Networking Program: User Networks for Experimentation and Computer Simulations

Presented by
Andrei M. Reinhorn
University at Buffalo
Program Coordinator
Networking Program: Users Networks for Experimentation and Computer Simulations

Objectives of Program:

Create, develop and maintain an advanced framework for sharing investigative resources and data - experimental and computational - through advanced electronic and computerized networks using latest information technology tools.
Planning and Management

Networking Program Tasks:

- Networking products from subtasks of main research tasks.
- Networking Infrastructure Development tasks
- Coordination tasks.
- Education tasks

Details:

1. The sub-tasks are part of the main research tasks in Thrusts 1, 2, and 3. The subtasks take distinct products and integrate them into networks.
2. Develops templates, guidelines, connectivity and resolve hardware issues required for networking. Develops communication systems for education.
3. The coordination tasks are dedicated to scout and identify networking products and advise researchers on integration issues.
Networking Plan

- Develop databases of information from tasks, from sensors, experiments, industries, etc.

- Develop platforms with procedures and software for evaluation and decision analysis.

- Develop links and quick transfer of information.

- Develop education tools for use of the above.
Networking Sub-tasks:

PERFORMANCE CRITERIA & INF.
DATABASE
- Fragility NonStruct (com) V - Soong
- Frag.Piping (exp) V - Maragakis
- Hospital(NYS)Syst-VII-VIII Lee
- FragilityStruct-VII-VIII Whittaker
- PipingSystem-VII-VIII Maragakis

PERFORMANCE ESTIMATION
SOFTWARE
- RiskEvalWater-VI-VII-Grigoriu
- CostEstim-VII-VIII - Grigoriu

RESILIENCE EVALUATION DECISION
SOFTWARE
- Loses, Soc, Resilience – VI, VII, VIII
- Chang
- Losses/Decision - VII-VIII
- Dargush/Petak
- LossEstimationsDecisions VII - Grigoriu

PERFORMANCE EVALUATION
SOFTWARE
- Fragility Eval – V, VI, VII - Grigoriu
- FragilityStruct-VII-VIII Reinhorn

REMEDIATION / MODIFICATION
SOFTWARE
- EvolOptim-V-VII-VIII Dargush

DATABASE
- EPS - VII - Constantinou
- Walls - V - Billinton
- Piping - VII - O'Rourke
- Walds-VII-Bruneau
- CompositeWalls-VII-VIII Aref

SURVEY AND EVALUATION
SOFTWARE
- Satellite Eval. – VI-VII-VIII - Eguchi

INVENTORY
DATABASE
- Satellite imaging - V VI-VII-VIII
- GIS/PipingIntegration-VII-VIII
- O'Rourke

INFRASTRUCTURE
DATABASE
- StrBenchMark - V-VII Reinhorn
- HospModels - VI-VII-VIII Whittaker
- NYS-HospitalsModels VII-VII Lee

RESPONSE
Websites:

http://mceer.buffalo.edu/research/

MULTIDISCIPLINARY CENTER FOR EARTHQUAKE ENGINEERING RESEARCH
MCEER Networking Facilitate Webcasts:

**MCEER Webcasts**

**brought to you by the Networking Project**

**Webcast Today!**

Dr. Tso-Chien Pan & Dr. Bing Li
The NIST-NINDS Protective Technology Research Centre
Tuesday, May 25th 2004
3:30 - 4:30 PM EST

**Previous Events**

Jay Lewis
Seismic Risk Mitigation Of Operational & Functional Components Of Buildings "The Tough Nut To Crack"
Tuesday, May 4th 2004

Scott Campbell, PhD, PE
Seismic Design Of Non-Structural Components
Thursday, April 8th 2004

David A. Friedman
Today's Structural Engineer as the Classic Master Builder
Monday, February 23rd 2004

Thomas Zemanek and Shubin Ruan, Ph.D., P.E.
Structural Control Technologies
Friday, January 29th 2004

Douglas P. Taylor
Damper Retrofit Of The London Millennium Footbridge - A Case Study Of Biodynamic Design Issues
Friday, April 4th 2003

Dr. Thomas D. O'Rourke
Lessons Learned From The World Trade Center Disaster For Critical Infrastructure
Monday, March 17th, 2003

Diego Lopez Garcia
Tri-Center Field Mission 2002: Taiwan
Friday, March 7th, 2003

Dr. F. Michael Bartlett, P.Eng.
Testing Full-Scale Houses Subjected to Simulated Extreme Wind Loads
Friday, February 28th, 2003
Seismic Risk Mitigation of Operational & Functional Components of Buildings

"The Tough Nut To Crack!"

May 4, 2004

Email questions to mceerwebcast@civil.eng.buffalo.edu during the presentation and they will be answered at the end of the presentation.

TERRA FIRM
Websites:

http://mceer.buffalo.edu/research/
Templates for Users Network Sites

The types of resources included into the Users Network are divided into two main categories: Computational and Experimental. For websites to be included into the Users Network it is recommended that they conform to some basic guidelines. Templates have been created so the authors can modify them to create their web site. This allows for a consistent navigation structure across all sites in the Users Network and gives a place to start for the authors. If you have any questions about these templates or need assistance, please contact Jason P. Hanley or Andrei M. Resh Horn.

Documentation

- Template usage manual (pdf) (doc)
- Frequently Asked Questions (FAQ)

Computational Platform

- Download template
- Browse template
- Example of template usage

Experimental Facility

- Download template
- Browse template
- Example of template usage

Experiment Information

- Download template
- Browse template
- Example of template usage

Page maintained by Jason P. Hanley
Last updated December 12, 2002
Computational Platform Name

Home

This template should be used to distribute a computational platform and information about it. A Computational Platform can be a computer program, an algorithm, or anything to do with numerical computations and data processing. This is the home page for this template and the first thing people will see when visiting your web site.

Page maintained by Your Name
Last updated December 12, 2002
MCEER New York State Hospital Information System

Please provide your login information to access the database or use the following anonymous identity:

User Name: [ ]
Password: [ ]

Login  Reset
Templates for Users Network Sites

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Computational Platform

- Threshold template
- Browse template
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Experimental Facility

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- Example of template usage

Experiment Information

- Download template
- Browse template
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Page maintained by Jason P. Hasley
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Networking Sub-tasks

Special Projects:

- Start development of an integrated computational platform (that covers the system diagram) based on individual modules evolving to a streamlined simulation system.

- Develop and deploy distributed tools and remote access capabilities, integration of advanced computing capabilities capable to process the advanced tools.

- Provide distributed infrastructure for access to the information generated at MCEER or used by MCEER in its projects (i.e. webcast, distributed repositories).
Networking Sub-tasks

- S. Chang "Direct Losses, Social Impacts, and Community Resilience – Los Angeles Lifeline Study“ (Subtask of Thrust Area 1 and 3)
- R. Eguchi: “Satellite Imagery Database & MCEER Virtual Reconnaissance System (VRS)“ (Subtask of Thrust Area 3)
- M. Grigoriu: "Fragility Based and Rehabilitation Decision Analysis” (Subtask of Thrust Area 2 (and 1)
- A.S. Whittaker: “Fragility database for hospital structures” (SubTask of Thrust Area 2)
- G. Dargush: “Software for Evolutionary Methodologies for Decision Support ” (Subtask of Thrust Area 2 and 3)
- G.C. Lee “Database of the information system of NY State hospitals” (Subtask of Thrust Area 2)
- Tom O’Rourke: “Web-Based GIS database of water distribution system”, (Subtask of Thrust Area 1)
- M. Shinozuka: “Integrated evaluation of system performance – Transportation – software” (Subtask Thrust Area 1 and FHWA Transportation.)
- E. Maragakis: “Implementation of Database for Experiments on Fragility of Non-structural Hospital Piping Systems” (Thrust Area 1 and Networking Program)
Hospital building models

- Mathematical models
  - M3: 1970s MRF $T1=0.7$ s
  - M6: 1960s MRF $T1=1.6$ s
  - M7: M6 + BR braces
  - M8, M9: M6 + FVDs
  - M10, M11: M3 + LVE isolator
  - M12, M13: M3 + LVE isolators
  - M14, M15: M3 + BL isolators

- OpenSees simulation platform
  - www.opensees.berkeley.edu

- OpenSees input files
supported the development of new evolutionary approaches for decision support associated with critical care organizations. The methodology represents an extension of the EADR framework to include an organizational model, a sociopolitical model, an enhanced damage model, and the definition of a decision space that incorporates retrofit options along with other organizational policies. A preliminary version of the corresponding software is now operational for model validation and hypothesis testing. An initial release of the code Evolutionary Analytic Decision Support (EADS 1.0), within the MCEER research community, is targeted for the end of Year 6.

NYS-HIS

NYS-HIS: New York State Hospital Information System.

Hospitals are one of the most important public facilities. They are expected to provide uninterrupted and efficient medical services during and after an earthquake or any natural hazard. Hospitals are also important part in public hazard emergency management. This database is set up to provide the necessary information of selected hospitals in New York State for the participating researchers to carry out their individual research tasks. We can regularly modify and update the database as more information becomes available. Because it is not easy to obtain a complete set of information to represent a typical hospital (especially difficult for all the non-structural components and medical equipment), we intend to provide databases for several different hospitals in this information system. We will label each hospital by roman numerals (e.g. Hospital I, Hospital II, etc.). In this way, we also protect the identities of those hospitals that cooperate with MCEER.

Please use the following information to Log on to the system, for further information please contact Dr. Mai Tong.

Username: Guest Password: Guest

RDAT

RDAT: Rehabilitation Decision Analysis Toolbox (RDAT).

A method is presented for calculating the seismic performance of structural/nonstructural systems and developing rational strategies for increasing the seismic resilience of these systems. The seismic performance is measured by fragility surfaces, that is, the probability of system failure as a function of ground motion and site-to-source distance, consequences of system damage and failure, and system recovery time following seismic events. The input to the analysis consists of seismic hazard, geo-technical and structural/nonstructural systems properties, performance criteria, rehabilitation strategies, and a reference time. Estimates of losses and recovery times, referred to as life cycle losses and recovery times, can be derived using fragility information, financial models, and available resources. A structural/nonstructural system located in New York City is used to demonstrate the methodology. Fragilities are obtained for nonstructural components and system for several limit states. Also, statistics are obtained for life time losses and recovery times corresponding to different rehabilitation alternatives.

GMS

GMS: Ground Motion Simulator (GMS).

A computer code along with a user interface is developed for the seismic ground accelerations at a collection of sites in a specified region. The code uses a stationary non-Gaussian model for the seismic ground accelerations. The model is based on (i) the specific hazard model defining the spectral densities of the ground motion at a site, (ii) a postulated coherence function characterizing the phase differences between motions at different sites, and (iii) non-Gaussian translation processes.

MULTIDISCIPLINARY CENTER FOR EARTHQUAKE ENGINEERING RESEARCH
MULTIDISCIPLINARY CENTER FOR EARTHQUAKE ENGINEERING RESEARCH
Computational Platforms

To add your own program, click here for the computational platform template and instruction on how to use it.

ABAQUS | DIANA | ENOSIM | FRANC | IDARC 2D | IDARC 3D | 3D BASIS | NSPECTRA

ABAQUS

ABAQUS is a suite of general-purpose, nonlinear finite element analysis (FEA) programs developed and supported by Hibbitt, Karlsson & Sorensen, Inc. ABAQUS is used throughout the world for stress, heat transfer, and other types of analysis in mechanical, structural, civil, biomedical, and related engineering applications.

Although ABAQUS is not developed solely for earthquake engineering applications, considerable capability is available for overall nonlinear dynamic analysis of structures and for detailed component-level analysis. ABAQUS is intended for the high-end user. A strong background in structural mechanics and finite element methods is generally required.

The following items are some of the more significant features of the code:

- A wide range of element types, including continuum elements (1d, 2d, 3d), beams, membranes and shells
- Element formulations suitable for large displacements, rotations and strains; Implemented within an updated Lagrangian framework
- Material models for metals, sand, clay, concrete, jointed rock, plastics and rubber; In some cases these models are limited to mostly monotonic loading
- User-defined subroutines permit inclusion of additional material models and element types
- Automatic time incrementation within an implicit time integration algorithm (Hibber-Hughes) for nonlinear dynamic analysis
- Sparse symmetric and unsymmetric solvers with capability for parallel processing; Lanczos eigensolver
- Surface-to-surface contact with frictional sliding
- Material removal and addition to model construction sequences
- Simplified rebar placement facility
- Fracture mechanics capability
- Coupled formulations for quasistatic thermomechanics and for consolidation processes involving pore fluid flow

DIANA

DIANA is a multi-purpose finite element package with special emphasis on advanced linear and nonlinear structural engineering and flow applications. Some of the key features include:

- Full 2D and 3D modelling capabilities
- Around 200 element types to meet your modelling requirements
- Vast choice of concrete models
- Advanced algorithms for discrete and smeared cracking, crushing, creep, shrinkage and bond slip
- Unique feature for easy modeling of embedded reinforcement in concrete
- Pre/Post-tensioning option
- Influence lines, influence fields, tension force, optimization

MULTIDISCIPLINARY CENTER FOR EARTHQUAKE ENGINEERING RESEARCH
A cooperative platform for inelastic dynamic analysis of collapsing structures: IDARC-LARSA  [Sivaselvan (UB), Reinhorn (UB), Karakaplan (LARSA Inc.)]

•Based on analysis methods developed at MCEER in Thrust Area 2
•Integrates GUI developed by LARSA Inc.
Three types of software can be found on this page regarding the simulation of earthquake strong motion:

- time histories (acceleration, velocity, etc. Stochastic Approach)
- parameters (peak ground acceleration, PSV, PSA, etc. Stochastic Approach)
- time histories compatible with a user specified response spectra

Any questions or comments regarding the codes or their usage should be submitted using the forms on the Feedback page.

UPDATE - 2004/07/14:
Simulation of Strong Ground Motion

The specific barrier model has recently been calibrated to earthquakes of inter-plate, intra-plate and extensional regime earthquakes. The corresponding SGMS and SGMP codes and user manuals are in the process of being made available on this page. These codes will eventually replace the older versions SGMS_ENA and SGMP_ENA.

Please refer to the Strong Motion Synthesis page and a recent presentation for an overview of the methods and approaches that we have taken for strong ground motion simulations.

In the meantime, please use the Feedback page on this website or email Benedikt Hallgardsson to inquire about the updates and/or the usage of the codes.

Strong Ground Motion Simulation (of time histories)

Code: SGMS (v5)
User manual: Erath.

Strong Ground Motion Parameters (of e.g., PGA, PSV etc)

Code: SGMP (v5)
User manual: See the included sample input file for information until the user manual is completed.
GMS: Ground Motion Simulator (GMS).

A computer code along with a user interface is developed for the seismic ground accelerations at a collection of sites in a specified region. The code uses a stationary non-Gaussian model for the seismic ground accelerations. The model is based on (i) the specific barrier model defining the spectral densities of the ground motion at a site, (ii) a postulated coherence function characterizing the phase differences between motions at different sites, and (iii) non-Gaussian translation processes.

VIEWS:

VIEWS: Visualizing the Impacts of Earthquakes using Remote Sensing Images

Through MCEER funding, considerable effort has been invested in developing automated building damage detection methods, together with techniques for visualizing damage. The Bam earthquake marks their first deployment as a post-earthquake reconnaissance tool, within the VIEWS.

Running on a notebook for portability, VIEWS enables reconnaissance teams to compare satellite images acquired before and after an earthquake. The system directs responders to the hardest hit areas, using the damage assessment map. For more detailed damage information, collapsed buildings are easily identified in the high-resolution satellite coverage. This also serves as a base map and orientation device for teams deployed to unfamiliar sites. To help users gain and maintain their bearings, VIEWS tracks their current position using a real-time GPS feed. The system also provides easy recall for observations made in the field. As users enter comments such as building damage descriptions and the ID number of their photographs, all information is automatically linked to the current GPS location. Back in the office, VIEWS datasets are readily transferred to a GIS environment, for further analysis.

The VIEWS system was deployed by the BEM reconnaissance team. During the course of reconnaissance activities in Bam, the GPS functionality was used to track routes followed through the city. Figure 12 illustrates one of the routes taken towards the cinder. The position of digital photographs was also overlaid and their identification numbers and associated comments added as attributes. Following the initial trial, important lessons have been learned which will improve logistical and technical aspects of VIEWS deployment for future earthquakes.

VRS:

VRS: Virtual Reconnaissance Survey

The use of spatial information is a crucial element of emergency response efforts. However, datasets are typically acquired through a range of media (CD, PDA, laptop, GPS) and are therefore difficult to transmit, organize, project and analyze.

The objective of this research task is to develop an online GIS-type system, called the Virtual Reconnaissance Survey (VRS). It will allow responders to transmit and share remote sensing imagery and GIS databases online, and view them using a suite of custom visualization tools.
Gaussian/Non-Gaussian Ground Motion Generation in Single/Multiple Sites

Home

A computer code along with a user interface is developed for the seismic ground accelerations at a collection of sites in a specified region.

Page maintained by Cagdas Kafaki
Last updated November 01, 2004
Ground Motion Simulator version 1 (completed)

GROUND MOTION SIMULATOR v. 1.0
(For Eastern North America)

- Gaussian model
- Non-Gaussian model
- Stationary model
- Non-stationary model
- Single site
- Multiple sites

- Moment magnitude: 6.00
- Source-to-site distance (km): 100.00
- Soil: 1
- Site geometry/soil level: coord.txt
- Number of samples: 1
- Seed for random number generation: 123
- Estimated run time: help

Multidisciplinary Center for Earthquake Engineering Research
Three types of software can be found on this page regarding the simulation of earthquake strong motion:

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Networking Sub-tasks:

- **Performance Criteria & Inf.**
  - Database
    - Fragility NonStruct (com) V - Soong
    - Frag.Piping (exp) V - Maragakis
    - Hospital (NYS) Syst-VII-VIII Lee
  - Excitation
    - Database
      - GrdMot - V - Papageorgiou

- **Performance Estimation**
  - Software
    - RiskEvalWater-VI-VII-Grigoriu
    - CostEstim-VI-VII-Grigoriu

- **Resilience Evaluation Decision**
  - Software
    - Losses, Soc. Resilience – VI, VII, VIII
      - Dargush/Petak
      - LossEstimationsDecisions VII - Grigoriu

- **Performance Evaluation**
  - Software
    - Fragility Eval – V, VI, VII – Grigoriu
      - FragilityStruct-VII-VIII Reinhorn

- **Remediation / Modification**
  - Software
    - EvolOptim-VI-VII-VIII Dargush
  - Database
    - EPS - VII - Constantinou
      - Walls - V - Billington
      - Piping - VII - O'Rourke
      - CompositeWalls - VII - Aref

- **Survey and Evaluation**
  - Software
    - Satellite Eval – VI-VII-VIII - Eguchi

- **Infrastructure**
  - Database
    - StrBenchMark - V-VI-VII Reinhorn
      - HospModels - VI-VII-VIII Whittaker
      - NYS-HospitalsModels VII-VIII Lee

- **Response**
  - Performance
    - Database
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      - Hospital (NYS) Syst-VII-VIII Lee
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**Multidisciplinary Center for Earthquake Engineering Research**
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Running on a notebook for portability, VIEWS enables reconnaissance teams to compare satellite images acquired before and after an earthquake. The system directs responders to the hardest hit areas, using the damage assessment map. For more detailed damage information, damaged buildings are easily identified on the high-resolution satellite coverage. This also serves as a base map and orientation device for teams deployed to unfamiliar cities. To help users gain and maintain their bearings, VIEWS tracks their current position using a real-time GPS feed. The system also provides easy recall for observations made in the field. As users enter comments such as building damage descriptions and the ID number of their photographs, all information is automatically linked to the current GPS location. Back in the office, VIEWS datasets are readily transferred to a GIS environment, for further analysis.

The VIEWS system was deployed by the BEM reconnaissance team. During the course of reconnaissance activities in Bam, the GPS functionality was used to track routes followed through the city. Figure 12 illustrates one of the routes taken towards the citadel. The position of digital photographs was also overlaid and their identification numbers and associated comments added as attributes. Following this initial trial, important lessons have been learned which will improve logistical and technical aspects of VIEWS deployment for future earthquakes.

VRS: Virtual Reconnaissance Survey

The use of spatial information is a crucial element of emergency response efforts. However, datasets are typically acquired through a range of media (CD, PDA, laptop, GPS) and are therefore difficult to transmit, organize, project and analyze.

The objective of this research task is to develop an online GIS-type system, called the Virtual Reconnaissance Survey (VRS). It will allow responders to transmit and share remote sensing imagery and GIS databases online, and view them using a suite of custom visualization tools.
VIEWS® Reconnaissance and Visualization System

ImageCat, Inc.
Year 7 System Specifications

(a) ‘VIEWS’ for Field Data Collection

- ‘Before’ and ‘after’ satellite imagery
- Building damage maps included for reference in field
- Linked to real-time GPS
- Provides route tracking
- Collects and organizes damage observations
- Can be linked to photos and video
- Can be linked to central server through wireless connection
- Deployed from moving vehicle or on foot
2004-2005 VIEWS® Deployment

1. Bam, Iran earthquake
2. Hurricane Charley
3. Hurricane Ivan
4. Parkfield earthquake
5. Niigata, Japan earthquake
6. Thailand, Indian ocean tsunami
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- ‘Before’ and ‘after’ satellite imagery
- Building damage maps included for reference in field
- Linked to real-time GPS
- Provides route tracking
- Collects and organizes damage observations
- Can be linked to photos and video
- Can be linked to central server through wireless connection
- Deployed from moving vehicle or on foot

Satellite imagery, maps + ‘GPS’ referenced:
- Damage observations
- Digital photographs
- Digital video

(b) ‘VRS’ for Online & Desktop Visualization

- Serves all data collected by VIEWS
- Repository for other georeferenced reconnaissance data (e.g. FEMA maps)
- Enables data integration
- Serves high-resolution raster imagery
- Serves vector attribute data
Refinements for Year 8

‘VIEWS’® - 1 integrated program for reconnaissance data collection and visualization

- New User-friendly interface
- Hand-held replaces laptop for on-foot surveys
- Integrated D-VRS (desktop virtual reconnaissance system) mode for replay and analysis
- New panoramic video capture and display
- Field data download streamlined for online hosting
Networking: Water Supply

- Unique GIS
- Critical Infrastructure Response to 1994 Northridge EQ
- 164 Geo-coded Strong Motion Records
- ~ 1100 Geo-coded pipeline repairs
- ~ 1100 km distribution pipelines
- ~ 1000 km trunk lines
Networking: Timber Structures

- ~ $22B Northridge EQ Damage
- 164 Geo-coded Strong Motion Records
- Census Tract & Tax Assessor Records: 280,000 Buildings
- OES Damage Assessment Surveys: 47,000 Buildings
- Major Roads, Topography, etc.
Networking Sub-tasks:

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**INFRATESTRUCTURE**
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**RESPONSE**
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    - FragilStruct-VII-VIII Reinhorn
COMPUTATIONAL PLATFORM: FRAGILITY BASED REHABILITATION DECISION ANALYSIS

Seismic Hazard  (Papageorgiou/ Grigoriu)

Fragility Analysis  (Filiatrault / Maragakis / Grigoriu)

Life Cycle Capacity / Cost Estimates  (von Winterfeldt / Grigoriu)

Leading developers: Grigoriu (CU), Cagdas (CU)
IMPLEMENTATION OF MULTIFUNCTIONAL FRAGILITY IN EVALUATION SOFTWARE: idarc2d

- Implementation can be transferred to other programs
- Best when used with supercomputer analysis
PROGRAMES

MULTIPLE ANALYSES

PROGRAM A

IDARC 2D 6.0

OUTPUT

PROGRAM B

FRAGILITY ANALYSIS
PROGRAM A

PSHA

Accelerograms

Model (W70)

OPTION 1: RUN DIFFERENT INTENSITIES OF ACCELEROGRAMS' LIST

OPTION 1: RUN ACCELEROGRAMS' LIST

STORED RESPONSE DATA

INPUT FILES

QUAKE LIST
(FILE WITH ACCELEROGRAMS' LIST)

IDARC 2D 6.0 EXE FILE

LIMIT STATE
(FILE WITH LIST OF LIMIT STATE)

OUTPUT FILE

Data are saved in different folders with the same name of the accelerogram’s file.
Information for each story:
• Displacement,
• Story drift,
• Story shear,
• Acceleration,
• Damage beam slab,
• Damage Col-wall.
• Out file

MULTIDISCIPLINARY CENTER FOR EARTHQUAKE ENGINEERING RESEARCH
PROGRAM B

OPTION 1: [PGA]

- Fragility curves
- Max Drift
- Max Accelerations
- Max displacements

OPTION 2: [Return period]

- Fragility curves
- Max Drift
- Max Accelerations
- Max displacements

P_{\text{failure}}
Conceptual and Measurement Framework

**Business Characteristics**
- Business size
- Occupancy tenure
- Sector
- Other characteristics

**Vulnerability Dimensions**
- Financial condition
- Location of customers
- Type of competition
- Location of competitors

**Loss Factors**
- Physical damage
- Mitigation & preparedness

**Vulnerability Index**
- Access to resources
- Market diversification
- Market stability

**Loss Determinants**
1. Speed of reopening
2. Survival of market
3. Change in competitiveness

**Outcome**
- Extent of business loss & recovery

**Influence**
- Measured variables
Evolutionary Aseismic Design & Retrofit (EADR)

Over the past several years, MCEER has supported the development of an evolutionary optimization approach for the aseismic design and retrofit of passively damped structural systems. An initial C++ version of the software is intended for use within the MCEER community of researchers and industry partners. This initial release of the code Evolutionary Aseismic Design and Retrofit (EADR_1.0) includes the capability to optimize the type, size, and location of passive damping elements in a structure subjected to an uncertain seismic environment. Available damper types include metallic, viscous, and viscoelastic devices. The seismic environment utilizes far-field and near-field synthetic ground motions based upon the Hypogeocent model for eastern North America. The structural system idealization for EADR_1.0 is limited to lumped parameter models with the nonlinear transient dynamic analysis performed using an explicit state-space formulation. Options provide for the specification of the design space of period, strength, drift, and evaluation loads, and cost/performance function.

Evolutionary Aseismic Decision Support (EADS)

While the evolutionary approach for aseismic design and retrofit is useful in distinguishing the various structural design alternatives, decisions regarding whether or not to retrofit an existing structure are seldom based strictly on engineering grounds. The social/technical nature of organizational decision-making must be considered. Beginning in Year 6, MCEER has supported the development of new evolutionary approaches for decision support associated with critical care organizations. The methodology represents an extension of the EADR framework to include an organizational model, a sociopolitical model, an enhanced damage model, and the definition of a decision space that incorporates retrofit options along with other organizational factors. A preliminary version of the corresponding software is now operational for model validation and hypothesis testing. An initial release of the code Evolutionary Aseismic Decision Support (EADS_1.0), within the MCEER research community, is targeted for the end of Year 6.

NYS-HIS

NYS-HIS: New York State Hospital Information System.

Hospitals are one of the most important public facilities. They are expected to provide uninterrupted and efficient medical services during and after an earthquake or any natural hazard. Hospitals are also important part in public hazard emergency management. This database is set up to provide the necessary information of selected hospitals in New York state for the participating researchers to carry out their individual research tasks. We can regularly modify and update the database as more information becomes available. Because it is not easy to obtain a complete set of information to represent a typical hospital (especially difficult for all the non-structural components and medical equipment), we intend to provide databases for several different hospitals in the information system. We will label each hospital by urban numerals (e.g. Hospital A, Hospital B, etc.). In this way, we also protect the identities of those hospitals that cooperate with NCEER.

Please use the following information to Log on to the system, for further information please contact Dr. Mei Tong.

Username: Guest Password: Guest

RDAT

RDAT: Rehabilitation Decision Analysis Toolbox (RDAT).

A method is presented for calculating the seismic performance of structural/nonstructural systems and developing rational strategies for increasing the seismic resilience of these systems. The seismic performance is measures by fragility surfaces, that is, the probability of system failure as a function of magnitude and site-to-source distance, consequences of system damage and failure, and system recovery time following seismic events. The input to the analysis consists of seismic hazard, seismotectonic and structural systems properties, performance criteria, rehabilitation strategies, and a reference time. Estimates of losses and recovery times, referred to as life cycle losses and recovery times, can be derived using fragility information, Financial models, and available...
Evolutionary Aseismic Decision Support

Objective
Provide seismic retrofit guidance for health care organizations

Features
Incorporates both engineering and sociotechnical aspects
Analytical system dynamics approach for organization modeling
Uncertain seismic and socioeconomic environment with risk aversion
EADR for optimal retrofit selection
Unix version functional; Windows version under development

Acute Care Facility
Memphis, TN

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Evolutionary Aseismic Design and Retrofit Networking Aspects

General framework, along with associated software and interfaces, have been developed for:

- Collaborative Research
- Collaborative Design
- Interactive Education

Permits access to CCR high-power resources and grid computing

Initial application to EADR appears promising

Extension to Evolutionary Aseismic Decision Support (EADS) planned for Year 8
MCEER-CCR-NEES Collaborative Platform

- Common platform for exchange of information and visualization
- Outreach and education (Access Grid Capabilities)
- Serve 3D stereo graphics to the SGI 3300W Visualization Display
- Serve 2D and 3D graphics to the Tiled-Display Wall
- Advanced Computational Data Center - Grid (ACDC-Grid) grid-enabled node
- Website server with a Gigabit Ethernet connection
- MySQL database with SSL connections and authentications
Networking Sub-tasks:

**PERFORMANCE CRITERIA & INF.**
- DATABASE
  - Fragility NonStruct (com) V - Soong
  - Frag.Piping (exp) V - Maragakis
  - Hospital (NYS) Syst-VII-VIII Lee
  - Fragility Struct-VII-VIII Whittaker Piping System-VII-VIII Maragakis

**PERFORMANCE ESTIMATION**
- SOFTWARE
  - RiskEvalWater-VI-VII-Grigoriu
  - CostEstim-VI-VII-Grigoriu

**RESILIENCE EVALUATION DECISION**
- SOFTWARE
  - Loses/Decision – VII-VIII Dargush/Petak
  - LossEstimationsDecisions – VII-Grigoriu

**PERFORMANCE EVALUATION**
- SOFTWARE
  - Fragility Eval – V, VI, VII – Grigoriu
  - FragilStruct-VII-VIII Reinhor

**EXCITATION**
- DATABASE
  - GrdMot - V - VII - Papageorgiou
  - Satellite Eval. – VI-VII-VIII Eguchi

**REMEDIATION / MODIFICATION**
- SOFTWARE
  - EvolOptim-VI-VII-VIII Dargush

**SURVEY AND EVALUATION**
- SOFTWARE
  - Satellite Eval – VI-VII-VIII Eguchi

**INVENTORIES**
- DATABASE
  - Satellite imaging – V VI-VII-VIII Eguchi
  - GIS Piping Integration – VII-VIII O’Rourke

**MULTIDISCIPLINARY CENTER FOR EARTHQUAKE ENGINEERING RESEARCH**
A method is presented for calculating the seismic performance of structural/nonstructural systems and developing rational strategies for increasing the seismic resilience of these systems. The seismic performance is measured by fragility surfaces, that is, the probability of system failure as a function of moment magnitude and site-to-source distance, consequences of system damage and failure, and system recovery time following seismic events. The input to the analysis consists of seismic hazard, geo-technical and structural/nonstructural systems properties, performance criteria, rehabilitation strategies, and a reference time. Estimates of losses and recovery times, referred to as life cycle losses and recovery times, can be derived using fragility information, Financial models, and available resources. A structural/nonstructural system located in New York City is used to demonstrate the methodology. Fragilities are obtained for nonstructural components and systems for several limit states. Also, statistics are obtained for life time losses and recovery times corresponding to different rehabilitation alternatives.

A computer code along with a user interface is developed for the seismic ground accelerations at a collection of sites in a specified region. The code uses a stationary non-Gaussian model for the seismic ground accelerations. The model is based on (i) the specific bender model defining the spectral densities of the ground motion at a site, (ii) a postulated coherence function characterizing the phase differences between motions at different sites, and (iii) non-Gaussian translation processes.

Through MCEER funding, considerable effort has been invested in developing automated building damage detection methods, together with techniques for visualizing damage. The Bam earthquake marks their first deployment as a post-earthquake reconnaissance tool, within the VIEWS.

Running on a notebook for portability, VIEWS enables reconnaissance teams to compare satellite images acquired before and after an earthquake. The system directs responders to the hardest hit areas, using the damage assessment map. For more detailed damage information, collapsed buildings are easily identified on the high-resolution satellite coverage. This also serves as a base map and orientation device for teams deployed to unfamiliar cities. To help users gain and maintain their bearings, VIEWS tracks their current position using a real-time GPS feed. The system also provides easy recall for observations made in the field. As users enter comments such as building damage descriptions and the ID number of their photographs, all information is automatically linked to the current GPS location. Back in the office, VIEWS datasets are readily transferred to a GIS environment, for further analysis.

The VIEWS system was deployed by the BERM reconnaissance team. During the course of reconnaissance activities in Bam, the GPS functionality was used to track routes followed through the city. Figure 12 illustrates one of the routes taken towards the citadel. The position of digital photographs was also overlaid and their identification numbers and associated comments added as attributes. Following this initial trial, important lessons have been learned which will improve logistical and technical aspects of VIEWS deployment for future earthquakes.
Fragility Based Rehabilitation Decision Analysis

Home

A methodology for assessing the seismic performance of a system with structural and nonstructural components is developed using fragility analysis and loss estimation. System properties, seismic hazard characterization and performance criteria are required to calculate system fragility and estimate losses and recovery times.

Page maintained by Capdas Kafal.
Last updated November 01, 2004.
COMPUTATIONAL PLATFORM: FRAGILITY BASED REHABILITATION DECISION ANALYSIS

Seismic Hazard (Papageorgiou/ Grigoriu)  

Fragility Analysis (Filiatrault / Maragakis / Grigoriu)  

Life Cycle Capacity / Cost Estimates (von Winterfeldt / Grigoriu)  

Leading developers: Grigoriu (CU), Cagdas (CU)
Life Cycle Capacity / Cost Estimates (Matlab based platform)
Rehabilitation Decision Analysis Toolbox (RDAT) version 1 (completed)

Decision Analysis Toolbox v. 1.0
(Linear single degree of freedom system subjected to stationary Gaussian excitation)

Number of Rehabilitation Alternatives to be evaluated: 3
Number of Damage States to be considered: 4

Fragility Information
Lifetime Seismic Hazard Information
Financial Information
Quit Run

Rehabilitation Decision Analysis Toolbox

System Information
Lifetime Seismic Hazard Information
Fragility Information
Recovery Information
Financial Information
Quit Simulate
Evolutionary Asismic Design & Retrofit (EADR)

Over the past several years, MCEER has supported the development of an evolutionary optimization approach for the asismic design and retrofit of passively damped structural systems. An initial beta version of the software is intended for use within the MCEER community of researchers and industry partners. This initial release of the code Evolutionary Asismic Design and Retrofit (EADR_1.0) includes the capability to optimize the type, size and location of passive damping elements in a structure subjected to an uncertain seismic environment. Available damper types include metallic, viscous and viscoelastic devices. The seismic environment utilizes far-field and near-field synthetic ground motions based upon the Hype-Geo model for Eastern North America. The structural system idealization for EADR_1.0 is limited to lumped parameter models with the nonlinear transient dynamic analysis performed using an explicit state-space formulation. Options provide for the specification of the design space of possible structural, drift and acceleration limits, and cost/benefit functions.

Evolutionary Asismic Decision Support (EADS)

While the evolutionary approach for asismic design and retrofit is useful in distinguishing the various structural design alternatives, decisions regarding whether or not to retrofit an existing structure are seldom based strictly on engineering grounds. The socio-technical nature of organizational decision-making must be considered. Beginning in Year 5, MCEER has supported the development of new, evolutionary approaches for decision support associated with critical care organizations. The methodology represents an extension of the EADR framework to include an organizational model, a sociopolitical model, an enhanced damage model, and the definition of a decision space that incorporates retrofit options along with other organizational practices. A preliminary version of the corresponding software is operational for model validation and hypothesis testing. An initial release of the code Evolutionary Asismic Decision Support (EADS_1.0), within the MCEER research community, is targeted for the end of Year 6.

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Evolutionary Aseismic Design and Retrofit

Objective
Determine optimal size, placement and type of passive dampers

Features
Fitness depends on damper cost, achievement of satisfactory levels for interstory drift and total acceleration, performance of non-structural components, pounding prevention, risk aversion

Uncertain seismic environment or fixed ensemble of earthquakes

Multilevel genetic algorithm for efficient simulations

Windows and Unix versions
Computational Platform: Evolutionary Analysis

- Engineering -> Evolutionary Aseismic Design & Retrofit (EADR)
  - Modeling Aspects
    - Passive Energy Dissipation Elements
    - Reinforced Concrete Structures (IDARC)
    - Non-structural Components
  - Computational Aspects
    - Fast Multigrid Dynamics
    - Massively Parallel Environment & Grid Computing
    - Visualization (MCEER/CCR/NEES Collaboration)

Developed: Gary Dargush / Mark Green (UB)
Shinozuka et al

Performance Analysis of Power Supply System

- Use 47 scenario earthquakes [Maximum Credible Earthquakes and User Defined Earthquakes]
- For each scenario earthquake, simulate equipment damage using fragility curves for with and without rehabilitation
- Simulate damage to the transmission network
- Calculate power flow using IPFLOW under network failure criteria
- Compute the seismic performance of the power network in terms of percentage of power supply and number of households in the entire area of service as well as each service area under each scenario earthquake
- Evaluate reduction in the seismic performance
- Develop seismic risk curve (which plots the annual probability that system performance will be reduced more than a specified level due to earthquake as a function of each level)
- Examine system performance relative to performance criteria, with and without rehabilitation.
- Determine the effectiveness of rehabilitation
Shinozuka et al

Performance Analysis of Power Supply System

47 Scenarios Earthquake

USC-EPEDAT

Isolate Disabled Nodes

Isolate Disabled Lines

IPFLOW

Abnormal Node?

Yes

No

Power Output for Each Service Area**

Risk Curves for Pw, Hw, and GRP

Technical, Social, and Economic Loss

System Performance Criteria, Effectiveness of Rehabilitation

Annual Occurrence Probability

Attenuation Relationship

Annual Occurrence of 47 Scenario Earthquakes

Western Electricity Coordinating Council

* Includes the case of system-wide blackout
The code generates performance of power system in terms of power supply and household without power for every service area immediately after each scenario earthquake. These are serve as basic input information to the ensuing socio-economic input analysis.
This code provides a decision support tool to evaluate the cost-effectiveness of bridge retrofit.

1. Probabilistic Earthquake Scenario Set
2. Bridge Inventory
3. Retrofit
4. J-th Earthquake Scenario
5. Ground Shaking at Bridge Site
6. State of Link Damage
7. State of Bridges Damage
8. Link Capacity
9. Traffic Flow Analysis
10. Drivers’ Delay
11. Repair Cost
12. Delay Cost
13. Benefit = Loss Avoided - Retrofit Cost

Shinozuka et al
## Benefit-Cost Analysis

### Los Angeles*

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<tr>
<th>Bridge Name</th>
<th>Annual Probability</th>
<th>Annual Expected Loss</th>
<th>Cost Avoided</th>
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<td>Before Retrofit</td>
<td>After Retrofit</td>
<td>Before Retrofit</td>
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<td>Model 3</td>
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<td>(Gavin Canyon)</td>
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<td>Model 4</td>
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<td>(Santa Clara)</td>
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<td>(SR14/I5 Interchange)</td>
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**Total Annual Expected Loss**

(Assumed 3000 Bridges)

- 61 milions
- 24 milions
- 37 milions

*Using Zip Code 90089*
Summary Networking Plan

- Develop databases of information from tasks, from sensors, experiments, industries, etc

- Develop platforms with procedures and software for evaluation and decision analysis

- Develop links and quick transfer of information

- Develop education tools for use of the above