RESEARCH NOTES
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ShakeCast – Developing a Tool for Rapid Post-Earthquake Response

The GeoResearch Group (GRG) is currently working with the United States Geological Survey (USGS) to develop and implement a Caltrans-specific version of ShakeCast, a post-event analysis tool that could ultimately lead to changes in the way Caltrans responds following a major earthquake. ShakeCast is a web-based application that, within ten minutes of an event, automatically retrieves measured earthquake shaking data, analyzes this against individual bridge performance characteristics, and generates inspection prioritization emails and other web-based products for responders.

Why We Pursued This Research

Following a major earthquake, one of Caltrans' most critical tasks is to assess the condition of all potentially impacted bridges and roadway corridors in the state highway system (Figure 1). Timely response is important to ensure public safety, guide emergency vehicle traffic, and re-establish critical lifeline routes.

Figure 1 – Cypress Viaduct, 1989 Loma Prieta

However, in the past, inspectors had difficulties setting priorities because they lacked precise information about where the worst shaking and, most likely, the greatest damage had taken place. Absent such data, they were forced to locate the earthquake's epicenter, find the closest fault, and develop a list of bridges within a specified buffer zone surrounding that fault or the epicenter. Inspection teams were then dispersed widely within that region to perform initial reconnaissance. That can take precious time. Moreover, shaking levels can vary dramatically within the buffer zone, which can lead to misdirected resources (Figure 2).

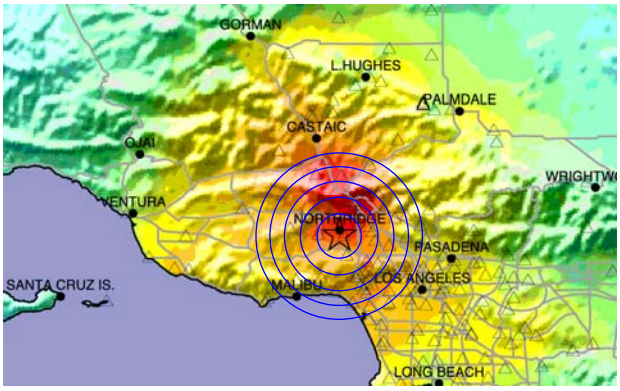


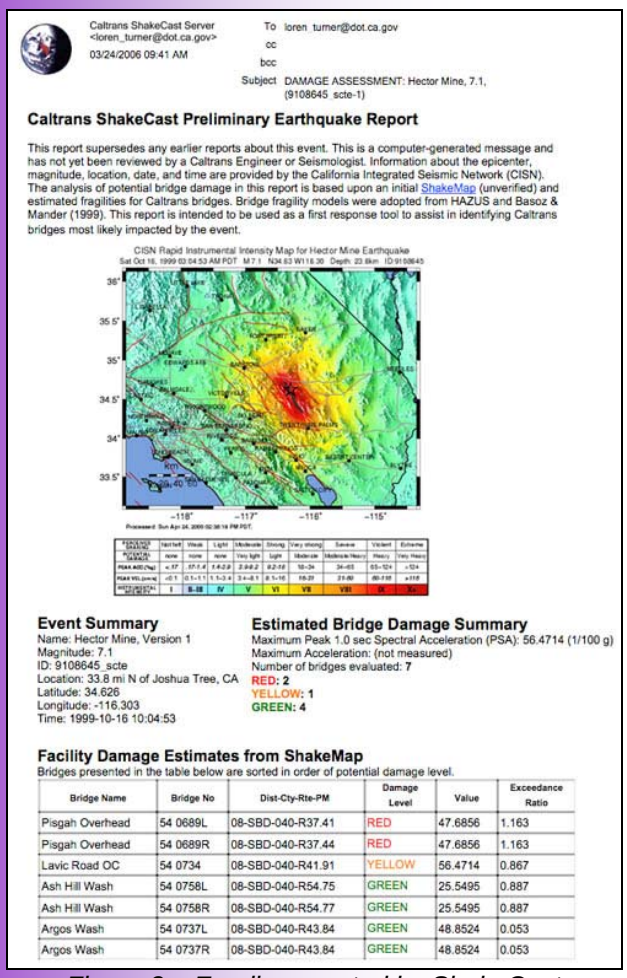
Figure 2 – Shaking isn't uniformly distributed

What We're Doing

A couple of years ago, the USGS released an early version of *ShakeCast*, short for "ShakeMap Broadcast," an automated system for delivering *ShakeMap* products to critical users and triggering established post-earthquake response protocols. *ShakeCast* is built upon *ShakeMap*, another USGS system that takes ground motion data from a network of sensors throughout California and combines it with geological data to create ground shaking intensity maps. These maps provide a level of detail that far surpasses general epicenter/magnitude information (Figure 2).

The GRG is currently test deploying *ShakeCast* on two redundant servers at the TransLab in Sacramento to support a focus group of responders. For this Caltrans version, *ShakeCast* automatically determines the shaking value at the locations of over 11,000 bridges and facilities for events greater than magnitude 3.5, sets thresholds for notification of damage states for each facility,

and then automatically distributes email messages to specified responders within about 5 minutes of the event. The email messages contain general information about the event, a summary of potential damage to bridges, and, notably, a table of bridges sorted by potential damage states (Figure 3).



Caltrans ShakeCast Server
<loren_turner@dot.ca.gov>
03/24/2006 09:41 AM

To loren_turner@dot.ca.gov
cc
bcc
Subject DAMAGE ASSESSMENT: Hector Mine, 7.1, (9108645 scte-1)

Caltrans ShakeCast Preliminary Earthquake Report

This report supersedes any earlier reports about this event. This is a computer-generated message and has not yet been reviewed by a Caltrans Engineer or Seismologist. Information about the epicenter, magnitude, location, date, and time are provided by the California Integrated Seismic Network (CISN). The analysis of potential bridge damage in this report is based upon an initial ShakeMap (unverified) and estimated fragilities for Caltrans bridges. Bridge fragility models were adopted from HAZUS and Basoz & Mander (1999). This report is intended to be used as a first response tool to assist in identifying Caltrans bridges most likely impacted by the event.

CISN Rapid Instrumental Intensity Map for Hector Mine Earthquake

Event Summary
Name: Hector Mine, Version 1
Magnitude: 7.1
ID: 9108645_scte
Location: 33.8 mi N of Joshua Tree, CA
Latitude: 34.626
Longitude: -116.303
Time: 1999-10-16 10:04:53

Estimated Bridge Damage Summary
Maximum Peak 1.0 sec Spectral Acceleration (PSA): 56.4714 (1/100 g)
Maximum Acceleration: (not measured)
Number of bridges evaluated: 7
RED: 2
YELLOW: 1
GREEN: 4

Facility Damage Estimates from ShakeMap
Bridges presented in the table below are sorted in order of potential damage level.

Bridge Name	Bridge No	Dist-Cty-Rte-PM	Damage Level	Value	Exceedance Ratio
Pisgah Overhead	54 0689L	08-SBD-040-R37.41	RED	47.6856	1.163
Pisgah Overhead	54 0689R	08-SBD-040-R37.44	RED	47.6856	1.163
Lavic Road OC	54 0734	08-SBD-040-R41.91	YELLOW	56.4714	0.867
Ash Hill Wash	54 0758L	08-SBD-040-R54.75	GREEN	25.5495	0.887
Ash Hill Wash	54 0758R	08-SBD-040-R54.77	GREEN	25.5495	0.887
Argos Wash	54 0737L	08-SBD-040-R43.84	GREEN	48.8524	0.053
Argos Wash	54 0737R	08-SBD-040-R43.84	GREEN	48.8524	0.053

Figure 3 – Email generated by ShakeCast

Each bridge has a unique fragility assigned to it in the system's database, based upon bridge damage models published by Basoz & Mander (1999). The fragility models use peak spectral accelerations, and take into account bridge geometry (e.g. span lengths, number of spans, column heights, skew, etc.); year of design, construction, and retrofit; material types; and soil conditions. Damage states are coded as RED, YELLOW, and GREEN, corresponding to varying degrees of damage, with green roughly correlated to "moderate" damage, and red correlated to "severe damage".

Although the analysis engine for *ShakeCast* has been demonstrated to effectively identify and prioritize potential bridge damage states, the interface to setting up and maintaining *ShakeCast* had not been fully developed. The GRG recently set up an interagency agreement with the USGS to further develop *ShakeCast* to meet the needs of Caltrans users. Once completed, *ShakeCast* will feature intranet-based account management, system administration, and map-based visualization tools, such as exports to Google Earth (Figure 4), as well as customized e-mail and pager messages specific to bridge damage assessment.

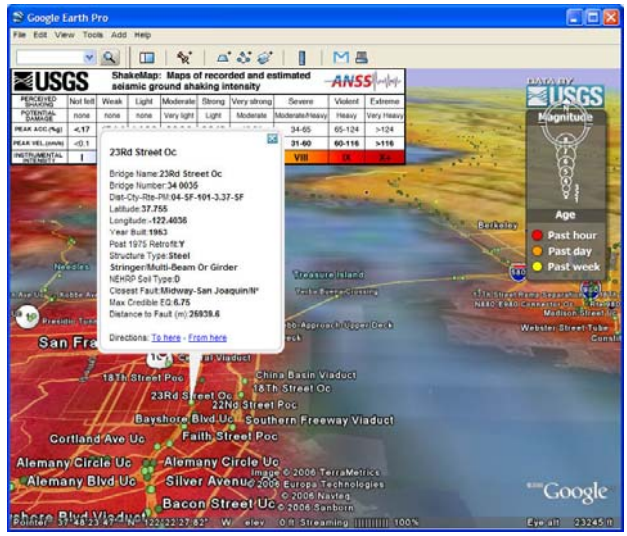


Figure 4 – ShakeCast and Google Earth

Summary

When completed in 2008, *Caltrans-ShakeCast* will provide a valuable and easily deployable tool for the Department. Benefits are already being realized through the test deployment of the earlier *ShakeCast* software by the GRG. The capability to automatically retrieve measured earthquake data in near real-time, analyze shaking levels against Caltrans bridge inventory, and generate preliminary bridge inspection priority lists can significantly enhance situational awareness for responders and managers.

For More Information on GeoResearch Projects

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