight	15.0	18.0	32
Moderate	30.0	29.0	24
Extensive	24.0	13.0	10
Complete	17.0	17.0	13

Economic Loss Table - Figure 2

Redmond Armory

Loss Category	Building Exposure & Economic Loss		
	Exposure($)	Loss ($)	Damage Ratio
Building-Structural		125	6.43
Building-Nonstructural	1,940	336	17.30
Contents	0	0	0.00
Business Interruption		0	
Total	1,940	460	

Seattle Armory

Loss Category	Building Exposure & Economic Loss		
	Exposure($)	Loss ($)	Damage Ratio
Building-Structural		2,027	9.42
Building-Nonstructural	21,527	6,538	30.37
Contents	0	0	0.00
Business Interruption		0	
Total	21,527	8,565	

Kent Armory

Loss Category	Building Exposure & Economic Loss		
	Exposure($)	Loss ($)	Damage Ratio
Building-Structural		161	1.24
Building-Nonstructural	12,849	556	4.29
Contents	0	0	0.00
Business Interruption		0	
Total	12,849	717	

Port Orchard Armory

Loss Category	Building Exposure & Economic Loss		
	Exposure($)	Loss ($)	Damage Ratio
Building-Structural		695	11.02
Building-Nonstructural	6,336	2,567	40.51
Contents	0	0	0.00
Business Interruption		0	
Total	6,336	3,265	

Bremerton Readiness Center

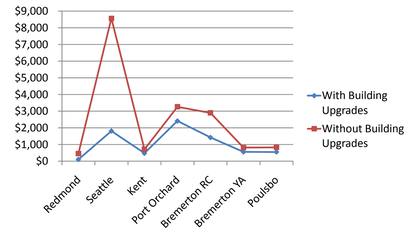
Loss Category	Building Exposure & Economic Loss		
	Exposure($)	Loss ($)	Damage Ratio
Building-Structural		700	5.24
Building-Nonstructural	13,370	2,200	16.45
Contents	0	0	0.00
Business Interruption		0	
Total	13,370	2,900	

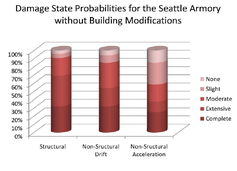
Bremerton Youth Academy

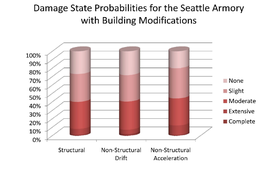
Loss Category	Building Exposure & Economic Loss		
	Exposure($)	Loss ($)	Damage Ratio
Building-Structural		155	3.09
Building-Nonstructural	5,000	664	13.28
Contents	0	0	0.00
Business Interruption		0	
Total	5,000	819	

Poulsbo Armory

Loss Category	Building Exposure & Economic Loss		
	Exposure($)	Loss ($)	Damage Ratio
Building-Structural		199	5.69
Building-Nonstructural	3,493	633	18.11
Contents	0	0	0.00
Business Interruption		0	
Total	3,493	831	







CONCLUSION:

Hazard mitigation should be considered for the Seattle Armory, Port Orchard Armory and the Bremerton Readiness Center. The analysis has shown that the Seattle Armory has an estimated total loss for structural and non-structural damage of $8.5 million. Following Seattle is the Port Orchard Armory with $3.2 million and the Bremerton Readiness Center with $2.9 million in estimated damage.

REFERENCE MATERIAL:

HAZUS-MH MR3 Earthquake Technical & User's Manual
HAZUS-MH MR1 Advanced Engineering Building Module Technical & User's Manual
USGS Fact Sheet FS-087-03 "ShakeMap - A Tool for Earthquake Response"

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