



REDARS™ SOFTWARE FOR SEISMIC RISK ANALYSIS OF HIGHWAY SYSTEMS

- **Estimates EQ-Induced Roadway System Damage and its Effect on Post-EQ Traffic Flows**
- **For Use in Guiding Seismic-Risk-Reduction Decision Making**

Introduction. Effects of earthquake damage to highway components (e.g., bridges, tunnels, roadways, etc.) can go well beyond life-safety risks and costs to repair the damaged components. Such damage can also disrupt traffic flows which, in turn, can impact the region's economic recovery and emergency response. These impacts will depend not only on the seismic performance of the components, but also on the characteristics of the overall highway system such as its network configuration and roadway-link characteristics (e.g., link locations, redundancies, and traffic capacities). Unfortunately, such traffic impacts are usually not considered in seismic improvement activities at state transportation departments. One reason for this has been the lack of a technically-sound and practical tool for estimating these impacts. Therefore, since the mid-1990s, the FHWA has sponsored multi-year seismic-research projects at MCEER that have included development and programming of such a tool. This has led to new software named REDARS (Risks from Earthquake Damage to Roadway Systems) that was released for public use in March 2006.

REDARS Methodology. REDARS™ is a multi-disciplinary tool for seismic risk analysis (SRA) of highway systems nationwide. For any given earthquake, REDARS™ uses state-of-knowledge models to estimate: (a) the seismic hazards (ground motions, liquefaction, and surface fault rupture) throughout the system; (b) the resulting damage states (damage extent, type, and location) for each component in the system; and (c) how each component's damage will be repaired, including its repair costs, downtimes, and time-dependent traffic states (i.e., its ability to carry traffic as the repairs proceed over time after the earthquake). Next, REDARS™ incorporates these traffic states into a highway-network link-node model, in order to form a set of system-states that reflect the extent and spatial distribution of link closures at various times after the earthquake. Then, REDARS™ applies network analysis procedures to each system-state, in order to estimate how these closures affect system-wide travel times and traffic flows. Finally, REDARS™ estimates corresponding economic losses and increases in travel times to/from key locations or along key lifetime routes. These steps can be applied for single earthquakes and no uncertainties (deterministic analysis) or for multiple earthquakes and simulations in which uncertainties in earthquake occurrence and in estimates of seismic hazards and component damage are considered (probabilistic analysis).

Application. REDARS™ can serve as a pre- and post-earthquake decision-guidance tool. As a pre-earthquake planning tool, it can be used to: (a) estimate the effectiveness of various seismic-improvement options in reducing earthquake losses; (b) compare costs and benefits (i.e., reduction in traffic-related losses/risks) for each option; and (c) enable decision-makers to use these results in order to make a more informed selection of a preferred option to implement. As a post-earthquake emergency-response tool in real time, REDARS™ can incorporate actual damage data from the field, and then assess the relative abilities of various repair strategies/priorities and traffic-management options to facilitate traffic flows.

The Future. REDARS™ will continue to be further developed to meet the seismic-risk-reduction needs of state transportation agencies nationwide. This development will be directed by a user group of state agencies that is now being formed. Future earthquake-related work will include: (a) software maintenance and user support; (b) continued technical development, such as incorporation of future updated earthquake, hazards, and component models; and (c) application/testing for highway systems in various regions nationwide that may be at risk from future earthquakes. In addition, REDARS™ can be extended to accommodate other natural and man-made hazards (e.g., terrorist incidents), by incorporating appropriate hazard and component damage/repair models. For example, flooding risk analyses would use flood-hazard and bridge-scour models. Assessment of risks from explosions would use models for estimating blast loads and ground-movement hazards, and the response of highway components to these hazards.

- **Developed for Federal Highway Administration, Washington DC through contract from MCEER, Buffalo NY**
- **Work performed by REDARS Group, a joint venture of Seismic Systems & Engineering Consultants and ImageCat, Inc.**

REDARS™ 2 Sample Output

File Analysis View Help

REDARS v2r1 - C:\Documents and Settings\ID\5...rdf

Loma Prieta Simulation
Configure and Run...

Bridge: 112

Attribute	Value
Location Unverified	False
Year Built	1953
Bridge Group	205
Mander Group	13
PGD Group	7
Total Length (meters)	1262.4
Number of Main Sp.	54
Min Column Height	4.42
Num Lanes	4
Max Span Length (f)	48.8
Deck Width (meters)	36
Avg Daily Traffic (ci)	157200
Skew Angle (deg)	0
Num Approach Spa	0
Soil Code	D
Is Seismically Desig	False
Is Column Jacketed	False
Can Liquefy	False
Replacement Cost (f)	0

Seismic Hazards:
Shakemap Earthquake: LomaPrieta
Max. Component GMs and PGDs:
SA 1.0: 0.80g Map
Liq. PGD: 0.00in Map
SFR PGD: 0.00in Map

Component Damage States

Damage:	1 = None	2 = Slight	3 = Moderate	4 = Extensive	5 = Complete
Bridge	77	284	0	0	0
Abutment	9	0	0	0	0
Column	37	0	0	0	0
Deck	18	0	0	0	0
Other	8	0	0	0	0
Map	149	284	0	0	0

Component Damage

Bridge	Abutment	Column	Exit
1. None	77	284	6
2. Slight	9	0	0
3. Moderate	37	0	0
4. Extensive	18	0	0
5. Complete	8	0	0
Map	149	284	6

Travel Impacts (reduction relative to baseline)

Lane Miles	7 days	30 days	60 days	150 days
Days	6%	7%	3%	2%
Days	2%	2%	0%	0%

Travel-Related \$ Losses (in million \$)

Cost Per Day: \$0.831
Time (days): 0, 7, 60, 150
Total: \$176.0
SRT=221

Loss Summary (in million \$)

Upgrade Cost: \$0.0
Repair Cost: \$38.9
Travel Time: \$176.0
Total Loss: \$215.0

Traffic Impacts

Cost Impacts

Damage: 1 = None, 2 = Slight, 3 = Moderate, 4 = Extensive, 5 = Complete

37°50'5.83"N 122°19'10.03"W

start

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