ShakeCast: A Tool for Post-Earthquake Decision-making and Response

Loren Turner

Caltrans Division of Research & Innovation

David Wald Kuo-Wan Lin U.S. Geological Survey





ShakeCast Activities in 2008

- Caltrans-USGS contract completed
- ShakeCast v.2 released and deployed at Caltrans
- Benefits of ShakeCast demonstrated
- Outreach efforts
- Planning for next steps

To Caltrans-ShakeCastAdmin@dot.ca.go Caltrans ShakeCast Server (C) <Loren.Turner@dot.ca.gov 05/09/2008 11-18 AM Subject BRIDGE ASSESSMENT: 6.9, 7 km NNE of Aptos, CA (Loma Prieta sete Versio

ShakeCast v.2

- Software system that runs on a web server
- Retrieves measured shaking data within minutes after an earthquake
- Compares shaking distribution with unique bridge vulnerabilities
- Provides hierarchical lists and maps of bridges most likely impacted
- Emails info to responders within 10 to 15 minutes following event
- Provides suite of tools on ShakeCast website





Caltrans ShakeCast Preliminary Earthquake Bridge Impact Report

This report supersedes any earlier reports about this event. This is a computer-generated message and has not yet be wiewed by an 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 <u>hateMang</u> (unvertified) and estimated fragitistes for Caltrans bridges. Bridge fragitity 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 likel spacted by the event.



Event Summary Name: (Unnamed Event), Version 1

Anonitude: 6.0

Downloads & Resources Caltrans Intranet Links: Caltrans ShakeCast Intrane altrans ShakoMan Produ oleEarth KML file

Magnitude: 6.9 ID: Lona Prieta scte-1 Location: 7 km NNE of Aptos, CA Latitude: 37.04 Longitude: -121.88 Time: 1989-10-18 00:04:00 GMT Bridge Assessment Summary Aximum Peak 1.0 sec Spectral Acceleration: 105.3903%g faximum Acceleration: (not measured) Total number of bridges assessed: 2030 Summary by inspection priority:

High Priority for full engineering assessment 22 full engineering assessment

107	Medium-High Priority for f
106	Modium Priority for full on

gineering assessment Low Priority for full engineering assessment: guick visual inspection likely sufficient

1795 Bridge Assessment Details

				1sec Peak	
Bridge Name	Bridge Number	Dist-Cty-Rte-PM	Inspection Priority	Spectral Acceleration (%g)	Exceedance Ratio
Raiston Avenue OC	35 0114	04-SM-101-9.55-BMT	High	105.3903	2.934
Via Del Oro OH	37 0477L	04-SCL-085-1.22-SJS	High	49.2711	2,472
San Mateo-Hayward Bridge	35 0054	04-SM-092-R14.44-FSTC	High	49.6514	2.167
Constitution Way OC	33 0513K	04-ALA-260-R.86-ALA	High	68.2755	1.415
Meridian Road Underpass	37 0258	04-SCL-280-R3.89-SJS	High	59.9229	1.122
Campbell Underpass	37 0135	04-SCL-017-12.22-CMB	High	70.2112	1.087
East Hillsdale Blvd OC	35 0138	04-SM-101-11.15-SM	High	68.3762	1.071
Redwood Creek	35 01 45	04-SM-101-6.2-RDWC	High	61.0924	1.064
Stobb-Approach Lower Deck	34 0118R	04-SF-080-4.95-SF	High	33.2578	1.057
Holly Street OC	35 0037	04-SM-101-8.4	High	65.904	1.048
Route 13/80 Separation (North)	33 0191G	04-ALA-013-13.92-BER	High	66.6766	1.046
Race Street Overcrossing	37 0260	04-SCL-280-R3.76-SJS	High	59.9229	1.045
Presidio Viaduct	34 0019	04-SF-101-9.14-SF	High	68.3123	1.035
South Delaware Street UC	35 0158L	04-SM-092-R11.61-SM	High	35.1822	1.030
South Delaware Street UC	35 0158R	04-SM-092-R11.61-SM	High	35.1822	1.030
Powell Street UC	33 0020	04-ALA-080-3.79-EMV	High	66.6766	1.020
Redwood Harbor Overhead	35 0065	04-SM-101-5.5-RDWC	High	56.8606	1.018
Macarthur Avenue OC	37 0100	04-SCL-280-L5.18-SJS	High	54.4613	1.012
N101-S84 Connector OC	35 0081G	04-SM-101-5.39-RDWC	High	56.8606	1.009
N17-N85 Connector Separation	37 0515G	04-SCL-017-9.24-LGTS	High	86.2137	1.008
San Francisquito Creek	35 0013	04-SM-10101	High	55.3678	1.007
Separation	37 0396H	04-SCL-087-5.1-SJS	High	50.5564	1.001
Blossom Hill Road OC	37 0345	04-SCL-082-R.35-SJS	Medium-High	49.4998	0.951
Harkins Slough Road OC	36 0089	05-SCR-001-R2.27-WAT	Medium-High	56.0768	0.938
Sunol Street Rr UC	37 0263L	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909
Sunol Street Rr UC	37 0263R	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909

ShakeCast v.2

- Raises situational awareness after earthquake.
- Represents the most reliable information within the first hours following an event.





T CALTRANS SHAKE CAST 2

Home Earthquakes Search FAQ Profile Administration Panel Log out [scadmin] Latest Earthquake

Earthquake Archive Scenarios

Map View											
M 6.7 - Chino Hills Fault Scenario (ID: Chino_Hills6.7_se_scte - 5)											
Facility ID	Туре	Description	Inspection Priority ▼	Latitude	Longitude	ммі	PGA (%g)	PGV (cm/sec)	PSA03 (%g)	PSA10 (%g)	PSA30 (%g)
56 0633	BRIDGE	Green River Drive OC	High	33.87848421	-117.6578573	VIII	46.6934	61.9509	119.4515	64.2799	19.6343
54 0748	BRIDGE	Benson Avenue OC	Medium-High	34.03032662	-117.6804218	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
54 0747	BRIDGE	Central Avenue OC	Medium-High	34.03026777	-117.6891927	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
53 1873G	BRIDGE	E60-N57 Connector OC	Medium-High	34.02202039	-117.8133506	VIII	39.693	47.723	101.3087	50.4097	17.9044
53 1788	BRIDGE	Fairway Drive UC	Medium-High	33.9965290			. 35.7487 . Map View			40 //RRR	- 46-1639
56 0497	BRIDGE	Magnolia Avenue OC	Medium-High	33.8		5		Man	Cotallita	Clo	ose 1711
54 0746	BRIDGE	Monte Vista Avenue OC	Medium-High	34.(* -		the the	Map	Joaleinie		788
54 0744	BRIDGE	Pipeline Avenue OC	Medium-High	34.0		2 A	Gi Lat: 33.87	reen River D 7848421 Lon	rive OC : -117.657	3573	411
53 1873	BRIDGE	Prospectors UC	Medium-High	34.0			MM	1:	8.56		9044
54 0745	BRIDGE	Ramona Avenue OC	Medium-High	34.0			PG/ PG/	4: /:	46.6934 61.9509		788
53 1933	BRIDGE	Spadra OH	Medium-High	34.0	PRI DE	COL	PSA0 PSA1)3: IO:	119.4515 64 2700		109
53 2106	BRIDGE	State Street OC	Medium-High	34.0		5	PSA3	30:	19.6343		234
53 2078K	BRIDGE	Valley Blvd UC	Medium-High	34.0							962
53 2078	BRIDGE	Valley Blvd UC	Medium-High	34.0	and the second second		1 and	5 - F - F		X	962
56 0445	BRIDGE	West Grand Blvd UC	Medium-High	33.6			1		Riverside	FWV	688
53 2081R	BRIDGE	Garey Ave UC	Medium	34.¢	No.	· []	1 100-		TERN RIVER B		851
53 2081L	BRIDGE	Garey Ave UC	Medium	34.C GO	magery ©20	08 Dioit	alGlobe, M	ap data ©200	3 Tele Atlas	- Terms of L	1851
53 1022L	BRIDGE	Gibson OH (Eb&Wb Buswy)	Medium	34.0 <i>rzs</i> 0404	£	- vı	19792910	-13.2002	42:15/11	14.00751	10.6483

Foundation for ShakeCast



Technologies

WAMP

□ Windows (Server 2003)

- □ Apache

- Perl
- Javascript
- RSS
- GoogleMaps





Caltrans-ShakeCast Notifications

- 250+ current subscribers to ShakeCast
 - Structures Maintenance & Investigations
 - Earthquake Engineering
 - Post EQ Investigations Team
 - Structures Construction
 - □ Geotechnical Services Office Chiefs
 - Traffic Management Centers
 - □ Mid/Upper Caltrans Management
- ShakeCast is now an integral component of Caltrans' response protocol

5.4 Diamond Bar

CISN ShakeMap : 4.0 mi SE of Diamond Bar, CA Tue Jul 29, 2008 11:42:15 AM PDT M 5.4 N33.96 W117.76 Depth: 13.7km ID:14383980



Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: 34.7183%g Maximum Acceleration: (not measured) Total number of bridges assessed: **468** Summary by inspection priority:

High	NULL	High Priority for full engineering ass
Medium-High	NULL	Medium-High Priority for full enginee
Medium	NULL	Medium Priority for full engineering a
Low	468	Low Priority for full engineering asse

Bridge Assessment Details

Bridges presented in the table below are sorted in order of severity of impact (exceedance ratio). The list includes

Bridge Name	Bridge Number	Dist-O
53 2078 - VALLEY BLVD UC	53 2078	07-LA
53 2078K - VALLEY BLVD UC	53 2078K	07-LA
53 1158 - GRIER STREET POC	53 1158	07-LA
53 2107 - TEMPLE AVENUE OC	53 2107	07-LA

Grier St. POC on Route 71 Bridge 53-1158 7/30/08

SPEED

Golden Guardian

							🚍 CALTRANS S	SHAKE CAST
Home	Earthquakes	Search	FAQ	Profile	Administration Panel	Log out [scadmin]		
Lates	t Earthquake	Earthq	uake A	rchive	Scenarios			



Organizations Using ShakeCast



Sempra Energy*

Sunoco Logistics™

Commerical/Business





Califran has deployed the prototype ShakeCast system (Version 1.0). Following a major earthquake, Califrans face as array of decisionmaking challenges. Perhans no other agency has a contourable verthquake exposure in the State Example Uses and Users: The California Department of Transportation (Caltrans) Calitans has deployed the prototype ShakeCast system (Version 1.0). Following a major earthquake, Calitans faces an array of decisionmulting challenges. Perhaps no other agency has a comparable vaributive in California: having a of California. Calitans has more than 11.000 bridges and overwesses under its responsibility in California: having a an acray of decision making challenges. Perhaps no other agency has a comparable varihquake exposure in the State of California. California than 10,000 bridges and overpasses under its responsibility in California, resource, elements instruments mannehr of the likely damage to each will allow California to set with rife requires for traffic requires. of California. Caltrans has more than U.000 bridges and overpesses under its responsibility in California; having an instantaneous snapshot of the likely damage to each will allow Caltrans to set priorities for traffic resource an earth-make is and inspections following a damateing southemake. One of several critical tasks facing Caltrans after an earth-make is instances may not of the likely damage to each will allow Caltums to set priorities for traffic recuting, closures, and inspections following a damaging carthquake. One of several critical tasks facing Caltures after an earthquake is to modely assess the condition of all bridges and readway corridors in the State biologies events. Timely remained is ties for response, and inspections following a damaging carthquake. One of several critical tasks facing Caltrans after an earthquake is to rapidly assess the condition of all bridges and readway corridors in the State highway system. Timely response important to ensure earlier, aid routing of energenear vehicle traffic, and irred establish critical lifetine mutes to rapidly assess the condition of all bridges and roadway corridors in the State highway system. Timely response is important to ensure public rafety, aid routing of emergency vehicle traffic, and (re-) establish critical lifeting more.

allomatically operations are managed value a men contract, with the base of th the solution for neuroscience of counting states for each memory, and then automatically notify (by pager, cell phone, or etaal) specithen auronaucoury noury toy pager, can priome, or ensure who are fiel operators and inspectors within their organizations who are nea operators and mappeorate within their organizations who are responsible for these particular facilities so they can set priori-

Fact Shapt 2017-308

many required inspections.

Colleges of the interstate Si State Highway 14 interchange show-ing damage north of Los Angieles caused by the 1994 magnitude 6.7 Northeland Collegenia and Provide Theorematic of State and Downer mų damage nertu or Los angelės causeo by the Yala magnuole 6.7 Nerthridge, Californis, aarthquaka, Thousenis of Stata and County Northinoge, Lamanna, earningana, mansenne or aran and Landy Indges were shaken at verying intensity levels during this earthqueks;

ShukaCast, short for ShakeMap Broadcast, is a fully autoshakel as snor for inarcharp produces is a ruly auto-mand system for delivering specific ShakeMap products to What is ShakeCast? nares system for conversion spacific snakessap produces to ortical users and for triggering established post-carbiquake CHICH users and ice triggering estimations part caringpase (sponse proceeds. ShakeMap is a well-established too) used to before the return of echoaristic destantion electricity entertains and response prevocots. Snakennap is a well-estanteshed tool usen to portray the entent of potentially dantiging shaking following an poncey one entern or poncountry unnoverog snaking rougowag an suthquake. Shakablap is automatically generated for sual and inturquence, sommerving is automatically generated for small and intege earthquences in access where it is available and can be found on the basement of later (intercompany) is a second product to any company. tage earnoquates to areas where it is wrating and can be source on the internet at http://www.beuche.ucgs.gov/shakemapi.ft.was on the internet of any meaningtonic west source assering in was developed and is used prinarily for emergency response, less neverspent and is uses primarily for emergency response, rest estimation, and public information. Rewever, for an informed extension, and produc incomments, concerer, for an incomme response to a serious earlighting, critical users such go beyond response to a serious eartisquate, critical users must go beyond just booking at ShakeMap, and anderstand the likely establish and just booking at population, and understand the mustly excert and soverity of impact on the facilities for which they are responseventy or impact on the treatmest for which they are responsible. To this end the U.S. Geological Survey (USGS) has veroped snakel ast. ShakeCast allows withins, transportation agencies, busi-

Survey, and anony statutes, transportant, agencies, unser-tests, and other large organizations to control and optimize the

uesses, and other large loganizations to control and optimize the earthquake information they receive. With ShekeCast, they can

excurquance incommunes, oney receive, with connect, and were con-anomalically determine the shaking value at their facilities, set

ShakeMap for Post-Earthquake Decisionmaking bakeCast is a tozely available, post-sorthquake situwhen a wareness application that attornatically and Response etrieves earthquake shaking data terra ShakeMap. compares incrusivy measures against mens, facilities, and Nautemen warmen y measures ogennet mens menures, and generates potential damage assessment ordifications, facility generates potential canage assessment occurcations, thermy damage maps, and other Web-based products for emergency panagers and responders,

developed ShakeCast.

USGS ShakeCast Automating, Simplifying, and Improving the Use of



ROVER: Rapid Observation of Vulnerability and Estimation of Risk

- Implements FEMA 154 on smartphone and tablet PC
- ROVER is funded by FEMA (C. Carlisle, Program Officer)
- Objective: rapidly (10-20 min/building) create an inventory buildings exposed to risk; ID those warranting detailed examination
- Improves FEMA 154 efficiency, accuracy & data handling
 - ♦ Integral database, GPS, photos, sketches
 - Site automated soil & hazard lookup
 - Enhanced risk scoring
 - Integrated with HAZUS & ShakeCast



Caltrans-USGS Project (Phase 2)

- Landslide/Liquefaction Hazards
- Improved bridge fragilities
- Complex fragility calculations
- End-user and Administrative interface enhancements
- Enterprise IT deployement strategies