

*Geohazards in Transportation
in the Appalachian Region*

*August 5, 2009
Lexington, KY*

Seismic Hazard Mitigation of Transportation Structures

Issam Harik

**Department of Civil Engineering, and
Kentucky Transportation Center**

**University of Kentucky
Lexington, Kentucky USA**

Outline

- **Introduction**
- **Hazard Mitigation**
- **Conclusions**

Outline

■ Introduction

- Hazard Mitigation
- Conclusions

Disaster and Emergency Management

```
graph TD; A[Disaster and Emergency Management] --> B[Medical]; A --> C[Water]; A --> D[Power]; A --> E[Law Enforcement]; A --> F[Transportation]; A --> G[Other]; style F fill:#ffff00,stroke:#ffff00
```

Medical

Water

Power

Law Enforcement

Transportation

Other

Department of Transportation



```
graph TD; DOT[Department of Transportation] --- Airports; DOT --- Roadways; DOT --- Railways; DOT --- Bridges; DOT --- Navigable_Waterways[Navigable Waterways]; DOT --- Other;
```

The diagram is an organizational chart for the Department of Transportation. At the top is a box labeled "Department of Transportation". A vertical line descends from this box and connects to a horizontal line. From this horizontal line, six vertical lines descend to connect to six separate boxes arranged in two rows. The top row contains "Airports", "Railways", and "Bridges". The bottom row contains "Roadways", "Navigable Waterways", and "Other". The word "Bridges" is highlighted in yellow, while all other text is white.

Airports

Railways

Bridges

Roadways

Navigable Waterways

Other

Hazards on Bridges and Highway Structures

```
graph TD; A["Hazards on Bridges and Highway Structures"] --> B["Man-Made Hazards"]; A --> C["Natural Hazards"];
```

Man-Made Hazards

Natural Hazards

Man-Made Hazard

A man-made hazard is an accidental or intentional event of unusual magnitude that threatens the activities of people or people themselves.

Man-Made Hazards

```
graph TD; A[Man-Made Hazards] --> B[Biological]; A --> C[Chemical]; A --> D[Blast]; A --> E[Fire]; A --> F[Impact]; A --> G[Nuclear]; A --> H[War]; A --> I[Other];
```

Biological

Chemical

Blast

Fire

Impact

Nuclear

War

Other



Pike County, Kentucky, USA

Pike County, Kentucky, USA



Pike County, Kentucky, USA



Truck Impact



I-44, Lebanon, Missouri

Truck Impact



I-44, Lebanon, Missouri



I-44, Lebanon, Missouri

Truck Impact



I-44, Lebanon, Missouri

Activities in Kentucky

I-64 Parallel Bridges over US60



SPAN 1

SPAN 2

SPAN 3

Eastbound I-64
(Towards Lexington)

Westbound US60
(Towards Frankfort)

Eastbound US60
(Towards Versailles)

This outer girder on Eastbound I-64 over Eastbound US60 gets hit by trucks exceeding the height restriction due to low clearance at that station

I-64 Parallel Bridges over US60

Eastbound US 60
(To Versailles)

Westbound US 60
(To Frankfort)

North



This girder in Span 3 on Westbound I-64 underwent excessive deflection and vibration under truck loading. Cracks had formed on this girder and the adjacent girders.

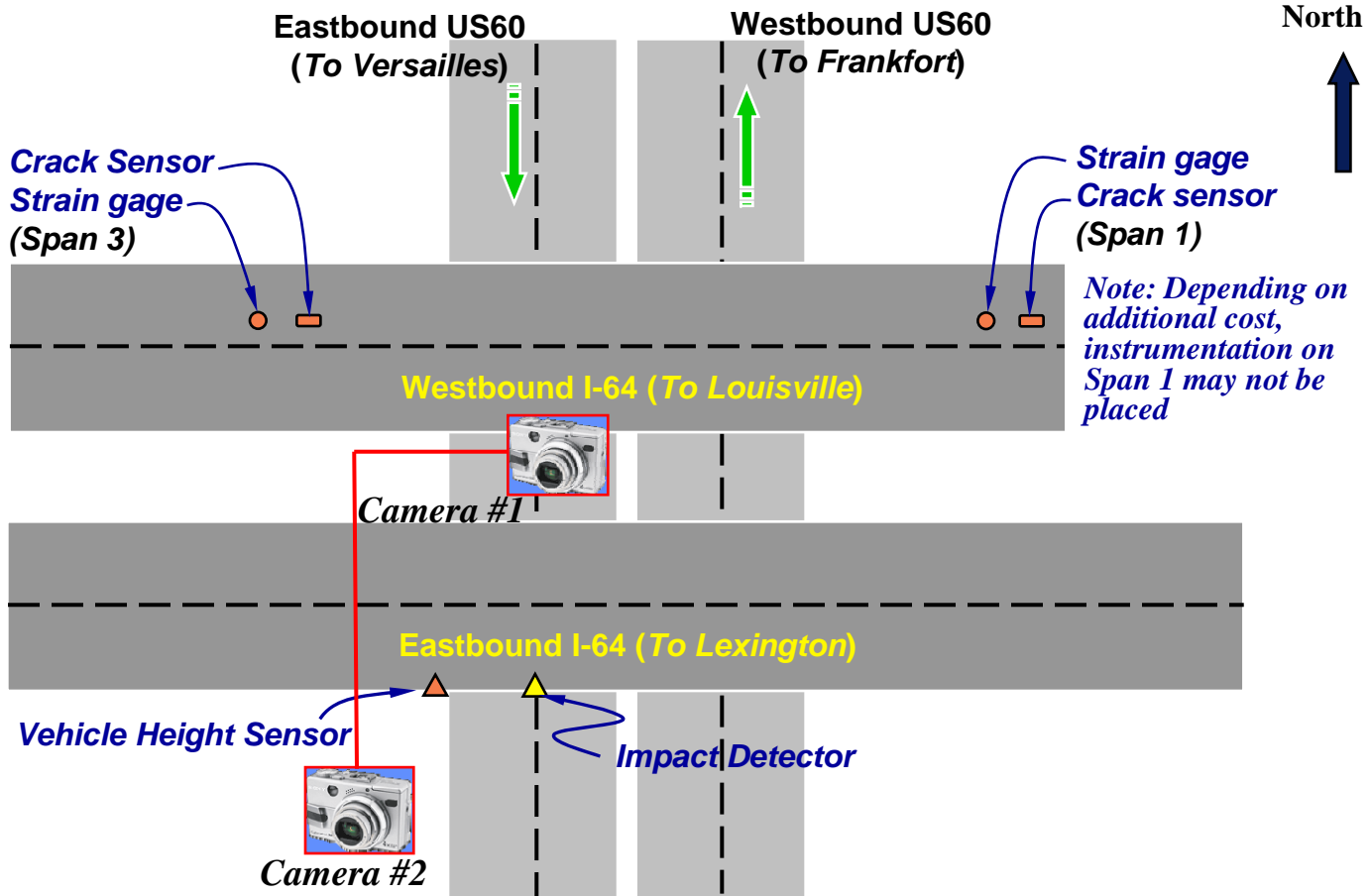
This girder in Span 1 on Westbound I-64 underwent excessive deflection and vibration under truck loading. Cracks had formed on this girder and the adjacent girders.

Westbound I-64
(To Louisville)

Eastbound I-64
(To Lexington)

The outer girder on Eastbound I-64 over Eastbound US60 gets hit by trucks exceeding the height restriction due to low clearance at that location

Possible Instrumentation Plan



Truck Fire



I-65/I-59/I-20 Interchange in Birmingham, Alabama

Truck Fire



I-65/I-59/I-20 Interchange in Birmingham, Alabama

**Tanker Truck Fire - MacArthur Maze Freeway
Oakland, California
29 April, 2007**



Special to the Chronicle / Philip Liborio Gangi



**Tanker Truck Fire - MacArthur Maze Freeway
Oakland, California
29 April, 2007**

**Tanker Truck Fire - MacArthur Maze Freeway
Oakland, California
29 April, 2007**



Special to the Chronicle / Robert Campbell

BARGE IMPACT ON BRIDGES



Lexington Herald Leader – Monday, May 27, 2002



JERRY WILLIS | ASSOCIATED PRESS

Emergency crews surveyed the scene of the bridge collapse where Interstate 40 crosses the Arkansas River near Webbers Falls, Okla.

Barge collapses Oklahoma bridge

MOTORISTS TRAPPED AS VEHICLES FALL INTO RIVER

HERALD-LEADER WIRE SERVICES

WEBBERS FALLS, Okla. — A barge struck the Interstate 40 bridge over the Arkansas River early yesterday, causing a 600-foot section of the span to collapse into the river.

Officials said as few as seven people or as many as 20 might have died in the 7:45 a.m. collapse, but the fear that the remainder of the bridge would collapse slowed recovery efforts.

The barge's crew said their

pilot, Joe Dedmon, 61, of Florence, Miss., was at the helm at the time of the accident and appeared to suffer a seizure just before the collision, investigators said.

He had no previous medical conditions, according to Joel Henderson of Magnolia Marine Transportation Co., which owns the tugboat and barges.

See BRIDGE, A9



Barges smash bridge; cars plummet 85 feet

By Lynn Brezsky
ASSOCIATED PRESS

PORT ISABEL, Texas — A group of barges smashed a 240-foot section out of the only bridge leading to popular South Padre Island early yesterday, and at least four people died after their vehicles plunged into the water 85 feet below.

An unknown number of people were missing. Thirteen were rescued from the Laguna Madre, part of the Intracoastal Waterway shipping route along the Gulf Coast, and three were hospitalized.

Five vehicles were located in the 50-foot-deep water, and divers took pictures of their license plates for identification, said Cameron County Sheriff Conrado Cantu. The sheriff said as many as 10 vehicles could be in the water.

Rhonda Fife stood near the four-lane bridge yesterday afternoon and said she had not heard from her 18-year-old daughter, Tiffany, since she went to the island with friends late Friday.

"Nobody called, and they always call," Fife said, her voice trembling.

Michael Burke, whose two sons had gone out with Tiffany, anxiously waited with Fife.

"I just want to know where my kids are at. I hope they're all right and just can't call me," Burke said.

Recovery efforts were suspended late yesterday afternoon when the third 80-foot section of the bridge collapsed, said Adrian Rivera, a spokesman for the Department of Public Safety. The search is resuming this morning.

The Coast Guard was notified around 2:30 a.m. that the tug Brown Water V and its four barges, loaded with coiled steel and phosphate, had struck the



RIC VASQUEZ/ASSOCIATED PRESS

A Coast Guard ship helped with the rescue and recovery of drivers near the Queen Isabella Causeway off South Padre Island, Texas. A tug boat and barges smashed the bridge.

2.37-mile-long span, the longest bridge in Texas. None of the cargo spilled.

The crash dropped two adjacent 80-foot segments of the Queen Isabella Causeway into the channel near the center of the span.

The tug operator was questioned and passed a sobriety test, officials said.

Three people died at the scene, and a fourth died at a hospital. One victim was identified as Port Isabel Fire Marshal Robert Harris, said Desi Najera, an emergency management coordinator.

One man was hospitalized in guarded condition, and two of the injured were in good condition.

The state hired two boats to serve as ferries, and was considering bringing a state-owned vehicle ferry from Corpus Christi, Texas, said Randall Dillard of the Texas Department of Transportation.

South Padre Island has 2,000 permanent residents, and island hotels were about 70 percent booked for the weekend.

Most tourists on the island came to celebrate Mexico's Diez y Seis de Septiembre independence day.

In addition, thousands of volunteers had been expected yesterday to help with beach cleanup, part of Adopt-A-Beach day, said local home builder Clayton Brashear.

The island is a spring break mecca, when crowds of up to 200,000 students stay on the island or in nearby cities.

The barges were owned by American Commercial Lines LLC of Jeffersonville, Ind., and were being pushed by a tugboat owned by Brown Water Marine Services Inc. of Rockport, Texas, said American Commercial assistant vice president Jim Adams.

Lexington Herald Leader September 16, 2001

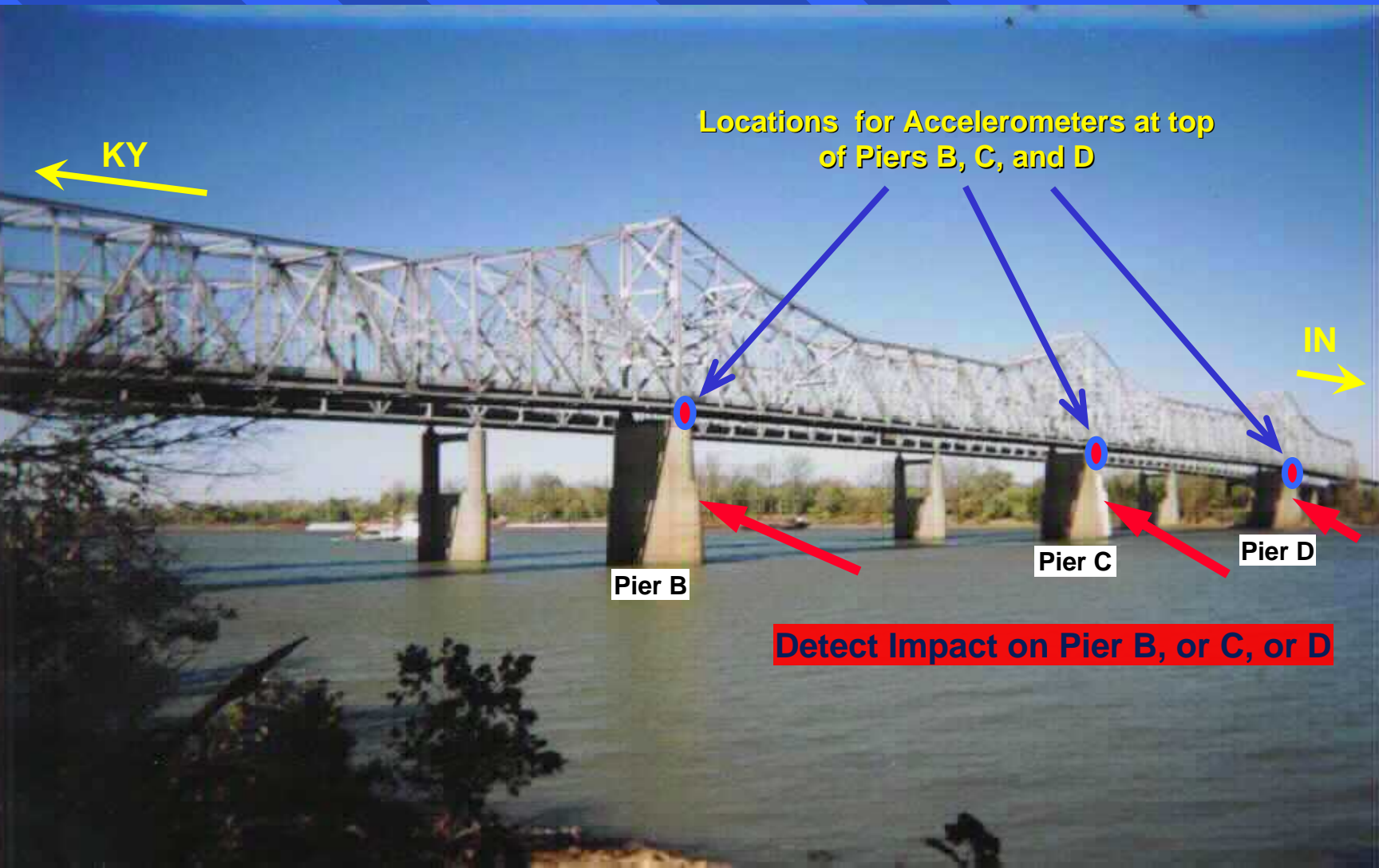


Amtrak Accident Scene, 1993



Activities in Kentucky

Instrumentation Plan - US 41N Bridge



Locations for Accelerometers at top of Piers B, C, and D

KY

IN

Pier B

Pier C

Pier D

Detect Impact on Pier B, or C, or D

Natural Hazard

“A natural hazard is an unexpected or uncontrolled natural event of unusual magnitude that threatens the activities of people or people themselves.”

Source: www.naturalhazards.org

Natural Hazards

```
graph TD; NH[Natural Hazards] --> EQ[Earthquake]; NH --> FG[Fog]; NH --> TN[Tornadoes]; NH --> OT[Other]; EQ --> DR[Drought]; EQ --> TP[Typhoon]; FG --> EN[El Nino]; TN --> HU[Hurricane]; TN --> FL[Flood]; OT --> VC[Volcano]; OT --> TS[Tsunamis];
```

Earthquake

Fog

Tornadoes

Other

El Nino

Hurricane

Volcano

Drought

Typhoon

Flood

Tsunamis



**Bridge Dropped in the Bay in
Biloxi, Mississippi**

Hurricane Katrina, August 2005



Eastern Section of I-10 Causeway

Hurricane Katrina, August 2005



**Highway I-90,
Gulf Coast of
Mississippi**

**Hurricane
Katrina, August
2005**

Highway I-90, Gulf Coast of Mississippi



Hurricane Katrina, August 2005



**US 90 to I-10 Interchange
Over Mobile Bay, Alabama**

Hurricane Katrina, August 2005



Flooded Roadway in New Orleans, Louisiana

**Hurricane
Katrina,
August 2005**

Natural Hazards

```
graph TD; NH[Natural Hazards] --- EQ[Earthquake]; NH --- FOG[Fog]; NH --- TORN[Tornadoes]; NH --- OTHER[Other]; NH --- FLOOD[Flood]; EQ --- DROUGHT[Drought]; EQ --- TYPHOON[Typhoon]; FOG --- ELNINO[El Nino]; TORN --- HURRICANE[Hurricane]; OTHER --- VOLCANO[Volcano]; OTHER --- TSUNAMIS[Tsunamis];
```

Earthquake

Fog

Tornadoes

Other

El Nino

Hurricane

Volcano

Drought

Typhoon

Flood

Tsunamis

Typhoon #18, September 8, 2004



The Ohmori-Ohashi Bridge – Hokkaido, Japan

Construction of Temporary Bridge

(Completed on December 10, 2004)



The Ohmori-Ohashi Bridge – Hokkaido, Japan

Natural Hazards

```
graph TD; NH[Natural Hazards] --> EQ[Earthquake]; NH --> FOG[Fog]; NH --> TORN[Tornadoes]; NH --> OTHER[Other]; EQ --> DROUGHT[Drought]; EQ --> TYPHOON[Typhoon]; FOG --> ELNINO[El Nino]; TORN --> HURRICANE[Hurricane]; OTHER --> VOLCANO[Volcano]; OTHER --> TSUNAMIS[Tsunamis]; FLOOD[Flood];
```

Earthquake

Fog

Tornadoes

Other

El Nino

Hurricane

Volcano

Drought

Typhoon

Flood

Tsunamis

Earthquake Hazard

```
graph TD; A[Earthquake Hazard] --> B[Airports]; A --> C[Roadways]; A --> D[Railways]; A --> E[Navigable Waterways]; A --> F[Bridges]; A --> G[Other];
```

Airports

Roadways

Railways

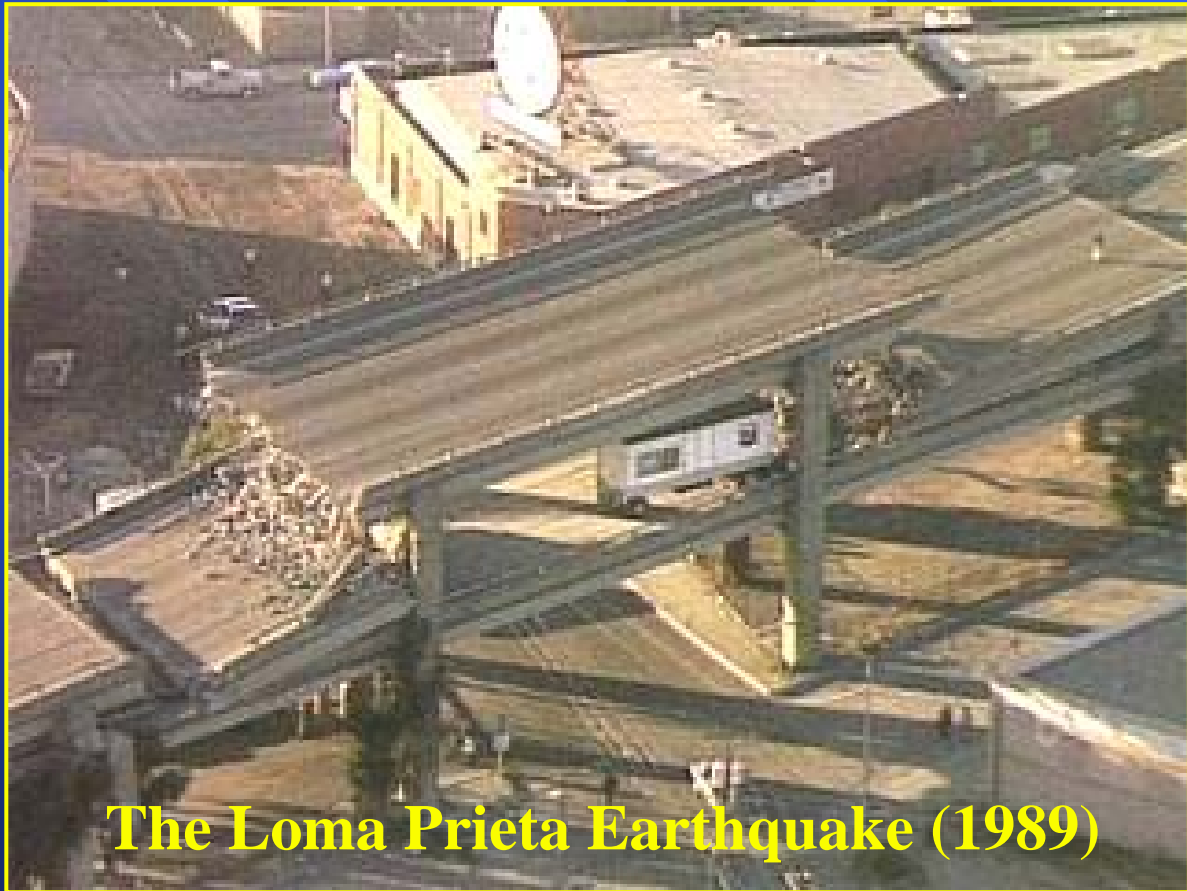
Navigable Waterways

Bridges

Other

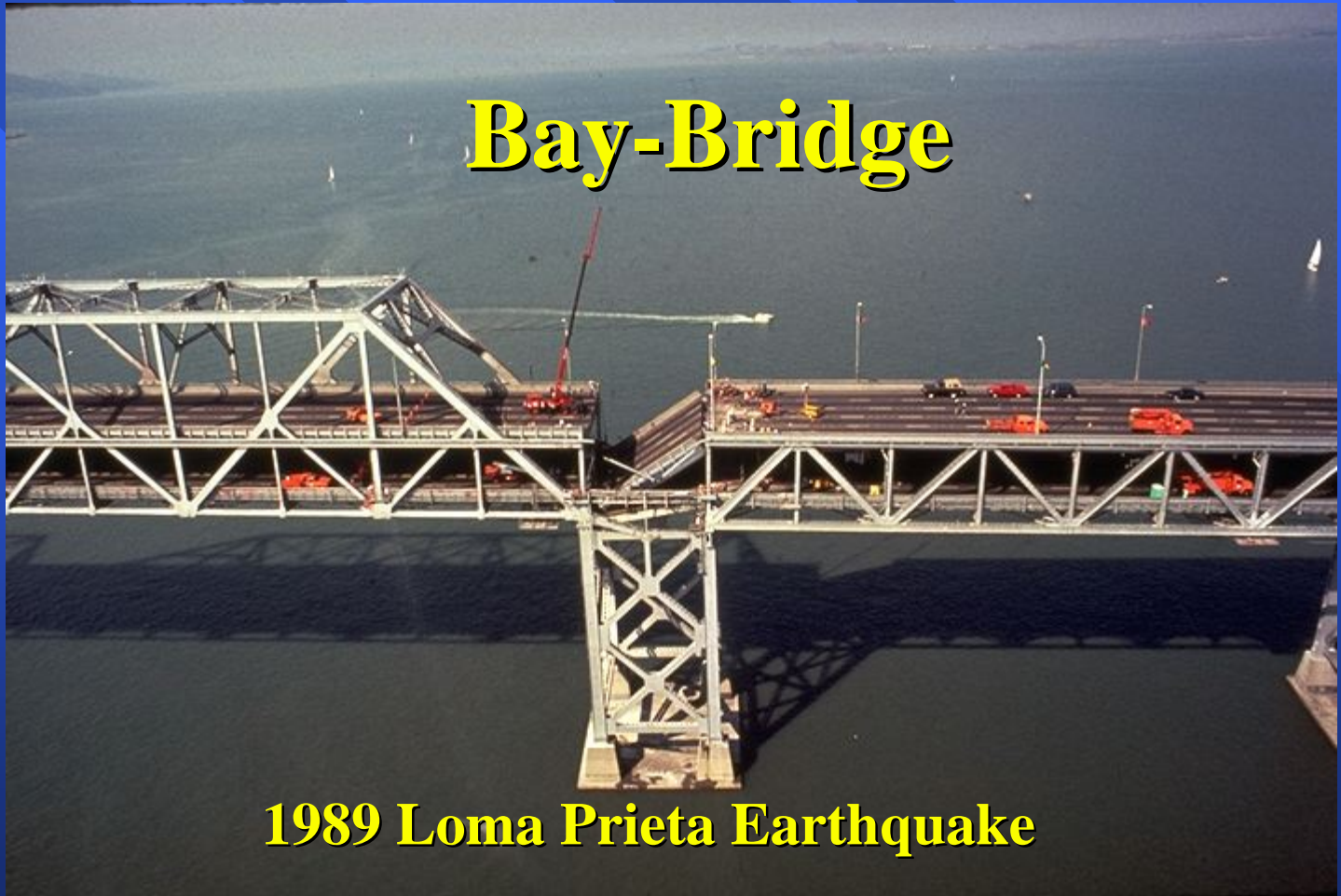
Earthquake Hazard on Bridges

Elevated Portion of I-880



The Loma Prieta Earthquake (1989)

Bay-Bridge



1989 Loma Prieta Earthquake



The Northridge Earthquake (1994)



Chi-Chi Earthquake, Taiwan (1999)

Tangshan Earthquake - China

July 28, 1976 at 03:42 AM



Outline

- Introduction

- **Hazard Mitigation**

- Conclusions

How Do We Cope With Earthquakes?

*Earthquakes are very difficult to predict and are unpreventable. Therefore, **mitigation** of earthquakes requires designing structures (including buildings, roadways, bridges, etc.) that can withstand repeated shaking.*

Source: www.naturalhazards.org

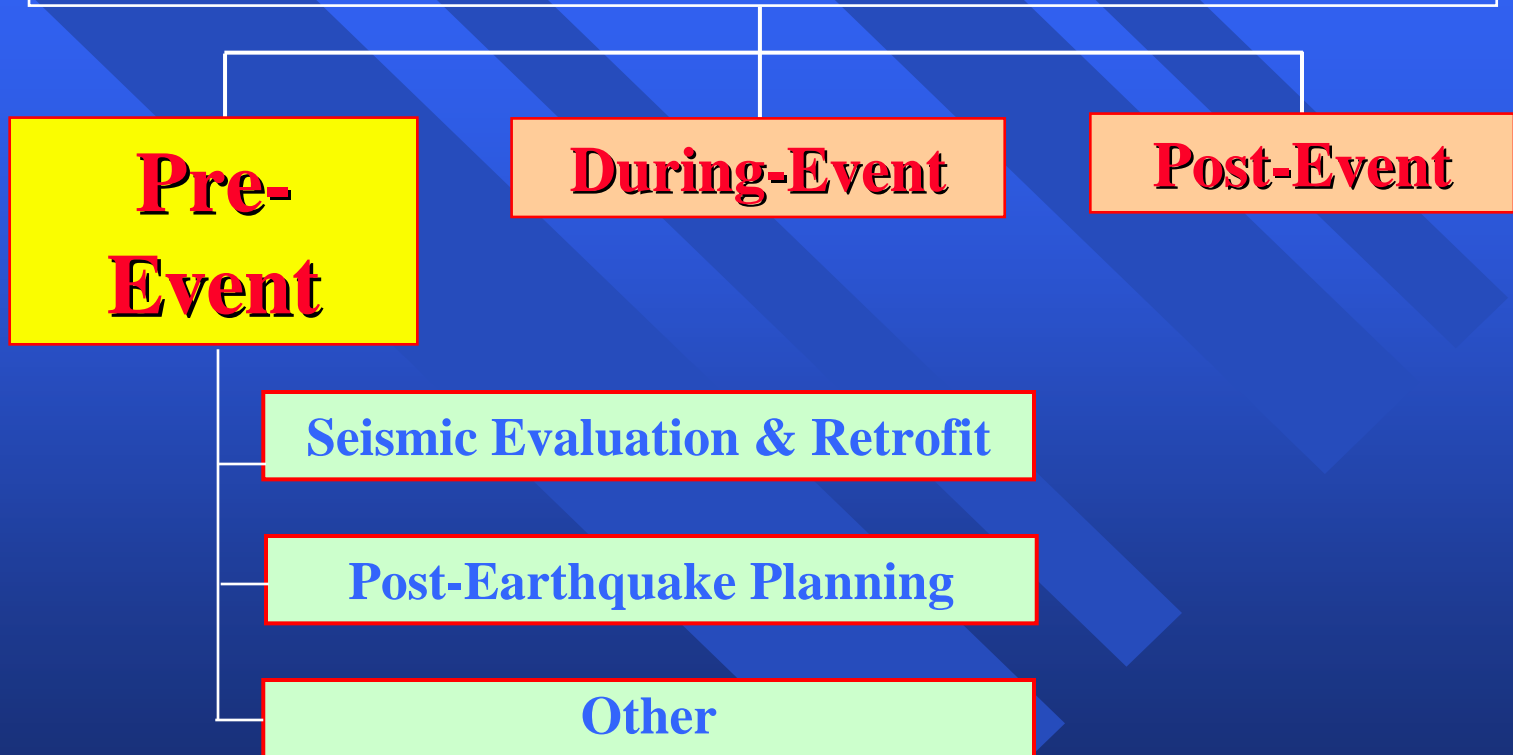
Earthquake Mitigation for Bridges and Highway Structures

Pre-Event

~~**During-Event**~~

Post-Event

Earthquake Mitigation of Bridges and Highway Structures



Earthquake Mitigation of Bridges and Highway Structures:

Pre-Event

During-Event

Post-Event

Seismic Evaluation and Retrofit

Post-Earthquake Planning

Other

- **Seismic Input**
- **Prioritization**
- **Seismic Evaluation**
- **Recommendation**
- **Seismic Retrofit**
- **Other**

Earthquake Mitigation of Bridges and Highway Structures:

Pre-Event

During-Event

Post-Event

Seismic Evaluation and Retrofit

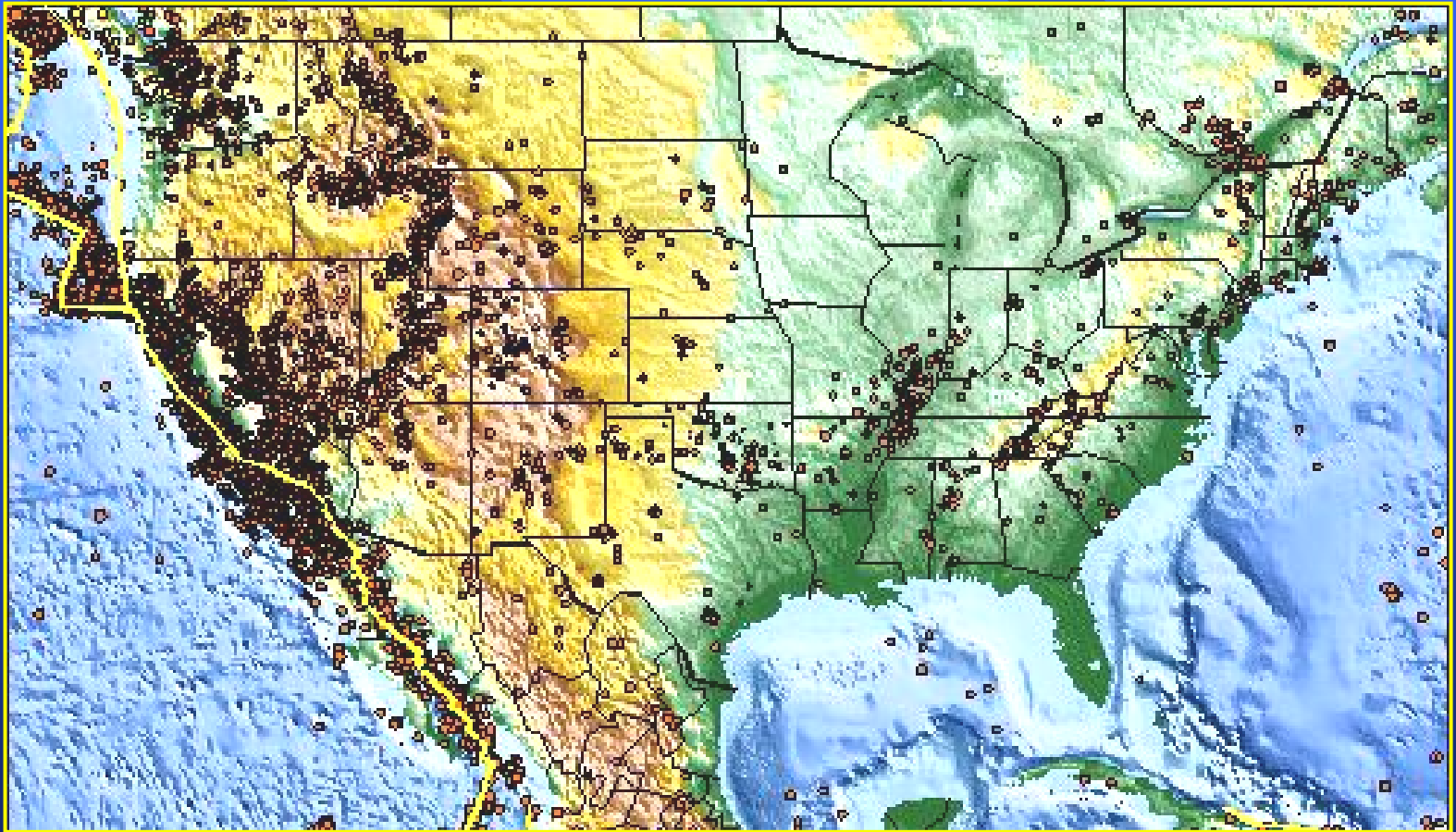
Post-Earthquake Planning

Other

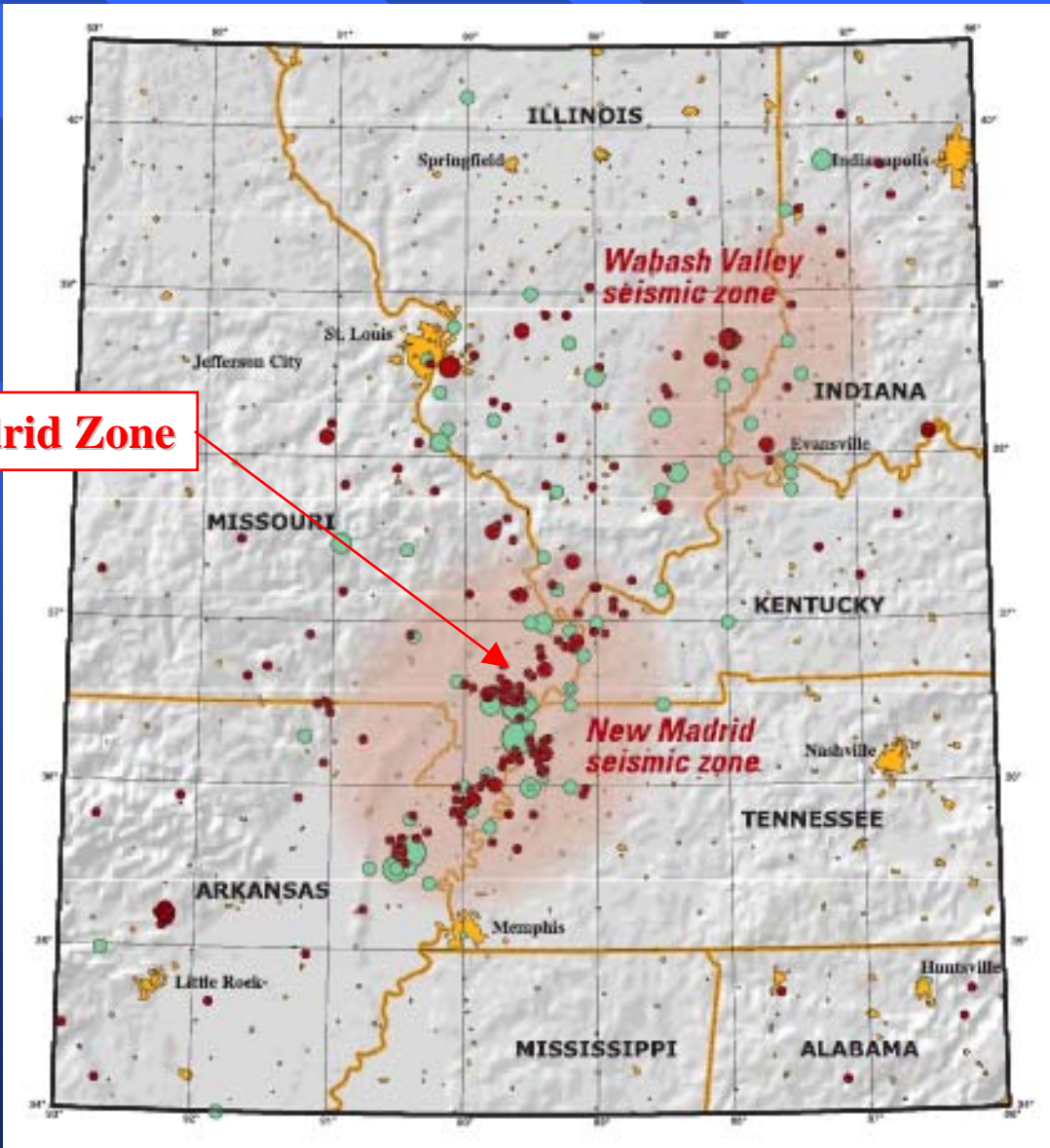
• Seismic Input

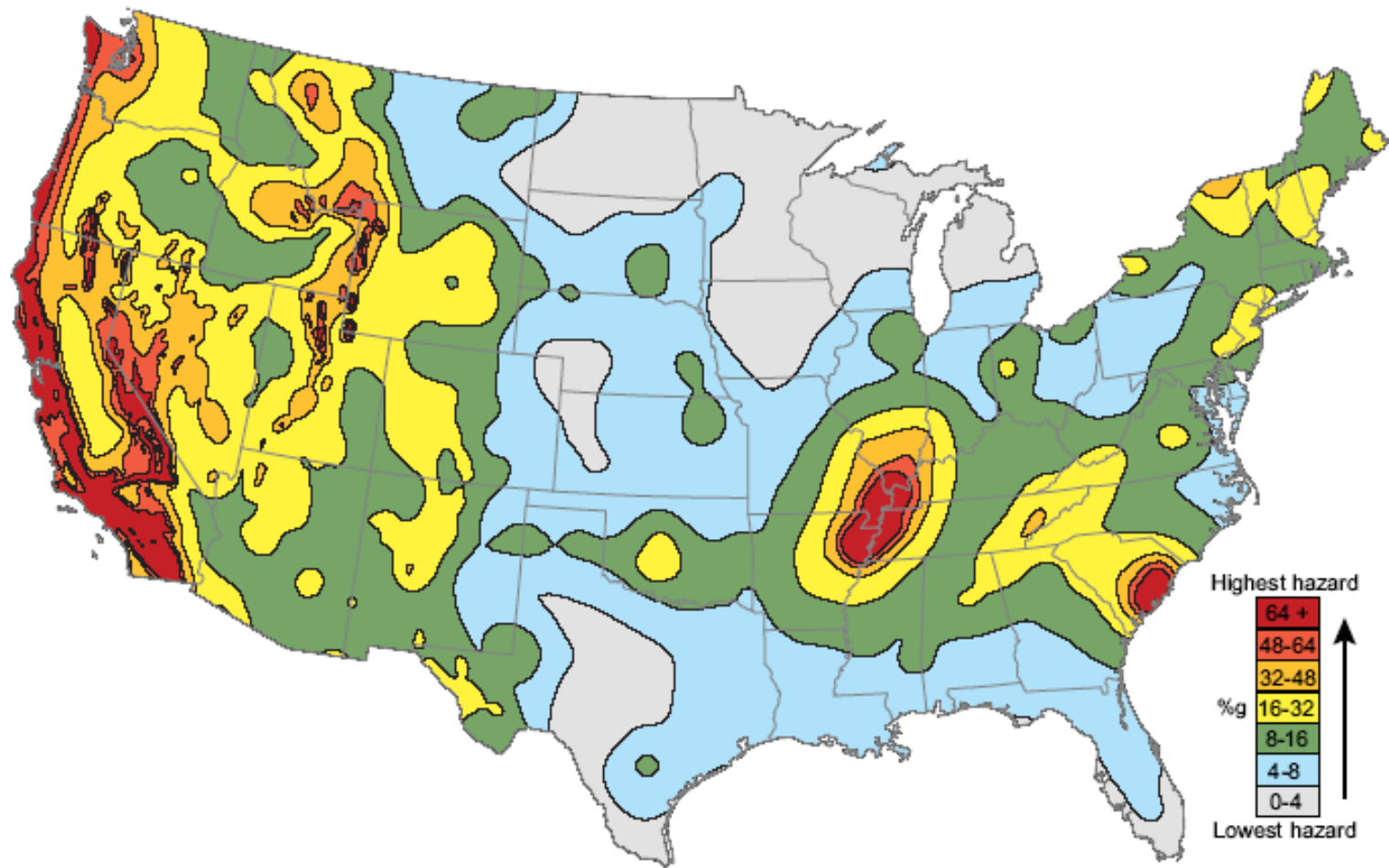
- Prioritization
- Seismic Evaluation
- Recommendation
- Seismic Retrofit
- Other

Seismicity in the United State

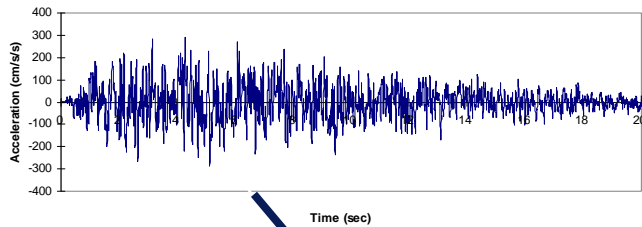


New Madrid Zone

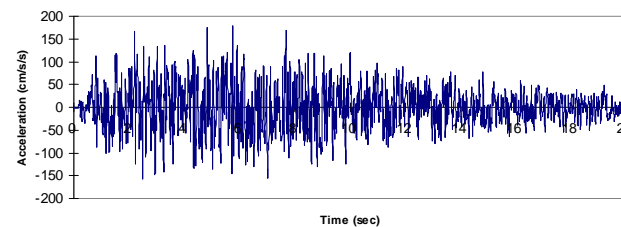




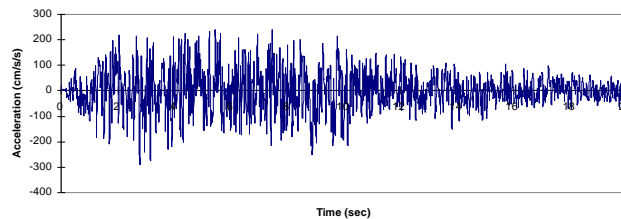
Activities in Kentucky



Acceleration time history for component-1 of the 500-Year event for counties identified by 0.3g-1



Acceleration time history for component-2 of the 500-Year event for counties identified by 0.3g-1



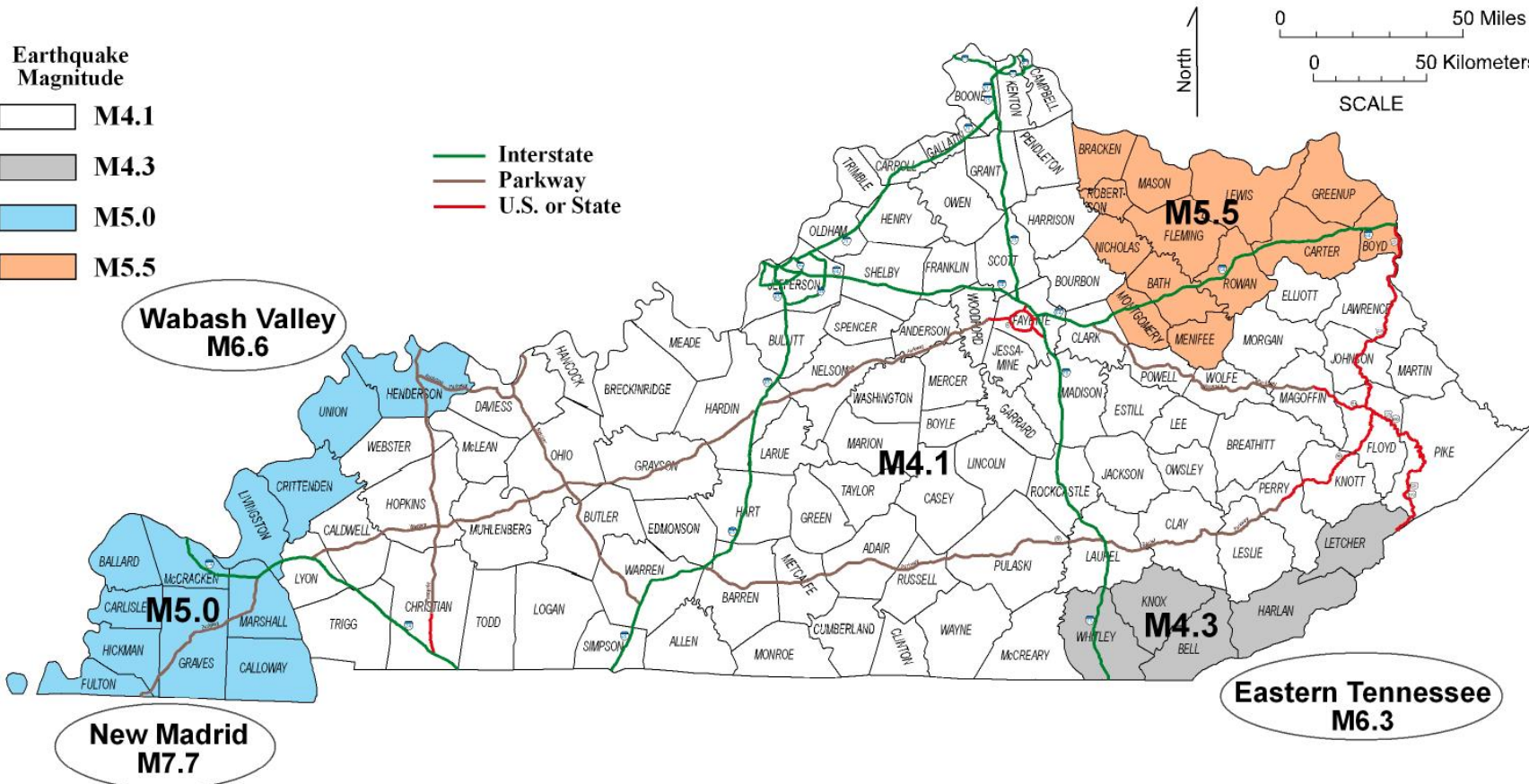
Acceleration time history for component-3 of the 500-Year event for counties identified by 0.3g-1

St. Louis
5.5mb,50
6.3mb,500
New Madrid
6.3mb,50
7.0mb,500

Tennessee
4.7mb,50
6.2mb,500

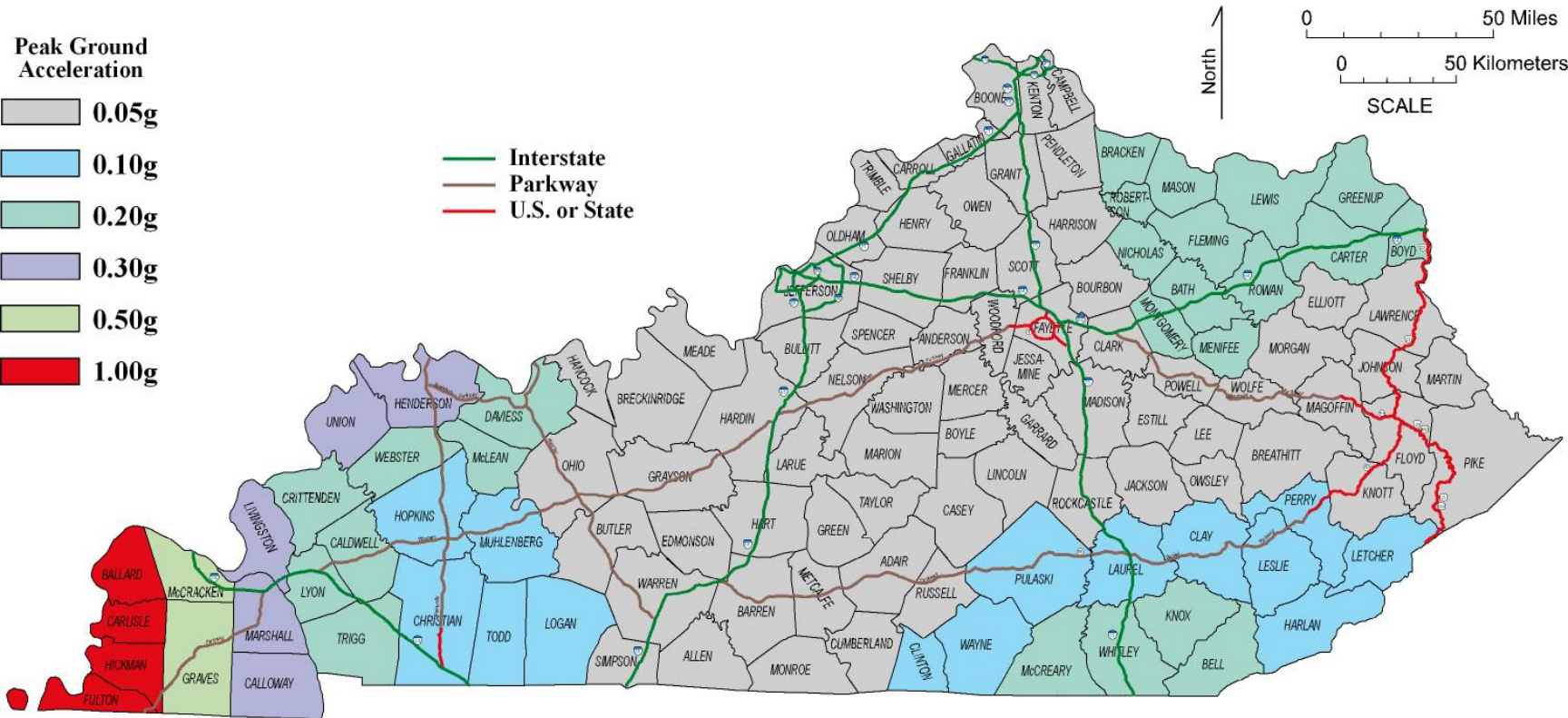
Mississippi
5.5
500

Maximum Credible Earthquake (MCE)



Maximum Credible Earthquake (MCE)

Maximum Credible Earthquake (MCE) Ground Motion: 0.2 Sec Spectral Response Acceleration (5% of Critical Damping), Site Class A (Hard Rock)



Earthquake Mitigation of Bridges and Highway Structures:

Pre-Event

During-Event

Post-Event

Seismic Evaluation and Retrofit

Post-Earthquake Planning

Other

• Seismic Input

• **Prioritization**

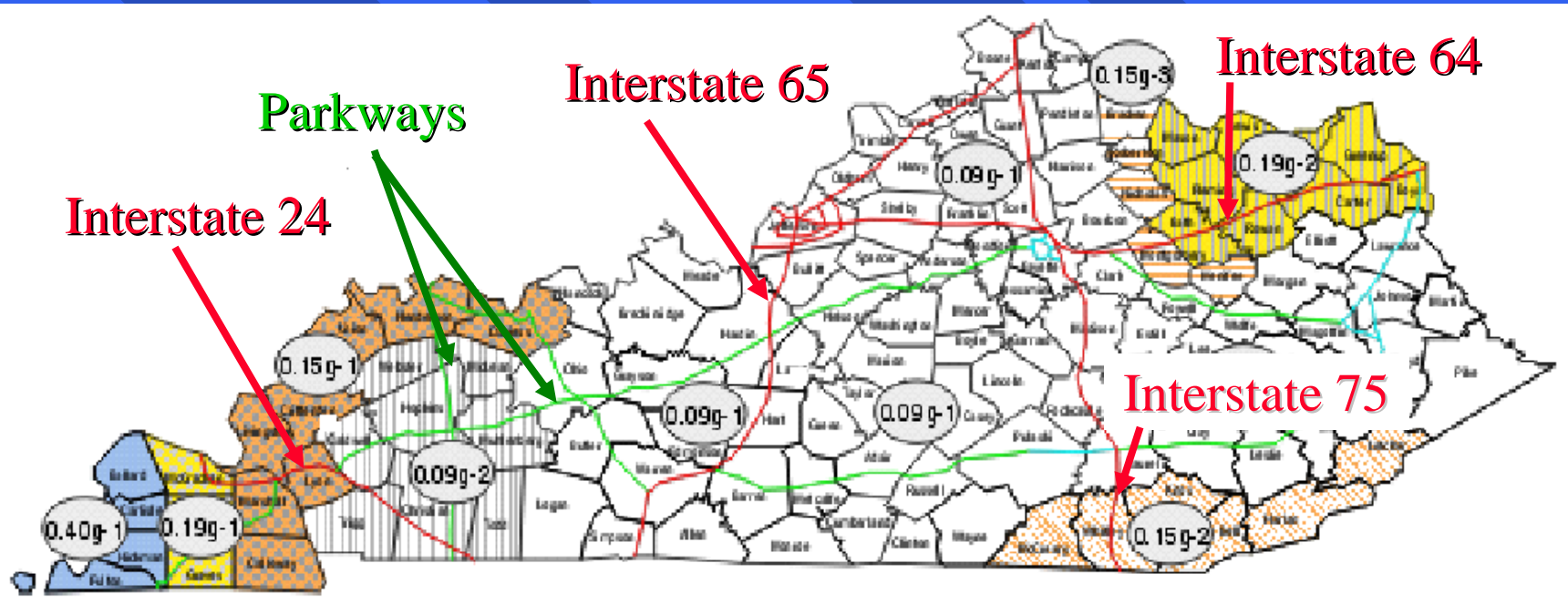
• Seismic Evaluation

• Recommendation

• Seismic Retrofit

• Other

I-24 and Parkways



Interstate 24

Parkways

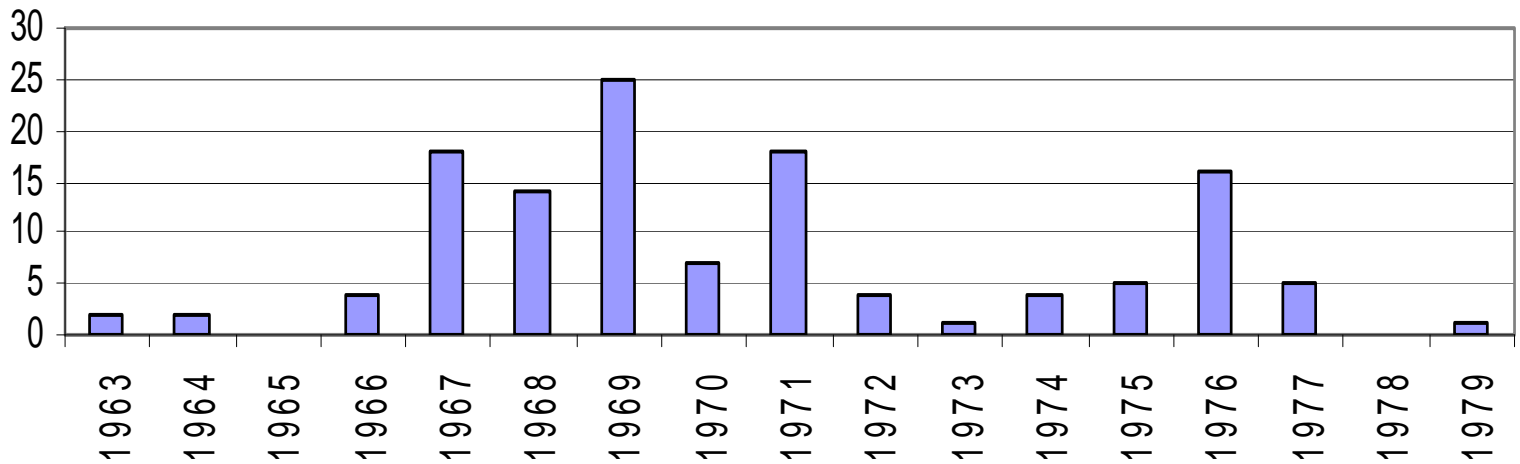
Interstate 65

Interstate 64

Interstate 75

Bridge Timeline

Bridges Built on and over I-24





U.S. Department
of Transportation
Federal Highway
Administration

Publication No. FHWA-RD-94-052
May 1995

Seismic Retrofitting Manual for Highway Bridges

Preliminary Screening

StartUp : Form



Seismic Inventory of Bridges

This program is designed to aid the user in a preliminary seismic inventory of bridges in a particular region. The program will also allow the user to export an Excel spreadsheet or generate a report detailing the information.

Please make your selection below.

Enter or Modify Data

Preview Seismic Report

Export Excel Spreadsheet

Print Seismic Report

Close

Exit

General Information

Bridge Name: Henderson, Audubon Parkway

BIN Number: 51-9005-800074

Location: 1.2 MI SE OF JCT US 41

vehicles

Page Index: 6

Year Designed/built: 1988

Alignment: Skewed Additional C

Skew: 45 degrees

Overall Length: 264.59 ft

Overall Width: 37.5 ft

Detour Length: miles

Roadway carried by bridge: Parkway

Feature crossed by bridge: Roadway

Does the bridge cross a body of water? Has the bridge been seismically retrofitted?

Description/Date of Retrofit:

Geometry: Regular Remarks:

Columns and Piers**Bearings****General info****Note:**

Feature crossed by bridge is the roadway, river, valley, or other landform that the bridge is used to cross.

PRIORITIZATION (Preliminary Screening):

DataEntry : Form

General Information | Site and Superstructure | Columns and Piers | Abutments and Bearings | Bearings Continued | **Seismic Rank**

Seismic Rank

Vulnerability Ratings

Connections, Bearings, and Seatwidths..... V1:

CVR:

Other Components AVR: V2:

LVR:

Overall Rating..... V:

Seismic Hazard Rating: E:

Seismic Rank: R:

IMPORTANT NOTE:
This seismic ranking is based solely upon the physical features of the bridge. The ranking may need to be adjusted according to location of nearest detour route or other social factors. For example, a critical river crossing may need a higher ranking than an overpass that can be bypassed easily by on/offramps. It may be necessary to create a second ranking system, using this ranking as a factor in the ultimate determination of the rankings for the bridges in question.

Seismic Rank

R ranges between 0 (Not Critical) to 100 (Highly Critical).

Calculate Save Export Excel Spreadsheet

Record: 6 of 90

Earthquake Mitigation of Bridges and Highway Structures:

Pre-Event

During-Event

Post-Event

Seismic Evaluation and Retrofit

Post-Earthquake Planning

Other

- Seismic Input
- Prioritization

• **Seismic Evaluation**

- Recommendation
- Seismic Retrofit
- Other



Steel Beam with RC Slab



Steel Beam with RC Slab



**Pre-stressed Concrete I-Girder
with RC Slab**



**Pre-stressed Concrete I-Girder
with RC Slab**

Single Span Bridges



Two-span Bridges



Multi-span Bridges



Evaluation Process For Critical Bridges

- **Field Testing**
- **FE Model Calibration**
- **Seismic Evaluation**



Roebling Bridge over Ohio River



The Maysville Bridge



The Maysville Bridge







System File Edit Window Help Lamp

Microphone Input

0.000	Show
0.000	Show
0.000	Show
0.000	Show
0.000	Show
0.000	Show

Load File
[65_26907810]

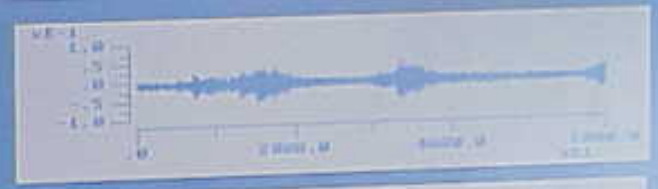
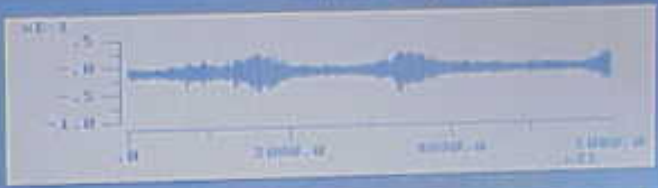
Reset
View Data



Microphone Input

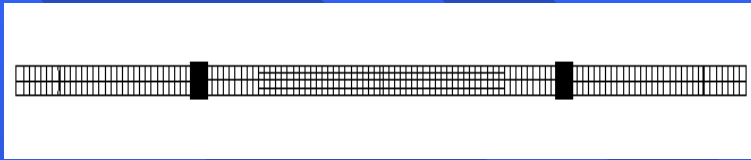
Reset Button
Trigger LED
Initiation Trigger Threshold
MIDI

PAUSE STOP

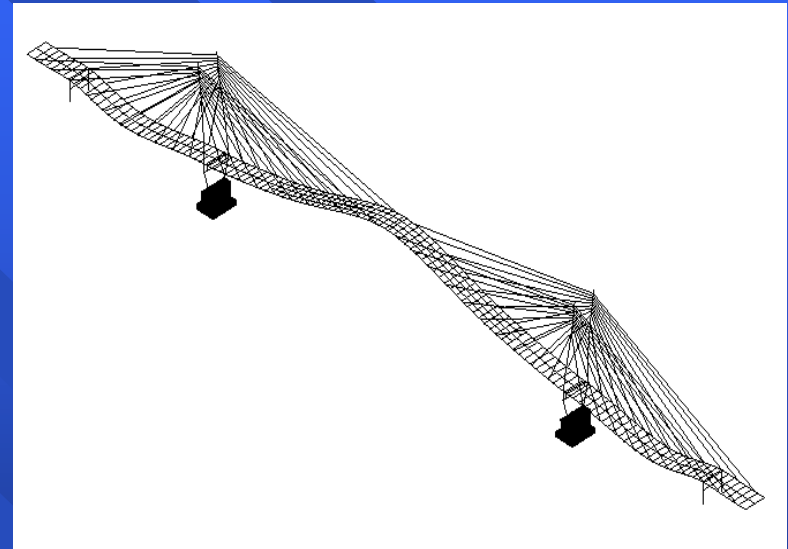


700

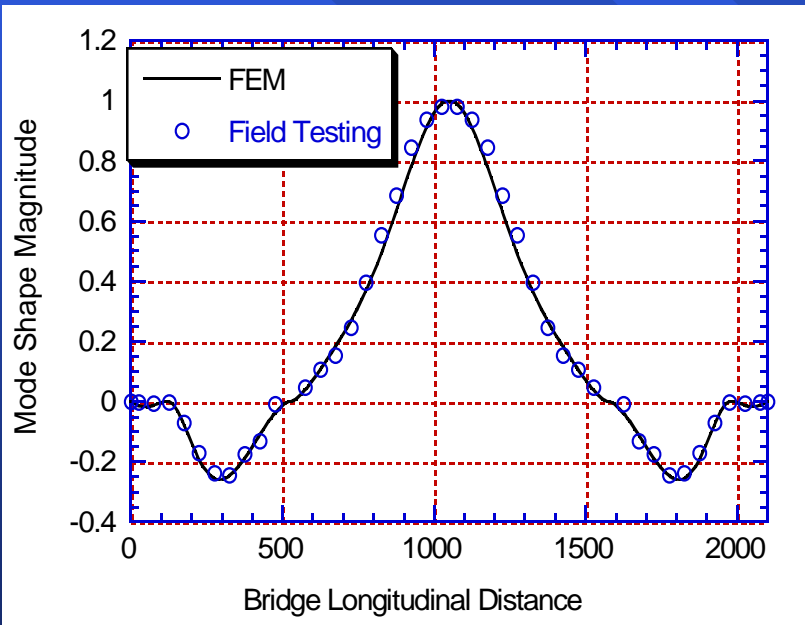
Task 3: FE Modeling Maysville Bridge



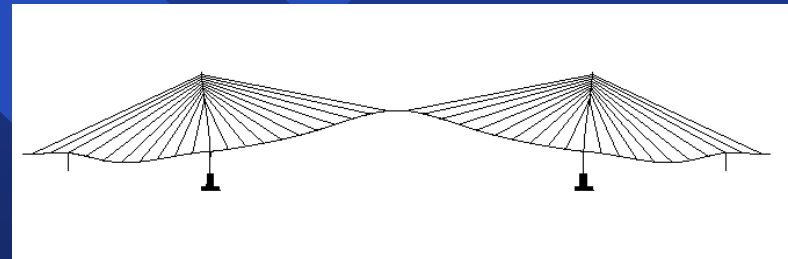
Plan



3-D View

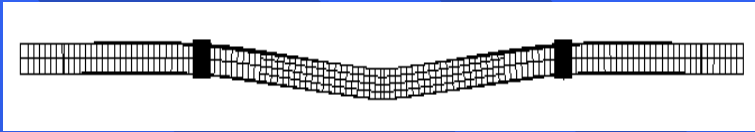


1st Vertical Mode

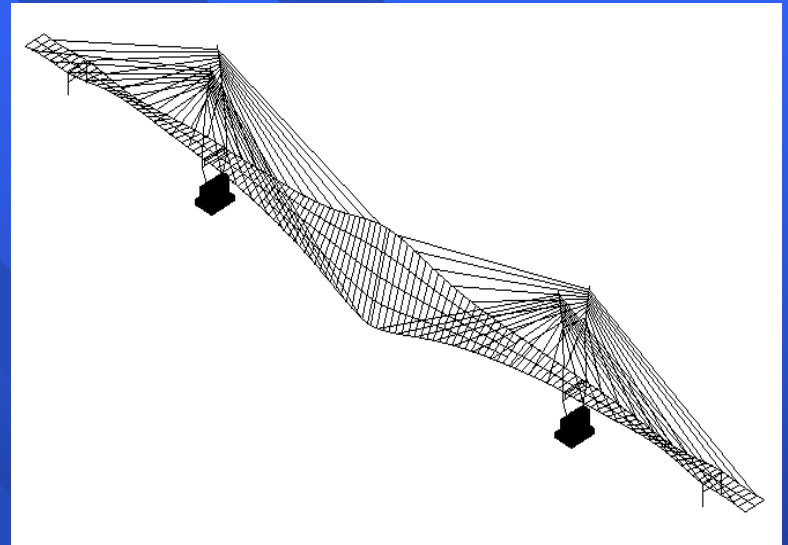


Elevation

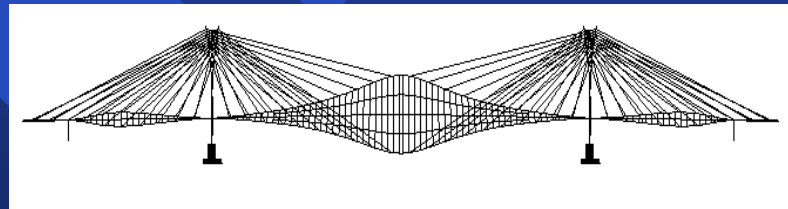
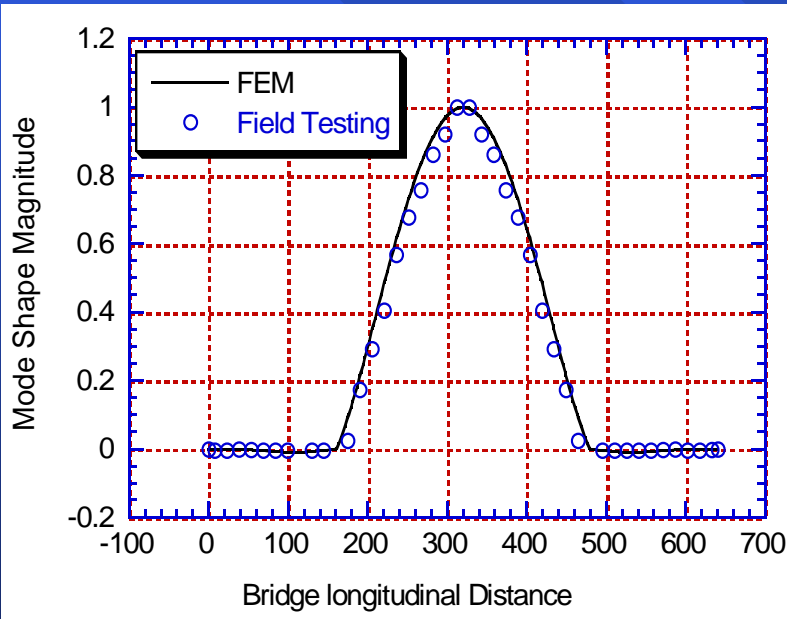
Task 3: FE Modeling Maysville Bridge



Plan



3-D View



Elevation

1st Transverse Mode (+Torsion)

The Owensboro Bridge



Owensboro Bridge



THE BRENT-SPENCE BRIDGE



**I 64 over the Ohio River
(Sherman-Minton Bridge)
Between Louisville, KY and New Albany, IN**



US 51 Bridge Over the Ohio River



Wickliffe, KY to Cairo, IL

10 23 '96



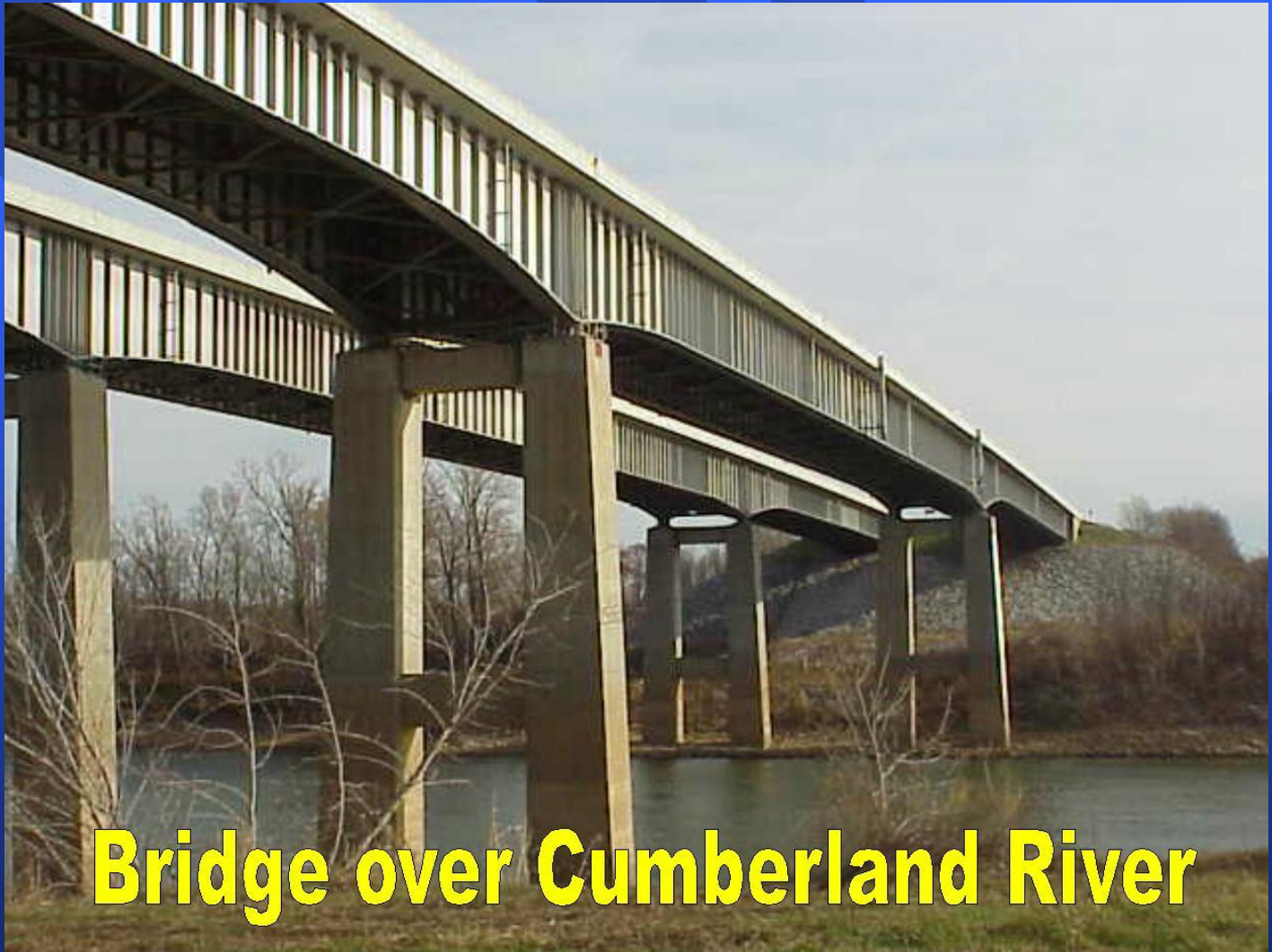
Henderson, KY to Evansville, IN

Bridge on US-41

10 23 '96



Bridge over Tennessee River



Bridge over Cumberland River

Earthquake Mitigation of Bridges and Highway Structures:

Pre-Event

During-Event

Post-Event

Seismic Evaluation and Retrofit

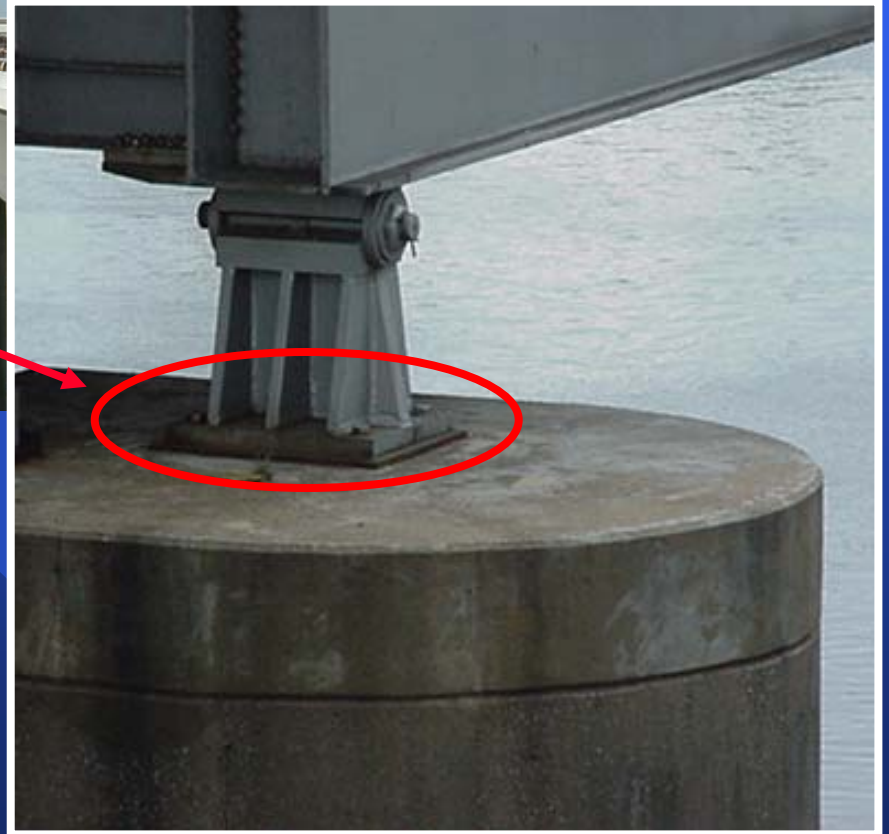
Post-Earthquake Planning

Other

- Seismic Input
- Prioritization
- Seismic Evaluation

• Recommendation

- Seismic Retrofit
- Other



**Provide additional
shear bolts or
replace bearing**

Earthquake Mitigation of Bridges and Highway Structures:

Pre-Event

During-Event

Post-Event

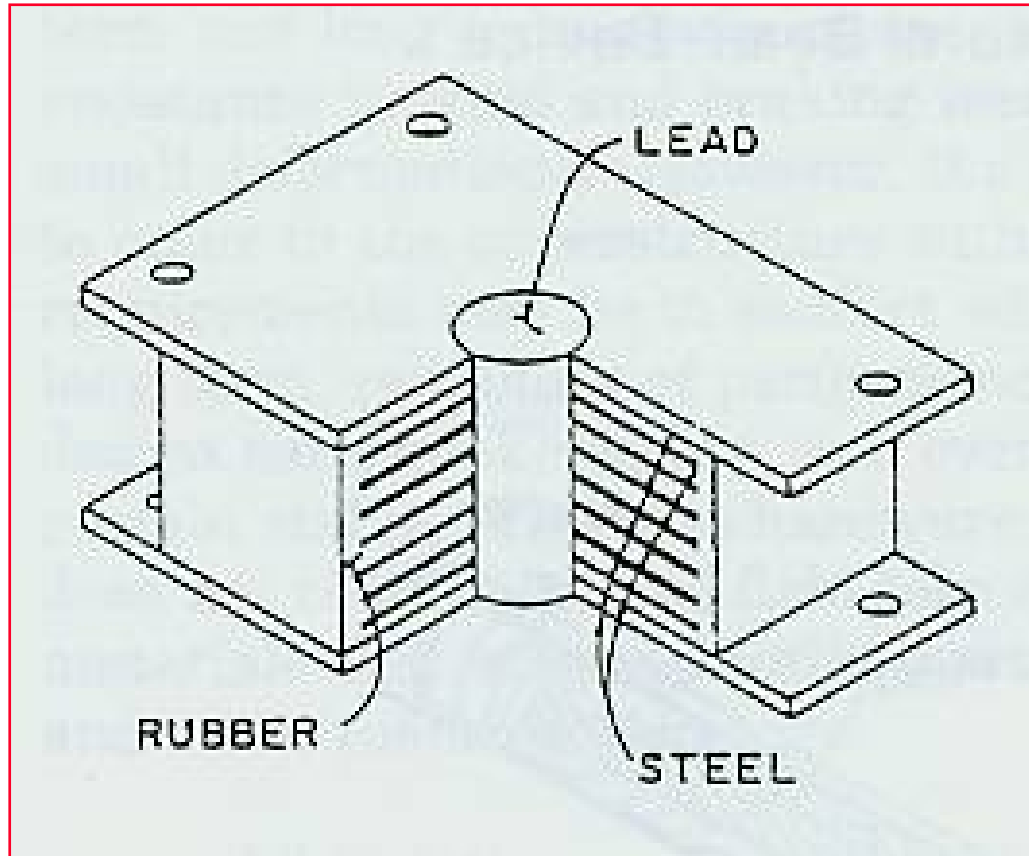
Seismic Evaluation and Retrofit

Post-Earthquake Planning

Other

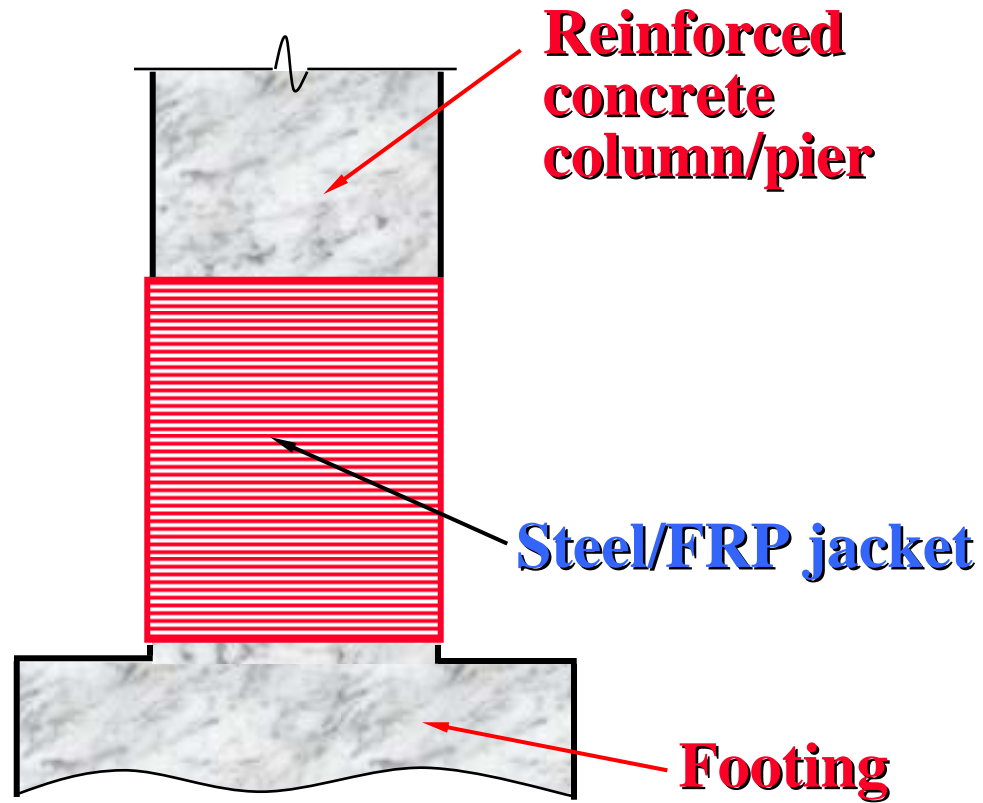
- Seismic Input
- Prioritization
- Seismic Evaluation
- Recommendation

- **Seismic Retrofit**
- Other



**Lead-filled Elastomeric
Isolation Bearing**

Retrofit measure: Example



Earthquake Mitigation of Bridges and Highway Structures:

Pre-Event

During-Event

Post-Event

Seismic Evaluation & Retrofit

Post-Earthquake Planning

Other

- **Develop Contingency Plan**
- **Provide Training**
- **Instrumentation & Monitoring**
- **Other**

Earthquake Mitigation of Bridges and Highway Structures:

Pre-Event

During-Event

Post-Event

Seismic Evaluation & Retrofit

Post-Earthquake Planning

Other

- Develop Contingency Plan
- Provide Training

- **Instrumentation & Monitoring**
- Other

Activities in Kentucky



Bridge over Tennessee River



Henderson, KY to Evansville, IN

Bridge on US-41

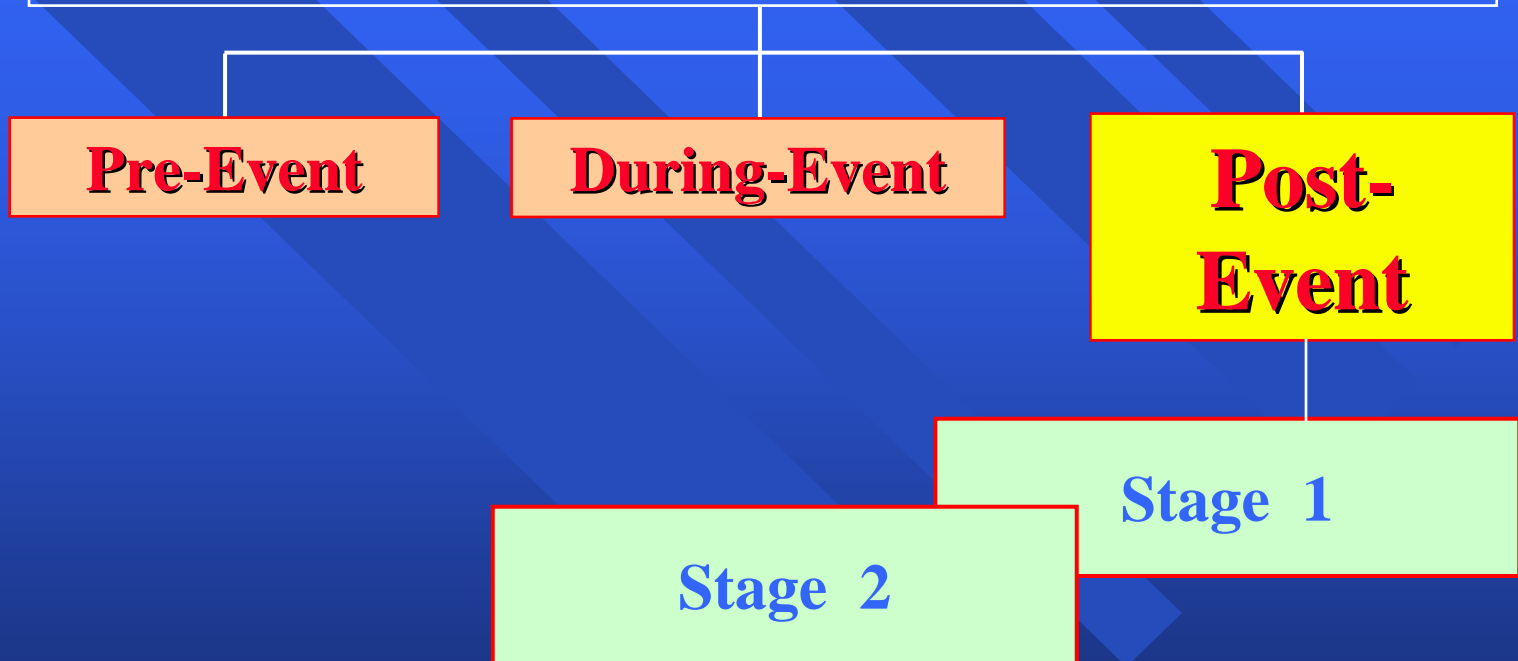
10 23 '96

Earthquake Mitigation of Bridges and Highway Structures



- An earthquake lasts for few seconds.
- Action during the event is not possible.

Earthquake Mitigation of Bridges and Highway Structures



Earthquake Mitigation of Bridges and Highway Structures:

Pre-Event

During-Event

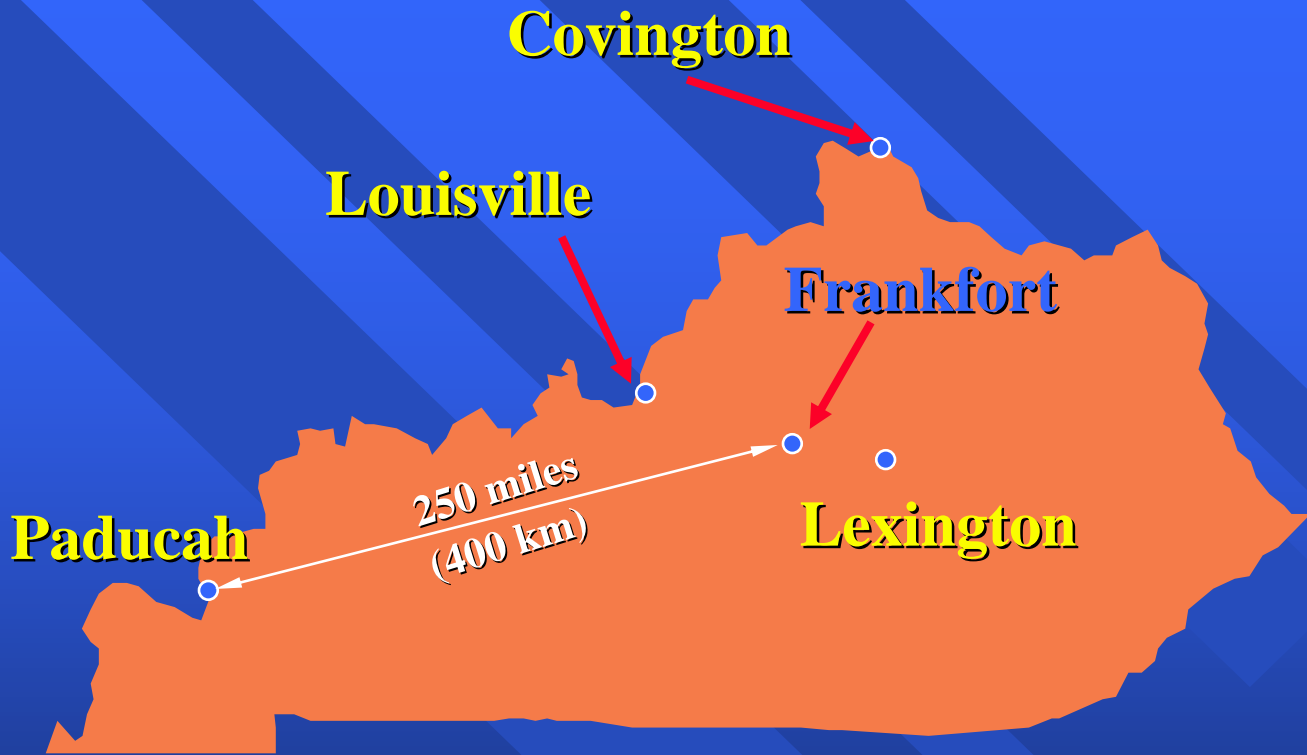
Post-Event

Stage 1

Stage 2

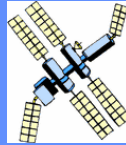
- **Preliminary Assessment**
- **Prioritization**
- **Recommendation**
- **Immediate Action**
- **Other**

Activities in Kentucky



- Response Team ≥ 2 hours
 - Driving ≥ 4 hours
 - Delays = ?? hours
 - Other = ?? hours
- } At Least 6 hours

- Expert Support System (ESS)
- Global Positioning System (GPS)
- Geographical Information system (GIS)



Stage 1



*Local Inspectors
in Western Kentucky*



- Live Pictures
- Electronic Data
- Report

Stage 2



Stationary Team in Frankfort



Mobile Team en Route

Objective of Stage 1

Triage

*In Cooperation with the
Kentucky National Guard*



Kentucky Post-Earthquake Investigation Software (KyPEIS)

Post Earthquake Investigation

Start Location

Inspect or View

Inspect View

For Inspect option, input following information.

Inspector

First Name Middle Name Last Name

Issam E Harrik

Affiliation

University of Kentucky

GPS Settings

Port COM2 Start

1 / 2

Inspector: ISSAM E HARRIK

Select Inspect or View

Enter Name and Affiliation

Press start if connected to GPS receiver and require data

Next to continue

GPS receiver detection message

Check here to use GPS data to select bridge

Post Earthquake Investigation

Start **Location**

GPS Status **GPS Receiver Detected**

Location

DDMM.MMMM

Lat. 3650.0140

Long. 8739.8780

Choose a Bridge below

BRIDGE SEARCH

new bridge

Information

ID

County

Route

MilePoint

Choose a Inspector below

Inspector:

Post Earthquake Investigation

Start | Location **Embankment** Concrete Spa | [< >]

Approach Slab Damage

None Minor Moderate Severe

Settlement

None Minor Moderate Severe

Side Movement

None Minor Moderate Severe

0 1 1 50

Inspector: ISSAM E HARRIK

Enter damage level

Next to continue

Post Earthquake Investigation

Start Location Embankmen **Concrete Span**

Flexural Crack

None Minor Moderate Severe

Shear Crack

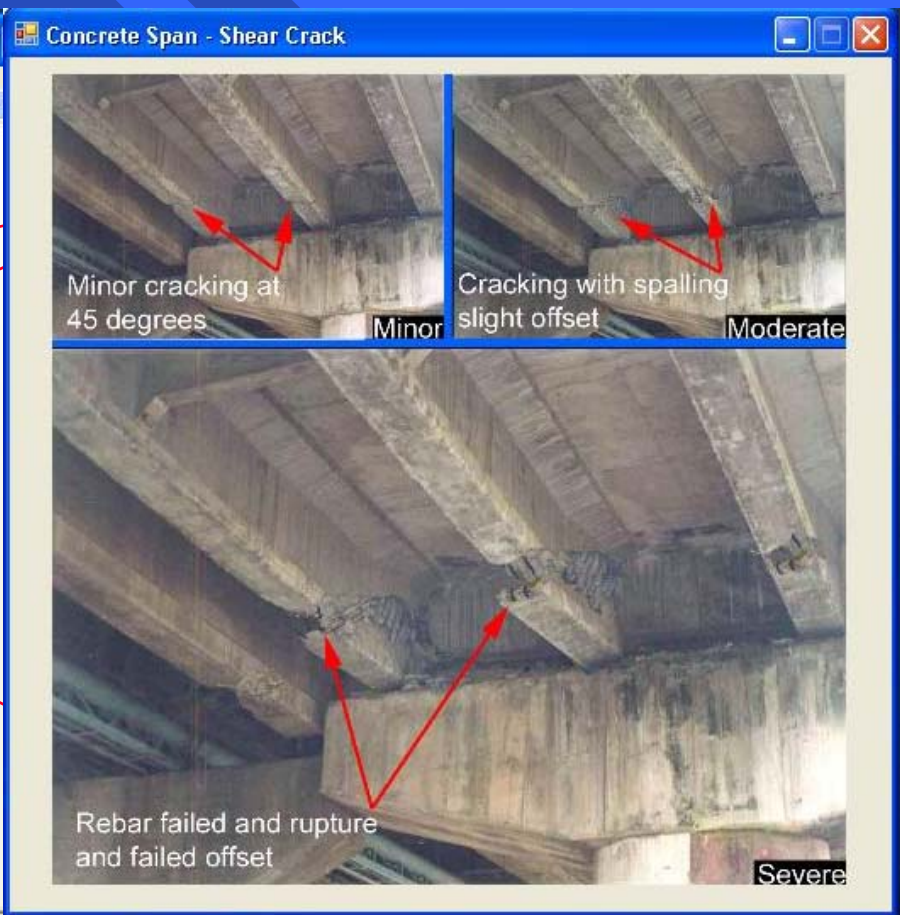
None Minor Moderate Severe

Spalling at Bearing

None Minor Moderate Severe

Inspector: ISSAM E HARRIK

4 / 10



Next to continue

Backwall Movement

? None Minor Moderate Severe

Wingwall Movement

? None Minor Moderate Severe

Flexure/Shear Cracking

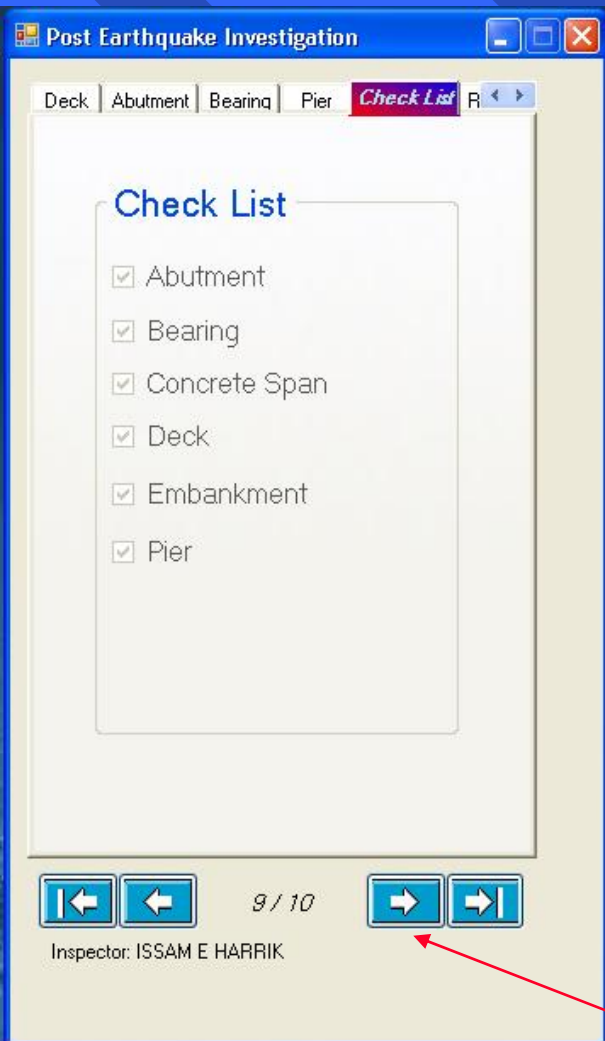
? None Minor Moderate Severe

Foundation Movement

? None Minor Moderate Severe



Next to continue



Next to continue

Post Earthquake Investigation

Abutment Bearing Pier Check List **Result**

Damage Level

Low Guarded Elevated High Severe

0 <50 <1000 <15000 >15000

Posting

Bridge Closed. Emergency Vehicles Only at Reduced Speeds.

Recommendation

Significant risk of vehicle accident occurrence resulting from bridge damage. Bridge must be closed to non-essential emergency vehicles. Emergency vehicles must proceed at reduced speeds.

Note

Print...

Inspector: ISSAM E HARRIK

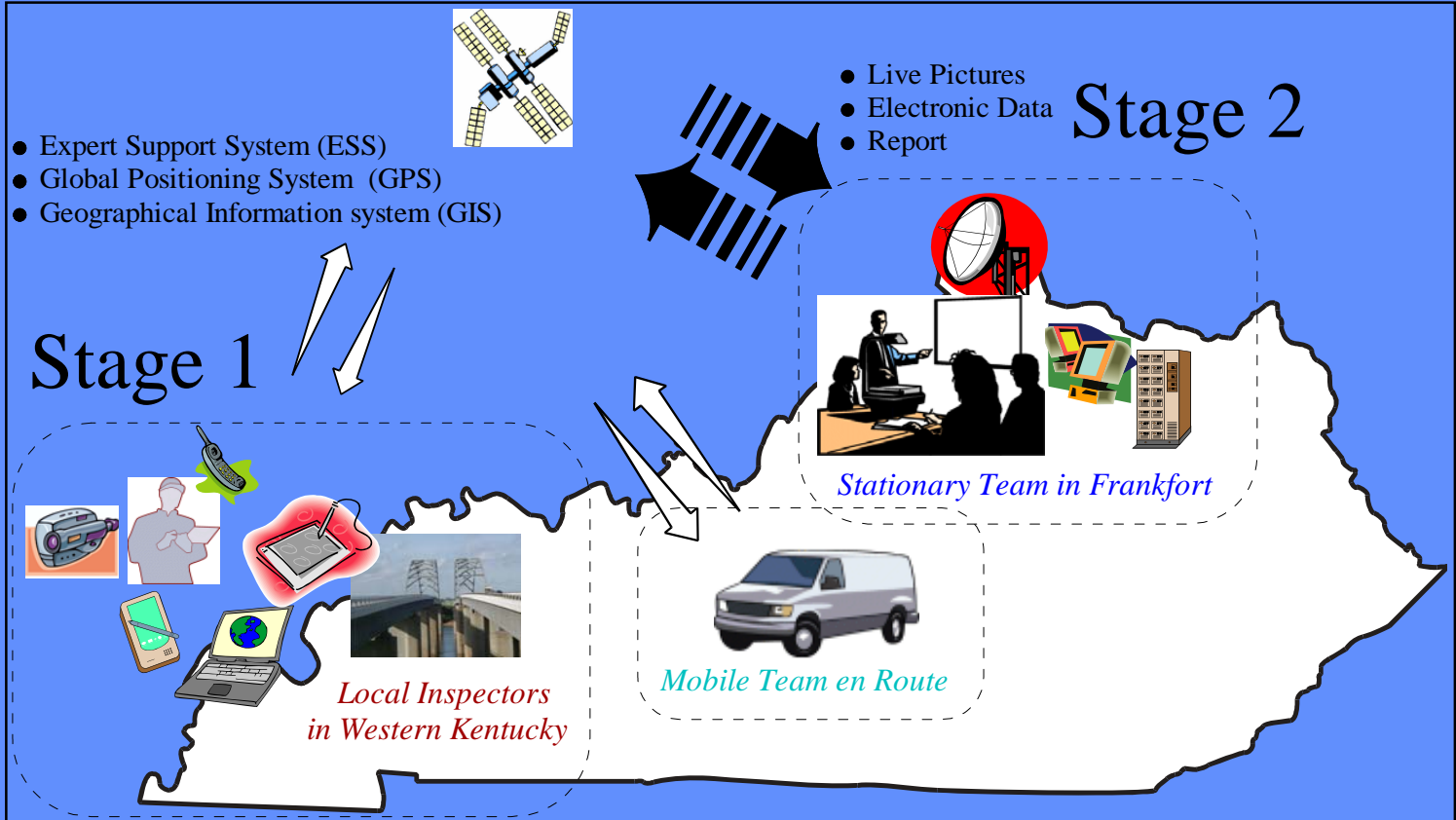
Exit

Enter notes

Printout of entered data

Enter another bridge

Teams in Stage 2



Outline

- Introduction
- Hazard Mitigation

■ Conclusions

Conclusions

- **We Can no Longer Accept the High Cost of Life or Ensuing Economic Losses When Natural or Man-Made Disasters Strike**

Conclusions

- We Can no Longer Accept the High Cost of Life or Ensuing Economic Losses When Natural or Man-Made Disasters Strike
- We Cannot **“Prevent”** nor **“Predict”** | Disasters

Conclusions

- We Can no Longer Accept the High Cost of Life or Ensuing Economic Losses When Natural or Man-Made Disasters Strike
- We Cannot Be “**Prevent**” nor “**Predict**” Disasters
- We Now Have the Means to Better “**Prepare**” for Disasters

Conclusions

- We Can no Longer Accept the High Cost of Life or Ensuing Economic Losses When Natural or Man-Made Disasters Strike
- We Cannot Be “**Prevent**” nor “**Predict**” Disasters
- We Now Have the Means to Better “**Prepare**” for Disasters
- We Now Have the Means to “**Respond**” Immediately Following a Disaster

Conclusions

- We Can no Longer Accept the High Cost of Life or Ensuing Economic Losses When Natural or Man-Made Disasters Strike
- We Cannot Be “**Prevent**” nor “**Predict**” Disasters
- We Now Have the Means to Better “**Prepare**” for Disasters
- We Now Have the Means to “**Respond**” Immediately Following a Disaster
- We Now Have the Means to Quickly and Effectively “**Restore**” Defective Structures Following a Disaster

Questions?

**Thank You
and
Have a Nice Day**