Earthquake Priority Routes for McLean County, Kentucky

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EARTHQUAKE PRIORITY ROUTES FOR MCLEAN COUNTY, KENTUCKY

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in cooperation with
Transportation Cabinet
Commonwealth of Kentucky

and

Federal Highway Administration
U. S. Department of Transportation

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July 1988
INTRODUCTION

In 1811-1812, three of the most severe earthquakes in American history shook the country. The location of these quakes was not on the infamous San Andreas fault nor anywhere along the well-known fault laden Pacific coast but was near a small town on the Mississippi River where the state of Kentucky and Missouri share a border. It is this river town, New Madrid, Missouri, that is the namesake of a region now regarded by seismologists and disaster response planners as the most hazardous earthquake zone east of the Rocky Mountains -- the New Madrid seismic zone.

In addition to previous occurrences of these great earthquakes, there are several other well documented factors demonstrating the susceptibility of this region to the recurrence of major quakes. Through a decade of extensive research, an ancient crustal rift has been found to underlie the relatively shallow sediments comprising the region's surface. This type of geologic structure, in general, is prone to seismic activity. The New Madrid rift, in particular, has been identified as being of sufficient size to generate major quakes. Further evidence of the area's seismicity is the record of over 2,000 earthquakes detected in the zone since 1974. Though most have been of a magnitude below the threshold of human perception, their existence clearly indicates the high level of seismic activity occurring in the zone even today.

Seismologists have calculated the probabilities of recurrence of sizeable quakes in the New Madrid rift zone. The probability of a 6.3 quake (Richter scale) within 50 years is from 86 to 97 percent. The probability (1) of that same quake occurring within the next 15 years is from 40 to 63 percent. The probability of a 7.6 quake occurring within 50 years is from 19 to 29 percent. The probabilities for this size
quake occurring within 15 years drop quickly to a range of 5.4 to 8.7 percent.

These observations -- prior great earthquakes, an identified geologic structure, and continuing activity -- have created an awareness of the high hazard potential of the New Madrid zone. The very real threat of another significant earthquake coupled with the existence of a number of large population centers and vital facilities in or near the zone have made the formulation of a comprehensive policy for dealing with the effects of an earthquake of utmost importance. A number of steps have already been taken in response to this need.

In 1981, the Federal Emergency Management Agency (FEMA) initiated the Central United States Earthquake Preparedness Project (CUSEPP) to help state governments increase their capability to respond to damaging earthquakes, to promote mitigation activities, and to encourage cooperation between states in the area of emergency planning.

In 1982, the Governor's Task Force on Earthquake Hazards and Safety was created to evaluate Kentucky's earthquake risk and to make recommendations for responding to those risks. This task force recommended increased public awareness and education programs, improved emergency response planning and training, improved building codes and seismic restraint designs, evaluation of other mitigation measures, and participation in national and regional earthquake forums and funding programs.

In 1983, seven states surrounding the New Madrid rift zone joined to form the Central United States Earthquake Consortium (CUSEC), resulting in increased public awareness and closer cooperation among participating states.

In 1984, Governor Collins created the Governor's Earthquake Hazards and Safety Technical Advisory Panel (GEHSTAP) to analyze scientific and
engineering data regarding seismic risks in Kentucky and to make specific recommendations on mitigation, public awareness, response planning, and policy development for public health and safety.

The state's dependence on transportation systems for interstate and intrastate activities and the possible adverse effects a major quake could have on these systems led to the formation of the Earth Stability and Transportation Subcommittee (ESTS) of GEHSTAP. ESTS has made a number of recommendations concerning formulation and implementation of a seismic mitigation policy -- among them the creation of an interagency task force of affected agencies to implement a proposed action plan. The ESTS action plan is synopsized as follows:

1) Establish high priority routes that are vital to the movement of goods and services with special consideration being given to those transportation facilities located in areas of high earthquake probability.

2) Compile seismic risk maps of all natural and man-made features susceptible to earthquake damage that could jeopardize those priority transportation routes.

3) Educate and train key personnel in the Transportation Cabinet in seismic safety; this includes but is not limited to bridge inspectors, district engineers, construction inspectors, designers, and maintenance personnel.

4) Review mitigation planning and establish a program for implementation.

5) Use relevant seismic code provisions for all new construction, repair, and maintenance.

This report documents the priority routes that have been established for McLean County, KY. In Appendix A is a detailed list of seismically significant features that have been logged by their milepoints on KY 136
in McLean County. This report also contains a list of retrofitting concepts for various features, a strip map showing the features that were logged (Figure 1), Seismic Performance Categories (SPC) for the bridges in this county (Table 1), and a alluvium map for McLean County (Figure 2).

RETROFITTING CONCEPTS FOR MCLEAN COUNTY, KY., KY 136.

The state maintenance garage is located at the milepost 13.0 on KY 136. The garage should be stocked with various supplies (DGA, steel ramps, chain saws, etc.) in the event of an earthquake. Each individual garage should have an emergency action plan for response during an earthquake.

The bridge/culvert located at milepost 13.1 should have rock berms placed on the toe of both fills approaching the culvert. Several culverts were observed to have settlement problems in their surrounding approaches. Culverts were not logged in our study because they are not seismically prone to failure. But, the fills surrounding the culverts might present a problem. Rock berms should be place at the toe of the fills approaching the culverts.

A rock berm could be placed at milepost 13.2 along the north side of the road adjacent to the swampy area. The rock berm should help hold the road in place if liquifaction occurs in the underlying subgrade. This is probably low priority since the adjacent parking lot will allow for a alternate detour.

At milepost 13.6 two crude oil storage tanks are surrounded by a severely eroded containment dike. The dike should be rebuilt and covered with 57 stone to help prevent erosion. A diverson trench should
also be dug between the dike and KY 136.

A clay core dike should be placed around the tanks at milepost 15.5.

At milepost 16.4 the grain elevator should be tied with restraining cables in the opposite direction of the road.

At milepost 16.45 a large farm pond with an earthen dam faces KY 136. The toe of the dam should be reinforced with a rock berm.

The bridge approaches at milepost 17.1 should be reinforced with rock berms.

The crude oil tanks at milepost 18.4 should be relocated if they are still in service.

The bridge at milepost 19.2 should be retrofitted with cable restraints. Cable restraints should be used at the abutment to keep the main span in contact with the abutment. Restraints should also be used to tie the box beams to each other and to the pier. The current open abutments are allowing the soil to migrate through the abutment piers. The abutments should be lined with a heavy shot rock. Rock berms should also be placed around the toe of the approach fills.

A gasline crosses under the road at milepost 19.45. A shut off valve is located approximately 300-feet south of the road. County officials should contact the Webster KY. Gas Corporation and correlate an emergency response plan.

At milepost 19.7 a farm pond with an earth embankment structure lies uphill from the road. A rock berm should be placed around the base of the dam.

The bridge at milepost 20.9 should be retrofitted with cable
restraints. Cable restraints should be used at the abutments. Cable restraints should also be used to tie the box beams to each other and to the pier.

Three electrical lines cross Ky 136 at milepost 24.39. The utility which owns the lines should be contacted and an emergency response plan should be coordinated.

A farm pond dam at milepost 24.35 needs a rock berm placed at the toe of the dam road.

BRIDGES

There are four bridges located on KY 136. To determine if these bridges need retrofitting, their Seismic Performance Categories (SPC) were defined. The SPC permit variation in the retrofitting requirements and analysis methods in accordance with the seismic risk associated with a particular bridge location. According to the Applied Technology Concil's publication entitled "Seismic Retrofitting Guidelines for Highway Bridges" (ATC-6-2), bridges classified as SPC A are designed for the lowest level of seismic activity and those classified as SPC D are designed for the highest level of seismic activity. The SPC are determined from the importance classification (IC) and the acceleration coefficient (A). The bridges under consideration in this county were classified as essential bridges and were assigned IC values of one. The acceleration coefficient map recommended by ATC-6-2, gives a value of 0.05 for McLean County. Using the described values of IC and A as inputs for the computer program written for this study, the SPC for the bridges in this county were defined. A copy of the program output is shown in Table 1. Important information about the bridges in this
county such as locations, number of spans, types (steel or concrete), beam types, length, and width are also summarized in the program output. All of the bridges classified as SPC A. The retrofitting guidelines recommended by ATC-6-2, indicate that bridges in SPC A generally are not considered for seismic retrofitting. However, the areal extent of alluvium that is present in Western Kentucky could change the SPC ratings to a B or possibly even a C.

Conclusions

It is recommended the bridges in McLean County be retrofitted with cable restraints, cover the embankment slopes under the bridge with large stone, and surround the bridge approaches with rock berms.

Oil tanks should be surrounded with clay core dikes, and diversion trenches where needed.

The local or county utility companies that have major water, gas, or electrical lines that cross under or over the road should be contacted and an emergency response plan should be established.

Large farm ponds with dams should be retrofitted with rock berms.

Approximately 15 fills were logged on Ky 136. Rock berms should be placed at the toe of fills. Fills built over or near swampy terrain is a major concern. The bottom of fills if saturated with water could liquify during seismic activity and collapse the entire structure.

Additional problems involving fills could occur at bridge and culvert approach fills. Rock berms should also be placed at the toe of these fills.

There appears to be a large amount of alluvium present in McClean County (Figure 2). Special care should be taken in the areas built on
alluvium, because of the possibility of liquefaction occurring in these areas, especially where high water tables may be present.

There have been eight geologic faults logged in the database for KY 136 in McLean County. These faults are seismically since a large earthquake could trigger additional movement along one or more of those old slip planes.
APPENDIX A

SEISMICALLY SIGNIFICANT FEATURES
<table>
<thead>
<tr>
<th>MILEPOINT</th>
<th>FEATURE DATA</th>
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<tbody>
<tr>
<td>12.90</td>
<td>OTHER JCT US 61 HEADING NE ROAD SURFACE TYPE - FLEXIBLE</td>
</tr>
<tr>
<td>12.90</td>
<td>OTHER CITY OF CALHOUN ROAD SURFACE TYPE - FLEXIBLE</td>
</tr>
<tr>
<td>12.90</td>
<td>OTHER BEGIN KY 136 EARTHQUAKE STUDY ROAD SURFACE TYPE - FLEXIBLE</td>
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<td>13.05</td>
<td>FILL MATERIAL TYPE - SOIL HEIGHT 8 LENGTH 200 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE</td>
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<td>13.15</td>
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<td>13.20</td>
<td>OTHER SWAMPY AREA ROAD SURFACE TYPE - FLEXIBLE</td>
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<td>13.30</td>
<td>PIPELINE PIPELINE TYPE - GAS SIZE 1 IN DEPTH 10 FT PIPELINE NUMBER 1 ROAD SURFACE TYPE - FLEXIBLE</td>
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<tr>
<td>13.35</td>
<td>FAULT FAULT ROAD SURFACE TYPE - FLEXIBLE</td>
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<td>13.60</td>
<td>TANK OIL TANK NUMBER OF TANKS 2 TOTAL CAPACITY UNKNOWN DISTANCE FROM ROAD 20 ROAD SURFACE TYPE - FLEXIBLE</td>
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<td>14.80</td>
<td>OTHER JCT KY 250 HEADING NORTH ROAD SURFACE TYPE - FLEXIBLE</td>
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<tr>
<td>16.40</td>
<td>OTHER GRAIN SILO ROAD SURFACE TYPE - FLEXIBLE</td>
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<tr>
<td>16.41</td>
<td>FAULT FAULT ROAD SURFACE TYPE - FLEXIBLE</td>
</tr>
<tr>
<td>16.45</td>
<td>OTHER POND: 42' FROM ROAD, (400 x 200)' ROAD SURFACE TYPE - FLEXIBLE</td>
</tr>
<tr>
<td>17.05</td>
<td>FILL MATERIAL TYPE - SOIL HEIGHT 10 LENGTH 500 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE</td>
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<td>FAULT FAULT ROAD SURFACE TYPE - FLEXIBLE</td>
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<td>FILL MATERIAL TYPE - SOIL HEIGHT 10 LENGTH 1000 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE</td>
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<td>FILL MATERIAL TYPE - SOIL HEIGHT 10 LENGTH 200 SIDESLOPE 3:2 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE</td>
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REPORT BY COUNTY AND MILEPOINT
FOR MCLEAN COUNTY - KENTUCKY
KY 136

MILEPOINT FEATURE DATA

19.17 BRIDGE NUMBER OF SPANS 3 OVER STREAM CONCRETE - BOX BEAM END 1 FIXED PIER 1 FIXED PIER 2 FIXED END 2 FIXED DECK TYPE - CONCRETE LENGTH 119' WIDTH 19 SURFACE TYPE - FLEXIBLE SPC A NO RETROFIT EXPANSION TYPE - OTHER END 1 SUBSTRUCTURE - STUB END 2 SUBSTRUCTURE - STUB PIER TYPE - SOLID FOUNDATION TYPE - UNKNOWN

19.25 FILL MATERIAL TYPE - SOIL HEIGHT 10 LENGTH 800 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE

19.31 TREES NUMBER OF TREES 200 HEIGHT 30 DIAMETER 18 IN ENDING MILEPOINT 19.70 DISTANCE FROM ROAD 15 ROAD SURFACE TYPE - FLEXIBLE

19.45 PIPELINE PIPELINE TYPE - GAS SIZE 10 IN DEPTH 10 FT PIPELINE NUMBER 1 ROAD SURFACE TYPE - FLEXIBLE

19.45 OTHER GAS SHUTOFF VALVE 300' SOUTH OF ROAD ROAD SURFACE TYPE - FLEXIBLE

19.70 OTHER FOND: 25' FROM ROAD, (150 x 200)' ROAD SURFACE TYPE - FLEXIBLE

19.72 FAULT FAULT ROAD SURFACE TYPE - FLEXIBLE

19.90 FILL MATERIAL TYPE - SOIL HEIGHT 15 LENGTH 70 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE

20.10 OTHER CAVED MINE ADITS ROAD SURFACE TYPE - FLEXIBLE

20.63 FAULT FAULT ROAD SURFACE TYPE - FLEXIBLE

20.85 FILL MATERIAL TYPE - SOIL HEIGHT 15 LENGTH 200 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
MILEPOINT: 20.88
FEATURE: BRIDGE
DATA: NUMBER OF SPANS 7 OVER STREAM CONCRETE T-BEAM END 1 FIXED PIER 1 FIXED PIER 2 FIXED PIER 3 FIXED PIER 4 FIXED PIER 5 FIXED PIER 6 FIXED END 2 FIXED DECK TYPE - CONCRETE LENGTH 153 WIDTH 19 SURFACE TYPE - FLEXIBLE SPc A NO RETROFIT EXPANSION TYPE - OTHER END 1 SUBSTRUCTURE - STUB END 2 SUBSTRUCTURE - STUB PIER TYPE - SOLID FOUNDATION TYPE - UNKNOWN

MILEPOINT: 20.95
FEATURE: FILL
DATA: MATERIAL TYPE - SOIL HEIGHT 15 LENGTH 200 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE

MILEPOINT: 20.96
FEATURE: FAULT
DATA: ROAD SURFACE TYPE - FLEXIBLE

MILEPOINT: 21.50
FEATURE: TREES
DATA: NUMBER OF TREES 50 HEIGHT 25 DIAMETER 18 IN ENDING MILEPOINT 21.70 DISTANCE FROM ROAD 15 ROAD SURFACE TYPE - FLEXIBLE

MILEPOINT: 21.70
FEATURE: OTHER
DATA: CITY OF LIVERMORE ROAD SURFACE TYPE - FLEXIBLE

MILEPOINT: 21.70
FEATURE: FILL
DATA: MATERIAL TYPE - SOIL HEIGHT 10 LENGTH 100 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE

MILEPOINT: 22.40
FEATURE: TREES
DATA: NUMBER OF TREES 100 HEIGHT 50 DIAMETER 24 IN ENDING MILEPOINT 23.10 DISTANCE FROM ROAD 15 ROAD SURFACE TYPE - FLEXIBLE

MILEPOINT: 22.50
FEATURE: OTHER
DATA: JCT US 431 HEADING N-S ROAD SURFACE TYPE - FLEXIBLE

MILEPOINT: 23.40
FEATURE: OTHER
DATA: TANK ROAD SURFACE TYPE - FLEXIBLE

MILEPOINT: 23.60
FEATURE: PIPELINE
DATA: PIPELINE TYPE - GAS SIZE 1 IN DEPTH 10 FT PIPELINE NUMBER 1 ROAD SURFACE TYPE - FLEXIBLE

MILEPOINT: 23.80
FEATURE: FILL
DATA: MATERIAL TYPE - SOIL HEIGHT 15 LENGTH 100 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE

MILEPOINT: 24.10
FEATURE: FILL
DATA: MATERIAL TYPE - SOIL HEIGHT 15 LENGTH 100 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
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<td>24.20</td>
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<td>POWER</td>
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<td>CUT</td>
<td>CUT SLOPE TYPE - SOIL HEIGHT 15 LENGTH 75 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE BACKSLOPE 2:1</td>
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<td>25.10</td>
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<td>25.40</td>
<td>FILL</td>
<td>MATERIAL TYPE - SOIL HEIGHT 15 LENGTH 100 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE</td>
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<td>25.70</td>
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<td>25.80</td>
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<tr>
<td>25.80</td>
<td>OTHER</td>
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FIGURE 1. STRIP MAP FOR MCLEAN COUNTY

Legend of Features:

- AM
- TANK
- SIGN
- PIPELINE
- MINE
- POWER LINE
- BRIDGE
- TREE
- FILL