Rapid Damage Assessment of Infrastructure Components in the Central United States

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ABSTRACT

A number of destructive earthquakes have occurred in the central United States on the New Madrid Fault at the beginning of the 19th century. In the eight central U.S. states included in this investigation, rivers intersect major land routes of importance to commodity flow. The Mississippi River, for example, divides the US into two parts, namely the Eastern and Pacific parts. There are many different long-span bridges crossing these rivers. Moreover, most of the major dams were built on these rivers, and at least thousands of storage tanks are located in cities and towns in the central U.S. If earthquakes occurred in the New Madrid seismic area as large as the historic 19th Century series, some of these major structures would likely suffer at least slight-to-moderate damage. Bridge damage would interrupt the transportation network, and floods caused by dams failures would result in further destruction to regions already devastated by earthquake shaking. As part of the ongoing impact assessment project funded by FEMA, this study deals with the rapid damage assessment of these major river crossings (MRCs) and dams, as well as levees and storage tanks that frequently hold hazardous materials. As a result of a broad classification, six types of MRCs, two types of dams and several types of steel storage tanks have been identified. The majority of the bridges fall into the ‘multispan simply supported and continuous steel truss bridges’, while most dams are classified as ‘earth and concrete gravity dams’. The tanks considered are steel, concrete and wooden storage tanks. In order to provide more realistic damage assessments, previous research conducted on fragility curve development for bridges, dams and levees, and storage tanks, as well as damage evaluations of these infrastructure subjected to several earthquakes, have been reviewed. Threshold values have been established to be utilized in rapid assessment of the damage to infrastructure components in the central U.S.

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1. INTRODUCTION

A series of powerful earthquakes in North America occurred on the New Madrid Fault at the beginning of the 19th century. The seismic events occurred over a two month period, between Dec. 16, 1811, and February 7, 1812. The estimated magnitudes of these earthquake series are nearly 8. Thousands of additional smaller earthquakes occurred over a the three month period from Dec. 16, 1811 to March 16, 1812 (MNDR, 2008).

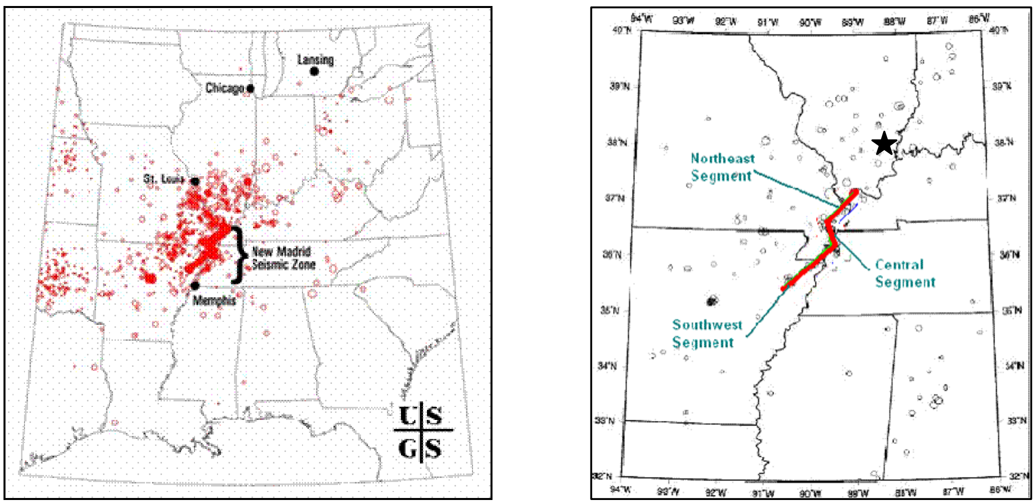


Figure 1. The Earthquakes in NMSZ since 1974 (*left*) and NMSZ Fault Segments (*right*)

Moreover, more than 4,000 earthquakes have been reported in the New Madrid Seismic Zone (NMSZ) since 1974. Figure 1 shows the distribution of epicenters throughout the region (USGS). More recently an earthquake of magnitude 5.4 occurred on April 18, 2008, in the northeast section of the NMSZ (bold star in Figure 1 shows its epicenter).

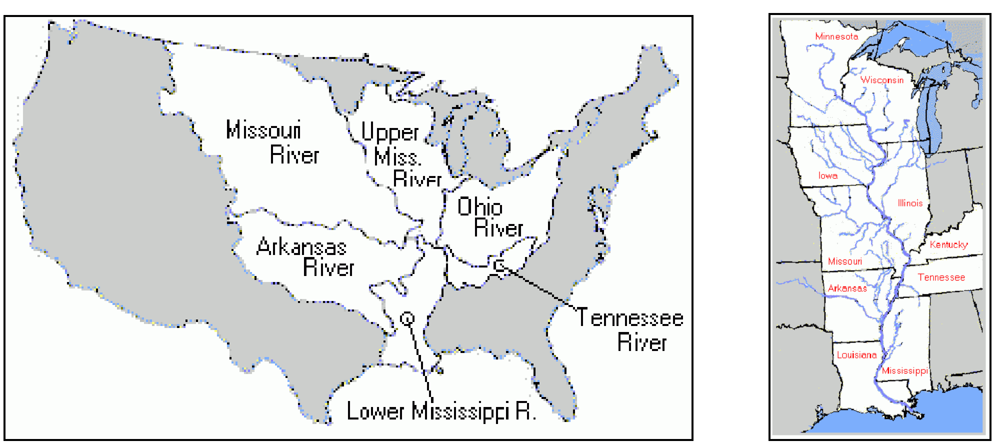


Figure 2. The rivers in the central United States

In the central U.S., the Mississippi River divides the region into two parts, namely the Eastern and Pacific parts. Additionally the Ohio, Missouri, Illinois, and Arkansas Rivers divide the geography. There are more than one hundred long-span bridges crossing these rivers. The highway as well as railway connections between states are provided by these structures. Incidentally, some of these bridges, located on the Mississippi and Ohio rivers, cross the central and northeast segments of the New Madrid Fault. The first major highway and railway bridges on the Mississippi River were built in 1855 and 1856, respectively. Stretching from southwest Illinois to northeast Arkansas, the NMSZ is located in portions of five states in the central U.S.: Illinois, Missouri, Kentucky, Tennessee, and Arkansas. However, the ongoing project in the MAE Center, entitled as "New Madrid Seismic Zone Catastrophic Event Planning," includes loss estimations in eight central U.S. states surrounding the NMSZ: Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee.

It is likely that if an earthquake similar to those in 1811 and 1812 occurred in the NMSZ today, the event would cause at least light-to-moderate damage to both highway and railway transportation infrastructure as well as the dams, levees, hazardous materials facilities, et cetera. It would most likely interrupt transportation services and cause substantial economic loss (Hildenbrand et al., 1996; Elnashai et al., 2008). Most localized transportation activities would be hampered by a lack of useable surface transportation infrastructure and resources. Moreover, the damage to the transportation infrastructure may influence the means and accessibility of relief services and supplies. This would cause additional economic loss, casualties, and various negative social impacts. It is crucial to prioritize the infrastructure systems for seismic retrofit with an optimal strategy to take precautions against future destructive earthquakes and mitigate disasters in probable seismic events. Initially, seismic vulnerability of the infrastructure components need to be evaluated where the most damage is expected. Subsequently, the most essential infrastructure systems should be retrofitted to withstand likely seismic events, considering the allocated limited budget. Retrofitting all systems would require massive financial resources. Reasonable approximate threshold values, which are mostly the median pga values of the fragility relationships, are established for damage state levels described in HAZUS (slight, moderate, extensive, and complete) to be utilized in rapid assessment of the damage to selected infrastructure systems in the central U.S.

1.1. Definition of The Problem

This report presents an approximate procedure for the rapid evaluation of seismic vulnerability of selected major infrastructure components: the bridges crossing major rivers as well as dams, levees, and storage tanks located within eight central U.S. states.

It is evident that comprehensive damage assessment analyses of these unique and complex structural systems are rather complicated, tedious, and time consuming. On the other hand, seismic vulnerability of these infrastructure components are needed to evaluate damage. This study reports rapid damage assessment of the selected major infrastructure elements in eight central U.S. states.

The methodology adopted for deriving approximate threshold values is based on engineering judgement. Previous research which focused on the development of bridge fragility curves and damage evaluation of the infrastructure systems subjected to several earthquakes have been reviewed thoroughly. The purpose of such an extensive literature review was not only to reduce the uncertainties but also to provide a more realistic vulnerability assessment.

The methodology utilized in generating the approximate threshold values can be summarized as follows:

- The peak ground acceleration (PGA) is used as the ground shaking parameter for the generation of the approximate threshold values since it is readily available from earthquake records.

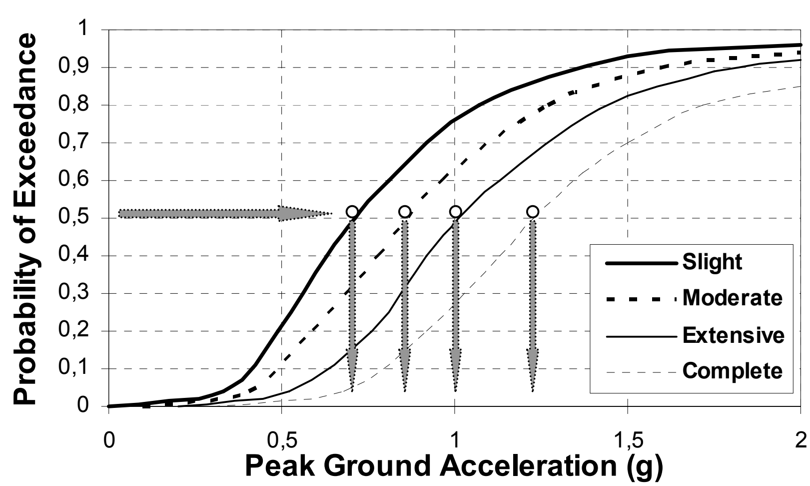


Figure 3. Generation of Approximate Threshold Values from Fragility Curves

- Reasonable approximate threshold values have been selected from the developed fragility curves using engineering judgment for damage state levels described in HAZUS, namely slight, moderate, extensive, and complete.
- The median PGA values of the fragility curves have been selected as approximate threshold values (see Figure 3).
- Fragility curves (of infrastructure exemplifying the identified infrastructure element groups) have been taken into consideration as much as possible to minimize the uncertainties and provide a more realistic vulnerability assessment,
- When fragility curves were unavailable, previous research containing bridge damage data collected via field-survey after earthquakes has been taken into consideration.
- Reasonable lower bounds were kept as the threshold values for each infrastructure category.
- Finally, four ranges of approximate threshold values have been established for each infrastructure type and damage state to be utilized in rapid assessment of the damage to the selected infrastructure components.

1.2. Objective and Scope

The objective of this study is to provide approximate threshold values to be utilized in rapid seismic response assessment of the selected infrastructure elements in eight earthquake prone states surrounding the NMSZ in the Central U.S.

The report considers six groups of major river crossings, three classes of storage tanks, and two types of dams and levees. The selected bridge systems are located on five major central U.S. rivers. The dams, levees, and storage tanks are located within the eight central U.S. states in and around the NMSZ.

Approximate threshold values have been established using PGA as the ground shaking parameter. The limit state threshold values represent several pre-defined damage states. The location of infrastructure elements were compared to the PGA ground motion map to determine damage levels for each item. Consequently, four ranges of threshold values are proposed for each class of the infrastructure element class.

2. BRIDGES

2.1. Survey of Major River Crossings

The Mississippi, Ohio, Missouri, Illinois, and Arkansas rivers are the only major rivers in the eight states of the central U.S. considered. There are many different long-span bridges crossing these rivers. Some of these river crossings are with approaches which are not considered in this study. The first highway and railroad bridges crossing the Mississippi River were built in 1855 and 1856, respectively. The first highway bridge spans the river in Minneapolis, Minnesota, whereas the first railroad bridge is located between Arsenal and Rock Islands, at the Illinois/Iowa border.

The bridges located on these five rivers, within the eight states surrounding the NMSZ, are presented in the following table. Some of the bridges on the canals, waterways, and rivers are vertical lift or are side- or center-mounted swing bridges. Vertical lift bridges lift without tilting to provide sufficient clearance over the navigation channel for marine traffic. Vertical lift bridges can be traced to the late 1840s in England where several small lift spans were built.

More detailed information about each of these complex river crossings can be found in Appendix A.

Table 1. Bridge Inventory

	Bridge	Location
1	Caruthersville Bridge	Caruthersville, Missouri and Dyersburg, Tennessee
2	Harahan Bridge	West Memphis, Arkansas and Memphis, Tennessee
3	Lyons-Fulton Bridge	Clinton, Iowa and Fulton, Illinois
4	Quincy Bayview Bridge	West Quincy, Missouri Quincy, Illinois
5	Cairo Mississippi River Bridge	Bird's Point, Missouri and Cairo, Illinois
6	Cairo I-57 Bridge	Charleston, Missouri and Cairo, Illinois
7	Thebes Bridge	Illmo, Missouri and Thebes, Illinois
8	Bill Emerson Memorial Bridge	Cape Girardeau, Missouri and East Cape Girardeau, Illinois
9	Chester Bridge	Perryville, Missouri and Chester, Illinois
10	Crescent City Connection	New Orleans, Louisiana
11	Hernando de Soto Bridge	West Memphis, Arkansas and Memphis, Tennessee
12	Frisco Bridge	West Memphis, Arkansas and Memphis, Tennessee
13	Memphis & Arkansas Bridge	West Memphis, Arkansas and Memphis, Tennessee
14	Savanna-Sabula Bridge	Savanna, Illinois and Sabula, Iowa, River Mile 537.8
15	Sabula Rail Bridge	Sabula, Iowa and Savanna, Illinois
16	Huey P. Long Bridge	Jefferson Parish, Louisiana
17	New Chain Of Rocks Bridge	River Mile 190.8
18	Chain of Rocks Bridge	St. Louis, Missouri

Table 1. Bridge Inventory (Continued)

	Bridge	Location
19	Clark Bridge	West Alton, Missouri and Alton, Illinois
20	Martin Luther King Bridge	St. Louis, Missouri and East St. Louis, Illinois
21	Eads Bridge	St. Louis, Missouri and East St. Louis, Illinois
22	McKinley Bridge	St. Louis, Missouri and Venice, Illinois
23	Poplar Street Bridge	St. Louis, Missouri and East St. Louis, Illinois
24	MacArthur Bridge	St. Louis, Missouri and East St. Louis, Illinois
25	Gateway Bridge	Clinton, Iowa and Fulton, Illinois
26	Merchants Bridge	St. Louis, MO
27	Jefferson Barracks Bridge	St. Louis, Missouri and Columbia, Illinois
28	Fred Schwengel Memorial Bridge	Le Claire, Iowa and Rapids City, Illinois
29	I-74 Bridge	Bettendorf, Iowa and Moline, Illinois
30	Rock Island Government Bridge	Davenport, Iowa and Rock Island, Illinois
31	Rock Island Centennial Bridge	Davenport, Iowa and Rock Island, Illinois
32	Helena Bridge	Helena-West Helena, Arkansas and Lula, Mississippi
33	I-280 Bridge	Davenport, Iowa and Rock Island, Illinois
34	Dubuque-Wisconsin Bridge	Dubuque, Iowa, with Grant County, Wisconsin
35	Julien Dubuque Bridge	Dubuque, Iowa, and East Dubuque, Illinois
36	Old Vicksburg Bridge	Delta, Louisiana and Vicksburg, Mississippi
37	Vicksburg Bridge	Delta, Louisiana and Vicksburg, Mississippi
38	Sunshine Bridge	Sorrento, Louisiana and Donaldsonville, Louisiana
39	Norbert F. Beckey Bridge	Muscatine, Iowa and Illinois
40	Louisiana Rail Bridge	Louisiana, Missouri and Illinois
41	Champ Clark Bridge	Louisiana, Missouri and Illinois
42	Burlington Rail Bridge	Burlington, Iowa and Gulf Port, Illinois
43	Great River Bridge	Burlington, Iowa and Gulf Port, Illinois
44	Greenville Bridge	Lake Village, Arkansas and Greenville, Mississippi
45	Benjamin G. Humphreys Bridge	Lake Village, Arkansas and Greenville, Mississippi
46	Horace Wilkinson Bridge	Baton Rouge, Louisiana
47	Black Hawk Bridge	Lansing, Iowa and Crawford County, Wisconsin, River Mile 663.4
48	Fort Madison Toll Bridge	Fort Madison, Iowa and Niota, Illinois
49	John James Audubon Bridge	Pointe Coupee Parish, Louisiana, West Feliciana Parish, Louisiana
50	Mark Twain Memorial Bridge	Hannibal, Missouri
51	Wabash Bridge (w/ vertical lift)	Hannibal, Missouri and Illinois
52	Keokuk Rail Bridge	Keokuk, Iowa and Hamilton, Illinois
53	Keokuk-Hamilton Bridge	Keokuk, Iowa and Hamilton, Illinois
54	Natchez-Vidalia Bridge	Vidalia, Louisiana and Natchez, Mississippi
55	Quincy Memorial Bridge	West Quincy, Missouri and Quincy, Illinois
56	Bayview Bridge	West Quincy, Missouri Quincy, Illinois
57	Quincy Rail Bridge	West Quincy, Missouri and Quincy, Illinois
58	Moline-Arsenal Bridge	River Mile 485.7
59	Crescent Railroad Bridge	River Mile 481.4
60	Double Chain Bridge	St. Louis, MO
61	Single Chain Bridge	St. Louis, MO
62	Grand Tower Pipeline Bridge	Grand Tower, Illinois
63	A. W. Willis. Jr. Bridge	River Mile 737.1
64	Mud Island Monorail/ Memphis Suspension Railway	Memphis, Tennessee

Table 1. Bridge Inventory (Continued)

	Bridge	Location
65	Cairo Ohio River Bridge	Wickliffe, Kentucky and Cairo, Illinois
66	Cairo Rail Bridge	Wickliffe, Kentucky and Cairo, Illinois
67	Metropolis Bridge	Metropolis, Illinois
68	Interstate 24 Bridge	Metropolis, Illinois
69	Irvin S. Cobb Bridge	Paducah, KY and Brookport, IL
70	Shawneetown Bridge	Old Shawneetown, Illinois
71	Henderson Bridge	Henderson, Kentucky
72	Bi-State Vietnam Gold Star Bridges/ Twin Bridges	Henderson, Kentucky and Evansville, Indiana
73	Glover H. Cary Bridge	Owensboro, Kentucky and Spencer County, Indiana
74	William H. Natcher Bridge	Owensboro, Kentucky to Rockport, Indiana
75	Bob Cummings - Lincoln Trail Bridge	Indiana-Kentucky State Line
76	Matthew E. Welsh Bridge	Brandenburg, Kentucky and Mauckport, Indiana
77	Lewis Bridge	St. Louis County and St. Charles County, Missouri
78	Bellefontaine Bridge	St. Louis County and St. Charles County, Missouri
79	Discovery Bridge	St. Louis County and St. Charles County, Missouri
80	Wabash Bridge	Bridgeton and Saint Charles, MO
81	Blanchette Memorial Bridge	St. Louis County and St. Charles County, Missouri
82	Veterans Memorial Bridge	St. Louis County and St. Charles County, Missouri
83	Daniel Boone Bridge	St. Louis County and St. Charles County, Missouri
84	Washington Bridge	Washington, Missouri
85	Christopher S. Bond Bridge	Hermann, MO
86	Jefferson City Bridge	Jefferson City, Missouri
87	Rocheport Interstate 70 Bridge	Cooper County and Boone County , MO
88	Boonslick Bridge	Boonville, Missouri
89	Glasgow Bridge	Glasgow, Missouri
90	Glasgow Railroad Bridge	Glasgow, Missouri
91	Hardin Bridge	Hardin, IL
92	Florence Bridge	Florence, IL
93	Valley City Eagle Bridges	Valley City, IL
94	Meredosia Bridge	Meredosia, IL
95	Beardstown Bridge	Beardstown, IL
96	Scott W. Lucas Bridge	Havana, IL
97	Pekin Bridge	Pekin, IL
98	Shade-Lohmann Bridge	Bartonville, IL and Creve Coeur, IL
99	Cedar Street Bridge	Peoria, Illinois and East Peoria, Illinois
100	Bob Michel Bridge	Peoria, Illinois and East Peoria, Illinois
101	Murray Baker Bridge	Peoria, Illinois and East Peoria, Illinois
102	McClugage Bridge	Peoria, IL
103	Lacon Bridge	Sparland and Lacon, IL
104	Henry Bridge	Henry, IL
105	Gudmund "Sonny" Jessen Bridge	Hennepin, IL
106	Spring Valley Bridge	Spring Valley, IL
107	Peru Bridge	Peru, IL
108	Abraham Lincoln Memorial Bridge	La Salle, Illinois and Oglesby, Illinois
109	Utica Bridge	Utica, IL
110	Ottawa Bridge	Ottawa, IL
111	Seneca Bridge	Seneca, IL

Table 1. Bridge Inventory (Continued)

	Bridge	Location
112	Morris Bridge	Morris, IL
113	Pendleton Bridge	Arkansas Post
114	Lawrence Blackwell Bridge	Pine Bluff
115	Rob Roy Bridge	Pine Bluff
116	79-B Bridge	Pine Bluff
117	Pipeline bridge	Redfield
118	I-440 Bridge	Little Rock
119	Rock Island Bridge	Little Rock
120	I-30 Bridge	Little Rock
121	Junction Bridge	Little Rock
122	Main Street Bridge	Little Rock
123	Broadway Bridge	Little Rock
124	Union Pacific Rail Bridge	Little Rock
125	Big Dam Bridge	Little Rock
126	I-430 Bridge	Little Rock
127	Highway 9 Bridge	Morrilton

2.2. Classification of Major River Crossings

It is possible to classify these bridges based on material, age, length, soil conditions, etc. In this study, however, classification of the Major River Crossings (MRCs) is based on respective construction type and construction material. Six types of MRCs have been identified as a result of grouping common features leading to the classifications shown below;

i) Cable Stayed/Suspension Bridges (CSS)
ii) Multispan Continuous Steel Truss Bridges (MCST)
iii) Multispan Simply Supported Steel Truss Bridges (MSSST)
iv) Multispan Continuous Steel Girder Bridges (MCSG)
v) Multispan Simply Supported Steel Girder Bridges (MSSSG)
vi) Multispan Simply Supported Concrete Girder Bridges (MSSCG)

Based on these categories, the majority of the bridges fall into the 'multispan simply supported steel truss bridges' or 'multispan continuous steel truss bridges' groups. These two bridge categories contain nearly 75% of the total inventory considered in this study. The bridges investigated in this reserach are with or without approaches. It should be noted that this study does not contain seismic response assessment or evaluation of damage to bridge approaches. Appendix A contains information on each bridges accompanied by images of each. Most of the images and the brief summaries presented in the Appendix are provided from two sources.

2.2.1. Cable Stayed and Suspension Bridges

Cable Stayed Bridges and Suspension Bridges constitute 9% of the total bridge inventory investigated in this study. Figure 4 shows samples of this type of MRC. More details about the MRCs can be noticed in Appendix A.


Figure 4. Quincy Bayview Bridge, 1987 (*left*) and I-74 Bridge, 1935&1959 (*right*)

Cable Stayed Bridges and Suspension Bridges included in the inventory investigated are listed in Table 2.

Table 2. Cable Stayed and Suspension Bridges

	Bridge
4	Quincy Bayview Bridge
8	Bill Emerson Memorial Bridge
19	Clark Bridge
25	Gateway Bridge
29	I-74 Bridge
43	Great River Bridge
44	Greenville Bridge
49	John James Audubon Bridge
56	Bayview Bridge
62	Grand Tower Pipeline Bridge
74	William H. Natcher Bridge
117	Pipeline bridge

2.2.2. Multispan Continuous Steel Truss Bridges

The majority of the bridges investigated are steel truss bridges. ‘Multispan Continuous Steel Truss Bridges’ constitute 42% of the total bridge inventory. Figure 5 shows two samples of this type of MRC. More details about the MRCs can be found in Appendix A.


Figure 5. Savanna-Sabula Bridge, 1932 (*left*) and Crescent City Connection Bridge, 1988 (*right*)

Multispan Continuous Steel Truss bridges examined in this study are listed in Table 3.

Table 3. Multispan Continuous Steel Truss Bridges

	Bridge
1	Caruthersville Bridge
2	Harahan Bridge
3	Lyons-Fulton Bridge
5	Cairo Mississippi River Bridge
6	Cairo I-57 Bridge
7	Thebes Bridge
9	Chester Bridge
10	Crescent City Connection
11	Hernando de Soto Bridge
12	Frisco Bridge
13	Memphis & Arkansas Bridge
14	Savanna-Sabula Bridge
15	Sabula Rail Bridge
16	Huey P. Long Bridge
17	New Chain of Rocks Bridge
18	Chain of Rocks Bridge
20	Martin Luther King Bridge
32	Helena Bridge
35	Julien Dubuque Bridge
36	Old Vicksburg Bridge
37	Vicksburg Bridge
38	Sunshine Bridge
45	Benjamin G. Humphreys Bridge
46	Horace Wilkinson Bridge
47	Black Hawk Bridge
50	Mark Twain Memorial Bridge
54	Natchez-Vidalia Bridge
55	Quincy [Soldier's] Memorial Bridge
60	Double Chain Bridge
61	Single Chain Bridge
64	Mud Island Monorail/ Memphis Suspension Railway
65	Cairo Ohio River Bridge
70	Shawneetown Bridge
72	Bi-State Vietnam Gold Star Bridges/ Twin Bridges
73	Glover H. Cary Bridge
75	Bob Cummings - Lincoln Trail Bridge

Table 3. Multispan Continuous Steel Truss Bridges (Continued)

	Bridge
80	Wabash Bridge
81	Blanchette Memorial Bridge
82	Veterans Memorial Bridge
83	Daniel Boone Bridge
84	Washington Bridge
85	Christopher S. Bond Bridge
86	Jefferson City Bridge
87	Rocheport Interstate 70 Bridge
94	Meredosia Bridge
96	Scott W. Lucas Bridge
98	Shade-Lohmann Bridge
99	Cedar Street Bridge
101	Murray Baker Bridge
102	McClugage Bridge
103	Lacon Bridge
107	Peru Bridge
109	Utica Bridge

2.2.3. Multispan Simply Supported Steel Truss Bridges

'Multispan Simply Supported Steel Truss Bridges' constitute 31% of the total bridge inventory investigated in this study. Two samples of this type of MRC are shown in Figure 6. More details about the MRCs can be found in Appendix A.

Figure 6. Metropolis Bridge, 1917 (*left*) and Menchants Bridge, 1889 (*right*)

Multispan Simply Supported Steel Truss Bridges are listed in Table 4.

Table 4. Multispan Simply Supported Steel Truss Bridges

	Bridge
21	Eads Bridge
22	McKinley Bridge
24	MacArthur Bridge
26	Merchants Bridge
30	Rock Island Government Bridge
31	Rock Island Centennial Bridge
33	I-280 Bridge
34	Dubuque-Wisconsin Bridge
39	Norbert F. Beckey Bridge
40	Louisiana Rail Bridge
41	Champ Clark Bridge
42	Burlington Rail Bridge
48	Fort Madison Toll Bridge
51	Wabash Bridge
52	Keokuk Rail Bridge
57	Quincy Rail Bridge
59	Crescent Railroad Bridge
66	Cairo Rail Bridge
67	Metropolis Bridge
69	Irvin S. Cobb Bridge
71	Henderson Bridge
76	Matthew E. Welsh Bridge
78	Bellefontaine Bridge
79	Discovery Bridge
89	Glasgow Bridge
90	Glasgow Railroad Bridge
91	Hardin Bridge
92	Florence Bridge
95	Beardstown Bridge
104	Henry Bridge
106	Spring Valley Bridge
108	Abraham Lincoln Memorial Bridge
110	Ottawa Bridge
111	Seneca Bridge
115	Rob Roy Bridge
119	Rock Island Bridge
121	Junction Bridge
124	Union Pacific Rail Bridge
127	Highway 9 Bridge

2.2.4. Multispan Continuous Steel Girder Bridges

'Multispan Continuous Steel Girder Bridges' constitute 6% of the total bridge inventory. Figure 7 shows two samples of this type of MRC. More details about the MRCs can be found in Appendix A.

Figure 7. Lewis Bridge, 1979 (*left*) and Moline-Arsenal Bridge, 1982 (*right*)

Multispan Continuous Steel Girder Bridges are listed in Table 5.

Table 5. Multispan Continuous Steel Girder Bridges

	Bridge
53	Keokuk-Hamilton Bridge
58	Moline-Arsenal Bridge
68	Interstate 24 Bridge
77	Lewis Bridge
97	Pekin Bridge
100	Bob Michel Bridge
113	Pendleton Bridge
120	I-30 Bridge
126	I-430 Bridge

2.2.5. Multispan Simply Supported Steel Girder Bridges

'Multispan Simply Supported Steel Girder Bridges' constitute only 9% of the total bridge inventory. Figure 8 shows two samples of this type of MRC. More details about the MRCs can be found in Appendix A.

Figure 8. Poplar Street Bridge, 1967 (*left*) and Morris Bridge, 2002 (*right*)

Multispan Simply Supported Steel Girder Bridges are listed in Table 6.

Table 6. Multispan Simply Supported Steel Girder Bridges

	Bridge
23	Poplar Street Bridge
27	Jefferson Barracks Bridge
28	Fred Schwengel Memorial Bridge
63	A. W. Willis. Jr. Bridge
88	Boonslick Bridge
105	Gudmund "Sonny" Jessen Bridge
112	Morris Bridge
118	I-440 Bridge
123	Broadway Bridge
125	Big Dam Bridge

2.2.6. Multispan Simply Supported Concrete Girder Bridges

As the minority of the bridge inventory investigated in this study, ‘Multispan Simply Supported Concrete Girder Bridges’ constitute only 3% of the 127 long-span bridges. Figure 9 shows a sample of this type of MRC. More detailed information and images of these MRCs can be found in Appendix A.

Figure 9. Valley City Eagle Bridges, 1988

Multispan Simply Supported Concrete Girder Bridges are listed in Table 7.

Table 7. Multispan Simply Supported Concrete Girder Bridges

	Bridge
93	Valley City Eagle Bridges
114	Lawrence Blackwell Bridge
116	79-B Bridge
122	Main Street Bridge

2.3. Survey of Published Works

Previous studies performed by several authors on topics related to aspects of this study have been summarized. Most of the previous work has been conducted on the development of bridge fragility curves. The bridge types which are threshold values suggested for in the previous studies are as follows: Multispan Continuous Concrete Girder Bridges (MCCG), Multispan Continuous Steel Girder Bridges (MCSG), Multispan Continuous Slab Bridges (MCS), Multispan Simply Supported Concrete Girder Bridges (MSSCG), Multispan Simply Supported Concrete Box Bridges (MSSCB), Multispan Simply Supported Slab Bridges (MSSS), Multispan Simply Supported Steel Girder Bridges (MSSSG), Single Span Concrete Girder Bridges (SSCG), Multispan Prestressed-deck Bridges (MPD).

In this study, Nielsen and DesRoshes (2007) have developed seismic fragility curves for nine classes of bridges located in the central and southeastern United States. Three dimensional models were used and nonlinear time-history analyses were completed. The authors emphasized that multispan steel girder bridges are the most vulnerable of the bridge classes considered Additionally, single-span bridges tend to be the least vulnerable. A comparison of the proposed fragility curves with those currently found in HAZUS-MH revealed that there is strong aggreement within the multispan simply supported steel girder bridge class. However, for other simply supported bridge classes (concrete girder, slab), the proposed fragility curves suggest a lower vulnerability level than those presented in HAZUS-MH.

The span lengths of eight representative bridge configurations of the ‘Multispan Continuous Steel Girder’ bridges range between 43.95 feet (13.4m) and 133.82 feet (40.8m).

Table 8. Threshold values suggested for several bridge types

Bridge Type	Slight	Moderate	Extensive	Complete
MCCG	0.15	0.52	0.75	1.03
MCSG	0.18	0.31	0.39	0.50
MCS	0.17	0.45	0.78	1.73
MSSCG	0.20	0.57	0.83	1.17
MSSCB	0.21	0.65	1.19	2.92
MSSS	0.18	0.52	0.94	1.92
MSSSG	0.24	0.44	0.56	0.82
SSCG_1	0.41	1.84	2.62	3.64
SSCG_2	0.63	1.14	1.52	2.49

Based on the fragility relationships, the median values suggested by the authors for several bridge classes are presented in Table 8.

In the study by Elnashai et al (2004), vulnerability functions for reinforced concrete bridges were derived analytically. Deformation-based limit states were employed. The analytically-derived vulnerability functions were then compared to a data set comprised of observational damage data from the Northridge (California, 1994) and Hyogo-ken Nanbu (Kobe, 1995) earthquakes. By varying the dimensions of the prototype bridge used in the study and the span lengths supported by piers, three more bridges are obtained with different overstrength ratios (ratio of design-to-available base shear). The prototype bridge which was analyzed was straight, 60 meters long and 16 meters wide. The superstructure is supported by the abutments and two rows of piers. The superstructure is a holllow prestressed concrete deck. To quantify the deformational capacity of the piers, static inelastic pushover analysis was employed. Inelastic time-history analyses were undertaken to evaluate the displacement on the bridge piers using 7 accelerograms, which had been selected to represent earthquakes with several magnitudes. These magnitudes are typical of areas of moderate seismic hazard, which constitute the majority of seismically active areas around the world.

The threshold values suggested by the authors for 'Multispan Prestressed-Deck Bridge' class are as follows:

Table 9. Threshold values suggested for multispan prestressed-deck bridges

Damage State Level	**Slight**	**Moderate**	**Extensive**	**Complete**
PGA (g)	0.43	0.56	0.67	N/A
Standard Deviation (g)	0.165	0.178	0.180	N/A

Choi et al. (2004) developed a set of fragility curves for the bridges commonly found in the central and southeastern United States presented in this study. Using the results of an inventory analysis, four typical bridge types are identified. Using non-linear analytical models, analytical fragility curves are developed for the four bridge types. It is stated that, comparison of the fragility curves shows that the most vulnerable bridge types are the multi-span simply supported and multi-sapn continuous steel-girder bridges. In addition, it is emphasized that the least vulnerable bridge is the multi-span continuous pre-stressed concrete-girder bridges. Consequently, the median values suggested by the authors for several bridge classes are presented in Table 10.

Table 10. Threshold values suggested for several bridge types

Bridge Type	Slight	Moderate	Extensive	Complete
MSSSG	0.20	0.33	0.47	0.61
MSSCG	0.20	0.56	0.77	1.14
MCSG	0.20	0.34	0.48	0.69
MCCG	0.24	1.31	2.01	3.47

In the research conducted by Karim and Yamazaki (2000) an analytical method utilized to construct fragility curves for highway bridge piers considering both structural parameters and variation of input ground motion. In this study an analytical approach was adopted to construct the empirical fragility curves. A typical bridge structure was considered, and its piers were designed using the seismic design codes of Japan. Earthquake records were selected from the 1995 Hyokogen-Nanbu earthquake based on peak ground acceleration and peak ground velocity. Nonlinear dynamic response analyses of the typical bridge with RC piers and girder and deck were performed using the earthquake records from Japan and the United States as input ground motion. And the damage indices fort he bridge piers were obtained. Using the damage indices and ground motion indices, fragility curves for the bridge piers were then constructed.

Median values that have been generated from the relationships developed by the authors for 'Multispan Simply Supported Concrete Girder Bridges' are as follows:

Table 11. Threshold values suggested for MSSCG bridges

Bridge Type	Slight	Moderate	Extensive	Complete
MSSCG	N/A	N/A	0.82	1.01

This study presented a statistical analysis of structural fragility curves. The authors, Shinozuka et al. (2000a), stated that, both empirical and analytical fracility curves were considered. Empirical fragility curves were developed by utilizing bridge damage data obtained from the 1995 Hyogo-ken-Nanbu (Kobe) earthquake. The analytical fragility curves are constructed on the basis of the nonlinear dynamic analysis. Empirical fragility curves for the Hanshin Expressway Public Cooperation's (HEPC's) bridges (columns) are developed on the basis of the damage resulting from the 1995 Kobe earthquake. To demonstrate the development of analytical fragility curves, two representative bridges with a precast, prestressed continuous deck inthe Memphis area were used.

The median values generated for 'Multispan Continuous Prestressed-Deck Bridges (MCPD)' are as follows:

Table 12. Threshold values suggested for MCPD bridges

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	0.47	0.68	0.80	N/A

In this study Shinozuka et al. (2000b) described the fragility relationships of a bridge created from two different analytical approaches; one utilized time-history analysis and the other used the capacity spectrum method. A sample of 10 nominally identical but statistically different bridges and 80 ground-motion time histories were considered to account for the uncertainties related to the structural capacity and ground motion, respectively. The comparison of fragility curves developed with the nonlinear static procedure to those developed with time-history analysis indicated that the agreement was excellent for the at least minor damage state, but not as good for the severe damage state. However, the agreement was adequate even in the severe damage state considering the large number of typical assumptions under which the analyses of fragility characteristics was performed.

Median values generated as a result of these analyses for 'Multispan Continuous Prestressed-Deck Bridges (MCPD) ' are as follows:

Table 13. Threshold values suggested by Shinozuka et al. (2000) for MCPD bridges

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	0.20	N/A	0.27	N/A

This study presented a procedure, developed by Hwang et al. (2000), for the evaluation of the expected seismic damage to bridges and highway systems in Memphis and Shelby County, Tennessee. Data pertinent to 452 bridges and major arterial routes were collected and implemented in a geographic information system (GIS) database. Bridge damage states considered are: none/minor damage, repairable damage, and significant damage. Fragility curves corresponding to these damage states were established for various bridge types.

The median values generated from the developed fragility curves for 'Multispan Simply Supported Prestressed Girder Bridges (MSSPG)' are tabulated in Table 14.

Table 14. Threshold values suggested by Hwang et al. (2000) for MSSPG bridges

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	N/A	0.12	0.17	N/A

The authors, Filiatrault et al. (1993), stated in the study that the Shipshaw Cable-Stayed Bridge, which crosses the Seguenay River near Jonquiere, Quebec, suffered significant structural damage during the 1988 Saguenay Earthquake. This earthquake is the largest seismic event recorded in eastern Canada. The peak horizontal acceleration recorded in the epicentral region is 0.15g. One of four anchorage plates connecting the steel box girders to one abutment failed due to ground shaking. This paper dealt with the dynamic analyses and testing of the Shipshaw Cable-Stayed Bridge that were performed to confirm the cause of failure.

Threshold values generated for 'cable-stayed bridges (CSB)' using bridge damage data collected via field-survey after the earthquake and are as follows:

Table 15. Threshold values suggested by Filiatrault et al. (1993) for cable-stayed bridges

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	N/A	0.15	N/A	N/A

In this study, an analytical approach was adopted to construct fragility curves for highway bridge piers of specific bridges. Nonlinear dynamic response analyses were performed, and the damage indices for the bridge piers were obtained using strong ground motion records from Japan and the United States. Fragility curves for the bridge piers were constructed assuming a lognormal distribution using damage and ground motion indices.Based on the actual damage data of highway bridges from the 1995 Hyokogen-Nanbu (Kobe) earthquake , a set of empirical fragility curves was constructed. The analytical fragility curves were then compared with the empirical fragility curves (Karim and Yamazaki 2001).

The median values generated for 'Multispan Simply Supported Prestressed Girder Bridges (MSSPG)' are as follows:

Table 16. Threshold values suggested by Karim and Yamazaki (2001) for MSSPG bridges

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	0.28	0.61	0.73	1.00

In this research, Ranf et al. (2007) evaluated the influence of ground motion and bridge properties on the likelihood of a bridge suffering damage during an earthquake in the Pacific Northwest. The 2001 Nisqually earthquake damaged 78 bridges, of which 67 had slight or mild damage. They emphasized that the percentage of bridges damaged correlated best with the estimated spectral acceleration at a period of 0.3 sec., the year of construction, and whether the bridge was movable or an older steel truss. The mechanical components of movable bridges make them particularly vulnerable. Older truss bridges suffered a disproportional amount of damage to their movement joints and bracing members. In addition, it is emphasized that the data suggested that simply supported bridges are not more vulnerable than continuous bridges at the low level of damage. Furthermore, the authors stated that damage to movable bridges and truss type bridges are greatly underestimated by the HAZUS procedure, which categorizes movable bridges and older trusses as "other" bridges.

In this study the authors evaluated the damage of a base-isolated, cable-stayed bridge subjected to two strong ground motions (Bessason et al. 2004). The Thjorsa River Bridge, built in 1950 and retrofitted with base isolation in 1991, was instrumented by strong-motion accelerometers. The bridge has one 83 meter long main sapan and two 12 meter long approach spans. Only the main span, a steel arch truss with concrete deck, was base isolated. The bridge was subjected to moderate earthquakes of magnitudes 6.6 and 6.5 occurred in South Iceland on June 17th and June 21st 2000, respectively. The epicenter was to close to the bridge. The PGA recorded during the first and second earthquakes were 0.53g and 0.84g, respectively. The authors emphasized that the bridge survived the earthquakes without any significant damage and was open to traffic immediately after the earthquakes. It was concluded that, the recorded data shows the earthquake excitation on each side of the river was significantly different for the short natural periods. For the long periods, which are most important for the response of the base-isolated bridge, the differnce is less. The recorded earthquake action showed considerably higher reaction force than the bearings were expected to be able to resisit before upgrading. The loads were also higher than the superstructure was expected to be able to resist. It is highly emphasized that the bridge would probably have been severely damaged in June 2000 South Iceland earhtquakes if it had not been base-isolated.

2.4. Definitions of Bridge Damage States

Four structural damage limit states are utilized, i.e., slight, moderate, extensive, and complete. Primarily, damage state definitions are based on recommendations from previous studies and the qualitative descriptions of the damage states as provided by HAZUS. However, since the damage limit states depend on the bridge type, condition and year of construction, as well as soil liquefaction beneath the bridge, engineering judgment should be used in determination of the damage state levels (Choi et al., 2004).

Description of bridge damage state levels considered in this study are summarized below:

Slight Damage

- Minor cracking and spalling to the abutment, cracks in shear keys at abutments, minor spalling and cracks at hinges, minor spalling at the column (damage requires no more than cosmetic repair) or minor cracking to the deck.
- For cable-stayed bridges: small deck movement and its nonstructural damage.

Moderate Damage

- Any column experiencing moderate (shear cracks) cracking and spalling (column structurally still sound), moderate movement of the abutment (<2"), extensive cracking and spalling of shear keys, any connection having cracked shear keys or bent bolts, keeper bar failure without unseating, rocker bearing failure or moderate settlement of the approach.
- For cable-stayed bridges: anchorage plate failure, small number of hangers breaking off from the deck.

Extensive Damage

- Any column degrading without collapse – shear failure - (column structurally unsafe), significant residual movement at connections, or major settlement approach, vertical offset of the abutment, differential settlement at connections, shear key failure at abutments.

Complete Damage

- Any column collapsing and connection losing all bearing support, which may lead to imminent deck collapse, tilting of substructure due to foundation failure.

2.5. Performance Threshold Values

The threshold values identified in previous research activities are shown in the following tables for each of the four damage state levels. Reasonable approximate threshold values, which are the median pga values of the fragility relationships, are selected for damage state levels described in HAZUS (slight, moderate, extensive, and complete) based on engineering judgment. The approximate threshold values constituted to be utilized in rapid vulnerability assessment of the MRCs.

Some of the previous work put emphasis on the truss bridges because they are thought to be the most vulnerable bridge types. Additionally, the mechanical components of movable bridges, such as the swing bridges and vertical lift bridges that provide clearance for marine traffic, are also especially vulnerable. Moreover, it was emphasized that simply supported bridges are less vulnerable than continuous bridges (Ranf et al., 2007). There has been significant research conducted on the fragility of the steel and concrete girder bridges. Since there have been a limited number of studies conducted on development of the fragility relationships for Cable Stayed and Suspension Bridges, the threshold values generated for these types of the bridges are based on the damage data gathered via field-surveys after the earthquakes primarily.

Table 17. Threshold values suggested for several bridge types

BridgeType	Reference	Slight	Moderate	Extensive	Complete
CSS	Filiatrault et al. (1993)	N/A	0.15	N/A	N/A
MCST	Nielsen and DesRoshes (2007)	0.18	0.31	0.39	0.50
	Choi et al. (2004)	0.20	0.34	0.48	0.69
MSSST	Nielsen and DesRoshes (2007)	0.24	0.44	0.56	0.82
	Choi et al. (2004)	0.20	0.33	0.47	0.61
MCSG	Nielsen and DesRoshes (2007)	0.18	0.31	0.39	0.50
	Choi et al. (2004)	0.20	0.34	0.48	0.69
MSSSG	Nielsen and DesRoshes (2007)	0.24	0.44	0.56	0.82
	Choi et al. (2004)	0.20	0.33	0.47	0.61
MSSCG	Nielsen and DesRoshes (2007)	0.24	0.44	0.56	0.82
	Choi et al. (2004)	0.20	0.33	0.47	0.61
	Karim and Yamazaki (2000)	N/A	N/A	0.82	1.01
	Hwang et al. (2000)	N/A	0.12	0.17	N/A
	Karim and Yamazaki (2001)	0.28	0.61	0.73	1.00
	Elnashai et al. (2004)	0.43	0.56	0.67	N/A

2.6. Suggested Threshold Values

After assessment of all results achieved in the previous work and damage data provided by field observations after earthquakes, threshold values for each bridge class have been proposed for four damage state levels and are designed to be utilized in rapid assessment of the damage to MRCs. The proposed approximate threshold values are as follows:

Table 18. Threshold values proposed for long-span bridges

Bridge Type	Slight	Moderate	Extensive	Complete
CSS	N/A	0.15	N/A	N/A
MCST	0.18	0.31	0.39	0.50
MSSST	0.20	0.33	0.47	0.61
MCSG	0.18	0.31	0.39	0.50
MSSSG	0.20	0.33	0.47	0.61
MSSCG	0.28	0.61	0.73	1.00

3. SELECTED INFRASTRUCTURE ELEMENTS

3.1. DAMS and LEVEES

Dams and levees are man-made infrastructure components which restrain naturally flowing water and serve several purposes including water storage for farm irrigation, prevention of flooding, hydro-electric power, water supply to towns or industry, maintenance of safe water levels in the highest reaches of canals, etc.

Dams and levees are critical infrastructre components in modern societies which are also vulnerable to natural hazards, especially earthquake hazards. They as relatively critical infrastructure that, if damaged or destroyed, would disrupt the security, economic health, safety, and welfare of the general public. On September 8, 2005, during Hurricane Katrina, the City of New Orleans, Louisiana, was largely submerged in the floodwaters, mainly caused by levee failure (Luther, 2008). It is important to note that floods continue to pose an important threat to the property and safety of population centers in the U.S. Inhabitants face a serious threat of flooding because of earthquake damage to dams and levees. The annual economic loss due to floods is estimated in the billions of dollars (FEMA 549). As a result, dam and levee performance is a critical concern for engineers when considering economic impacts as well as public safety. Engineering decisions are based on lessons learned from previous hazard events, and subsequent preventative measures are taken to reduce failure risks. Figure 10 shows a map of large dams constructed in the central U.S. and their respective years of contruction.

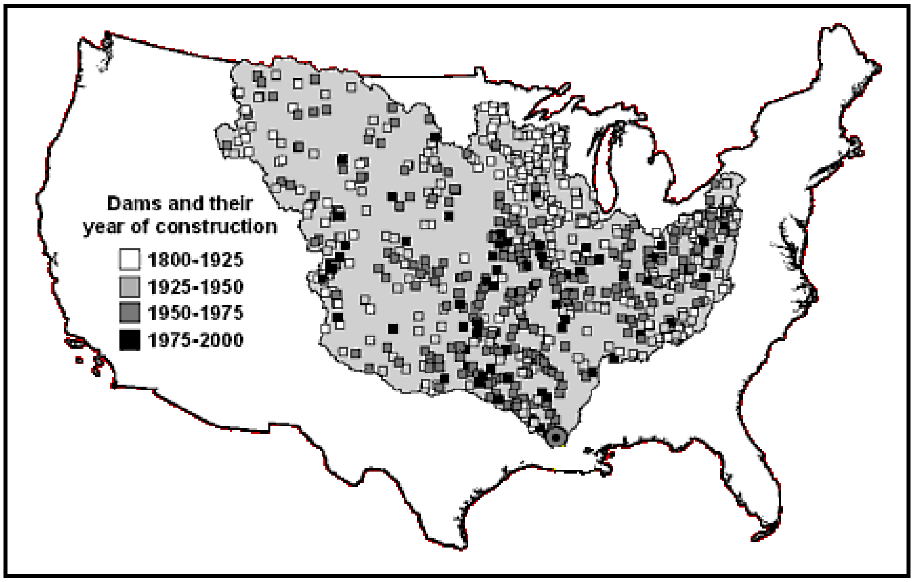


Figure 10. Large dams located in the central United States

3.1.1. Classification of Dams

Dams can be classified based on the building material used, such as earth or concrete. Earth dams are built with earth and/or rockfill and are resistant to water pressure because of their weight. These types of dams are commonly refered to as gravity dams. If the material is not inherently watertight, they are faced with an impervious material or have a watertight core. Earth dams are the oldest and most common type of dams. Concrete dams have several types: gravity dams, arch dams, buttress dams, multiple arch dams, barrages, and several others. Concrete gravity dams have a roughly triangular cross section and are also resistant to water pressure because of their weight. This type of dam is the most common type of concrete dam (ICOLD - International Commission of Large Dams). Concrete arch dams transmit most of the water load into the surrounding earth or large concrete thrust blocks.

There are many different dams within the eight states of interest in the central U.S. that are investigated in this study. The majority of the dams located in these states are either earth dams, concrete gravity dams, or concrete arch dams. Seismic vulnerability of these dams should be addressed when assessing risk from earthquake hazards becuase these infrastructure types create substantial secondary hazards when damaged. This report presents approximate threshold values for use in rapid damage assessment of earth dams, concrete gravity dams, and concrete arch dams.

Figure 11. Damage at the Lower Van Norman Dam by the February 9, 1971, San Fernando, California, earthquake (FEMA, 2005).

Figure 12. Dam suffered damage during the 7.6 magnitude 1999 Chi-Chi earthquake**,** Taiwan (Images by Prof.Y. Hashash, University of Illinois)

3.1.2. Survey of Published Works

There is a relatively large number of dams and levees which have suffered damage during past earthquakes. Observational post-earthquake damage data is a very reliable form of data to use in the generation of threshold values. A summary of previous investigations predominantly based on the records from post-earthquake surveys of dams and levees subjected to strong ground motions are presented below.

The main purpose of this research, performed by Tepel (1985), was to report the effects (or lack of effects) of a moderate earthquake (Morgan Hill Earthquake of April 24, 1984) on the well-designed facilities of a major water utility. These facilities were located from six to twenty-seven miles (10km to 43 km) from the epicenter. The Santa Clara Valley Water District, a public agency with flood control and water supply management authority in Santa Clara County, California, operate ten dams and reservoirs. Immediately after the April 24, 1984, Morgan Hill Earthquake, the District's Emergency Operations Center was activated. Major dams were inspected immediately afterwards by operations staff in accordance with standard procedures. It was stated that no damage occurred at eight out of the District's ten dams. Functionally insignificant (or minor) damage was found at the Leroy Anderson and Coyote earth dams.

The earthquake caused to two linear sets of longitudinal cracks on the crest of Leroy Anderson Dam, which were roughly twenty feet apart and had a extented of 1,100 feet and 920 feet longitudinally along the surface of the dam.

The Coyote Dam is one of the few dams in the U.S. knowingly built across an active fault. Minor surficial cracks were found in three areas of the dam: the upstream face, the crest, and in the vicinity of the spillway. The author concluded that the damaging effects of the earthquake were less severe than what was previously thought possible from a cursory review of peak acceleration response data. The author also emphasized that the damaging effects were also less severe than anticipated by many (including the author) who personally experienced the earthquake shaking.

As a result of dam damage data collected via field observations after the earthquake the threshold values suggested by the author are as follows:

Table 19. Threshold values suggested for several dams

Dam	**Slight**	**Moderate**	**Extensive**	**Complete**
Leroy Anderson dam - downstream	0.41	N/A	N/A	N/A
Leroy Anderson dam - crest	0.63	N/A	N/A	N/A
Coyote dam	1.29	N/A	N/A	N/A

In this study it is stated that the upstream slope of the Lower San Fernando Dam in California, failed due to liquefaction during the 1971 San Fernando earthquake (Boulanger and Duncan). The peak ground acceleration of the earthquake was 1.25g at Pacoima Dam record. The dam was constructed by hydraulic filling, which involves mixing the fill soil with a large amount of water, transporting it to the dam site by pipeline, depositing the soil and water on the embankment in stages, and allowing the excess water to drain away. The fill that remains is loose and liquefied during the extended period of earthquake shaking. Figure 12 shows the aerial view and slide in the upstream shell of the dam after the earthquake.

Figure 13. Aerial view of the crest (left) and the slide in the upstream shell of the Lower San Fernando Dam, in California, after the 1971 San Fernando earthquake

Table 20. Threshold values suggested for Lower San Fernando Dam

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	N/A	N/A	1.25	N/A

In this study, performance evaluation of two reservoirs during 1994 Northridge Earthquake were conducted (Davis and Bardet, 1996). The authors concluded that this earthquake affected each of the dams in different ways. The Los Angeles Dam (LAD) and North Dike of the Los Angeles Reservoir (LAR) both moved slightly and settled, sustaining small, superficial cracks. The left abutment of the North Dike experienced a noticeable increase in seepage without significantly impeding the reservoir operations. The earthquake uplifted and shifted the foundation of the LAR by 30cm, causing tectonic effects on embankments. The tectonic tilt created a differential settlement across the embarkments. Moreover, the authors stated that the Power Plant Tailrace, which is a small reservoir serving as the afterbay fort he San Francisco Power Plant and channels aqueduct water to a filtration plant, slowly failed by piping due to transverse cracks and differential lateral spreading induced by liquefaction.

The threshold values suggested by the authors as a result of the field survey performed after the earthquake can be seen in Table 21.

Table 21. Threshold values suggested for Los Angeles Dam and Los Angeles Reservoir

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	N/A	0.56	N/A	N/A

Rathje et al. (2006) evaluated the behavior of earth dams and levees which survived the 2004 Niigata Ken Chuetsu, Japan, earthquake, stating that induced significant geotechnical and geologic failures occurred throughout the affected region. The most prevalent geotechnical observations from this earthquake were related to ground failure, including landslides in natural ground, failures of highway embankments and residental earth fills, and limited liquefaction in alluvial deposits. The absence of considerable levee deformations and surface faulting was also noted.

They reported that one earth dam experienced significant deformation but did not release its reservoir. The levee system adjacent to the Shinano and Uono Rivers performed well, with only minor deformation in a few areas. Strong ground motions with PGA values of 0.82g-1.73g were observed at stations located immediately above the source region (Honda et al., 2005).

The threshold values suggested in this study are presented in the following table.

Table 22. Threshold values suggested for earth dams and levees

Dams/Levee	Slight	Moderate	Extensive	Complete
Earth dams	N/A	0.82	N/A	N/A
Levees	0.82	N/A	N/A	N/A

This paper related to seismic hazard assessment of the earth dams subjected to earthquake events (Nusier and Alawneh, 2006). The authors investigated the seismic hazard of the Kafrein Earth Dam located in Jordan. They stated that the site of the dam had been affected by major earthquakes of magnitudes greater than 6.0 in the last seven decades. They reported that the Jordan Valley Fault is a very significant strike-slip fault, similar to the Wabash Valley Fault in southeastern Illinois and southwestern Indiana. This fault extends about 60 miles north-northeastward from just north of Shawneetown, Illinois and the Rough Creek Fault Zone.

They concluded that, according to ICOLD (International Commission on Large Dams, 1989), the operating basis earthquake should have a 50% probability of non-exceedance throughout the 100-year lifetime of dam structures. For the Kafrein Dam, this nonexeedance probability represents a return period of 145 years and a design acceleration of 0.11g. The equivalent 90% confidence level results in a design acceleration of 0.25g.

A Safety Evaluation Earthquake is defined as the earthquake that produces the most severe level of ground motion under which the safety of the dam should be insured. The authors also concluded that the return period quoted for the Safety Evaluation Earthquake for the Kafrein Dam (Risk Class II Dam) is 3,000 years, representing an annual probability of exceedance of 0.03%. The resulting Maximum Design Earthquake, which produces the maximum level of ground motion according to which the dam should be designed, bedrock acceleration applicable to this exceedance probability is 0.486g.

The suggested threshold value for Kafrein Dam is given in Table 23.

Table 23. Threshold values suggested for Kafrein Dam

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	0.49	N/A	N/A	N/A

The main design characteristics of Karameh Dam located in the Jordan Valley were presented in this paper by Al-Homoud (1995). The author pointed out that the primary seismic source contributing to the hazard at the dam site is the active Jordan Valley Fault, which extends from the Dead Sea to the Sea of Galilee with an expected maximum earthquake magnitude of 7.8. A probabilistic method was used to evaluate the seismic hazard at the dam site. PGA was selected as a measure of ground motion severity. Analyses were carried out for 50%, 90%, and 95% exceedance probabilities throughout the structure lifetimes of 50, 100, and 200 years. It was stated that according to the guidelines of ICOLD, PGA for a Maximum Design Earthquake is 0.50g, and for Operating Basis Earthquake, which has a 50% probability of non-exceedence in 100 years lifetime of the dam, it is 0.17g. It is anticipated that OBE may result in slight damage but the strucutre is still expected to be functional.

It is reported that a PGA of 0.50g associated with the MDE will trigger liquefaction of the sand layers existing in the dam foundation. Similarly, liquefaction may occur beneath the dam foundation layers for a magnitude 7.8 earthquake, resulting in an expected crest settlemet of 14.43 feet (4.4m). The expected horizontal rupture displacement for an earthquake of this magnitude is approximately 39.36 feet (12m). Slope stability analysis indicated deep failure planes in the foundation zone.

Threshold value generated in this study is shown in Table 24.

Table 24. Threshold values suggested for Karameh Dam

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	0.17	N/A	N/A	N/A

The paper examines the seismic performance and deformation of levees via contains four case studies (Miller and Roycroft, 2004). The authors stated that, during the 7.1 magnitude Loma Prieta earthquake of October 17, 1989, severe ground shaking caused permanent ground displacement of levees at many locations along the Pajaro River near Watsonville, California. The area is in the seismically active region adjoining the San Andreas Fault Zone.

They estimated the bedrock acceleration to have been 0.25g at the sites. The bedrock acceleration was amplified to an estimated 0.33g at the ground surface of soft soil sites. The yield accelerations for the critical failure surface are 0.50g and 0.49g, depending on the depth of the assumed crack.

They concluded that one levee was severely damaged and three levees sustained minor damage. At the Artichoke Farm site, the levee experienced 24 inches (60 cm) of lateral spreading. There were major longitudinal cracks 2 feet wide and 8 feet deep in this section of levee. The South Side Levee experienced 2 inches 5 cm lateral spreading.

The threshold value suggested by the authors is shown in the following table.

Table 25. Threshold values suggested by Miller and Roycroft (2004) for Levees

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	0.33	N/A	N/A	N/A

The study by Trinufac and Hudson (1971) related to the 6.6 magnitude San Fernando, California, earthquake of February 9, 1971, where over 200 accelerographs were recorded. The horizontal peak ground acceleration of this earthquake was 1.25g. Although this earthquake did not have a large magnitude, it was associated with very severe ground motions and must be ranked as a major event from the standpoint of damage. However, it is stated that strong earthquake ground motion is taht large ground acceleration amplitudes in themselves do not necessarily indicate severe damage to structures. And Pacoima Dam, as an example, suffered no significant damage.

Threshold values generated based on the post-earthquake field-survey can be shown in Table 26.

Table 26. Threshold values suggested for Pacoima Concrete Gravity Dam

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	N/A	1.25	N/A	N/A

In this study, it was reported by Chopra (1992) that the Pacoima Dam (located in San Fernando, California), a concrete arch structure, sustained damage to one abutment during the 1971 San Fernando earthquake; its reservoir was only partly full at the time of the strong ground motion.

The median PGA values resulting from this research are given in the following table:

Table 27. Threshold values suggested by Chopra (1992) for Pacoima Dam

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	N/A	1.25	N/A	N/A

The paper is related to structural deformation monitoring at the Pacoima Dam (Behr et al., 1998). The authors stated that this typical structure experienced severe shaking (>1 g) during the 1971 San Fernando and 1994 Northridge earthquakes (Swanson and Sharma, 1979; USGS and SCEC Scientists, 1994). The dam itself is 370.64 feet (113m) tall, making it the tallest dam in the world at the time of its completion in 1929. This dam sustained significant damage during both earthquake events.

The threshold value extracted from the study are presented in the following table.

Table 28. Threshold values suggested for Pacoima Concrete Gravity Dam

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	N/A	1.25	N/A	N/A

In this study, the post-earthquake damage state of the Koyna Dam subjected to the December 11, 1967, Koyna earthquake, was evaluated by Chopra and Chakrabarti (1973). This structure is a concrete gravity dam and was constructed between 1954 and 1963. The longitunal horizontal peak ground acceleration recorded during the Koyna earthquake was 0.63g.

The response of the dam to the strong ground motion recorded during the earthquake was analyzed using the finite element method, and included the dynamic effects of the reservoir. The dam was in the epicentral region of the earthquake, and suffered notable structural damage. The authors emphasized that the most important structural damages to the dam were horizontal cracks on either the upstream or the downstream face or on both faces of a number of monoliths. Although the dam did not appear to be in danger of a major failure, the damage was serious enough to result in the lowering of the reservoir for inspection and repairs and required permanent strengthening. Considerations and criteria that had been employed in designing Koyna Dam were similar to those used in many parts of the world, including the United States.

The PGA threshold values generated from the study are given in the following table.

Table 29. Threshold values suggested for Koyna Dam

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	N/A	0.63	N/A	N/A

3.1.3. Definition of Damage States for Dams and Levees

Four structural damage limit states are determined: slight, moderate, extensive, and complete. The damage state definitions used are based on recommendations from previous studies containing field survey damage data collected after earthquakes primarily.

Descriptions of damage states for dams and levees are summarized below.

<u>Slight Damage</u>

- For earth dams, slight damage is defined as minor transverse or longitudinal surficial cracking in the area of the dam (i.e., upstream face, downstream face, crest, spillway vicinity).
- For concrete gravity dams, slight damage is defined as hairline cracks in the arc concrete structure.
- For levees, slight damage is defined as minor permanent ground deformation at some locations as well as longitudinal and transverse cracking.

Moderate Damage

- For earth dams, moderate damage is defined as small movement and settlement of the dam as well as small superficial cracks. There is no release of the reservoir in the moderate damage state.
- For concrete gravity dams, moderate damage is defined as damage to the arc structure abutment, and horizontal cracks on either or both of the upstream or the downstream faces of the dam.
- For levees, moderate damage is defined as lateral spreading, longitudinal and transverse cracking, and deformations at some locations.

Extensive Damage

- For earth dams, extensive damage is defined as relatively large movement and settlement, permanent liquefaction deformations, and large superficial cracking.
- For concrete gravity dams, extensive damage is defined as damage to arc structure abutments and large cracking on either or both of the upstream or the downstream faces of the dam.
- For levees, extensive damage is defined as considerable lateral spreading, large longitudinal and transverse cracking, and deformations.

Complete Damage

- For earth dams, complete damage is defined as large settlement and movement, large superficial cracks, and the release of the reservoir without flood damage.
- For concrete gravity dams, complete damage is defined as substantial damage to arc structure abutments, large and widespread horizontal and transverse cracks on either of both of the upstream or the downstream faces of the dam, leading to the release of water.
- For levees, complete damage is defined as deep and large longitudinal and transverse cracks as well as large lateral spreading.

3.1.4. Performance Threshold Values

The following tables are designed to compare data collected from various previous studies presented previously. Reasonable approximate threshold values, which are defined as the median PGA values of the fragility relationships, are selected for damage state levels considered and are based on engineering judgment. Threshold values have been established to be utilized in rapid assessment of the damage to dams and levees in the central US.

Table 30. Threshold values suggested for dams and levees

Dams and Levees	Reference	Slight	Moderate	Extensive	Complete
Earth Dams	Tepel (1985)-1	0.41	N/A	N/A	N/A
	Tepel (1985)-2	0.63	N/A	N/A	N/A
	Tepel (1985)-3	1.29	N/A	N/A	N/A
	Davis and Bardet (1996)	N/A	0.56	N/A	N/A
	Rathje et al. (2006)	N/A	0.82	N/A	N/A
	Nusier and Alawneh (2006)	0.49	N/A	N/A	N/A
	Al-Homoud (1995)	0.17	N/A	N/A	N/A
	Boulanger	N/A	N/A	1.25	N/A
Concrete Gravity and Arch Dams	Trinufac and Hudson (1971)	N/A	1.25	N/A	N/A
	Chopra (1992)	N/A	1.25	N/A	N/A
	Behr et.al. (1998)	N/A	1.25	N/A	N/A
	Chopra and Chakrabarti (1973)	N/A	0.63	N/A	N/A
Levees	Rathje et al. (2006)	0.82	N/A	N/A	N/A
	Miller and Roycroft (2004)	0.33	N/A	N/A	N/A

3.1.5. Suggested Threshold Values

Approximate threshold values for the earth dams, concrete gravity dams, and levees are based on detailed engineering judgment and are presented in the following tables:

Table 31. Threshold values proposed for dams and levees

Dams &Levees	Slight	Moderate	Extensive	Complete
Earth Dams	0.50	0.63	1.25	N/A
Concrete Gravity and Arch Dams	0.63	1.25	N/A	N/A
Levees	0.33	N/A	N/A	N/A

3.2. HAZMAT FACILITIES (TANKS)

3.2.1. Classification of Tanks

It has been observed in past earthquakes that steel and concrete storage tanks are one of the most important and common types of the hazardous materials facilities, and are also quite vulnerable to seismic activity. Broad classification of these infrastructure elements were employed based on the identification of common structural features.

The storage tanks located in the region of interest can be classisfied as:

a. Steel storage tanks
   - i) Un-anchored steel storage tanks
   - ii) Anchored steel storage tanks

b. Concrete storage tanks
   - i) Un-anchored concrete storage tanks
   - ii) Anchored concrete storage tanks
   - iii) Elevated concrete storage tanks

c. Wood tanks

It has been observed with past earthquakes that storage tanks, especially metal cylindrical tanks, undergo considerable damage during strong ground motions. Figures 14 and 15 show typical "elephant foot buckling" and "deformation" damage to steel storage tanks.

Figure 14. Elephant foot buckling of Tupras Rafinery cylindrical tanks (*left*) and deformation of tanks in Kocaeli (*right*) after the 17 August 1999 Marmara Earthquake, Turkey.

Figure 15. Damage at the OSB Amylum Factory by the 1995 Ceyhan, Turkey, earthquake

It has been shown in previous research that a tank's height to diameter (H/D) ratio, as well as the relative amount of stored contents (% fill level), had a considerable effect upon the seismic performance of tank (O'Rourke and So, 2000; Kilic and Ozdemir, 2007).

3.2.2. Survey of Published Works

There is a wide variety of post-earthquake observational data available on the performance of tanks under seismic loading. The data and fragilities generated via field-survey after earthquakes are based on the expert opinion primarily. Previous research conducted on the vulnerability assessment of storage tanks have been briefly summarized.

In this study, which is recently conducted by Berahman and Behnamfar (2007), seismic fragilities of un-anchored, on-grade steel storage tanks (with fill level greater than 50%) were estimated based on historical data and the American Lifeline Alliance tanks database. Two hundred tank databases (which comprises 532 individual tanks) were considered in this study. The fragility curves developed in this study used PGA as the predictive parameter for damage to tanks. Fragility curves developed were compared to corresponding relations currently available in the technical literature. The authors stated that the comparisons suggest that actual tank performance is better than that predicted in the literature.

The threshold values suggested by the authors for the un-anchored steel storage tanks are given in the following table:

Table 32. Threshold values suggested by Berahman and Behnamfar (2007) for un-anchored steel storage tanks

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	0.60	0.87	1.07	N/A

This study presents the fragility curves of cylindrical, on-grade steel liguid storage tanks subjected to ground shaking hazard (O'Rourke and So 2000). The fragility curves are based on analysis of the reported performance of over 400 tanks in nine separate earthquake events. The amount of the ground shaking is quantified by the PGA each specific site. The influence of the tanks height to diameter ratio, H/D, as well as the relative amount of stored contents, or % full, were investigated and found to have a significant affect on tank performance under seismic loading. Fragility curves developed were compared to corresponding relations in the technical literature.

The median fragility values, which consider the height to diameter ratio (H/D) and fill ratio of the contents (fullness), recommended in this comprehensive research are tabulated in the following table.

Table 33. Threshold values suggested by O'Rourke and So (2000) for several tanks

Tank Type	Slight	Moderate	Extensive	Complete
Un-anchored steel storage tanks (H/D<70%)	0.67	1.18	1.56	1.79
Un-anchored steel storage tanks (H/D≥70%)	0.45	0.69	0.89	1.07
Un-anchored steel storage tanks (%Full<50%)	0.64	N/A	N/A	N/A
Un-anchored steel storage tanks (%Full≥50%)	0.49	0.86	0.99	1.17
On-grade steel storage tanks (if base connection unknown)	0.70	1.10	1.29	1.35

In HAZUS (1997), several median fragility values were estimated using PGA as the ground shaking parameter. These values correspond to on-ground concrete (anchored and unanchored), on-ground steel (anchored and unanchored), elevated steel, and on-ground wood water storage tanks. Anchored and unanchored conditions refer to positive connection, or a lack thereof, between the tank wall and the supporting concrete ring wall.

Medians and dispersions of the PGA related to identified damage state levels are proposed as follows:

Table 34. Threshold values suggested in HAZUS for several types of storage tanks

Tank Type	**Slight**	**Moderate**	**Extensive**	**Complete**
Anchored concrete tanks	0.25	0.52	0.95	1.64
Un-anchored concrete tanks	0.18	0.42	0.70	1.04
Anchored steel tanks	0.30	0.70	1.25	1.60
Un-anchored steel tanks	0.15	0.35	0.68	0.95
Elevated steel tanks	0.15	0.55	1.15	1.50
Wood tanks	0.15	0.40	0.70	0.90
Buried concrete tanks	2.00	4.00	8.00	12.00

It is important to emphasize that the approximate threshold values defined in HAZUS do not consider the fill level and H/D ratios of tanks. It was shown in the previous studies, which were comprised of fragility relationships and field observations of damage to storage tanks after past earthquakes, that the ratio of fill level (% full) and H/D (height/diameter) ratio affect the response of the tanks considerably (O'Rourke and So, 2000; Kilic and Ozdemir, 2007). These results indicate how effective the aforementioned characteristics are and encourage the consideration of these factors in the vulnerability assessment of storage tanks in order to reduce the potential loss in future devastating seismic events.

In the American Lifeline Alliance (2001a), the inventory of 424 tanks, developed by Cooper (1997), was reviewed from source material and, for the most part, was found to be correct. In a few instances, the damage states for broken pipes were adjusted as follows: if damage to a pipe created only slight leaks on minor repairs such as damage to an overflow pipe, the damage state was assigned to be slight (same as O'Rourke and So). However, if damage to a pipe led to complete loss of contents or a complete breaking of the inlet-outlet line, then the damage state was assigned to be extensive. In addition, it was stated that steel and concrete storage tanks supported above grade by columns or frames have failed because of the inadequacy of the support system under lateral seismic forces. This occurred to a steel/cement silo in Alaska in 1964 and a concrete tank in Izmit, Turkey in 1999. Many elevated concrete water reservoirs failed or were severely damaged in the 1960 Chilean earthquake. Such failures most often lead to complete loss of contents.

The median PGA values generated from this research are given in the following table.

Table 35. Threshold values suggested in the American Lifeline Alliance (2001) for un-anchored steel storage tanks

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	0.15	0.63	1.08	N/A

In this study, empirical seismic fragility curves and probit functions were defined both for building-like and non building-like industrial components (Fabbrocino et al. 2005).

Table 36. Threshold values suggested by Fabbrocino et al. (2005) for several tank types

Tank Type	Slight	Moderate	Extensive	Complete
Anchored steel storage tanks (nearly full)	N/A	0.30	0.71	N/A
Anchored steel storage tanks (%Full ≥ 50%)	N/A	1.25	3.72	N/A
Un-anchored steel storage tanks (nearly full)	N/A	0.15	0.68	N/A
Un-anchored steel storage tanks (%Full ≥ 50%)	N/A	0.15	1.06	N/A

These components were crossed with outcomes of probabilistic seismic hazard analysis for a test site located in southern Italy. Once the seismic failure probabilities were quantified, consequence analyses were performed for those events which may result in a loss of containment following seismic activity. The median PGA values suggested by the authors can be shown in Table 36.

In this study, field observations were made of damage to metal cylindrical liquid storage tanks during the August 17, 1999, (M_w=7.4) Marmara earthquake and analyses were performed to show the seismic behavior of such structures (Kilic and Ozdemir, 2007). It should be stated that the horizontal peak ground acceleration of Yarımca (YPT) EW record is 0.32g.

The authors emphasized that the earthquake caused significant structural damages to petrochemical containment tanks at the Tupras Rafinery. Sloshing actions of combustible liquid inside the tanks deformed the tank roofs and upper tank walls. Insufficient freeboard in fixed-roof tanks may have resulted in plate buckling at the roof level. The roof-shell junction of the tanks ruptured due to excessive joint stresses. In their analyses, they considered the tanks to be fully anchored to the base.

The threshold values generated from the investigation are tabulated in the following table.

Table 37. Threshold values suggested by Kilic and Ozdemir (2007) for anchored steel tanks

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	N/A	0.32	N/A	N/A

The author of this study (Shinsaku, 2003) stated that oil storage tanks at TUPRAS Refinery, close to the North Anatolian Fault in Turkey, suffered severe damage including large fires and sinking of floating roofs on oil storage tanks. This damage occurred because of liquid sloshing, which was generated by long-period strong ground motions. Fires continued for one week until liquids in tanks had burned off completely. In the ChiChi earthquake in Taiwan, damage such as buckling of floating roofs, rupturing of shell plates, buckling of shell-to-roof joints, and deformation of tank equipment was also caused by liquid sloshing, although the tank sites were located far from the epicenter. Also the peak ground accelerations were about 0.1g (100 gal.) The most severe damage was rupture of the lowest course shell plate, where the lower end of the guide pole was supported. Tank contents were released and subsequently spilled out inside a dike, and contaminated nearby soil.

The threshold values generated from the investigation are tabulated as follows:

Table 38. Threshold values suggested by Shinsaku (2003) for un-anchored steel tanks

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	N/A	0.32	N/A	N/A

In this research, the damage to oil storage tanks and sloshing behavior during the earthquake are presented (Shinsaku et al., 2003). It was determined that the 2003 Tokachi-oki earthquake (M=8.0), which occurred on September 26th, east of Hokkaido and north of Japan, caused to tsunami and more than one hundred collapsed houses. Overall, the extent of damage was not so large considering its magnitude. On the other hand, oil storage tanks in and around Tomakomai, a coastal city in southern Hokkaido, were severely damaged by liquid sloshing. In the Idmitsu Refinery, two fires broke out, six floating roofs sank, and thirty tanks suffered some amount of damage, such as overflow and splashing of oil, deformation of refinery components including; a rolling ladder, weather shield, guide pole, gauge pole and air foam dam, among others.

The threshold values suggested in this study are presented in Table 39.

Table 39. Threshold values suggested by Shinsaku et al. (2003) for un-anchoreged steel storage tanks

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	N/A	N/A	1.01	N/A

In this study, Jaiswal et al. (2007) asserted that liquid storage tanks generally possess lower energy-dissipating capacity than conventional buildings. During lateral seismic excitation, tanks are subjected to hydrodynamic forces. These two aspects are recognized by most seismic codes governing liquid storage tanks and, accordingly, provisions specify higher design seismic forces than buildings and require modeling of hydrodynamic forces during structural analyses. In addition, the authors emphasized that the review carried out revealed that there are significant differences among the codes governing seismic design forces for various types of tanks.

3.2.3. Definitions of Tanks Damage States

Four structural damage limit states (slight, moderate, extensive and complete) defined in HAZUS are considered in the damage evaluation of the storage tanks. The damage state definitions used are based on recommendations made by experts after field-survey and the qualitative descriptions of the damage states as provided by HAZUS primarily.

Descriptions of tanks damage state levels are summarized below:

Slight Damage

- For anchored tanks, slight damage is defined as minor anchor damage and stretched anchor bolts. With slight damage, the anchored tanks remain functional.
- For unanchored tanks, slight damage is defined as elephant foot buckling of tanks with no leakage or loss of contents. With slight damage, the unanchored tanks remain functional.
- For buried tanks, slight damage is defined as minor uplift (few inches) of the buried tanks or minor cracking of concrete walls.

Moderate Damage

- For anchored tanks, moderate damage is defined as elephant foot buckling of tanks with no leakage or loss of contents but considerable damage to tank occurs.

- For unanchored tanks, moderate damage is defined as elephant foot buckling of tanks with partial loss of contents.
- For buried tanks, moderate damage is defined as damage to roof supporting columns and considerable cracking of walls.

Extensive Damage

- For anchored tanks, extensive damage is defined as elephant foot buckling of tanks with loss of contents. Inlet-outlet pipe breaks are also common in cases of extensive damage.
- For unanchored tanks, extensive damage is defined as weld failure at the base of the tank with loss of contents, breaking of inlet-outlet pipes, and partial collapse of the roof system into the tank.
- For buried tanks, extensive damage is defined as considerable uplift (more than a foot) of the tanks and rupture of the attached piping.

Complete Damage

- For anchored tanks, complete damage is defined as weld failure at base of the tank with loss of contents.
- For unanchored tanks, complete damage is defined as tearing of the tank wall or implosion of the tank (with total loss of content).
- For buried tanks, complete damage is defined as considerable uplift (more than a foot) of the tanks and rupture of the attached piping.

3.2.4. Performans Threshold Values

Several threshold values were developed for various damage state levels as described in HAZUS which are based on peak ground acceleration. These values correspond to on-ground concrete (anchored and unanchored), on-ground steel (anchored and unanchored), elevated steel, and on-ground wood tanks. For tanks, anchored and unanchored refers to connection between the steel or concrete tank wall and the supporting concrete ring wall.

Table 40. Threshold values suggested for storage tanks

Storage Tank Type	Reference	Slight	Moderate	Extensive	Complete
Unanchored steel tanks	Berahman et al. (2007)	0.60	0.87	1.07	N/A
	HAZUS (2003)	0.15	0.35	0.68	0.95
	ALA (2001a)	0.15	0.63	1.08	N/A
	Shinsaku (2003)	N/A	0.32	N/A	N/A
	Shinsaku et al. (2003)	N/A	N/A	1.01	N/A
Anchored steel tanks	HAZUS (1997)	0.30	0.70	1.25	1.60
	Kilic & Ozdemir(2007)	N/A	0.32	N/A	N/A
Anchored steel tanks (nearly full)	Fabbrocino et al. (2005)	N/A	0.30	0.71	N/A
Anchored steel tanks (Fill ≥ 50%)	Fabbrocino et al. (2005)	N/A	1.25	3.72	N/A
Unanchored steel tanks (H/D<70%)	O'Rourke & So (2000)	0.67	1.18	1.56	1.79
Unanchored steel tanks (H/D≥70%)	O'Rourke & So (2000)	0.45	0.69	0.89	1.07
Unanchored steel tanks (Fill <50%)	O'Rourke & So (2000)	0.64	N/A	N/A	N/A
Unanchored steel tanks (Fill≥50%)	O'Rourke & So (2000)	0.49	0.86	0.99	1.17
	Fabbrocino et al. (2005)	N/A	0.15	1.06	N/A
Unanchored steel tanks(nearly full)	Fabbrocino et al. (2005)	N/A	0.15	0.68	N/A
Elevated steel tanks	HAZUS (2003)	0.15	0.55	1.15	1.50
Unanchored concrete tanks	HAZUS (2003)	0.18	0.42	0.70	1.04
Anchored concrete tanks	HAZUS (2003)	0.25	0.52	0.95	1.64
Buried concrete tanks	HAZUS (2003)	2.00	4.00	8.00	12.00
Wood tanks	HAZUS (2003)	0.15	0.40	0.70	0.90

3.2.5. Suggested Threshold Values

Numerous previous studies have concluded that the ratio of fill level (% full) and H/D (height/diameter) ratio considerably affected the response of the tanks. However, in HAZUS, the fill level of the tanks (whether the tanks are full, nearly full, ≥50%full, empty) as well as H/D (height/diameter) ratio of tanks are not taken into consideration. Therefore, in addition to the threshold values available in the HAZUS, the threshold values generated from previously conducted studies considering H/D (height/diameter) and fill level of tanks are proposed herein. The proposed threshold values can be seen in the Tables 41 and 42.

Table 41. Threshold values proposed for storage tanks

Tank Type	Slight	Moderate	Extensive	Complete
Unanchored steel tanks (H/D<70%)	0.67	1.18	1.56	1.79
Unanchored steel tanks (H/D≥70%)	0.45	0.69	0.89	1.07
Unanchored steel tanks (Fill Level <50%)	0.64	N/A	N/A	N/A
Unanchored steel tanks (Fill Level ≥50%)	0.49	0.86	0.99	1.17
Unanchored steel tanks (nearly full)	N/A	0.15	0.68	N/A
Anchored steel tanks (Nearly Full)	N/A	0.30	1.25	N/A
Anchored steel tanks (Fill Level≥50%)	N/A	0.71	3.72	N/A

Table 42. Threshold values proposed for on-grade steel storage tanks (if the base connection type is unknown)

Damage State Level	Slight	Moderate	Extensive	Complete
PGA (g)	0.70	1.10	1.29	1.35

4. CONCLUSIONS

This study was conducted as part of the ongoing Mid-America Earthquake Center project, "*New Madrid Seismic Zone Catastrophic Event Planning*".

The research addresses the problem of rapid vulnerability assessment of a number of critically-important infrastructure components, namely major river crossings, dams and levees, and hazardous materials storage tanks, located within eight states surrounding the New Madrid Seismic Zone in the central United States. Approximate threshold values have been determined for use in rapid earthquake damage assessment of the aforementioned infrastructure components.

Using PGA as the ground shaking intensity parameter, approximate threshold values, corresponding to the four damage state levels described in HAZUS, are proposed for each subcategory of the various infrastructure components.

The following conclusions are achieved as a result of the literature reviewed in this study:

Continuous and simply supported truss bridges constitute nearly three quarters of the total MRCs inventory investigated. However, it is crucial to note that bridges constructed before the 1940s, movable bridges, and older truss bridges were particularly vulnerable. Furthermore, previous research indicated that damage to these types of bridges were underestimated by the HAZUS procedure, which categorizes movable bridges and older trusses as 'other' bridges. This indicates how serious the consequences of seismic events are and suggests the necessity of the vulnerability assessment of this infrastructure in order to mitigate the potential damage and loss in future earthquakes.

It is observed that simply supported bridges are less vulnerable than continuous bridges.

It is important to state that truss bridges are as vulnerable as the steel girder bridges, especially in low damage levels.

Transportation networks with collapsed bridges could lead to loss of system functionality and hamper post-earthquake disaster response. Hence, it is essential to ensure that bridges that sustain damage can retain their traffic carrying capacities to ensure that emergency relief resources are dispatched to the impact area in a timely manner.

Although it was common to classify MRCs simply based on their construction type and construction material, it should be emphasized that seismic vulnerability of the bridges greatly depends on the bridge type, materials, year of construction, site conditions, liquefaction, and mobility, among others. Even though the comprehensive fragility analyses of such complex structural systems are time consuming, they are necessary in order to reduce the uncertainties and basic engineering judgment. Fragility relationships based on analytical modeling provide more reasonably accurate vulnerability assessments, than the threshold values proposed in this study. Further work on these analytical and bridge-specific fragilities will improve the damage characterizations that are based on the threshold values presented herein.

The majority of the dams located in the eight states are categorized as earth dams, concrete gravity, and arch dams.

Based on the proposed approximate threshold values generated from previous research, which are based on the records from post-earthquake surveys predominantly, it is evident that earth dams are relatively more vulnerable when compared to concrete gravity and arch dams.

It should be underlined that floods continue to pose an important threat to the property and safety of population centers in the United States. Inhabitants face a serious threat of flooding due to earthquake damage to dams and levees. The annual economic loss due to floods is estimated in the billions of dollars. Hence, dam and levees safety should be a major concern of the engineers and necessary measures should be taken to reduce risks.

Past earthquakes have shown that steel and concrete storage tanks are some of the most important and common types of hazardous materials storage tanks and are quite vulnerable infrastructure elements to seismic activity.

Although the approximate threshold values defined in HAZUS do not consider the fill level and H/D ratios of tanks, previous studies primarily based on post-earthquake field observation of damage to storage tanks, confirmed that the ratio of fill level (% full) and H/D (height/diameter) ratio considerably affect the response of the tanks.

The values of pass-fail peak ground accelerations presented in this study are ready for use in regional impact assessment in the Central USA. The methodology is applicable to other situations where detailed analytical modeling approaches are not feasible.

Under the constraints of limited resources and budget, it is vital to prioritize the MRCs, dams and levees, and storage tank infrastructure systems for seismic retrofit with an optimal strategy. Since it is not possible to retrofit all systems, it would be highly recommended that the most essential systems should be retrofitted for seismic hazard.

5. REFERENCES

Al-Homoud, A.S., 1995, "Evaluation of Seismic Hazard, Local Site Effect, Liquefaction Potential, and Dynamic Performance of a World Example of an Embankment Dam Characterized by Very Complex and Unique Foundations Conditions: Karameh Dam in the Jordan Valley", *Bulletin of the International Association of Engineering Geology*, Paris, No.52,October 1995, pp.9-32.

American Lifeline Alliance (ALA), 2001, "Seismic Fragility Formulation for Water System: Part 1:Guideline", *ASCE*.

API 650: "Welded Storage Tanks for Oil Storage", *American Petroleum Institute Standard*, Washington D.C., 2003.

Behr, J., K. Hudnut, N. King, 1998, "Monitoring Structural Deformation at Pacoima Dam, California Using Continuous GPS," *Proceedings of ION* (The Institute of Navigation) GPS.

Berahman, F., F. Behnamfar, 2007, "Seismic Fragility Curves for Un-Anchored On-Grade Steel Storage Tanks: Bayesian Approach," *Journal of Earthquake Engineering*, Vol.11, pp.166-192.

Bessason B., E. Haflidason, 2004, "Recorded and Numerical Strong Motion Response of a Base-Isolated Bridge," *Earthquake Spectra*, Vol.20, No.2, pp.309-331.

Boulanger, R.W., J.M. Duncan, Geotechnical Engineering Photo Album from http://cee.engr.ucdavis.edu/faculty/boulanger/geo_photo_album/GeoPhoto.html

Choi, E., R. DesRoshes, B. Nielson, 2004. ,"Seismic Fragility of Typical Bridges in Moderate Seismic Zones," *Engineering Structures*, Vol.26, pp.187-199.

Chopra, A.K., 1992, “Earthquake Analysis, Design and Safety evaluation of Concrete Arch Dams,” *Proceedings of the Tenth World Conference on Earthquake*, Spain, Vol.8, p.6763.

Chopra, A.K., P. Chakrabarti, 1973, “The Koyna Earthquake and The Damage to Koyna Dam,” *Bulletin of Seismological Society of America*, Vol.63, No.2, pp.381-392, April, 1973.

Elnashai, A.S., B. Borzi, S. Vlachos, 2004, "Deformation-based vulnerability functions for RC bridges," *Journal of Structural Engineering and Mechanics*, February.

Elnashai, A.S., A. Mwafy, Oh-Sung Kwon, 2006, “Analytical Assessment of a Major Bridge in the New Madrid Seismic Zone,” *Transportation Research Board of the National Academies*, Report No: A15.

Elnashai, A.S., L.J. Cleveland, T. Jefferson, J. Harrald, 2008, “Impact of Earthquakes on the Central USA”, Report No.08-02, Mid-America Earthquake (MAE) Center, University of Illinois at Urbana-Champaign, Urbana, IL.

Fabbrocino, G., I. Ievolino, F. Orlando, E. Salzano, 2005, “Quantitative Risk Analysis of Oil Storage Facilities in Seismic Areas,” *Journal of Hazardous Materials*, Vol.A123, pp.61-69.

FEMA, Federal Guidelines for Dam Safety, Earthquake Analyses and Design of Dams, May 2005.

FEMA 549, 2006, “Hurricane Katrina in the Gulf Coast,” Mitigation Assessment Team Report, Building Performance Observations, Recommendations, and Technical Guidance

Filiatrault, A., R. Tinawi, B. Massicotte, 1993, “Damage To Cable-Stayed Bridge During 1988 Saguenay Earthquake, II: Dynamic Analysis,” *Journal of Structural Engineering, ASCE*, 119(5); pp.1450-1463.

HAZUS, 1997, National Institute of Building Science“Earthquake Loss Estimation Methodology,” prepared by *Risk Management Solution*, Menlo Park, CA.

Hildenbrand, T.G.,V.E. Langenheim, E. Schweig, P.H. Stauffer, J.W. Hendley II, 1996, “*Uncovering Hidden Hazards in the Mississippi Valley*” from http://quake.usgs.gov/prepare/factsheets/HiddenHazs/.

Honda, R., S. Aoi, N. Morikawa, H. Sekiguchi, T. Kunugi, and H. Fujiwara, 2005, “Ground motion and rupture process of the 2004 Mid Niigata Prefecture earthquake obtained from strong motion data of K-NET and KiK-net,” *Earth Planets Space*, Vol. 57, pp.527–532.

Housner G.W., August, 1954, “Earthquake Pressures on Fluid Containers,” *8th Technical Report under Office of Naval Research*, California Institute of Technology, Pasadena, California.

Hwang, H., J.B. Jernigan, Y. Lin, 2000, “Evaluation of Seismic Damage to Memphis Bridges and Highway Systems,” *Journal of Bridge Engineering*, ASCE 2000, 5(4); pp.322-330.

Jaiswal, O.R., C.R. Durgesh, K.J. Sudhir, 2007, “Review of Seismic Codes on Liquid-Containing Tanks” *Earthquake Spectra*, Vol.23(1), pp.239-260.

Karim, K.R., F. Yamazaki, 2000, “Comparison of Empirical and Analytical Fragility Curves for RC Bridge Piers in Japan”, *8th Specialty Conference on Probabilistic Mechanics and Structural Reliability*, pp.1-6.

Karim, K.R., Yamazaki, F., 2001, "Effect of Earthquake Ground Motions on Fragility Curves of Highway Bridge Piers Based on Numerical Simulation," *Journal of Earthquake Engineering and Structural Dynamics*, Vol.30, pp.1839-1856.

Luther, L., 2008, "Disaster Debris Removal After Hurricane Katrina: Status and Associated Issues," CRS Report for Congress, Congressional Research Service, from http://ftp.fas.org/sgp/crs/misc/RL33477.pdf

Miller E.A., G.A. Roycroft, 2004, "Seismic Performance and Deformation of Levees: Four Case Studies," *Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, April 2004, pp.344-354.

MDNR, 2008, Missouri Department of Natural Resources, Division of Geology and Land Sources Technical Bulletin from
http://www.dnr.mo.gov/geology/geosrv/geores/techbulletin1.htm

Mississippi River Bridge Crossings from,
http://en.wikipedia.org/wiki/Mississippi_River#Bridge_crossings.

National Institute of Building Sciences, N. (2003), Multi-Hazard Loss Estimation Methodology, Earthquake Model, Washington, D.C., Federal Emergency Management Agency (FEMA), Technical and User's Manual.

Nielson, Bryant G., R. DesRoshes, 2007, "Analytical Seismic Fragility Curves for Typical Bridges in the Central and Southeastern United States", *Earthquake Spectra*, Vol.23, No. 3, pp. 615-633.

Nusier, O.K., A.S. Alawneh, 2006, "Kafrein Earth Dam Probabilistic Seismic Hazard Assessment", *Soil Mechanics and Foundation Engineering*, Vol.43, No.6, pp.211-215.

O'Rourke, M.J. and P. So, 2000, "Seismic Fragility Curves for On-Grade Steel Tanks," *Earthquake Spectra*, Vol.16(4), pp.801-814.

R. W. Boulanger's Career Award CMS-9502530, Virginia Tech through J. M. Duncan's University Distinguished Professorship and the Center for Geotechnical Practice and Research, the PEER Center, and the UC Davis Teaching Resources Center Project,

Ranf, R.T., M.O. Eberhard, S. Malone, 2007, "Post-earthquake Prioritization of Bridge Inspections," *Earthquake Spectra*, Vol.23, No.1, pp.131-146.

Rathje, E.M., K. Kelson, S.A. Ashford, Y. Kawamata, I. Towhata, T. Kokusho, J.P. Bardet, 2006, "Geotechnical Aspects of the 2004 Niigata Ken Chuetsu, Japan, Earthquake," *Earthquake Spectra*, Vol.22, No.S1, pp.S23-S46.

Kilic, S.A., Z. Ozdemir, 2007, "Simulation of Sloshing Effects in Cylindrical Containers under Seismic Loading", *6. LS-DYNA Anwenderforum*, Frankenthal 2007, Bauwesen.

Shinozuka, M., M.Q. Feng, H. Kim, S. Kim, 2000, "Nonlinear Static Procedure for Fragility Curve Development," *Journal of Engineering Mechanics*, ASCE 2000, 126(12); pp.1287-1295.

Shinozuka, M., M.Q. Feng, J. Lee, T. Naganuma, 2000, "Statistical Analysis of Fragility Curves," *Journal of Engineering Mechanics*, ASCE 2000, 126(12); pp.1224-1231.

Shinsaku, Z., 2003, "Damage and Failure of Oil Storage Tanks due to the 1999 Kocaeli Earthquake in Turkey and Chi-Chi Earthquake in Taiwan," *Journal of High Pressure Institute of Japan*, Vol.41; No.2; pp.79-86 from http://sciencelinks.jp/j-east/article/200311/000020031103A0275606.php

Shinsaku, Z., M. Yamada, H. Nishi, M. Hirokawa, K. Hatayama, T. Yanagisawa, R. Inoue, 2003, “Damage of Oil Storage Tanks due to the 2003 Tokachi-oki Earthquake,” *http://www.fri.go.jp/*

Tepel, R.E., 1985, "The Morgan Hill Earthquake of April 24, 1984-Effects on Facilities of the Santa Clara Valley Water District", *Erthquake Spectra*, Vol.1, No.3, pp.633-656.

Trifunac, M.D, D.E. Hudson, 1971, “Analysis of The Pacoima Dam Accelerogram – San Fernando, California, Earthquake of 1971,” *Bulletin of Seismological Society of America*, Vol.61, No.5, pp.1393-1141.

Wozniak, R.S, W.W. Mitchell, 1978, “Basis of Seismic Design Provisions for Welded Steel Oil Storage Tanks,” *American Petroleum Institute, 43rd Mid-year Meeting*, Session on Advances in Storage Tank Design, Toronto, Canada.

6. APPENDIX A : Bridges

There are 127 major river crossings located on five rivers (the Mississippi, Ohio, Missouri, Illinois, and Arkansas Rivers) within the eight states of interest in the central U.S.: Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee.

Appendix A gives brief information about each major river crossings considered. Most of the images and the brief summaries are provided from two sources:

i) http://en.wikipedia.org/wiki/Mississippi_River#Bridge_crossings, and

ii) http://www.johnweeks.com/menu/hwy.html.

1. Caruthersville Bridge

Carries	4 lanes of I-155 / US 412
Crosses	Mississippi River
Locale	Caruthersville, Missouri and Dyersburg, Tennessee
Design	Cantilever bridge
Longest span	920 feet (280 m) and 520 feet (158 m)
Total length	7,102 feet (2,165 m)
Width	78 feet (24 m)
Clearance below	99 feet (30 m)
Opening date	December 1, 1976
Coordinates	36°06′54″N 89°36′47″W

The **Caruthersville Bridge** is a cantilever bridge carrying Interstate 155 and U.S. Route 412 across the Mississippi River between Caruthersville, Missouri and Dyersburg, Tennessee.

The Caruthersville Bridge on I-155 has 59 spans with a total length of 7,100 feet and was built in the early seventies across the Mississippi River between Missouri and Tennessee. The site is in the vicinity of the New Madrid central fault, at a distance of about 5 km from a presumed major fault. The superstructure consists of eleven units supported on a variety of elastomeric and steel bearings. The main river crossing is composed of two-span cantilever steel truss and ten-span steel girders, whilst approach spans are precast prestressed concrete girders. The substructure includes piers on deep caissons and bents on steel friction piles. (Elnashai et al. 2006)

2. Harahan Bridge

Memphis&Arkansas Bridge (*left*), Frisco Bridge (*center*), Harahan Bridge (*right*)

Carries	Rail line
Crosses	Mississippi River
Locale	West Memphis, Arkansas and Memphis, Tennessee
Maintained by	Union Pacific Railroad
Design	Cantilevered through Truss bridge
Longest span	791 feet (241 m)
Total length	4,973 feet (1,516 m)
Clearance below	108 feet (33 m)
Opening date	July 14, 1916
Coordinates	35°07′45″N 90°04′33″W

The **Harahan Bridge** is a cantilevered through truss bridge carrying two rail lines across the Mississippi River between West Memphis, Arkansas and Memphis, Tennessee. The bridge also carried motor vehicles from 1917-1949, when the Memphis & Arkansas Bridge opened. The bridge is currently owned by Union Pacific Railroad.

3. Lyons-Fulton Bridge

Carries	2 lanes of Iowa Highway 136/IL-136
Crosses	Mississippi River
Locale	Clinton, Iowa and Fulton, Illinois
Design	Truss bridge
Opening date	January 1975
Coordinates	41°51′53″N 90°10′23″W

The **Lyons-Fulton Bridge** (actually named the Mark N. Morris Bridge, but locally called the North Bridge) is a 2 lane automobile truss bridge across the Mississippi River in the United States. It connects the cities of Clinton, Iowa and Fulton, Illinois. (The town of Lyons, Iowa, was annexed to Clinton in 1895, but the north end of the city is still referred to as Lyons; hence the name Lyons-Fulton Bridge). The bridge is the terminus of both Iowa Highway 136 and Illinois Route 136.

The bridge was opened in January 1975, replacing an older span upstream that once carried the Lincoln Highway, U.S. Route 30. The older span, was originally built in 1891 with a wooden deck; this was replaced in 1933 with a metal grate to allow snow to melt through.

4. Quincy Bayview Bridge

Carries	2 lanes of Westbound US 24
Crosses	Mississippi River
Locale	West Quincy, Missouri Quincy, Illinois
Design	Cable-stayed bridge
Longest span	900 feet (274 m)
Total length	4,507 feet (1,374 m)
Width	27 feet (8 m)
Clearance below	63 feet (19 m)
Opening date	August 22, 1987
Coordinates	39°56′00″N, 91°25′17″W

The **Bayview Bridge** is a cable-stayed bridge bringing westbound U.S. Highway 24 over the Mississippi River. It connects the cities of West Quincy, Missouri and Quincy, Illinois. Eastbound U.S. 24 is served by the older Quincy Memorial Bridge.

The bridge was built to alleviate traffic over the downstream Memorial Bridge. It was built prior to the extension of Interstate 72 west into Hannibal, Missouri. Traffic levels increased when the existing, downstream U.S. Highway 36 bridge over the Mississippi River was closed to make room for the new Interstate 72 bridge.

5. Cairo Mississippi River Bridge

Carries	2 lanes of US 60/US 62
Crosses	Mississippi River
Locale	Bird's Point, Missouri and Cairo, Illinois
Design	Cantilever bridge
Longest span	701 feet (214 m)
Total length	5,175 feet (1,577 m)
Clearance below	114 feet (35 m)
Opening date	1929
Coordinates	36°58′43″N 89°08′52″W

The **Cairo Mississippi River Bridge** is a cantilever bridge carrying U.S. Route 60 and U.S. Route 62 across the Mississippi River between Bird's Point, Missouri and Cairo, Illinois.

Traveling downstream, the Cairo Mississippi River Bridge is the last bridge across the Mississippi River before the confluence of the Mississippi and Ohio Rivers.

6. Cairo I-57 Bridge

Carries	4 lanes of I-57
Crosses	Mississippi River
Locale	Charleston, Missouri and Cairo, Illinois
Design	Arch bridge
Longest span	821 feet (250 m)
Clearance below	107 feet (33 m)
Opening date	1978
Coordinates	37°01′23″N 89°12′42″W

The **Cairo I-57 Bridge** is an arch bridge carrying Interstate 57 across the Mississippi River between Charleston, Missouri and Cairo, Illinois.

This bridge is the newest of the three major river bridges that cross the Mississippi and Ohio rivers at the little town of Cairo, Illinois.

7. Thebes Bridge

Carries	Union Pacific, previously the Missouri Pacific Railroad
Crosses	Mississippi River
Locale	Illmo, Missouri and Thebes, Illinois
Design	Continuous truss bridge
Longest span	651 feet (198 m)
Total length	3,959 feet (1,207 m)
Clearance below	104 feet (32 m)
Opening date	April 18, 1905
Coordinates	37°13′00″N 89°28′01″W

The **Thebes Bridge** is a truss bridge carrying the Union Pacific Railroad (previously carried the Missouri Pacific and Southern Pacific, in a joint operation) across the Mississippi River between Illmo, Missouri and Thebes, Illinois.

8. Bill Emerson Memorial Bridge

Carries	4 lanes of MO 34/MO 74/IL 146
Crosses	Mississippi River
Locale	Cape Girardeau, Missouri and East Cape Girardeau, Illinois
Design	Cable-stayed bridge
Longest span	1,149 feet (350 m)
Total length	3,955 feet (1,205 m)
Width	94 feet (29 m)
Clearance below	60 feet (18 m)
Opening date	December 13, 2003
Coordinates	37°17′43″N 89°30′57″W

The **Bill Emerson Memorial Bridge** is a cable-stayed bridge connecting Missouri's Route 34 and Route 74 with Illinois Route 146 across the Mississippi River between Cape Girardeau, Missouri and East Cape Girardeau, Illinois.

It was built just south of its predecessor, the Cape Girardeau Bridge, which was completed in 1928 and demolished in 2004. Prior to its destruction, it was documented for the Library of Congress Historic American Engineering Record Survey number HAER MO-84.

The bridge is named after Bill Emerson, a Missouri politician who served in the U.S. House of Representatives from 1981 until his death in 1996.

9. Chester Bridge

Carries	2 lanes of MO 51/IL 150
Crosses	Mississippi River
Locale	Perryville, Missouri and Chester, Illinois
Design	Truss bridge
Longest span	670 feet (204 m)
Total length	2,826 feet (861 m)
Width	22 feet (7 m)
Clearance below	104 feet (32 m)
Opening date	August 23, 1942
Coordinates	37°54′11″N, 89°50′11″W

The **Chester Bridge** is a truss bridge connecting Missouri's Route 51 with Illinois Route 150 across the Mississippi River between Perryville, Missouri and Chester, Illinois. The Chester Bridge can be seen in the beginning of the 1967 film "in the Heat of the Night".

In the 1940's the main span was destroyed by a tornado. The current span was built to replace it on the original piers.

10. Crescent City Connection

Carries	8 lanes of BUS US 90 / I-910 2 reversible HOV lanes
Crosses	Mississippi River
Locale	New Orleans, Louisiana
Design	Twin steel truss cantilever bridges
Longest span	1,575 ft (480 m)
Total length	13,428 ft (4,093 m)
Width	52 ft (16 m) (eastbound) 92 ft (28 m) (westbound)
Clearance below	170 ft (52 m)
Opening date	April 1958 (eastbound) September 1988 (westbound)
Coordinates	29°56′19″N, 90°03′27″W

The **Crescent City Connection**, abbreviated as **CCC**, (formerly the **Greater New Orleans Bridge**) refers to twin cantilever bridges that carry U.S. Route 90 Business over the Mississippi River in New Orleans, Louisiana. They are tied as the fifth-longest cantilever bridges in the world. Each span carries four general-use automobile lanes; additionally the westbound span has two reversible HOV lanes across the river. It is the most downstream bridge on the Mississippi River.

11. Hernando de Soto Bridge

Carries	6 lanes of I-40
Crosses	Mississippi River
Locale	West Memphis, Arkansas and Memphis, Tennessee
Design	Through arch bridge
Longest span	900 feet (274 m) each
Total length	19,535 feet (5,954 m)
Width	90 feet (27 m)
Clearance below	109 feet (33 m) (varies some due to river level)
Opening date	August 2, 1973
Coordinates	35°09′10″N 90°03′50″W

The **Hernando de Soto Bridge** is a through arch bridge carrying Interstate 40 across the Mississippi River between West Memphis, Arkansas and Memphis, Tennessee. It is often called the "M Bridge" as the arches resemble the letter M. Memphians also call the bridge the "New Bridge", as it is newer than the Memphis & Arkansas Bridge (carrying Interstate 55) downstream.

The bridge is named for 16th century Spanish explorer Hernando de Soto who explored this stretch of the Mississippi River.

On August 27, 2007, an inspector discovered that a bridge pier on the approach bridge west of the river had settled overnight, and the bridge was subsequently closed to perform a precautionary inspection. The bridge was reopened later that day.

12. Frisco Bridge

Memphis&Arkansas Bridge (*left*), Frisco Bridge (*center*), Harahan Bridge (*right*)

Carries	1 BNSF Railway rail line
Crosses	Mississippi River
Locale	West Memphis, Arkansas and Memphis, Tennessee
Design	Cantilevered through Truss bridge
Longest span	791 feet (241 m)
Total length	4,887 feet (1,490 m)
Width	30 feet (9 m)
Clearance below	109 feet (33 m)
Opening date	May 12, 1892
Coordinates	35°07′43″N, 90°04′35″W

The **Frisco Bridge**, previously known as the **Memphis Bridge**, is a cantilevered through truss bridge carrying a rail line across the Mississippi River between West Memphis, Arkansas and Memphis, Tennessee.

At the time of the Memphis Bridge construction, it was a significant technological challenge. No other bridges had ever been attempted on the Lower Mississippi River. Besides the difficulty of crossing this far south, it was required to provide at least 75 feet clearance, have a main span of more than 770 ft for the main river channel. It was also required to provide for vehicular and pedestrian traffic on the same level as the rail traffic. Construction began in 1888 and was completed May 12, 1892. In the end the project created a bridge that was the farthest south on the Mississippi River, featured the longest span in the United States. The bridge is listed as a Historic Civil Engineering Landmark.

13. Memphis & Arkansas Bridge

Memphis&Arkansas Bridge (*left*), Frisco Bridge (*center*), Harahan Bridge (*right*)

Carries	4 lanes of I-55/US 61/US 64/US 70/US 79
Crosses	Mississippi River
Locale	West Memphis, Arkansas and Memphis, Tennessee
Design	Cantilevered through Truss bridge
Longest span	770 feet (235 m)
Total length	5,222 feet (1,592 m)
Width	52 feet (16 m)
Clearance below	112 feet (34 m)
Opening date	December 17, 1949
Coordinates	35°07′42″N, 90°04′36″W

The **Memphis & Arkansas Bridge** is a cantilevered through truss bridge carrying Interstate 55 across the Mississippi River between West Memphis, Arkansas and Memphis, Tennessee. It is referred as the "Old Bridge" to distinguish it from the "New Bridge", or Hernando de Soto Bridge, upstream.

The span is unusual among interstate bridges for the fact that it has a carriageway alongside the vehicular traffic lane that is capable of carrying both pedestrian and bicycle traffic. This area is positioned just outside the main steel support girders on the south side of the bridge and is accessible from the interstate right-of-way on the Arkansas side and a sidewalk access on the Memphis side.

14. Savanna-Sabula Bridge

Carries	2 lanes of U.S. Route 52/Iowa Highway 64/IL 64
Crosses	Mississippi River
Locale	Savanna, Illinois and Sabula, Iowa, River Mile 537.8
Design	Steel truss through deck
Total length	2,482 feet
Width	20 Feet, 2 lanes
Opening date	December 31, 1932
Coordinates	42°06′16″N 90°09′38″W

The **Savanna-Sabula Bridge** is a truss bridge and causeway crossing the Mississippi River and connecting the city of Savanna, Illinois with the island city of Sabula, Iowa. The bridge carries U.S. Highway 52 over the river. It is also the terminus of both Iowa Highway 64 and Illinois Route 64.

15. Sabula Rail Bridge

Carries	Single railroad track
Crosses	Mississippi River
Locale	Sabula, Iowa and Savanna, Illinois
Design	Steel truss bridge with swing span
Coordinates	42°03′51″N 90°09′58″W

The **Sabula Rail Bridge** is a swing bridge that carries a single rail line across the Mississippi River between the island town of Sabula, Iowa and Savanna, Illinois. Originally built for the Milwaukee Railroad, the bridge is operational and is currently owned by the Iowa, Chicago and Eastern Railroad.

16. Huey P. Long Bridge

Carries	4 lanes of US 90 2 tracks of the NOPB
Crosses	Mississippi River
Locale	Jefferson Parish, Louisiana
Design	Cantilever truss bridge
Longest span	790 feet (241 m)
Total length	8,076 feet (2,462 m) (road) 22,996 feet (7,009 m) (rail)
Clearance below	153 feet (47 m)
Opening date	December 1935
Coordinates	29°56′39″N, 90°10′08″W

The **Huey P. Long Bridge** in Jefferson Parish, Louisiana, is a cantilevered steel through truss bridge that carries a two-track railroad line over the Mississippi River.

Opened in December 1935 to replace the Walnut Street Ferry Bridge. The bridge was the first Mississippi River span built in Louisiana and the 29th along the length of the river.

The widest clean span is 790 feet (240 m) long and sits 135 feet (41 m) above the water. There are three navigation channels below the bridge, the widest being 750 feet (230 m). The distinctive rail structure is 22,996 feet (7,009 m) long and extends as a rail viaduct well into the city. The highway structure is 8,076 feet (2,462 m) long with extremely steep grades on both sides. Each roadway deck is a precarious 18 feet (5.5 m) wide, with 2 9-foot lanes, but because of the railroad component, is unusually flat for a bridge of this height. Normally, bridges this high have a hump to accommodate the height but this bridge is flat to accommodate rail traffic.

The bridge is the longest railroad bridge in the U.S.

17. New Chain of Rocks Bridge

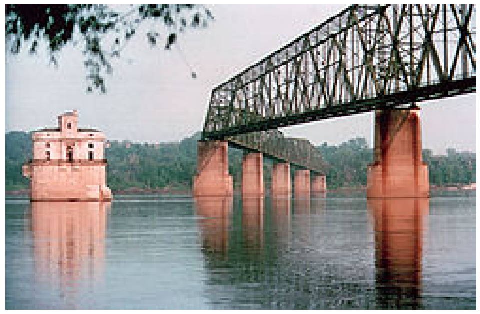

New bridge in foreground, old bridge background

Carries	4 lanes of I-270
Crosses	Mississippi River
Locale	St. Louis, Missouri
Opening date	September 2, 1966
Coordinates	38°45′53″N 90°10′25″W

The New Chain of Rocks Bridge is a pair of bridges across the Mississippi River on the north edge of St. Louis, Missouri. It was constructed in 1966 to bypass the Chain of Rocks Bridge immediately to the south. It originally carried traffic for Bypass US 66 and currently carries traffic for Interstate 270. The bridge opened to traffic on September 2, 1966.

The original Chain of Rocks Bridge was a narrow bridge with a 22 degree bend midway over the river. Reportedly, two tractor-trailers could not pass each other on that bridge. The Illinois Department of Transportation marks Historic Route 66 over the New Chain of Rocks Bridge, but it is only considered a way to make the route continuous.

18. Chain of Rocks Bridge



Carries	Pedestrians and bicycles
Crosses	Mississippi River
Locale	St. Louis, Missouri
Maintained by	Trailnet
Design	Cantilever through-truss
Total length	5,353 feet (1,632 m)
Width	24 feet (7 m)
Opening date	1929
Coordinates	38°45′38″N, 90°10′35″W

The **Chain of Rocks Bridge** spans the Mississippi River on the north edge of St. Louis, Missouri. The eastern end of the bridge is on Chouteau Island, (part of Madison, Illinois), while the western end is on the Missouri shoreline.

The Bridge was the route used by U.S. Route 66 to cross over the Mississippi. Its most notable feature is a 22-degree bend occurring at the middle of the crossing, necessary for navigation on the river. Originally a motor route, it now carries walking and biking trails over the river.

The bridge's name comes from a rock-ledged reach of river literally described as a chain of rocks, stretching for seven miles (11 km) immediately to the north of the city of St. Louis.

The bridge was built in 1929. In the late 1930s, Bypass US 66 was designated over this bridge and around the northern and western parts of St. Louis to avoid the downtown area (City US 66 continued to cross the Mississippi River over the MacArthur Bridge). In 1967, the New Chain of Rocks Bridge was built immediately to the bridge's north in order to carry I-270; the Chain of Rocks Bridge was subsequently closed in 1967.

19. Clark Bridge

Carries	4 lanes of US 67
Crosses	Mississippi River
Locale	West Alton, Missouri and Alton, Illinois
Design	Cable-stayed bridge
Longest span	756 feet (230 m)
Total length	4,620 feet (1,408 m)
Opening date	January 1994
Coordinates	38°52′56″N, 90°10′44″W

The **Clark Bridge** (sometimes referred to as the **Superbridge** as the result of its construction being the subject of a documentary aired by Nova) is a cable-stayed bridge across the Mississippi River between West Alton, Missouri and Alton, Illinois.

The bridge was built in 1994 and carries U.S. Route 67 across the river. It is the northernmost river crossing in the St. Louis metropolitan area. The new Clark Bridge replaces the *old Clark Bridge*, a truss bridge built in 1928, also named after explorer William Clark. The bridge carries four lanes of divided highway traffic, as well as two bike lanes, whereas the old bridge only carried two lanes (similar to the upstream Champ Clark Bridge).

20. Martin Luther King Bridge

Carries	4 lanes of Image:MO-799.svg Route 799
Crosses	Mississippi River
Locale	St. Louis, Missouri and East St. Louis, Illinois
Design	Cantilever truss bridge
Longest span	962 feet (293 m)
Total length	4,009 feet (1,222 m)
Width	40 feet (12 m)
Vertical clearance	19.4 feet (6 m)
Clearance below	98 feet (30 m)
Opening date	1951
Coordinates	38°37′52″N 90°10′46″W

The **Martin Luther King Bridge** (formerly known as the **Veterans Bridge**) in St. Louis is a cantilever truss bridge of about 4000 feet in total length across the Mississippi River, connecting St. Louis with East St. Louis, Illinois. The bridge serves as traffic relief connecting the concurrent freeways of Interstate 55, Interstate 70, Interstate 64, and U.S. Route 40 with the downtown streets of St. Louis.

The bridge was built in 1951 as the **Veterans' Memorial Bridge** to relieve congestion on the MacArthur Bridge to the south.

Eventually, ownership was transferred dually to the Missouri and Illinois Departments of Transportation and the bridge was renamed after Martin Luther King, Jr. In the spring of 1989, the rebuilt bridge was reopened.

21. Eads Bridge

Carries	4 highway lanes 2 MetroLink tracks
Crosses	Mississippi River
Locale	St. Louis, Missouri and East St. Louis, Illinois
Design	Arch bridge
Longest span	520 feet (158 m)
Total length	6,442 feet (1,964 m)
Width	46 feet (14 m)
Clearance below	88 feet (27 m)
Opening date	1874
Coordinates	38°37′45″N 90°10′47″W

The **Eads Bridge** is a combined road and railway bridge over the Mississippi River at St. Louis, connecting St. Louis and East St. Louis, Illinois.

When completed in 1874, the Eads Bridge was the longest arch bridge in the world, with an overall length of 6,442 feet (1,964 m). The ribbed steel arch spans were considered daring, as was the use of steel as a primary structural material: it was the first such use of true steel in a major bridge project.

The Eads Bridge was also the first bridge to be built using cantilever support methods exclusively, and one of the first to make use of pneumatic caissons. The particular physical difficulties of the site stimulated interesting solutions to construction problems. The deep caissons used for pier and abutment construction signalled a new chapter in civil engineering. The triple span, tubular metallic arch construction was supported by two shore abutments and two mid-river piers. The Eads Bridge is still in use.

22. McKinley Bridge

Carries	1 dedicated service lane, 2 lanes of traffic, and 1 dedicated pedestrian/bicycle lane
Crosses	Mississippi River
Locale	St. Louis, Missouri and Venice, Illinois
Design	Steel truss bridge
Longest span	3 519 feet (158 m) spans
Total length	6,313 feet (1,924 m)
Clearance below	90 feet (27 m)
Opening date	November 10, 1910 November 17, 2007 (pedestrian reopening) December 17, 2007 (full reopening)
Coordinates	38°39′54″N 90°10′58″W

The **McKinley Bridge** is a steel truss bridge across the Mississippi River. It connects northern portions of the city of St. Louis, Missouri with Venice, Illinois. It opened in 1910 and was taken out of service on October 30, 2001. The bridge was reopened for pedestrian and bicyclists on a November 17, 2007. Since December 2007, McKinley has been open to vehicular traffic as well. The bridge carried both railroad and vehicular traffic across the Mississippi River for decades. By 1978, the railroad line over the span was closed, and an additional set of lanes were opened for vehicles in the inner roadway.

Rehabilitation began in 2004. The Bridge reopened to pedestrians and bicycles on November 17, 2007. The bridge was fully reopened to traffic on December 17, 2007.

23. Poplar Street Bridge

Official name	Bernard F. Dickmann Bridge
Carries	8 lanes of I-55/I-64/I-70/US 40
Crosses	Mississippi River
Locale	St. Louis, Missouri and East St. Louis, Illinois
Design	Steel girder bridge
Longest span	600 feet (183 m)
Total length	2,164 feet (660 m)
Width	104 feet (32 m)
Clearance below	92 feet (28 m)
Opening date	1967
Coordinates	38°37′05″N 90°10′59″W

The **Poplar Street Bridge**, officially the **Bernard F. Dickmann Bridge**, completed in 1967, is a 647-foot (197 m) long (197m) deck girder bridge across the Mississippi River between St. Louis, Missouri and East St. Louis, Illinois. The bridge arrives on the Missouri shore line just south of the Gateway Arch.

Interstate 55, Interstate 64, Interstate 70, and U.S. Route 40 cross the Mississippi on the Poplar Street bridge. It is crossed by approximately 120,000 vehicles daily, making it possibly the most heavily used bridge on the river.

24. MacArthur Bridge

Carries	Terminal Railroad Association of St. Louis, Union Pacific
Crosses	Mississippi River
Locale	St. Louis, Missouri and East St. Louis, Illinois
Design	Truss bridge
Longest span	677 feet (206 m)
Total length	18,261 feet (5,566 m)
Clearance below	108 feet (33 m)
Opening date	1917
Destruction date	To auto traffic 1981
Coordinates	38°36′53″N 90°11′01″W

The MacArthur Bridge over the Mississippi River between St. Louis, Missouri and East St. Louis, Illinois is a 647 foot (197 m) long truss bridge. Construction on the bridge began in 1909 by the city of St. Louis to break the monopoly the Terminal Railroad Association of St. Louis had on the area's railroad traffic at the time. However, money ran out before the bridge approaches could be finished and the bridge did not open until 1917, and even then only to automobile traffic. Railroad traffic would not make use of the bridge's lower deck until 1928.

Initially, the bridge was called the "St. Louis Municipal Bridge" and known as the "Free Bridge."

The MacArthur Bridge was one of several bridges in St. Louis which carried U.S. Highway 66 until the completion of the nearby Poplar Street Bridge. At one time, U.S. Highway 460 crossed the bridge, terminating on the west side of the bridge. The bridge is now in use only by railroads.

25. Gateway Bridge

Carries	2 lanes of U.S. Route 30
Crosses	Mississippi River
Locale	Clinton, Iowa and Fulton, Illinois
Design	Suspension bridge
Opening date	June 1956
Coordinates	41°50′16″N 90°11′02″W

The **Gateway Bridge** (locally called the **South Bridge**) is a suspension bridge over the Mississippi River in Clinton, Iowa, USA. It carries U.S. Route 30 from Iowa into Illinois just south of Fulton, Illinois. The bridge itself is two travel lanes wide. The Gateway Bridge was closed in March 2006 for repainting and reconstruction of U.S. Route 30 on the Illinois side of the river, and reopened in November 2006. Traffic on U.S. Route 30 intending to cross the river was detoured north to the Lyons-Fulton Bridge.

26. Merchants Bridge

Carries	Rail line
Crosses	Mississippi River
Locale	St. Louis, Missouri
Design	Steel truss bridge
Opening date	1889
Coordinates	38°40′29″N 90°11′10″W

The **Merchants Bridge** is a rail bridge crossing the Mississippi River in St. Louis, Missouri owned by the Terminal Railroad Association of St. Louis. It opened in May 1889 and crossed the river three miles north of Eads Bridge.

The bridge was originally built by the St. Louis Merchants Exchange after it lost control of the Eads Bridge it had built to the Terminal Railroad. The Exchange feared a Terminal Railroad monopoly on the bridges but it would eventually lost control of the Merchants Bridge also.

27. Jefferson Barracks Bridge

Carries	6 lanes of I-255/US 50
Crosses	Mississippi River
Locale	St. Louis, Missouri and Columbia, Illinois
Design	Two tied arch bridges
Longest span	910 feet (277 m)
Total length	3,998 feet (1,219 m)
Clearance below	88 feet (27 m)
Opening date	September 30, 1983 (westbound) 1992 (eastbound)
Coordinates	38°29′14″N 90°16′38″W

The **Jefferson Barracks Bridge**, often called the **J.B. Bridge**, is a pair of bridges that span the Mississippi River on the south side of St. Louis, Missouri. Both bridges are 909-foot (277 m) long steel arch bridges. The first bridge was built in 1983, the south bridge opened in 1992. A delay occurred during the construction of the second bridge when a crane dropped a section of it into the river and it had to be rebuilt.

They replaced the former steel truss bridge built in 1941 that originally carried U.S. Highway 50. It carries traffic for Interstate 255 (part of the St. Louis beltway) and U.S. Highway 50.

28. Fred Schwengel Memorial Bridge

Carries	4 lanes of I-80
Crosses	Mississippi River
Locale	Le Claire, Iowa and Rapids City, Illinois
Total length	3,483 feet (1,062 m)
Width	66 feet (20 m)
Opening date	October 27, 1966
Coordinates	41°34′49″N 90°21′54″W

The **Fred Schwengel Memorial Bridge** is a 4-lane steel girder bridge that carries Interstate 80 across the Mississippi River between Le Claire, Iowa and Rapids City, Illinois.

The bridge opened October 27, 1966 and overlooks the Iowa and Illinois Welcome centers, as well as Rapids City, Illinois and LeClaire, Iowa.

The bridge is named for Fred Schwengel, a former U.S. Representative from Davenport, Iowa and one of the driving forces behind the Interstate Highway Act.

29. I-74 Bridge

Carries	4 lanes of I-74/U.S. Route 6
Crosses	Mississippi River
Locale	Bettendorf, Iowa and Moline, Illinois
Design	Twin suspension bridges
Total length	3,372 feet (1,028 m)
Width	27 feet (8 m)
Opening date	November 1935 (northbound) December 1959 (southbound)
Coordinates	41°31′12″N, 90°30′48″W

Originally known as the **Iowa-Illinois Memorial Bridge**, today it is more commonly referred to as the **I-74 Bridge**. The bridge crosses the Mississippi River and connects Bettendorf, Iowa and Moline, Illinois. It is located near the geographic center of the Quad Cities. The first span opened in 1935 as a toll bridge. In 1959 an identical twin span was added to satisfy increased traffic. The twin spans were upgraded to carry interstate traffic in the mid-1970's.

30. Rock Island Government Bridge

Carries	2 lanes of roadway 1 rail line
Crosses	Mississippi River
Locale	Davenport, Iowa and Rock Island, Illinois
Designer	Ralph Modjeski[1]
Design	two riveted Pratt trusses five riveted Baltimore trusses one pin-connected Baltimore swing truss
Material	steel
Total length	1,608 feet (490 m)
Width	27 feet (8 m)
Opening date	1896
Coordinates	41°31′09″N 90°34′01″W

The **Rock Island Government Bridge**, or Arsenal Bridge, spans the Mississippi River connecting Rock Island, Illinois and Davenport, Iowa. The current structure, the fourth in a succession at this location, includes a swing section to accommodate traffic navigating the locks. The first bridge, constructed in the early 1850s and located around 1500 feet upstream of the present, was the first bridge to ever span the Mississippi River. All that remains of the first bridge are two piers on opposite sides of the river.

The current Government Bridge is the fourth crossing of the Mississippi in this vicinity, having been built in 1896 on the same location and using the same piers as the 1872 structure.

31. Rock Island Centennial Bridge

Carries	4 lanes of US 67
Crosses	Mississippi River
Locale	Davenport, Iowa and Rock Island, Illinois
Design	Steel arch bridge
Total length	4,447 feet (1,355 m)[1]
Clearance below	66 feet (20 m)
Opening date	July 12, 1940[3]
Coordinates	41°30′54″N, 90°34′54″W

The **Centennial Bridge**, or Rock Island Centennial Bridge, connects Rock Island, Illinois and Davenport, Iowa. The bridge is 3,850 feet (1,173 m) long and stands 170 feet (52 m) above water level. Construction of the bridge began in 1938 and it opened on July 12, 1940.

It was originally going to be named the "Galbraith Bridge", after Rock Island's mayor at the time, Robert Galbraith. He suggested it be named the Centennial Bridge, in commemoration of the city of Rock Island's centennial.

The five arches of the bridge are a symbol often used to represent the Quad Cities.

32. Helena Bridge

Carries	2 lanes of US 49
Crosses	Mississippi River
Locale	Helena-West Helena, Arkansas and Lula, Mississippi
Design	Cantilever bridge
Longest span	804 feet (245 m)
Total length	5,204 feet (1,586 m)
Width	28 feet (9 m)
Clearance below	119 feet (36 m)
Opening date	July 27, 1961
Coordinates	34°29′48″N 90°35′17″W

The **Helena Bridge** is a cantilever bridge carrying US 49 across the Mississippi River between Helena-West Helena, Arkansas and Lula, Mississippi.

The main cantilever span was modeled on the similar Benjamin G. Humphreys Bridge which had been built downstream by Arkansas & Mississippi roughly two decades earlier. However, the river navigation issues that led to the pending replacement of the Humphreys Bridge with the Greenville Bridge do not apply to the Helena Bridge, as the river curve here is far less severe than the one just upstream from the Humphreys Bridge.

33. I-280 Bridge

Carries	4 lanes of I-280
Crosses	Mississippi River
Locale	Davenport, Iowa and Rock Island, Illinois
Design	Tied arch Bridge
Total length	4,194 feet (1,278 m)
Width	82 feet, 4 lanes
Opening date	October 25, 1973
Coordinates	41°28′45″N 90°37′56″W

The **I-280 Bridge** carries Interstate 280 across the Mississippi River between Davenport, Iowa and Rock Island, Illinois.

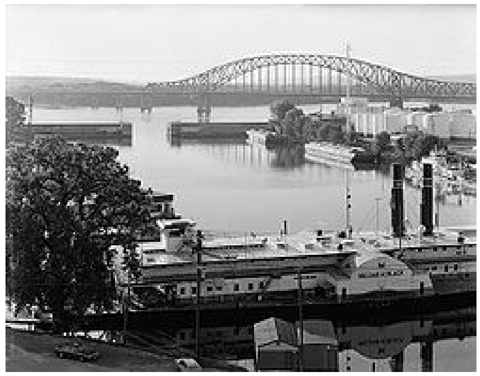
34. Dubuque-Wisconsin Bridge

Carries	4 lanes of U.S. Route 61/U.S. Route 151
Crosses	Mississippi River
Locale	Dubuque, Iowa, with Grant County, Wisconsin
Design	Tied arch bridge
Longest span	670 feet (204 m)
Total length	2,951 feet (899 m)
Clearance below	65 feet (20 m)
Opening date	August 21, 1982
Coordinates	42°30′56″N 90°38′08″W

The **Dubuque-Wisconsin Bridge** is a steel tied arch bridge connecting Dubuque, Iowa, with still largely rural Grant County, Wisconsin. It is an automobile bridge that traverses the Mississippi River. It is one of two automobile bridges in the Dubuque area. A railroad bridge is between them. The Julien Dubuque Bridge - the other automobile bridge - is located about three miles (5 km) south.

The bridge is a four lane, limited access bridge. It is part of the US Highway 61/151 route. This bridge replaced the older Eagle Point Bridge that previously served as the connection between Dubuque and Wisconsin.

35. Julien Dubuque Bridge



Carries	2 lanes of U.S. Route 20 1 pedestrian walkway
Crosses	Mississippi River
Locale	Dubuque, Iowa, and East Dubuque, Illinois
Design	Continuous steel arch truss bridge
Longest span	845 feet (258 m)
Total length	5,760 feet (1,756 m)
Width	29 feet (9 m)
Clearance below	64 feet (20 m)
Opening date	1943
Coordinates	42°29′30″N 90°39′22″W

The **Julien Dubuque Bridge** traverses the Mississippi River. It joins the cities of Dubuque, Iowa, and East Dubuque, Illinois. The bridge is part of the U.S. Highway 20 route. It is one of two automobile bridges over the Mississippi in the area (the Dubuque-Wisconsin Bridge three miles (5 km) north links Dubuque with Wisconsin), and is listed in the National Register of Historic Places. In 1942, the first parts of the bridge were begun. In 1943, the bridge was completed.

In the early 1990s, the bridge underwent an extensive renovation. The deck was completely replaced, and a new walkway was installed on the bridge.

On June 9, 2008 the bridge was struck by a number of runaway barges. On June 10th the Iowa Department of Transportation inspected the bridge and determined that it was safe and they had reopened the bridge to traffic.

36. Old Vicksburg Bridge

Carries	1 Kansas City Southern rail line, one service lane
Crosses	Mississippi River
Locale	Delta, Louisiana and Vicksburg, Mississippi
Design	Cantilever bridge
Longest span	825 feet (251 m)
Total length	8,546 feet (2,605 m)
Clearance below	116 feet (35 m)
Opening date	May 1, 1930
Coordinates	32°18′52″N 90°54′17″W

The **Old Vicksburg Bridge** is a cantilever bridge carrying one rail line across the Mississippi River between Delta, Louisiana and Vicksburg, Mississippi. Until 1998, the bridge was open to motor vehicles and carried US 80 across the Mississippi River, though one road lane runs through the bridge for inspection by workers.

37. Vicksburg Bridge

Carries	4 lanes of I-20/US 80
Crosses	Mississippi River
Locale	Delta, Louisiana and Vicksburg, Mississippi
Design	Cantilever bridge
Longest span	870 feet (265 m)
Total length	12,974 feet (3,954 m)
Width	60 feet (18 m)
Clearance below	116 feet (35 m)
Opening date	February 14, 1973
Coordinates	32°18′55″N 90°54′30″W

The **Vicksburg Bridge** is a cantilever bridge carrying Interstate 20 and US 80 across the Mississippi River between Delta, Louisiana and Vicksburg, Mississippi. Next to it is the Old Vicksburg Bridge.

38. Sunshine Bridge

Carries	4 lanes of LA 70
Crosses	Mississippi River
Locale	Sorrento, Louisiana and Donaldsonville, Louisiana
Design	Cantilever bridge
Longest span	825 feet (251 m)
Total length	8,236 feet (2,510 m)
Width	4 lanes
Clearance below	170 feet (52 m)
Opening date	August 1964
Coordinates	30°05′53″N 90°54′44″W

The **Sunshine Bridge** is a cantilever bridge over the Mississippi River in St. James Parish, Louisiana. Completed in 1963, it carries LA 70, which connects Donaldsonville on the west bank of Ascension Parish with Sorrento on the east bank of Saint James Parish as well as with Gonzales on the east bank of Ascension Parish. The approach roads on the east and west banks begin in Ascension Parish before crossing into St. James Parish.

At time of construction it was the only bridge across the Mississippi between New Orleans and Baton Rouge.

39. Norbert F. Beckey Bridge

Carries	2 lanes of Iowa Highway 92 and IL 92
Crosses	Mississippi River
Locale	Muscatine, Iowa and Illinois
Total length	3,018 feet (920 m)
Opening date	December 2, 1972
Coordinates	41°25′21″N, 91°02′01″W

The **Norbert F. Beckey Bridge**, or Beckey Bridge for short, carries Iowa Highway 92 and Illinois Route 92 across the Mississippi River between Muscatine, Iowa and Rock Island County, Illinois. Completed in December 1972, it replaced the Muscatine High Bridge which stood from 1891-1973. A pillar from the old High Bridge still stands at Riverside Park in Muscatine.

40. Louisiana Rail Bridge

Carries	Single track rail line
Crosses	Mississippi River
Locale	Louisiana, Missouri and Illinois
Coordinates	39°26′43″N 91°02′01″W

The **Louisiana Railroad Bridge** carries a single track rail line across the Mississippi River between Louisiana, Missouri and Pike County, Illinois. It is currently owned by the Kansas City Southern Railway. This bridge was opened for service in 1873.

41. Champ Clark Bridge

Carries	2 lanes of US 54
Crosses	Mississippi River
Locale	Louisiana, Missouri and Illinois
Design	Truss bridge
Longest span	418 feet (127 m)
Total length	2,286 feet (697 m)
Width	20 feet (6 m)
Opening date	1928
Coordinates	39°27′24″N 91°02′52″W

The **Champ Clark Bridge** is a five-span truss bridge over the Mississippi River connecting Louisiana, Missouri with the state of Illinois. It carries U.S. Route 54 northeast to Pittsfield, Illinois, where U.S. 54 terminates.

The bridge is narrow, allowing for two lanes of traffic on a 20 feet (6 m) deck. It was built in 1928. The bridge, originally painted silver, was repainted deep green in 1983, and repaired in 1999. In 2005, the Missouri Department of Transportation again rehabbed and repainted the bridge, replacing the green color of the bridge with gray. The bridge is 2,286.4 feet (697 m) in length. The span over the main channel of the Mississippi River is 418.5 feet (128 m) in length.

42. Burlington Rail Bridge

Carries	Double track rail line
Crosses	Mississippi River
Locale	Burlington, Iowa and Gulf Port, Illinois
Design	6 truss spans and one swing-span
Opening date	1893
Coordinates	40°47′55″N 91°05′31″W

The **Burlington Bridge** carries a double tracked rail lines across the Mississippi River between Burlington, Iowa, and Gulf Port, Illinois. The bridge is currently owned by BNSF Railway as part of its Chicago to Denver mainline. It is somewhat controversial in that its swing-span only allows one barge to pass at a time.

The original bridge at this location was constructed in 1868. It was reconstructed in 1893 in its current form.

43. Great River Bridge

Carries	4 lanes of US 34
Crosses	Mississippi River
Locale	Burlington, Iowa and Gulf Port, Illinois
Design	Cable-stayed bridge
Longest span	660 feet (201 m)
Total length	1,245 feet (379 m)
Width	27 feet (8 m)
Clearance below	60 feet (18 m)
Opening date	October 4, 1993
Coordinates	40°48′43″N, 91°05′44″W

The **Great River Bridge** is an asymmetrical, one-tower cable-stayed bridge over the Mississippi River. It carries U.S. Highway 34 from Burlington, Iowa to the town of Gulf Port, Illinois.

Construction began in 1989, but work on the main tower did not begin until April 1990. The main tower is 370 feet (113 m) in height from the top of the tower to the riverbed. During the Great Flood of 1993, construction continued despite record crests on the Mississippi below.

The Great River Bridge replaced the MacArthur Bridge, an aging two-lane toll steel bridge built in 1917. The new bridge is five lanes wide (two westbound, three eastbound) and provides a safer crossing across the Mississippi River than the old bridge.

44. Greenville Bridge

Carries	4 lanes of US 82 and US 278
Crosses	Mississippi River
Locale	Lake Village, Arkansas and Greenville, Mississippi
Design	Cable-stayed bridge
Longest span	1,378 feet (420 m)
Total length	13,560 feet (4,133 m)
Width	80 ft.
Clearance below	122 feet (37 m)
Opening date	Fall 2009
Coordinates	33°17′14″N 91°09′15″W

The **Greenville Bridge** is a cable-stayed bridge crossing the Mississippi River between the U.S. states of Arkansas and Mississippi.

The main span of the bridge was completed April 17, 2006, but has yet to open to traffic. When the approach roads are finished in early 2009, the bridge will carry US 82 (and, until the Charles W. Dean Bridge is built, US 278) across the river between Lake Village, Arkansas and Greenville, Mississippi.

45. Benjamin G. Humphreys Bridge

Carries	2 lanes of US 82 and US 278
Crosses	Mississippi River
Locale	Lake Village, Arkansas and Greenville, Mississippi
Design	Cantilever bridge
Longest span	840 feet (256 m)
Total length	9,957 feet (3,035 m)
Width	24 feet (7 m)
Clearance below	130 feet (40 m)
Opening date	October 4, 1940
Destruction date	Fall 2009
Coordinates	33°17′37″N 91°09′34″W

The **Benjamin G. Humphreys Bridge** is a two lane cantilever bridge carrying US 82 and US 278 across the Mississippi River between Lake Village, Arkansas and Greenville, Mississippi. The bridge is named for Benjamin G. Humphreys II, a former United States Congressman from Greenville. A new bridge, the Greenville Bridge, is being built as a replacement slightly downriver. This is because the bridge is a navigation hazard for vehicles on the bridge as well as barges going underneath the bridge.

On October 4, 1940, the Bridge was officially opened to traffic.

Until the Charles W. Dean Bridge is constructed, US 278 will cross the Mississippi River at Greenville.

46. Horace Wilkinson Bridge

Carries	6 lanes of I-10
Crosses	Mississippi River
Locale	Baton Rouge, Louisiana
Design	Cantilever bridge
Longest span	1,235 feet (376 m)
Total length	4,550 feet (1,387 m) (superstructure) 14,150 feet (4,313 m) (overall)
Width	80 feet (24 m)
Clearance below	175 feet (53 m)
Opening date	April 10, 1968
Coordinates	30°26′22″N 91°11′47″W

The **Horace Wilkinson Bridge** is a cantilever bridge carrying Interstate 10 across the Mississippi River from Port Allen in West Baton Rouge Parish to Baton Rouge, Louisiana. This is the only point where Interstate 10 crosses the Mississippi River in Louisiana. Around the Baton Rouge Metropolitan Area, the bridge is more commonly known as the "New Bridge" because it is the youngest of the two bridges that cross the river at Baton Rouge. The structure begins at the Louisiana Highway 1 exit south of Port Allen. After the interstate crosses the superstructure, it remains an elevated viaduct up to the Dalrymple Drive exit to Louisiana State University. Locally it is notorious for daily traffic snags due to the high volume of vehicles using the bridge and the style of entrances from Highway 1 on the west bank, and from St. Ferdinand Street in downtown on the east bank.

47. Black Hawk Bridge

Carries	2 lanes of IA 9 and WI 82
Crosses	Upper Mississippi River
Locale	Lansing, Iowa and Crawford County, Wisconsin, River Mile 663.4
Design	Melvin B. Stone
Total length	1,653 feet (504 m)
Width	21 feet (6 m), 2 Lanes
Clearance below	68 feet (21 m)
Opening date	June 17, 1931
Coordinates	43°21′55″N, 91°12′54″W

The **Black Hawk Bridge** spans the Mississippi River, joining the town of Lansing, in Allamakee County, Iowa, to rural Crawford County, Wisconsin. It is the northernmost Mississippi River bridge in Iowa. It carries Iowa Highway 9 and Wisconsin Highway 82.

This riveted cantilever through truss bridge (other examples) has one of the more unusual designs of any Mississippi River bridge. Construction started in 1929 and was completed in 1931.

48. Fort Madison Toll Bridge

Carries	2 lanes of IA 2 and IL 9 and rail lines
Crosses	Mississippi River
Locale	Fort Madison, Iowa and Niota, Illinois
Opening date	July 1928
Coordinates	40°37′37″N 91°17′45″W

The **Fort Madison Toll Bridge** (also known as the **Santa Fe Swing Span Bridge** for the old Santa Fe rail line) is a tolled, swinging truss bridge bridge over the Mississippi River that connects Fort Madison, Iowa and unincorporated Niota, Illinois. Rail traffic occupies the lower deck of the bridge, while two lanes of road traffic occupy the upper deck. It is widely considered the longest double-deck swing-span bridge in the world.

Completed in 1927, it replaced an inadequate combination single-track / roadway bridge completed in 1887. The main river crossing consists of four 270-foot (82 m) through truss spans and a swing span made of two equal arms, 266 feet (81 m) long.

49. John James Audubon Bridge

Carries	4 lanes of LA 10
Crosses	Mississippi River
Locale	Pointe Coupee Parish, Louisiana, West Feliciana Parish, Louisiana
Design	Cable-stayed bridge
Longest span	1,583 feet (482 m)
Total length	12,883 feet (3,927 m)
Width	64 feet (20 m)
Clearance below	65 feet (20 m)
Opening date	Approx. 2010
Coordinates	30°43′39″N 91°21′18″W

The **John James Audubon Bridge** project is a new Mississippi River crossing between Pointe Coupee and West Feliciana parishes in south central Louisiana.

The bridge--proposed to be the longest cable-stayed bridge in North America when complete--will replace an existing ferry between the communities of New Roads and St. Francisville.

The bridge will also serve as the only bridge structure on the Mississippi River between Natchez, Mississippi and Baton Rouge, Louisiana (approximately 90 river miles).

The Audubon Bridge project will include:

A 2.44-mile (3.93 km) four-lane elevated bridge structure with two 11-foot (3.4 m) travel lanes in each direction with 8-foot (2.4 m) outside shoulders and 2-foot (0.61 m) inside shoulders

The John James Audubon Bridge project is expected to be complete by summer 2010.

50. Mark Twain Memorial Bridge

Carries	4 lanes of I-72 and US 36
Crosses	Mississippi River
Locale	Hannibal, Missouri
Longest span	640 feet (195 m)
Total length	4,491 feet (1,369 m)
Width	86 feet (26 m)
Opening date	September 16, 2000
Coordinates	39°43′13″N 91°21′30″W

The **Mark Twain Memorial Bridge** is the name for two bridges over the Mississippi River at Hannibal, Missouri. The current bridge, north of the original site, was finished in 2000; the original bridge, built in 1936, was demolished. The bridge currently carries traffic for Interstate 72 and U.S. Highway 36.

The original bridge (also called the Mark Twain Memorial Bridge) was opened in 1936. It originally carried only US 36, but with the extension of Interstate 72 west across Missouri, a new bridge was needed and was built to the north of the original bridge.

The current bridge opened to traffic on September 16, 2000. As part of the construction project, U.S. 36 was rerouted further north, eliminating a dangerous sharp curve that had been on the Missouri approach. Prior to the rerouting, the old bridge ran through downtown Hannibal, just north of Hill Street.

51. Wabash Bridge (w/ vertical lift)

The Wabash Bridge looking southeast

Carries	1 track of Norfolk Southern
Crosses	Mississippi River
Locale	Hannibal, Missouri and Illinois
Design	5 Truss spans with Vertical lift over main channel
Longest span	409 feet (125 m)
Coordinates	39°43′27″N 91°21′44″W

The **Wabash Bridge** carries rail lines across the Mississippi River between Hannibal, Missouri and Illinois.

It has been a vertical lift bridge since 1994, but it was originally constructed as a swing span. The vertical lift span was relocated from a bridge over the Tennessee River at Florence, Alabama to increase the width of the navigational channel. During a three day outage, the previous span was removed and the replacement span was installed to minimize impact to traffic. Originally constructed for the Wabash Railroad.

A 250-foot truss span was struck by the towboat and collapsed into the river on May 3, 1982. The bridge span was repaired.

52. Keokuk Rail Bridge

Carries	Double deck single track railway and highway bridge
Crosses	Mississippi River
Locale	Keokuk, Iowa and Hamilton, Illinois
Design	Swing bridge
Opening date	1916
Coordinates	40°23′28″N 91°22′24″W

The **Keokuk Bridge**, also known as the Keokuk & Hamilton Bridge, carries a double deck single track railway and highway bridge across the Mississippi River between Keokuk, Iowa and Hamilton, Illinois. Designed and constructed 1915–1916 on the piers of its predecessor that was constructed in 1869–1871.

Following the completion of the Keokuk-Hamilton Bridge, the upper deck of this bridge, on the Keokuk side, was converted to an observation deck to view the nearby lock and dam and is no longer used for road traffic, but is still used for rail traffic.

53. Keokuk-Hamilton Bridge

Carries	4 lanes of US 136
Crosses	Mississippi River
Locale	Keokuk, Iowa and Hamilton, Illinois
Design	Steel girder bridge
Opening date	November 1985
Coordinates	40°23′25″N 91°22′24″W

The **Keokuk-Hamilton** bridge is a steel girder, 4-lane bridge from Keokuk, Iowa to Hamilton, Illinois. It carries U.S. Route 136 across the Mississippi River.

The Keokuk-Hamilton Bridge was built in 1985, taking over automobile traffic from the Keokuk Rail Bridge (though the latter bridge still carries rail traffic).

54. Natchez-Vidalia Bridge

Carries	4 lanes of US 65/US 84/US 425
Crosses	Mississippi River
Locale	Vidalia, Louisiana and Natchez, Mississippi
Design	Twin Cantilever bridges
Longest span	3 848 feet (258 m) spans per bridge
Total length	4,205 feet (1,282 m) (westbound) 4,202 feet (1,281 m) (eastbound)
Width	24 feet (7 m) (westbound) 42 feet (13 m) (eastbound)
Clearance below	125 feet (38 m)
Opening date	October 1940 (westbound) July 1988 (eastbound)
Coordinates	31°33′33″N 91°25′09″W

The **Natchez-Vidalia Bridge** are two twin cantilever bridges carrying US Routes 65, 84 and 425 across the Mississippi River between Vidalia, Louisiana and Natchez, Mississippi.

55. Quincy Memorial Bridge

Carries	2 lanes of Eastbound US 24
Crosses	Mississippi River
Locale	West Quincy, Missouri and Quincy, Illinois
Design	Truss bridge
Longest span	627 feet (191 m)
Total length	3,510 feet (1,070 m)
Width	27 feet (8 m)
Clearance below	63 feet (19 m)
Opening date	1928
Coordinates	39°55′53″N 91°25′14″W

The **Quincy Memorial Bridge** is a truss bridge over the Mississippi River in Quincy, Illinois. It brings eastbound U.S. Highway 24 into the city of Quincy from Missouri. It was built in 1928 and remains structurally sound.

In 1986, to serve additional traffic volumes crossing the Mississippi River into Quincy, the Illinois Department of Transportation constructed the Bayview Bridge just to the north of the Memorial Bridge. Westbound traffic was then routed onto the Bayview Bridge, while eastbound traffic was routed onto the Memorial Bridge.

56. Bayview Bridge

Carries	2 lanes of Westbound US 24
Crosses	Mississippi River
Locale	West Quincy, Missouri Quincy, Illinois
Design	Cable-stayed bridge
Longest span	900 feet (274 m)
Total length	4,507 feet (1,374 m)
Width	27 feet (8 m)
Clearance below	63 feet (19 m)
Opening date	August 22, 1987
Coordinates	39°56′00″N 91°25′17″W

The **Bayview Bridge** is a cable-stayed bridge bringing westbound U.S. Highway 24 over the Mississippi River. It connects the cities of West Quincy, Missouri and Quincy, Illinois. Eastbound U.S. 24 is served by the older Quincy Memorial Bridge.

The bridge was built to alleviate traffic over the downstream Memorial Bridge. It was built prior to the extension of Interstate 72 west into Hannibal, Missouri. Traffic levels increased when the existing, downstream U.S. Highway 36 bridge over the Mississippi River was closed to make room for the new Interstate 72 bridge.

57. Quincy Rail Bridge

Crosses	Mississippi River
Locale	West Quincy, Missouri and Quincy, Illinois
Design	Vertical lift span over main channel
Coordinates	39°56′30″N 91°25′51″W

The **Quincy Rail Bridge** carries rail lines across the Mississippi River between West Quincy, Missouri and Quincy, Illinois, USA. Originally constructed for the Chicago, Burlington and Quincy Railroad which is now BNSF Railway.

From the 1950s until 1971 it served the Kansas City Zephyr and American Royal Zephyr daily passemger trains between Chicago and Kansas City. It served Amtrak's Illinois Zephyr from Chicago to West Quincy, MO from 1971 to 1993.

Since the Great Flood of 1993 Amtrak *Illinois Zephyr* and *Carl Sandburg* service terminates at the Quincy station. This Mississippi river crossing does serve as a backup route should the Fort Madison Toll Bridge crossing be unavailable.

58. Moline-Arsenal Bridge

Carries	2 Lanes, Rodman Avenue
Crosses	Mississippi River
Locale	River Mile 485.7, Moline, Illinois
Design	Steel girder, concrete deck.
Longest span	230 feet
Total length	1,344 feet
Width	42 feet
Clearance below	28 feet
Opening date	April 1982.
Coordinates	41°30′37″N 90°31′07″W

This bridge is one of three highway bridges serving the Rock Island Arsenal. Prior to 9/11, one could simply drive across the bridge and tour the Arsenal. Today, security is high, and one has to have a need to enter the island. There is an Army museum, National River Visitors Center, Lock and Dam #15 overlook, National Cemetery, and a historical driving tour, all of which are good reasons to take a tour of the island.

This is a very historic river crossing. The first structure here was a dam built in 1837. It was used by pedestrians, and was wide enough for wagons to cross. That dam survived until 1868. A wooden bridge was built by the City of Moline in 1860, but it was destroyed by ice in 1867. An iron bridge was built in 1873, and was replaced by a concrete arch bridge in 1932. That bridge was built with substandard concrete, and it gradually crumbled under its own weight. It was closed in 1981, and replaced with the current modern steel girder bridge.

59. Crescent Rail Bridge

Carries	Burlington Northern Santa Fe Railroad.
Crosses	Mississippi River
Locale	Davenport, Iowa and Rock Island, Illinois
Design	Steel Truss Through Deck w/Swing Span
Longest span	442 ft swing span
Total length	2,383 ft
Width	1 track
Clearance below	26 ft
Opening date	1899
Coordinates	41°30′42″N 90°35′41″W

The **Crescent Rail Bridge** carries rail lines across the Mississippi River between Davenport, Iowa and Rock Island, Illinois. The bridge and the Illinois track are owned by BNSF, and the Iowa side is a Canadian Pacific line.

Bridge is called the Crescent Bridge due to its curved shape. The hump back bridge sections and the swing span form a straight line. But the three smaller flat top bridge sections form an arc to allow the bridge to meet up with the railroad that runs parallel to the river on the Illinois side without that railroad taking up a lot of space by making a big loop.

60. Double Chain Bridge

Carries	I-270
Crosses	Mississippi River
Locale	River Mile 190.8, St. Louis, Missouri
Design	Steel Truss Through Deck, Twin Spans
Longest span	480 feet
Total length	1,990 feet
Width	30 feet
Clearance below	82 feet
Opening date	1967
Coordinates	38°45′56″N 90°08′07″W

There are four bridges as part of the Chain of Rocks crossing, two on the new I-270 alignment, and two on the old US-66 alignment. This bridge, or rather, pair of twin spans, is on the new I-270 alignment, and they cross the Chain Of Rocks Canal.

The reason for two bridges on each alignment is that the highways have two waterways to cross, the Mississippi River main channel, and the Chain Of Rocks Canal.

Since the canal carries riverboat traffic, these bridges have to be very high above the water. There could also be no piers in the navigation channel, so the main span had to relatively long. The solution was to build a pair of massive steel truss bridges.

These bridges are often called the Double Chain Bridge in that there are two spans, and they cross the Chain Of Rocks Canal. They are the first of the big metal monster bridges that you find as your head south on the Mississippi River.

61. Single Chain Bridge

Carries	2 lanes, Old Chain Of Rocks Road, US-66
Crosses	Mississippi River
Locale	River Mile 190.5, St. Louis, Missouri
Design	Steel Truss Through Deck
Longest span	463 feet
Total length	2,368 feet
Width	26 feet
Clearance below	82 feet
Opening date	1949, (Rebuilt 1999)
Coordinates	38°45′43″N 90°08′18″W

There are four bridges as part of the Chain of Rocks crossing, two on the new I-270 alignment, and two on the old US-66 alignment. This bridge is on the old US-66 alignment, and it crosses the Chain of Rocks Canal. The old Chain of Rocks Bridge was built in 1929. When the canal was dug in 1949, a bridge had to be built in this spot to provide access to the Illinois side of the Chain Of Rocks Bridge.

While this crossing is lightly used today, it still has to be high enough and long enough to allow riverboat traffic to pass without being a navigation hazard. The solution was to build a steel truss bridge to stand up to the long span, and a pair of trusses handling the approaches at either end of the bridge.

This bridge is called the Single Chain Bridge given that there is only one structure in the bridge, as opposed to the Double Chain Bridge just upstream, which has two bridges in parallel. The Chain of Rocks Bridge was abandoned in 1970, so the Single Chain Bridge was largely ignored. It deteriorated to the point where it required major renovation in 1999. Today, it looks like a brand new bridge.

62. Grand Tower Pipeline Bridge

Carries	Natural gas
Crosses	Mississippi River
Locale	Grand Tower, Illinois
Maintained by	Natural Gas Pipeline Company of America
Design	Suspension bridge
Longest span	2,161.5 feet (659 m)
Opening date	1955
Coordinates	37°38′31″N 89°31′03″W

The **Grand Tower Pipeline Bridge** is a suspension bridge carrying a natural gas pipeline across the Mississippi River near Grand Tower, Illinois.

63. A. W. Willis. Jr. Bridge

Carries	4 lanes of Auction Road
Crosses	Mississippi River
Locale	River Mile 737.1, Memphis, Tennessee
Design	Steel Girder
Total length	1,405 feet
Width	57 feet (8 m)
Opening date	1987
Coordinates	35°09′30″N 90°03′11″W

Prior to 1987, the only access to Mud Island was via the monorail and pedestrian bridge that was built in 1982. The city desired to develop the north end of Mud Island, so an automobile bridge was built. It is an extension of Auction Road, and it is named after A. W. Willis Jr., a famous black attorney who practiced in Memphis for many years. Once this bridge was opened to traffic, developers started to build housing on Mud Island. This area has become a neighborhood that attracts younger upscale residents, partly due to the land prices being very high compared to the rest of Memphis.

This bridge does not cross the main channel of the Mississippi River. Rather, it crosses a back channel named Wolf Harbor.

64. Memphis Suspension Railway

Carries	1 lane
Crosses	Mississippi River
Locale	Memphis, Tennessee
Design	Suspended monorail bridge
Total length	1,700 feet
Opening date	1982
Coordinates	

The **Memphis Suspension Railway** or **Mud Island Monorail** is a suspended monorail that connects the city center of Memphis with the entertainment park on Mud Island.

The system consists of two suspended cars constructed in Switzerland, delivered in summer 1981. The 1,700 ft (518 m) long bridge opened to pedestrians on June 29, 1981; however, the suspended monorail would not be operational until July 1982. The cars are driven by a 3,500 ft (1,067 m) long, external cable instead of by internal motors. The two cars simultaneously shuttle back and forth on parallel tracks between the Front Street Terminal on the downtown side and the Mud Island Terminal. Each car has a maximum capacity of 180 passengers and travels at a speed of 7 mph (11.3 km/h).

At the time of its construction, both the U.S. Coast Guard stated that the proposed bridge would have to have the same clearance as the Hernando de Soto Bridge, as it was deemed it was spanning a commercially used public waterway. This resulted in the bridge being constructed at its current elevation.

65. Cairo Ohio River Bridge

Carries	2 lanes of US 51/US 60/US 62
Crosses	Ohio River
Locale	Wickliffe, Kentucky and Cairo, Illinois
Design	Cantilever bridge
Longest span	243 84 meters (800 feet)
Total length	1,787.26 meters {5,863.7 feet)
Width	6.10 meters (20 feet)
Vertical clearance	5.97 meters (19.6 feet)
Opening date	1937
Coordinates	36°59′39″N 89°08′45″W

The **Cairo Ohio River Bridge** is a cantilever bridge carrying US 51, US 60 and US 62 across the Ohio River between and Wickliffe, Kentucky and Cairo, Illinois. Of all the Ohio River crossings, it is the furthest downstream – the Mississippi River can be seen while crossing the bridge and looking westward.

66. Cairo Rail Bridge

Carries	Single track of Canadian National Railway (formerly Illinois Central Railroad)
Crosses	Ohio River
Locale	Wickliffe, Kentucky and Cairo, Illinois
Design	Simple truss bridge, with steel trestle approaches
Longest span	518.5 feet (158 m)
Total length	20,461 feet (6,236.5 m) (including approaches)
Opening date	October 29, 1889, rebuilt in 1951
Coordinates	37°01′23″N 89°10′32″W

Cairo Rail Bridge is the name of two bridges crossing the Ohio River near Cairo, Illinois. The first was an 1889 George S. Morison through truss and deck truss bridge replaced in 1951. The second and current bridge is a through truss bridge that reused many of the original bridge piers. As of 2007, trains like the City of New Orleans travel over the Ohio River supported by the same piers whose construction began in 1887.

The first train crossed the bridge from Illinois to Kentucky on October 29, 1889. Work continued until it was turned over to the railroad on March 1, 1890. In order to comply with regulations meant to allow steam boat travel on the Ohio, the bridge was required to be 53 feet (16.2 m) above the river's high water mark. This resulted in the structure extending nearly 250 feet (76.2 m) from the bottom of the deepest foundation to the top of the highest iron work. Cairo bridge's two 518.5 feet (158 m) main spans were the longest pin-connected Whipple truss spans ever built. At the time, the bridge was the largest and most expensive ever undertaken in the United States. At 10,580 feet (3,224.8 m), it was the longest metallic structure in the world. Its total length was 20,461 feet (6,236.5 m) including wooden approach trestles. Its construction completed the first rail link between Chicago and New Orleans and revolutionized north-south rail travel along the Mississippi River.

67. Metropolis Bridge

Carries	Single track of Canadian National Railway (formerly Chicago, Burlington and Quincy Railroad)
Crosses	Ohio River
Locale	Metropolis, Illinois and McCracken County, Kentucky
Design	Simple truss bridge, with steel trestle approaches
Longest span	708 feet (215.798 m)
Total length	6,424 feet (1958.035 m) (including approaches)
Opening date	1917
Coordinates	37°08′41″N 88°44′31″W

The **Metropolis Bridge** is a railroad bridge which spans the Ohio River at Metropolis, Illinois. Originally built for the Chicago, Burlington and Quincy Railroad, construction began in 1914.

The bridge consists of the following: (from north to south)

- Deck plate-girder approach spans
- One riveted, 9-panel Parker through truss
- Five pin-connected, Pennsylvania through trusses
- One pin-connected, 8-panel Pratt deck truss
- Deck plate-girder approach spans

Total length of the bridge is 6,424 feet (1958.035 meters).

68. Interstate 24 Bridge

Carries	I-24
Crosses	Ohio River
Locale	Metropolis, Illinois and Paducah, Kentucky
Design	Continuous box and plate girder bridge & two-span tied arch bridge
Total length	5,623.4 feet
Opening date	1973
Coordinates	37°08′00″N 88°41′13″W

The **Interstate 24 Bridge** may refer to one of two distinct bridges on Interstate 24. The Interstate 24 Bridge is a two-span tied arch bridge that carries I-24 across the Ohio River. Built in 1973, it is 5,623.4 feet (1,714.0 m) in length. The bridge is one of two that connects the Metropolis, Illinois area with Paducah, Kentucky.

69. Irvin S. Cobb Bridge

Carries	2 lanes of US 45
Crosses	Ohio River
Locale	Paducah, Kentucky and Brookport, Illinois
Design	Truss bridge
Longest span	711.0 feet (216.7 m)
Total length	5,385.8 feet (1,641.6 m)
Width	19.7 feet (6.0 m)
Vertical clearance	14.1 feet (4.3 m)
Completion date	1929
Coordinates	37°06′53″N 88°37′45″W

The **Irvin S. Cobb Bridge** (also known as the **Brookport Bridge**) is a ten-span, narrow two-lane truss bridge that carries U.S. Route 45 across the Ohio River in the U.S. states of Illinois and Kentucky. It runs from Paducah, Kentucky north to Brookport, Illinois.

The bridge is named after Irvin S. Cobb, an author and journalist who was born in Paducah.

70. Shawneetown Bridge

Carries	
Crosses	Ohio River
Locale	Old Shawneetown, Illinois
Design	Cantileverd truss bridge
Longest span	825.1 ft
Total length	3,200.2 ft
Width	23.9 ft
Vertical clearance	19 ft
Completion date	1955
Coordinates	37°41′28″N 88°07′53″W

The **Shawneetown Bridge** is a cantilever truss bridge carrying Kentucky Route 56 and Illinois Route 13 across the Ohio River. The bridge connects Old Shawneetown, Illinois to rural Union County, Kentucky.

71. Henderson Bridge

Carries	Railroad
Crosses	Ohio River
Locale	Henderson, Kentucky
Design	Truss bridge
Coordinates	37°50′45″N 87°35′47″W

The **Henderson Bridge** is an active railroad bridge located at at Henderson, Kentucky. It is a five spans truss bridge crossing the Ohio River just North of the Henderson boat ramp and downtown area.

72. Bi-State Vietnam Gold Star Bridges

Carries	US 41
Crosses	Ohio River
Locale	Henderson, Kentucky and Evansville, Indiana
Design	Cantilever truss bridges
Longest span	720 feet
Total length	5,395 feet
Vertical clearance	100 ft (30m)
Completion date	1932 (northbound) 1966 (southbound)
Coordinates	37°54'15"N 87°33'02"W

The **Bi-State Vietnam Gold Star Bridges**, also known as the **Twin Bridges**, connect Henderson, Kentucky and Evansville, Indiana along U.S. 41, one mile (1.6 km) south of the terminus of I-164. The northbound bridge opened to traffic on July 4, 1932 and the southbound bridge opened in December 1966. The main span of the bridges is 720 feet (220 m).

The northbound span of the Bi-State Vietnam Gold Star Bridges was the second of three bridges built in Henderson County in 1932. It was originally named the **John James Audubon Bridge**, or **Audubon Memorial Bridge.** Both of the Bi-State Vietnam Gold Star Bridges are 5,395-foot (1,644 m) long cantilever bridges. The northbound bridge stands 100 feet (30 m) over the Ohio River with a main span of 732 feet (223 m), with the steel gridwork extending 100 feet (30 m) above the driving surface. The southbound span has a main span of 600 feet (180 m).

73. Glover Cary Bridge

Carries	US 431
Crosses	Ohio River
Locale	Owensboro, Kentucky and Spencer County, Indiana
Design	Continuous truss bridge
Completion date	1940
Coordinates	37°46′45″N 87°06′33″W

Local residents call the **Glover H. Cary Bridge** the "Blue Bridge" because of its color. It is a continuous truss bridge that spans the Ohio River between Owensboro, Kentucky and Spencer County, Indiana. It was named for the late U.S. Congressman Glover H. Cary (1885-1936), and opened to traffic in September 1940.

At first, the bridge connected Kentucky Highway 75 to Indiana Highway 75; in 1954, Kentucky 75 was redesignated U.S. Highway 431 and Indiana 75 became U.S. Highway 231.

In the fall of 2002, when the William H. Natcher Bridge was completed, U.S. 231 was rerouted onto that bridge and the former U.S. highway became the southern leg of an extended State Road 161.

74. William H. Natcher Bridge

Carries	U.S. Highway 231
Crosses	Ohio River, Indiana State Road 66
Locale	Owensboro, Kentucky to Rockport, Indiana
Design	Cable stayed bridge
Total length	4,505 feet (1,373 m)
Width	67 feet (20 m)
Opening date	October 21, 2002
Coordinates	37°54′04″N 87°02′02″W

The **William H. Natcher Bridge** is a cable-stayed bridge that carries U.S. Highway 231 over the Ohio River. The bridge connects Owensboro, Kentucky to Rockport, Indiana and opened on October 21, 2002.

The William H. Natcher Bridge is 4,505 feet (1,373 m) in length (including its approaches) and 67 feet (20 m) wide. It is supported by cables connected to two identical diamond-shaped towers, each 374 feet (114 m) tall. At the time of its construction, it was the United States' longest cable-supported bridge over an inland waterway.

75. Bob Cummings - Lincoln Trail Bridge

Carries	Road traffic
Crosses	Ohio River
Locale	Indiana-Kentucky State Line
Design	Arch bridge with suspended deck
Longest span	824.6 feet (251.3 m)
Total length	2,708.3 feet (825.5 m)
Width	27.8 feet (8.5 m)
Opening date	1966

The **Bob Cummings - Lincoln Trail Bridge** crosses the Ohio River and connects the towns of Cannelton, Indiana and Hawesville, Kentucky. Indiana State Road 237 becomes Kentucky Route 69 upon entering Hawesville.

Construction began in June 1964 and the bridge opened on December 21, 1966. The steel arch bridge with its suspended deck was a toll facility until the state of Indiana lifted the tolls in the 1990s.

In 2006, the bridge was resurfaced with concrete that many drivers find to be rougher than the previous surface.

76. Matthew E. Welsh Bridge

Carries	KY 79/ IN 135
Crosses	Ohio River
Locale	Brandenburg, Kentucky and Mauckport, Indiana
Design	Continuous truss bridge
Longest span	725 ft
Total length	3098 ft
Completion date	November 19, 1966
Coordinates	38°01′02″N 86°11′49″W

Matthew E. Welsh Bridge is a two-lane, single-deck continuous truss bridge[1] on the Ohio River. The bridge connects Kentucky Route 79 and Indiana State Road 135, as well as the communities of Brandenburg, Kentucky and Mauckport, Indiana.

It is 3098 feet long and was built by the State of Indiana. The truss portion of the bridge is continuous across two 725-foot spans. Construction of the bridge began in August 1964 and the bridge was opened to traffic on November 19, 1966.

Although 90% of the Bridge is within the Commonwealth of Kentucky, the bridge is owned and maintained by the State of Indiana.

77. Lewis Bridge

Carries	4 lanes of US-67
Crosses	Missouri River
Locale	St. Louis County and St. Charles County in Missouri
Design	Deck girder bridge
Opening date	1979
Coordinates	38°50′38″N 90°14′03″W

The **Lewis Bridge** is a bridge carrying U.S. Route 67 across the Missouri River between St. Louis County and St. Charles County, Missouri. It replaced an earlier narrow, 2-lane through truss bridge of the same name that ran adjacent to the Bellefontaine Bridge.

78. Bellefontaine Bridge

Crosses	Missouri River
Locale	St. Louis County and St. Charles County, Missouri
Design	Four-span truss bridge
Longest span	440 foot
Total length	1760 foot
Completion date	December 27, 1893
Coordinates	38°50′37″N 90°14′11″W

The **Bellefontaine Bridge** is a four-span truss BNSF railroad bridge over the Missouri River between St. Charles County, Missouri and St. Louis County, Missouri. It has four 440 foot spans. Construction started on July 4, 1892 and it opened on December 27, 1893.

79. Discovery Bridge

Carries	6 lanes of Route 370
Crosses	Missouri River
Locale	St. Louis County and St. Charles County in Missouri
Design	Truss bridge
Longest span	190.5 m (625 ft)
Total length	1,053 m (3,455 ft)
Width	16.8 m (55 ft)
Opening date	1993
Coordinates	38°47′53″N 90°28′01″W

The **Discovery Bridge** are two twin truss bridges carrying Route 370 across the Missouri River between St. Louis County and St. Charles County, Missouri.

The shoulder on both sides is designated a bicycle (and pedestrian) path. Separate bicycle/pedestrian access ramps are available immediately on both sides of the bridge. This provides a connection to traffic to and from the Katy Trail, which passes under the bridge.

80. Wabash Bridge (St. Charles, Missouri)

Carries	Railroad
Crosses	Missouri River
Locale	St. Louis County and St. Charles County in Missouri
Design	Truss bridge
Coordinates	38°47′51″N 90°28′02″W

The **Wabash Bridge** carries a railroad from St. Louis County to the city of St. Charles. It is positioned next to the Discovery Bridge. It is used by the freight trains of Norfolk Southern Railway.

81. Blanchette Memorial Bridge

Carries	10 lanes of Interstate 70
Crosses	Missouri River
Locale	St. Louis County and St. Charles County in Missouri
Design	Cantilever
Longest span	146.3 m (480 ft)
Total length	1,244 m (4,083 ft)
Width	WB: 18.3 m (60 ft) EB: 20.7 m (68 ft)
Opening date	WB: 1958 EB: 1978
Coordinates	38°45′54″N 90°28′55″W

The **Blanchette Memorial Bridge** are two twin cantilever bridges carrying Interstate 70 across the Missouri River between St. Louis County and St. Charles County, Missouri, opened in 1959. Handling an average of 165,000 vehicle transits per day, it is the area's busiest bridge. Construction of the first interstate highway project under provisions of the Federal Aid Highway Act of 1956 started west of the bridge's present location. A sign commemorating the site of the nation's first interstate project stands next to Interstate 70 just east of the Missouri Route 94/First Capitol Drive overpass.

The bridge is named for French Canadian fur trader and hunter Louis Blanchette, who founded St. Charles as a post along the Missouri River; the village was the first European settlement along this waterway.

82. Veterans Memorial Bridge

Carries	MO-364 Route 364
Crosses	Missouri River
Locale	St. Louis County and St. Charles County, Missouri
Design	Twin Tied Arch Bridges
Longest span	617 ft
Total length	3,238 ft
Width	83 ft 4 traffic lanes
Opening date	1999
Coordinates	38°44′13″N 90°31′20″W

The **Veterans Memorial Bridge** is a twin steel through tied arch, suspended concrete deck bridge over the Missouri River connecting St. Louis County and St. Charles County, Missouri via Route 364. Steel Through Arch,

It was built and opened in 1999. It is 83 feet wide and 3,238 feet long. The longest span length is 617 feet.

83. Daniel Boone Bridge

Carries	7 lanes (4 EB, 3 WB) of I-64/US 40/US 61
Crosses	Missouri River
Locale	St. Louis County and St. Charles County in Missouri
Design	Twin Cantilever bridges
Opening date	1935 (westbound span) 1988 (eastbound span)
Coordinates	38°41′17″N 90°39′47″W

The **Daniel Boone Bridge** are two twin cantilever bridges carrying Interstate 64, U.S. Route 40 and U.S. Route 61 across the Missouri River between St. Louis County and St. Charles County, Missouri.

On December 10, 2004, the Missouri Highways and Transportation Commission approved the design location of a third span, to be built upstream (to the west) of the two current spans. This new span will carry eastbound traffic, while the the current eastbound span will carry westbound traffic and the current westbound span will carry westbound outer road traffic.

84. Washington Bridge

Carries	Route 47
Crosses	Missouri River
Locale	Washington, Missouri
Design	Cantilevered truss bridge
Longest span	474.6 ft
Total length	2,561.3 ft
Width	22 ft
Clearance below	14.6 ft
Opening date	1934
Coordinates	38°33′27″N 90°59′54″W

The **Washington Bridge** is a cantilevered truss bridge over the Missouri River at Washington, Missouri over which Route 47 passes between Franklin County, Missouri and Warren County, Missouri.

The bridge was built in 1934. Its main span is 474.6 feet and it has a total length of 2,561.3 feet and a deck width of 22 feet. Its vertical clearance is 14.6 feet. The bridge carries one lane of automobile traffic in each direction.

The Missouri Department of Transportation shut down the bridge on 11 August 2007, claiming to have discovered problems during regularly scheduled inspections. As the bridge is similar to the I-35W bridge which collapsed in Minnesota, locals have speculated that the inspection and closure were related to this incident. The nearest open crossing over the Missouri river is approximately sixty miles from the closed bridge. The bridge was reopened on 12 August 2007.

85. Christopher S. Bond Bridge (Hermann)

	
Carries	Route 364
Crosses	Missouri River
Locale	Hermann, Missouri
Design	Truss bridge
Total length	2247 ft
Width	55ft
Opening date	July 23, 2007
Coordinates	38°42′34″N 90°26′20″W

The **Christopher S. Bond Bridge** is a highway bridge crossing the Missouri River at Hermann, Missouri. The bridge was opened to vehicle traffic on July 23, 2007, replacing an adjacent span opened in 1930.

Construction on the bridge continues as a portion of the south end of old bridge needs to be removed to allow completion of the south approach. The 8-foot pedway will not be open until the bridge construction is finished.

The bridge is 2,247 feet long. The total width of the bridge is 55 feet, 4 inches, consisting of two 12-foot driving lanes, two 10-foot shoulders, and an 8-foot bicycle/pedestrian lane.

86. Jefferson City Bridge

Carries	US 54/ US 63
Crosses	Missouri River
Locale	Jefferson City, Missouri
Design	2 compression arch suspended-deck bridge
Longest span	639.9 feet (southbound) 595.6 feet (northbound)
Total length	3,093 feet (southbound) 3,124.2 feet (northbound)
Width	37.7 feet (southbound) 46.9 feet (northbound)
Opening date	1955 (southbound) 1991 (northbound)
Coordinates	38°35′15″N 92°10′42″W

The **Jefferson City Bridge** are two compression arch suspended-deck bridge bridges over the Missouri River at Jefferson City, Missouri over which U.S. Highway 54 and U.S. Highway 63 pass between Cole County, Missouri and Callaway County, Missouri.

The southbound bridge opened in August 1955. Its main span is 639.9 feet and has a total length of 3,093 feet and a deck width of 37.7 feet and vertical clearance of 37.7 feet.

The northbound bridge opened in 1991. Its main span is 595.6 feet with a total length of 3,124.2 feet. The deck width is 46.9 feet and it has vertical clearance of 16.1 feet.

The northbound bridge has a marked bicycle and pedestrian lane in the shoulder. It is used in both directions by users of the Katy Trail State Park. A city-maintained extension of the Katy (formerly a railroad spur) connects the North Jefferson trailhead to near the first exit north of the bridge.

87. Rocheport Interstate 70 Bridge

Carries	Interstate 70
Crosses	Missouri River
Locale	Cooper County and Boone County , MO
Design	Cantilevered truss bridge
Longest span	550.7 ft
Total length	3,017.2 ft
Width	60.3 ft
Opening date	1960
Coordinates	38°57′35″N 92°32′41″W

The **Rocheport Interstate 70 Bridge** is a four-lane Cantilevered through truss bridge over the Missouri River on Interstate 70 between Cooper County, Missouri and Boone County, Missouri at Rocheport, Missouri.

The bridge was built in 1960 and rehabilitated in 1993. Its main span is 550.7 feet and has a total length of 3,017.2 feet. Its deck width is 60.3 feet and vertical clearance is 20 feet.

88. Boonslick Bridge

Carries	US 40, Route 5 and Route 87
Crosses	Missouri River
Locale	Boonville, Missouri
Design	Girder bridges
Opening date	1995
Coordinates	38°58′51″N 92°44′45″W

The **Boonslick Bridge** is a series of girder bridges on U.S. Route 40, Route 5 and Route 87 across the Missouri River between Cooper County, Missouri and Howard County, Missouri at Boonville, Missouri.

The bridge also has a segregated pedestrian and bicycle path. The bridge which opened in 1995 replaced a six-span truss bridge built in 1924 that was 19 feet (5.8 m) wide. The earlier bridge was 2,100 feet (640 m) long with a 584-foot (178 m) approach in Cooper County and 500-foot (150 m) approach in Howard County. Three of its spans were 420 feet (130 m) and three were 280 feet (85 m).

89. Glasgow Bridge

Carries	Route 240
Crosses	Missouri River
Locale	Glasgow, Missouri
Design	five-span through truss
Longest span	343.7 ft
Total length	2,243.5 ft
Width	20.3 ft
Clearance below	14.8 ft
Opening date	1925
Coordinates	39°13′21″N 92°51′00″W

The **Glasgow Bridge** is five-span through truss bridge over the Missouri River on Route 240 between Howard County, Missouri and Saline County, Missouri at Glasgow, Missouri.

Glasgow Bridge from southwest along with rail bridge upstream from it. The bridge is single lane now with a stop light on either side.

It was built in 1925 and rehabilitated in 1986. Its main span is 343.7 feet and its total length is 2,243.5 feet. It has a deck width of 20.3 feet and vertical clearance of 14.8 feet.

A project to replace the trusses with a new superstructure began on August 4, 2008.

90. Glasgow Railroad Bridge

Crosses	Missouri River
Locale	Glasgow, Missouri
Design	four-span through truss
Opening date	1878
Coordinates	39°13′22″N 92°51′03″W

The **Glasgow Railroad Bridge** is four-span through truss bridge over the Missouri River belonging to the Kansas City Southern railroad between Howard County, Missouri and Saline County, Missouri.

It was originally built in 1878-79 by Gen. William Sooy Smith for the Chicago and Alton railroad as a five-span Whipple through truss and described as the world's first all-steel bridge. In 1900 it was rebuilt with Parker truss spans. It was damaged in the Great Flood of 1993.

91. Hardin-Joe Page Bridge

Carries	2 lanes on IL-16, IL-100
Crosses	Illinois River
Locale	Hardin Illinois
Design	Truss bridge
Longest span	308.7 ft
Total length	2,150 ft
Width	22 ft
Clearance below	26 ft
Opening date	July 23, 1931
Coordinates	39°09′36.23″N 90°36′48.61″W

The **Joe Page Bridge** is located in the small town of Hardin, Illinois. Many sources state that this is the longest bridge in Illinois, and the lift span of 308 foot 9 inches is the longest lift span in the world. While there may be some category of bridge where it is (or was) the longest in the world, both the Arthur Kill and Cape Cod Canal bridges have longer lift spans at 558 feet and 544 feet long, respectively.

The bridge consists of a series of Pennsylvania through truss spans that reach from high ground on the west side of the river to the levee on the east side of the river. The trusses include 6 that are fixed in size, the larger lift span, and then a somewhat shorter fixed truss between the lift span and the western shore. It is rare to have a lift bridge for vehicle traffic since cars can climb slopes that a train would find impossible to climb. In the case of the Illinois River, the first two automobile bridges, the Joe Page Bridge and the Florence Bridge just upstream are both automobile lift bridges. This 1931 era bridge was rehabilitated between March 2003 and December 2004.

92. Florence Bridge

Carries	2 lanes IL-100, IL-106
Crosses	Illinois River
Locale	Florence, Illinois
Design	Truss bridge
Longest span	217 ft
Total length	3,178 ft
Width	23 ft
Clearence below	27 ft
Opening date	1929 (Reconstructed 2004)
Coordinates	39°37′57.30″N 90°36′26.36″W

The **Florence Bridge** was installed as part of the US highway system. It carried US-36 until the new Valley City Eagle Bridges were built as part of the I-72 project in 1988. US-36 is now multiplexed on I-72 in western Illinois. Given that I-72 is only a few miles to the north, the Florence bridge is very lightly used.

The bridge consists of 4 Parker style through truss spans, the main lift span, and then 4 more Parker style through truss spans. There is a lengthy causeway on the east end of the crossing, and a very short fill on the west end.

The Florence bridge was refurbished in 1981, and refurbished again in 2004. In the 2004 project, the deck was replaced, the bridge was sandblasted and painted, the lift cables were replaced, a new operators house was built, and electrical work was performed.

93. Valley City Eagle Bridges

Carries	I-72 US 36, 2 lanes per span
Crosses	Illinois River
Locale	Valley City, Illinois
Design	Post Tensioned Cast-In-Place Concrete Box Girder
Longest span	616 ft
Total length	3,329 ft (Eastbound) 3,203 ft (Westbound)
Width	39 ft
Clearence below	72 ft
Opening date	1988
Coordinates	39°41′13.34″N 90°38′28.43″W

The two spans of the **Valley City Eagle Bridges** were built in 1988, but the highway itself was not fully finished until 1991. Prior to that time, US-36 was routed across the Florence Bridge a few miles south of the I-72 river crossing.

The bridges are anchored to the flat river plain on the east side of the Illinois River, and land high in the bluffs on the west side of the river, gaining about 80 feet in altitude as part of the river crossing.

The expressway runs from Decatur in the middle of Illinois west to Hannibal, Missouri. The highway required two major bridges. The bridge over the Mississippi River is called the Mark Twain Bridge, and it opened in 2000. The other is the Valley City Eagle Bridges, twin spans over the Illinois River.

The bridges were built with two relatively new construction techniques. First, the bridges were cast in place using a moving concrete form. Workers would cast one section of the bridge in place, then move the forms ahead a few feet and cast the next section.

94. Meredosia Bridge

Carries	IL 104
Crosses	Illinois River
Locale	Meredosia, Illinois
Design	Steel Truss Through Deck
Longest span	568 ft
Total length	2,232 ft
Width	24 ft, 2 lanes
Clearence below	72 ft
Opening date	1936, Reconstructed 1984
Coordinates	40°00′54.67″N 90°26′48.70″W

This 1936 era big metal monster crosses the Illinois River on the west side of the small town of Meredosia. The **Meredosia Bridge** bridge replaced an earlier wagon bridge. A railroad bridge once crossed the river a few hundred feet downstream from the highway bridge. The Meredosia bridge was reconstructed in 1984. A group of bad floor beams were discovered and fixed in the 1990s.

The bridge was quickly inspected and pronounced to be safe following the I-35W bridge collapse in August, 2007. Despite the bridge being safe, it has a very low sufficiency rating and is eligible for federal funds for replacement.

95. Beardstown Bridge

Carries	US-67, IL-100
Crosses	Illinois River
Locale	Beardstown, Illinois
Design	Truss bridge
Longest span	540 ft
Total length	3,624 ft
Width	28 ft
Clearance below	68 ft
Opening date	1955, (Reconstructed 1985)
Coordinates	40°00′54.67″N 90°26′48.70″W

A steel toll bridge was built by the city and opened in 1898. That bridge produced revenue for the city until 1955, when a new highway bridge was built in the mid-1950s to give highway US-67 a bypass route around the downtown area.

The **Beardstown Bridge** is one massive bridge, something that would only be expected on the lower Mississippi or other similarly large river. The main bridge is a through truss span about 1,365 feet long, with a 540 foot main span for navigation traffic. It rises nearly 70 feet above the water to the low steel line. To the north, there is a second through truss bridge about 710 feet long. A 1,000 foot long trestle crosses a backwater slough to the north, and a 500 foot steel deck truss bridge spans a creek on the south end. The overall river crossing is 2/3 of a mile.

96. Scott W. Lucas Bridge

Carries	US 136 IL 78 IL 97
Crosses	Illinois River
Locale	Havana, Illinois
Design	Steel Truss Through Deck
Longest span	420 ft
Total length	1727 ft
Width	29 ft, 2 lanes
Clearance below	70 ft
Opening date	1936, Reconstructed 1998
Coordinates	40°17′38.92″N 90°04′08.24″W

The **Scott Wike Lucas Bridge** (Havana Bridge) carries US-136 and two state highways across a narrow spot in the Illinois River. The bridge consists of a single large steel truss. Since the bridge has to be high enough to allow boats to travel under the main span, yet the bridge does not have any side spans, the resulting bridge approaches are relatively steep. The bridge is very much like a highway roller-coaster. The effect would be much more pronounced if the speed limit was higher than the posted 35 miles per hour.

97. Pekin Bridge

Carries	IL 9
Crosses	Illinois River
Locale	Pekin, Illinois
Design	Continuous Steel Girder bridge
Longest span	550 ft
Total length	2,634 ft
Width	23 ft
Clearence below	27 ft
Opening date	May 1, 1982
Coordinates	40°34′25.07″N 89°39′15.43″W

The **Pekin Bridge** is 9 span bridge over the Illinois River with 1,320in. It has 3 span steel box girder river section and the approaches are steel plate girders.

The Bridges' orthotropic roadway deck has longitudinal and transverse welds.

98. Shade-Lohmann Bridge

Carries	4 lanes (2 each WB/EB) of I-474
Crosses	Illinois River
Locale	Bartonville, IL and Creve Coeur, IL
Total length	WB: 3,424.9 ft (1,043.9 m) EB: 3,420.9 ft (1,042.7 m)
Width	39.0 ft (11.9 m)
Beginning date of construction	1973
Completion date	1975
Opening date	1975
Coordinates	40°38′05.86″N 89°37′20.89″W

The **Shade-Lohmann Bridge** carries Interstate 474 over the Illinois River near the Peoria Lock and Dam located at River Mile 158.0 in Tazewell County, in the U.S. state of Illinois. It connects U.S. Route 24 between Bartonville and Peoria, Illinois to Illinois Route 29 between Creve Coeur and North Pekin, Illinois.

Built in 1973, the bridge was named after Pekin's former Mayor and Illinois Legislator, Norman Shade, and Martin B. Lohmann who served in the Illinois Legislature continuously from 1923-1953.

99. Cedar Street Bridge

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Carries	4 lanes of ILL 8/ILL 29/ILL 116
Crosses	Illinois River
Locale	Peoria, Illinois and East Peoria, Illinois
Design	Truss arch bridge
Total length	3,750 ft (1,143 m)
Width	40 ft (15 m)
Load limit	53.1 metric tons
Clearance below	61.7 feet (18.8 m)
Opening date	1932
Coordinates	40°40′38.42″N 89°36′00.84″W

The **Cedar Street Bridge** carries Illinois Route 8, Illinois Route 29, and Illinois Route 116 over the Illinois River. It is about a mile and a half southwest from downtown. The bridge is a simple steel arch bridge that towers approximately 70 to 80 feet above the surface of the river, and is the shortest span of the five.

The name of the bridge comes from the original name of its street on the Peoria side of the river; the street itself is now called MacArthur Highway, while the bridge is still referred to as Cedar Street.

100. Bob Michel Bridge

Carries	4 lanes of ILL 40, sidewalk
Crosses	Illinois River
Locale	Peoria, Illinois and East Peoria, Illinois
Design	Steel girder
Total length	2,365 ft (720.9 m)
Width	62.0 ft (18.9 m)
Clearance below	65.9 ft (20.1 m)
Opening date	1993
Coordinates	40°41′04″N 89°35′31″W

The **Bob Michel Bridge** carries Illinois Route 40 over the Illinois River just 0.75 miles (1.21 km) up-river from the Cedar Street Bridge. Illinois 40 terminates at an interchange with Interstate 74 just east of the bridge. The bridge serves as a direct surface route from a major commercial center in East Peoria to the Civic Center in downtown Peoria. The Bob Michel bridge replaced the antiquated Franklin Street Draw Bridge. The bridge is located at mile 162.3 of the Illinois River.

The Bob Michel Bridge is named after former Congressman Robert H. Michel who served as a Congressman from 1956 to 1995.

101. Murray Baker Bridge

Carries	4 lanes of I-74
Crosses	Illinois River
Locale	Peoria, Illinois and East Peoria, Illinois
Design	Cantilever bridge
Total length	Original: 3,216 feet (980.2 m) Current: 3,036 feet (925.3 m)
Vertical clearance	14.4 ft (4.4 m)[1]
Clearance below	48.9 ft (14.9 m)[1]
Opening date	1958
Coordinates	40°41′16″N 89°35′00″W

The **Murray Baker Bridge** is a landmark cantilever bridge that carries Interstate 74 over the Illinois River from downtown Peoria to East Peoria in central Illinois. According to the Illinois Department of Transportation, the Murray Baker Bridge was built in 1958, and had an original length of 3,216 feet (980.2 m).

The bridge carries Interstate 74 over the Illinois River at the end of Peoria Lake. The bridge itself is a single cantilever bridge, with two lanes in each direction. Because it has no shoulders, the Baker Bridge is not up to modern Interstate standards.

102. McClugage Bridge

Carries	5 lanes (3 WB, 2 EB) of US 24/150
Crosses	Illinois River
Locale	Peoria, Illinois
Design	Dual Cantilever bridges
Total length	4,745.1 ft (1446.3 m)
Width	WB: 39.0 ft (11.9 m) EB: 28.9 ft (8.8 m)
Clearance below	14.9 m
Opening date	WB: 1982 EB: 1948, reconstructed 2000
Coordinates	40°43′11.08″N 89°32′40.27″W

The **McClugage Bridge** carries U.S. Route 24 and U.S. Route 150 over Upper Peoria Lake in Illinois, United States.

The route is actually two steel cantilever bridges, side by side, with three lanes on the westbound bridge and two on the eastbound bridge.

There was an effort to change the name of the bridge to "Ironworkers Memorial Bridge" after an accident in 2000 killed three iron workers when scaffolding on the bridge collapsed 60 feet into the river. However, instead of the name change, the iron workers were memorialized by a monument near the bridge that was dedicated in April 2001.

103. Lacon Bridge

Carries	IL-17
Crosses	Illinois River
Locale	Sparland and Lacon, Illinois
Design	Steel truss
Longest Span Length	378 ft
Total length	1,573 ft
Width	26 ft 2 lanes
Clearance below	60 ft
Opening date	1939
Coordinates	41°01′32.43″N 89°25′00.28″W

The Lacon Bridge is a large steel through truss bridge carries Illinois State Highway 17 across the Illinois River south of the Peru-La Salle area and north of the Peoria area.

This style truss bridge is called a continuous truss as opposed to a simple truss. The Lacon Bridge has 4 piers, one on each end, and two mid-channel. The continuous truss bridge is one rigid structure that spans more than 2 piers. The continuous truss can be built with longer main channel spans than simple truss bridges, so they are used in cases where a wide navigation channel preferred. There are many continuous truss bridges over the major rivers, but they have the disadvantage that they are costly to maintain.

104. Henry Bridge

Carries	IL-18
Crosses	Illinois River
Locale	Henry, Illinois
Design	Steel Truss Through Deck
Largest span	364 ft
Total length	1,719 ft
Width	23 ft 2 lanes
Clearance below	60 ft
Opening date	August 15, 1935
Coordinates	41°06′29.89″N 89°21′07.68″W

The **Henry Bridge** was dedicated on August 15, 1935. It is a steel bridge that consists of six Pennsylvania style through truss spans. Five of the spans are the same size, while the main river span is slightly larger.

The new Henry Bridge was in service until 1988. The deck had deteriorated to the point where it was no longer safe. The deck system, under deck braces, and a number of rivets were replaced. The structure was then sandblasted and painted. The bridge emerged in like-new condition, and it serves traffic to this day with only routine inspections and maintenance.

105. Gudmund Sonny Jessen Bridge

	
Carries	I-180, IL-26
Crosses	Illinois River
Locale	Hennepin, Illinois
Design	Steel girder
Total length	3,084 ft
Width	59 ft 4 lanes
Clearance below	60 ft
Opening date	1969
Coordinates	41°15′39.13″N 89°20′50.79″W

Prior to the **Gudmund Sonny Jessen Bridge,** which is formerly known as I-180 Bridge, IL-26 crossed the Illinois River at Hennepin. It was crossed on a huge metal monster bridge that featured a 3-span through truss connected back to back with a 2-span through truss. The designation for highway IL-26 was moved to share the I-180 bridge in 1990. The old bridge continued to deteriorate until it became a hazard. The state of Illinois attempted to sell the old bridge, but no takers had the wherewithal to refurbish the structure to make it safe. As a result, the old bridge was removed in 2000.

Interstate highway I-180 is one of the least traveled Interstate highways in the US. I-180 serves the small city of Hennepin, Illinois.

106. Spring Valley Bridge

Carries	IL-89
Crosses	Illinois River
Locale	Spring Valley, Illinois
Design	Steel truss
Longest Span Length	364 ft
Total length	1,776 ft
Width	23 ft 2 lanes
Clearance below	63 ft
Opening date	1934
Coordinates	41°18′43.62″N 89°11′59.82″W

The bridge at **Spring Valley** is almost a duplicate of the Henry Bridge, with the exception that the Spring Valley bridge has only 5 spans, whereas the Henry bridge has 6 spans. Like the Henry Bridge, the main channel span is slightly larger than the other bridge spans. This bridge was also built at the time that the 9-foot navigation project was being constructed.

The Spring Valley bridge was rebuilt in 1989 and 1990. The contractor used an innovative overhead crane system.

107. Peru Bridge

Carries	IL-251 Highway
Crosses	Illinois River
Locale	Peru, Illinois
Design	Steel truss
Longest span	477 ft
Total length	2,292 ft
Width	30 ft, 2 lanes
Clearance below	65 ft
Opening date	1958
Coordinates	41°19′25.80″N 89°07′12.48″W

The **Peru Bridge** (or IL-251 Bridge) was built between the two cities of Peru and La Salle in 1958. The original river crossing in the Peru and La Salle area was the Shippingsport Bridge, just up river from this structure. A wagon bridge was built prior to 1900. It was replaced with a multi-span steel truss bridge with a lift span in 1929.

The original name of this bypass took the name US-51, so the Shippingsport Bridge alignment was called Business-51. The new US-51 bypass crossed the Illinois Waterway with a large steel truss structure about a mile west of the Shippingsport Bridge.

Then the US-51 bypass was turned back to the state of Illinois, which gave it the name IL-251.

Major work was completed on the bridge in 1992. The deck was removed and replaced, bearings were repaired, and the pins that held key beams together were replaced.

108. Abraham Lincoln Memorial Bridge

Carries	Four lanes of U.S. 51/I-39
Crosses	Illinois River, IL 351, Illinois and Michigan Canal ,Iowa Interstate Railroad, and Buzzi Unicem industrial rail lead (the former Illinois Central Railroad mainline).
Locale	La Salle, Illinois and Oglesby, Illinois
Design	Tied arch
Longest span	619.9 feet (189 m)
Total length	2,170.8 metres (7,122.0 ft)
Width	4 traffic lanes, 82 ft (25 m)
Vertical clearance	19.3 feet (5.88 m)
Opening date	1987
Coordinates	41°19′29″N 089°04′37″W

The **Abraham Lincoln Memorial Bridge** in Illinois is a four-lane bidirectional road bridge that spans the Illinois River, Illinois Route 351, Illinois and Michigan Canal, and numerous local roads, lakes, and railroads. It carries Interstate 39, a major north-south Interstate through central Illinois, and its U.S. Route counterpart, U.S. Route 51.

The bridge connects the cities of La Salle and Oglesby, and (like the Mississippi River) maintains an elevation of about 60 feet (18 m) above the Illinois River Valley for its 2 mile (3 km) length. The main span is 619 ft (189 m) long, with approaches in excess of a mile and a half (2½ km). It is the longest arch bridge in Illinois.[1]

The bridge was built in 1987 when Interstate 39 was first extended south to what is now Illinois Route 251.

109. Utica Bridge

Carries	IL-178
Crosses	Illinois River
Locale	Utica, Illinois
Design	Steel truss
Longest Span Length	378 ft
Total length	1,158 ft
Width	30 ft 2 lanes
Clearance below	63 ft
Opening date	1962
Coordinates	41°19′37.67″N 89°00′38.31″W

The main truss structure of the **Utica Bridge** is 812 feet long, with a center span of 378 feet, which is flanked by two side spans of 217 feet each. This 1962 vintage bridge replaced an earlier swing bridge. The higher and wider truss bridge is much safer for river navigation than a narrow swing span. The bridge is a bit narrow.

While this bridge looks like a continuous style truss, it is actually a cantilever style truss. On each side of the bridge, the first span and 1/4 of the center span balance each other out. That is, if you removed the middle half of the main span, the two end sections would remain standing and be structurally sound. The middle half of the center span is then suspended by the outside sections. The outside sections count on being balanced properly to resist the force that wants them to tip towards the middle of the river and drop the center span into the water. This works as long as there is more weight on the outside of the main span than between the main span piers. The cantilever effect results in the center span having a flat top, where as a continuous truss would have the U-shape or catenary shape like an upside down arch.

110. Ottawa Bridge

Carries	IL 23 IL 71 Railroad
Crosses	Illinois river
Locale	Ottawa, Illinois
Design	Steel truss w/ lift span
Width	1 track
Clearance below	21 ft
Opening date	1868
Coordinates	41°19′22.85″N 88°42′36.61″W

The **Ottawa Bridge** is a railroad bridge carrying IL 23 IL 71. It is a steel truss span with lift span. The new lift span would likely have been installed, along with raising the rest of the bridge to match the height of new lift span.

It was built in 1868. The first bridge built at this location was part of the Chicago, Burlington, & Quincy Railroad mainline heading from Chicago to the Mississippi River. The key rival was the Santa Fe, which had a Chicago to Mississippi River mainline that crossed the Illinois River at Chillicothe. The CB&Q became the Burlington Northern Railway.

111. Seneca Bridge

Carries	IL-170
Crosses	Illinois River
Locale	Seneca, Illinois
Design	Steel truss
Longest Span Length	364 ft
Total length	1,510 ft
Width	23 ft 2 lanes
Clearance below	48 ft
Opening date	1932, (Reconstructed 1986)
Coordinates	41°17′56.80″N 88°36′33.01″W

The **Seneca Bridge** is on the endangered list. A new bridge is under construction as of 2008, and this old 4 span through truss bridge will be removed in a few years. It is a shame to lose yet another truss style bridge. It is unfortunate that they are so expensive to maintain and cost-prohibitive to expand the narrow lanes. The only thing that can be said is to get out and see this old bridge before it is removed in 2010.

The village of Seneca was incorporated in 1865, and the first bridge across the Illinois River was built in 1866. That bridge collapsed, so an iron bridge was built in 1877. That bridge was replaced in 1932 by the current highway bridge.

The new bridge will be a 2 lane structure very much like the IL-351 bridge at Shippingsport. It will feature high strength steel girders with a concrete deck. The deck will be 40 feet wide, enough room for two 12-foot lanes, shoulders, and a walkway on one side. The walkway will be separated from the bridge by a concrete barrier. The main span is expected to be 350 to 375 feet.

112. Morris Bridge

Carries	IL-47
Crosses	Illinois River
Locale	Morris, Illinois
Design	Steel Girder Concrete Deck
Longest Span Length	410 ft
Total length	1,730 ft
Width	61 ft 4 lanes
Opening date	November 2002
Coordinates	41°01′32.43″N 89°25′00.28″W

The **Morris Bridge** is very new, having been completed in late 2002. The old bridge was a graceful metal monster built from 5 sections of Pennsylvania style through truss spans. The old bridge, built in 1934 and rehabilitated in 1978, was 1,456 feet long, had a 363 foot main span supporting a 350 foot wide navigation channel. It stood 50 feet from the water to low steel. The key figure that lead to its eventual doom was its 22 foot deck width. That was too narrow for modern highway lanes, and two lanes was too few to support a growing region.

To meet the needs of the 21st century, a modern steel girder bridge supporting 4 traffic lanes and a 10 foot wide regional trail was built. To meet the needs of river navigation, the bridge was built with a 410-foot main span soaring high over the water. Side spans of 300 feet and 360 feet flank the main span. The new bridge is purely functional with no decorative elements. The piers are large and blocky, designed to withstand the pressures of ice and barge strikes.

There is good access under the north end of the bridge. The I&M Canal runs under the far north end of the bridge, along with the tow path trail. There is also a boat launch and city park between the canal and the Illinois River.

113. Pendleton Bridge

Carries	US 165
Crosses	Arkansas River
Locale	Arkansas Post, Arkansas
Design	Steel girder
Coordinates	33°58′49″N 91°23′05″W

The **Pendleton Bridge** is a steel girder bridge located in Arkansas Post, nearly 8 miles (13 km) southeast of Gillett, Arkansas. The bridge crosses the Arkansas River at the 22.6 mile and carries Highway 165.

114. Lawrence Blackwell Bridge

Carries	US 79 AR 63
Crosses	Arkansas River
Locale	Pine Bluff, Jefferson County, Arkansas
Design	Concrete girder
Coordinates	34°14′56″N 91°54′13″W

The **Lawrence Blackwell Bridge** is concrete girder bridge crossing the Arkansas River in Pine Bluff, Jefferson County, Arkansas. The bridge carries US 79 and AR 63.

115. Rob Roy Bridge

Crosses	Arkansas River on the Union Pacific Railroad northeast of Pine Bluff
Locale	Pine Bluff, Jefferson County, Arkansas
Design	Vertical lift Warren through truss
Coordinates	34°15'58" N 91°54'52" W

The **Rob Roy Bridge** is a historic railroad bridge. It is a truss bridge over the Arkansas River on the Union Pacific Railroad northeast of Pine Bluff. It was designed with vertical lift Warren through truss and its vertical lift span was renewed. The bridge is open to railroad traffic.

116. 79-B Bridge

Carries	US 79 Bybass
Crosses	Arkansas River
Locale	Pine Bluff, Arkansas
Design	Concrete girder
Largest span	51.8 ft
Total length	91.8 ft
Width	49.8 ft
Opening date	1929; rehabilitated 1973
Coordinates	34°17′23″N 91°59′49″W

The **79-B Bridge** is an arch bridge on US 79B in Pine Bluff, Arkansas. It crosses the Arkansas River. It was built in 1923 and rehabilitated in 1973. Its longest span is 51.8 ft length. The total length is 91.8 ft. The deck with is 49.8 ft. It is open to traffic. The average daily traffic (as of 2005)of the bridge is 5,300.

117. Pipeline Bridge

Carries	Pipeline
Crosses	Arkansas River
Locale	Redfield, Arkansas
Design	Suspension bridge
Coordinates	34°28′47″N 92°07′26″W

The **Pipeline Bridge** is a suspension bridge carrying pipeline. The bridge crosses the Arkansas River.

118. I-440 Bridge

Carries	Interstate 440
Crosses	Arkansas River
Locale	Little Rock, Arkansas
Design	Steel girder
Coordinates	34°43′26″N 92°10′40″W

The **I-440 Bridge** is located in Little Rock, Arkansas. The bridge crosses the Arkansas River. It carries the Interstate 440 (abbreviated I-440) which connects the Gates Island to the Jones Island. Interstate 440 (abbreviated I-440) in Arkansas is a 10-mile-(16-km)-long partial loop connecting Interstate 40 with Interstate 30 and Interstate 530 near Little Rock. The bridge has two bounds; east and west bounds.

119. Rock Island Bridge

Crosses	Arkansas River
Locale	Little Rock, Pulaski County, Arkansas
Design	Railroad bridge with vertical-lift
Total length	1,614 ft
Opening date	1899
Coordinates	34°44'55" N 92°15'29" W

The **Rock Island Bridge** is a closed railroad over the Arkansas River in Little Rock, Pulaski County, Arkansas. It was built in 1899 by the Choctaw and Memphis Railroad and on December 10, 1899, first regularly scheduled train service crossed the bridge from Memphis to Oklahoma City. The lift span of the bridge was added in 1972. It was designed as two 14-panel Pennsylvania through truss spans and one 12-panel, polygonal Warren through truss vertical lift span. The bridge is awaiting for rehabilitation to reopen for pedestrian traffic.

120. I-30 Bridge

Carries	Interstate 30
Crosses	Arkansas River
Locale	Little Rock, Arkansas
Design	Steel girder
Coordinates	34°45′01″N 92°15′46″W

The **I-30 Bridge** is a continuous steel girder bridge in Little Rock, Arkansas. The bridge is over the Arkansas River. It is on the Interstate 30 which links the downtowns of Little Rock to North Little Rock, Arkansas.

121. Junction Bridge

Carries	Connect the Little Rock and Fort Smith rail line with the Little Rock, Mississippi River and Texas railway
Crosses	Arkansas River
Locale	Little Rock
Design	Steel truss (railroad)
Longest span	360 ft
Total length	1800 ft
Clearance below	38 ft
Opening date	1884
Coordinates	34°45′03″N 92°15′59″W

The **Junction Bridge** was constructed in 1884 as the primary railroad bridge connecting the northern and southern railway lines. In 1985, the then-owners of the bridge, Union Pacific closed the bridge to rail traffic and in 1999 ceded the bridge to the City of Little Rock. Through an inter-local agreement the bridge was leased for 99 years to the Pulaski County Bridges Facilities Board for the purpose of developing the pedestrian/bicycle bridge. After the planning for the conversion of the bridge into a pedestrian and bicycle venue for public use, construction was begun in 2007.

The bridge is believed to be the only "lift span" bridge that has been converted to a pedestrian/bicycle bridge in the United States. The "lift span" is locked into place in a raised position to allow for uninterrupted barge traffic on the river. Visitors to the bridge may transverse the entire length of the structure by riding elevators up to and down from the 360 foot (length) lift span. The overall length of the bridge is 1,800 feet. To accommodate passing river traffic, lift span is now raised 38 feet above the fixed bridge span.

122. Main Street Bridge

Carries	Main Street in North Little Rock
Crosses	Arkansas River
Locale	Little Rock, Pulaski County, Arkansas
Design	Open-spandrel arch
Opening date	Rebuilt 1973
Coordinates	34°45′04″N 92°16′08″W

The **Main Street Bridge** is a seven-span open-spandrel arch bridge over the Arkansas River on Main Street at Little Rock in North Little Rock, Pulaski County, Arkansas. In 1973 it replaced by a modern bridge.

123. Broadway Bridge

Carries	US 67
Crosses	Arkansas River
Locale	Little Rock, Pulaski County, Arkansas
Design	Steel through arch
Max. span length	419.8 ft
Total length	2,786.3 ft
Width	40 ft
Vertical clearance	24.3 ft
Opening date	March 1923, rebuilt 1974
Coordinates	34°45′09″N 92°16′27″W

The **Brodway Bridge** is an arch bridge over the Arkansas River on US 70 (Broadway Street) at Little Rock in North Little Rock, Pulaski County, Arkansas. It is open to traffic. It was completed on March 1923 as a five-span open-spandrel arch bridge. Two spans of the bridge were replaced with a single steel through arch span in 1974. The length of largest span is 419.8 ft, total length is 2,786.3 ft, and deck width is 40.0 ft. Vertical clearance of the bridge above deck is 24.3 ft. The average daily traffic *(as of 2004) is* 24,900.

124. Union Pacific Rail Bridge

Carries	Union Pacific Railroad
Crosses	Arkansas River
Locale	Little Rock, Pulaski County, Arkansas
Design	Steel truss
Opening date	Dec. 21, 1873; destroyed April 3, 1927; rebuilt 1929
Coordinates	34°45′16″N 92°16′55″W

The **Union Pacific Rail Bridge** is a railroad bridge over the Arkansas River in Little Rock on the Union Pacific Railroad. The bridge has vertical-lift. The steel truss Union Pacific Rail Bridge is located in Little Rock, Arkansas. The bridge is originally completed Dec. 21, 1873; destroyed by flooding on April 3, 1927 and rebuilt 1929. It is open to two tracks of railroad traffic.

125. Big Dam Bridge

Carries	Pedestrians and bicycles
Crosses	Arkansas River
Locale	Little Rock, Arkansas North Little Rock, Arkansas
Total length	4,226 feet (1,288 m)
Width	14 feet (4 m)
Opening date	September 30, 2006
Coordinates	34°47′37″N 92°21′31″W

The Pulaski County Pedestrian and Bicycle Bridge, better known as the **Big Dam Bridge**, is the newest bridge to span the Arkansas River at Little Rock, Arkansas, over the Murray Lock and Dam, and is open only to pedestrian and bicycle traffic.

The bridge is the longest pedestrian-only bridge built for that purpose in North America. The longest in the United States is the Chain of Rocks Bridge on the north edge of St. Louis, Missouri at 5,350 feet (1,630 m), but it was originally a highway bridge. At 4,226 feet (1288 m.) in length, the **Big Dam Bridge** rises to 65 feet (20 m) over the surface of the Arkansas River and 30 feet (9.1 m) over the dam. The span over the river is 3463 feet (1055 m.), with the ramps on either side of the river accounting for the rest of the length.

126. I-430 Bridge

Carries	Interstate 430
Crosses	Arkansas River
Locale	Little Rock, Arkansas
Design	Steel girder
Coordinates	34°48′02″N 92°22′28″W

The **I-430 Bridge** is a steel girder bridge carrying Interstate 430 (abbreviated I-430). The bridge crosses the Arkansas River in Little Rock, Arkansas.

127. Highway 9 Bridge

Carries	AR 9 AR 113
Crosses	Arkansas River
Locale	Morrilton, Arkansas
Design	Steel girder
Coordinates	35°07′34″N 92°43′58″W

The **Highway 9 Bridge** is the unique highway bridges crossing the Arkansas River in Morrilton, Arkansas. It carries the Highway 9 in Morrilton.