Guide to Performing a Concept-Level Earthquake Scenario Study in Alaska

ASHSC Alaska Seismic Hazards Safety Commission

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Abbreviations used in this guide:

AEC	Alaska Earthquake Center
ASHSC	Alaska Seismic Hazards Safety Commission
DCRA	Alaska Division of Community and Regional Affairs
DGGS	Alaska Division of Geological & Geophysical Surveys
DHS&EM	Alaska Division of Homeland Security & Emergency Management
DOT&PF	Alaska Department of Transportation & Public Facilities
FEMA	Federal Emergency Management Agency
RVS	Rapid Visual Screening (see FEMA, 2002)
USGS	U.S. Geologic Survey

Photo Credits:

1964 Great Alaska Earthquake
(Cover, Table of Contents image and Figure 1)
http://earthquake.usgs.gov/earthquakes/states/events/1964_03_28.php

2002 Denali Earthquake (Figure 2)
https://www.fhwa.dot.gov/publications/publicroads/03nov/05.cfm

Structural damage and ground failure during the 1964 Great Alaska Earthquake: Cover – residence in the Turnagain Slide, Anchorage; Above – overturned fuel tank at the Port of Anchorage.

Introduction

Scenario earthquake studies are a proven means for local governments and the public to assess and understand the vulnerability of a specific locality to the effects of a major credible earthquake by:

- *Identifying the potential types and extent of likely earthquake related hazards, such as strong ground shaking, landslides and avalanches, fault displacement, liquefaction, ground spreading and settlement, tsunamis and inundation;*

- *Qualifying the potential scale and distribution of damage to existing buildings and other infrastructure in the community (e.g. roads, runways, bridges, utilities, etc.);*

- *Providing a structured format for a community or group to visualize the risks, and to discuss problems and potential solutions associated with a damaging-level earthquake;*

- *Helping to prioritize the local infrastructure most at risk of damage during a strong earthquake for retrofit and/or other mitigation (e.g. buildings, airports and roads, utilities, lifelines, etc.);*

- *Improving the scope, validity and testing of local emergency response plans and training exercises; and,*

- *Serving as an advocacy tool to more effectively build community commitment to reducing earthquake risk, and to justify and support requests for funds and resources to implement those risk mitigation strategies.*

A full scale scenario earthquake study is an involved process, bringing together experts in several key technical fields (e.g. geology, seismology and engineering), local planners and policy makers, as well as the public. Such full studies also can take a year or more to complete. However, abbreviated scenario studies utilizing fewer persons, existing technical resources, and simplified screening methods can also be a viable and much less expensive approach to at least qualify the local earthquake hazards and extent of possible damage.

This guide is intended to help local jurisdictions in Alaska complete a concept-level, or abbreviated earthquake scenario study, including the general steps, existing Alaska resources, and technical reference materials. Once completed, the concept-level study could then be used to improve local planning, or to determine the need for and justify funding of a more extensive, full scale scenario study.

Background

Alaska is the most seismically active state, where on average roughly 40-50 earthquakes exceeding magnitude 5[a] occur annually[b]. The state has experienced two destructive earthquakes over the past 50 years, including: the M9.2 Great Alaska Earthquake in 1964 (cover, table of contents, and Figure 1) — the second largest instrumented earthquake in the world; and the M7.9 Denali Earthquake in 2002 (Figure 2) — the largest on-land earthquake in North America in almost 150 years.

While it is not possible to predict the time and location of the next big earthquake, the large number of active earthquake sources in Alaska guarantees that major, potentially damaging earthquakes will continue to occur. Further, despite advancements in seismic hazards analysis and engineering, the age and structural resilience of buildings and infrastructure vary across Alaska, especially in areas of higher seismicity.

For example, a recent study by the Federal Emergency Management Agency (FEMA, 2008) ranked Alaska second in the United States only to California in annualized earthquake losses (replacement value per year of the estimated long-term earthquake damage); and found the annualized earthquake losses per capita along the rail belt, between Anchorage and Fairbanks, to compare with that in the greater Los Angeles and San Francisco metropolitan areas.

The risks to public safety and infrastructure from these events can be reduced through planning and preparations. Scenario earthquake studies are a way for local governments and the public to understand the vulnerability of a specific locality to the effects of a major earthquake.

The following framework describes six general steps for performing a concept-level earthquake scenario study in Alaska, and the key resources to support such an effort. Additional and more detailed guidance for completing full scale scenario studies can be found in EERI (2006).

[a] An earthquake of magnitude greater than about 5 is generally considered large enough to cause structural damage, subject to the distance, site conditions, and type of construction.

[b] www.aeic.alaska.edu

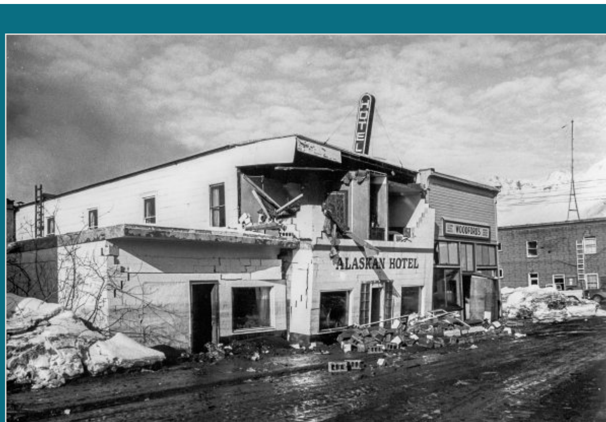

FIGURE 1: *Tsunami and strong shaking damage at Valdez, 1964 Great Alaska Earthquake*

FIGURE 2: *Ground failure in the Northway Airport runway, 2002 Denali Earthquake*

General Steps to Performing the Study

1 DEVELOP THE PLAN

The first step to completing an earthquake scenario study is to identify and meet with the key community stakeholders (e.g. police, fire and planning departments, public works, school district, medical, major utilities, social and cultural groups, etc.). Once together, define the limits of the study area; and identify the critical infrastructure (e.g. rescue, medical, evacuation center(s), lifelines {such as utilities, airports and evacuation routes}, etc.). Then prepare an outline plan for the scenario study identifying the specific subtasks and work elements, responsible parties, and project schedule.

2 COMPILE EXISTING REGIONAL AND PROJECT AREA INFORMATION

The value and effectiveness of scenario earthquake studies must (i) reflect the current understanding and interpretation of the local geology, geotechnical conditions, seismic setting; (ii) account for the specific characteristics of the local infrastructure (e.g. buildings, airports and roads, utilities, lifelines, etc.); as well as (iii) reflect the social and cultural aspects of the community. The second step of the earthquake scenario study is then to compile the important regional and project area information (see Alaska Resources below), including:

- Topographic mapping;
- Surficial geologic mapping (e.g. distribution, age, and type of surficial deposits, known fault structures, etc.);
- Geotechnical information (e.g. general soil profile and conditions, groundwater level, permafrost, etc.);
- List of historic earthquakes (e.g. magnitude and location);
- Local/Tribal All Hazard Mitigation Plans;
- Tsunami hazard mapping; and,
- Building inventory including the age and type of construction (e.g. structural framing, design code vintage, etc.), number of stories, type of foundation (e.g. shallow footing, continuous rigid mat, post and pads, deep piling, etc.).

3 DETERMINE A SCENARIO EARTHQUAKE(S)

The credibility and usefulness of the study depends on using earthquake scenarios (e.g. magnitude and location) that are both plausible and relevant to the community. Therefore, scenario earthquakes must reflect the current understanding and interpretation of the local geology and seismic setting. Numerous resources are available in Alaska (see below) that the community or group can use or consult to help formulate credible earthquake scenarios and their relevant characteristics (e.g. fault location and mechanism, earthquake magnitude, rupture area, project area ground motions, duration of strong shaking, etc.).

4 QUALIFY THE LIKELY TYPES OF GEOLOGIC HAZARDS AND POTENTIAL EXTENT OF GROUND FAILURE USING SIMPLIFIED SCREENING METHODS

Considering the purpose of this guide focuses on a concept-level, or abbreviated earthquake scenario study, Figure 3 (based on world-wide case histories) can be used to qualify the more likely types of earthquake hazard (e.g. landslide, liquefaction, ground spreading/cracking, settlement, tsunami, etc.), and the potential extent of ground failures as a function of the local geology, and scenario earthquake magnitude and distance.

Other simplified methods relevant to a concept-level earthquake scenario study for screening potential earthquake hazards are presented in CGS (2004, 2008), USCOE (2005), and Youd & Perkins (1987).

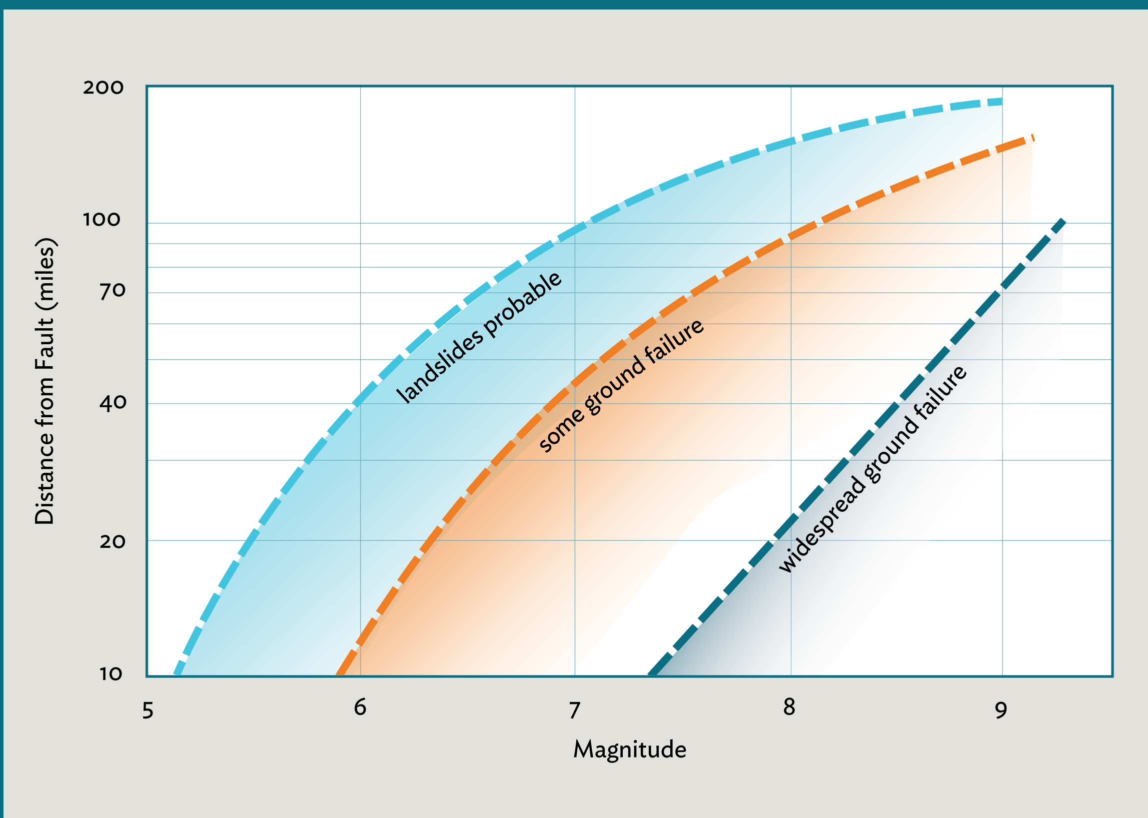

FIGURE 3: *Simplified screening of Earthquake Impacts*
Areas experiencing "some ground failure" can expect very sparse and minor liquefaction, minor ground cracking and settlement, primarily along active drainage courses, flood plains, and shorelines. Areas experiencing "widespread ground failure" can expect extensive liquefaction, damaging ground spreading, cracking and settlements, large slumps and spreading along river/stream banks. (Curves are generalized from documented ground failures during earthquakes worldwide.)

5 QUALIFY THE VULNERABILITY OF CRITICAL INFRASTRUCTURE TO A STRONG EARTHQUAKE

Rapid Visual Screening (RVS) is a demonstrated procedure to assess the vulnerability of buildings to damage during a strong earthquake (FEMA, 2002). While RVS procedures are not appropriate for quantifying the exact probability or damage to a single particular structure, RVS can identify the larger portion of the building inventory most at risk. Therefore, RVS procedures could be used as an integral part of a concept-level earthquake scenario to both further qualify the potential extent of possible damage, and maybe more importantly to identify the local buildings most likely at risk. RVS procedures (FEMA, 2002) are straight forward, can be completed in relatively little time, and utilize much of the information obtained during the previous steps; in particular the building inventory and construction attributes (Step 2), the ground motions associated with the scenario earthquake (Step 3), and the ground failure potential (Step 4).

6 PRESENT THE STUDY RESULTS

The final step is to compile the findings and results of the study into a single report. This report should describe the scope of the study and area covered (Step 1); the existing and new information used (Step 2); description of the scenario earthquake(s) (Step 3); the likely types of earthquake hazards and extent of potential damage (Steps 4 and 5); and conclusions regarding the need for a more in-depth earthquake scenario study.

Alaska Resources

The following describe existing sources for most of the key information required to complete a concept-level earthquake scenario study in Alaska.

SURFICIAL GEOLOGY:

The USGS and Alaska DGGS have published maps, at various scales, delineating the surficial geology for many areas of the state. Most of these maps and reports are available online from the DGGS (http://www.dggs.alaska.gov/pubs/advanced-search).

GEOTECHNICAL INFORMATION:

The Alaska DOT&PF archives reports from geotechnical and engineering geology investigations associated with all state road, bridge, airport, and port projects. Over the past 20-30 years, the DOT&PF was completed such geotechnical investigations in or close to just about every Alaska community, and their reports contain valuable information on the geotechnical conditions of particular importance for concept-level earthquake scenario studies (i.e. soil types, bedrock, groundwater, permafrost, etc.). These geotechnical reports can be obtained by contacting the Materials Section in the appropriate DOT&PF region. (http://www.dot.state.ak.us)

LOCAL/TRIBAL ALL HAZARD MITIGATION PLANS:

Communities and local governing entities prepare a 'hazard mitigation plan' to qualify for FEMA disaster mitigation funding eligibility. These plans provide a first-level review of all the local hazards (e.g. flooding, earthquakes, etc.). The Alaska plans approved by FEMA are available on the DCRA website (http://commerce.state.ak.us/dnn/dcra/PlanningLandManagement/CommunityPlansLibrary.aspx.

The State of Alaska Hazard Mitigation Plan is available online from the DHS&EM (http://ready.alaska.gov/plans/Mitigationplan).

SCENARIO EARTHQUAKE MODELS:

The DGGS has recently developed an online database of the earthquake faults and seismic zones (Koehler, 2013), which is valuable information for developing realistic earthquake scenarios. The Alaska Seismic Hazards Safety Commission (http://seismic.alaska.gov/), as well as the geologic staff at the DGGS can also be consulted to help develop the required characteristics of plausible and credible earthquake scenarios. A database of historic earthquakes documented in Alaska since about 1900 is available at the Alaska Earthquake Center (AEC) at the University of Alaska Fairbanks (http://www.aeic.alaska.edu/).

SEISMIC GROUND MOTIONS:

The USGS Earthquake Hazards Program maintains several web sites containing resources pertaining to earthquake ground motions in Alaska including: maps of the probabilistic earthquake-induced ground motions across the entire state (Wesson et al., 2007) (http://earthquake.usgs.gov/hazards/products/ak/2007/maps/); an online program that qualifies the likely earthquake sources and magnitude-distance events that control the predicted local probabilistic ground motions (http://eqint.cr.usgs.gov/deaggint/1996/index.php); and an online program that determines the 'design-level' ground motions at a specific location for national building codes from 2003 to date (http://earthquake.usgs.gov/designmaps/us/application.php).

Further, the AEC (http://www.aeic.alaska.edu/) can produce ShakeMaps (Wald et al., 2006) which illustrate the distribution of potential shaking intensity and spectral ground motions in the area surrounding the scenario earthquake.

TSUNAMI HAZARD:

The AEC and DGGS have been producing maps and reports of the tsunami and inundation potential at a number of coastal Alaska communities. These maps and reports are available online from the DGGS (http://www.dggs.alaska.gov/pubs/advanced-search).

EARTHQUAKE RISK MITIGATION:

FEMA has produced a significant number of publications specifically focused on strategies and procedures to help mitigate the risk of earthquake damage (FEMA, 2013), all available online (http://www.fema.gov/earthquake-publications). Particularly relevant publications include FEMA 83 (Seismic Considerations for Communities at Risk), and FEMA E-74 (Reducing Risks of Nonstructural Earthquake Damage: A Practical Guide, 4th Edition). Additional resources for mitigating earthquake risks in Alaska are also available from the DHS&EM (http://ready.alaska.gov/).

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