Research Report

KTC-90-7

SEISMIC ANALYSIS AND RETROFITTING PRIORITIES FOR HIGHWAY BRIDGES ON EARTHQUAKE PRIORITY ROUTE SYSTEM IN WESTERN KENTUCKY

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16. Abstract

Concern has grown in recent years over the seismic activity of the New Madrid seismic zone in Western Kentucky. Bridges, as the vital links of the priority route system, need to be prevented from sever earthquake damages in order to keep the routes paasible after an earthquake has occurred. In this report, seismic rating and seismic analysis were performed for each of 276 bridges on the priority route system. A priority order of retrofitting for the bridges was listed according to their vulnerability to the earthquake. At least 111 bridges need retrofitting based on the results of seismic analyses. The numbers of bridges needing to be retrofitted were determined for different confidence levels. The methods of estimating span-loss type of bridge collapse due to earthquake induced abutment sliding and evaluating bridge damages related to earthquake induced vibration of pier or bent were developed. ATC analysis was also conducted for each bridge.

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NOTATIONS IN MAIN CONTENT

IC	Importance Classification
IR	Importance Rating
A	Acceleration Coefficient
SPC	Seismic Performance Category
ACR	Acceleration Coefficient Rating
LSLR	Local Soil Profile and Liquefaction Rating
SR	Seismicity Rating
VRB	Vulnerability Rating for Bearing
VRCPF	Vulnerability Rating for Column, Pier and Footing
VRA	Vulnerability Rating for Abutment
VR	Vulnerability Rating
CR	Condition Rating
CRS	Span Condition Rating
CRA	Alignment Condition Rating
CRC	Continuity Condition Rating
CRP	Physical Condition Rating
SER	Seismic Rating
W	actual weight of abutment per unit length, kips/ft
W_{req}	required minimum weight of abutment per unit length, kips/ft
D_{max}	maximum dynamic displacement at pier, bent or open abutment, in
D_{sp}	length of support at pier, bent or open abutment top, in
C/D	capacity/demand ratio
D_{req}	required minimum support length
L	length of the bridge deck to adjacent expansion joint, ft
H	average height of piers or bents supporting the bridge deck to the next expansion joint

NOTATIONS IN APPENDIX A

K_h	horizontal earthquake acceleration coefficient
K_v	vertical earthquake acceleration coefficient
γ	unit weight of soil
H	height of soil surface, i.e. height of abutment back
K_{ae}	seismic active earth pressure coefficient
K_{pe}	seismic passive earth pressure coefficient
E_{ae}	seismic active earth pressure resultant
E_{pe}	seismic passive earth pressure resultant
θ	interim variable
ϕ	friction angle of soil
δ	friction angle between soil and abutment wall
β	slope angle of soil face
i	backfill slope angle
E_a	static earth pressure resultant acting at 1/3H
ΔE_{ae}	additional seismic earth pressure force at 0.6H
K_{hcr}	critical seismic acceleration coefficient
F_t	magnification ratio
W_s	vertical force transmitted from the superstructure per abutment length
W_{sup}	dead load of superstructure transmitted to the abutment
L	the length of abutment
E_{ih}, E_{iv}	horizontal, vertical inertia forces acting at center of gravity
a_h, a_v	horizontal, vertical accelerations of the motion.
A_h, A_v	horizontal, vertical acceleration coefficients
W	weight of the abutment per unit length
H	height of abutment
H_b	height of berm or slope protection if any
W_s	vertical load transmitted from superstructure per length
W	weight of abutment per unit length
E_s	resultant of equivalent earth pressure due to wheel load on the backfill adjacent to the abutment
E_{ae}	resultant of active seismic earth pressure
E_a	resultant of active static earth pressure

E_{pe} resultant of passive seismic earth pressure due to berm

E_p resultant of passive static earth pressure due to berm

$K_{ho}W$ critical horizontal inertia force

K_vW vertical inertia force

K_v vertical earthquake acceleration coefficient

K_{ho} maximum acceleration coefficient under which an abutment can just prevent sliding

V_e seismic total vertical resultant at base of abutment

V static total vertical resultant at base of abutment

S_e seismic total horizontal resultant at base of abutment

S static total horizontal resultant at base of abutment

i backfill slope angle

β slope angle of back face of abutment wall

β_2 slope of angle front face of abutment wall

δ friction angle between abutment wall and backfill

ϕ_b friction angle at abutment base

D_{max} maximum relative sliding displacement of abutment

D_{ma} maximum allowable sliding displacement of abutment

D_{sp} support length of superstructure on the pier top

D_{pier} maximum displacement at top of pier during vibration

A maximum acceleration coefficient of an earthquake

v maximum ground velocity of an earthquake

K_{href} reference resistance coefficient under which the abutment will have sliding displacement of D_{ma}

W_{req} required minimum weight of abutment per unit length

NOTATIONS IN APPENDIX B

M_{max} maximum seismic moment at the bottom of a pier column

M_{fsc} flexural strength of a column

V_{max} maximum seismic shear force at the bottom of a pier column

V_{fsc} shear strength of a column

m concentrated mass of the system

c damping coefficient

k lateral stiffness the system

u(t) absolute motion

w(t) relative motion

$z(t)$	ground translated motion
ω_n	natural frequency of the system
ξ	pamping factor
w_{max}	maximum value of relative displacement
t_{max}	time that maximum relative displacement occurs
v_{max}	maximum velocity
a_{max}	maximum acceleration
T_n	natural period of the system
W	weight of the system
K	stiffness of the system
K_l	the stiffness of pier or bent in the longitudinal direction
K_t	the stiffness of pier or bent in the transverse direction
E	modulus of elasticity of pier or bent material
I_{il}	moment of inertia of individual column or pile in the longitudinal direction
I_{it}	moment of inertia of individual column or pile in the transverse direction
ΣI_{il}	total moment of inertia of pier/bent in the longitudinal direction
ΣI_{it}	total moment of inertia of pier/bent in the transverse direction
L	height of pier column or bent pile.
M_{xmax}	maximum seismic column moment in the longitudinal direction,
V_{xmax}	maximum seismic column shear force in the longitudinal direction,
M_{ymax}	maximum seismic column moment in the transverse direction,
V_{ymax}	maximum seismic column shear force in the transverse direction,
M_{max}	total maximum seismic moment in the column,
V_{mam}	total maximum seismic shear force in the column,
E	modulus of elasticity of pier or bent material,
I_{il}	moment of inertia of individual column or pile in the longitudinal direction,
I_{it}	moment of inertia of individual column or pile in the transverse direction,
L	height of pier column or bent pile, and
D_{max}	maximum dynamic deflection at pier top.

INTRODUCTION

An awareness of earthquakes and their possible effects upon the nation's infrastructure is critically important to the public, and in particular, to public officials. The nation's highway system is one of the most important components of the infrastructure. After the occurrence of an earthquake, the highway system is the primary mode of transporting emergency supplies and services into an affected area. Thus, it is important to catalog the important components of the highway system and attempt to anticipate the possible damage to these components from an earthquake.

Western Kentucky is in a high risk seismic zone. In 1811-1812, three of the most severe earthquakes in American history shook the country. The location of these quakes was near a small town on the Mississippi River where the states of Kentucky and Missouri share a border, as shown in Figure 1. It is this river town, New Madrid, Missouri, that is the namesake of a region now regarded by seismologists and disaster response planners as the most hazardous earthquake zone east of the Rocky Mountains — the New Madrid seismic zone.

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

Seismologists[1] have calculated the probabilities of recurrence of sizeable earthquakes in the New Madrid rift zone. The probability of a magnitude 6.3 earthquake (Richter scale) within 50 years is from 86 to 97 percent. The probability of that same earthquake occurring within the next 15 years is from 40 to 63 percent.

The probability of a magnitude 7.6 earthquake occurring within 50 years is from 19 to 29 percent. The probability for this size earthquake occurring within 15 years drops to a range of 5.4 to 8.7 percent.

For a given earthquake, effects at a given location are described by the Modified Mercalli Intensity (MMI) scale which ranges from I (no damage and felt only by instruments) to XII (total destruction), in Appendix N. Values of MMI associated with the 1811-1812 earthquakes are shown in Figure 2. The potential for damage and destruction from earthquakes in the region is significant.

In 1982, the Governor's Task Force on Earthquake Hazards and Safety was created to evaluate Kentucky's earthquake risk and to make recommendations for responding to those risks. This task force recommended increased public awareness and education programs, improved emergency response planning and

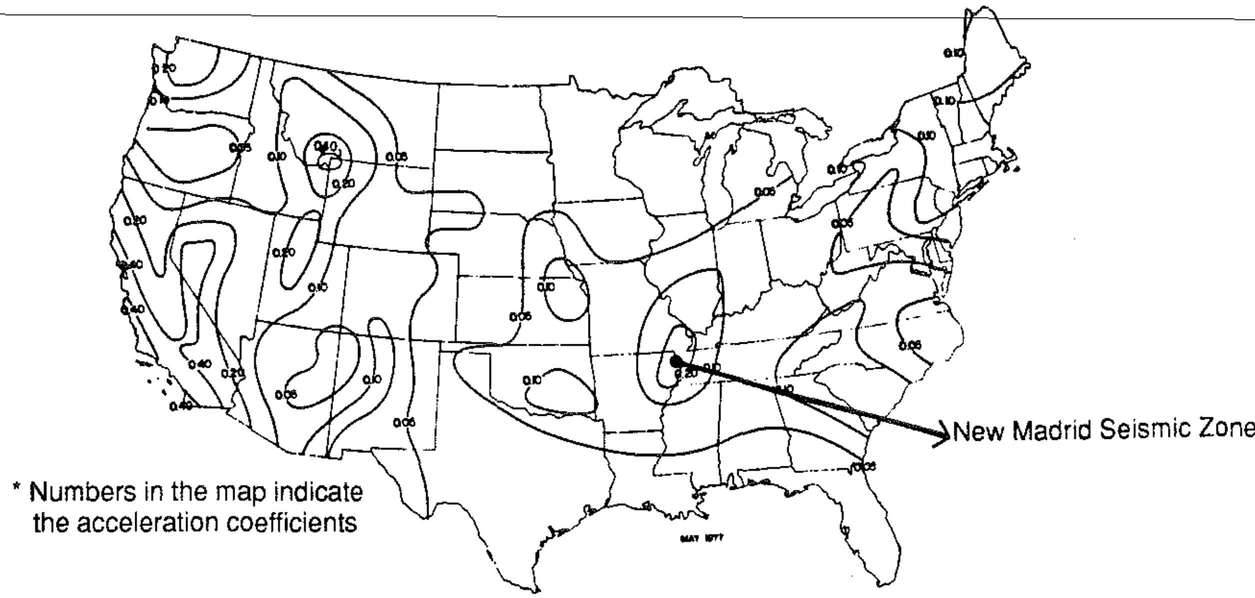

Figure 1. Location of New Madrid Seismic Zone

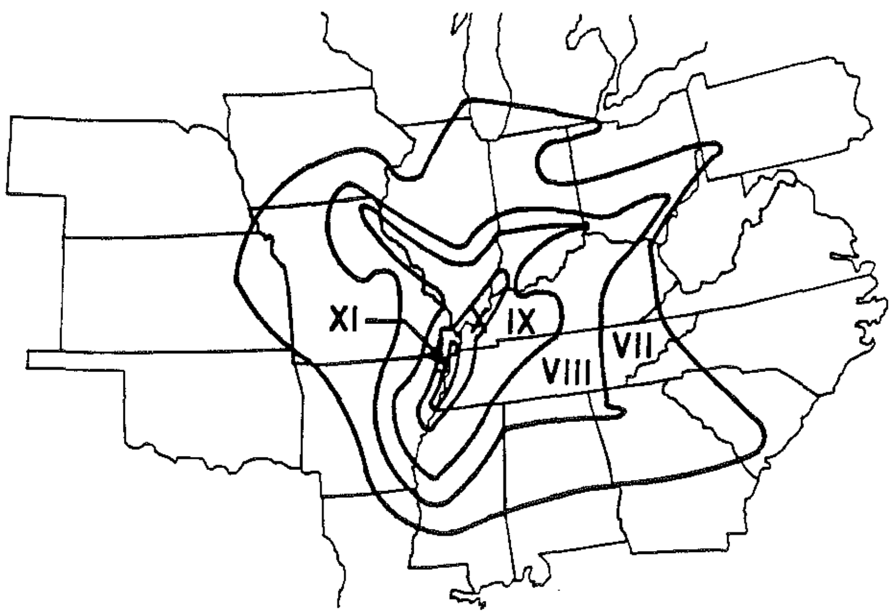

Figure 2. MMI Scale for New Madrid Seismic Zone

training, improved building codes and seismic restraint designs, evaluation of other mitigation measures, and participation in national and regional earthquake forums and funding programs.

In 1984, Governor Collins created the Governor's Earthquake Hazards and Safety Technical Advisory Panel (GEHSTAP) to analyze scientific and engineering data regarding seismic risks in Kentucky and to make specific recommendations on mitigation, public awareness, response planning, and policy development for public health and safety. The States are dependent upon their highway systems for the movement of goods and services. Due to the possible adverse effects a major earthquake could have on this system, the Earthquake Stability and Transportation Subcommittee (ESTS) of GEHSTAP was formed.

ESTS encouraged Kentucky Transportation Cabinet officials to secure funding for generating and implementing an earthquake hazard mitigation plan in an attempt to safeguard the highway system against catastrophic earthquake failure. As a result, Cabinet officials commissioned Kentucky Transportation Center investigators at the University of Kentucky to analyze and assess the possible effects of an earthquake on highway facilities. The study area includes the 26 western-most counties in Kentucky that are adjacent to the New Madrid seismic zone. To date, one of the results of this study has been the recommendation that over 1,000 miles of highways in the study area be utilized as emergency or "priority" routes. These would be the primary routes used for transporting emergency supplies and personnel after an earthquake. Also, it is anticipated that these would be the first routes repaired after an earthquake.

INITIAL TASKS

The initial task in identifying these priority routes was to decide where they should begin; that is, in the event of a major earthquake, the point at which the transport of goods and services would originate. Ideally, the city chosen should possess the following attributes:

1. Sufficient size to contain all necessary personnel, supplies, and facilities to respond quickly to a major emergency;
2. Proximity to the high hazard area to speed the relief effort but not so close as to suffer the same high risk potential;
3. Easy access from other major cities in the State; and
4. Sufficient routes to provide relatively direct access to all 26 high-risk counties.

The city best fitting these criteria is Bowling Green. Located at the eastern edge of the earthquake zone in Warren County, Bowling Green meets both the size criterion (population 40,450) and the accessibility criterion (Louisville and Nashville via Interstate 65 and Lexington via the Bluegrass Parkway). Bowling Green provides access to the 26-county area via US 68/KY 80; this road was chosen as the main east-west artery because it crosses Lake Barkley and Kentucky Lake upstream from the dams impounding those bodies of water.

As a first step towards establishing an overall policy for earthquake hazard mitigation in the highway system, these priority routes have been visually surveyed and all natural and man-made features along these routes that are considered seismically significant were cataloged. With this information, a realistic and cost-effective plan for "hardening" these routes against earthquakes may be established.

In 1988, an interim report entitled "Earthquake Hazard Mitigation of Transportation Facilities"[2] was submitted (Research Report UKTRP-88-2), and in 1989, individual research reports for each of the 26 counties in the study area were published (Research Reports KTC-89-4 through KTC-89-29). An additional report was issued for priority routes in Northern Tennessee (KTC-89-41). The reports list and discuss all natural and manmade features that were logged along the priority routes that are considered seismically significant such as bridges, dams, pipelines, buildings,trees, high fills, faults, rock cuts, etc. Bridges form the critical links on the priority routes and thus need to be protected from the earthquake damages.

SEISMIC RETROFITTING

The seismic retrofitting is one solution for minimizing the hazard for existing bridges on the priority route system. Theoretically, most of the bridges on the priority routes need to be retrofitted. However, not all bridges can be retrofitted simultaneously. The most critical bridges should be retrofitted first. The priority order of bridge retrofitting requires an appreciation for the economic, social, administrative, political and practical aspects of the problem, as well as engineering aspects. The order of retrofitting priority presented in this report will provide important and helpful information for the decision-making process, but will not necessarily dictate the process, since it only reflects the engineering aspects. The priority order for bridge retrofitting is based on the following three major steps:

- o DATA BASE SYSTEM
- o SEISMIC RATING SYSTEM
- o SEISMIC ANALYSIS

The DATA BASE SYSTEM contains the available engineering data and information that are related to the seismic rating and seismic analysis. The data were obtained from the "as-built" bridge plans and field investigations when plans were not available. The data base consists of five major areas: (1) general information, (2) seismicity information, (3) structural information, (4) foundation information and (5) soil properties. Although a major data base system is set up for general use, not all the information are in this data base. Some related information and detailed data, which are used to perform a specific analysis or rating, may be in other related data bases.

A Seismic Rating System was developed to rate the bridges according to their degree of need for seismic retrofitting. This effective and simple way of preliminary screening provides an overall view of a bridge's earthquake resistive capacity and its relative order of retrofitting needs as compared to other bridges in the system. Four individual ratings are evaluated and are then combined through different weighting methods to arrive at an overall seismic rating. These four ratings are importance rating, seismicity rating, vulnerability rating, and condition rating. These ratings reflect the aspects of importance of the bridge as a vital transportation link, seismicity of the bridge site, local soil profile and liquefaction potential, structural characteristics, component vulnerability to the earthquake, current physical condition of the bridge, physical features of a bridge, etc. The seismic rating scores of bridges, as well as the results of seismic analyses of bridges, mainly contribute to the determination of priority order of retrofitting needs for bridges on the priority route system.

The primary goal of retrofitting bridges on the priority route system is to minimize the risk of unacceptable earthquake damage which might cut access to the routes. The most critical damage is the so called "span-loss" type of bridge collapse. Therefore, the seismic analyses performed during this study emphasize estimation of the span-loss type of bridge collapse due to earthquake induced ground motion. Based upon structural dynamics and soil dynamics, analyses methods were developed to evaluate the potential earthquake damages and span-loss type collapse. These methods provide an effective way for seismic analysis of existing bridges, particularly bridges investigated during this study, which (in most cases) have simply supported superstructures. The technical details of the criteria and analysis procedures of abutment related span-loss collapse and pier or bent related damages are presented in Appendix A and Appendix B, respectively. Several computer programs were developed (based upon different types of analyses) to perform the calculations. Three major analyses have been conducted. Pier/intermediate bent analysis and end bent/open abutment analysis are based upon procedures of evaluating bridge collapse from earthquake induced vibration of pier or bent. Solid abutment analysis is based on procedures of estimating span-loss type bridge collapse from earthquake induced abutment sliding. All analyses have been applied to each bridge by using corresponding computer programs. Results of the analyses are presented by a capacity/demand ratio which indicates the potential of span-loss type bridge collapse. In addition to the span-loss collapse analysis, the maximum seismic moments and shear forces in columns and piers were also analyzed. The results will assist in further detailed evaluations of structural components.

In addition to the theoretical seismic analyses described, the Applied Technology Council's "Seismic Design Guidelines for Highway Bridges"[4] (ATC-6) has been used to check existing bridges for minimum support lengths. The ATC analysis has been applied to all bridges for pier or intermediate bent, solid abutment, and end bent or open abutment. Several computer programs were developed and used to perform the ATC analysis. The results are presented by a capacity/demand ratio which indicates the potential of span-loss type of bridge collapse.

From the results of seismic rating, seismic analysis and the ATC analysis, an order of priority for bridge retrofitting on the priority route system was obtained. The number of bridges requiring retrofitting bridges was determined by statistical and probabilistic analyses based upon different confidence levels.

DATA BASE SYSTEM FOR BRIDGES

The data base system for priority routes includes some information of the bridges on the priority routes. The Data Base System in this report contains detailed information required in the seismic analysis of the bridges on the priority routes. The major sources for this data base are the "as-built" bridge plans. Necessary field surveys and measurements were done for bridges for which plans were not available. The main data base system is set up by using Dbase III Plus software. However, not all the data are in this main data base. Some detailed information relating to the analysis and rating is in the respective seismic analysis computer program input or the seismic rating program. Therefore, the main data base together with all data in the analysis programs form the complete data base system. The data provided in this data base system are as follows.

GENERAL INFORMATION

Location Of Bridge

Every bridge is identified by:

a. county (26 counties)
b. route (34 priority routes)
c. milepost (956 miles)

Seismic Performance Category (SPC)

The SPC is determined by computer program SEISPEC.[2] Each bridge is assigned one of following categories:

a. A
b. B
c. C
d. D

Number Of Spans

FOUNDATIONS

Spread Footing On

a. rock
b. gravel
c. sand
d. soil

Footing On Piles

a. friction piles
   - steel
   - precast reinforced concrete
   - timber

b. rock point bearing piles
  - o steel
  - o precast reinforced concrete
  - o timber

PIER AND INTERMEDIATE BENT

Pier Type (including bent)

a. solid pier on rock (single column)
b. open pier on rock (multi column)
c. solid pier on piles (single column)
d. open pier on piles (multi column)
e. pile bent (multi pile)

Pier Type Code

a. 1 — solid pier on rock (S.P.R.)
b. 2 — open pier on rock (O.P.R.)
c. 3 — solid pier on pile (S.P.P.)
d. 4 — open pier on pile (O.P.P.)
e. 10 — pile bent (BENT)

Pier Height and Bent Pile Height

a. pier height from bottom of footer to bridge seat
b. pier height from ground surface to bridge seat
c. bent pile height from tip of pile to cap of pile
d. bent pile height from ground surface to cap of pile
e. pile height under pier

Number of Piers and Bents in a Bridge

a. number of piers in a bridge
b. number of pile bents in a bridge

Number of Columns in Each Pier and Number of Piles in Each Bent

a. number of columns in each pier
b. number of piles in each bent

Geometric Properties of Pier Column and Bent Pile

a. cross section of pier column and bent pile
b. moment of inertia of pier column and bent pile
  - o longitudinal direction
  - o transverse direction

Length of Support at Pier Top

Weight

a. transmitted weight of superstructure to pier or bent
c. weight of pier
d. weight of pile bent

ABUTMENT AND END BENT

Abutment Type and End Bent Type

a. solid abutment with wingwall
  - o spread footing on rock, gravel, sand or soil
  - o supported by piles

b. open multi-column abutment without wingwall
  - o spread footing on rock, gravel, sand or soil
  - o supported by piles

c. end pile bent
  - o with sub wingwall
  - o without sub wingwall
  - o with battered piles
  - o without battered piles

Height of Abutment and Height of End Bent Pile

a. height of abutment from bottom of footer to bridge seat
b. height of end bent pile from tip of pile to pile cap

Transverse Project Length of Abutment

Length of Support at Abutment

Weight

a. transmitted weight of superstructure to abutment
b. weight of abutment

SOIL PROPERTIES

The soil property information was obtained from "*GEOTECHNICAL ENGINEERING DATA*" by Kentucky Transportation Center.[5] The plasticity indexes, PI, of soils at different locations and different depths in each county are available. As described in Appendix A, the soil friction angles used in the analyses were determined based upon a statistical and probabilistic analyses having a confidence level of 95 percent. The soil friction angle is one of the major parameters in seismic analysis, and the results of the analyses are very sensitive to the values of friction angles used. Because the real values of soil friction angles are not always available, the estimated values used in the analyses must be conservative. The effect of this conservative estimate is to create an additional factor-of-safety in the analysis. The estimated soil friction angles determined by the statistical and probabilistic analyses with a 95 percent confidence level has only a 5% chance that estimated friction angles are greater than actual values of soil friction angles. Therefore, it is assumed that the analysis using these estimated values of soil friction angles are 95% on the conservative side (probabilistically), as far as friction angles are concerned. The estimated soil friction angles ϕ for each county are listed in Table 1. The two spread sheet programs used to estimate the soil friction angles by statistical and probabilistic methods, SPPROB and SPDEN, are included in Appendix M.

TABLE 1. ESTIMATED SOIL FRICTION ANGLES FOR EACH COUNTY

COUNTY	PHI (deg.)	COUNTY	PHI (deg.)	COUNTY	PHI (deg.)
BALLARD	26.58	GRAVES	24.11	McLEAN	24.26
BUTLER	26.19	HENDERSON	28.24	MUHLENBERG	26.79
CALDWELL	25.46	HICKMAN	29.04	OHIO	25.93
CALLOWAY	27.25	HOPKINS	26.47	TODD	28.20
CARLISLE	28.95	LIVINGSTON	26.32	TRIGG	25.52
CHRISTIAN	25.59	LOGAN	24.37	UNION	27.83
CRITTENDEN	28.68	LYON	25.96	WARREN	24.29
DAVIESS	29.92	MARSHALL	27.36	WEBSTER	26.76
FULTON	25.11	McCRACKEN	22.94		

SEISMIC RATING SYSTEM

An efficient and comprehensive retrofitting program requires that structures be rated according to their seismic retrofitting needs by a preliminary screening process. Preliminary screening of seismically vulnerable bridges should be carried out efficiently and with a minimum effort. The first step in this process is to obtain critical information about each bridge on the priority route system. The Data Base System accomplishes this step. The second step is to determine a relative order of retrofitting needs for all the bridges on the priority routes by a rational seismic rating system. Although numerical ratings based upon a few selected parameters are rarely a totally satisfactory means for determining the priority of needs, they provide a systematic way of considering the major variables that should be considered. These variables include the vulnerability of the structural system, the seismicity of the bridge site, the condition of the bridge, and the importance of the bridge. The proposed Seismic Rating System addresses each of these variables separately by requiring that vulnerability, seismicity, importance ratings and, condition ratings be calculated for each bridge. Each of these four areas are assigned a rating, weight, and score. These individual rating scores are combined to arrive at a seismic rating. The Seismic Rating System considers only the technical aspects of the problem and does not include administrative, economic, or political considerations. In cases where these other considerations are important, the Seismic Rating System will provide useful information but will not necessarily dictate the order in which bridges should be selected for evaluation and possible retrofitting.

IMPORTANCE RATING

All of the bridges on the priority routes are essential and have the Importance Classification (IC)[6] value of I. The Importance Ratings (IR) for the Importance Classification I are from 6 to 10 points. According to the relative importance of each individual route on the priority route system, the Importance Ratings are listed as following,

ROUTE	FROM	TO	LENGTH-MILES	IR
US68/KY80	BOWLING GREEN (US231)	AURORA (US68 & KY80 SPLIT)	100.77	10
US68	AURORA (KY80)	PADUCAH (KY284)	27.50	10
KY408	US68	BENTON	4.00	10
KY284	US68	PADUCAH (US45)		10
KY80	AURORA (US68)	KY58	16.80	10
US231	BOWLING GREEN	OWENSBORO	66.80	10
US431	RUSSELLVILLE	CENTRAL CITY	35.30	8
KY176	DRAKESBORO (US431)	GREENVILLE	7.80	8
KY136	HARTFORD (KY231)	CALHOUN (KY81)	22.10	8
US41	HOPKINSVILLE (US68/KY80)	PENNRYRILE PKWY (US41A)	18.47	10
US41A	PENNRYRILE PKWY (US41A)	MADISONWILLE (US41)	16.10	10
US41	MADISONVILLE	HENDERSON	33.50	10
KY351	HENDERSON	KY416	11.50	10
KY416	KY351	AUDUBON PKWY	2.20	10
A-PKWY	KY461	KY1554	7.57	10
KY1554	A-PKWY	KY56	1.00	10
KY56	KY1554	OWENSBORO	4.00	10
KY91	HOPKINSVILLE (US68/KY80)	FREDONIA (US641/KY91)	39.05	10
US641/KY91	FREDONIA (KY91)	MARION	9.10	10
KY672	KY91	DAWSON SPRINGS	14.20	9
US62	KY DAM	US68	32.50	10
KY109	DAWSON SPRINGS (US62)	SULLIVAN (US60)	35.27	9
KY94	AURORA (US68/KY80)	HICKMAN (KY125)	65.40	9
KY125	HICKMAN (KY94)	KY166	4.10	8
KY166	KY125	FULTON	13.06	8
US45	INTERSECTION (US45/KY80)	FULTON	20.64	10
KY58	US45	CLINTON	14.85	9
US60	WICKLIFFE	HENDERSON	118.06	10
KY121	MURRY (KY80)	WICKLIFFE	50.50	10
US62	KY121	BARDWELL	5.73	8
KY58/KY80	INTERSECTION (KY58/KY80)	MAYFIELD	11.10	10
KY1751	INTERSECTION (US41)	INTERSECTION (US41A)	1.70	9
US45/KY58	MAYFIELD	INTERSECTION US45/KY58)	11.70	10
US62/US641	INTERSECTION (US62/US641)	KY DAM	14.50	10
US79	RUSSELLVILLE	US641	94.52	9
TRACE	INTERSECTION (US68/KY80)	US79	25.5	9

SEISMICITY RATING

The seismicity rating in this report includes two aspects, Acceleration Coefficient Rating (ACR) and Local Soil Profile / Liquefaction Rating (LSLR). The Acceleration Coefficient Rating is based on the acceleration coefficient, and the Local Soil Profile / liquefaction Rating is based on the Seismic Performance Category (SPC) from the previous study.[2]

Acceleration Coefficient Rating

According to the Acceleration Coefficient (A) provided by ASSHTO Guide Specifications For Seismic Design Of Highway Bridges 1983[7], the maximum acceleration coefficients for 26 counties included in the study area range from 0.2 to 0.05 as shown in Figure 1, on the basis of a 50-year return period. The Acceleration Coefficient Rating (ACR) is calculated by multiplying the maximum acceleration coefficient (A) by 50. This is due to the fact that the formula must yield a maximum rating of 10.

$$ACR = 50\ A$$

If acceleration coefficients 0.05 to 0.2 were used in the formula, the ACR would range from 2.5 to 10. However, the ACR values were raised about 30% based upon the consideration that acceleration coefficient of 250-year return period might increase. Each county is assigned an Acceleration Coefficient Rating from 4 points to 10 points which is shown in Figure 3.

Local Soil Profile and Liquefaction Rating

Local soil profile and liquefaction rating is determined from the SPC obtained in the previous work.[2]

According to ATC's Seismic Retrofitting Guidelines for Highway Bridges,[4] Seismic Performance Category (SPC) should be determined from the Importance Classification (IR) and Acceleration Coefficient (A) as follows.

Acceleration Coefficient	Importance Classification I	Importance Classification II
$A \le 0.09$	A	B
$0.09 < A \le 0.19$	B	B
$0.19 < A \le 0.29$	C	C
$0.29 < A$	D	C

The computer program SEISPEC, which was used to determine the SPC for each bridge on the priority routes, considered not only the Importance Classification and the Acceleration Coefficient but the Micro-Zone effects as well. That was included in the interim report "Earthquake Hazard Mitigation of Transportation Facilities".[2] The SPC determined by this program reflects more the nature of local soil profile and liquefaction potential than the nature of seismicity and importance since each bridge has been assigned the same importance classification and the range of the acceleration coefficient only covers two seismic performance categories. Therefore, it is proper and reasonable to use the SPC determined by the program SEISPEC as the source for

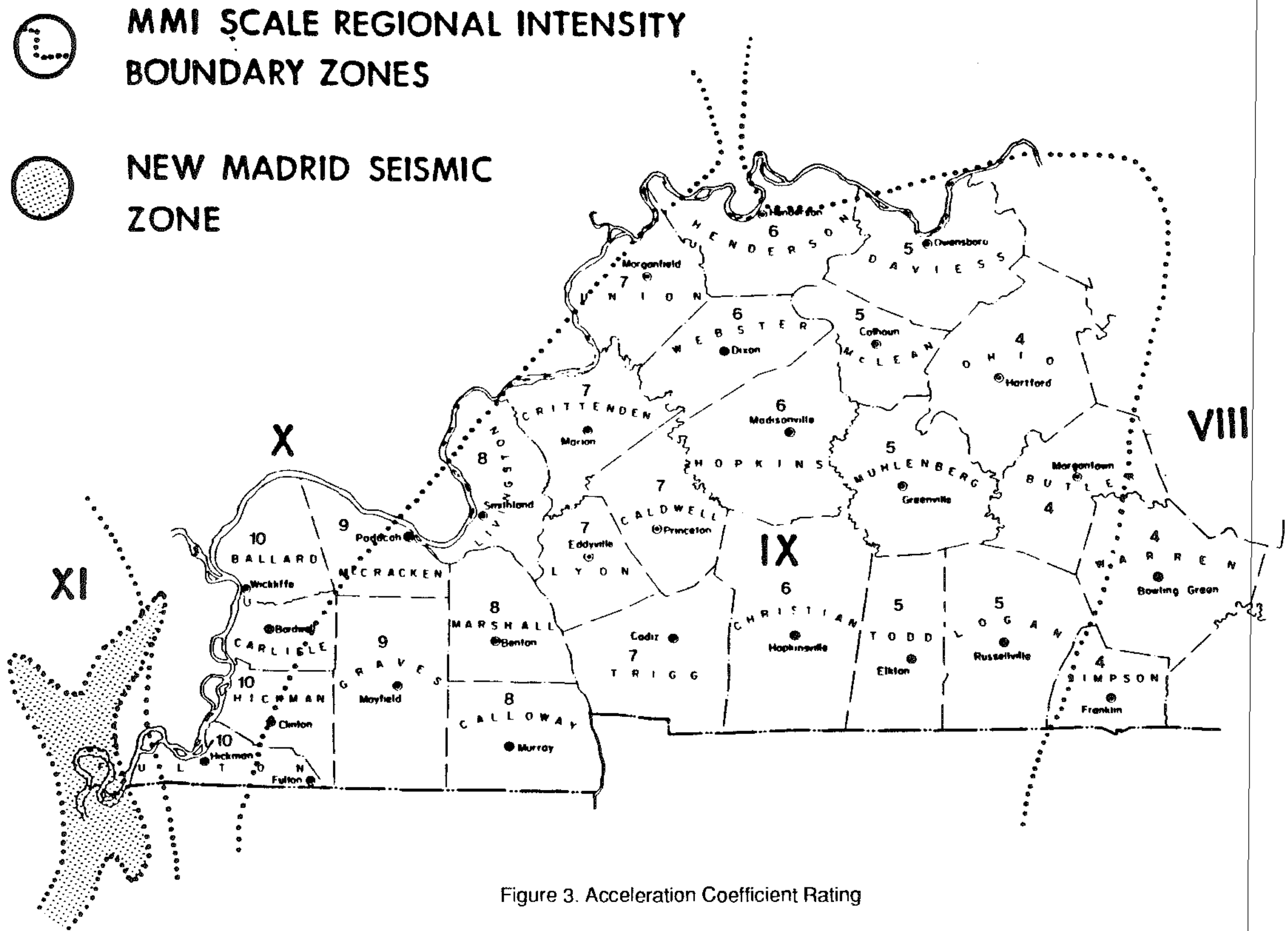

Figure 3. Acceleration Coefficient Rating

the Local Soil Profile and Liquefaction Rating (LSLR). The following ratings also reflect the philosophy that bridges in SPC-A do not require retrofitting and screening of bridges in SPC-B is optional.

SPC	A	B	C	D
LSLR	0	5	8	10

Seismicity Rating (SR)

$$SR = \frac{1}{2}(ACR + LSLR)$$

VULNERABILITY RATING

Although the performance of a bridge is based upon the interaction of all of its components, it has been noted during prior earthquakes that certain bridge components are most vulnerable to earthquake damage. These are the bearings, columns, piers, footings, abutments, and foundations (liquefaction damage). For this reason, the vulnerability rating used in this seismic rating system is determined by examining each component separately from the remainder of the structure. The vulnerability rating of the entire structure is assumed to be equal to the component having the greatest vulnerability rating.

Bearings

Bearings are used at superstructure/substructure interfaces as well as at in-span joints. There are basically four types of bearings used in bridge construction. One type, the rocker bearing, is most seismically vulnerable. Another type of bearing, the roller bearing, is relatively stable during an earthquake, with the exception it may become misaligned or horizontally displaced. The third type is the elastromeric bearing pad which is highly stable during an earthquake. The final bearing type is the sliding bearing which relies on the sliding of one surface over another. A Vulnerability Rating for Bearing (VRB) for each type of bearing follows. The integral abutments have no bearing problems and are assigned a VRB of 0.

Bearings	VRB
Rocker	10
Roller	5
Elastromeric	2
Sliding	2

Columns, Piers and Footings

Columns have failed during previous earthquakes due to lack of proper transverse reinforcement and poor structural details. Excessive ductility demands have resulted in degradation of column strength in shear and flexure. In several serious failures during previous earthquakes, columns have failed in shear resulting in severe vertical settlements or total column disintegration. Another serious type of column failure resulted from longitudinal reinforcing steel pullout at the footings. Fortunately, serious bridge column failures only occurred during earthquakes having fairly high ground acceleration of relatively long duration. Based upon these facts, the Vulnerability Rating of Columns, Piers and Footings (VRCPF) are determined as follows:

SPC	VRCPF
A	0
B	0
C	0
D	Computed by eq. (1)

$$VRCPF = C - 6 \left(\frac{L_c}{F P_s b_c}\right) \qquad (1)$$

where,

L_c — effective column length in feet

P_s — percent main reinforcing steel (%)

b_c — transverse column dimension in feet

F — framing factor

F = 2 (multi-column bents fixed top and bottom)

F = 1 (multi-column bents fixed at one end)

F = 1.5 (single column)

C — condition factor

C = 12 (continuous structures with diaphragm abutment)

C = 11 (right structure - skew $<$ 20 degrees)

C = 10 (other cases for A $<$ 0.4)

An average column main reinforcing steel percentage of 4% is assumed, which is between the maximum value of 8% and the minimum value of 1%., when the reinforcing steel detail is not available. For pile bents, the VRCPF is assigned to be a value of 0.

Abutments and Backfill

Abutment failures during earthquakes do not usually result in the total collapse of the bridge. This is especially true for earthquakes of low-to-moderate intensity. Therefore, the Vulnerability Rating of Abutment should be based upon damage that would temporarily prevent access to the bridge. One of the major problems observed in previous earthquakes has been settlement of the approach embankment. Settlement is expected to be one of the major problems in a New Madrid earthquake. The settlement is assumed to be 3% to 5% of the fill height. This figure is based upon the amount of settlement that has generally been experienced in other prior earthquakes throughout the world. The Vulnerable Rating of Abutments (VRA) is determined by following method.

For end bents and open abutments having backfill:

SPC	VRA	SETTLEMENT
A	0	
B	0	
C	10 if S > 6 inches	$S = 0.03\ H_f$
	5 if S < 6 inches	$S = 0.03\ H_f$
D	10 if S > 6 inches	$S = 0.05\ H_f$
	5 if S < 6 inches	$S = 0.05\ H_f$

For the freestanding, earth-retaining abutments

SPC	VRA
A	0
B	0
C	0 if H_f < 10 feet
	5 if H_f > 10 feet
D	5 if H_f < 10 feet
	10 if H_f > 10 feet

where,

S — settlement, in

H_f— fill height, ft

Vulnerability Rating

The Vulnerability Rating (VR) of a bridge is determined as the greatest of the Vulnerability Ratings for each of the components.

VR = maximum of VRB or VRCPF or VRA

CONDITION RATING

Condition Rating (CR) is based on the geometric and physical features of a bridge that should be considered in a retrofitting analysis. Four physical features contribute to the Condition Rating. They are Span Condition (CRS), Alignment Condition (CRA), Continuity Condition (CRC), and Current Physical Condition (CRP).

CONDITION		Rating
CRS	Single span bridge	0
	Multi span bridge	10
CRA	Straight bridge	0
	Skewed bridge <20 degree	5
	Skewed and curved bridge	10
CRC	Continuous superstructure	0
	Continuous superstructure with a few joints	5
	Simply supported superstructure	10
CRP	Good current physical condition	0
	Fair current physical condition	5
	Poor current physical condition	10

The overall Condition Rating is the average value of each related individual rating obtained from above.

$$CR = \frac{1}{4} (CRS + CRA + CRC + CRP) \qquad (2)$$

SEISMIC RATING

Seismic Rating is a combination of all the previously discussed individual ratings. According to the importance of each rating, a relative weight is assigned to each of the four individual ratings as well. A score is calculated from each individual rating and is weighted by the following procedure.

Importance Rating	* Weight for IR	= Score for IR
Seismicity Rating	* Weight for SR	= Score for SR
Vulnerability Rating	* Weight for VR	= Score for VR
Condition Rating	* Weight for CR	= Score for CR
Seismic Rating		= Total Score

The Seismic Rating reflects the need for retrofitting. The higher the seismic rating score, the greater the need for the bridge to be evaluated for seismic retrofitting.

Since the bridges included in this study are all considered important, the smallest weight is assigned to importance rating. The largest weight is assigned to the seismicity rating because the bridges are in an area having a relatively wide range of seismicity (Acceleration Coefficients range from 0.05 to 0.2)

RATING	WEIGHT
Seismicity	4
Vulnerability	3
Condition	2
Importance	1

$$SER = 4\ SR + 3\ VR + 2\ CR + IR \quad (3)$$

The total weight is 10 and the total score for Seismic Rating is 100. This weighting distribution is the group 1 in the following discussion.

RESULTS OF SEISMIC RATING

A computer program, SEISRATE, has been developed and used to evaluate the Seismic Rating scores for the 276 bridges on the priority route system. By using the program SEISRATE, the influence of weight distribution of each individual rating on the overall seismic rating score was studied. Five different distributions of weights are assigned to evaluate the seismic rating scores for the same bridges. The results of this study show the following statistical characteristics and are included in the interval frequency graphs in Figure 4. Since the frequency graph of group 2 is similar to group 1, it is not shown in Figure 4.

INDIVIDUAL	WEIGHT DISTRIBUTIONS GROUP				
RATINGS	1	2	3	4	5
Seismicity	4	4	4	3	2.5
Vulnerability	3	4	2	3	2.5
Condition	2	1	3	3	2.5
Importance	1	1	1	1	2.5
Seismic Rating Score					
Maximum Value	97.5	98.8	96.3	96.3	96.9
Minimum Value	18	18	18	15.5	26.3
Average Value	63.5	63.0	64.3	62.5	68.2

The results show that when relative weights are adjusted within reasonable limits, very little difference will result in the maximum values, minimum values, and average values of seismic rating scores. It indicates that the selected weight distributions are reasonable for the bridges included in the study and meet the particular needs and preferences for the priority of retrofitting. The frequency graphs show that the adjusted relative weights have little influence upon the relative priorities of the bridges having the greatest need for retrofitting and of those bridges having little need for seismic retrofitting. An examination of the types of bridges affected by varying the relative weights of individual ratings reveals that these bridges lie in a sensitive zone where subjective judgment should play a much greater role in assigning priorities.

The results of the Seismic Rating for weight distribution group 1 are listed in Appendix C. The highest possible score of Seismic Rating is 97.5 and the lowest is 18. The average score is 63.5. The distributions of seismic rating scores are shown as following tabulation and the frequency distributions are shown in Figure 4.

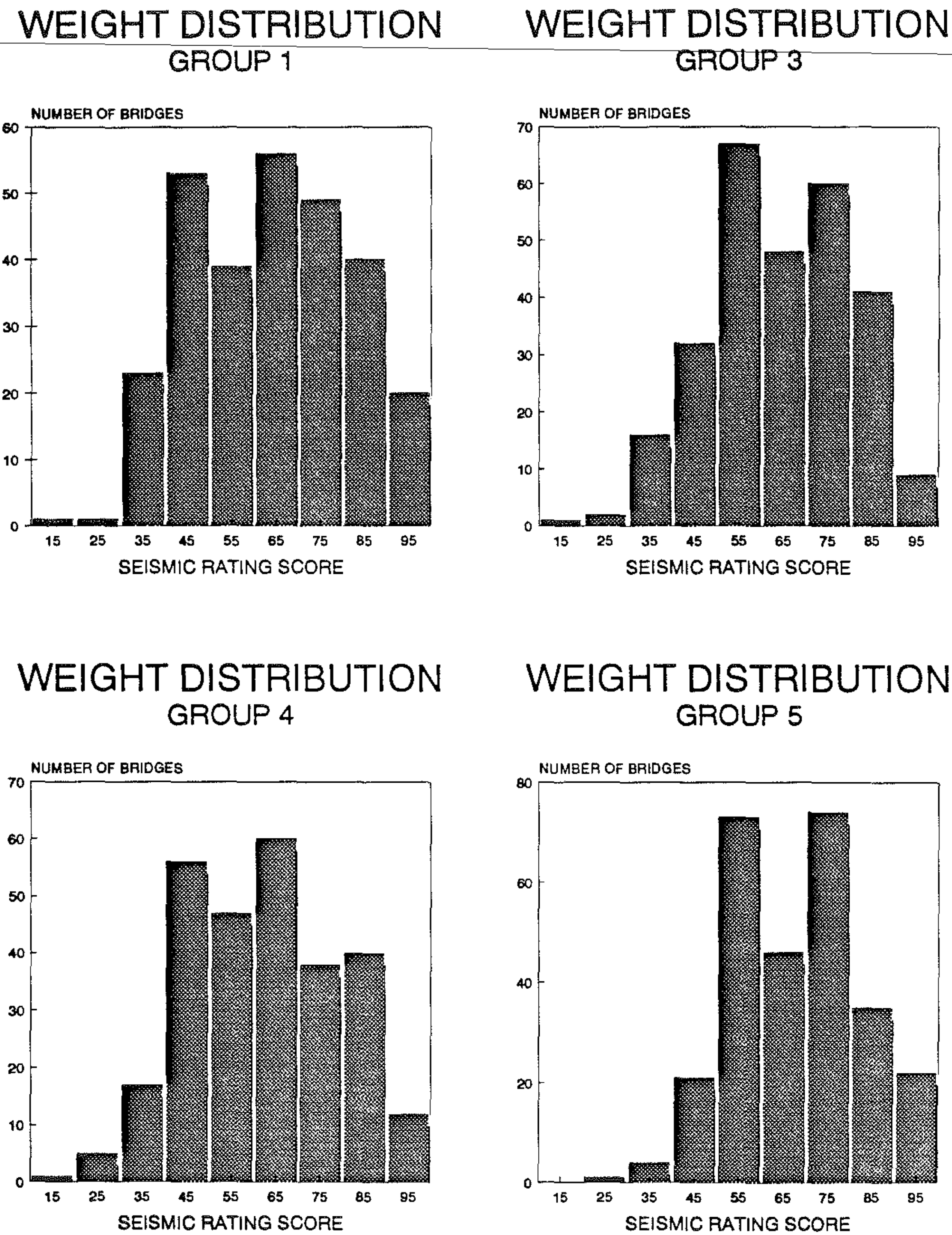

Figure 4. Seismic Rating Score Interval Frequency

SEISMIC RATING SCORE RANGE	No. OF BRIDGES IN THE RANGE	FREQUENCY PERCENTAGE
0 - 19.9	1	0.4%
20 - 29.9	1	0.4%
30 - 39.9	23	8.3%
40 - 49.9	53	19.2%
50 - 59.9	37	13.4%
60 - 69.9	55	19.9%
70 - 79.9	48	17.4%
80 - 89.9	40	14.5%
90 - 100	18	6.5%

These results, together with the results from seismic analyses of bridges during an earthquake, will be used to determine the priorities of retrofitting needs.

SEISMIC ANALYSIS

INTRODUCTION

The goal of retrofitting bridges on the priority route system is to prevent span-loss type of bridge collapse which will result in the loss of use of a vital transportation route that may pass over or under the bridge. Two types of analyses are employed in this study to estimate the potential of span-loss type of bridge collapse due to a major earthquake.

Span-loss Analysis

This analysis is applied to every bridge to estimate the potential span-loss type of bridge collapse. The span-loss type of collapse may be due to pier vibration and/or abutment sliding during an earthquake. The analysis approaches have been developed by the authors and included in two technical papers listed in Appendixes A and B.

ATC Analysis

The loss of support at bearing during an earthquake may result in a partial or total collapse of the bridge. This mode of failure is a type of span-loss collapse. The ATC-6 Code specifies the minimum bearing support length for the expansion ends of all superstructures. Based upon the Code requirement for length of support at joints, pier or bent seats, and abutment seats of bridge superstructures, the ATC analysis is used to estimate the potential bridge collapse during an earthquake due to insufficient support length.

Seismic Moment and Shear Force Analysis

Severe structural damage of the bridge may also cause collapse of the bridge. The failure of supporting components may be a major contributing factor to the collapse of a bridge. During an earthquake, the moments and shear forces in the supporting components, such as piers or columns, may increase significantly. These additional seismic moments and shear forces will result in excessive strength degradation of the supporting components and lead to the collapse of the superstructure. The seismic moment and shear force analysis is based on the structural dynamics and response spectrum analysis. The theoretical background of the analysis approach is given in one section ("The Maximum Seismic Moment And Shear Force") of Appendix B.

SPAN-LOSS COLLAPSE ANALYSIS

General Description

In this report, a bridge span falling due to lack of support is defined as a span-loss type of collapse. A pier vibrates when subjected to earthquake induced ground motion. The maximum dynamic deflection at the top of a pier may cause the loss of support length on which the superstructure sits. If the maximum dynamic deflection is greater than the support length, the superstructure will lose all support and collapse. Likewise, an abutment may slide from the increased seismic active earth pressure and the ground-motion-induced inertia force during an earthquake. If maximum sliding displacement is greater than the length of support at the adjacent pier top, the superstructure is likely to be "pushed off" the pier or bent top upon which the span rests and cause the span-loss type of collapse. Therefore, the span-loss type of collapse may be caused either by vibration of the pier or by sliding of the abutment during an earthquake. The following sections provide a summary of the factors involved in the span-loss collapse analysis.

Solid Abutment Analysis (Details in Appendix A)

a. criteria

o $W > W_{req}$	no collapse	presumed safe
o $W \leq W_{req}$	collapse	potentially unsafe-1

where:

W — actual weight of abutment per unit length, kips/ft

W_{req} — required minimum weight of abutment per unit length, kips/ft

b. analysis procedures

- o the forces acting on an abutment during earthquake
  - . seismic earth pressures
  - . load transmitted from superstructure
  - . gravity force
  - . inertia forces
- o evaluating the maximum pseudo static resistance to sliding due to earthquake ground motion
- o required minimum weight of abutment
  - . the maximum sliding displacement of abutment
  - . required minimum weight of abutment to prevent span-loss

c. calculations

o computer program SEISABSL (flow chart in Figure 14 of Appendix A)
o input data for calculation
 . general information
 . height of abutment, ft
 . weight of abutment, kips
 . transmitted load from superstructure, kips
 . length of support at top of adjacent pier or bent, in
 . maximum dynamic displacement at top of adjacent pier or bent (from pier or bent analysis), in
 . soil properties
o output of calculation
 . required minimum weight to prevent span-loss, kips/ft
 . capacity/demand ratio of abutment weight
 if C/D ratio > 1 — safe
 if C/D ratio ≤ 1 — unsafe-1
 . conclusion of analysis
 safe: presumed safe
 no span-loss type of collapse in earthquake
 unsafe-1: potentially unsafe
 possible span-loss type of collapse in quake

If the maximum dynamic deflection at the pier or bent top is greater than the support length at pier or bent top, the span will collapse regardless of results of calculation for weight requirement. In this case, the bridge is assigned to the category of unsafe-1 even though the weight C/D ratio may be greater than 1.

Pier and Intermediate Bent Analysis (Details in Appendix B)

a. criteria

o $D_{max} < D_{sp}$ — no collapse
o $D_{max} \geq D_{sp}$ — collapse

where:
 D_{max} — maximum dynamic displacement at pier or bent top, in
 D_{sp} — provided length of support of span on pier top, in

b. analysis procedures

o response of pier to ground motion
 . single degree of freedom system
 . response spectra
o pseudo-velocity and -displacement response spectra of bridge
o structure modeling
 . substructure types
 . deformation shapes in both critical directions
 . fixity assumptions
 . stiffness in both critical directions
o maximum dynamic displacement at pier or bent top
 . weight considerations
 . natural periods in both critical directions
 . maximum displacement

c. calculations

o computer program SEISPIER (flow chart in Figure 13 of Appendix B)

o input data for calculation
  . general information
  . pier type
  . number of columns for a pier / number of piles for a bent
  . cross section or moment of inertia for a column / a pile
  . self weight of a pier or a bent, kips
  . superstructure transmitted weight, kips
  . height of column or bent, ft
  . material of pier or bent
  . length of support at pier or bent top, in

o output of calculation
  . maximum dynamic deflections at pier top in both critical directions, in
  . capacity/demand ratio for dynamic deflection
    - if C/D ratio > 1 — safe
    - if C/D ratio ≤ 1 — unsafe-1
  . conclusion of analysis
    - safe: presumed safe; no span-loss type of collapse in earthquake
    - unsafe-1: potentially unsafe; possible span-loss type of collapse in quake

End Bent and Open Abutment Analysis (Details in Appendix B)

a. criteria

o $D_{max} < D_{sp}$ — no collapse

o $D_{max} \geq D_{sp}$ — collapse

where:

D_{max} — maximum dynamic displacement at end bent or open abutment, in

D_{sp} — length of support of end bent or open abutment, in

b. analysis procedures

o response of pier to ground motion
  . single degree of freedom system
  . response spectra

o pseudo-velocity and -displacement response spectra of bridge

o structure modeling
  . substructure types
  . deformation shapes in both critical directions
  . fixity assumptions
  . stiffness in both critical directions

o maximum dynamic displacement at end bent or open abutment top
  . weight considerations
  . natural periods in both critical directions
  . maximum displacement

c. calculations

o computer program SEISEBOP (flow chart in Figure 13 of Appendix B)

o input data of calculation

. general information
. end bent or open abutment type
. number of columns for an open abut
. number of piles for a end bent
. cross section or moment of inertia for a column / a pile
. self weight of a open abutment or a end bent, kips
. superstructure transmitted weight, kips
. height of column or bent, ft
. material of open abutment or end bent
. length of support at open abutment or bent top, in

o output of calculation

. maximum dynamic deflections at end bent and open abutment top in both critical directions, in
. capacity/demand ratio for dynamic deflection

if C/D ratio > 1	safe
if C/D ratio ≤ 1	unsafe-1

. conclusion of analysis

safe:	presumed safe no span-loss type of collapse in earthquake
unsafe-1:	potentially unsafe possible span-loss type of collapse in quake

ATC ANALYSIS

General Description

The length of support provided at abutments, piers and bents must accommodate displacements resulting from the overall inelastic response of the bridge structure, possible independent movement of different parts of the substructure, and out-of-phase rotation of abutments and columns resulting from traveling surface wave motions. Based on the current state-of-the-art analysis, minimum support lengths have been specified by Applied Technology Council in 1981. However, this analysis does not include differential displacements between the pier and abutment that may occur when a bridge is subjected to earthquake loads. The ATC requirements vary for different Seismic Performance Categories.

ATC Requirements

SPC	Required minimum support length	
A & B	$D_{req} = 8 + 0.02L + 0.08H$	(in.)
C & D	$D_{req} = 12 + 0.03L + 0.12H$	(in.)

For abutment:

D_{req} — required minimum support length, in

L — length in feet of the bridge deck to adjacent expansion joint, or to the end of the bridge deck

H — average height in feet of piers or bents supporting the bridge deck to the next expansion joint

For pier or bent:

D_{req} — required minimum support length, in

L — length in feet of the bridge deck to adjacent expansion joint or to the end of the bridge deck

H — column or pier height in feet

Input of the Calculation

a. general information
b. span length, ft.
c. pier or bent height, ft.
d. SPC
e. length of support, in.

Calculations

a. computer program SEISABATC for abutment ATC analysis
b. part of computer program SEISPIER for pier and intermediate bent ATC analysis
c. part of computer program SEISEBOP for end bent and open abutment ATC analysis

Output of the Calculation

a. minimum required support length, in
b. capacity/demand ratio for minimum support length

    if C/D ratio > 1 safe

    if C/D ratio ≤ 1 unsafe-2

c. conclusion of analysis

    safe — satisfy the minimum support length requirement

    unsafe-2 — do not satisfy the minimum support length requirement and may have potential span-loss risk

MAXIMUM SEISMIC MOMENT AND SHEAR FORCE ANALYSIS

General Description

The maximum moments and shear forces in the pier or bent may be calculated based on the maximum dynamic displacement at pier or bent top. The procedures of the analysis are presented in one section ("Seismic Moment And Shear Force") in Appendix B. These additional inertial forces may cause the collapse of the columns and the supporting components of the whole bridge. The capacities of columns are unknown because of the lack of detailed information on reinforcement. Nevertheless, it is important to compute the maximum moments and shear forces since it may help when further retrofitting designs are performed.

Analysis Procedures

a. maximum dynamic displacements at pier or bent top in both longitudinal direction and transverse direction (from pier and bent analysis)
b. structure modeling according to different types of pier or bent
c. stiffness in both critical direction
d. maximum seismic moments and seismic shear force in both directions
e. total maximum seismic moment and seismic shear force in a column

Calculations

a. computer program SEISMOSH

b. input data of calculation
- o general information
- o pier or bent type
- o number of columns in a pier
- o number of piles in a bent
- o cross section and moment of inertia of column and bent, ft^4
- o height of column and bent, ft
- o material properties of column and bent
- o maximum dynamic displacements at pier or bent top in both longitudinal and transverse directions, in

c. output of calculation
- o maximum seismic moments and shear forces in longitudinal direction
- o maximum seismic moments and shear forces in transverse direction
- o total maximum seismic moments and shear forces

Unit for moment is kips-ft and unit for shear force is kips.

RESULTS OF SEISMIC ANALYSIS

GENERAL DESCRIPTIONS

The results of the analyses are presented according to types of analyses and computer programs used. The results are listed alphabetically by county. The routes for each county are also listed in alphabetical order. In addition, the milepost for each bridge is listed. The analyses are divided into the following five parts:

1. Pier and Intermediate Bent Analysis (program SEISPIER)

   a. span-loss collapse analysis for pier and intermediate bent
   b. ATC analysis for pier and intermediate bent

2. Solid Abutment Analysis

   a. span-loss collapse analysis for solid abutment (program SEISABSL)
   b. ATC analysis for solid abutment (program SEISABATC)

3. End Bent and Open Abutment Analysis (program SEISEBOP)

   a. span-loss collapse analysis for end bent and open abutment
   b. ATC analysis for end bent and open abutment

4. Maximum Seismic Moment and Shear Force Analysis (program SEISMOSH)

5. Summary Report

The summary report combines all the analysis results mentioned. If a bridge falls into any one of the six analyses, it is considered potentially unsafe during an earthquake.

PIER AND INTERMEDIATE BENT ANALYSIS RESULTS

The results of the analyses of piers and intermediate bents for each county are contained in Appendix D. The analyses consist of span-loss type of bridge collapse and required minimum length of support according to the ATC-6 Code. The number of bridges considered in this analysis is as follows.

Total number of bridges in the data base	:	276
Number of single span bridges	:	69
Number of bridges not analyzed	:	4
Number of bridge in this analysis	:	203

The single-span bridges have no piers or intermediate bents, and hence have no pier or bent related potential damage. Therefore, the analysis has not been applied to the single-span bridge. There are four bridges, (two TVA bridges and two railroad bridges), that were not analyzed, since the study is limited to highway bridges. Detours are provided for those four bridges in page 30.

Seismic Analysis Results

The results of these analyses are as follows.

a. span-loss collapse analysis results

Number of bridges in the analysis	:	203	
Number of presumed safe bridges	:	185	91.1%
Number of potentially unsafe-1 bridges	:	18	8.9%

b. ATC analysis

Number of bridges in the analysis	:	203	
Number of presumed safe bridges	:	145	71.4%
Number of potentially unsafe-2 bridges	:	58	28.6%

c. results from both analyses (span-loss collapse and ATC analysis)

Number of bridges in the analysis	:	203	
Number of presumed safe bridges	:	138	68.0%
Number of potentially unsafe-1 bridges	:	7	3.4%
Number of potentially unsafe-2 bridges	:	47	23.2%
Number of unsafe-1 and unsafe-2 bridges	:	11	5.4%

Pier Type Distributions

Table 2 shows the pier type distribution for three different categories of analyses results. The results demonstrate that the bent is more vulnerable to earthquakes than other types of intermediate substructures.

TABLE 2. SAFTY CATAGORIES OF VARIOUS PIER TYPES

TYPE	SAFE	UNSAFE-1	UNSAFE-2	UNSAFE-1/ UNSAFE-2	SUB TOTAL
BENT (10)	28	6	31	7	72
S.P.R.(1)	37	0	1	2	40
O.P.R.(2)	36	1	5	1	43
S.P.P.(3)	13	0	1	0	14
O.P.P.(4)	24	0	9	1	34
TOTAL	138	7	47	11	203

SOLID ABUTMENT ANALYSIS

The results of span-loss type of collapse analyses of solid abutments for each county are contained in Appendix E. The results of the ATC analysis of solid abutments for each county are contained in Appendix F. The results are summarized as follows:

Analysis of Span-loss Type Collapse

Total number of bridge with solid abutments	:	139	
Number of single span bridges with solid ab.	:	57	
Number of bridges in the analysis	:	82	
Number of presumed safe bridges	:	68	82.9%
Number of potentially unsafe-1 bridges	:	14	17.1%

The single-span bridges will not have the span-loss type of collapse as defined in this report. Therefore, the span-loss collapse analysis has not been conducted to the single-span bridges. A category of presumed safe has been assigned to all the single-span bridges with solid abutment.

ATC Analysis

Total number of bridge having solid abutments	:	139	
Number of presumed safe bridges	:	122	87.8%
Number of potentially unsafe-2 bridges	:	17	12.2%

Results from Both Analyses (Span-Loss Collapse and ATC Analysis)

Total number of bridge with solid abutments	:	139	
Number of presumed safe bridges	:	110	79.2%
Number of potentially unsafe-1 bridges	:	12	8.6%
Number of potentially unsafe-2 bridges	:	15	10.8%
Number of unsafe-1 and unsafe-2 bridges	:	2	1.4%

END BENT AND OPEN ABUTMENT ANALYSIS

The results of span-loss collapse analysis and the ATC analysis for end bents and open abutments for each county are contained in Appendix G.

Span-Loss Collapse Analysis Results

Number of bridges having end bents	:	107	
~~Number of bridges having open abutments~~	~~:~~	~~14~~	
Number of bridges in this analysis	:	121	
Number of presumed safe bridges	:	104	86.0%
Number of potentially unsafe-1 bridges	:	17	14.0%

ATC Analysis

Number of bridges in this analysis	:	121	
Number of presumed safe bridges	:	65	53.7%
Number of potentially unsafe-2 bridges	:	56	46.3%

Results From Both Analysis (Span-Loss Collapse and ATC Analysis)

Number of bridges in the analysis	:	121	
Number of presumed safe bridges	:	60	49.6%
Number of potentially unsafe-1 bridges	:	5	4.1%
Number of potentially unsafe-2 bridges	:	44	36.4%
Number of unsafe-1 and unsafe-2 bridges	:	12	9.9%

MAXIMUM SEISMIC MOMENT AND SHEAR FORCE ANALYSES

The results of maximum seismic moment and shear force analyses are shown in Appendix H. The maximum seismic moments and shear forces in the longitudinal direction and transverse direction are listed. The total maximum seismic moments and shear forces in each column are given also. These internal forces should be compared with the capacities of the columns to obtain a capacity/demand ratio which may indicate the need for retrofitting. Unfortunately, the details of reinforcement for the columns are not available. Therefore, the capacities of the columns cannot be determined. Further study is recommended to determine the capacities of the columns as well.

SUMMARY REPORT OF SEISMIC ANALYSIS

The results of all the seismic analyses are listed in a summary report. Combining the results of the seismic analyses for each individual component of the bridge, this report indicates the overall earthquake resistance capacity of a bridge and its need for retrofitting. The summary report is in Appendix I. The sources, format and results of the summary report are described as follows.

Sources of Summary Report

- o results of span-loss collapse analysis and ATC analysis for pier and intermediate bent - Appendix D
- o results of span-loss collapse analysis for solid abutment - Appendix E
- o results of ATC analysis for solid abutment - Appendix F
- o results of span-loss collapse analysis and ATC analysis for end bent and open pier - Appendix G

Format of Summary Report

o general information:
- . county
- . route
- . milepost
- . number of spans
- . SPC

o intermediate substructure
- . single span
- . pier and column
  - .. span-loss collapse analysis results
  - .. ATC analysis results
- . pile bent
  - .. span-loss collapse analysis results
  - .. ATC analysis results

o end substructure
- . solid abutment
  - .. span-loss collapse analysis results
  - .. ATC analysis results
- . end bent and open abutment
  - .. span-loss collapse analysis results
  - .. ATC analysis results

o retrofitting recommendation
  - .. YES — retrofitting is needed
  - .. NO — retrofitting is not needed

If the seismic analysis result indicates any component of a bridge is unsafe, a symbol (*) is marked for this bridge in the respective category. If any of the eight categories has a symbol (*), the bridge is considered unsafe with respect to this category, and as a consequence, the bridge is recommended for retrofitting. Some bridges are unsafe in several categories.

Summary of All Seismic Analysis Results

a. SPC distribution

The SPC distributions for bridges are listed in Table 3

TABLE 3 DISTRIBUTION OF BRIDGES BY SPC CATEGORY

SPC	No. BRIDGES	PERCENTAGE
A	26	9.42%
B	71	25.72%
C	151	54.71%
D	28	10.14%

b. bridges in the analysis

bridges on priority routes	: 276
culverts	: 7
railroad bridges	: 3
TVA bridges	: 2
bridges which have no-info	: 4
bridges in the analysis	: 260
bridges which need retrofitting	: 111

B6 + B8	C4
B7 + B9	C5
B4 + B9	C6
B2 + B7	C7
B1 + B5 + B6 + B10	C8
B1 + B6	C9
B5 + B7 + B9	C10
B2 + B4 + B7 + B9	C11
B4 + B6 + B9	C12
B1 + B3 + B6	C13
B2 + B5 + B10	C14
B1 + B3 + B6 + B8	C15
B6 + B9	C16
B3 + B8	C17
B2 + B7 + B9	C18
B2 + B7 + B9	C19
B1 + B5	C20
B3 + B6	C21
B2 + B9	C22

iii. Summary of all analyses results

The numbers of bridges in each type of potential damages are listed as follows:

TYPE CODE	No. BRIDGES	TYPE CODE	No. BRIDGES
B1	0	C7	2
B2	2	C8	1
B3	9	C9	1
B4	3	C10	1
B5	0	C11	2
B6	8	C12	1
B7	6	C13	1
B8	11	C14	1
B9	15	C15	2
B10	2	C16	1
C1	1	C17	1
C2	1	C18	2
C3	1	C19	1
C4	4	C20	1
C5	21	C21	1
C6	7	C22	1

The total number of bridges which need retrofitting is 111. This is 42.7% of a total of 260 bridges in the analysis and 40.2% of 276 bridges on the priority route system.

PRIORITY ORDER OF RETROFITTING

Based upon the seismic analysis results, seismic rating scores, and some rules of retrofitting, a priority order of retrofitting needs for all bridges on the priority route system was compiled. The priorities are based upon the following order:

- o bridges which need retrofitting according to the seismic analysis and having higher seismic rating scores.
- o bridges which need retrofitting according to the seismic analysis and having lower seismic rating scores.
- o bridges which do not need retrofitting according to seismic analysis and having higher seismic rating scores.
- o bridges which do not need retrofitting according to the seismic analysis and having lower seismic rating scores.
- o single span bridges having higher seismic rating scores.
- o single span bridges having lower seismic rating scores.

A priority route system list of the order of priority for retrofitting the 276 bridges on the priority route system is included in Appendix J. Each bridge is assigned a priority number which is defined as a global priority number since it shows the relative order of retrofitting need among all the bridges on the priority route system. The smaller the priority number, the higher the need for retrofitting. For each county, a local priority number is assigned to each bridge to show the relative need of retrofitting as compared to the other bridges within the same county. A county list of the priority order of retrofitting for each county is included in Appendix K. In the county list, both local priority number and global priority number are given. In both appendixes, the seismic rating scores and seismic analysis summary are presented. A list of bridge retrofitting priority order in corridors is included in Appendix O. In the list, the priority of corridors and the priority within corridors along with the system priority are provided.

NUMBER OF BRIDGES NEEDING RETROFITTING

The priority order of retrofitting is available in the last section. The next step is to determine the number of bridges which need to be retrofitted. This is a decision-making process which involves not only engineering factors but economic, administrative, social, and political factors as well. The following discussion and conclusions are based strictly upon results of the engineering analysis.

The basic principle for determination of the number of bridges which need retrofitting is that all bridges having a potential of span-loss collapse should be retrofitted. Using this rule, all bridges which are unsafe according to the seismic analysis need to be retrofitted.

A probability density analysis of all seismic rating scores shows that the seismic rating score distribution is approximately equal to a normal distribution. The statistical analysis results are:

Number of samples (scores)	:	276
Mean value	:	63.5
Variance	:	193.0
Standard deviation	:	13.9
Coefficient of variance	:	0.218

The statistical analysis also shows the lower bound of seismic rating scores for each level of the confidence. If only the bridges having the seismic rating scores larger than mean value are retrofitted, the confidence level is 50 percent. If all bridges are retrofitted, the confidence level will be 100 percent. The following data indicate the lower bound of seismic rating score which defines the boundary line between the bridges needing retrofitting and the bridges which do not need retrofitting with a certain confidence level.

LOWER BOUNDARY OF SEISMIC RATING	CONFIDENCE LEVEL
63.5	50%
60.0	60%
56.2	70%
51.8	80%
45.7	90%
40.6	95%

As an example, if the bridges having seismic rating scores of 60.0 or above are retrofitted, the confidence level will be 60 percent, and if the bridges having seismic rating scores of 45.7 or above are retrofitted, the confidence level will be 90 percent.

The number of bridges which need retrofitting and their confidence levels cannot be determined by the seismic ratings only. The 111 presumed unsafe bridges from seismic analyses must be taken into consideration. These 111 bridges need to be retrofitted first. If only these 111 potentially unsafe bridges are retrofitted, the confidence level will be less than 50-percent because 57 of the presumed safe bridges have a seismic rating score higher than 63.5 which corresponds to the 50-percent confidence level. Therefore, if both the 111 presumed unsafe bridges and 57 presumed safe bridges having seismic rating scores higher than 63.5 are taken into account, 168 bridges need retrofitting to reach a 50-percent confidence level. Similarly, if a confidence level of 90 percent needs to be reached for the retrofitting program, at least 234 bridges need to be retrofitted, among which there are 111 unsafe bridges and 123 presumed safe bridges having a seismic rating higher than 45.7. That corresponds to 90-percent confidence level. The following table indicates the number of bridges needing retrofitting and the corresponding confidence level.

There are some of the bridges which have recently been replaced by concrete culverts. They were assumed to be safe during an earthquake. As stated previously, two TVA bridges and three railroad bridges are not included in this analysis because of lacking detailed information. The two TVA bridges are built ontop of Kentucky Lake Dam on US62/US641 in Livingston County and US62 in Marshall County. These route were not chosen as primary routes due to the possibility of the dam's being damaged during a major seismic event. Other available priority routes are US60 North of the dam, US68/KY80 and US79 through Tennesse South of the dam. Railroad bridges are assumed to have better chance of surviving during earthquakes than highway bridges. Detours are provided if the railroad bridge fail in earthquakes. For two railroad bridges on US41A Christian County, detour is US41A South to East KY1027 to South KY736 back to US41A, or US41A South to Locust Ground Road to Beverly Road back to US41A. For the railroad bridge on KY 94 Hickman County, detour is North KY307 to West KY924 then South to Murcherson Road to Fulton County back to KY94. There were a few bridges where there was no detailed information to conduct all of the analysis. According to results of the analysis and the field survey, they are assumed to be safe at this time. Field surveys and preliminary analyses indicate these bridges may be safe; however, further study would be required.

c. potential damage type

There are 10 basic types of potential failures for which retrofitting would aid preventing failure. Because some bridges may be susceptible to more than one type of possible failure, there are a total of 32 types of failure modes included in the analysis. These types, along with their codes, are listed in the following sections.

i. Basic types of possible failure modes and the type codes

TYPE	CODE
Pier, span-loss collapse:	B1
Intermediate bent, span-loss collapse:	B2
Solid abutment, span-loss collapse:	B3
End bent, span-loss collapse:	B4
Open abutment, span-loss collapse:	B5
Pier, insufficient support length:	B6
Intermediate bent, insufficient support length:	B7
Solid abutment, insufficient support length:	B8
End bent, insufficient support length:	B9
Open abutment, insufficient support length:	B10

ii. Combinations of basic types and the type code

COMBINATION	CODE
B3 + B7	C1
B2 + B4	C2
B2 + B4 + B7	C3

NUMBER OF BRIDGES	TOTAL PERCENTAGE	RATING CONFIDENCE LEVEL
111	40.2%	<50%
168	60.7%	50%
178	64.5%	60%
189	68.5%	70%
199	72.1%	80%
234	84.8%	90%
252	91.3%	95%
276	100%	100%

SUMMARY AND CONCLUSIONS

To keep the priority routes system open after an earthquake, bridges (as the vital lines of the system) need to be protected from unacceptable damage such as a span-loss type of collapse. Retrofitting is one solution to minimize the these damages which may cut access to the priority routes. The Data Base System, the Seismic Rating System, and the Seismic Analysis System have been compiled to estimate potential damage to bridges during an earthquake and to establish the order of priority for retrofitting.

The engineering data for each of the 276 bridges on the priority route system have been obtained from the "as-built" plans or from field investigations, and have been input into the data base system.

The seismic rating system has considered the importance, the seismicity, the structural vulnerability, and the current condition of each bridge. Rating of individual components and an overall seismic rating score have been assigned to each bridge. The higher the seismic rating, the greater the need for retrofitting. The seismic rating plays an important role in the determination of retrofitting priorities for bridges. A statistical analysis was applied to show the effects of individual rating weights on the overall seismic rating scores. The computer program, SEISRATE, was developed and applied to calculate the seismic rating scores for the bridges.

Two types of analyses were conducted for each bridge to estimate the potential damage to bridges during an earthquake. One is seismic analysis and another is the ATC analysis. The seismic analysis method was developed by the authors to estimate the potential seismic responses of bridges to a large New Madrid Earthquake in Western Kentucky. The analyses procedures were based upon the theories of structural dynamics and soil dynamics to predict the potential of span-loss type bridge collapses (the most critical failure) due to earthquake induced abutment sliding and pier/bent vibration. The ATC analysis method is based upon the required minimum length of support according to the ATC-6 Code. Four computer programs, SEISABSL, SEISABATC, SEISPIER, and SEISEBOP were developed and used to perform the seismic analysis and the ATC analysis for the various components of a bridge. From seismic analysis and the ATC analysis, 111 bridges (42.7% the total number of bridges on the priority route system) have a potential of span-loss type collapses and/or insufficient support lengths at seat bearings according to the ATC minimum support length requirements.

Based upon results of the seismic analysis, the ATC analysis and the seismic rating scores, at least 111 bridges should be retrofitted. With a 90 percent confidence level, 234 bridges need to be retrofitted. The order of priority for retrofitting bridges that is recommended in this report reflects engineering considerations only. The economic, social, administrative, and political aspects should also be considered when final decisions on retrofitting are made.

The span-loss collapse analyses and the ATC analyses indicate that bents are more susceptible to an earthquake than other substructure components. There are more bridges which do not meet the ATC minimum support length requirements than those which do not meet the span-loss collapse criterion. From the results of the seismic analyses, Graves County and Marshall County have the largest numbers of potentially unsafe bridges, while Todd County and Mclean County have no potentially unsafe bridges. US60, US62(US60/KY641), US68/KY80, and KY121 have more bridges needing retrofitting than other routes. In Trigg, Union, Hickman, and Graves Counties, more than 65 percent of the bridges need retrofitting. Hichman County and Ballard County have the highest average seismic rating scores, and Todd County and Warren County have the lowest.

The study and its recommendations are only a first step of a retrofitting program. Detailed evaluations and retrofitting designs of existing bridges are necessary before retrofitting may begin. It is recommended that Transportation Cabinet officials begin an immediate program of bridge retrofitting.

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APPENDIX A

ESTIMATING SPAN-LOSS TYPE BRIDGE COLLAPSE DUE TO EARTHQUAKE INDUCED ABUTMENT SLIDING

ESTIMATING SPAN-LOSS TYPE BRIDGE COLLAPSE
DUE TO EARTHQUAKE INDUCED ABUTMENT SLIDING

INTRODUCTION

The priority routes[1] have been selected for Western Kentucky which shares the most hazardous earthquake zone east of the Rocky Mountains - the New Madrid seismic zone as shown in Figure 1. As the vital links on the priority routes, bridges should be protected from earthquake damage in order to keep the priority routes open for transportation of goods and services after the occurrence of an earthquake. An abutment which supports the end of a bridge span and provides the lateral support for the soil or rock upon which the roadway rests immediately adjacent to the bridge is one of the most critical elements of a bridge during an earthquake. As the numerous cases of damage or failure to bridges induced by abutment displacement or failure have clearly demonstrated in prior earthquakes, the damage of an abutment is mainly associated with the movement and failure induced by the strong earthquake ground motion and high seismic lateral earth pressure. Severe abutment damage or movement may cause loss of bridge spans and hence cut the access of a route. In this appendix, a span-loss type of bridge collapse due to earthquake induced abutment sliding is analyzed and corresponding criteria to this type of collapse is established. The forces involved in the movement of abutments during an earthquake are discussed and the analyses methods for existing bridge abutments are advanced. A spreadsheet program based upon the these methods has been developed and used to estimate potential earthquake damages of 276 bridges on the priority routes.

THE FORCES ACTING ON AN ABUTMENT DURING AN EARTHQUAKE

SEISMIC EARTH PRESSURES

Active Seismic Earth Pressure

Commonly known as the Mononobe-Okabe analysis,[2][3] the seismic earth pressure on a retaining wall type of abutment was derived based upon the following assumptions:

a. The failure in soil takes place along a plane such as BC shown in Figure 2. At failure, full strength along the failure surface is mobilized;

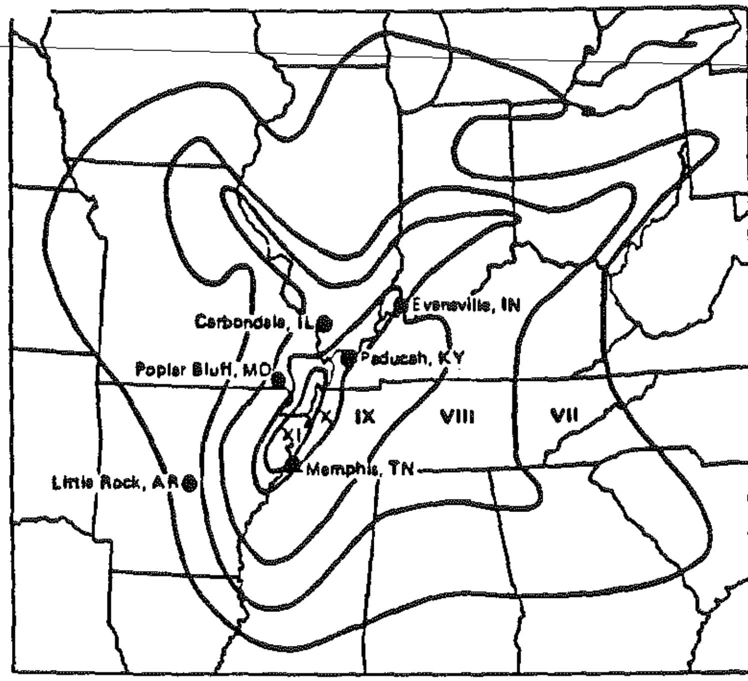


Figure 1. Location of New Madrid Seismic Zone

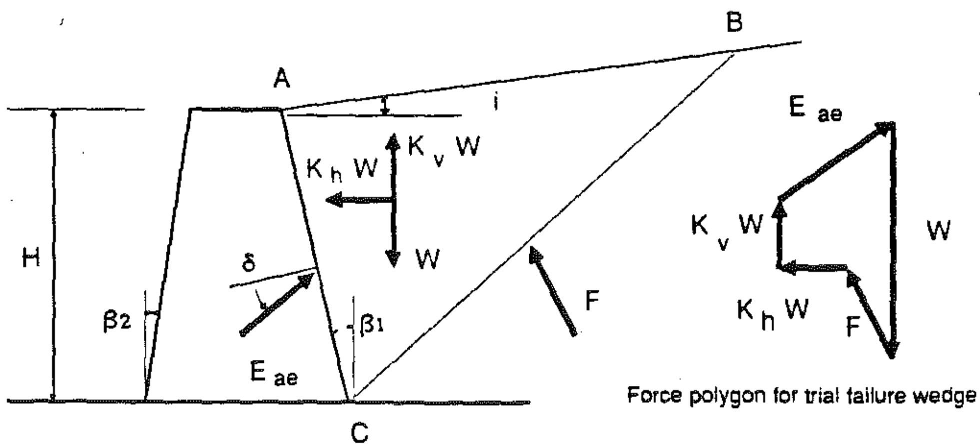


Figure 2. Seismic Active Earth Pressure

b. The abutment is free to move sufficiently to produce minimum active seismic earth pressure;

c. The backfill is cohesionless soil, with a friction angle ϕ and the shear strength (s) can be given by :

$$s = \sigma' \tan\phi \tag{1}$$

d. The soil behind the abutment behaves as a rigid body.

The forces on the failure wedge per unit length of the abutment are:

- weight of wedge W
- active seismic earth pressure E_{ae}
- horizontal inertia force $K_h W$
- vertical inertia force $K_v W$

where,

K_h — horizontal earthquake acceleration coefficient

K_v — vertical earthquake acceleration coefficient

Equilibrium established for the soil wedge behind the abutment which will fail gives the active earth pressure resultant as

$$E_{ae} = \frac{1}{2} \gamma H^2 (1 - K_v) K_{ae} \tag{2}$$

where:

γ — unit weight of soil
H — height of soil surface, i.e. height of abutment back
K_{ae} — seismic active earth pressure coefficient

$$K_{ae} = \frac{\cos^2(\phi - \theta - \beta)}{\cos\theta \cos^2\beta \cos(\delta+\beta+\theta) \left[1 + \sqrt{\dfrac{\sin(\phi+\delta)\sin(\phi-\theta-i)}{\cos(\delta+\beta+\theta)\cos(i-\beta)}}\right]^2} \tag{3}$$

where:

ϕ — friction angle of soil

$$\theta = \tan^{-1}\left(\frac{K_h}{1-K_v} \right) \tag{4}$$

δ — friction angle between soil and abutment wall
β — slope angle of soil face
i — backfill slope angle

Figure 3 shows the variation of seismic earth pressure coefficient K_{ae} versus soil friction angle for different levels of K_h. The seismic active earth pressure increases as soil friction angle decreases and as the horizontal earthquake acceleration increases. The seismic earth pressure appears to be very sensitive to the friction angle ϕ and if ϕ is fixed, the seismic active earth pressure coefficient changes more rapidly for larger values of K_h than for smaller values of K_h. In Western Kentucky, K_h is estimated to be 0.2, ϕ is approximately 25 to 30 degrees, and the seismic earth pressure is approximately 1.5 times the static active earth pressure.

Passive Seismic Earth Pressure

The equivalent expressions for seismic passive earth pressure resultant and coefficient are given below for an abutment being pushed toward the backfill.

$$E_{pe} = \frac{1}{2} \gamma H^2 (1 - K_v) K_{pe} \tag{5}$$

$$K_{pe} = \frac{\cos^2(\phi - \theta + \beta)}{\cos\theta \cos^2\beta \cos(\delta-\beta+\theta) \left[1 - \sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\theta+i)}{\cos(\delta-\beta+\theta)\cos(i-\beta)}}\right]^2} \tag{6}$$

Figure 4 shows the variation of the seismic passive earth pressure coefficient versus soil friction angle for different levels of K_h. Seismic passive earth pressure behaves just the opposite as active earth pressure. For seismic passive earth pressure, K_{pe} decreases as ϕ decreases and K_h increases. Comparing Figure 4 with Figure 3, it is clear that seismic passive earth pressure is much larger than active seismic earth pressure, for example, K_{pe} is approximately 4.5 times K_{ae} when ϕ=25, K_h=0.2, K_v=0.

Point of Application of Resultant Earth Pressure

The Mononobe-Okabe solution for active earth pressure on retaining walls implies that the resultant force will act at a distance of 1/3H measured from the bottom of the wall (H = height of the wall, ft), which is similar to the static case. However, laboratory tests indicate that the distance of resultant force from the bottom of the wall becomes greater as effects of the earthquake increase.

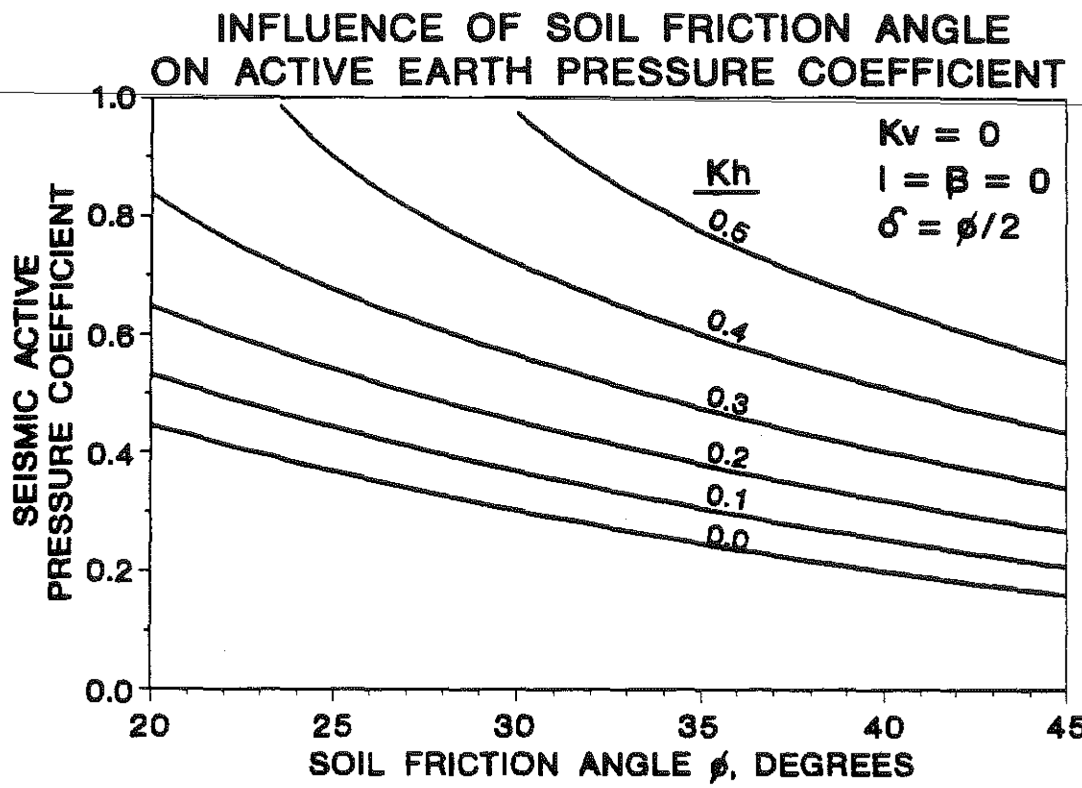


Figure 3. Seismic Active Earth Pressure Coefficient

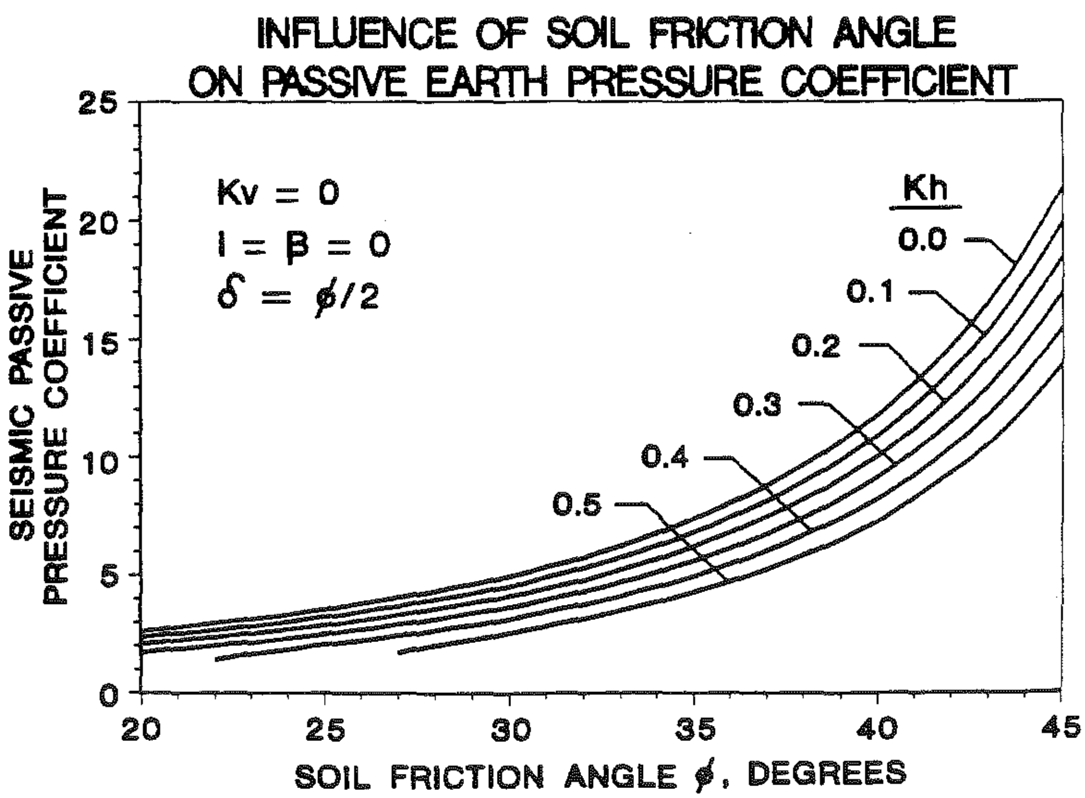


Figure 4. Seismic Passive Earth Pressure Coefficient

For practical considerations, Seed and Whitman[4] suggested the distance of the earth pressure resultant from the bottom of the wall can be calculated by:

$$\bar{H} = [E_a (\frac{1}{3}H) + (\Delta E_{ae})(0.6H)]/E_{ae} \tag{7}$$

where:

E_a — static earth pressure resultant acting at 1/3H

ΔE_{ae} — additional seismic earth pressure force at 0.6H

$$\Delta E_{ae} = E_{ae} - E_a$$

let $$F_t = \frac{K_{ae}}{K_a} \tag{8}$$

F_t is called the magnification ratio which shows the increase of soil active pressure due to earthquake effects. The influence of the soil friction angle on the magnification ratio F_t is shown in Figure 5. Substituting eq. (8) into eq. (7), the following formula is obtained

$$\bar{H} = (0.6 - \frac{0.267}{F_t})\ H \tag{9}$$

For the case of K_h=0.2, $\bar{H}$ is approximately 0.45H.

Limitations of Mononobe-Okabe Analysis

Figure 5 indicates the slight effect of ϕ on the F_t until ϕ becomes relatively small. In a range of small values of ϕ, F_t increases sharply and becomes infinite for a specific critical value of ϕ_{cr}. This condition may be presented as

$$\phi \geq i + \theta = i + \tan^{-1}(\frac{K_h}{1-K_v}) \tag{10}$$

This is also the necessary condition under which eq.(3) could have a real solution. If the stated condition is not satisfied, this implies that an equilibrium condition will not exist. The limiting value of K_{hcr} which provides an absolute upper bound for the seismic acceleration which may be transmitted to any structure whatsoever that is constructed on a soil having given strength characteristics can be given by

$$K_{hcr} = (1 - K_v)\tan(\phi - i) \tag{11}$$

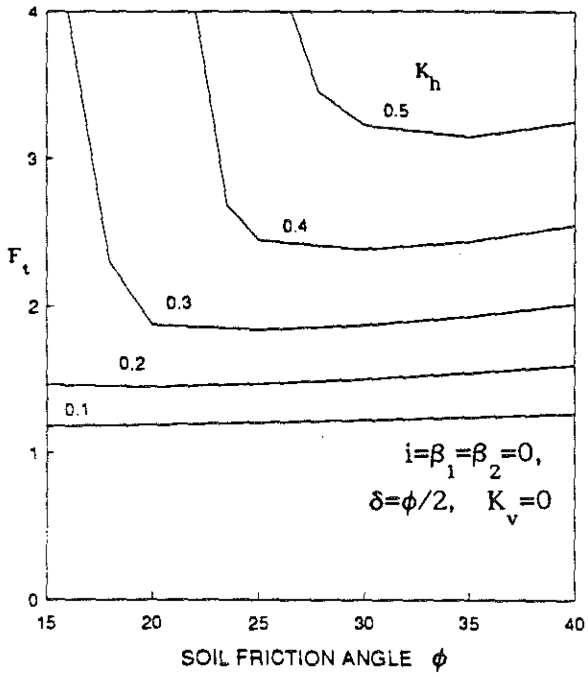


Figure 5. Magnification Ratio

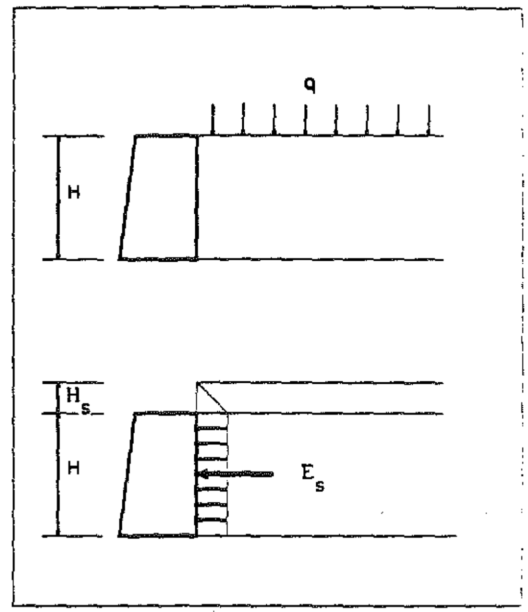


Figure 6. Wheel Load Induced Equivalent Earth Pressure

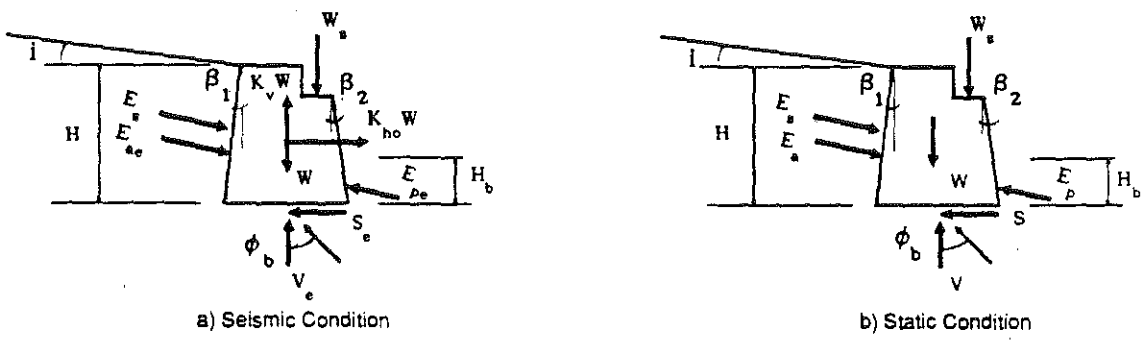


Figure 7. Force Diagrams

For the cases involved in this study, ϕ ranges from approximately 25 to 30 degrees and maximum earthquake acceleration coefficient is 0.2. Calculating K_{hcr} from eq. (10), K_{hcr} = 0.37 which is greater than K_h=0.2. Therefore, the Mononobe-Okabe analysis is valid for this study. Some of the values of K_{hcr} are shown in Figure 8. These values are absolute values as previously described.

GRAVITY FORCE

The weight of an abutment acting at its center of gravity is the major force in maintaining its stability against sliding.

LOADS

The Reactions from the Superstructure

The reactions from the superstructure may be transmitted to the bridge seat of an abutment through the bearings in several ways. Roller and rocker bearings providing for expansion and contraction are assumed to transmit only vertical forces to the abutment. On the other hand, fixed bearings at the end of the bridge subject the abutment to vertical as well as horizontal reactions. The loads from the superstructure are assumed to be distributed over the entire length of the front wall of an abutment. Only the vertical reaction is taken into account in this analysis. This vertical force transmitted from the superstructure per length of abutment is

$$W_s = \frac{W_{sup}}{L} \qquad (12)$$

where:

W_{sup} — dead load of superstructure transmitted to the abutment (half the weight of first span should be used since the most critical case is that without consideration of the live load)

L — the length of abutment (the total projected length is suggested to be used for the abutment with wing wall to simplify the calculation)

Additional Earth Pressure due to Wheel Loads

The active earth pressure against the back of the abutment is increased whenever wheel loads are transmitted to the backfill immediately behind the abutment. The magnitude of this additional active earth pressure depends upon the properties of soil, position of the wheel and magnitude of the wheel load. This earth pressure increase should be considered in the analysis since it will increase the tendency for sliding of the abutment. Usually, wheel loads are assumed to be equivalent to a uniformly distributed load, q, often taken as 240 psf for H-10 highway loading.[5] This uniform surcharge is commonly considered as an additional backfill layer as shown in Figure 6 having a height $H_s = q/\gamma$, where γ is the unit weight of backfill material. The corresponding additional horizontal earth pressure is assumed to be uniformly distributed across the height of the abutment with a magnitude of $K_a H_s$, where K_a is the static active earth pressure coefficient which may be obtained from Figure 4 for $K_h = 0$ (static conditions). The resultant of this additional earth pressure E_s may be assumed to act at the mid height of the abutment and may be calculated by

$$E_s = K_a \gamma H_s H = K_a q H \tag{13}$$

INERTIA FORCES

The inertia forces exist as long as an abutment is in a state of motion, which is induced by the ground motion of the earthquake.

$$E_{Ih} = m a_h = m A_h g = A_h W$$

$$E_{Iv} = m a_v = m A_v g = A_v W$$

where:

E_{Ih}, E_{Iv} — horizontal, vertical inertia forces acting at center of gravity

a_h, a_v — horizontal, vertical accelerations of the motion.

A_h, A_v — horizontal, vertical acceleration coefficients

W — weight of the abutment per unit length

PSEUDOSTATIC RESISTANCE TO SLIDING

ABUTMENT SLIDING

For an existing abutment, the static resistance against sliding has a minimum factor of safety of 1. However, the dynamic factor of safety could be less than 1 because of the increased active earth pressure induced by the earthquake. The result is that those abutments which have no sliding problem in the static state might have the potential of sliding which might result in collapse of the bridge span during an earthquake. It is important to know whether sliding will occur during an earthquake and what the magnitude of the sliding would be. A criterion is established and a pseudo-static method is employed to determine the dynamic resistance against sliding.

FREE BODY DIAGRAM

Figure 7 shows the force diagram of a free body abutment with the different forces acting on it both in static state and in seismic state.

where:

- H — height of abutment
- H_b — height of berm or slope protection if any
- W_s — vertical load transmitted from superstructure per length
- W — weight of abutment per unit length
- E_s — resultant of equivalent earth pressure due to wheel load on the backfill adjacent to the abutment
- E_{ae} — resultant of active seismic earth pressure
- E_a — resultant of active static earth pressure
- E_{pe} — resultant of passive seismic earth pressure due to berm
- E_p — resultant of passive static earth pressure due to berm
- $K_{ho}W$ — critical horizontal inertia force
- K_vW — vertical inertia force
- K_v — vertical earthquake acceleration coefficient
- K_{ho} — maximum acceleration coefficient under which an abutment can just prevent sliding
- V_e — seismic total vertical resultant at base of abutment
- V — static total vertical resultant at base of abutment
- S_e — seismic total horizontal resultant at base of abutment
- S — static total horizontal resultant at base of abutment
- i — backfill slope angle
- β — slope angle of back face of abutment wall
- β_2 — slope of angle front face of abutment wall
- δ — friction angle between abutment wall and backfill
- ϕ_b — friction angle at abutment base

The comparison of the forces related to the sliding of an abutment under static conditions and under seismic conditions is summarized hereinafter. In most cases, total resisting forces under seismic conditions are less than those under the static conditions while total driving forces under seismic conditions are greater than those under static conditions. As a consequence, the factor of safety for sliding under seismic conditions will be less than the factor of safety for sliding under static conditions. The abutment, therefore, is more likely to slide during earthquakes.

	Seismic Conditions		Static Conditions
Driving	$E_s \cos(\delta+\beta_1)$	=	$E_s \cos(\delta+\beta_1)$
Forces	$E_{ae} \cos(\delta+\beta_1)$	>	$E_a \cos(\delta+\beta_1)$
	$E_{pe} \sin(\delta-\beta_2)$	<	$E_p \sin(\delta-\beta_2)$
	K_{ho} W	>	0
	K_v W	>	0
Resisting	$E_s \sin(\delta+\beta_1)$	=	$E_s \sin(\delta+\beta_1)$
Forces	$E_{ae} \sin(\delta+\beta_1)$	>	$E_a \sin(\delta+\beta_1)$
	$E_{pe} \cos(\delta-\beta_2)$	<	$E_p \cos(\delta-\beta_2)$
	W	=	W
	W_s	=	W_s
Factor of Safety	FS_e	<	FS

MAXIMUM RESISTANCE AGAINST SLIDING

Define a coefficient K_{ho} corresponding to a steady acceleration $K_{ho}g$, where g is the acceleration of gravity, acting in the proper direction which would just overcome the resistance to sliding of the abutment. For a given value of horizontal earthquake acceleration, $K_h g$, the following criterion is established.

If $K_h g \geq K_{ho} g$, sliding will take place.

If $K_h g < K_{ho} g$, sliding will not occur.

The value of K_{ho} for a given abutment may be calculated through the force equilibrium shown in the Figure 7a,

$$V_e = W_s + (1-K_v)\ W + (E_s+E_{ae})\ \sin(\delta+\beta_1) - E_{pe}\ \sin(\delta-\beta_2) \quad (14)$$

$$S_e = K_{ho}\ W + (E_s+E_{ae})\ \cos(\delta+\beta_1) - E_{pe}\ \cos(\delta-\beta_2) \quad (15)$$

$$S_e = V_e \tan \phi_b \quad (16)$$

Note that E_{ae} and E_{pe} are functions of K_{ho} (See eq.(2) – eq. (5)), it is very difficult to derive an explicit expression for the direct calculation of K_{ho} from the equations. A rough but conservative estimate of K_{ho} is given in Figure 8, based upon the following assumptions:

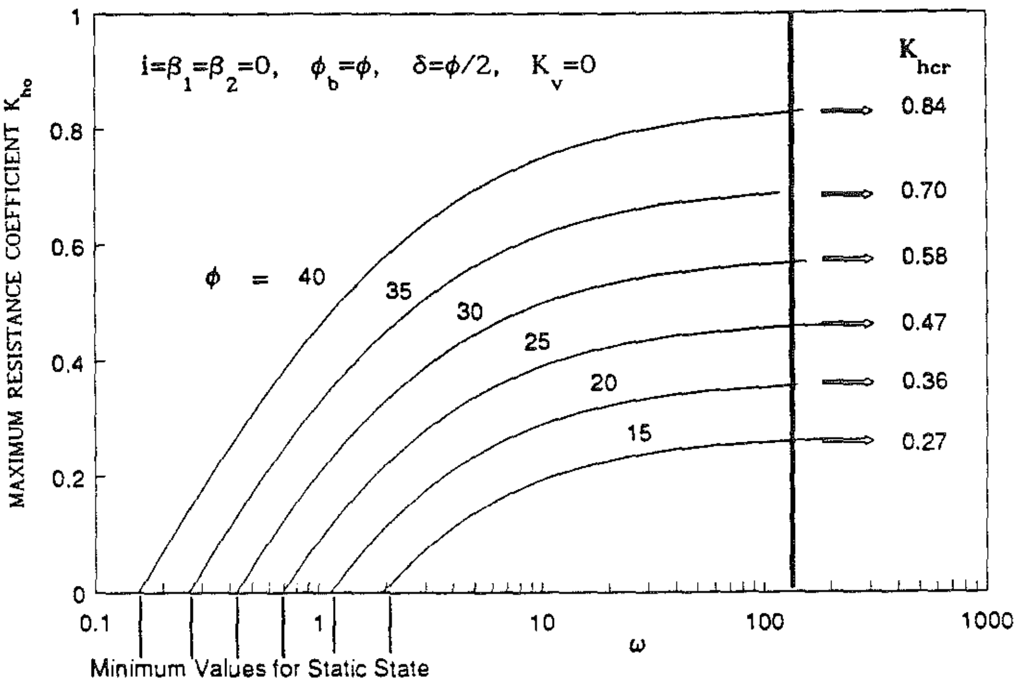


Figure 8. Maximum Resistance Coefficient Against Sliding

$D_{ma} = D_{sp} - D_{pier}$

If $D_{max} < D_{ma}$, No Collapse

If $D_{max} >= D_{ma}$, Collapse

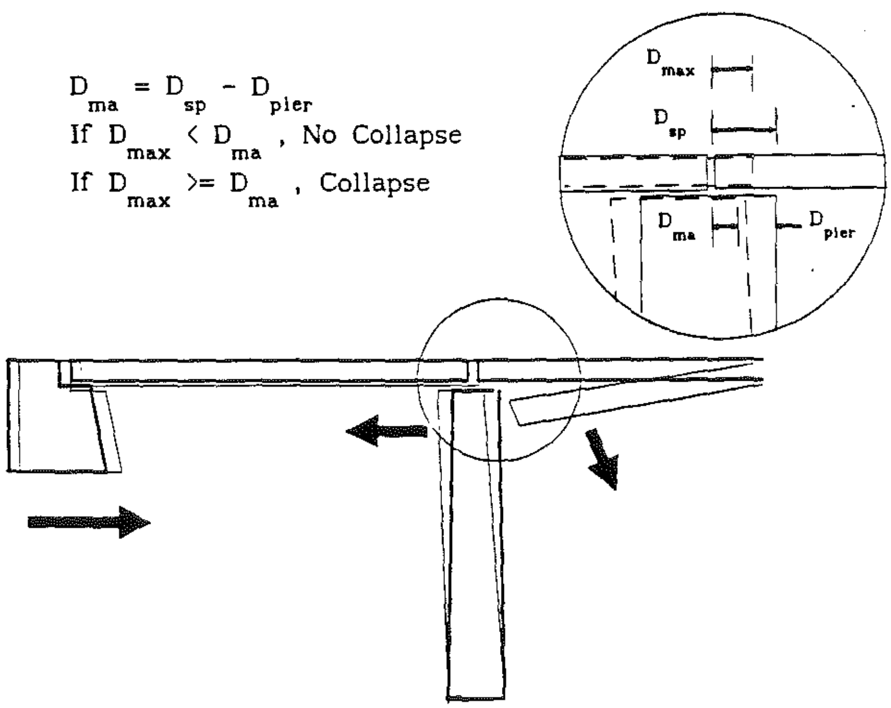


Figure 9. Span-Loss Type of Collapse and Criteria

a) $W_s = 0$

b) $i = \beta_1 = \beta_2 = 0$

c) $\phi_b = \phi$

d) $\delta = \phi /2$

e) $\omega = \dfrac{W}{1/2\gamma\ H^2}$

f) $E_{pe} = 0$

g) $K_v = 0$

h) $E_s = 0$

If the value of K_h is less than K_{ho} in Figure 8 for a given abutment having a known ω and ϕ, the abutment will not slide due to an earthquake. However, if K_h is greater than K_{ho}, it does not necessarily mean that the abutment will slide during an earthquake since the K_{ho} is very conservative without considering the positive effects of W_s and E_{pe}. The sliding might occur in some of the abutments and might not in some others. Therefore, K_{ho} should be used only for a rough estimate and may not be used for further calculations such as the magnitude of the sliding, etc. A more accurate and simple method is presented in the following sections.

REQUIRED MINIMUM WEIGHT OF ABUTMENT

CRITERION FOR SPAN-LOSS TYPE OF COLLAPSE

Assuming that an abutment will slide during an earthquake, it should have sufficient weight to limit the resulting displacement, thus preventing any serious damage to the superstructure and the abutment itself. A critical condition called span-loss type of collapse is presented and corresponding criteria are established.

Among those bridges analyzed during this study, most of the superstructures belong to the simply supported system. Usually, the bearings at two abutments are fixed ones. Consequently, at least one of the piers adjacent to either abutment will have two expansion bearings, which allow for relatively free horizontal movement. The displacement at the abutment will be transmitted totally to the superstructure of the end span if the superstructure is assumed to be rigid. Because of the expansion bearings, the superstructure of the end span will move freely in the direction of the abutment sliding and hence push the superstructure of the next end span with the same displacement in the same direction. If the total sliding displacement of an abutment during an earthquake is greater than the length of support of the second end span superstructure at the top of the pier, the superstructure of the second end span will consequently be pushed off the top of the pier as illustrated in Figure 9 and route access will be cut off completely. This critical condition is defined as the span-loss type of collapse. However, this is still not the most critical situation. Since the abutment and pier will respond to the earthquake motion simultaneously, the most critical case occurs when the direction of the earthquake induced vibration of the pier is just opposite to the direction of abutment sliding as shown in Figure 9. The criterion for the most critical condition in span-loss type of collapse may be expressed as:

$$D_{max} < D_{ma} = D_{sp} - D_{pier} \qquad \text{no collapse}$$

$$D_{max} \geq D_{ma} = D_{sp} - D_{pier} \qquad \text{collapse}$$

where:

D_{max} — maximum relative sliding displacement of abutment

D_{ma} — maximum allowable sliding displacement of abutment

D_{sp} — support length of superstructure on the pier top

D_{pier} — maximum displacement at top of pier during vibration

THE MAXIMUM DISPLACEMENT OF ABUTMENT

The total relative displacement of a retaining wall depends on the earthquake acceleration, velocity time history, and critical acceleration coefficient of the wall, K_{ho}.

Newmark[6] and then Franklin and Chang[7] computed the maximum displacement response of several natural and synthetic earthquake records by scaling all records at a normalized maximum acceleration of 0.5g (A=0.5) and a normalized maximum ground velocity of 30 in/sec. An upper bound envelope curve of all recorded maximum displacements in terms of the ratio of the maximum resistance coefficient, K_{ho}, to the maximum earthquake acceleration coefficient, A, is shown in Figure 10. An approximation to the curve for relatively low displacement is expressed in the following relation for any consistent set of units

$$D_{max} = 0.087 \frac{v^2}{A\,g} \left[\frac{K_{ho}}{A}\right]^{-4} \qquad (17)$$

where:

D_{max} — maximum relative displacement of the wall subjected to an earthquake record with A and v

A — maximum acceleration coefficient of an earthquake

v — maximum ground velocity of an earthquake

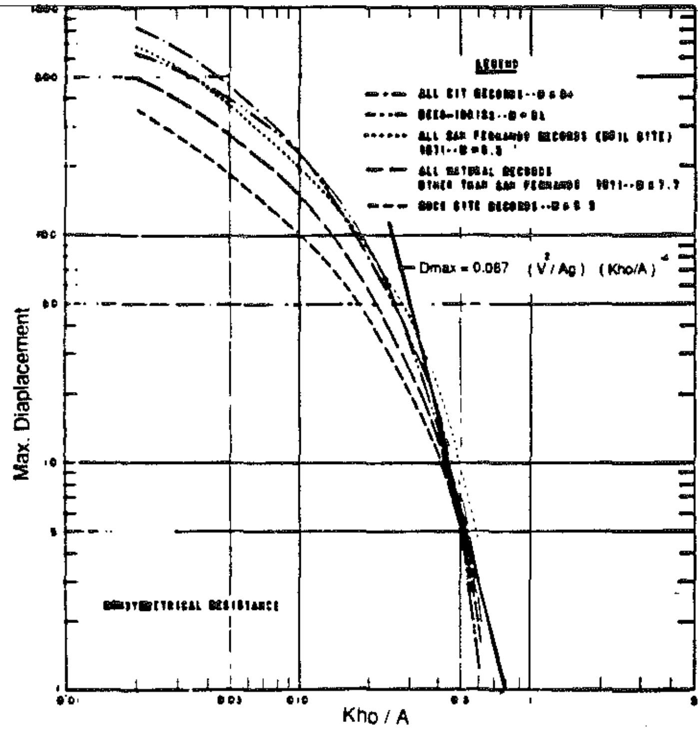


Figure 10. Upper Bound Envelope of Max. Diaplacement
(from Franklin and Chang 1977)

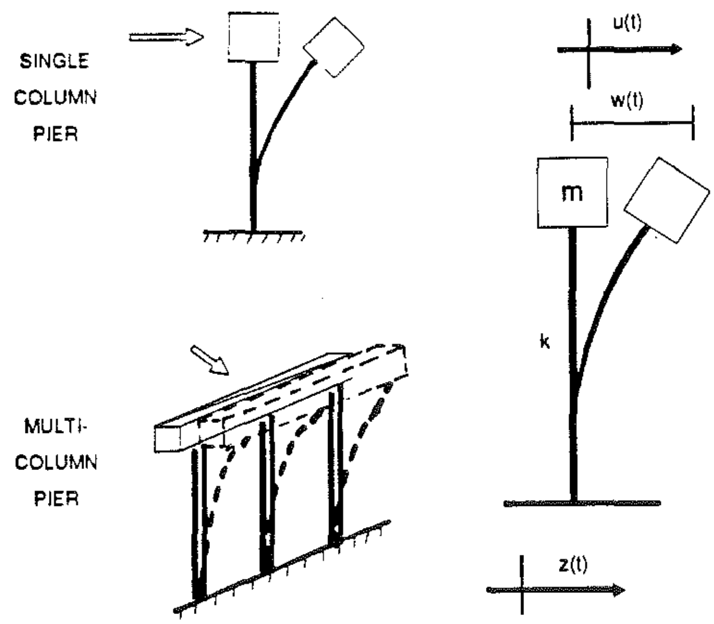


Figure 12. Dynamic Modeling for Pier during Earthquake

Since this expression is obtained from the envelope curve and the data base for the envelope includes most of the big recorded earthquakes in California and other locations, it may reasonably be used directly to estimate the maximum displacement for an earthquake in many other areas where the possible acceleration coefficient, A, and ground velocity, v, are less than 0.5 and 30 in/sec, respectively.

CALCULATION OF REQUIRED MINIMUM WEIGHT

Corresponding to the criterion described previously, an abutment is not allowed to have a sliding displacement more than D_{ma} in order to prevent the span-loss type of collapse. In other words, a minimum weight of abutment is required to ensure that the possible sliding displacement is less than the maximum allowable displacement D_{ma}. For a given potential earthquake having a possible A and v, the maximum resistance coefficient K_{href} corresponding to the allowable maximum displacement D_{ma} may be obtained by converting eq. (17)

$$K_{href} = 0.543\ A \sqrt[4]{\frac{v^2}{Ag\ D_{ma}}} \qquad (18)$$

where:

K_{href} — reference resistance coefficient under which the abutment will have sliding displacement of D_{ma}

This indicates that an abutment subject to earthquake motion having a horizontal acceleration of K_{href} g will have a displacement of D_{ma}. Since any displacement greater than D_{ma} will lead to collapse of the span, the abutment must have a certain amount of weight which will prevent the abutment from having this much displacement. This certain weight of abutment is defined here as the required minimum weight, W_{req}. Therefore the criteria in terms of D_{ma} can be rewritten to a criterion in terms of W_{req}.

$D_{max} < D_{ma} \Rightarrow W > W_{req}$ no collapse

$D_{max} \geq D_{ma} \Rightarrow W \leq W_{req}$ collapse

where:

W — actual weight of abutment per unit length

W_{req} — required minimum weight of abutment per unit length

If the actual weight of abutment is less than the required minimum weight, the abutment will have a sliding displacement sufficiently large to cause a span-loss type of collapse. The formula for calculating W_{req} may be derived from eq.(14), (15), and (16).

$$W_{req} = + \left[\frac{\cos(\delta+\beta_1) - \sin(\delta+\beta_1)\tan\phi_b}{(1-K_v)\tan\phi - \tan\theta_{ref}} \right] E_{ae}$$

$$- \left[\frac{\cos(\delta-\beta_2) - \sin(\delta-\beta_2)\tan\phi_b}{(1-K_v)\tan\phi - \tan\theta_{ref}} \right] E_{pe}$$

$$- \left[\frac{\tan\phi_b}{(1-K_v)\tan\phi - \tan\theta_{ref}} \right] W_s$$

$$+ \left[\frac{\cos(\delta+\beta_1) - \sin(\delta+\beta_1)\tan\phi_b}{(1-K_v)\tan\phi - \tan\theta_{ref}} \right] E_s \qquad (19)$$

$$\theta_{ref} = \tan^{-1}\left[\frac{K_{href}}{1-K_V} \right] \qquad (20)$$

From eq. (19), the effects of various types of force on the required minimum weight may be clearly seen. The seismic active earth pressure and wheel load induced equivalent active earth pressure are the forces leading to sliding and therefore increase the required weight as they increase. On the other hand, the seismic passive earth pressure and superstructure transmitted vertical load are the forces resisting sliding and therefore decrease the required weight as they increase. Separating the earthquake affected factors from the four terms in eq.(19), the equation may be rewritten as

$$W_{req} = C_{ae}\,\gamma\,H^2 - C_{pe}\,\gamma\,H_b^2 - C_{ws}\,W_s + C_s\,q\,H \qquad (21)$$

where:

$$C_{ae} = \left[\frac{\cos(\delta+\beta_1) - \sin(\delta+\beta_1)\tan\phi_b}{(1-K_v)\tan\phi - \tan\theta_{ref}} \right] \frac{K_{ae}}{2}(1-K_v) \qquad (22)$$

$$C_{pe} = \left[\frac{\cos(\delta-\beta_2) - \sin(\delta-\beta_2)\tan\phi_b}{(1-K_v)\tan\phi - \tan\theta_{ref}} \right] \frac{K_{pe}}{2}(1-K_v) \qquad (23)$$

$$C_{ws} = \left[\frac{\tan\phi_b}{(1-K_v)\tan\phi - \tan\theta_{ref}} \right] \qquad (24)$$

$$C_{s} = \left[\frac{\cos(\delta+\beta_1) - \sin(\delta+\beta_1)\tan\phi_b}{(1-K_v)\tan\phi - \tan\theta_{ref}} \right] K_a \qquad (25)$$

The values of the coefficients C_{ae}, C_{pe}, C_{ws}, C_s are given in Figure 11 for known maximum allowable displacement D_{ma} and soil friction angle ϕ. These charts are for the situation when $i=\beta_1=\beta_2=0$, $\phi_b=\phi$, $\delta=\phi/2$, $K_v=0$ and when A=0.2 and V=30A inch/sec which is assumed for all practical purposes. By these charts and eq. (21), the required minimum weight of the abutment corresponding to the maximum allowable displacement D_{ma} may be calculated. After comparing calculated W_{req} with the actual W, the possibility of span-loss type of collapse may be estimated.

DETERMINATION OF MAXIMUM EARTHQUAKE DISPLACEMENT OF PIER

All aspects involved in the analysis have been discussed except D_{ma}. As defined, $D_{ma}=D_{sp} - D_{pier}$. The support length of the superstructure on the top of the pier adjacent to the abutment, D_{sp}, may be obtained from plans or from the field measurement. The problem remaining is how to determine the maximum displacement at the top of the pier during an earthquake induced vibration, D_{pier}. A simple procedure is provided here which is based upon the dynamic theory with some simplifying assumptions.

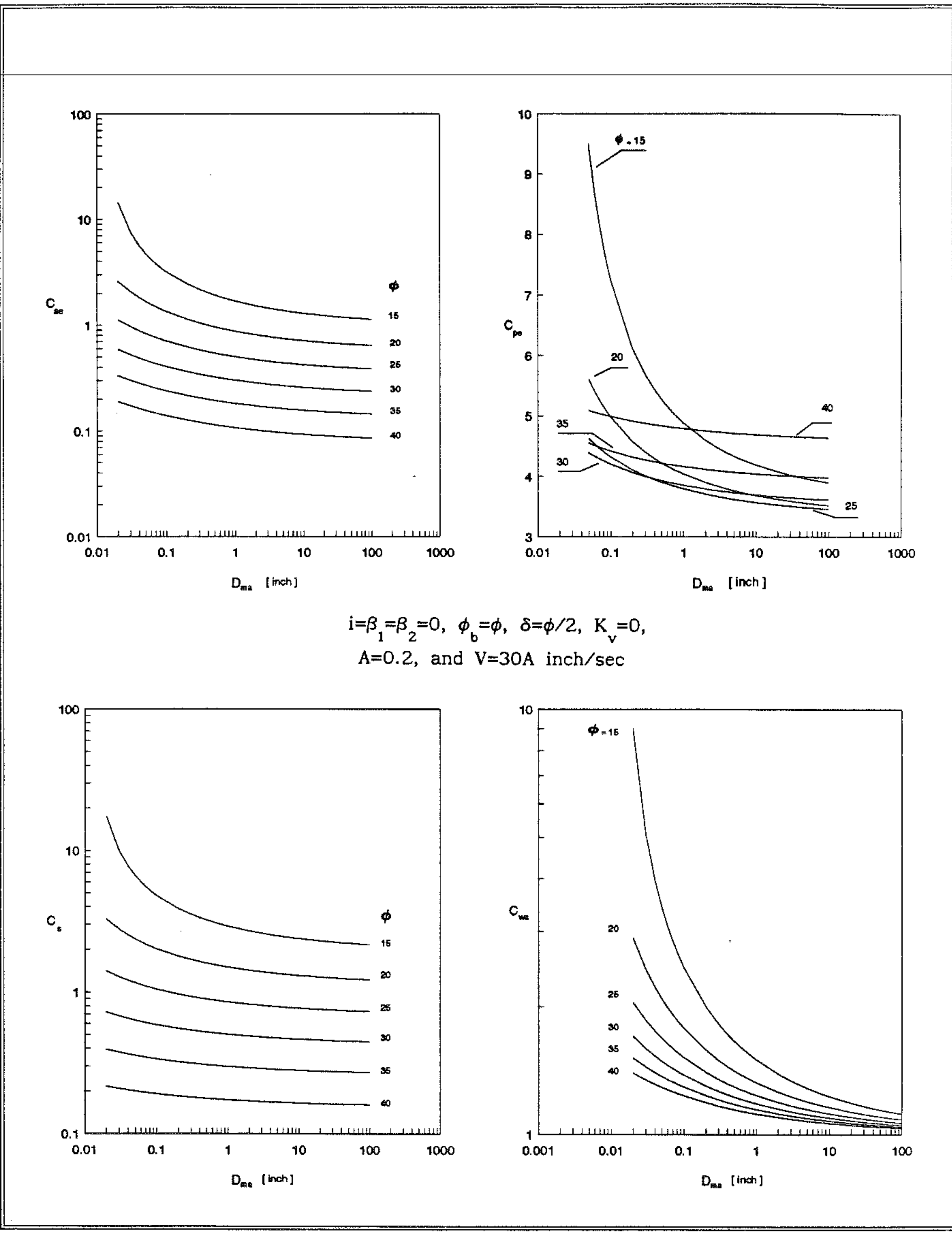


Figure 11. Coefficient Related to the Calculation of W_{req}

Basic Assumptions for a Pier in Vibration

a) Single degree of freedom system (SDOF) with the mass concentrated at top of pier,
b) Flexural type of deformation in the longitudinal direction of bridge, and
c) Rigid fixed end at the foundation.

Basic Theory for SDOF System and Response Spectra

If a SDOF system, as shown in Figure 12, is subjected to ground motion z(t), the equations for absolute motion u(t) and relative motion w(t) are

$$m\,\ddot{u}(t) + k\,u(t) = k\,z(t)$$
$$m\,\ddot{w}(t) + k\,w(t) = -m\ddot{z}(t) \quad (26)$$

where.

m — concentrated mass of the system
k — lateral stiffness the system
u(t) — absolute motion
w(t) — relative motion
z(t) — ground translated motion

The Duhamel integral solution of eq.(26) is

$$w(t,\omega_n) = \frac{1}{\omega_n} W(t) \quad (27)$$

where:

$$W(t) = \int_0^t \ddot{z}(\tau)\,\sin \omega_n(t-\tau)\,d\tau$$

ω_n — natural frequency of the system

The maximum value of relative displacement occurs at time t_m

$$w_{max} = \left(\frac{1}{\omega_n}\right) W(t_m) = \left(\frac{T_n}{2\pi}\right) W(t_m) \quad (28)$$

where $T_n = \frac{2\pi}{\omega_n}$ is the natural period of the system

The maximum velocity:

$$v_{max} = \omega_n w_{max} \tag{29}$$

The maximum acceleration:

$$a_{max} = \omega_n^2 w_{max} \tag{30}$$

Plots of w_{max}, v_{max}, and a_{max} versus T_n are called the pseudo-displacement, pseudo-velocity, and pseudo-acceleration response spectra, respectively. Simulated pseudo-velocity spectra for ground motion at three sites in Western Kentucky for large and medium sized New Madrid Earthquakes are available.[8] The velocity spectrum for a large size earthquake at site 3 will have the strongest response and hence were chosen for the analysis as shown in Figure 13a. The maximum displacement spectrum as shown in Figure 13b is generated based upon the envelope which represents the maximum response among the different directions.

Maximum Earthquake Displacement at Pier Top

According to the AASHTO Standard Specification For Highway Bridges, the natural period of vibration of a structure can be computed by

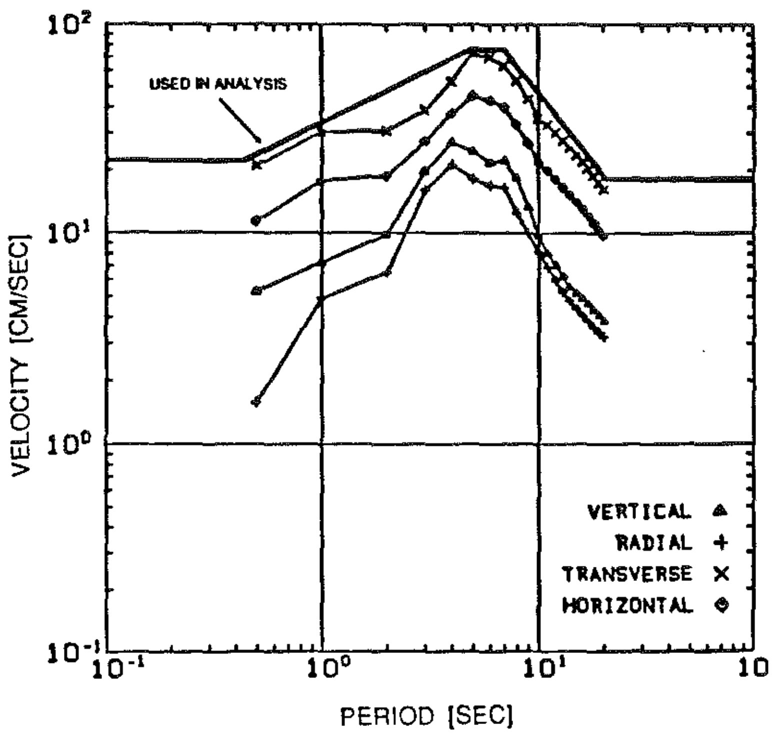
$$T_n = 0.32 \sqrt{\frac{W}{k}} \tag{31}$$

where:

- W — the weight of system (total superstructure transmitted loads on the pier plus half of the pier weight)
- k — the stiffness of system (total static uniform force pound required to cause a 1-inch maximum horizontal deflection at pier top)

When the natural period T is calculated, the maximum displacement, D_{pier} during an earthquake may be easily determined from Figure 13b. The D_{ma} may be calculated by $D_{ma} = D_{sp} - D_{pier}$. Notice that D_{pier} might be greater than D_{sp} and makes D_{ma} less than 0. This means that the dynamic deflection of pier at top is sufficiently great to cause the span-loss type of collapse itself. Regardless of the response of the abutment, the dynamic deflection of the pier will cause the collapse of a span and hence cut access to the route. This method also may be used to estimate the possibility of span-loss type of collapse due to the dynamic deflection of any pier or bent rather than the pier adjacent to the abutment.

PSEUDO-VELOCITY RESPONSE SPECTRUM
(from Herrmann and Jost 1988)



PSEUDO-DISPLACEMENT SPECTRUM

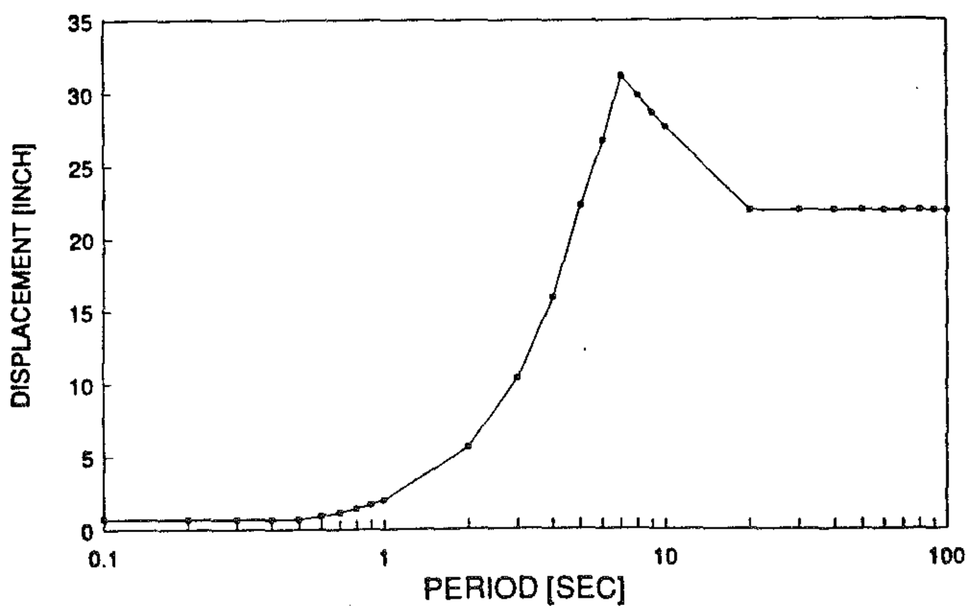


Figure 13. Velocity and Displacement Spectra

APPLICATION OF THE ANALYSIS

COMPUTER PROGRAM

A spread sheet computer program has been developed to carry out all the analyses described in this paper. Figure 14 is the flow chart for the program. Material properties and geometric properties of the abutment are required as input. By using this program, 276 bridges on the referenced priority routes have been analyzed. The results indicate that about 10% of the bridges have the potential possibility of span-loss type of collapse either due to a combination of abutment sliding and pier dynamic deflection or due to the dynamic deflection of the pier itself. Of course, the analysis is on the conservative side because some of the positive factors such as the strong lateral links between the superstructure and abutment have not been taken into account and also because the most critical conditions are always employed for the analysis when the exact behavior is not known or the necessary data are not available.

DETERMINATION OF SOIL FRICTION ANGLE

In the analyses of the 276 bridges, most of the soil friction angles for the bridge sites are not available. Because the soil friction angle is one of the most important factors in the analysis and the analysis results are very sensitive to this factor, reliable results will not be obtained if erroneous values are used for the analysis. Fortunately, the information relative to the plasticity index, PI, of soils at different locations and different depths in every county are available. It provides the basis for determination of soil friction angle used in the analyses. Since the locations for soils having PI data are different from the locations of those bridges, statistical and probability analyses have been applied to determine the value of friction angle. The analysis includes the following steps:

a. convert the PI values to the friction angle values through the relationship between the two[9];

$$\phi = 44.7 - 12\log(\text{PI }\%) \tag{32}$$

b. consider each value as a "sample" as per the statistical definition;
c. determine the frequency density distribution for the samples;
d. normalize the population of the samples as a lognormal distribution which best matches the frequency density distribution;
e. calculate the mean value and standard deviation of the population; and
f. estimate the value with 95% confidence level.

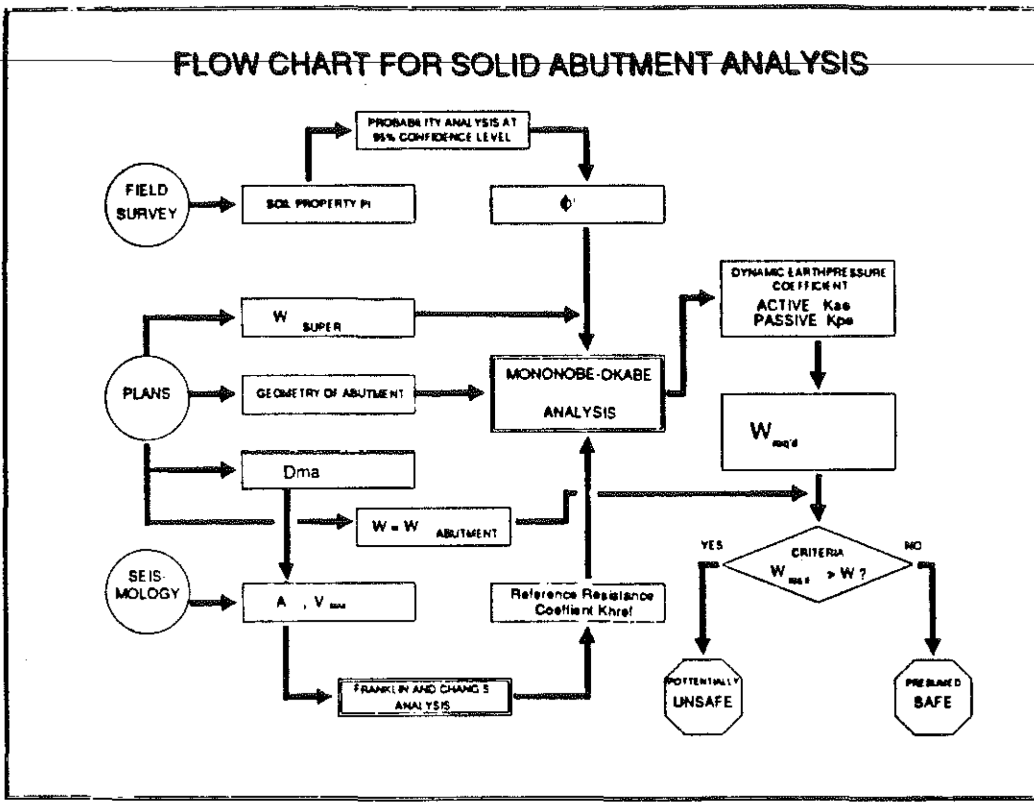


Figure 14. Flow Chart For the Computer Program

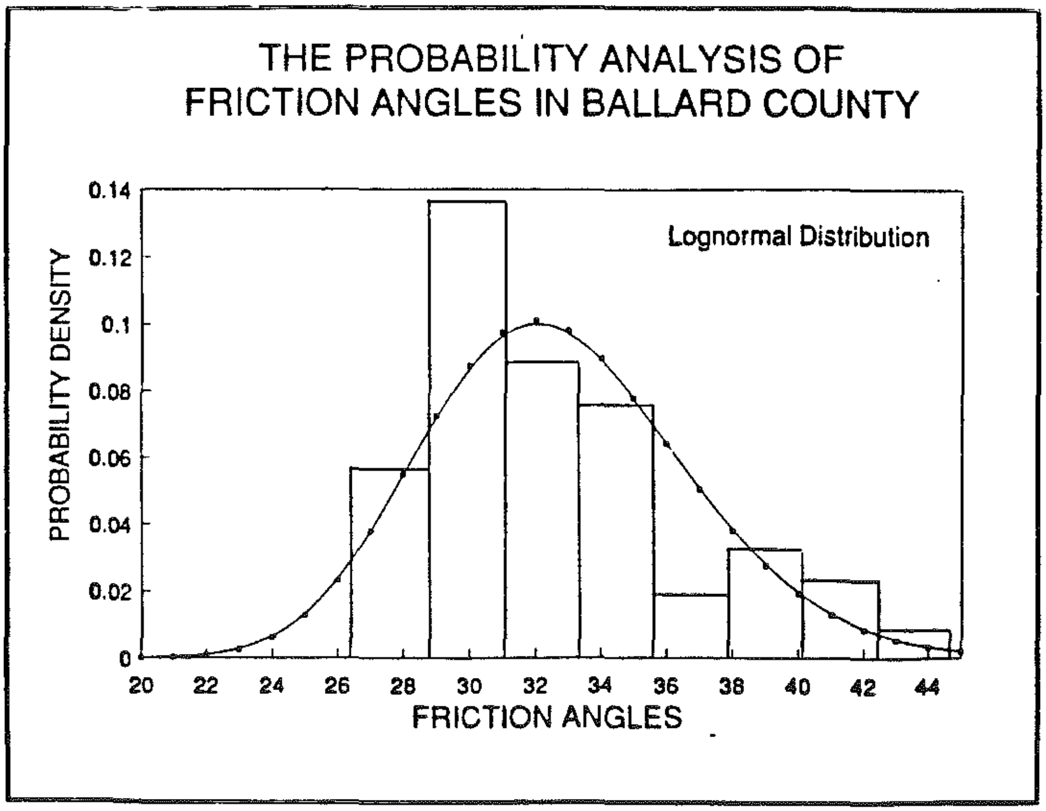


Figure 15. Example of Probability Analysis of Friction Angle

The value of soil friction angle determined by the previous procedure will be less than the true value with 95% confidence. By using the values, the analysis with the value, therefore, has only a 5% probability that the analysis is on the unsafe side. This meets the general civil engineering requirement of 95%-confidence level for this type of analysis. The statistical and probability analyses have been carried out for the 26 counties by using a spreadsheet computer program developed for this purpose. One of the results is shown in Figure 15.

SUMMARY AND CONCLUSIONS

A system of priority routes for use after an earthquake has been selected by the Kentucky Transportation Center for the western part of Kentucky. It was necessary to analyze nearly 300 bridges to determine whether they might succumb to the possibility of span-loss type failures. An analysis procedure was developed and used. From this study, it was determined that:

The most important forces acting on an abutment during an earthquake are seismic active and passive earth pressures, superstructure transmitted load, gravity force of the abutment, wheel load induced equivalent active earth pressure, horizontal and vertical inertia forces. The effects of different forces on and abutment sliding also have been shown.

The maximum dynamic resistance against the sliding of an abutment during an earthquake is analyzed and a conservative and approximate method for estimating the maximum dynamic resistance coefficient has been provided. If the potential earthquake horizontal acceleration coefficient is greater than the maximum dynamic resistance coefficient, the abutment is likely to slide during an earthquake.

A span-loss type of collapse has been formulated and the corresponding criterion has been established. If the sliding displacement of an abutment plus the dynamic deflection at the top of a pier adjacent to the abutment are greater than the support length of superstructure on the pier top, the span is likely to collapse and hence the route will be cut off.

The procedures for calculating the required minimum weight of an abutment is advanced and a formula along with several charts are presented for the practical use. The span-loss type of collapse is not likely to occur when the actual weight of an abutment is greater than the required minimum weight.

Related to the maximum allowable displacement, a simple method to determined the maximum dynamic lateral deflection of a pier by using the displacement spectra is described. The method may also be applied to the analysis of a pier.

Statistical and probability analyses are employed to determine the soil friction angles used in the analysis. The values of the friction angles which have been used in the analysis ensured that analysis is on the safe side with a 95%-confidence level.

A spreadsheet program has been developed and applied to analyze 276 bridges on the priority routes.

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APPENDIX B

EVALUATING BRIDGE DAMAGES RELATED TO EARTHQUAKE INDUCED VIBRATION OF PIER OR BENT

EVALUATING BRIDGE DAMAGES RELATED TO EARTHQUAKE INDUCED VIBRATION OF PIER OR BENT

INTRODUCTION

Earthquake induced ground motion will generate vibrations of bridge piers. The maximum dynamic deflection of a pier during vibration may cause the collapse of the bridge span. In this appendix, the criterion for estimating this span-loss type of bridge collapse is established and corresponding calculation procedures are provided. A pier in vibration from earthquake induced ground motion is simplified as a single degree of freedom system, and hence the theory of SDOF is applied to analyze the dynamic response of a pier to an earthquake. The procedure for obtaining earthquake response spectra from recorded earthquake ground motion or from numerically simulated earthquake ground motion is also presented. An earthquake response spectrum based upon a simulated large New Madrid Earthquake in Western Kentucky is chosen as the analysis response spectrum to estimate the earthquake response of a pier or bent. The structural models for different types of piers or bents are discussed and a spread sheet program was developed to estimate the potential damage to a pier or bent during an earthquake.

CRITERION TO SPAN-LOSS TYPE OF BRIDGE COLLAPSE

SPAN-LOSS TYPE OF BRIDGE COLLAPSE

During an earthquake, a pier or a bent is in a state of vibration. The vibration may lead to a significant dynamic deflection and seismic moments and shear forces in the pier or bent. For an existing bridge, both the dynamic deflection and dynamic stress may cause the collapse of the bridge span. If the dynamic deflection causes a total loss of the support length of the superstructure on the pier or bent top, the span will collapse. If the dynamic moment or shear exceeds the maximum flexural or shear strength of the pier column, the pier will lose its bearing capacity and the span will collapse because its support components (columns) have collapsed. Both failures cause loss of support. Therefore, they are classified in a same failure category which is defined as a span-loss type of collapse. This type of bridge failure must be prevented for bridges which are on the priority routes.

FAILURE CRITERIA

Failure From Dynamic Deflection

The maximum dynamic displacement of a pier occurs at the top when it is subjected to earthquake vibrations. If this maximum dynamic displacement is greater than the length of support of a span on the pier top, the span will fall as shown in Figure 1a. The criterion for this type of collapse is:

If	$D_{max} < D_{sp}$	No Collapse
If	$D_{max} \geq D_{sp}$	Collapse

where,

D_{max} — Maximum dynamic displacement at pier top,

D_{sp} — Length of support of span on pier top.

Failure From Seismic Moment or Shear Force

Earthquake induced vibrations result in a seismic moment and shear in the pier column. The most critical section of a column will be at the bottom just above the footing. This location has the largest dynamic moment and shear, as shown in Figure 1b. Because neither the "Guide Specifications For Seismic Design Of Highway Bridges"[1] nor any other seismic design specification were used in designing the bridges studied and reported on herein, the columns are generally weak in resisting earthquake loadings. The earthquake induced seismic moment or shear may exceed the maximum flexural strength or shear strength of a column and it will cause the column to collapse. If one column collapses, the other columns will take more seismic moments or shear forces due to the redistributions of moments and shear forces. In this case, the other columns are more likely to collapse, and hence pier may lose all bearing capacity. The superstructure supported on such a pier will collapse as a result of losing support. The criterion for this kind of span-loss type of collapse may be formulated as follows.

For seismic moment

If	$M_{max} < M_{fsc}$	No Collapse
If	$M_{max} \geq M_{fsc}$	Collapse

For seismic shear

If	$V_{max} < V_{fsc}$	No Collapse
If	$V_{max} \geq V_{fsc}$	Collapse

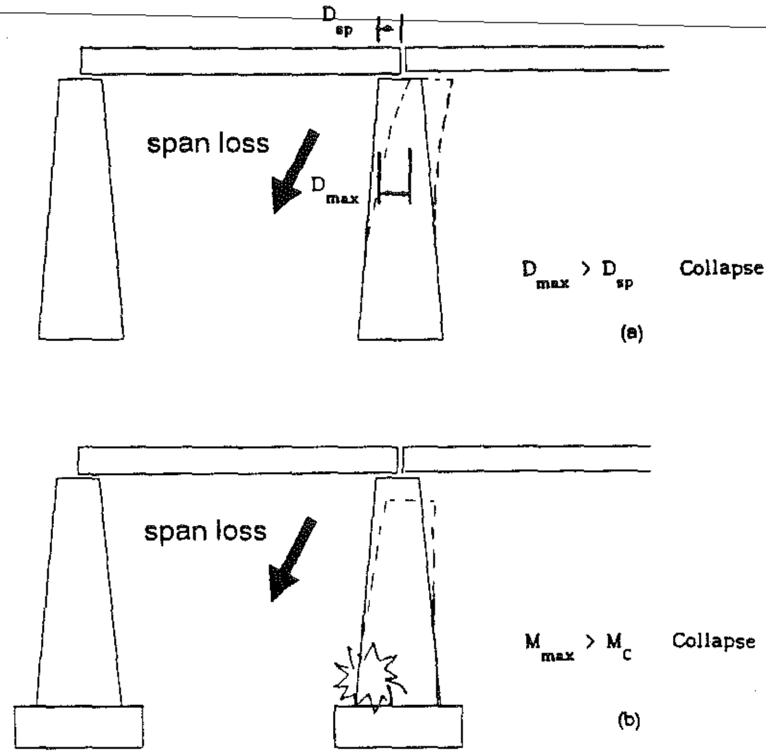


Figure 1. Criteria for Span-loss type of Collapse

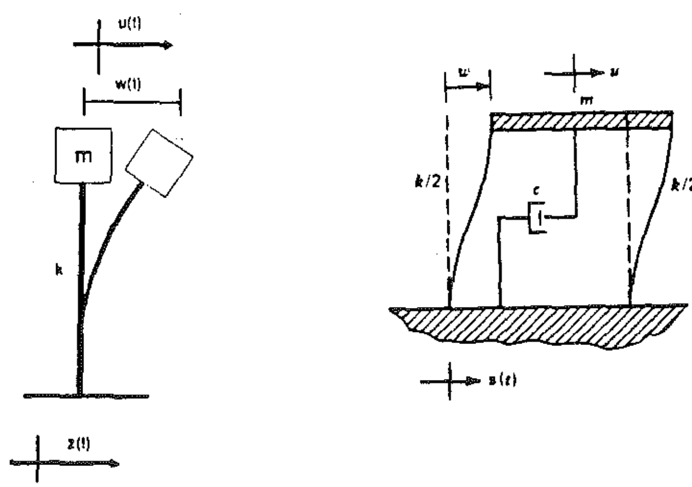


Figure 2. Single Degree of Freedom System

where,

M_{max} — Maximum seismic moment at the bottom of a pier column,

M_{fsc} — The flexural strength of a column,

V_{max} — Maximum seismic shear force at the bottom of a pier column,

V_{fsc} — The shear strength of a column.

RESPONSE OF PIERS TO GROUND MOTION

BASIC ASSUMPTIONS FOR A PIER SUBJECTED TO GROUND MOTION

a. Single degree of freedom system (SDOF) having the mass concentrated at the top of the pier,
b. Flexural type of deformation in the longitudinal direction of a bridge, and shear type of deformation in the transverse direction of a bridge,
c. Rigidly fixed end at the foundation.

BASIC THEORY FOR SDOF SYSTEM AND RESPONSE SPECTRA[2]

If a SDOF system, as shown in Figure 2, is subjected to ground motion z(t), the equations for absolute motion, u(t), and relative motion, w(t), are

$$m\,\ddot{u}(t) + c\,\dot{u}(t) + k\,u(t) = c\,\dot{z}(t) + k\,z(t) \qquad (1)$$

$$m\,\ddot{u}(t) + c\,\dot{w}(t) + k\,w(t) = -m\ddot{z}(t) \qquad (2)$$

where.

m — concentrated mass of the system,
c — damping coefficient,
k — lateral stiffness the system,
u(t) — absolute motion,
w(t) — relative motion,
z(t) — ground translated motion.

The Duhamel integral solution of eq.(2) is

$$w(t,\omega_n,\xi) = \left(\frac{1}{\omega_n}\right) W(t) \qquad (3)$$

where:

$$W(t) = \int_0^t \ddot{z}(\tau)\, e^{-\xi\omega_n(t-\tau)} \sin \omega_n(t-\tau)\, d\tau \qquad (4)$$

ω_n — natural frequency of the system

ξ — damping factor

The maximum value of relative displacement occurs at time t_m

$$w_{max} = \left(\frac{1}{\omega_n}\right) W(t_m) = \left(\frac{T_n}{2\pi}\right) W(t_m) \qquad (5)$$

where $T_n = \frac{2\pi}{\omega_n}$ is the natural period of the system

The maximum velocity equals

$$v_{max} = \omega_n w_{max} \qquad (6)$$

The maximum acceleration equals

$$a_{max} = \omega_n^2 w_{max} \qquad (7)$$

Plots of w_{max}, v_{max}, and a_{max} versus T_n are called the pseudo-displacement, pseudo-velocity, and pseudo-acceleration response spectra, respectively. The maximum response of the structure to a specific ground motion may be determined by using the response spectra, as long as the natural period of the structure is known.

DESIGN AND ANALYSIS RESPONSE SPECTRA

As discussed previous, the response spectra provide an effective way to determinate the maximum responses of a structure to earthquake induced ground motions. The spectra used in designing earthquake resistance of new structures and predicting potential earthquake damage of existing structures are defined as design response spectra and analysis response spectra, respectively, in this appendix. Both spectra may be generated from either recorded earthquake ground motions or from numerically simulated earthquake ground motions.

RESPONSE SPECTRA FROM RECORDED EARTHQUAKE GROUND MOTIONS[3]

Recorded Accelerograms

Accelerograms are sets of plots which record the change of acceleration of ground motion versus time during an earthquake. Figure 3 includes accelerograms for several representative earthquakes. Each plot shows the record for a specific location and a specific direction.

Ground Velocity and Displacement

Further details can be developed from an accelerogram. By integrating the acceleration, a plot of ground velocity versus time may be obtained. Similarly, a plot of ground displacement may also be generated by integration of ground velocity. Figure 4 shows ground velocity and ground displacement derived from the recorded ground acceleration.

Maximum Response

The most important step in creating a design response spectrum is determination of the maximum response of a given structure to a specific ground motion. The underlying theory is based upon the response of a SDOF system. The vibrational characteristics of such a simple system may be reduced to two: the natural frequency and the amount of damping. By recalculating the time record of response to a specific ground motion for a wide range of natural frequencies and for each of a set of common amount of damping, the response spectra for one ground motion may be determined. It is simply the plot of the maximum response for each combination of frequency and damping. Figure 5 shows an example of such maximum response and illustrates that the random nature of ground motion leads to a response that is very erratic in that a slight change in natural period brings about a very large change in response.

Design Spectrum

Different ground motion leads to response spectra having peaks and valleys at different points with respect to the natural frequency. Thus, computing response spectra for several different ground motions and then averaging them, based upon some normalization for different amplitudes of shaking, will lead to a smoother set of spectra. Such smoothed spectra may be used as design spectra, as shown in Figure 6.

RESPONSE SPECTRA FROM NUMERICALLY SIMULATED GROUND MOTION[4]

Earthquake Modeling

The technique used to numerically model the ground motion requires elementary Green's function as the most important input parameter. Both synthetic and empirical Green's functions may be superposed to model the seismic rupture of a large earthquake.

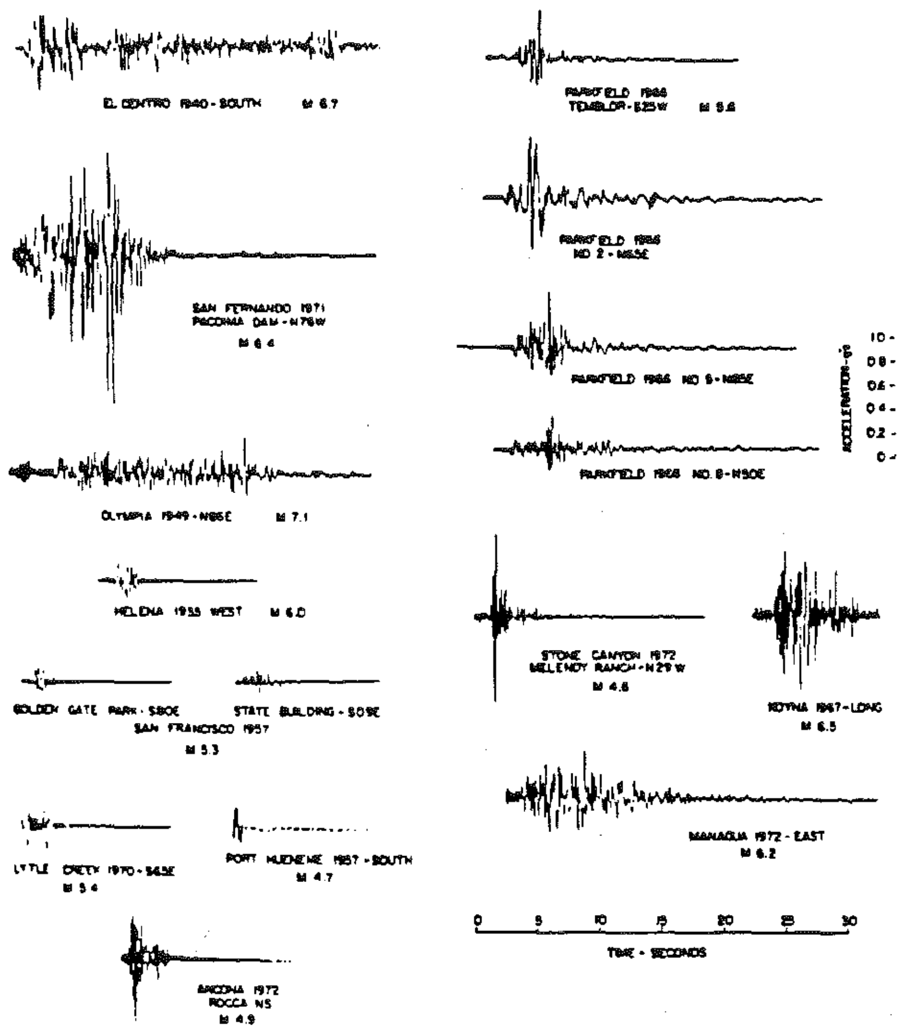


Figure 3. Earthquake Ground Accelerations in Epicentral Region (D. E. Hudson, "Reading and Interpreting Strong Motion Accelerograms", EERI, 1979)

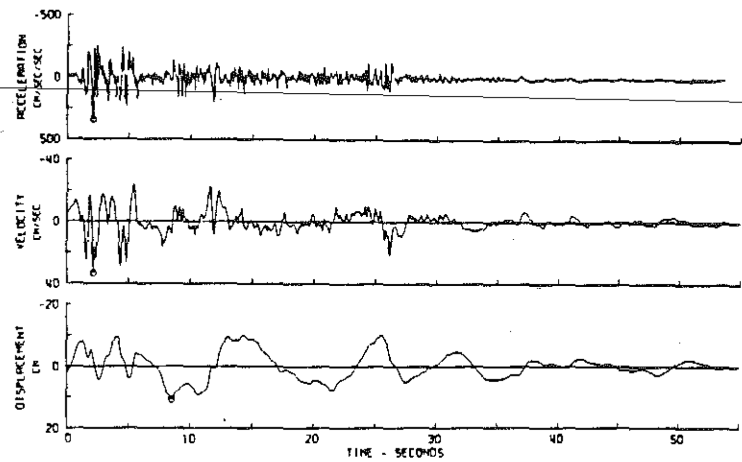


Figure 4. Ground Acceleration, Velocity and Displacement Curves for the El Centro Earthquake (D. E. Hudson, "Strong Motion Earthquake Accelerogrms", EERI 1971

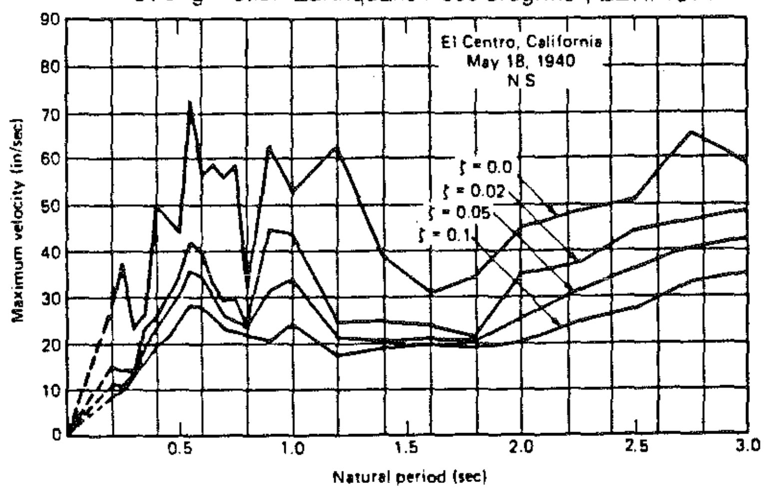


Figure 5. Pseudovelocity Response Spectrum for the N-S Component of the El Centro Earthquake of May 1940 (G. W. Housner, "Strong Ground Motion", Earthquake Engineering, 1970)

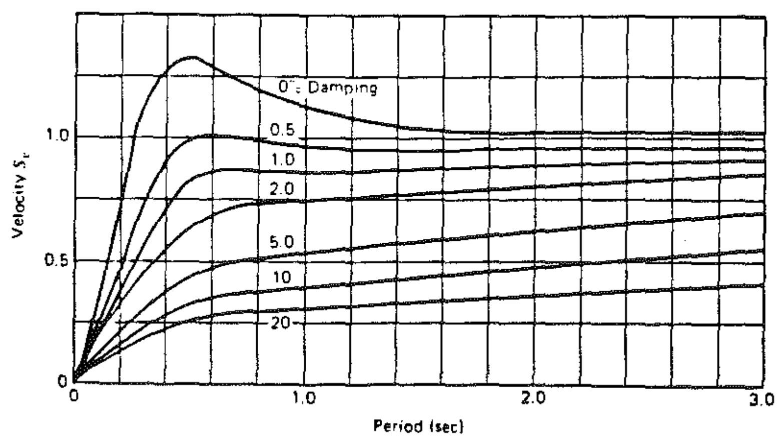


Figure 6. Average Velocity Response Spectrum, 1940 El Centro Intensity (G. W. Housner, "Design Spectrum", Earthquake Engineering, 1970)

Numerical Modeling Technique

This technique is based upon a kinematic model of the seismic rupture process, leading to the construction of synthetic seismograms that may, in turn, be used for calculating peak ground-motion values and response spectra.

Synthetic Seismograms

Figure 7 shows the synthetic accelerogram calculated by the numerical modeling technique for a large New Madrid Earthquake at the Cumberland River Bridge in Western Kentucky. This figure displays the vertical, Z, radial, R, and transverse, T, acceleration histories that are computed. The radial and transverse orientation are with respect to the azimuth from the source to the site.

Response Spectra

Figure 8 shows the 5-percent damped response spectra (cm/sec) obtained from the synthetic accelerogram for a large New Madrid Earthquake at the Cumberland River Bridge in Western Kentucky. The response spectra for three components together with the spectra for the calculated horizontal component are shown. The horizontal component was calculated as the arithmetic mean of the spectra of the radial and transverse components.

SPECTRA USED IN THE ANALYSIS

Available Response Spectra

The available response spectra for the bridges in Western Kentucky are provided by M.L. Jost and R.B. Herrmann of Saint Louis University in their paper entitled Numerical Simulation Of Ground Motions At 3 Sites In Western Kentucky For A Large And A Medium Size New Madrid Earthquake[5]. Two sizes for model earthquakes are considered, a large size (M_s = 8.4) and a medium size (M_s =7.2). Three sites in Western Kentucky, namely the Barkly Dam, the Eggners Ferry Bridge, and the Cumberland River bridge are addressed. A complete set of synthetic time histories is presented. Furthermore, a set of 5-percent damping velocity response spectra, obtained from synthetic seismograms, was calculated for all three model earthquakes at the selected three sites.

Spectra Selected for Analysis

Among all the stimulated pseudo-velocity spectra described previously, the response spectrum at the Cumberland River Bridge is the largest. Therefore, it was chosen as the spectra for the analysis in this report. Figure 8 is the velocity response spectra for this special case. An envelope of this velocity spectra is shown in Figure 8 and is replotted in Figure 9, which covers all possible maximum velocities in vertical, radial, transverse, and horizontal directions. Using this envelope in the calculations will lead to conservative results.

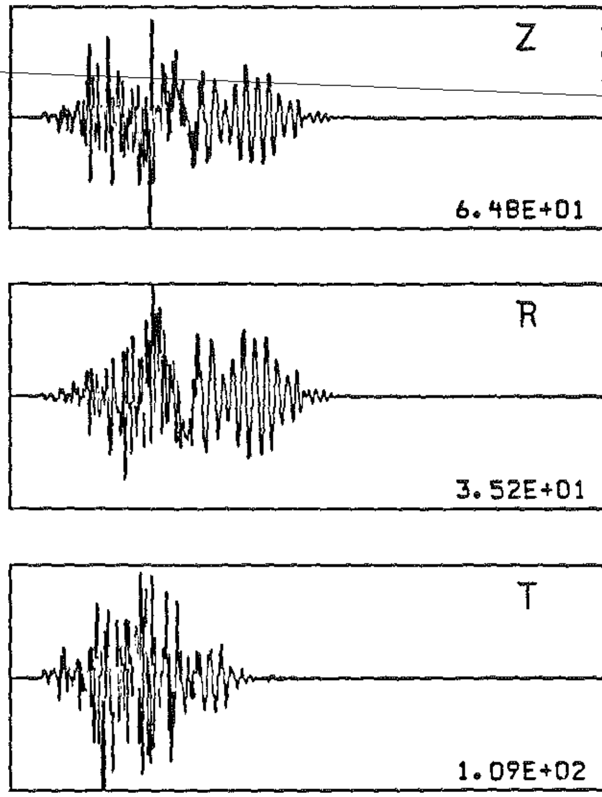


Figure 7. Synthesized Ground Acceleration in W. Kentucky

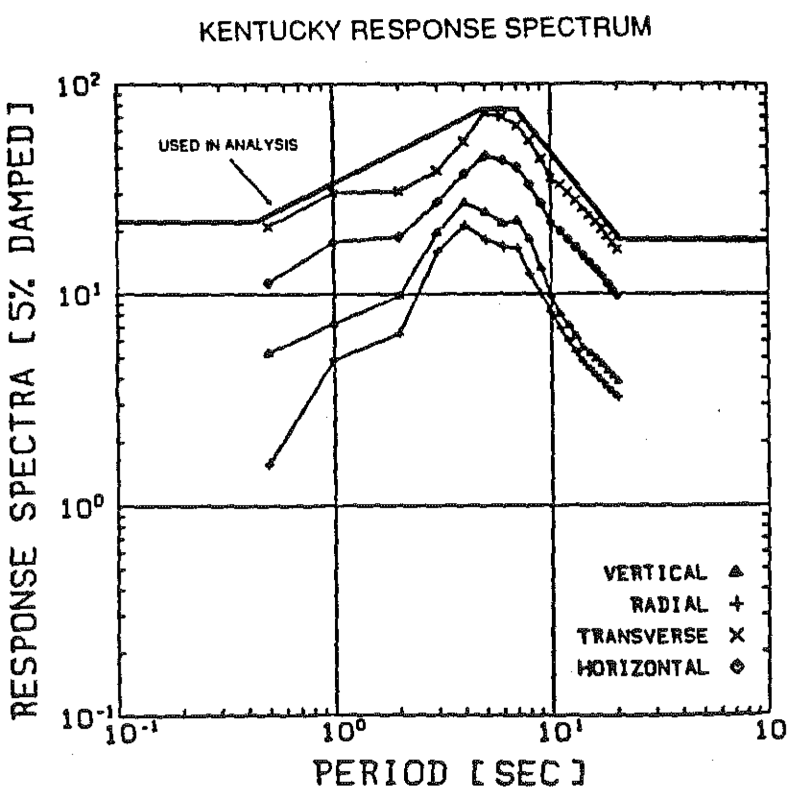


Figure 8. Response Spectrua Used in the Analysis

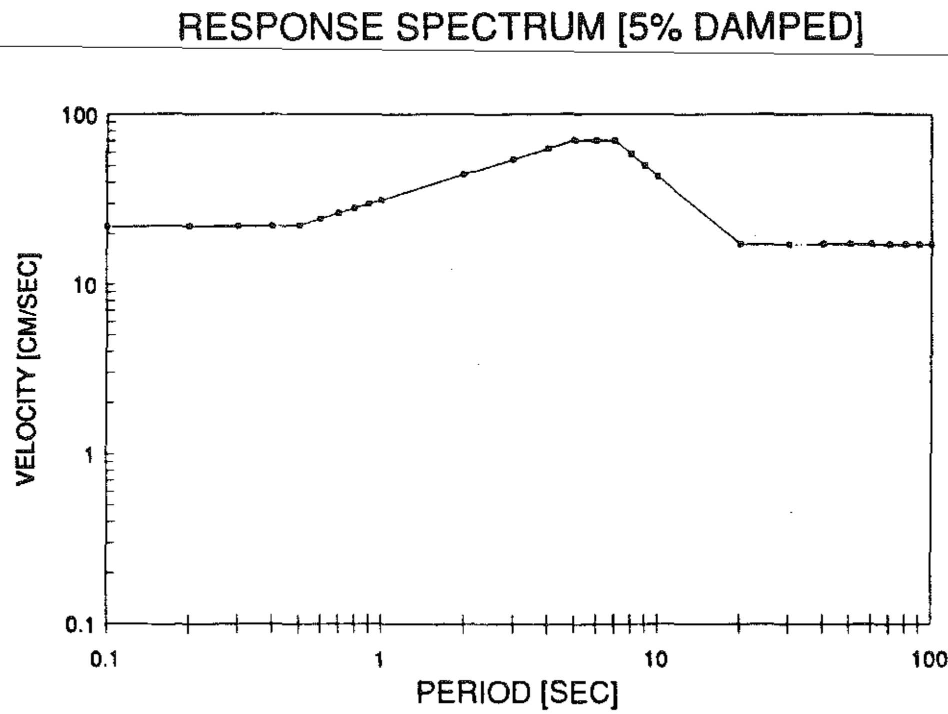


Figure 9. Envelope of Velocity Response Spectra in W. KY

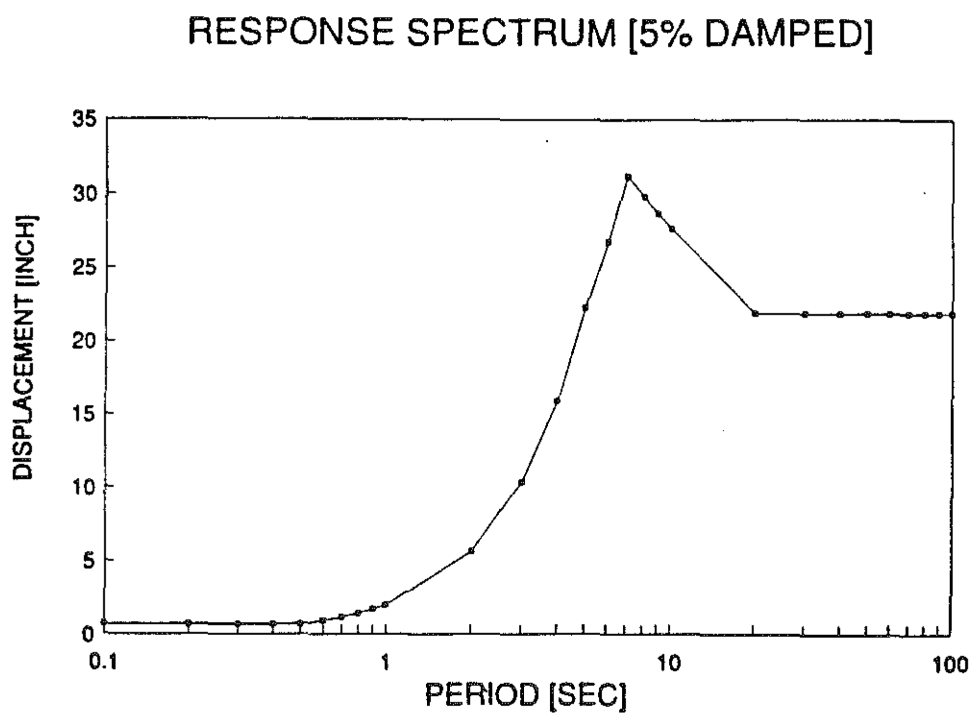


Figure 10. Maximum Displacement Spectra in W. Kentucky

Displacement Response Spectra

Based on the previously selected envelop of velocity response spectra which represent the maximum response in all directions at all sites, the maximum displacement response spectra may be obtained by:

$$w_{max} = \frac{T_n}{2\pi} v_{max} \qquad (8)$$

The displacement response spectra are shown in Figure 10. This is used with the maximum velocity response spectra in the pseudo-static analysis of the piers.

MAXIMUM DYNAMIC DISPLACEMENT AT PIER OR BENT TOP

The maximum dynamic displacement at the pier or bent top may be determined from the maximum displacement spectra and natural period of the pier, T_n.

SUBSTRUCTURE MODELING

Substructure Types

There are five major types of substructures in those bridges involved in this study:

a) Solid pier on rock	(Single column pier)
b) Open pier on rock	(Multi column pier)
c) Solid pier on piles	(Single column pier)
d) Open pier on piles	(Multi column pier)
e) Pile bent	(Multi pile bent)

These five types of substructure may be modeled in two types of structural systems, single-column system and multi-column system, as shown in Figure 11.

Deformation Shapes

The deformation shapes depend upon the directions of the deformations. Two critical deformation directions are considered in the analyses. They are the longitudinal direction and transverse direction with respect to the bridges global direction ordinates. The following assumptions are made for the deformation shapes in each direction,

a. Flexural type of deformation for longitudinal direction
b. Shear type of deformation for transverse direction

The deformation shapes for each structural model and each direction are shown in Figure 11.

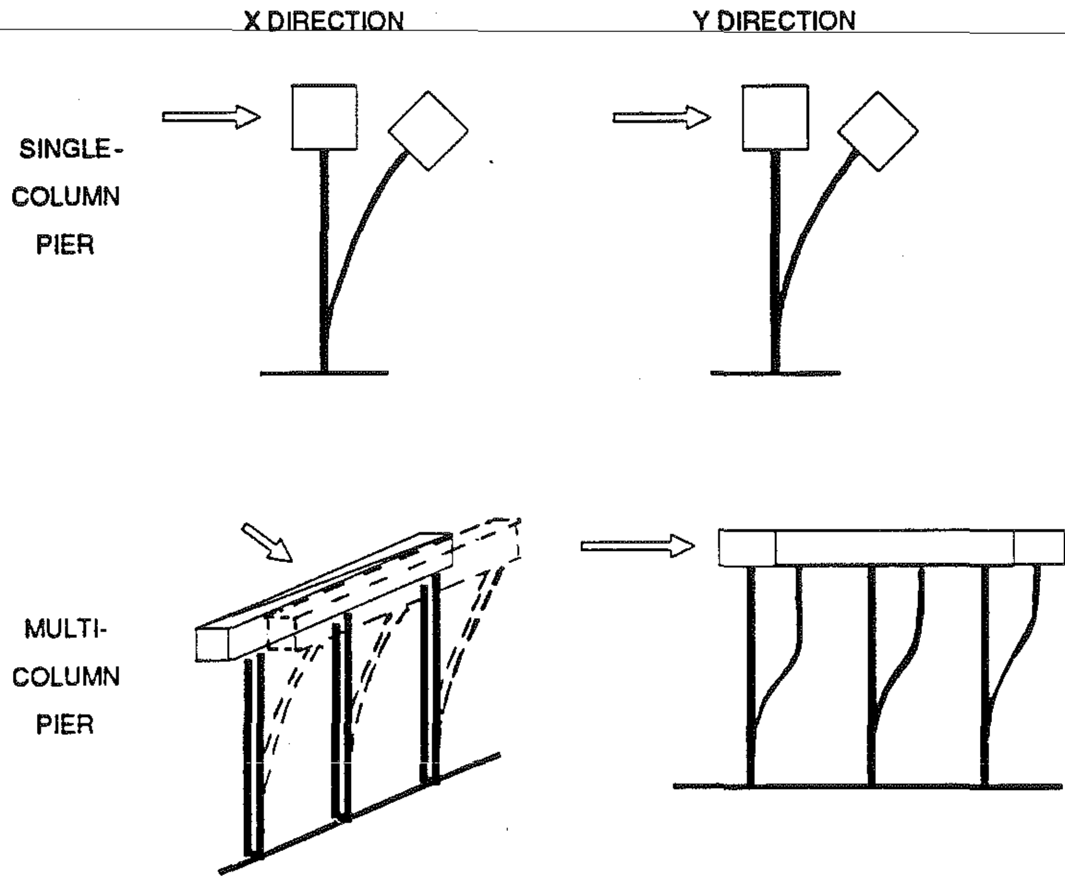


Figure 11. Structure Modeling

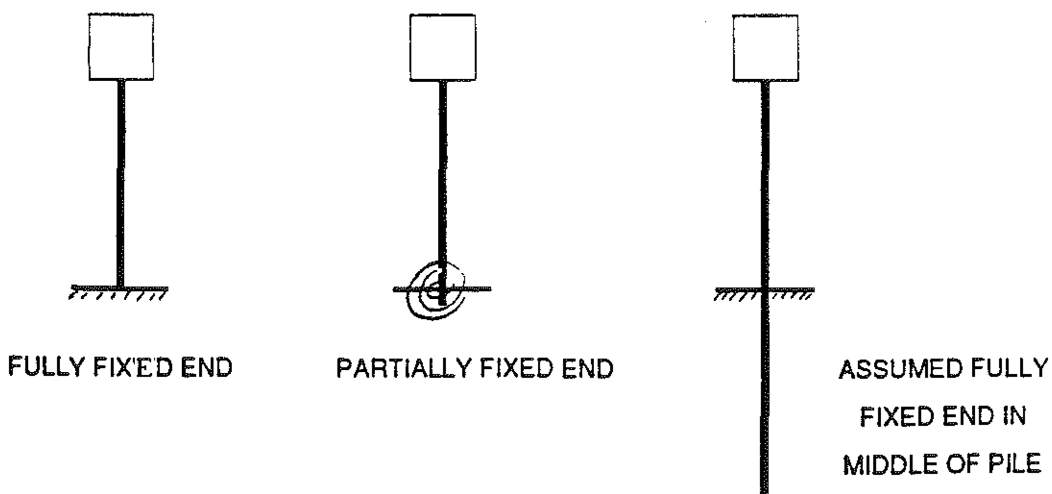


Figure 12. Fixity Assumption

Fixity Assumptions

Two types of fixity at the bottom of substructures are assumed to simulate the foundation conditions, as shown in Figure 12.

a. Fully fixed end
b. Partially fixed end

Since the stiffness of a vibrational system will differ for different end fixities and the response of the system to vibration is largely dependent upon the stiffness of the system, all the substructures are analyzed using a fully-fixed-end assumption and partially-fixed-end assumption. The maximum displacements are used as criteria.

For pile bents, it is assumed that the piles are fixed at mid length of the piles, as shown in Figure 12. Half of the pile length is used for the stiffness calculation.

STIFFNESS OF PIER OR BENT

The stiffness of pier or bent depends upon the shape of deformation and the number of columns or bents. The following basic formulae are applied to calculate the stiffness. For the case of a bent, the fixed end is assumed to be at the mid point of the pile. For the case of partially-fixed end, the stiffness is assumed to be only 1/4 of the stiffness of the fully-fixed end.[6]

a. For a flexural type of deformation in the longitudinal direction

	Fully-Fixed End	Partially-Fixed End
Pier	$K_l = \dfrac{3\ E\ \Sigma I_{il}}{L^3}$	$K_l = \dfrac{3\ E\ \Sigma I_{il}}{4L^3}$
Bent	$K_l = \dfrac{3\ E\ \Sigma I_{il}}{(L/2)^3}$	$K_l = \dfrac{3\ E\ \Sigma I_{il}}{4(L/2)^3}$

b. For a shear type of deformation in the transverse direction

	Fully-Fixed End	Partially-Fixed End
Pier	$K_t = \dfrac{12E\ \Sigma I_{it}}{L^3}$	$K_t = \dfrac{12E\ \Sigma I_{it}}{4L^3}$
Bent	$K_t = \dfrac{12E\ \Sigma I_{it}}{(L/2)^3}$	$K_t = \dfrac{12E\ \Sigma I_{it}}{4(L/2)^3}$

where,

K_l — the stiffness of pier or bent in the longitudinal direction,

K_t — the stiffness of pier or bent in the transverse direction,

E — modulus of elasticity of pier or bent material,

I_{il} — moment of inertia of individual column or pile in the longitudinal direction,

I_{it} — moment of inertia of individual column or pile in the transverse direction,

ΣI_{il} — total moment of inertia of pier or bent in the longitudinal direction,

ΣI_{it} — total moment of inertia of pier or bent in the transverse direction,

L — height of pier column or bent pile.

NATURAL PERIOD OF PIER OR BENT

According to the AASHTO Standard Specification For Highway Bridges,[7] Section 3.21.1.3., the natural period of vibration of a structure may be computed from

$$T_n = 0.32 \sqrt{\frac{W}{K}} \tag{9}$$

where:

W — the weight of system, and

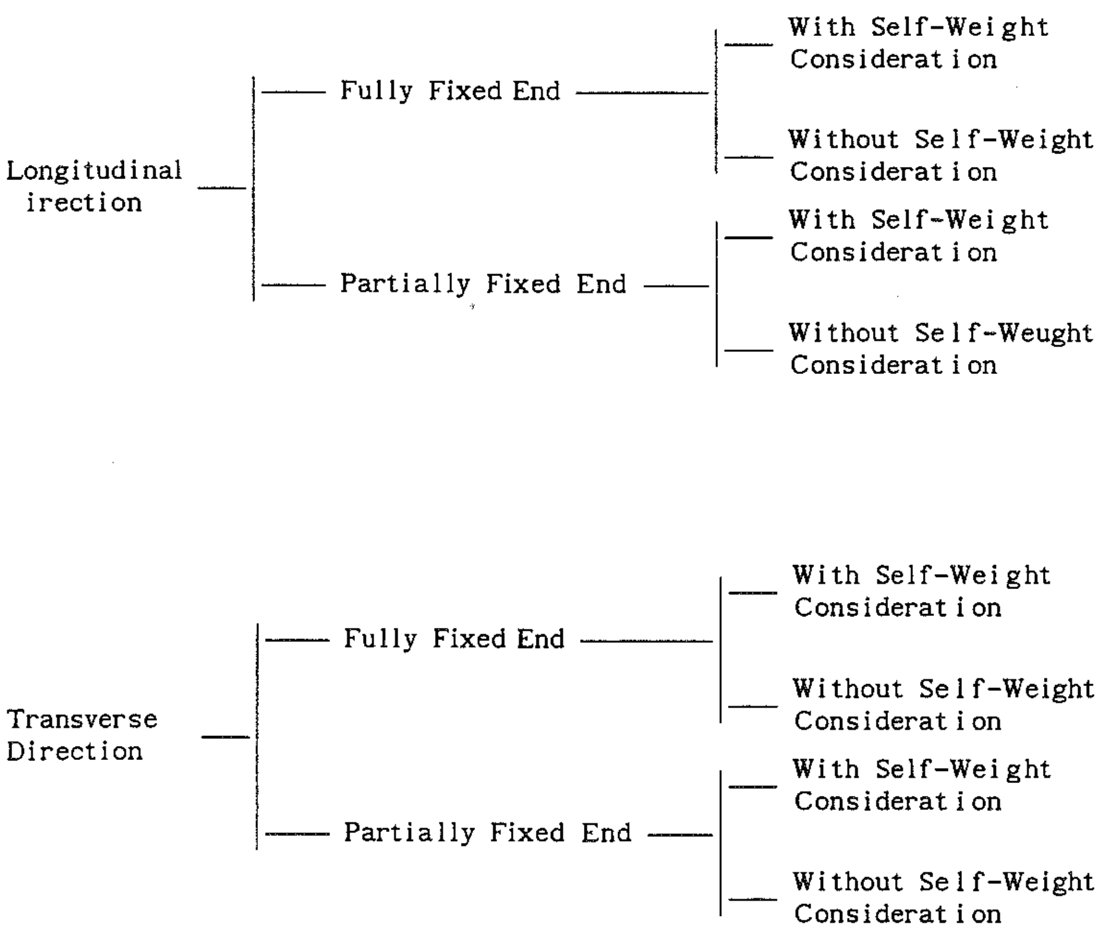
K — the stiffness of system (total static uniform force-pounds required to cause a 1-inch maximum horizontal deflection at pier top)

Two assumptions are made relative to the weight of the system. One considers the weight of pier or bent. The other does not.

a. W equals the total superstructure weight transmitted to the pier or the bent.
b. W equals the total superstructure weight transmitted to the pier or the bent plus one-half of the pier or bent weight

MAXIMUM DISPLACEMENT AT PIER OR BENT TOP

As described previously, natural period for each pier or bent was computed for a combination of eight cases. The combinations are summarized in the following diagram. Based upon the pseudo-velocity and pseudo-displacement response spectra of a numerically simulated earthquake and the natural period of the pier or bent, the displacements at the pier or bent top may be computed for eight cases. These cases include two directions, two fixity assumptions, self-weight considerations, and their combinations. The largest displacement among the eight is chosen as the maximum displacement and is used to judge failure of the component and/or structure.



The maximum seismic moments and shear forces may be computed using the maximum dynamic displacement by the following equations:

For the longitudinal direction:

(including transverse direction of single column pier)

$$M_{x\ max} = \frac{3\ E\ I_{ll}}{L^2} D_{x\ max}$$

$$V_{x\ max} = \frac{3\ E\ I_{ll}}{L^3} D_{x\ max}$$

For the transverse direction:

$$M_{y\ max} = \frac{6\ E\ I_{lt}}{L^2} D_{y\ max}$$

$$V_{y\ max} = \frac{12\ E\ I_{lt}}{L^3} D_{y\ max}$$

Total maximum seismic moments and shear forces:

$$M_{max} = (M^2_{x\ max} + M^2_{y\ max})^{1/2}$$

$$V_{max} = (V^2_{x\ max} + V^2_{y\ max})^{1/2}$$

where,

$M_{x\ max}$ — maximum seismic column moment in the longitudinal direction,

$V_{x\ max}$ — maximum seismic column shear force in the longitudinal direction,

M_{ymax} — maximum seismic column moment in the transverse direction,

$V_{y\ max}$ — maximum seismic column shear force in the transverse direction,

M_{max} — total maximum seismic moment in the column,

V_{max} — total maximum seismic shear force in the column,

E — modulus of elasticity of pier or bent material,

I_{ll} — moment of inertia of individual column or pile in the longitudinal direction,

I_{lt} — moment of inertia of individual column or pile in the transverse direction,

L — height of pier column or bent pile, and

D_{max} — maximum dynamic deflection at pier top.

The maximum flexural capacity and shear capacity of a pier column, M_{fsc} and V_{ssc} may be determined by the reinforced concrete structure theory or steel structure theory based upon the material properties and geometry properties of the column.

A flow chart of the procedures using the pier and bent analysis is shown in Figure 13.

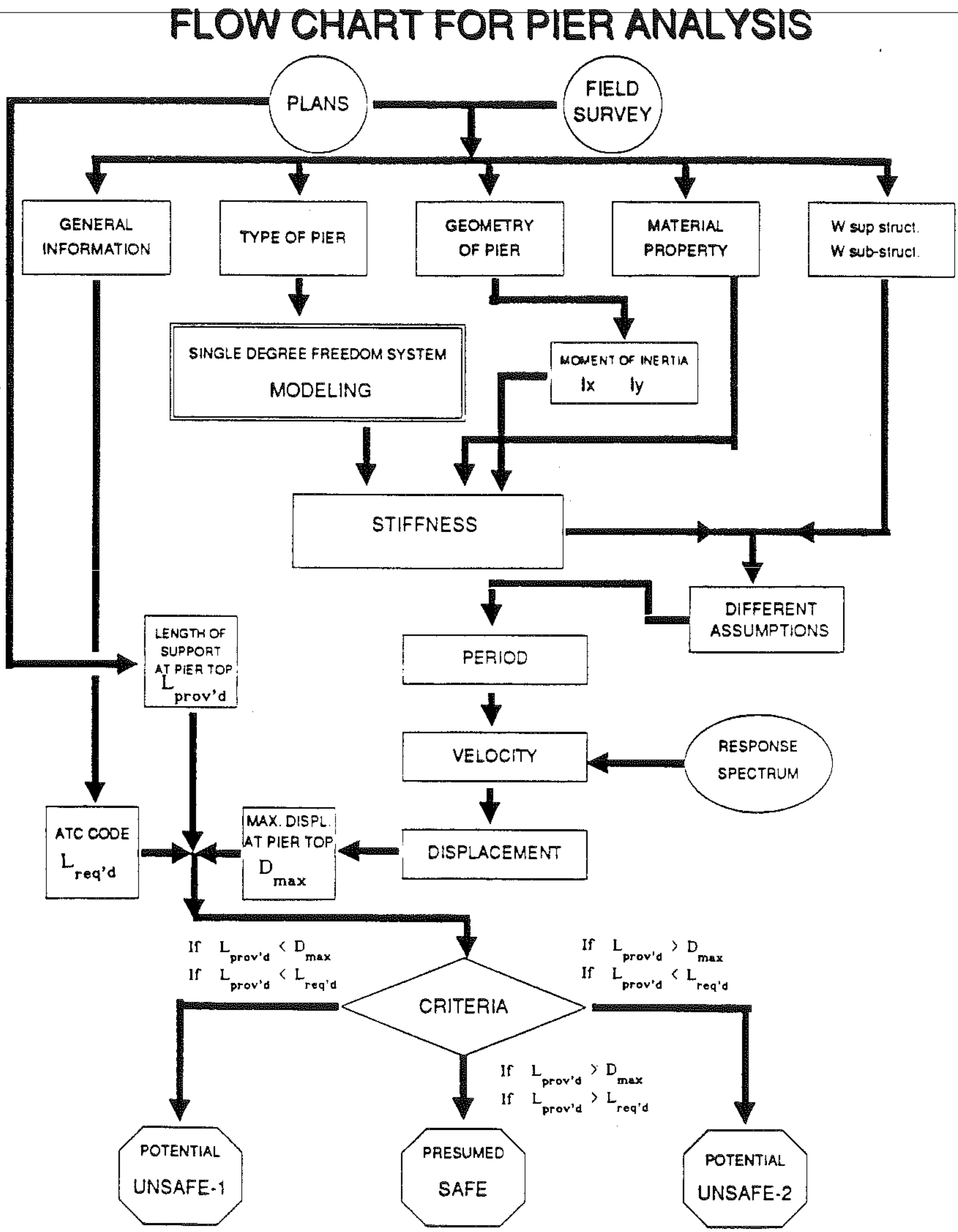


Figure 13. Flow Chart for Pier/Bent Analysis

SUMMARY

A span-loss type of bridge collapse due to an earthquake induced pier or bent vibration has been formulated.

If maximum dynamic displacement at the pier or bent top is greater than the length of support for the superstructure, a span-loss type of collapse will occur.

If the maximum dynamic moment in a pier column exceeds the maximum flexural capacity of the column, it may also lead to collapse of the pier and cause collapse of the superstructure which is supported on the pier.

Earthquake response spectra can be obtained from either the recorded earthquake motions or from numerically simulated earthquake motions. One response spectrum based on a numerically simulated large New Madrid Earthquake in Western Kentucky has been chosen as the analysis response spectrum for the calculation of the maximum dynamic displacement and maximum dynamic moment in the pier or bent column.

The single degree of freedom system theory has been applied to estimate the dynamic response of the pier or bent to a possible earthquake. The various structural models are discussed and a simple procedure to determine the maximum dynamic displacement and maximum dynamic moment are presented.

The analysis is employed to estimate the potential earthquake damages to 276 bridges on the priority routes in Western Kentucky.

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[3] Building Seismic Safety Council, " **Guide To Application Of The HEHRP Recommended Provisions In Earthquake-Resistant Building Design"**, 1987

[4]. Herrmann, R.B. and Jost, M. **"Simulation of Long Period Ground Motions for a Large New Madrid Earthquake"**, *in* Cassaro, M.A. and Cooper, J.D., Editors, Seismic Design and Construction of Complex Civil Engineering System, ASCE New York, pp 1-15, 1988

[5]. Jost, M.L. and Herrmann, R.B. **"Numerical Simulation of Ground Motions at 3 Sites in Western Kentucky for a Large and a Medium Size New Madrid Earthquake"**, private communication, 1988

[6]. Harik, I.E., **"Calculation Sheet for Pier No.3 of Eggners Ferry Bridge"**, private communication, 1989

[7]. AASHTO, **"Standard Specifications for Highway Bridges"**, The American Association of State Highway and Transportation Officials, 1983

APPENDIX C

RESULTS OF SEISMIC RATING

RESULTS OF SEISMIC RATING (SEISRATE)

---------- GENERAL INFORMATION ----------						-- IR --	-- SEISMICITY RATING --			------ VULNERABILITY RATING ------				---------- CONDITION RATING ----------					SEISMIC RATING
COUNTY	ROUTE	TB	MILE POST	No.OF SPANS	SPC	IR	ACR	LSLR	SR	VRB	VRCPF	VRA	VR	CRS	CRA	CRC	CRP	CR	
BALLARD	KY121		0.00	21	D	10	10	10	10	2	0	10	10	10	0	10	5	6.25	92.5
BALLARD	KY121		3.15	9	D	10	10	10	10	2	0	10	10	10	0	10	5	6.25	92.5
BALLARD	KY121		5.30	3	D	10	10	10	10	2	0	10	10	10	0	10	5	6.25	92.5
BALLARD	US60		1.94	2	D	10	10	10	10	2	5.3451	10	10	10	10	10	5	8.75	97.5
BALLARD	US60		2.50	2	D	10	10	10	10	2	10	5	10	10	0	10	5	6.25	92.5
BALLARD	US60		3.93	1	D	10	10	10	10	2	0	10	10	0	10	0	5	3.75	87.5
BALLARD	US60		5.32	1	D	10	10	10	10	2	0	10	10	0	0	0	5	1.25	82.5
BALLARD	US60		5.74	1	D	10	10	10	10	2	0	10	10	0	10	0	0	2.5	85
BALLARD	US60		10.23	1	D	10	10	10	10	2	0	10	10	0	0	0	5	1.25	82.5
BALLARD	US60		11.51	3	D	10	10	10	10	2	0	10	10	10	0	10	5	6.25	92.5
BALLARD	US60		11.81	3	D	10	10	10	10	2	0	10	10	10	10	0	0	5	90
BUTLER	US231		4.63	5	B	10	4	5	4.5	2	0	0	2	10	0	10	5	6.25	46.5
BUTLER	US231		8.00	1	B	10	4	5	4.5	2	0	0	2	0	0	0	5	1.25	36.5
BUTLER	US231	TB	8.8	2	B	10	4	5	4.5	2	0	0	2	10	10	0	5	6.25	46.5
BUTLER	US231		9.92	1	B	10	4	5	4.5	2	0	0	2	0	0	0	5	1.25	36.5
BUTLER	US231		12.26	10	B	10	4	5	4.5	10	0	0	10	10	0	10	5	6.25	70.5
BUTLER	US231		16.32	6	B	10	4	5	4.5	2	0	0	2	10	0	10	5	6.25	46.5
BUTLER	US231		17.11	5	B	10	4	5	4.5	2	0	0	2	10	0	10	5	6.25	46.5
BUTLER	US231		17.76	2	A	10	4	0	2	10	0	0	10	10	10	0	5	6.25	60.5
CALDWELL	KY672		14.08	4	C	9	7	8	7.5	2	0	5	5	10	0	10	5	6.25	66.5
CALDWELL	KY91		7.79	1	C	10	7	8	7.5	2	0	5	5	0	0	0	5	1.25	57.5
CALDWELL	KY91		12.24	4	B	10	7	5	6	5	0	0	5	10	10	0	5	6.25	61.5
CALDWELL	KY91		13.91	1	B	10	7	5	6	0	0	0	0	0	0	0	0	0	34
CALDWELL	KY91		14.57	1	C	10	7	8	7.5	2	0	0	2	0	10	0	5	3.75	53.5
CALDWELL	US62		18.38	1	B	10	7	5	6	10	0	0	10	0	0	0	5	1.25	66.5
CALDWELL	US641		1.43	1	B	10	7	5	6	2	0	0	2	0	0	0	5	1.25	42.5
CALDWELL	US641		4.62	1	C	10	7	8	7.5	2	0	10	10	0	10	10	5	6.25	82.5
CALLOWAY	KY121		21.57	8	C	10	7	8	7.5	2	0	10	10	10	10	10	5	8.75	87.5
CALLOWAY	KY94		1.77	1	C	9	7	8	7.5	2	0	5	5	0	0	0	5	1.25	56.5
CALLOWAY	KY94		5.15	1	C	9	7	8	7.5	2	0	5	5	0	0	0	5	1.25	56.5
CALLOWAY	KY94		6.44	1	C	9	7	8	7.5	2	0	5	5	0	0	0	5	1.25	56.5
CALLOWAY	KY94		11.07	4	C	9	7	8	7.5	2	0	10	10	10	10	10	5	8.75	86.5
CALLOWAY	KY94		11.30	5	C	9	7	8	7.5	2	0	10	10	10	0	10	5	6.25	81.5
CALLOWAY	KY94		11.44	4	C	9	7	8	7.5	2	0	10	10	10	10	10	5	8.75	86.5
CALLOWAY	KY94		16.49	1	C	9	7	8	7.5	2	0	5	5	0	0	0	5	1.25	56.5
CALLOWAY	KY94		17.10	2	C	9	7	8	7.5	2	0	5	5	10	0	0	5	3.75	61.5
CALLOWAY	KY94		23.03	3	C	9	7	8	7.5	2	0	0	2	10	0	10	5	6.25	57.5
CALLOWAY	US641		1.15	4	C	10	7	8	7.5	2	0	10	10	10	0	10	5	6.25	82.5
CALLOWAY	US641		5.49	1	C	10	7	8	7.5	2	0	5	5	0	0	0	5	1.25	57.5
CALLOWAY	US641		5.66	3	C	10	7	8	7.5	2	0	10	10	10	10	0	5	6.25	82.5
CALLOWAY	US641		8.92	3	C	10	7	8	7.5	2	0	5	5	10	0	10	5	6.25	67.5
CALLOWAY	US641	TB	15.65	3	C	10	7	8	7.5	2	0	5	5	10	10	10	5	8.75	72.5
CALLOWAY	US641	TB	15.81	3	C	10	7	8	7.5	2	0	10	10	10	5	10	5	7.5	85
CARLISLE	KY121		9.10	1	D	9	10	10	10	2	0	10	10	0	0	0	5	1.25	81.5
CARLISLE	KY121		9.38	5	D	9	10	10	10	2	0	10	10	10	10	10	5	8.75	96.5
CARLISLE	US62		3.88	3	D	8	10	10	10	2	7.75	10	10	10	0	10	5	6.25	90.5
CARLISLE	US62		6.04	1	D	8	10	10	10	2	0	10	10	0	0	0	5	1.25	80.5

RESULTS OF SEISMIC RATING (SEISRATE)

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COUNTY	ROUTE	TB	MILE POST	No.OF SPANS	SPC	IR	ACR	LSLR	SR	VRB	VRCPF	VRA	VR	CRS	CRA	CRC	CRP	CR	
CHRISTIAN	KY91		2.16	1	A	10	6	0	3	2	0	0	2	0	0	0	5	1.25	30.5
CHRISTIAN	KY91		4.43	3	B	10	6	5	5.5	2	0	0	2	10	0	10	5	6.25	50.5
CHRISTIAN	KY91		11.26	2	B	10	6	5	5.5	2	0	0	2	10	0	10	5	6.25	50.5
CHRISTIAN	KY91		13.07	2	B	10	6	5	5.5	2	0	0	2	10	0	10	5	6.25	50.5
CHRISTIAN	US41		15.33	3	A	10	6	0	3	2	0	0	2	10	10	0	5	6.25	40.5
CHRISTIAN	US41		29.51	2	B	10	6	5	5.5	2	0	0	2	10	10	10	10	10	58
CHRISTIAN	US41		30.88	5	B	10	6	5	5.5	2	0	0	2	10	10	10	5	8.75	55.5
CHRISTIAN	US41A	TB	4.43	2	A	10	6	0	3	2	0	0	2	10	10	10	5	8.75	45.5
CHRISTIAN	US41A		8.74	3	A	10	6	0	3	2	0	0	2	10	10	10	5	8.75	45.5
CHRISTIAN	US41A		8.74	2	A	10	6	0	3	2	0	0	2	10	10	10	5	8.75	45.5
CHRISTIAN	US41A	TB	10.87	2	B	10	6	5	5.5	2	0	0	2	10	10	10	5	8.75	55.5
CHRISTIAN	US41A	TB	13.44	2	A	10	6	0	3	2	0	0	2	10	10	10	5	8.75	45.5
CHRISTIAN	US68/KY80		3.56	3	A	10	6	0	3	2	0	0	2	10	0	10	5	6.25	40.5
CHRISTIAN	US68/KY80		4.68	3	A	10	6	0	3	2	0	0	2	10	0	10	5	6.25	40.5
CHRISTIAN	US68/KY80		10.76	3	A	10	6	0	3	2	0	0	2	10	0	10	5	6.25	40.5
CHRISTIAN	US68/KY80		11.20	2	A	10	6	0	3	2	0	0	2	10	5	10	5	7.5	43
CHRISTIAN	US68/KY80		18.16	3	B	10	6	5	5.5	2	0	0	2	10	0	10	5	6.25	50.5
CRITTENDEN	US60		8.37	1	B	10	7	5	6	2	0	0	2	0	0	0	5	1.25	42.5
CRITTENDEN	US60		10.76	1	B	10	7	5	6	2	0	0	2	0	0	0	5	1.25	42.5
CRITTENDEN	US60		12.40	1	C	10	7	8	7.5	2	0	0	2	0	0	0	0	0	46
CRITTENDEN	US60		14.69	1	C	10	7	8	7.5	2	0	5	5	0	0	0	5	1.25	57.5
CRITTENDEN	US60		15.79	1	C	10	7	8	7.5	0	0	0	0	0	0	0	0	0	40
CRITTENDEN	US60		17.22	1	C	10	7	8	7.5	0	0	0	0	0	0	0	0	0	40
CRITTENDEN	US60		20.32	1	C	10	7	8	7.5	2	0	5	5	0	0	0	0	0	55
CRITTENDEN	US60		22.99	3	C	10	7	8	7.5	2	0	10	10	10	10	10	5	8.75	87.5
CRITTENDEN	US641		5.36	1	C	10	7	8	7.5	2	0	0	2	0	0	0	5	1.25	48.5
DAVIESS	KY1554		0.90	2	B	10	5	5	5	2	0	0	2	10	5	0	5	5	46
DAVIESS	KY1554		1.42	3	B	10	5	5	5	2	0	0	2	10	10	10	5	8.75	53.5
DAVIESS	US231		3.76	5	B	10	5	5	5	2	0	0	2	10	0	10	5	6.25	48.5
DAVIESS	US231		3.91	5	B	10	5	5	5	2	0	0	2	10	5	10	5	7.5	51
DAVIESS	US231		4.03	5	B	10	5	5	5	2	0	0	2	10	0	10	5	6.25	48.5
DAVIESS	US231		4.18	5	B	10	5	5	5	2	0	0	2	10	0	10	5	6.25	48.5
DAVIESS	US231		4.29	5	B	10	5	5	5	2	0	0	2	10	0	10	5	6.25	48.5
DAVIESS	US231		8.84	3	B	10	5	5	5	2	0	0	2	10	10	10	5	8.75	53.5
DAVIESS	US231		8.94	7	B	10	5	5	5	2	0	0	2	10	0	10	5	6.25	48.5
DAVIESS	US231		9.22	4	B	10	5	5	5	2	0	0	2	10	0	10	5	6.25	48.5
DAVIESS	US231	TB	11.29	4	B	10	5	5	5	2	0	0	2	10	5	10	5	7.5	51
FULTON	KY166		2.09	3	D	8	10	10	10	2	0	10	10	10	10	10	5	8.75	95.5
FULTON	KY166		9.03	3	D	8	10	10	10	2	0	10	10	10	0	10	5	6.25	90.5
FULTON	KY166	TB	12.71	3	D	8	10	10	10	2	5	10	10	10	10	10	5	8.75	95.5
FULTON	KY94		15.87	1	D	9	10	10	10	2	0	10	10	0	0	0	0	0	79
FULTON	KY94		17.22	1	D	9	10	10	10	2	0	10	10	0	0	0	0	0	79
FULTON	KY94		17.85	2	D	9	10	10	10	2	10	10	10	10	0	10	0	5	89
FULTON	KY94		24.04	1	D	9	10	10	10	2	0	10	10	0	0	10	5	3.75	86.5
FULTON	KY94		24.22	1	D	9	10	10	10	2	0	10	10	0	0	0	5	1.25	81.5
FULTON	KY94		25.52	1	D	9	10	10	10	2	0	10	10	0	10	0	5	3.75	86.5
FULTON	US51		1.16	2	D	9	10	10	10	2	8.3125	10	10	10	5	0	5	5	89

RESULTS OF SEISMIC RATING (SEISRATE)

---------- GENERAL INFORMATION ----------						-- IR --	-- SEISMICITY RATING --			------ VULNERABILITY RATING ------				---------- CONDITION RATING ----------					SEISMIC RATING
COUNTY	ROUTE	TB	MILE POST	No.OF SPANS	SPC	IR	ACR	LSLR	SR	VRB	VRCPF	VRA	VR	CRS	CRA	CRC	CRP	CR	
GRAVES	KY121		7.96	7	C	10	9	8	8.5	2	0	5	5	10	10	10	5	8.75	76.5
GRAVES	KY121		8.14	4	C	10	9	8	8.5	2	0	5	5	10	0	10	5	6.25	71.5
GRAVES	KY121		8.27	6	C	10	9	8	8.5	2	0	5	5	10	0	10	5	6.25	71.5
GRAVES	KY121		8.75	2	C	10	9	8	8.5	2	0	5	5	10	0	10	5	6.25	71.5
GRAVES	KY121		11.73	4	C	10	9	8	8.5	2	0	10	10	10	5	10	5	7.5	89
GRAVES	KY121		20.19	5	C	10	9	8	8.5	2	0	5	5	10	5	10	5	7.5	74
GRAVES	KY58		0.51	3	C	9	9	8	8.5	2	0	5	5	10	0	10	10	7.5	73
GRAVES	KY58		2.83	2	C	9	9	8	8.5	2	0	5	5	10	0	10	5	6.25	70.5
GRAVES	KY58		5.27	2	C	9	9	8	8.5	2	0	10	10	10	10	0	5	6.25	85.5
GRAVES	KY58		7.90	1	C	9	9	8	8.5	2	0	5	5	0	0	0	5	1.25	60.5
GRAVES	KY58/KY80		6.68	3	C	10	9	8	8.5	2	0	5	5	10	0	10	5	6.25	71.5
GRAVES	KY58/KY80		12.25	3	C	10	9	8	8.5	2	0	5	5	10	0	10	5	6.25	71.5
GRAVES	KY58/KY80		12.44	1	C	10	9	8	8.5	2	0	5	5	0	0	0	5	1.25	61.5
GRAVES	KY94		0.20	1	C	9	9	8	8.5	2	0	5	5	0	0	0	5	1.25	60.5
GRAVES	KY94		2.00	4	C	9	9	8	8.5	2	0	5	5	10	10	10	5	8.75	75.5
GRAVES	KY94		2.9	1	C	9	9	8	8.5	10	0	5	10	0	0	0	0	0	73
GRAVES	KY94	TB	2.96	3	C	9	9	8	8.5	2	0	5	5	10	0	10	5	6.25	70.5
GRAVES	US45		1.68	3	C	10	9	8	8.5	2	0	5	5	10	0	10	5	6.25	71.5
GRAVES	US45		1.80	1	C	10	9	8	8.5	2	0	5	5	0	0	0	5	1.25	61.5
GRAVES	US45		6.09	1	C	10	9	8	8.5	2	0	0	2	0	0	0	0	0	50
GRAVES	US45		7.8	1	C	10	9	8	8.5	2	0	5	5	0	0	10	5	3.75	66.5
GRAVES	US45		7.86	1	C	10	9	8	8.5	2	0	5	5	0	0	10	5	3.75	66.5
GRAVES	US45		17.80	3	C	10	9	8	8.5	2	0	10	10	10	10	10	5	8.75	91.5
GRAVES	US45		17.86	3	C	10	9	8	8.5	2	0	5	5	10	10	10	10	10	79
GRAVES	US45/KY58		10.54	4	C	10	9	8	8.5	2	0	10	10	10	10	10	10	10	94
GRAVES	US45/KY58		12.20	3	C	10	9	8	8.5	2	0	5	5	10	0	10	5	6.25	71.5
GRAVES	US45/KY58		13.10	1	C	10	9	8	8.5	2	0	5	5	0	10	0	5	3.75	66.5
HENDERSON	A-PKY		15.78	4	C	10	6	8	7	10	0	10	10	10	0	10	5	6.25	80.5
HENDERSON	KY351	TB	1.40	3	C	10	6	8	7	2	0	5	5	10	5	10	5	7.5	68
HENDERSON	KY351		8.59	4	C	10	6	8	7	2	0	5	5	10	10	10	5	8.75	70.5
HENDERSON	KY416		16.88	2	C	10	6	8	7	2	0	10	10	10	5	0	5	5	78
HENDERSON	US41		0.65	3	C	10	6	8	7	2	0	5	5	10	0	10	5	6.25	65.5
HENDERSON	US41		6.20	3	C	10	6	8	7	2	0	5	5	10	10	10	5	8.75	70.5
HENDERSON	US41		6.32	3	C	10	6	8	7	2	0	5	5	10	0	10	5	6.25	65.5
HENDERSON	US41		11.27	3	C	10	6	8	7	2	0	5	5	10	0	10	5	6.25	65.5
HENDERSON	US41		12.65	3	C	10	6	8	7	2	0	5	5	10	10	10	5	8.75	70.5
HENDERSON	US60		0.01	13	C	10	6	8	7	2	0	5	5	10	10	10	5	8.75	70.5
HENDERSON	US60		0.01	1	C	10	6	8	7	2	0	5	5	0	10	0	5	3.75	60.5
HENDERSON	US60		10.00	3	C	10	6	8	7	2	0	5	5	10	0	0	5	3.75	60.5
HENDERSON	US60		10.57	3	C	10	6	8	7	2	0	5	5	10	0	0	5	3.75	60.5
HENDERSON	US60		10.64	3	C	10	6	8	7	2	0	5	5	10	0	10	5	6.25	65.5
HICKMAN	KY58		19.82	5	D	9	10	10	10	2	9.76	10	10	10	0	10	5	6.25	91.5
HICKMAN	KY94		0.24	3	D	9	10	10	10	2	0	10	10	10	10	10	5	8.75	96.5
HICKMAN	KY94		2.01	2	D	9	10	10	10	2	7.25	10	10	10	10	10	5	8.75	96.5
HOPKINS	KY109		3.81	4	B	9	6	5	5.5	2	0	0	2	10	5	0	5	5	47
HOPKINS	KY109		4.50	3	B	9	6	5	5.5	2	0	0	2	10	10	10	5	8.75	54.5
HOPKINS	KY109		6.49	3	B	9	6	5	5.5	2	0	0	2	10	10	10	5	8.75	54.5

RESULTS OF SEISMIC RATING (SEISRATE)

---------- GENERAL INFORMATION ----------						-- IR --	-- SEISMICITY RATING --			------ VULNERABILITY RATING ------				---------- CONDITION RATING ----------					SEISMIC RATING
COUNTY	ROUTE	TB	MILE POST	No.OF SPANS	SPC	IR	ACR	LSLR	SR	VRB	VRCPF	VRA	VR	CRS	CRA	CRC	CRP	CR	
HOPKINS	KY109		7.24	5	C	9	6	8	7	2	0	5	5	10	10	10	5	8.75	69.5
HOPKINS	KY109		14.74	11	C	9	6	8	7	2	0	5	5	10	0	10	5	6.25	64.5
HOPKINS	KY109		16.39	5	C	9	6	8	7	2	0	5	5	10	0	10	5	6.25	64.5
HOPKINS	KY1751		1.14	3	C	9	6	8	7	2	0	0	2	10	10	10	5	8.75	60.5
HOPKINS	US41		6.13	4	C	10	6	8	7	2	0	10	10	10	10	10	5	8.75	85.5
HOPKINS	US41A		0.49	3	C	10	6	8	7	2	0	5	5	10	0	10	5	6.25	65.5
HOPKINS	US41A		0.82	3	C	10	6	8	7	2	0	5	5	10	0	10	5	6.25	65.5
HOPKINS	US41A		3.42	7	C	10	6	8	7	2	0	5	5	10	0	10	10	7.5	68
HOPKINS	US41A	TB	5.30	6	C	10	6	8	7	10	0	10	10	10	10	5	5	7.5	83
HOPKINS	US41A		6.59	9	C	10	6	8	7	2	0	5	5	10	10	10	5	8.75	70.5
HOPKINS	US41A		9.00	3	B	10	6	5	5.5	2	0	0	2	10	10	10	5	8.75	55.5
HOPKINS	US41A		12.65	1	C	10	6	8	7	2	0	5	5	0	0	0	5	1.25	55.5
HOPKINS	US41A		13.11	2	B	10	6	5	5.5	5	0	0	5	10	10	10	5	8.75	64.5
HOPKINS	US41A		15.33	6	B	10	6	5	5.5	2	0	0	2	10	10	10	5	8.75	55.5
HOPKINS	US41A		15.73	1	C	10	6	8	7	2	0	5	5	0	0	0	5	1.25	55.5
HOPKINS	US62		0.23	3	B	10	6	5	5.5	2	0	0	2	10	0	10	5	6.25	50.5
LIVINGSTON	US60		12.37	15	C	10	8	8	8	10	0	5	10	10	0	10	10	7.5	87
LIVINGSTON	US60		16.66	1	C	10	8	8	8	2	0	8	8	0	0	0	5	1.25	68.5
LIVINGSTON	US60		21.31	1	C	10	8	8	8	2	0	0	2	0	0	0	5	1.25	50.5
LIVINGSTON	US60		25.98	1	C	10	8	8	8	2	0	0	2	0	0	0	5	1.25	50.5
LIVINGSTON	US60		29.06	1	B	10	8	5	6.5	0	0	0	0	0	0	0	0	0	36
LIVINGSTON	US62/US641		0.31	3	C	10	8	8	8	0	0	0	0	10	0	0	5	3.75	49.5
LIVINGSTON	US62/US641		0.64	10	C	10	8	8	8	2	0	5	5	10	10	10	5	8.75	74.5
LIVINGSTON	US62/US641		0.97	3	C	10	8	8	8	5	0	10	10	10	10	10	5	8.75	89.5
LIVINGSTON	US62/US641		2.78	12	C	10	8	8	8	10	0	10	10	10	0	10	5	6.25	84.5
LIVINGSTON	US62/US641	TB	1.20	3	C	10	8	8	8	2	0	5	5	10	10	10	5	8.75	74.5
LOGAN	US431		20.31	3	B	8	5	5	5	2	0	0	2	10	10	10	5	8.75	51.5
LOGAN	US431		27.41	5	B	8	5	5	5	2	0	0	2	10	0	10	5	6.25	46.5
LOGAN	US431		27.73	3	B	8	5	5	5	2	0	0	2	10	0	10	5	6.25	46.5
LOGAN	US431		28.91	2	B	8	5	5	5	2	0	0	2	10	0	10	5	6.25	46.5
LOGAN	US68/KY80		2.80	2	A	10	5	0	2.5	2	0	0	2	10	0	10	5	6.25	36.5
LOGAN	US68/KY80		9.64	7	A	10	5	0	2.5	2	0	0	2	10	10	10	5	8.75	43.5
LOGAN	US68/KY80		10.38	1	B	10	5	5	5	2	0	0	2	0	0	0	5	1.25	38.5
LOGAN	US68/KY80		20.94	2	B	10	5	5	5	2	0	0	2	10	10	10	5	8.75	53.5
LOGAN	US68/KY80		21.91	3	A	10	5	0	2.5	10	0	0	10	10	10	0	5	6.25	62.5
LOGAN	US79		2.91	3	A	9	5	0	2.5	2	0	0	2	10	10	10	5	8.75	42.5
LOGAN	US79		4.64	3	A	9	5	0	2.5	2	0	0	2	10	0	10	5	6.25	37.5
LOGAN	US79		5.93	2	A	9	5	0	2.5	2	0	0	2	10	0	10	5	6.25	37.5
LOGAN	US79		9.43	1	B	9	5	5	5	2	0	0	2	0	0	0	5	1.25	37.5
LYON	US62		11.60	3	B	10	7	5	6	2	0	0	2	10	10	10	5	8.75	57.5
LYON	US62	TB	12.20	4	C	10	7	8	7.5	2	0	10	10	10	10	10	5	8.75	87.5
LYON	US62/US641		2.78	12	C	10	7	8	7.5	10	0	5	10	10	10	10	5	8.75	87.5
LYON	US62/US641		3.65	4	C	10	7	8	7.5	2	0	5	5	10	10	10	5	8.75	72.5
LYON	US62/US641	TB	39.51	4	C	10	7	8	7.5	10	0	10	10	10	10	0	5	6.25	82.5
MARSHALL	KY408		8.10	1	C	10	8	8	8	2	0	5	5	0	10	0	5	3.75	64.5
MARSHALL	KY408		8.82	3	C	10	8	8	8	2	0	5	5	10	10	10	5	8.75	74.5
MARSHALL	KY408		8.92	3	C	10	8	8	8	2	0	5	5	10	10	10	5	8.75	74.5

RESULTS OF SEISMIC RATING (SEISRATE)

---------- GENERAL INFORMATION ----------						-- IR --	-- SEISMICITY RATING --			------ VULNERABILITY RATING ------				---------- CONDITION RATING ----------					SEISMIC RATING
COUNTY	ROUTE	TB	MILE POST	No.OF SPANS	SPC	IR	ACR	LSLR	SR	VRB	VRCPF	VRA	VR	CRS	CRA	CRC	CRP	CR	
MARSHALL	KY408		9.34	5	C	10	8	8	8	2	0	5	5	10	0	10	5	6.25	69.5
MARSHALL	KY408		9.73	21	C	10	8	8	8	2	0	5	5	10	0	10	5	6.25	69.5
MARSHALL	KY408		10.87	1	C	10	8	8	8	2	0	5	5	0	0	0	5	1.25	59.5
MARSHALL	KY58/KY80		1.12	3	C	10	8	8	8	2	0	5	5	10	0	10	5	6.25	69.5
MARSHALL	KY80		8.72	2	C	10	8	8	8	2	0	5	5	10	0	10	5	6.25	69.5
MARSHALL	KY80		9.67	10	C	10	8	8	8	2	0	5	5	10	0	10	5	6.25	69.5
MARSHALL	KY80		9.86	17	C	10	8	8	8	10	0	5	10	10	0	10	5	6.25	84.5
MARSHALL	KY80		12.52	7	C	10	8	8	8	2	0	10	10	10	0	10	10	7.5	87
MARSHALL	KY80		15.06	1	C	10	8	8	8	2	0	5	5	0	0	0	5	1.25	59.5
MARSHALL	US62		2.47	4	C	10	8	8	8	2	0	5	5	10	10	10	5	8.75	74.5
MARSHALL	US62	TB	8.81	2	C	10	8	8	8	2	0	5	5	10	10	10	5	8.75	74.5
MARSHALL	US62		9.48	5	C	10	8	8	8	2	0	5	5	10	0	0	5	3.75	64.5
MARSHALL	US62		10.87	3	C	10	8	8	8	2	0	5	5	10	10	10	5	8.75	74.5
MARSHALL	US62		11.94	30	C	10	8	8	8	2	0	5	5	10	10	10	5	8.75	74.5
MARSHALL	US641	TB	0.24	3	C	10	8	8	8	2	0	10	10	10	10	10	5	8.75	89.5
MARSHALL	US641	TB	7.94	1	C	10	8	8	8	2	0	5	5	0	5	0	5	2.5	62
MARSHALL	US641		9.40	3	C	10	8	8	8	2	0	5	5	10	0	0	0	2.5	62
MARSHALL	US641		9.83	4	C	10	8	8	8	2	0	5	5	10	10	10	0	7.5	72
MARSHALL	US641		9.87	4	C	10	8	8	8	0	0	5	5	10	0	0	0	2.5	62
MARSHALL	US68	TB	9.43	2	C	10	8	8	8	2	0	5	5	10	5	10	5	7.5	72
MARSHALL	US68		22.48	5	C	10	8	8	8	2	0	5	5	10	0	10	5	6.25	69.5
MARSHALL	US68/KY80		27.8	27	C	10	8	8	8	10	0	10	10	10	10	10	5	8.75	89.5
McCRACKEN	US60		4.10	1	C	10	9	8	8.5	2	0	5	5	0	0	0	5	1.25	61.5
McCRACKEN	US60		4.96	1	C	10	9	8	8.5	2	0	5	5	0	0	0	5	1.25	61.5
McCRACKEN	US60		6.69	3	C	10	9	8	8.5	2	0	5	5	10	0	10	5	6.25	71.5
McCRACKEN	US60		8.30	5	C	10	9	8	8.5	2	0	5	5	10	0	10	5	6.25	71.5
McCRACKEN	US60	TB	10.80	3	C	10	9	8	8.5	2	0	10	10	10	5	10	5	7.5	89
McCRACKEN	US60		11.09	3	C	10	9	8	8.5	2	0	5	5	10	0	0	5	3.75	66.5
McCRACKEN	US60		11.76	3	C	10	9	8	8.5	2	0	10	10	10	10	0	5	6.25	86.5
McCRACKEN	US60		18.64	4	C	10	9	8	8.5	10	0	10	10	10	0	10	5	6.25	86.5
McCRACKEN	US60		19.86	24	C	10	9	8	8.5	2	0	5	5	10	0	10	5	6.25	71.5
McCRACKEN	US62	TB	12.95	3	C	10	9	8	8.5	2	0	0	2	10	10	10	5	8.75	67.5
McCRACKEN	US62		13.06	5	C	10	9	8	8.5	2	0	10	10	10	10	10	5	8.75	91.5
McCRACKEN	US62	TB	13.06	5	C	10	9	8	8.5	2	0	10	10	10	10	10	5	8.75	91.5
McCRACKEN	US62		13.91	3	C	10	9	8	8.5	2	0	5	5	10	10	10	5	8.75	76.5
McCRACKEN	US62		12.98	5	C	10	9	8	8.5	2	0	5	5	10	10	10	5	8.75	76.5
McCRACKEN	US68	TB	1.01	2	C	10	9	8	8.5	2	0	5	5	10	0	10	5	6.25	71.5
McLEAN	KY136		17.13	1	B	8	5	5	5	2	0	0	2	0	0	0	5	1.25	36.5
McLEAN	KY136		19.17	3	B	8	5	5	5	2	0	0	2	10	0	10	5	6.25	46.5
McLEAN	KY136		20.88	7	B	8	5	5	5	2	0	0	2	10	10	10	5	8.75	51.5
MUHLENBERG	KY176		4.29	9	B	8	5	5	5	2	0	0	2	10	0	10	5	6.25	46.5
MUHLENBERG	KY176		6.6	1	A	8	5	0	2.5	0	0	0	0	0	0	0	0	0	18
MUHLENBERG	US431		3.45	7	B	8	5	5	5	2	0	0	2	10	0	10	5	6.25	46.5
MUHLENBERG	US431		3.63	1	B	8	5	5	5	2	0	0	2	0	0	0	5	1.25	36.5
MUHLENBERG	US431		12.45	7	B	8	5	5	5	2	0	0	2	10	0	10	5	6.25	46.5
MUHLENBERG	US431		13.31	1	B	8	5	5	5	2	0	0	2	0	0	0	0	0	34
MUHLENBERG	US431		17.48	4	A	8	5	0	2.5	5	0	0	5	10	10	0	5	6.25	45.5

RESULTS OF SEISMIC RATING (SEISRATE)

---------- GENERAL INFORMATION ----------						-- IR --	-- SEISMICITY RATING --			------ VULNERABILITY RATING ------				---------- CONDITION RATING ----------					SEISMIC RATING
COUNTY	ROUTE	TB	MILE POST	No.OF SPANS	SPC	IR	ACR	LSLR	SR	VRB	VRCPF	VRA	VR	CRS	CRA	CRC	CRP	CR	
OHIO	KY136		1.06	4	B	8	4	5	4.5	2	0	0	2	10	0	10	5	6.25	44.5
OHIO	KY136		3.34	5	B	8	4	5	4.5	2	0	0	2	10	0	10	5	6.25	44.5
OHIO	KY136		5.67	2	B	8	4	5	4.5	2	0	0	2	10	0	10	5	6.25	44.5
OHIO	KY136		6.01	1	B	8	4	5	4.5	2	0	0	2	0	0	0	5	1.25	34.5
OHIO	US231	TB	6.70	3	B	10	4	5	4.5	2	0	0	2	10	5	10	5	7.5	49
OHIO	US231		11.46	4	B	10	4	5	4.5	2	0	0	2	10	10	10	5	8.75	51.5
OHIO	US231		11.95	4	B	10	4	5	4.5	2	0	0	2	10	0	10	5	6.25	46.5
OHIO	US231		12.30	1	B	10	4	5	4.5	2	0	0	2	0	10	0	5	3.75	41.5
OHIO	US231		13.32	3	B	10	4	5	4.5	10	0	0	10	10	0	10	5	6.25	70.5
OHIO	US231		13.49	6	B	10	4	5	4.5	2	0	0	2	10	0	10	5	6.25	46.5
OHIO	US231		13.88	6	B	10	4	5	4.5	2	0	0	2	10	0	10	5	6.25	46.5
OHIO	US231		14.12	3	B	10	4	5	4.5	0	0	0	0	10	0	0	5	3.75	35.5
OHIO	US231		15.80	3	B	10	4	5	4.5	2	0	0	2	10	0	10	5	6.25	46.5
OHIO	US231		20.30	4	B	10	4	5	4.5	2	0	0	2	10	0	10	5	6.25	46.5
TODD	US68/KY80		1.55	1	B	10	5	5	5	2	0	0	2	0	0	0	5	1.25	38.5
TODD	US68/KY80		3.15	1	A	10	5	0	2.5	2	0	0	2	0	0	0	5	1.25	28.5
TODD	US68/KY80		9.10	2	B	10	5	5	5	2	0	0	2	10	0	10	5	6.25	48.5
TODD	US79		1.95	3	A	9	5	0	2.5	2	0	0	2	10	0	10	5	6.25	37.5
TODD	US79		7.61	4	A	9	5	0	2.5	2	0	0	2	10	10	10	5	8.75	42.5
TRIGG	US68/KY80		3.11	3	C	10	7	8	7.5	2	0	5	5	10	10	10	5	8.75	72.5
TRIGG	US68/KY80	TB	8.27	32	C	10	7	8	7.5	10	0	5	10	10	10	10	5	8.75	87.5
TRIGG	US68/KY80		10.94	3	C	10	7	8	7.5	2	0	5	5	10	10	10	5	8.75	72.5
TRIGG	US68/KY80		17.89	6	C	10	7	8	7.5	2	0	5	5	10	0	10	5	6.25	67.5
TRIGG	US68/KY80	TB	24.50	1	C	10	7	8	7.5	2	0	10	10	0	5	0	5	2.5	75
UNION	KY130		12.54	3	C	8	7	8	7.5	2	0	5	5	10	5	10	5	7.5	68
UNION	KY130		13.47	3	C	8	7	8	7.5	0	0	5	5	10	0	10	5	6.25	65.5
UNION	US60		3.66	3	C	10	7	8	7.5	2	0	5	5	10	10	0	5	6.25	67.5
UNION	US60		5.20	3	C	10	7	8	7.5	2	0	5	5	10	0	10	5	6.25	67.5
UNION	US60		6.48	3	C	10	7	8	7.5	2	0	5	5	10	0	10	5	6.25	67.5
UNION	US60		9.94	1	C	10	7	8	7.5	0	0	0	0	0	0	0	0	0	40
UNION	US60		13.06	3	C	10	7	8	7.5	2	0	5	5	10	10	0	5	6.25	67.5
UNION	US60		14.78	1	C	10	7	8	7.5	0	0	0	0	0	0	0	0	0	40
WARREN	US231		15.43	4	A	10	4	0	2	2	0	0	2	10	10	10	5	8.75	41.5
WARREN	US231		21.53	3	A	10	4	0	2	2	0	0	2	10	10	0	5	6.25	36.5
WARREN	US231		22.61	3	A	10	4	0	2	2	0	0	2	10	0	10	5	6.25	36.5
WARREN	US68/KY80	TB	8.2	4	A	10	4	0	2	2	0	0	2	10	10	10	5	8.75	41.5
WEBSTER	KY109		1.03	1	B	9	6	5	5.5	2	0	0	2	0	10	0	5	3.75	44.5
WEBSTER	KY109		7.33	5	C	9	6	8	7	2	0	5	5	10	0	10	5	6.25	64.5
WEBSTER	KY109		10.72	4	C	9	6	8	7	2	0	5	5	10	0	10	5	6.25	64.5
WEBSTER	US41		6.86	3	C	10	6	8	7	10	0	5	10	10	0	0	5	3.75	75.5
WEBSTER	US41		11.68	4	C	10	6	8	7	2	0	5	5	10	10	10	5	8.75	70.5

APPENDIX D

RESULTS OF SPAN-LOSS COLLAPSE ANALYSIS AND ATC ANALYSIS FOR PIER AND INTERMEDIATE BENT

PIER AND INTERMEDIATE BENT
SPAN-LOSS ANALYSIS AND ATC ANALYSIS

------ GENERAL INFORMATION ------						- PIER INFO -		- MOMNET OF INERTIA -		PIER SPAN		- MAX. DISPLACEMENT -		-- ATC --	-- PROV'D --	-- C/D RATIOS --		-- CONCLUSION --	
COUNTY	ROUTE	TB	MILE POST	No. SPAN	SPC	PIER TYPE	No. COLUNM	IX (FT-4)	IY (FT-4)	H (FT)	L (FT)	LONGIT. DXmax (IN)	TRANSV. DYmax	L.SUP.REQ (INCH)	L.SUP.PROV (INCH)	SPAN-LOSS	ATC REQ'D	SPAN-LOSS	ATC REQ'D
BALLARD	KY121		0.00	21	D	10.0	5	2.48E-01	2.48E-01	45.00	33.00	8.73	3.09	18.39	16.00	1.8325811	0.8700380	SAFE	UNSAFE-2
BALLARD	KY121		3.15	9	D	10.0	5	2.48E-01	2.48E-01	35.00	33.00	4.97	1.76	17.19	16.50	3.3228527	0.9598603	SAFE	UNSAFE-2
BALLARD	KY121		5.30	3	D	10.0	5	2.48E-01	2.48E-01	40.00	33.00	6.78	2.40	17.79	16.00	2.3593032	0.8993816	SAFE	UNSAFE-2
BALLARD	US60		1.94	2	D	4.0	4	4.00E+00	4.00E+00	18.60	75.50	2.12	0.75	16.50	20.00	9.4303088	1.2123416	SAFE	SAFE
BALLARD	US60		2.50	2	D	1.0	1	2.22E+03	2.86E+01	12.00	85.00	0.70	0.70	15.99	18.00	25.714285	1.1257035	SAFE	SAFE
BALLARD	US60		11.51	3	D	10.0	7	1.54E-01	1.54E-01	22.30	30.00	2.06	0.73	15.58	18.00	8.7302040	1.1556240	SAFE	SAFE
BALLARD	US60		11.81	3	D	10.0	9	9.10E-02	9.10E-02	32.00	70.00	11.49	4.07	17.94	18.00	1.5670089	1.0033444	SAFE	SAFE
BUTLER	US231		4.63	5	B	3.0	1	2.66E+03	5.00E+01	16.00	48.00	0.70	0.70	10.24	18.00	25.714285	1.7578125	SAFE	SAFE
BUTLER	US231	TB	8.8	2	B	2.0	9	1.92E+00	1.92E+00	22.00	154.00	5.43	1.92	12.84	18.00	3.3149244	1.4018691	SAFE	SAFE
BUTLER	US231		12.26	10	B	1.3	1	2.76E+04	2.80E+03	128.00	276.00	13.30	2.40	23.76	24.00	1.8044912	1.0101010	SAFE	SAFE
BUTLER	US231		16.32	6	B	10.0	5	2.48E-01	2.48E-01	76.00	50.25	30.86	12.84	15.09	16.00	0.5184033	1.0606562	UNSAFE-1	SAFE
BUTLER	US231		17.11	5	B	10.0	5	2.48E-01	2.48E-01	75.00	50.25	30.50	12.61	15.01	15.00	0.4917412	0.9996667	UNSAFE-1	UNSAFE-2
BUTLER	US231		17.76	2	A	2.0	7	1.90E+02	2.75E+02	16.60	145.60	0.70	0.70	12.24	12.00	17.142857	0.9803921	SAFE	UNSAFE-2
CALDWELL	KY672		14.08	4	C	10.0	5	9.10E-02	9.10E-02	38.00	38.00	12.22	4.33	17.70	18.00	1.4735106	1.0169491	SAFE	SAFE
CALDWELL	KY91		12.24	4	B	2.0	3	6.75E+00	6.75E+00	22.00	90.00	3.11	1.10	11.56	18.00	5.7953579	1.5570934	SAFE	SAFE
CALLOWAY	KY121		21.57	8	C	10.0	8	9.00E-02	9.80E-02	35.00	33.00	11.31	4.27	17.19	15.50	1.3699988	0.9016870	SAFE	UNSAFE-2
CALLOWAY	KY94		11.07	4	C	4.0	3	4.00E+00	4.00E+00	21.50	60.00	3.68	1.31	16.38	18.00	4.8847229	1.0989010	SAFE	SAFE
CALLOWAY	KY94		11.30	5	C	4.0	3	4.00E+00	4.00E+00	23.50	80.00	4.03	1.43	17.22	26.00	6.4457999	1.5098722	SAFE	SAFE
CALLOWAY	KY94		11.44	4	C	4.0	4	4.00E+00	4.00E+00	22.00	58.00	3.10	1.10	16.38	19.00	6.1299782	1.1599511	SAFE	SAFE
CALLOWAY	KY94	-	17.10	2	C	1.0	1	6.21E+03	4.04E+01	20.00	41.00	2.64	0.70	15.63	18.00	6.8226838	1.1516314	SAFE	SAFE
CALLOWAY	KY94		23.03	3	C	1.0	1	2.22E+03	2.86E+01	10.00	46.00	0.71	0.70	14.58	18.00	25.328946	1.2345679	SAFE	SAFE
CALLOWAY	US641		1.15	4	C	1.0	1	2.28E+04	1.02E+02	17.00	43.00	0.70	0.70	15.33	18.50	26.428571	1.2067640	SAFE	SAFE
CALLOWAY	US641		5.66	3	C	10.0	1	6.45E+03	2.30E+01	20.75	80.00	0.70	0.70	16.89	19.50	27.857142	1.1545293	SAFE	SAFE
CALLOWAY	US641		8.92	3	C	10.0	6	1.54E-01	1.54E-01	44.00	33.00	11.84	4.20	18.27	18.00	1.5196293	0.9852216	SAFE	UNSAFE-2
CALLOWAY	US641	TB	15.65	3	C	10.0	15	1.54E-01	1.54E-01	32.00	80.00	6.99	2.48	18.24	19.50	2.7905744	1.0690789	SAFE	SAFE
CALLOWAY	US641	TB	15.81	3	C	10.0	8	1.54E-01	1.54E-01	33.00	40.00	7.13	2.53	17.16	18.50	2.5941433	1.0780885	SAFE	SAFE
CARLISLE	KY121		9.38	5	D	10.0	7	9.10E-02	9.10E-02	37.00	48.00	14.09	4.99	17.88	14.00	0.9935828	0.7829977	UNSAFE-1	UNSAFE-2
CARLISLE	US62		3.88	3	D	4.0	2	6.75E+00	6.75E+00	37.00	43.00	4.92	1.74	17.73	18.00	3.6612530	1.0152284	SAFE	SAFE
CHRISTIAN	KY91		4.43	3	B	1.0	1	1.52E+03	6.40E+00	19.00	39.00	3.79	0.70	10.30	16.00	4.2216549	1.5533980	SAFE	SAFE
CHRISTIAN	KY91		11.26	2	B	1.0	1	4.39E+03	5.85E+01	15.00	43.00	0.70	0.70	10.06	18.00	25.714285	1.7892644	SAFE	SAFE
CHRISTIAN	KY91		13.07	2	B	1.0	1	8.19E+03	7.20E+01	20.00	30.00	0.70	0.70	10.20	18.00	25.714285	1.7647058	SAFE	SAFE
CHRISTIAN	US41		15.33	3	A	1.0	1	1.33E+04	2.86E+01	20.00	30.00	0.70	0.70	10.20	12.00	17.142857	1.1764705	SAFE	SAFE
CHRISTIAN	US41		29.51	2	B	10.0	5	4.20E-01	4.20E-01	35.00	30.00	2.95	1.05	11.40	15.00	5.0825509	1.3157894	SAFE	SAFE
CHRISTIAN	US41		30.88	5	B	2.0	3	6.75E+00	6.75E+00	31.00	48.00	1.36	0.70	11.44	17.50	12.893116	1.5297202	SAFE	SAFE
CHRISTIAN	US41A		10.87	2	B	2.0	4	3.25E+00	3.25E+00	14.00	43.00	1.01	0.70	9.98	14.00	13.819824	1.4028056	SAFE	SAFE
CHRISTIAN	US41A	TB	4.43	2	A	4.0	4	1.46E+01	1.46E+01	23.00	125.00	1.56	0.70	12.34	16.00	10.276157	1.2965964	SAFE	SAFE
CHRISTIAN	US41A		13.44	2	A	2.0	6	6.75E+00	6.75E+00	33.00	122.00	12.15	4.30	13.08	18.00	1.4820693	1.3761467	SAFE	SAFE
CHRISTIAN	US68/KY80		3.56	3	A	2.0	3	1.91E+00	1.91E+00	25.00	58.08	10.16	3.60	11.16	18.50	1.8200042	1.6574684	SAFE	SAFE
CHRISTIAN	US68/KY80		4.68	3	A	2.0	1	5.93E+03	6.00E+00	18.50	26.00	1.80	0.70	10.00	14.50	8.0356166	1.45	SAFE	SAFE
CHRISTIAN	US68/KY80		10.76	3	A	1.0	1	7.32E+03	1.49E+02	22.00	50.00	1.19	0.70	10.76	12.00	10.083049	1.1152416	SAFE	SAFE
CHRISTIAN	US68/KY80		11.20	2	A	2.0	7	9.29E+00	9.29E+00	18.00	82.00	1.37	0.70	11.08	25.00	18.287757	2.2563176	SAFE	SAFE
CHRISTIAN	US68/KY80		18.18	3	B	1.0	1	4.52E+03	1.76E+01	20.00	33.00	0.70	0.70	10.26	18.50	26.428571	1.8031189	SAFE	SAFE
CRITTENDEN	US60		22.99	3	C	2.0	2	6.59E+02	1.25E+03	55.00	90.00	0.75	0.70	21.30	28.00	37.483316	1.3145539	SAFE	SAFE
DAVIESS	KY1554		0.90	2	B	2.0	4	8.44E-01	8.44E-01	16.50	94.00	4.06	1.44	11.20	16.50	4.0630005	1.4732142	SAFE	SAFE
DAVIESS	KY1554		1.42	3	B	4.0	1	1.73E+03	9.00E+00	25.50	38.00	3.44	0.70	10.80	17.50	5.0852026	1.6203703	SAFE	SAFE
DAVIESS	US231		3.76	5	B	10.0	5	2.48E-01	2.48E-01	27.00	33.00	3.07	1.09	10.82	15.50	5.0414067	1.4325323	SAFE	SAFE
DAVIESS	US231		3.91	5	B	10.0	5	2.48E-01	2.48E-01	45.00	33.00	10.95	3.88	12.26	24.00	2.1920982	1.9575856	SAFE	SAFE
DAVIESS	US231		4.03	5	B	10.0	5	2.48E-01	2.48E-01	45.00	33.00	26.89	10.44	12.26	15.50	0.5763632	1.2642740	UNSAFE-1	SAFE
DAVIESS	US231		4.18	5	B	10.0	5	2.48E-01	2.48E-01	45.00	33.00	26.89	10.44	12.26	15.50	0.5763632	1.2642740	UNSAFE-1	SAFE
DAVIESS	US231		4.29	5	B	10.0	5	2.48E-01	2.48E-01	45.00	33.00	9.78	3.47	12.26	15.50	1.5845523	1.2642740	SAFE	SAFE

PIER AND INTERMEDIATE BENT
SPAN-LOSS ANALYSIS AND ATC ANALYSIS

------ GENERAL INFORMATION ------						- PIER INFO -		- MOMNET OF INERTIA -		PIER SPAN		- MAX. DISPLACEMENT -		-- ATC --	-- PROV'D --	-- C/D RATIOS --		-- CONCLUSION --	
COUNTY	ROUTE	TB	MILE POST	No. SPAN	SPC	PIER TYPE	No. COLUNM	IX (FT-4)	IY (FT-4)	H (FT)	L (FT)	LONGIT. DXmax (IN)	TRANSV. DYmax	L.SUP.REQ (INCH)	L.SUP.PROV (INCH)	SPAN-LOSS	ATC REQ'D	SPAN-LOSS	ATC REQ'D
DAVIESS	US231		8.84	3	B	2.0	1	4.33E+03	5.90E+01	42.00	53.00	5.57	0.70	12.42	20.00	3.5900349	1.6103059	SAFE	SAFE
DAVIESS	US231		8.94	7	B	10.0	6	2.48E-01	2.48E-01	50.00	33.00	11.89	4.21	12.66	20.00	1.6824834	1.5797768	SAFE	SAFE
DAVIESS	US231		9.22	4	B	10.0	6	2.48E-01	2.48E-01	50.00	33.00	11.30	4.00	12.66	18.00	1.5930180	1.4218009	SAFE	SAFE
DAVIESS	US231	TB	11.29	4	B	2.0	3	6.18E+00	7.75E+00	30.00	53.00	4.47	1.88	11.46	18.50	4.1381226	1.6143106	SAFE	SAFE
FULTON	KY166		2.09	3	D	10.0	5	2.50E-01	2.50E-01	40.00	33.00	7.02	2.49	17.79	17.00	2.4221544	0.9555930	SAFE	UNSAFE-2
FULTON	KY166		9.03	3	D	10.0	5	2.50E-01	2.50E-01	40.00	33.00	6.87	2.43	17.79	15.00	2.1830417	0.8431703	SAFE	UNSAFE-2
FULTON	KY166	TB	12.71	3	D	4.0	3	6.75E+00	6.75E+00	28.00	51.00	2.68	0.95	16.89	17.00	6.3349318	1.0065127	SAFE	SAFE
FULTON	KY94		17.85	2	D	3.0	1	2.68E+03	1.07E+02	19.00	72.00	0.70	0.70	16.44	18.00	25.714285	1.0948905	SAFE	SAFE
FULTON	US51		1.16	2	D	4.0	6	9.88E+00	9.88E+00	19.00	80.00	1.15	0.70	16.68	20.00	17.441512	1.1990407	SAFE	SAFE
GRAVES	KY121		7.96	7	C	10.0	5	2.50E-01	2.50E-01	32.00	43.00	5.08	1.80	17.13	14.50	2.8568640	0.8464881	SAFE	UNSAFE-2
GRAVES	KY121		8.14	4	C	10.0	5	2.50E-01	2.50E-01	30.00	33.00	3.73	1.32	16.59	15.00	4.0235575	0.9041591	SAFE	UNSAFE-2
GRAVES	KY121		8.27	6	C	10.0	5	2.50E-01	2.50E-01	30.00	33.00	3.62	1.28	16.59	14.50	4.0037590	0.8740204	SAFE	UNSAFE-2
GRAVES	KY121		8.75	2	C	1.0	1	1.07E+04	7.88E+01	11.00	25.50	0.70	0.70	14.09	18.00	25.714285	1.2779552	SAFE	SAFE
GRAVES	KY121		11.73	4	C	4.0	2	6.75E+00	6.75E+00	26.00	48.00	3.90	1.38	16.56	18.00	4.6101196	1.0869565	SAFE	SAFE
GRAVES	KY121		20.19	5	C	2.0	3	6.75E+00	6.75E+00	40.00	48.00	9.26	3.28	18.24	20.50	2.2144330	1.1239035	SAFE	SAFE
GRAVES	KY58		0.51	3	C	2.0	2	6.75E+00	6.75E+00	40.00	48.00	6.78	2.40	18.24	18.00	2.6540709	0.9868421	SAFE	UNSAFE-2
GRAVES	KY58		2.83	2	C	3.0	1	1.71E+03	1.28E+02	12.00	43.00	0.70	0.70	14.73	18.00	25.714285	1.2219959	SAFE	SAFE
GRAVES	KY58		5.27	2	C	4.0	3	9.88E+00	9.88E+00	19.00	92.87	1.67	0.70	17.07	14.00	8.4056141	0.8203397	SAFE	UNSAFE-2
GRAVES	KY58		6.68	3	C	10.0	14	1.55E-01	1.55E-01	35.00	68.75	7.35	2.60	18.26	18.00	2.4490920	0.9856262	SAFE	UNSAFE-2
GRAVES	KY58/KY80		12.25	3	C	3.0	1	2.66E+03	5.00E+01	40.00	37.00	2.88	0.70	17.91	18.00	6.2430584	1.0050251	SAFE	SAFE
GRAVES	KY94		2.00	4	C	10.0	5	4.00E-02	4.00E-02	35.00	30.25	4.99	1.77	17.11	9.50	1.9030870	0.5553119	SAFE	UNSAFE-2
GRAVES	KY94		2.96	3	C	10.0	5	4.00E-02	4.00E-02	35.00	30.25	4.94	1.75	17.11	10.00	2.0246457	0.5845369	SAFE	UNSAFE-2
GRAVES	US45		1.68	3	C	2.0	3	1.69E+00	1.69E+00	29.00	53.00	7.40	2.62	17.07	17.00	2.2980928	0.9958992	SAFE	UNSAFE-2
GRAVES	US45		17.80	3	C	2.0	3	6.75E+00	6.75E+00	29.00	53.00	7.25	2.57	17.07	15.00	2.0681332	0.8787346	SAFE	UNSAFE-2
GRAVES	US45		17.86	3	C	2.0	4	6.75E+00	6.75E+00	29.00	32.00	2.06	0.73	16.44	18.00	8.7518400	1.0948905	SAFE	SAFE
GRAVES	US45/KY58		10.54	4	C	4.0	8	1.54E-01	1.54E-01	35.00	38.00	25.61	9.71	17.34	16.00	0.6247841	0.9227220	UNSAFE-1	UNSAFE-2
GRAVES	US45/KY58		12.20	3	C	1.0	1	2.73E+03	2.67E+00	22.00	37.00	10.75	0.70	15.75	18.00	1.6749757	1.1428571	SAFE	SAFE
HENDERSON	A-PKY		15.78	4	C	1.3	1	6.05E+04	4.83E+02	119.00	329.00	26.57	0.78	36.15	18.00	0.6774302	0.4979253	UNSAFE-1	UNSAFE-2
HENDERSON	KY351		8.59	4	C	10.0	6	1.54E-01	1.54E-01	38.00	33.00	6.63	2.35	17.55	14.50	2.1866761	0.8262108	SAFE	UNSAFE-2
HENDERSON	KY351	TB	1.40	3	C	4.0	3	2.73E+00	2.73E+00	24.00	53.00	6.00	2.12	16.47	18.00	3.0011348	1.0928961	SAFE	SAFE
HENDERSON	KY416		16.88	2	C	4.0	5	7.70E+00	7.70E+00	20.00	114.00	1.81	0.70	17.82	17.40	9.6326609	0.9764309	SAFE	UNSAFE-2
HENDERSON	US41		0.65	3	C	10.0	5	2.50E-01	2.50E-01	34.00	33.00	4.48	1.59	17.07	17.50	3.9065732	1.0251903	SAFE	SAFE
HENDERSON	US41		6.20	3	C	10.0	6	2.50E-01	2.50E-01	56.00	33.00	11.98	4.24	19.71	18.00	1.5027943	0.9132420	SAFE	UNSAFE-2
HENDERSON	US41		6.32	3	C	10.0	6	2.50E-01	2.50E-01	48.00	33.00	8.72	3.09	18.75	17.50	2.0070311	0.9333333	SAFE	UNSAFE-2
HENDERSON	US41		11.27	3	C	1.0	1	1.06E+04	3.20E+01	40.00	48.00	6.10	0.70	18.24	20.00	3.2785403	1.0964912	SAFE	SAFE
HENDERSON	US41		12.65	3	C	10.0	5	2.50E-01	2.50E-01	51.00	28.00	9.61	3.40	18.96	14.50	1.5094285	0.7647679	SAFE	UNSAFE-2
HENDERSON	US60		0.01	13	C	1.3	1	1.30E+04	1.66E+02	28.00	53.00	0.81	0.70	16.95	20.00	24.545766	1.1799410	SAFE	SAFE
HENDERSON	US60		10.00	3	C	10.0	11	6.10E-03	1.90E-02	79.00	80.00	28.35	29.57	23.88	16.00	0.5644153	0.6700167	UNSAFE-1	UNSAFE-2
HENDERSON	US60		10.57	3	C	4.0	3	4.39E+00	5.85E+00	28.00	100.00	9.22	4.05	18.36	18.00	1.9520441	0.9803921	SAFE	UNSAFE-2
HENDERSON	US60		10.64	3	C	4.0	3	4.39E+00	5.85E+00	26.00	53.00	4.04	1.77	16.71	18.00	4.4566058	1.0771992	SAFE	SAFE
HICHMAN	KY58		19.82	5	D	1.1	1	3.80E+03	5.08E+01	38.00	53.00	3.91	0.70	18.15	20.00	5.1156362	1.1019283	SAFE	SAFE
HICHMAN	KY58		19.82	5	D	10.1	4	6.10E-03	1.90E-02	60.00	53.00	30.14	30.48	20.79	15.00	0.4976622	0.7215007	UNSAFE-1	UNSAFE-2
HICHMAN	KY94		0.24	3	D	10.0	8	2.10E-02	5.92E-01	60.00	33.00	0.70	2.06	20.19	30.00	42.857142	1.4856841	SAFE	SAFE
HICHMAN	KY94		2.01	2	D	4.0	3	8.00E+00	8.00E+00	19.00	86.00	1.84	0.70	16.92	16.00	8.7078923	0.9456264	SAFE	UNSAFE-2
HOPKINS	KY109		3.81	4	B	2.0	2	6.75E+00	6.75E+00	22.00	68.25	3.07	1.09	11.13	12.00	3.9108156	1.0786516	SAFE	SAFE
HOPKINS	KY109		4.50	3	B	2.0	3	1.05E+01	7.34E+00	31.00	46.00	4.13	1.12	11.44	21.00	5.0792801	1.8356643	SAFE	SAFE
HOPKINS	KY109		6.49	3	B	2.0	3	7.83E+00	6.30E+00	35.00	48.00	6.44	1.94	11.76	21.00	3.2603938	1.7857142	SAFE	SAFE
HOPKINS	KY109		7.24	5	C	10.0	5	2.50E-01	2.50E-01	40.00	33.00	7.88	2.79	17.79	11.00	1.3956279	0.6183249	SAFE	UNSAFE-2
HOPKINS	KY109		14.74	11	C	10.0	5	2.50E-01	2.50E-01	50.00	33.50	12.43	4.40	19.01	15.00	1.2066203	0.7892659	SAFE	UNSAFE-2
HOPKINS	KY109		16.39	5	C	10.0	5	2.50E-01	2.50E-01	50.00	33.50	12.47	4.42	19.01	15.00	1.2031400	0.7892659	SAFE	UNSAFE-2
HOPKINS	KY1751		1.14	3	C	1.0	1	7.66E+03	1.02E+02	38.00	53.00	2.76	0.70	18.15	23.00	8.2767126	1.2672176	SAFE	SAFE
HOPKINS	US41		6.13	4	C	10.0	5	2.50E-01	2.50E-01	47.00	33.00	10.86	3.85	18.63	14.00	1.2896045	0.7514761	SAFE	UNSAFE-2

PIER AND INTERMEDIATE BENT
SPAN-LOSS ANALYSIS AND ATC ANALYSIS

------ GENERAL INFORMATION ------						- PIER INFO -		- MOMNET OF INERTIA -		PIER SPAN		- MAX. DISPLACEMENT - LONGIT. (IN)	TRANSV.	-- ATC --	-- PROVD --	-- C/D RATIOS --		-- CONCLUSION --	
COUNTY	ROUTE	TB	MILE POST	No. SPAN	SPC	PIER TYPE	No. COLUMM	IX (FT-4)	IY (FT-4)	H (FT)	L (FT)	DXmax	DYmax	L.SUP.REQ (INCH)	L.SUP.PROV (INCH)	SPAN-LOSS	ATC REQ'D	SPAN-LOSS	ATC REQ'D
HOPKINS	US41A		0.49	3	C	10.0	10	1.55E-01	1.55E-01	46.00	43.00	11.08	3.93	18.81	19.50	1.7596391	1.0366826	SAFE	SAFE
HOPKINS	US41A		0.82	3	C	10.0	10	2.63E-01	2.63E-01	46.00	43.00	7.51	2.66	18.81	17.50	2.3305596	0.9303561	SAFE	UNSAFE-2
HOPKINS	US41A		3.42	7	C	3.0	3	1.25E+01	1.25E+01	27.00	48.00	1.83	4.16	16.68	21.00	11.498889	1.2589928	SAFE	SAFE
HOPKINS	US41A		6.59	9	C	2.0	3	6.91E+00	9.50E+00	39.00	42.50	6.46	2.92	17.96	22.00	3.3929683	1.2252854	SAFE	SAFE
HOPKINS	US41A		9.00	3	B	4.0	4	6.58E+01	6.58E+01	33.00	100.00	1.20	0.70	12.64	48.00	39.982977	3.7974683	SAFE	SAFE
HOPKINS	US41A		13.11	2	B	1.0	1	3.64E+03	1.26E+02	21.00	58.00	0.70	0.70	10.84	30.00	42.857142	2.7675276	SAFE	SAFE
HOPKINS	US41A		15.33	6	B	2.0	2	4.80E+01	4.80E+01	29.00	70.00	1.38	0.70	11.72	22.50	16.339913	1.9197952	SAFE	SAFE
HOPKINS	US41A	TB	5.30	6	C	4.0	3	6.75E+00	6.75E+00	35.00	67.00	16.89	5.98	18.21	18.00	1.0659473	0.9884676	SAFE	UNSAFE-2
HOPKINS	US62		0.23	3	B	3.0	1	8.00E+03	3.94E+01	11.00	50.00	0.70	0.70	9.88	18.00	25.714285	1.6218623	SAFE	SAFE
LIVINGSTON	US60		12.37	15	C	1.3	1	1.60E+04	3.25E+02	165.00	500.00	29.90	5.27	46.80	21.00	0.7023764	0.4487179	UNSAFE-1	UNSAFE-2
LIVINGSTON	US62/US641		0.64	10	C	2.1	5	1.03E+01	1.03E+01	33.00	53.00	4.21	1.49	17.55	27.00	6.4077990	1.5384615	SAFE	SAFE
LIVINGSTON	US62/US641		0.64	10	C	10.2	6	6.10E-03	1.90E-02	50.00	53.00	29.62	26.13	19.59	27.00	0.9116830	1.3782542	UNSAFE-1	SAFE
LIVINGSTON	US62/US641		0.97	3	C	4.0	5	6.75E+00	6.75E+00	31.00	100.00	10.44	3.70	18.72	19.00	1.8205143	1.0149572	SAFE	SAFE
LIVINGSTON	US62/US641		2.78	12	C	2.0	2	1.65E+01	1.65E+01	108.00	175.00	22.52	28.45	30.21	22.50	0.9990893	0.7447864	UNSAFE-1	UNSAFE-2
LIVINGSTON	US62/US641	TB	1.20	3	C	4.0	3	6.75E+00	6.75E+00	26.00	95.00	3.90	1.38	17.97	18.00	4.6101196	1.0016694	SAFE	SAFE
LOGAN	US431		20.31	3	B	2.0	3	2.75E+00	2.75E+00	27.00	48.60	5.85	2.07	11.13	18.00	3.0766126	1.6169801	SAFE	SAFE
LOGAN	US431		27.41	5	B	1.3	1	3.04E+03	5.18E+01	36.00	53.00	3.36	0.70	11.94	17.00	5.0596340	1.4237855	SAFE	SAFE
LOGAN	US431		27.73	3	B	3.0	1	1.31E+03	3.85E+00	20.00	48.00	4.89	0.70	10.56	18.00	3.6802461	1.7045454	SAFE	SAFE
LOGAN	US431		28.91	2	B	3.0	1	1.31E+03	3.85E+00	17.00	41.50	2.95	0.70	10.19	18.00	6.0979158	1.7664376	SAFE	SAFE
LOGAN	US68/KY80		2.80	2	A	1.0	1	4.29E+02	5.25E+00	25.00	35.00	6.54	0.70	10.70	20.00	3.0565203	1.8691588	SAFE	SAFE
LOGAN	US68/KY80		9.64	7	A	2.0	3	3.46E+01	2.42E+01	37.00	53.00	4.10	1.11	12.02	20.50	4.9974150	1.7054908	SAFE	SAFE
LOGAN	US68/KY80		20.94	2	B	1.0	1	3.62E+04	1.18E+02	16.00	23.00	0.70	0.70	9.74	19.50	27.857142	2.0020533	SAFE	SAFE
LOGAN	US68/KY80		21.91	3	A	2.0	3	1.25E+01	1.25E+01	39.00	100.00	8.15	2.89	13.12	22.50	2.7608946	1.7149390	SAFE	SAFE
LOGAN	US79		2.91	3	A	1.0	1	6.91E+03	7.23E+01	15.00	33.00	0.70	0.70	9.86	18.50	26.428571	1.8762677	SAFE	SAFE
LOGAN	US79		4.64	3	A	1.0	1	5.85E+03	4.34E+01	23.00	36.50	1.36	0.70	10.57	16.50	12.091964	1.5610217	SAFE	SAFE
LOGAN	US79		5.93	2	A	1.0	1	6.26E+03	5.37E+01	19.00	40.00	1.00	0.70	10.32	20.00	19.983268	1.9379844	SAFE	SAFE
LYON	US62		11.60	3	B	4.0	5	5.12E+00	5.12E+00	33.00	89.00	6.46	2.29	12.42	17.00	2.6309007	1.3687800	SAFE	SAFE
LYON	US62	TB	12.20	4	C	4.0	3	6.75E+00	6.75E+00	23.00	56.10	2.69	0.95	16.44	18.00	6.7032713	1.0946907	SAFE	SAFE
LYON	US62/US641		3.65	4	C	3.0	1	7.81E+03	4.50E+02	49.00	81.00	2.04	0.70	20.31	32.00	15.692577	1.5755785	SAFE	SAFE
LYON	US62/US641	TB	39.51	4	C	4.0	4	6.75E+00	6.75E+00	27.00	91.50	2.61	0.93	17.99	17.00	6.5087607	0.9452321	SAFE	UNSAFE-2
MARSHALL	KY408		8.82	3	C	10.0	3	2.50E-01	2.50E-01	30.00	33.00	3.39	1.20	16.59	15.50	4.5669269	0.9342977	SAFE	UNSAFE-2
MARSHALL	KY408		8.92	3	C	3.0	1	3.91E+03	1.90E+01	20.00	24.00	0.89	0.70	15.12	18.00	20.234611	1.1904761	SAFE	SAFE
MARSHALL	KY408		9.34	5	C	10.0	3	2.50E-01	2.50E-01	30.00	33.00	4.10	1.45	16.59	15.50	3.7791024	0.9342977	SAFE	UNSAFE-2
MARSHALL	KY408		9.73	21	C	10.0	3	2.50E-01	2.50E-01	30.00	33.00	3.94	1.40	16.59	15.50	3.9295747	0.9342977	SAFE	UNSAFE-2
MARSHALL	KY58/KY80		1.12	3	C	1.0	1	2.64E+03	3.37E+01	24.00	43.00	2.10	0.70	16.17	19.00	9.0465045	1.1750154	SAFE	SAFE
MARSHALL	KY80		8.72	2	C	1.0	1	2.58E+03	3.14E+01	14.00	33.00	0.70	0.70	14.67	18.00	25.714285	1.2269938	SAFE	SAFE
MARSHALL	KY80		9.67	10	C	1.0	1	3.22E+03	6.28E+01	12.00	33.00	0.70	0.70	14.43	20.00	28.571428	1.3860013	SAFE	SAFE
MARSHALL	KY80		9.86	17	C	1.0	1	3.31E+03	6.64E+01	23.00	33.00	0.70	0.70	15.75	18.00	25.714285	1.1428571	SAFE	SAFE
MARSHALL	KY80		12.52	7	C	4.0	4	3.36E-01	3.36E-01	17.00	34.00	4.60	1.63	15.06	17.00	3.6961035	1.1288180	SAFE	SAFE
MARSHALL	US62		9.48	5	C	10.0	7	9.00E-02	9.00E-02	45.00	38.00	16.54	5.86	18.54	20.00	1.2092188	1.0787486	SAFE	SAFE
MARSHALL	US62		10.87	3	C	10.0	9	2.50E-01	2.50E-01	50.00	48.00	11.95	4.23	19.44	19.50	1.6315401	1.0030864	SAFE	SAFE
MARSHALL	US62		2.47	4	C	10.0	9	9.00E-02	9.00E-02	45.00	43.00	16.14	5.72	18.69	18.00	1.1149640	0.9630816	SAFE	UNSAFE-2
MARSHALL	US62 (I24)	TB	8.81	4	C	4.0	2	4.20E+00	4.20E+00	25.00	85.75	12.50	4.43	17.57	16.00	1.2797350	0.9105135	SAFE	UNSAFE-2
MARSHALL	US641		9.40	3	C	3.0	1	1.85E+04	9.50E+01	16.00	100.00	0.70	0.70	16.92	18.00	25.714285	1.0638297	SAFE	SAFE
MARSHALL	US641		9.83	4	C	3.0	1	1.85E+04	9.50E+01	16.00	50.00	0.70	0.70	15.42	18.00	25.714285	1.1673151	SAFE	SAFE
MARSHALL	US641		9.87	4	C	10.0	11	9.10E-02	9.10E-02	25.00	58.00	4.91	1.74	16.74	18.00	3.6657390	1.0752688	SAFE	SAFE
MARSHALL	US641	TB	0.24	3	C	10.0	11	9.00E-02	9.00E-02	34.00	65.00	2.69	0.95	18.03	18.00	6.6934498	0.9983361	SAFE	UNSAFE-2
MARSHALL	US68		22.48	5	C	4.0	2	1.56E+01	1.24E+01	38.00	63.00	6.78	2.03	18.45	17.00	2.5073008	0.9214092	SAFE	UNSAFE-2
MARSHALL	US68	TB	9.43	2	C	4.0	3	1.25E+01	1.25E+01	19.00	81.00	1.26	0.70	16.71	20.50	16.239467	1.2268102	SAFE	SAFE
MARSHALL	US68/KY80		27.8	27	C	1.0	1	7.88E+03	1.07E+02	90.00	323.00	30.12	5.23	32.49	48.00	1.5937445	1.4773776	SAFE	SAFE
McCRACKEN	US60		6.69	3	C	2.0	2	6.75E+00	6.75E+00	31.00	48.00	6.45	2.28	17.16	23.50	3.6439343	1.3694638	SAFE	SAFE
McCRACKEN	US60		8.30	5	C	1.0	1	3.91E+03	5.63E+01	26.00	48.00	1.56	0.70	16.56	21.00	13.479960	1.2681159	SAFE	SAFE

PIER AND INTERMEDIATE BENT
SPAN-LOSS ANALYSIS AND ATC ANALYSIS

------ GENERAL INFORMATION ------						- PIER INFO -		- MOMNET OF INERTIA -		PIER	SPAN	- MAX. DISPLACEMENT -		-- ATC --	-- PROV'D --	-- C/D RATIOS --		-- CONCLUSION --	
			MILE	No.		PIER	No.					LONGIT.	TRANSV.	L.SUP.REQ	L.SUP.PROV	SPAN-	ATC	SPAN-	ATC
COUNTY	ROUTE	TB	POST	SPAN	SPC	TYPE	COLUMN	IX (FT-4)	IY (FT-4)	H (FT)	L (FT)	DXmax (IN)	DYmax	(INCH)	(INCH)	LOSS	REQ'D	LOSS	REQ'D
McCRACKEN	US60		11.09	3	C	10.0	24	9.00E-02	9.00E-02	60.00	50.00	28.98	11.68	20.70	12.50	0.4913759	0.6038647	UNSAFE-1	UNSAFE-2
McCRACKEN	US60		11.76	3	C	2.0	4	8.20E+00	8.20E+00	35.00	35.00	2.79	0.99	17.25	18.50	8.6370624	1.0724637	SAFE	SAFE
McCRACKEN	US60		18.64	4	C	4.0	2	5.21E+01	5.21E+01	43.00	110.00	10.67	3.78	20.46	30.00	2.8116884	1.4662756	SAFE	SAFE
McCRACKEN	US60		10.80	3	C	4.0	3	6.75E+00	6.75E+00	21.00	79.50	2.02	0.72	16.91	18.00	8.8950565	1.0647737	SAFE	SAFE
McCRACKEN	US62		13.06	5	C	10.4	10	9.00E-02	9.00E-02	40.00	53.00	18.22	6.45	18.39	18.00	0.9880663	0.9787928	UNSAFE-1	UNSAFE-2
McCRACKEN	US62		13.06	5	C	4.1	3	6.75E+00	6.75E+00	30.00	53.00	4.87	1.73	17.19	18.00	3.6952112	1.0471204	SAFE	SAFE
McCRACKEN	US62		13.91	3	C	4.0	2	6.75E+00	6.75E+00	26.00	80.00	5.39	1.91	17.52	18.00	3.3381722	1.0273972	SAFE	SAFE
McCRACKEN	US62	TB	12.95	3	C	4.0	4	6.75E+00	6.75E+00	35.00	78.00	4.59	1.63	18.54	18.00	3.9179391	0.9708737	SAFE	UNSAFE-2
McCRACKEN	US62		12.98	5	C	2.0	2	1.13E+01	1.46E+01	35.00	69.00	5.45	2.35	18.27	25.50	4.6775388	1.3957307	SAFE	SAFE
McCRACKEN	US68	TB	1.01	2	C	4.0	3	6.75E+00	6.75E+00	25.00	92.00	3.35	1.19	17.76	18.00	5.3683072	1.0135135	SAFE	SAFE
McLEAN	KY136		19.17	3	B	3.0	1	1.93E+03	2.73E+01	18.00	53.00	0.70	0.70	10.50	17.00	24.285714	1.6190476	SAFE	SAFE
McLEAN	KY136		20.88	7	B	3.1	1	3.81E+03	3.80E+01	18.25	53.00	0.70	0.70	10.52	23.40	33.428571	2.2243346	SAFE	SAFE
McLEAN	KY136		20.88	7	B	10.3	4	2.48E-01	2.48E-01	40.00	53.00	8.99	3.19	12.26	15.50	1.7240782	1.2642740	SAFE	SAFE
MUHLENBERG	KY176		4.29	9	B	10.0	5	2.50E-01	2.50E-01	40.00	33.00	7.22	2.56	11.86	18.00	2.4947432	1.5177065	SAFE	SAFE
MUHLENBERG	US431		3.45	7	B	10.0	4	2.50E-01	2.50E-01	35.00	32.50	5.00	1.77	11.45	10.00	1.9996294	0.8733624	SAFE	UNSAFE-2
MUHLENBERG	US431		12.45	7	B	10.0	7	1.55E-01	1.55E-01	43.00	38.00	9.98	3.54	12.20	18.00	1.8032754	1.4754098	SAFE	SAFE
MUHLENBERG	US431		17.48	4	A	2.0	3	1.25E+01	1.25E+01	21.00	80.00	1.56	0.70	11.28	18.00	11.534295	1.5957446	SAFE	SAFE
OHIO	KY136		1.06	4	B	10.0	4	2.48E-01	2.48E-01	45.00	33.00	8.89	3.15	12.26	20.00	2.2486836	1.6313213	SAFE	SAFE
OHIO	KY136		3.34	5	B	10.0	4	4.40E-01	4.40E-01	40.00	33.00	4.44	1.57	11.86	14.50	3.2621701	1.2225969	SAFE	SAFE
OHIO	KY136		5.67	2	B	1.0	1	3.43E+03	3.80E+01	16.00	27.00	0.70	0.70	9.82	18.00	25.714285	1.8329938	SAFE	SAFE
OHIO	US231		11.46	4	B	2.0	6	3.81E+00	8.88E-01	18.00	33.00	3.95	0.70	10.10	15.00	3.7948924	1.4851485	SAFE	SAFE
OHIO	US231		11.95	4	B	10.0	5	2.48E-01	2.48E-01	40.00	33.00	7.03	2.49	11.86	16.00	2.2757884	1.3490725	SAFE	SAFE
OHIO	US231		13.32	3	B	1.0	1	7.50E+03	9.53E+01	35.00	73.00	1.96	0.70	12.26	17.00	8.6519878	1.3866231	SAFE	SAFE
OHIO	US231		13.49	6	B	10.0	5	2.48E-01	2.48E-01	46.00	33.00	8.18	2.90	12.34	15.00	1.8327097	1.2155591	SAFE	SAFE
OHIO	US231		13.88	6	B	10.0	5	2.48E-01	2.48E-01	46.00	33.00	8.18	2.90	12.34	15.50	1.8938000	1.2560777	SAFE	SAFE
OHIO	US231		14.12	3	B	10.0	8	1.00E-02	2.00E-02	53.00	70.00	26.39	17.05	13.64	18.00	0.6821824	1.3196480	UNSAFE-1	SAFE
OHIO	US231		15.80	3	B	2.0	5	2.48E-01	2.48E-01	20.00	23.00	22.13	7.84	10.06	18.00	0.8132481	1.7892644	UNSAFE-1	SAFE
OHIO	US231		20.30	4	B	10.0	6	2.48E-01	2.48E-01	50.00	33.00	8.66	3.07	12.66	14.50	1.6739659	1.1453396	SAFE	SAFE
OHIO	US231	TB	6.70	3	B	2.0	3	6.75E+00	6.75E+00	23.00	49.00	2.16	0.76	10.82	18.00	8.3429641	1.6635859	SAFE	SAFE
TODD	US68/KY80		9.10	2	B	1.0	1	5.49E+03	6.30E+01	15.00	40.00	0.70	0.70	10.00	18.00	25.714285	1.8	SAFE	SAFE
TODD	US79		1.95	3	A	2.0	2	2.76E+00	2.76E+00	30.00	40.00	8.87	3.14	11.20	17.50	1.9739143	1.5625	SAFE	SAFE
TODD	US79		7.61	4	A	1.0	1	1.07E+03	1.23E+01	18.00	43.00	1.81	0.70	10.30	17.00	9.3679646	1.6504854	SAFE	SAFE
TRIGG	US68/KY80		3.11	3	C	2.0	4	6.75E+00	6.75E+00	46.00	44.00	8.34	2.95	18.84	18.00	2.1586112	0.9554140	SAFE	UNSAFE-2
TRIGG	US68/KY80		8.27	32	C	1.0	1	3.81E+04	2.83E+03	160.00	321.00	30.94	5.98	40.83	40.00	1.2929634	0.9796718	SAFE	UNSAFE-2
TRIGG	US68/KY80		10.94	3	C	10.0	7	9.00E-02	9.00E-02	70.00	33.00	30.43	15.57	21.39	40.00	1.3146414	1.8700327	SAFE	SAFE
TRIGG	US68/KY80		17.89	6	C	1.0	1	8.10E+03	1.17E+02	46.00	53.00	3.05	0.70	19.11	22.00	7.2217359	1.1512297	SAFE	SAFE
UNION	KY130		12.54	3	C	3.0	1	2.60E+03	1.70E+01	16.00	16.00	0.70	0.70	14.40	12.00	17.142857	0.8333333	SAFE	UNSAFE-2
UNION	KY130		13.47	3	C	10.0	5	2.50E-01	2.50E-01	47.00	38.00	9.86	3.49	18.78	15.50	1.5718689	0.8253461	SAFE	UNSAFE-2
UNION	US60		3.66	3	C	10.0	6	6.10E-03	1.90E-02	40.00	53.00	14.36	11.91	18.39	16.00	1.1139350	0.8700380	SAFE	UNSAFE-2
UNION	US60		5.20	3	C	10.0	9	9.00E-02	9.00E-02	40.00	48.00	19.41	6.88	18.24	19.00	0.9789307	1.0416666	UNSAFE-1	SAFE
UNION	US60		6.48	3	C	10.0	9	9.00E-02	9.00E-02	40.00	48.00	18.40	6.52	18.24	17.50	0.9510108	0.9594298	UNSAFE-1	UNSAFE-2
UNION	US60		13.06	3	C	10.0	9	9.00E-02	9.00E-02	40.00	41.60	14.65	5.19	18.05	16.50	1.1265236	0.9142287	SAFE	UNSAFE-2
WARREN	US231		15.43	4	A	2.0	6	6.75E+00	6.75E+00	30.00	86.00	4.05	1.44	12.12	20.00	4.9374940	1.6501650	SAFE	SAFE
WARREN	US231		21.53	3	A	2.0	3	2.68E+03	5.56E+00	25.00	55.00	2.28	0.70	11.10	24.00	10.542841	2.1621621	SAFE	SAFE
WARREN	US231		22.61	3	A	1.0	1	3.33E+02	2.50E+01	25.00	82.00	2.84	0.70	11.64	18.00	6.3350439	1.5463917	SAFE	SAFE
WARREN	US68/KY80		8.2	4	A	2.0	3	1.92E+00	1.92E+00	26.00	56.00	11.57	4.10	11.20	18.00	1.5553234	1.6071428	SAFE	SAFE
WEBSTER	KY109		7.33	5	C	2.0	1	6.75E+00	6.75E+00	12.00	48.00	0.72	0.70	14.88	18.00	24.956116	1.2096774	SAFE	SAFE
WEBSTER	KY109		10.72	4	C	1.0	1	2.66E+03	4.95E+01	28.00	48.00	3.10	0.70	16.80	18.00	5.8063679	1.0714285	SAFE	SAFE
WEBSTER	US41		6.86	3	C	2.0	3	6.75E+00	6.75E+00	31.00	100.00	5.86	2.08	18.72	20.50	3.4955643	1.0950854	SAFE	SAFE

PIER AND INTERMEDIATE BENT
SPAN-LOSS ANALYSIS AND ATC ANALYSIS

------ GENERAL INFORMATION ------						- PIER INFO -		- MOMNET OF INERTIA -		PIER SPAN		- MAX. DISPLACEMENT -		-- ATC --	-- PROVD --	-- C/D RATIOS --		-- CONCLUSION --	
			MILE	No.		PIER	No.					LONGIT.	TRANSV.	L.SUP.REQ	L.SUP.PROV	SPAN-	ATC	SPAN-	ATC
COUNTY	ROUTE	TB	POST	SPAN	SPC	TYPE	COLUNM	IX (FT-4)	IY (FT-4)	H (FT)	L (FT)	DXmax (IN)	DYmax	(INCH)	(INCH)	LOSS	REQ'D	LOSS	REQ'D
WEBSTER	US41		11.68	4	C	2.0	3	1.09E+01	1.09E+01	25.00	43.00	1.70	0.70	16.29	19.50	11.453209	1.1970534	SAFE	SAFE

APPENDIX E

RESULTS OF SPAN-LOSS COLLAPSE ANALYSIS FOR SOLID ABUTMENT

SPAN-LOSS TYPE OF COLLAPSE ANALYSIS FOR SOLID ABUTMENT

COUNTY	ROUTE	B	MILE POST	No. SPAN	ABUTMENT INFORMATION HEIGHT (FT)	WEIGHT (KIP)	LENGTH (FT)	WSUP (KIP)	L-S (INCH)	Dmax (INCH)	SOIL PROPERTIES PHI	DELTA	THETA	WEIGHT REQ'D	PROVD	C/D RATIOS SUPPORT	WEIGHT	
BALLARD	US60		2.5	2	25	260	66	70.125	18	0.7	26.58	13.29	2.52	13.33	3.94	25.71	0.30	UNSAFE-1
BUTLER	US231		4.63	3	16	79	22	123	18	0.7	26.19	13.10	2.52	-0.09	3.59	25.71	50.00	SAFE
BUTLER	US231		8.8	2	14	431.5	107	783.5	18	5.43	26.19	13.10	2.72	-3.42	4.03	3.31	50.00	SAFE
BUTLER	US231		12.26	10	19.25	468.00	59.00	110.00	18	13.3	26.19	13.10	3.48	7.15	7.93	1.35	1.11	SAFE
BUTLER	US231		17.76	2	12.75	412.00	94.50	956.00	12	0.7	26.19	13.10	2.80	-7.33	4.36	17.14	50.00	SAFE
CALDWELL	KY91		12.24	4	13	306.5	55	387.5	18	3.11	25.46	12.73	2.61	-3.63	5.57	5.79	50.00	SAFE
CALLOWAY	KY94		17.10	2	25.00	174.30	74.00	93.00	18	2.64	27.25	13.63	2.59	12.72	2.36	6.82	0.19	UNSAFE-1
CALLOWAY	KY94		23.03	3	12	37	41	57	18	0.71	27.25	13.63	2.52	1.71	0.90	25.35	0.53	UNSAFE-1
CALLOWAY	US641		1.15	4	17.50	723.00	19.00	222.00	18	0.7	27.25	13.63	2.52	-5.90	38.05	25.71	50.00	SAFE
CARLISE	US62		3.88	3	15	66	19	91	18	4.92	28.98	14.49	2.70	-0.53	3.47	3.66	50.00	SAFE
CHRISTIAN	KY91		4.43	3	19.00	435.00	39.80	85.00	18	1.56	25.59	12.80	2.55	6.44	10.93	11.54	1.70	SAFE
CHRISTIAN	KY91		11.26	2	15	88	26	116	18	0.7	25.59	12.80	2.52	0.56	3.36	25.71	6.05	SAFE
CHRISTIAN	KY91		13.07	2	15	108	32	62	18	0.7	25.59	12.80	2.52	3.34	3.38	25.71	1.01	SAFE
CHRISTIAN	US41		15.33	3	20.00	516.00	90.00	81.00	12	0.7	25.59	12.80	2.80	8.89	5.73	17.14	0.65	UNSAFE-1
CHRISTIAN	US41A		10.87	2	13.00	576.00	96.00	144.00	18	1.01	25.59	12.80	2.53	2.46	6.00	17.82	2.44	SAFE
CHRISTIAN	US41A	TB	4.43	2	22.00	1145.00	60.00	513.00	18	1.56	25.59	12.80	2.55	2.37	19.08	11.54	8.06	SAFE
CHRISTIAN	US68/KY80		10.76	3	21	138.6	28	62	12	1.19	25.59	12.80	2.83	8.46	4.95	10.08	0.59	UNSAFE-1
CHRISTIAN	US68/KY80		11.20	2	14.00	1196.00	88.00	812.00	26	1.37	25.59	12.80	2.30	-5.37	13.59	18.98	50.00	SAFE
CHRISTIAN	US68/KY80		18.18	3	21.00	426.00	48.00	85.00	18	0.7	25.59	12.80	2.52	8.77	8.88	25.71	1.01	SAFE
DAVIESS	KY1554		0.90	2	17.00	413.00	33.50	252.00	18	4.06	29.92	14.96	2.65	-2.43	12.33	4.43	50.00	SAFE
FULTON	KY94		17.85	2	10	106	47	318	17	0.7	25.11	12.56	2.55	-4.98	2.26	24.29	50.00	SAFE
FULTON	US51		1.16	2	18.00	615.00	78.75	197.00	16	1.15	25.11	12.56	2.53	5.31	7.81	15.65	1.47	SAFE
GRAVES	KY121		8.75	2	10.50	197.00	45.00	88.00	18	0.7	24.11	12.06	2.52	0.71	4.38	25.71	6.19	SAFE
GRAVES	KY121		20.19	5	16.00	310.00	35.00	121.00	18	9.26	24.11	12.06	2.98	2.95	8.86	1.94	3.00	SAFE
GRAVES	KY58		0.51	3	10	49.5	22	150	18	6.78	24.11	12.06	2.80	-5.00	2.25	2.65	50.00	SAFE
GRAVES	KY58		2.83	2	10	49.5	22	91	18	0.7	24.11	12.06	2.52	-1.98	2.25	25.71	50.00	SAFE
GRAVES	KY58		5.27	2	17.00	589.00	33.00	415.00	18	1.67	24.11	12.06	2.55	-6.41	17.85	10.78	50.00	SAFE
GRAVES	US45		17.80	3	12.00	807.00	53.00	307.00	18	7.25	24.11	12.06	2.83	-2.69	15.23	2.48	50.00	SAFE
GRAVES	US45		17.86	3	10	92.25	41	108	18	2.06	24.11	12.06	2.57	-0.31	2.25	8.74	50.00	SAFE
GRAVES	US45/KY58		12.2	3	24	500	84	1505	18	10.75	24.11	12.06	3.13	-4.83	5.95	1.67	50.00	SAFE
HENDERSON	KY416		16.88	2	12.00	690.00	60.00	618.00	18	1.81	28.25	14.13	2.56	-8.14	11.50	9.94	50.00	SAFE
HICKMAN	KY94		2.01	2	18.00	565.00	32.50	390.00	15	1.84	29.04	14.52	2.69	-6.36	17.38	8.15	50.00	SAFE
HOPKINS	KY109		3.81	4	10.00	213.00	30.00	203.00	18	3.07	26.47	13.24	2.61	-5.10	7.10	5.86	50.00	SAFE
HOPKINS	KY109		4.50	3	11.25	218.00	37.00	62.00	21	4.13	26.47	13.24	2.53	1.11	5.89	5.08	5.28	SAFE
HOPKINS	KY109		6.49	3	6.00	196.00	37.00	62.00	22	6.44	26.47	13.24	2.58	-1.00	5.30	3.42	50.00	SAFE
HOPKINS	KY1751		1.14	3	4.50	62.00	39.00	105.00	21	2.78	26.47	13.24	2.48	-2.48	1.59	7.55	50.00	SAFE
HOPKINS	US41A		3.42	7	12	84.4	32	192	21	1.83	26.47	13.24	2.45	-3.22	2.64	11.48	50.00	SAFE
HOPKINS	US41A		6.59	9	11.25	364.00	37.00	210.00	18	6.48	26.47	13.24	2.78	-3.29	9.84	2.76	50.00	SAFE
HOPKINS	US41A		13.11	2	28.00	224.00	38.00	176.00	18	0.7	26.47	13.24	2.52	13.14	5.89	25.71	0.45	UNSAFE-1
HOPKINS	US41A		15.33	6	10.00	224.00	38.00	176.00	27	1.38	26.47	13.24	2.28	-2.79	5.89	19.57	50.00	SAFE
LIVINGSTON	US60		12.37	15	17.00	185.00	31.00	72.00	27	29.21	26.32	13.16	2.25	4.16	5.97	0.92	1.44	UNSAFE-1.
LIVINGSTON	US62/641		2.78	12	29.00	405.00	36.00	200.00	22	22.52	26.32	13.16	2.37	13.52	11.25	0.98	0.83	UNSAFE-1.
LOGAN	US431		27.41	5	17.50	419.00	23.00	226.00	18	3.36	24.37	12.19	2.62	-2.99	18.22	5.36	50.00	SAFE
LOGAN	US431		27.73	3	20.75	579.00	23.00	181.00	18	4.89	24.37	12.19	2.70	2.43	25.17	3.68	10.36	SAFE
LOGAN	US431		28.91	2	16.75	366.00	23.00	150.00	18	2.95	24.37	12.19	2.60	0.02	15.91	6.10	894.64	SAFE

SPAN-LOSS TYPE OF COLLAPSE ANALYSIS FOR SOLID ABUTMENT

COUNTY	ROUTE	B	MILE POST	No. SPAN	ABUTMENT INFORMATION HEIGHT (FT)	WEIGHT (KIP)	LENGTH (FT)	WSUP (KIP)	L-S (INCH)	Dmax (INCH)	----- SOIL PROPERTIES ---- PHI	DELTA	THETA	------- WEIGHT ------- REQ'D	PROV'D	---- C/D RATIOS ---- SUPPORT	WEIGHT	
LOGAN	US68/KY80		2.80	2	18.50	294.00	68.00	109.00	20	6.56	24.37	12.19	2.68	7.12	4.32	3.05	0.61	UNSAFE-1
LOGAN	US68/KY80		20.94	2	16.00	127.00	64.00	63.00	18	0.7	24.37	12.19	2.52	5.51	1.98	25.71	0.36	UNSAFE-1
LOGAN	US79		2.91	3	15.50	306.00	53.00	84.00	25	0.7	24.37	12.19	2.31	4.38	5.77	35.71	1.32	SAFE
LOGAN	US79		4.64	3	21.00	522.00	56.00	126.00	16	1.36	24.37	12.19	2.62	8.93	9.32	11.76	1.04	SAFE
LOGAN	US79		5.93	2	18.00	293.00	56.00	167.00	16	1	24.37	12.19	2.61	5.08	5.23	16.00	1.03	SAFE
LYON	US62/US641		3.65	4	19.50	954.00	77.00	267.00	30	2.04	25.96	12.98	2.23	5.16	12.39	14.71	2.40	SAFE
MARSHALL	KY408		8.92	3	14	78.7	25	45.9	17	0.89	27.36	13.68	2.56	2.38	3.15	19.10	1.32	SAFE
MARSHALL	KY58/KY80		1.12	3	22.50	689.00	48.00	112.00	16	2.1	27.36	13.68	2.66	8.84	14.35	7.62	1.62	SAFE
MARSHALL	KY80		8.72	2	16.00	201.00	37.00	84.00	18	0.7	27.36	13.68	2.52	3.24	5.43	25.71	1.68	SAFE
MARSHALL	KY80		9.67	10	11.50	215.00	38.00	84.00	18	0.7	27.36	13.68	2.52	0.54	5.66	25.71	10.49	SAFE
MARSHALL	KY80		9.86	17	17.50	389.00	44.00	84.00	18	0.7	27.36	13.68	2.52	4.76	8.84	25.71	1.86	SAFE
MARSHALL	US60		8.81	2	20	335.78	43	247.7	16	12.5	27.36	13.68	3.75	3.04	7.81	1.28	2.57	SAFE
MARSHALL	US641		9.40	4	10	94.5	42	465	18	0.7	27.36	13.68	2.52	-10.38	2.25	25.71	50.00	SAFE
MARSHALL	US641		9.83	4	10	94.5	42	171	18	0.7	27.36	13.68	2.52	-2.21	2.25	25.71	50.00	SAFE
MARSHALL	US68	B	9.43	2	17.00	547.00	26.00	731.00	21	1.26	27.36	13.68	2.43	-24.21	21.04	16.67	50.00	SAFE
MARSHALL	US68/KY80		27.8	27	15	150	28	200	14	30.12	27.36	13.68	2.65	-2.78	5.36	0.46	50.00	UNSAFE-1.
McCRACKEN	US60		8.30	5	22.50	580.00	55.50	143.00	18	1.56	22.94	11.47	2.55	11.10	10.45	11.54	0.94	UNSAFE-1
McCRACKEN	US60		11.76	3	11.25	2220.00	110.50	1052.00	18	2.79	22.94	11.47	2.60	-7.16	20.09	6.45	50.00	SAFE
McCRACKEN	US60	B	10.80	3	19.00	709.00	40.25	229.00	12	2.02	22.94	11.47	2.89	3.71	17.61	5.94	4.75	SAFE
McCRACKEN	US62		12.95	3	16	169	47	203	18	4.59	22.94	11.47	2.68	2.27	3.60	3.92	1.58	SAFE
McCRACKEN	US62		12.98	5	16.00	169.00	47.00	203.00	18	5.45	22.94	11.47	2.73	2.28	3.60	3.30	1.58	SAFE
McCRACKEN	US68	B	1.01	2	20.00	727.00	39.25	250.00	18	3.35	22.94	11.47	2.62	3.95	18.52	5.37	4.68	SAFE
MUHLENBERG	US431		17.48	4	22	210	60	310	18	1.56	26.79	13.40	2.55	5.47	3.50	11.54	0.64	UNSAFE-1
OHIO	KY136		5.67	2	13.75	336.00	46.00	57.00	18	0.7	25.93	12.97	2.52	3.16	7.30	25.71	2.31	SAFE
OHIO	KY136		5.67	2	13.75	269.00	41.00	57.00	18	0.7	25.93	12.97	2.52	3.00	6.56	25.71	2.19	SAFE
OHIO	US231		11.46	4	20.00	621.00	57.25	73.00	24	3.95	25.93	12.97	2.42	8.12	10.85	6.08	1.34	SAFE
OHIO	US231		13.32	3	15.75	500.00	47.00	187.00	21	1.96	25.93	12.97	2.46	1.55	10.64	10.71	6.86	SAFE
OHIO	US231	B	6.70	3	9.00	148.00	42.50	184.00	18	2.16	25.93	12.97	2.57	-2.83	3.46	8.33	50.00	SAFE
TODD	US68/KY80		9.10	2	15	95	28	113	18	0.7	28.2	14.10	2.52	0.43	3.39	25.71	7.86	SAFE
TODD	US79		7.61	4	12.75	273.00	52.00	112.00	18	1.81	28.20	14.10	2.56	1.15	5.25	9.94	4.58	SAFE
TRIGG	US68/KY80		3.11	3	11	134	54	181	18	8.34	25.52	12.76	2.91	-0.73	2.48	2.16	50.00	SAFE
TRIGG	US68/KY80	B	8.27	32	30	263.11	28	200	18	30.94	25.52	12.76	2.49	14.07	9.40	0.58	0.67	UNSAFE-1.
UNION	KY130		12.54	3	10	37.5	26	60	12	0.7	27.83	13.92	2.80	-0.32	1.44	17.14	50.00	SAFE
WARREN	US231		22.61	3	10	78.8	35	500	18	2.84	24.29	12.15	2.60	-13.28	2.25	6.34	50.00	SAFE
WEBSTER	KY109		7.33	5	12	61	22.5	125	18	0.72	26.76	13.38	2.52	-2.77	2.71	25.00	50.00	SAFE
WEBSTER	KY109		10.72	4	10	50	22	125	18	3.12	26.76	13.38	2.61	-3.93	2.27	5.77	50.00	SAFE
WEBSTER	US41		11.68	4	10.00	297.00	67.50	170.00	20	1.7	26.76	13.38	2.48	-0.46	4.40	11.76	50.00	SAFE

APPENDIX F

RESULTS OF ATC ANALYSIS FOR SOLID ABUTMENT

SOLID ABUTMENT
ATC ANALYSIS

COUNTY	ROUTE		MILE POST	No. SPAN	SPC	PIER H (FT)	SPAN L (FT)	ATC L.SUP.REQ (INCH)	PROVD L.SUP.PROV (INCH)	RATIO C/D	CONCL.
BALLARD	US60		2.50	2	D	15.00	43.00	15.09	16.00	1.06	SAFE
BALLARD	US60		3.93	1	D	0.00	30.50	12.92	18.00	1.39	SAFE
BALLARD	US60		5.32	1	D	0.00	90.00	14.70	14.00	0.95	UNSAFE-2
BALLARD	US60		10.23	1	D	0.00	44.00	13.32	14.00	1.05	SAFE
BUTLER	US231		4.63	3	B	16.00	48.00	10.24	14.00	1.37	SAFE
BUTLER	US231		8.80	2	B	21.50	299.00	15.70	30.00	1.91	SAFE
BUTLER	US231		9.92	1	B	0.00	24.00	8.48	14.00	1.65	SAFE
BUTLER	US231		12.26	10	B	39.00	46.00	12.04	30.00	2.49	SAFE
BUTLER	US231		17.76	2	A	21.50	291.00	15.54	12.00	0.77	UNSAFE-2
BUTLER	US231		8.00	1	B	0.00	25.00	8.50	16.00	1.88	SAFE
CALDWELL	KY91		7.79	1	B	0.00	24.00	8.48	15.00	1.77	SAFE
CALDWELL	KY91		12.24	4	B	25.00	318.00	16.36	26.00	1.59	SAFE
CALDWELL	KY91		14.57	1	B	0.00	30.00	8.60	14.00	1.63	SAFE
CALDWELL	US62		18.38	1	B	0.00	165.00	11.30	30.00	2.65	SAFE
CALDWELL	US641		1.43	1	B	0.00	47.00	8.94	17.00	1.90	SAFE
CALDWELL	US641		4.62	1	C	0.00	95.00	14.85	24.00	1.62	SAFE
CALLOWAY	KY94		1.77	1	C	0.00	27.00	12.81	14.00	1.09	SAFE
CALLOWAY	KY94		5.15	1	C	0.00	39.00	13.17	14.00	1.06	SAFE
CALLOWAY	KY94		6.44	1	C	0.00	25.00	12.75	14.00	1.10	SAFE
CALLOWAY	KY94		16.49	1	C	0.00	43.00	13.29	14.00	1.05	SAFE
CALLOWAY	KY94		17.10	2	C	10.00	40.50	14.42	16.00	1.11	SAFE
CALLOWAY	KY94		23.03	3	C	5.00	46.00	13.98	18.00	1.29	SAFE
CALLOWAY	US641		1.15	4	C	17.50	43.00	15.39	17.00	1.10	SAFE
CALLOWAY	US641		5.49	1	C	0.00	75.00	14.25	20.00	1.40	SAFE
CARLISE	KY121		9.10	1	D	0.00	38.00	13.14	14.00	1.07	SAFE
CARLISE	US62		3.88	3	D	37.00	43.00	17.73	14.00	0.79	UNSAFE-2
CARLISE	US62		6.04	1	D	0.00	40.00	13.20	14.00	1.06	SAFE
CHRISTIAN	KY91		2.16	1	A	0.00	30.00	8.60	19.00	2.21	SAFE
CHRISTIAN	KY91		4.43	3	B	19.00	36.00	10.24	17.00	1.66	SAFE
CHRISTIAN	KY91		11.26	2	B	15.00	43.00	10.06	14.00	1.39	SAFE
CHRISTIAN	KY91		13.07	2	B	20.00	30.00	10.20	14.00	1.37	SAFE
CHRISTIAN	US41		15.33	3	A	20.00	74.00	11.08	13.00	1.17	SAFE
CHRISTIAN	US41A		10.87	2	B	13.00	43.00	9.90	11.00	1.11	SAFE
CHRISTIAN	US41A		13.44	2	A	33.00	244.00	15.52	14.00	0.90	SAFE
CHRISTIAN	US41A	TB	4.43	2	A	21.00	342.00	16.52	58.00	3.51	SAFE
CHRISTIAN	US68/KY80		10.76	3	B	22.00	50.00	10.76	14.00	1.30	SAFE
CHRISTIAN	US68/KY80		11.20	2	A	19.00	82.00	11.16	25.00	2.24	SAFE
CHRISTIAN	US68/KY80		18.18	3	B	19.75	33.00	10.24	18.00	1.76	SAFE
CRITTENDEN	US60		8.37	1	B	0.00	41.50	8.83	19.00	2.15	SAFE
CRITTENDEN	US60		10.76	1	B	0.00	34.00	8.68	17.00	1.96	SAFE
CRITTENDEN	US60		12.40	1	C	0.00	38.00	13.14	18.00	1.37	SAFE
CRITTENDEN	US60		14.69	1	A	0.00	74.00	9.48	14.00	1.48	SAFE
CRITTENDEN	US60		20.32	1	B	0.00	41.60	8.83	18.00	2.04	SAFE
CRITTENDEN	US641		5.36	1	C	0.00	46.00	13.38	14.00	1.05	SAFE
DAVIESS	KY1554		0.90	2	B	18.25	192.00	13.30	20.00	1.50	SAFE
FULTON	KY94		15.87	1	D	0.00	73.00	14.19	18.00	1.27	SAFE
FULTON	KY94		17.22	1	B	0.00	73.00	9.46	18.00	1.90	SAFE
FULTON	KY94		17.85	2	D	18.00	72.00	16.32	18.00	1.10	SAFE
FULTON	KY94		24.22	1	D	0.00	69.00	14.07	18.00	1.28	SAFE
FULTON	KY94		25.52	1	D	0.00	21.00	12.63	14.00	1.11	SAFE
FULTON	US51		1.16	2	D	12.00	160.00	18.24	23.00	1.26	SAFE
GRAVES	KY121		8.75	2	C	11.00	25.50	14.09	18.00	1.28	SAFE
GRAVES	KY121		20.19	5	C	31.00	33.00	16.71	14.00	0.84	UNSAFE-2
GRAVES	KY58		0.51	3	C	40.00	48.00	18.24	14.00	0.77	UNSAFE-2
GRAVES	KY58		2.83	2	D	12.00	41.00	14.67	14.00	0.95	UNSAFE-2

SOLID ABUTMENT
ATC ANALYSIS

------------- GENERAL INFORMATION -------------					HEIGHT AND LENGTH		-- ATC --	- PROV'D --	RATIO	CONCL.
COUNTY	ROUTE	MILE POST	No. SPAN	SPC	PIER H (FT)	SPAN L (FT)	L.SUP.REQ (INCH)	L.SUP.PROV (INCH)	C/D	
GRAVES	KY58	5.27	2	C	18.00	184.00	19.68	21.00	1.07	SAFE
GRAVES	KY58/KY80	12.44	1	C	0.00	34.00	13.02	22.00	1.69	SAFE
GRAVES	KY94	0.20	1	C	0.00	31.00	12.93	14.00	1.08	SAFE
GRAVES	US45	1.80	1	C	29.00	32.00	16.44	14.00	0.85	UNSAFE-2
GRAVES	US45	7.80	1	C	0.00	34.00	13.02	18.00	1.38	SAFE
GRAVES	US45	7.86	1	C	0.00	44.00	13.32	18.00	1.35	SAFE
GRAVES	US45	17.80	3	C	28.00	53.00	16.95	16.00	0.94	UNSAFE-2
GRAVES	US45	17.86	3	C	29.00	53.00	17.07	17.00	1.00	UNSAFE-2
GRAVES	US45/KY58	12.20	3	C	22.00	35.00	15.69	30.00	1.91	SAFE
GRAVES	US45/KY58	13.10	1	C	0.00	43.00	13.29	14.00	1.05	SAFE
HENDERSON	KY416	16.88	2	C	20.00	232.00	21.36	35.00	1.64	SAFE
HENDERSON	US60	0.01	1	C	0.00	53.50	13.61	24.00	1.76	SAFE
HICKMAN	KY94	2.01	2	D	19.00	88.00	16.92	26.00	1.54	SAFE
HOPKINS	KY109	3.81	4	B	21.50	239.00	10.70	27.00	2.52	SAFE
HOPKINS	KY109	4.50	3	B	33.00	28.00	11.20	21.00	1.88	SAFE
HOPKINS	KY109	6.49	3	B	33.00	28.00	11.20	21.00	1.88	SAFE
HOPKINS	KY1751	1.14	3	C	38.00	46.25	17.95	22.00	1.23	SAFE
HOPKINS	US41A	3.42	7	C	27.00	48.00	16.68	14.00	0.84	UNSAFE-2
HOPKINS	US41A	6.59	9	C	39.00	42.50	17.96	22.00	1.23	SAFE
HOPKINS	US41A	12.65	1	C	0.00	32.00	12.96	39.00	3.01	SAFE
HOPKINS	US41A	13.11	2	B	21.00	50.00	10.68	14.00	1.31	SAFE
HOPKINS	US41A	15.33	6	B	22.50	240.00	10.80	26.00	2.41	SAFE
HOPKINS	US41A	15.73	1	B	0.00	50.00	9.00	31.00	3.44	SAFE
LIVINGSTON	US60	12.37	15	C	17.00	34.50	15.08	26.00	1.72	SAFE
LIVINGSTON	US60	16.66	1	C	0.00	41.00	13.23	14.00	1.06	SAFE
LIVINGSTON	US60	21.31	1	C	0.00	21.00	12.63	14.00	1.11	SAFE
LIVINGSTON	US60	25.98	1	B	0.00	42.00	8.84	14.00	1.58	SAFE
LIVINGSTON	US62/US641	2.78	12	C	54.00	288.00	20.88	10.00	0.48	UNSAFE-2
LOGAN	US431	27.41	5	B	26.00	53.00	11.14	15.00	1.35	SAFE
LOGAN	US431	27.73	3	B	21.00	48.00	10.64	20.00	1.88	SAFE
LOGAN	US431	28.91	2	B	17.00	41.50	10.19	17.00	1.67	SAFE
LOGAN	US68/80	10.38	1	B	0.00	42.00	8.84	18.00	2.04	SAFE
LOGAN	US68/KY80	2.80	2	A	20.00	35.00	10.30	18.00	1.75	SAFE
LOGAN	US68/KY80	20.94	2	B	16.00	23.00	9.74	18.00	1.85	SAFE
LOGAN	US79	2.91	3	A	16.00	247.00	9.94	26.00	2.62	SAFE
LOGAN	US79	4.64	3	A	23.00	34.00	10.52	16.00	1.52	SAFE
LOGAN	US79	5.93	2	A	19.00	40.00	10.32	18.00	1.74	SAFE
LOGAN	US79	9.43	1	B	0.00	27.00	8.54	10.00	1.17	SAFE
LYON	US62/US641	3.65	4	C	42.75	82.50	19.61	40.00	2.04	SAFE
MARSHALL	KY408	8.10	1	C	0.00	41.00	13.23	14.00	1.06	SAFE
MARSHALL	KY408	8.92	3	C	28.00	27.00	16.17	14.00	0.87	UNSAFE-2
MARSHALL	KY408	10.87	1	C	0.00	48.00	13.44	14.00	1.04	SAFE
MARSHALL	KY58/KY80	1.12	3	C	23.00	43.00	16.05	19.00	1.18	SAFE
MARSHALL	KY80	8.72	2	C	14.00	33.00	14.67	18.00	1.23	SAFE
MARSHALL	KY80	9.67	10	C	12.00	33.00	14.43	17.00	1.18	SAFE
MARSHALL	KY80	9.86	17	C	16.00	33.00	14.91	19.00	1.27	SAFE
MARSHALL	KY80	15.06	1	C	0.00	44.00	13.32	25.00	1.88	SAFE
MARSHALL	US62	8.81	2	C	20.00	85.75	16.97	24.00	1.41	SAFE
MARSHALL	US641	7.94	1	C	0.00	40.00	13.20	17.00	1.29	SAFE
MARSHALL	US641	7.95	1	C	0.00	40.00	13.20	20.00	1.52	SAFE
MARSHALL	US641	9.40	4	C	16.00	100.00	16.92	18.00	1.06	SAFE
MARSHALL	US641	9.83	4	C	16.00	50.00	15.42	18.00	1.17	SAFE
MARSHALL	US68 TB	9.43	2	C	18.75	203.00	16.71	26.00	1.56	SAFE
MARSHALL	US68/KY80	27.80	27	C	24.00	45.00	16.23	18.00	1.11	SAFE
McCRACKEN	US60	4.10	1	C	0.00	43.00	13.29	16.00	1.20	SAFE
McCRACKEN	US60	4.96	1	C	0.00	34.00	13.02	12.00	0.92	UNSAFE-2

SOLID ABUTMENT
ATC ANALYSIS

------------- GENERAL INFORMATION -------------						HEIGHT AND LENGTH		-- ATC --	- PROV'D --	RATIO	CONCL.
			MILE	No.		PIER	SPAN	L.SUP.REQ	L.SUP.PROV	C/D	
COUNTY	ROUTE		POST	SPAN	SPC	H (FT)	L (FT)	(INCH)	(INCH)		
McCRACKEN	US60		8.30	5	C	26.00	48.00	16.56	15.00	0.91	UNSAFE-2
McCRACKEN	US60		11.76	3	C	27.00	255.00	17.79	24.00	1.35	SAFE
McCRACKEN	US60	TB	10.80	3	C	20.50	80.00	16.86	36.00	2.14	SAFE
McCRACKEN	US62		12.95	3	C	35.00	78.00	18.54	14.00	0.76	UNSAFE-2
McCRACKEN	US62		12.98	5	C	27.00	41.00	16.47	23.00	1.40	SAFE
McCRACKEN	US68	TB	1.01	2	C	29.50	182.00	18.30	20.00	1.09	SAFE
McLEAN	KY136		17.13	1	B	0.00	40.00	8.80	20.00	2.27	SAFE
MUHLENBERG	US431		3.63	1	B	0.00	45.00	8.90	14.00	1.57	SAFE
MUHLENBERG	US431		13.31	1	B	0.00	100.00	10.00	18.00	1.80	SAFE
MUHLENBERG	US431		17.48	4	A	21.00	255.00	10.42	18.00	1.73	SAFE
OHIO	KY136		5.67	2	B	16.00	27.00	9.82	17.00	1.73	SAFE
OHIO	KY136		6.01	1	B	0.00	53.00	9.06	14.00	1.55	SAFE
OHIO	US231		11.46	4	B	17.00	33.00	10.02	18.00	1.80	SAFE
OHIO	US231		12.30	1	B	0.00	30.00	8.60	15.00	1.74	SAFE
OHIO	US231		13.32	3	B	35.00	73.00	12.26	20.00	1.63	SAFE
OHIO	US231	TB	6.70	3	B	22.50	36.00	10.52	18.00	1.71	SAFE
TODD	US68/KY80		1.55	1	B	0.00	30.00	8.60	16.00	1.86	SAFE
TODD	US68/KY80		3.15	1	A	0.00	60.00	9.20	16.00	1.74	SAFE
TODD	US68/KY80		9.10	2	A	15.00	40.00	10.00	14.00	1.40	SAFE
TODD	US79		7.61	4	A	18.00	43.00	10.30	17.00	1.65	SAFE
TRIGG	US68/KY80		3.11	3	B	46.00	44.00	12.56	18.00	1.43	SAFE
TRIGG	US68/KY80		8.27	32	C	28.00	45.00	16.71	20.00	1.20	SAFE
TRIGG	US68/KY80	TB	24.50	1	C	0.00	112.00	15.36	17.00	1.11	SAFE
UNION	KY130		12.54	3	C	16.00	15.00	14.37	18.00	1.25	SAFE
WARREN	US231		22.61	3	A	25.00	82.00	11.64	18.00	1.55	SAFE
WEBSTER	KY109		7.33	5	C	12.00	48.00	14.88	14.00	0.94	UNSAFE-2
WEBSTER	KY109		10.72	4	C	28.00	48.00	16.80	14.00	0.83	UNSAFE-2
WEBSTER	US41		11.68	4	C	25.00	43.00	16.29	26.00	1.60	SAFE

APPENDIX G

RESULTS OF SPAN-LOSS COLLAPSE AND ATC ANALYSIS FOR END BENT AND OPEN ABUTMENT

EBD BENT AND OPEN ABUTMENT
SPAN-LOSS ANALYSIS AND ATC ANALYSIS

--- GENERAL INFORMATION ---					-- PIER INFO. --		- MOMNET OF INERTIA -		- PIER	SPAN -	- MAX. DISPLACEMENT -		-- ATC --	-- PROV'D --	----- C/D RATIOS -----		--- CONCLUSION ---	
COUNTY	ROUTE	TB	MILE POST	SPC	PIER TYPE	No. C & P	IX (FT-4)	IY (FT-4)	H (FT)	L (FT)	LONGIT. DXmax (IN)	TRANSV. DYmax	L.SUP.REQ (INCH)	L.SUP.PROV (INCH)	SPAN-LOSS	ATC REQ'D		
BALLARD	KY121		0.00	D	10.0	5	0.09090	0.09090	45	31.75	11.518607	4.0809200	18.3525	30	2.6044814	1.6346546	SAFE	SAFE
BALLARD	KY121		3.15	D	10.0	5	0.09090	0.09090	35	31.75	6.1255107	2.1702032	17.1525	30	4.8975507	1.7490161	SAFE	SAFE
BALLARD	KY121		5.27	D	10.0	5	0.09090	0.09090	40	31.75	7.8866405	2.7941527	17.7525	30	3.8039010	1.6899028	SAFE	SAFE
BALLARD	US60		1.94	D	10.0	16	0.15400	0.15400	42	117	8.0585030	2.8550417	20.55	28	3.4745907	1.3625304	SAFE	SAFE
BALLARD	US60		5.74	D	10.0	9	0.091	0.091	23	91	5.1759972	1.8338006	17.49	11	2.1251943	0.6289308	SAFE	UNSAFE-2
BALLARD	US60		11.51	D	10.0	7	0.15400	0.15400	23	90	1.7269739	0.7	17.46	30	17.371426	1.7182130	SAFE	SAFE
BALLARD	US60		11.81	D	10.0	11	0.091	0.091	18	40	1.2144893	0.7	15.36	18	14.821044	1.171875	SAFE	SAFE
BUTLER	US231		16.32	D	10.0	9	0.24900	0.24900	75	50	18.578860	6.5822925	15	18	0.9688430	1.2	UNSAFE-1	SAFE
BUTLER	US231		17.11	B	10.0	9	0.24900	0.24900	75	50	18.697085	6.6241784	15	18	0.9627168	1.2	UNSAFE-1	SAFE
CALDWELL	KY672		14.08	C	10.0	7	0.09090	0.09090	25	38	2.4534804	0.8692419	16.14	12	4.8910111	0.7434944	SAFE	UNSAFE-2
CALLOWAY	KY121		21.57	C	10.0	8	0.09090	0.09090	45	33	12.593671	4.4618037	18.39	14	1.1116694	0.7612833	SAFE	UNSAFE-2
CALLOWAY	KY94		11.07	C	10.0	13	0.1540	0.1540	42.3	60	9.6393403	3.4151156	18.876	18	1.8673477	0.9535916	SAFE	UNSAFE-2
CALLOWAY	KY94		11.30	C	10.0	16	0.1540	0.1540	30.62	80	4.9633785	1.7584721	18.0744	24	4.8354159	1.3278449	SAFE	SAFE
CALLOWAY	KY94		11.44	C	10.0	13	0.1540	0.1540	33.84	50	5.6280595	1.9939615	17.5608	18	3.1982604	1.0250102	SAFE	SAFE
CALLOWAY	US641		5.66	C	10.0	14	0.0061	0.0190	28	240	20.327081	16.856244	22.56	18	0.8855181	0.7978723	UNSAFE-1	UNSAFE-2
CALLOWAY	US641		8.92	C	10.0	5	0.09090	0.09090	44	23	10.916568	3.8676237	17.97	18	1.6488698	1.0016694	SAFE	SAFE
CALLOWAY	US641	TB	15.65	C	10.0	18	0.15400	0.15400	27	230	3.0239807	1.0713641	22.14	20	6.6137986	0.9033423	SAFE	UNSAFE-2
CALLOWAY	US641	TB	15.81	C	10.0	9	0.15400	0.15400	20	106	1.1510299	0.7	17.58	20	17.375742	1.1376564	SAFE	SAFE
CARLISLE	KY121		9.38	D	10.0	6	0.09090	0.09090	25	32	2.8216797	0.9996910	15.96	18	6.3791769	1.1278195	SAFE	SAFE
CHRISTIAN	US41		29.51	B	10.0	5	0.42	0.42	35	30	2.0432358	0.7238967	11.4	15	7.3412963	1.3157894	SAFE	SAFE
CHRISTIAN	US41		30.88	B	2.0	4	3.5000	20.7000	22	38	0.7	0.7	15.78	15	21.428571	0.9505703	SAFE	UNSAFE-2
CHRISTIAN	US68/KY80		3.56	A	10.0	8	0.0034	0.0101	23.25	41.5	2.6428157	2.1151811	16.035	18	6.8109175	1.1225444	SAFE	SAFE
CHRISTIAN	US68/KY80		4.68	A	2.0	3	2.5000	8.7900	16	26	0.7	0.7	14.7	18	25.714285	1.2244897	SAFE	SAFE
CRITTENDEN	US60		22.99	C	10.0	8	0.0061	0.0190	52.00	80	19.811670	16.429005	20.64	15	0.7571218	0.7267441	UNSAFE-1	UNSAFE-2
DAVIESS	KY1554		1.42	B	10.0	7	0.1540	0.1540	50	33	10.345139	3.6651725	18.99	15	1.4499563	0.7898894	SAFE	UNSAFE-2
DAVIESS	US231		3.76	B	10.0	5	0.24900	0.24900	30	31.75	2.4407794	0.8647421	11.035	15	6.1455779	1.3593112	SAFE	SAFE
DAVIESS	US231		3.91	B	10.0	5	0.24900	0.24900	45	32	6.9823711	2.4737797	12.24	30	4.2965347	2.4509803	SAFE	SAFE
DAVIESS	US231		4.03	B	10.0	5	0.24900	0.24900	45	32	6.3986424	2.2669708	12.24	30	4.6884945	2.4509803	SAFE	SAFE
DAVIESS	US231		4.18	B	10.0	5	0.24900	0.24900	45	32	6.3986424	2.2669708	12.24	30	4.6884945	2.4509803	SAFE	SAFE
DAVIESS	US231		4.29	B	10.0	5	0.24900	0.24900	45	32	6.3986424	2.2669708	12.24	30	4.6884945	2.4509803	SAFE	SAFE
DAVIESS	US231		8.84	B	10.0	8	0.24900	0.24900	46.5	53	8.1605053	2.8911801	12.78	13	1.5930386	1.0172143	SAFE	SAFE
DAVIESS	US231		8.94	B	10.0	5	0.24900	0.24900	55	33	11.107316	3.9352041	13.06	15	1.3504611	1.1485451	SAFE	SAFE
DAVIESS	US231		9.22	B	10.0	5	0.24900	0.24900	55	33	11.306451	4.0057552	13.06	15	1.3266762	1.1485451	SAFE	SAFE
DAVIESS	US231	TB	11.29	B	10.0	7	0.09090	0.09090	25	36	2.8253141	1.0009787	10.72	15	5.3091441	1.3992537	SAFE	SAFE
FULTON	KY166		2.09	D	10.0	5	0.24900	0.24900	40	32	5.2117838	1.8464795	17.76	15	2.8780932	0.8445945	SAFE	UNSAFE-2
FULTON	KY166		9.03	D	10.0	5	0.24900	0.24900	40	31.75	4.9620681	1.7580079	17.7525	15	3.0229330	0.8449514	SAFE	UNSAFE-2
FULTON	KY166		12.71	D	10.0	10	0.15400	0.15400	40	160	5.5128736	1.9531524	21.6	15	2.7209039	0.6944444	SAFE	UNSAFE-2
GRAVES	KY121		7.96	C	10.0	5	0.24900	0.24900	32	31.75	3.0748249	1.0893777	16.7925	15	4.8783265	0.8932559	SAFE	UNSAFE-2
GRAVES	KY121		8.14	C	10.0	5	0.24900	0.24900	38	32	4.2982144	1.5228116	17.52	15	3.4898212	0.8561643	SAFE	UNSAFE-2
GRAVES	KY121		8.27	C	10.0	5	0.24900	0.24900	30	32	2.4272840	0.8599608	16.56	15	6.1797465	0.9057971	SAFE	UNSAFE-2
GRAVES	KY121		11.73	C	10.0	8	0.09090	0.09090	37.5	48	5.5180870	1.9549994	17.94	18	3.2620000	1.0033444	SAFE	SAFE
GRAVES	KY58		6.68	C	10.0	8	0.09090	0.09090	35	45	7.8040944	2.7649075	17.55	18	2.3064815	1.0256410	SAFE	SAFE
GRAVES	KY94		2.00	C	10.0	5	0.09090	0.09090	35	30	3.6588443	1.2962895	17.1	14	3.8263447	0.8187134	SAFE	UNSAFE-2
GRAVES	KY94		2.9	C	10.0	6	0.091	0.091	40	80	25.870546	9.8557093	19.2	18	0.6957719	0.9375	UNSAFE-1	UNSAFE-2
GRAVES	KY94	TB	2.96	C	10.0	5	0.09090	0.09090	30	30	2.4972291	0.8847416	16.5	14	5.6062136	0.8484848	SAFE	UNSAFE-2
GRAVES	US45/KY58		10.54	C	4.0	8	0.154	0.154	35	36	18.324399	6.4921394	17.34	16	0.8731527	0.9227220	UNSAFE-1	UNSAFE-2
HENDERSON	KY351	TB	1.40	C	10.0	17	0.15510	0.15510	52	53	11.880738	4.2092190	19.83	18	1.5150573	0.9077155	SAFE	UNSAFE-2

EBD BENT AND OPEN ABUTMENT
SPAN-LOSS ANALYSIS AND ATC ANALYSIS

--- GENERAL INFORMATION ---					-- PIER INFO. --		- MOMNET OF INERTIA -		- PIER	SPAN -	- MAX. DISPLACEMENT -		-- ATC --	-- PROV'D --	----- C/D RATIOS -----		--- CONCLUSION ---	
COUNTY	ROUTE	TB	MILE POST	SPC	PIER TYPE	No. C & P	IX (FT-4)	IY (FT-4)	H (FT)	L (FT)	LONGIT. DXmax (IN)	TRANSV. DYmax	L.SUP.REQ (INCH)	L.SUP.PROV (INCH)	SPAN-LOSS	ATC REQ'D		
HENDERSON	KY351		8.59	C	10.0	5	0.15400	0.15400	40	32	6.4125659	2.2719038	17.76	15	2.3391572	0.8445945	SAFE	UNSAFE-2
HENDERSON	US41		0.65	C	10.0	5	0.09090	0.09090	42	33	11.168431	3.9568563	18.03	30	2.6661426	1.6638935	SAFE	SAFE
HENDERSON	US41		6.20	C	10.0	6	0.09090	0.09090	57	33	22.400349	7.9441848	19.83	15	0.6696324	0.7564296	UNSAFE-1	UNSAFE-2
HENDERSON	US41		6.32	C	10.0	5	0.24900	0.24900	50	33	8.4584852	2.9967512	18.99	15	1.7733671	0.7898894	SAFE	UNSAFE-2
HENDERSON	US41		11.27	C	10.0	6	0.24900	0.24900	42	48	7.7520694	2.7464756	18.48	15	1.9349671	0.8116883	SAFE	UNSAFE-2
HENDERSON	US45		12.65	C	10.0	5	0.24900	0.24900	51	28	8.7138336	3.0872184	18.96	15	1.7214007	0.7911392	SAFE	UNSAFE-2
HENDERSON	US60		0.01	C	10.0	20	0.1540	0.1540	44	53.5	6.8831687	2.4386404	18.885	24	3.4867560	1.2708498	SAFE	SAFE
HENDERSON	US60		10.00	C	10.0	8	0.00610	0.01900	79	222	30.484267	29.474770	28.14	15	0.4920570	0.5330490	UNSAFE-1	UNSAFE-2
HENDERSON	US60		10.57	C	10.0	26	0.26300	0.26300	53	230	10.985378	3.8920027	25.26	30	2.7309025	1.1876484	SAFE	SAFE
HENDERSON	US60		10.64	C	10.0	11	0.15510	0.15510	58	53	19.846500	7.0314038	20.55	30	1.5116014	1.4598540	SAFE	SAFE
HICKMAN	KY58		19.82	D	10.0	4	0.00610	0.01900	60	33	25.735217	22.709612	20.19	15	0.5828588	0.7429420	UNSAFE-1	UNSAFE-2
HOPKINS	KY109		7.24	C	10.0	5	0.24900	0.24900	40	31.25	5.2365325	1.8552477	17.7375	15	2.8644909	0.8456659	SAFE	UNSAFE-2
HOPKINS	KY109		14.74	C	10.0	5	0.24900	0.24900	50	31.75	8.1273964	2.8794500	18.9525	15	1.8456094	0.7914523	SAFE	UNSAFE-2
HOPKINS	KY109		16.39	C	10.0	5	0.24900	0.24900	50	31.75	8.2105874	2.9089236	18.9525	15	1.8269094	0.7914523	SAFE	UNSAFE-2
HOPKINS	US41		6.13	C	10.0	5	0.24900	0.24900	45	31.75	6.9343678	2.4567726	18.3525	15	2.1631387	0.8173273	SAFE	UNSAFE-2
HOPKINS	US41A		0.49	C	10.0	5	0.15510	0.15510	45	30.25	10.716188	3.7966315	18.3075	15	1.3997513	0.8193363	SAFE	UNSAFE-2
HOPKINS	US41A		0.82	C	10.0	5	0.15510	0.15510	45	30.25	10.716188	3.7966315	18.3075	15	1.3997513	0.8193363	SAFE	UNSAFE-2
HOPKINS	US41A		5.30	C	10.0	15	0.0061	0.0190	50	300	21.360865	17.713509	27	16	0.7490333	0.5925925	UNSAFE-1	UNSAFE-2
HOPKINS	US41A		9.00	B	10.0	22	0.0061	0.0190	41	90	5.7651853	4.7807833	13.08	16	2.7752793	1.2232415	SAFE	SAFE
HOPKINS	US62		0.23	B	10.0	12	0.1540	0.1540	42	50	7.7900218	2.7599217	18.54	27	3.4659723	1.4563106	SAFE	SAFE
LIVINGSTON	US62/US641		0.64	C	10.0	5	0.00610	0.01900	50	33	11.681047	9.6865154	18.99	12	1.0273051	0.6319115	SAFE	UNSAFE-2
LIVINGSTON	US62/US641		0.64	C	2.0	9	0.0061	0.0190	28	33	30.053030	30.747580	16.35	27	0.8984118	1.6513761	UNSAFE-1	SAFE
LIVINGSTON	US62/US641		0.97	C	10.0	19	0.0061	0.0190	55	66	30.029377	30.819502	20.58	24	0.7992173	1.1661807	UNSAFE-1	SAFE
LIVINGSTON	US62/US641		1.20	C	10.0	10	0.0061	0.0190	41	60.5	30.041126	26.509290	18.735	24	0.7989047	1.2810248	UNSAFE-1	SAFE
LOGAN	US431		20.31	B	2.0	3	3.8000	12.0000	15.5	43	0.7	0.7	15.15	27	38.571428	1.7821782	SAFE	SAFE
LOGAN	US68/KY80		9.64	A	2.0	3	23.6300	289.0000	40.5	50	0.7	1.1714067	18.36	24	34.285714	1.3071895	SAFE	SAFE
LOGAN	US68/KY80		21.91	A	10.0	13	0.00610	0.01900	38	70	9.4373546	7.8259318	12.44	15	1.5694284	1.2057877	SAFE	SAFE
LYON	US62		11.60	B	10.0	14	0.0061	0.0190	26	71.5	1.4843863	1.2309282	17.265	30	20.210372	1.7376194	SAFE	SAFE
LYON	US62		12.20	C	10.0	16	0.15400	0.15400	40	56.5	6.6250021	2.3471677	18.495	15	2.2641502	0.8110300	SAFE	UNSAFE-2
LYON	US62/US641		6.80	C	10.0	14	0.1540	0.1540	4.5	309	0.7	0.7	21.81	24	34.285714	1.1004126	SAFE	SAFE
MARSHALL	KY408		8.82	C	10.0	3	0.24900	0.24900	30	31	2.7641128	0.9792957	16.53	15	5.4266958	0.9074410	SAFE	UNSAFE-2
MARSHALL	KY408		9.34	C	10.0	3	0.24900	0.24900	30	31.75	2.5898286	0.9175487	16.5525	15	5.7918888	0.9062075	SAFE	UNSAFE-2
MARSHALL	KY408		9.73	C	10.0	3	0.24900	0.24900	30	33	2.5677687	0.9097331	16.59	15	5.8416474	0.9041591	SAFE	UNSAFE-2
MARSHALL	KY80		12.52	C	4.0	4	0.336	0.336	17	34	2.9255408	1.0364879	15.06	17	5.8108913	1.1288180	SAFE	SAFE
MARSHALL	US62		2.47	C	10.0	11	0.09090	0.09090	50	43	14.941208	5.2935109	19.29	18	1.2047218	0.9331259	SAFE	UNSAFE-2
MARSHALL	US62		9.48	C	10.0	5	0.15400	0.15400	49	38	12.223560	4.3306774	19.02	15	1.2271383	0.7886435	SAFE	UNSAFE-2
MARSHALL	US62		10.87	C	10.0	9	0.15400	0.15400	66	48	24.499876	9.0843999	21.36	15	0.6122479	0.7022471	UNSAFE-1	UNSAFE-2
MARSHALL	US641	TB	0.24	C	10.0	9	0.15400	0.15400	33.33	146	4.1632529	1.4749961	20.3796	15	3.6029518	0.7360301	SAFE	UNSAFE-2
MARSHALL	US641		7.94	C	10.0	7	0.049	0.049	30	50	5.8310726	2.0658869	17.1	15	2.5724254	0.8771929	SAFE	UNSAFE-2
MARSHALL	US641		9.87	C	10.0	6	0.091	0.091	30	52	7.0039627	2.4814294	17.16	18	2.5699736	1.0489510	SAFE	SAFE
MARSHALL	US68		22.48	C	10.0	6	0.24900	0.24900	35	63	5.4025110	1.9140521	18.09	15	2.7764866	0.8291873	SAFE	UNSAFE-2
McCRACKEN	US60		6.69	C	2.0	2	3.3300	20.8300	23.25	48	0.7395539	1.0335163	16.23	24	32.451994	1.4787430	SAFE	SAFE
McCRACKEN	US60		11.09	C	10.0	25	0.15400	0.15400	60	116	16.345161	5.7909167	22.68	20	1.2236036	0.8818342	SAFE	UNSAFE-2
McCRACKEN	US62		13.06	C	10.0	17	0.15400	0.15400	42	38	7.2906801	2.5830103	18.18	21	2.8803896	1.1551155	SAFE	SAFE
McCRACKEN	US62		13.91	C	10.0	18	0.15400	0.15400	45	62	9.3666137	3.3184914	19.26	36	3.8434380	1.8691588	SAFE	SAFE
McCRACKEN	US62		18.64	C	10.0	20	0.091	0.091	42	120	13.236573	4.6895769	20.64	26	1.9642546	1.2596899	SAFE	SAFE
McLEAN	KY136		19.16	B	10.0	4	0.24900	0.24900	37	32.25	5.2068618	1.8447356	11.605	15	2.8808139	1.2925463	SAFE	SAFE
McLEAN	KY136		20.88	B	10.0	4	0.24900	0.24900	40	32.25	5.5032039	1.9497265	11.845	15	2.7256849	1.2663571	SAFE	SAFE

EBD BENT AND OPEN ABUTMENT
SPAN-LOSS ANALYSIS AND ATC ANALYSIS

--- GENERAL INFORMATION ---					-- PIER INFO. --		- MOMNET OF INERTIA -		- PIER	SPAN -	- MAX. DISPLACEMENT -		-- ATC --	-- PROV'D --	----- C/D RATIOS -----		--- CONCLUSION ---	
			MILE		PIER	No.					LONGIT.	TRANSV.	L.SUP.REQ	L.SUP.PROV	SPAN-	ATC		
COUNTY	ROUTE	TB	POST	SPC	TYPE	C & P	IX (FT-4)	IY (FT-4)	H (FT)	L (FT)	DXmax (IN)	DYmax	(INCH)	(INCH)	LOSS	REQ'D		
MUHLENBER	KY176		4.29	B	10.0	5	0.24900	0.24900	40	30	4.9620681	1.7580079	11.8	12	2.4183464	1.0169491	SAFE	SAFE
MUHLENBER	US431		3.45	B	10.0	4	0.24900	0.24900	35	32.5	3.5946286	1.2735386	11.45	12	3.3383142	1.0480349	SAFE	SAFE
MUHLENBER	US431		12.45	C	10.0	7	0.15510	0.15510	47	38	9.7875684	3.4676666	18.78	18	1.8390488	0.9584664	SAFE	UNSAFE-2
OHIO	KY136		1.06	B	10.0	4	0.24900	0.24900	42	33	5.6764909	2.0111202	12.02	15	2.6424775	1.2479201	SAFE	SAFE
OHIO	KY136		3.34	B	10.0	4	0.24900	0.24900	40	33	5.0248859	1.7802635	11.86	15	2.9851423	1.2647554	SAFE	SAFE
OHIO	US231		11.95	B	10.0	5	0.24900	0.24900	40	31.75	5.1123905	1.8112655	11.835	15	2.9340481	1.2674271	SAFE	SAFE
OHIO	US231		13.49	B	10.0	5	0.24900	0.24900	46	31.75	6.9800805	2.4729682	12.315	15	2.1489723	1.2180267	SAFE	SAFE
OHIO	US231		13.88	B	10.0	5	0.24900	0.24900	46	31.75	6.9800805	2.4729682	12.315	15	2.1489723	1.2180267	SAFE	SAFE
OHIO	US231		14.12	B	10.0	8	0.00610	0.01900	52	212	19.085515	15.826675	16.4	15	0.7859363	0.9146341	UNSAFE-1	UNSAFE-2
OHIO	US231		15.8	B	2.0	3	0.248	0.248	20	23	20.407355	7.2301087	10.06	18	0.8820349	1.7892644	UNSAFE-1	SAFE
OHIO	US231		20.30	B	10.0	5	0.24900	0.24900	48	30	8.1634604	2.8922270	12.44	15	1.8374560	1.2057677	SAFE	SAFE
TODD	US79		1.94	A	2.0	2	2.6700	10.6700	21.5	40	0.8160882	0.8155161	15.78	24	29.408585	1.5209125	SAFE	SAFE
TRIGG	US68		17.89	C	10.2	9	0.0034	0.0101	48	33	29.755219	30.928185	18.75	18	0.6049358	0.96	UNSAFE-1	UNSAFE-2
TRIGG	US68		17.89	C	2.1	2	2.8300	12.7900	12	33	0.7	0.7	14.43	24	34.285714	1.6632016	SAFE	SAFE
TRIGG	US68/KY80		10.94	C	10.0	7	0.15400	0.15400	38	33	5.5019540	1.9492837	17.55	15	2.7263041	0.8547008	SAFE	UNSAFE-2
UNION	KY130		13.47	C	10.0	5	0.24900	0.24900	50	38	9.2480249	3.2764767	19.14	15	1.6219679	0.7836990	SAFE	UNSAFE-2
UNION	US60		3.66	C	10.0	5	0.00610	0.01900	40	136	11.398401	9.4521314	20.88	15	1.3159739	0.7183908	SAFE	UNSAFE-2
UNION	US60		5.20	C	10.0	7	0.15400	0.15400	40	48	10.417296	3.6907370	18.24	15	1.4399129	0.8223684	SAFE	UNSAFE-2
UNION	US60		6.48	C	10.0	7	0.15400	0.15400	40	43	9.7295523	3.4470767	18.09	15	1.5416947	0.8291873	SAFE	UNSAFE-2
UNION	US60		13.06	C	10.0	7	0.15400	0.15400	40	106	7.9193779	2.8057512	19.98	15	1.8940881	0.7507507	SAFE	UNSAFE-2
WARREN	US68/KY80		8.2	A	10.0	11	0.019	0.0061	25	54	4.6538260	0.7	11.08	12	2.5785235	1.0830324	SAFE	SAFE
WARREN	US231		15.43	A	10.0	29	0.00610	0.01900	27	58	2.4728426	2.0506061	11.32	24	9.7054296	2.1201413	SAFE	SAFE
WARREN	US231		21.53	A	2.0	3	10.5000	72.3600	17	35	0.7	0.7	15.09	14	20	0.9277667	SAFE	UNSAFE-2
WEBSTER	KY109		1.03	B	10.0	9	0.00610	0.01900	29	32	4.3717837	3.6253042	10.96	12	2.7448749	1.0948905	SAFE	SAFE
WEBSTER	US41		6.86	C	2.0	3	9.4400	79.3900	34	70	0.7578176	1.3216941	18.18	26	34.309045	1.4301430	SAFE	SAFE
WEBSTER	US41		11.68	C	2.0	3	3.3300	20.8300	21.5	43	0.7	0.7402739	15.87	24	34.285714	1.5122873	SAFE	SAFE

APPENDIX H

RESULTS OF SISMIC MOMENT AND SHEAR FORCE ANALYSIS FOR PIER AND COLUMN

THE EARHTQUAKE MOMENTS AND SHEAR FORCES
IN PIER COLUMNS AND INTERMEDIATE BENTS

------------ GENERAL INFORMATION --------------						---- PIER INFORMATION ----				- MOMNET OF INERTIA -		-- E --	- MAXIMUM DISPL. -		--- SEISMIC MOMENTS ---			--- SEISMIC SHEAR FORCES ---		
COUNTY	ROUTE		MILE POST	No. SPAN	SPC	PIER TYPE	No. COL.	MAT	HEIGHT H (FT)	IX (FT-4)	IY (FT-4)	E (KSF)	DXma (	DYmax	Mx (KIPS-FT)	My (KIPS-FT)	M total (KIPS-FT)	Vx (KIPS)	Vy (KIPS)	V total (KIPS)
BALLARD	KY121		0.00	21	D	10.0	5	C	45.00	2.48E-01	2.48E-01	4.61E+05	8.73	3.09	4.93E+02	3.49E+02	604.13140	2.19E+01	3.10E+01	37.998386
BALLARD	KY121		3.15	9	D	10.0	5	C	35.00	2.48E-01	2.48E-01	4.61E+05	4.97	1.76	4.63E+02	3.28E+02	567.98445	2.65E+01	3.75E+01	45.931901
BALLARD	KY121		5.30	3	D	10.0	5	C	40.00	2.48E-01	2.48E-01	4.61E+05	6.78	2.40	4.85E+02	3.43E+02	593.90354	2.42E+01	3.43E+01	42.024441
BALLARD	US60		1.94	2	D	4.0	4	C	18.60	4.00E+00	4.00E+00	4.61E+05	2.12	0.75	2.83E+03	2.00E+03	3463.5877	1.52E+02	2.15E+02	263.52952
BALLARD	US60		2.50	2	D	1.0	1	C	12.00	2.22E+03	2.86E+01	4.61E+05	0.70	0.70	1.60E+04	1.24E+06	1242890.4	1.34E+03	1.04E+05	103574.20
BALLARD	US60		11.51	3	D	10.0	7	C	22.30	1.54E-01	1.54E-01	4.61E+05	2.06	0.73	2.94E+02	2.09E+02	360.75063	2.64E+01	3.74E+01	45.787640
BALLARD	US60		11.81	3	D	10.0	9	C	32.00	9.10E-02	9.10E-02	4.61E+05	11.49	4.07	4.71E+02	3.33E+02	576.87469	2.94E+01	4.17E+01	51.021077
BUTLER	US231		4.63	5	B	3.0	1	C	16.00	2.66E+03	5.00E+01	4.61E+05	0.70	0.70	1.58E+04	8.39E+05	839041.91	9.85E+02	5.24E+04	52440.119
BUTLER	US231	TB	6.8	2	B	2.0	9	C	22.00	1.92E+00	1.92E+00	4.61E+05	5.43	1.92	2.48E+03	1.76E+03	3040.5890	1.13E+02	1.60E+02	195.46342
BUTLER	US231		12.26	10	B	1.3	1	C	128.00	2.76E+04	2.80E+03	4.61E+05	13.30	2.40	2.62E+05	4.66E+05	534264.56	2.05E+03	3.64E+03	4173.9418
BUTLER	US231		16.32	6	B	10.0	5	C	76.00	2.48E-01	2.48E-01	4.61E+05	30.86	12.84	6.11E+02	5.08E+02	794.61790	1.61E+01	2.67E+01	31.204309
BUTLER	US231		17.11	5	B	10.0	5	C	75.00	2.48E-01	2.48E-01	4.61E+05	30.50	12.61	6.20E+02	5.13E+02	804.51285	1.65E+01	2.73E+01	31.953311
BUTLER	US231		17.76	2	A	2.0	7	C	16.60	1.90E+02	2.75E+02	4.61E+05	0.70	0.70	8.05E+04	1.11E+05	137327.91	4.85E+03	1.34E+04	14254.307
CALDWELL	KY672		14.08	4	C	10.0	5	C	38.00	9.10E-02	9.10E-02	4.61E+05	12.22	4.33	3.55E+02	2.51E+02	434.95209	1.67E+01	2.65E+01	32.396930
CALDWELL	KY91		12.24	4	B	2.0	3	C	22.00	6.75E+00	6.75E+00	4.61E+05	3.11	1.10	5.00E+03	3.54E+03	6123.0030	2.27E+02	3.21E+02	393.65510
CALLOWAY	KY121		21.57	8	C	10.0	8	C	35.00	9.00E-02	9.80E-02	4.61E+05	11.31	4.27	4.17E+02	2.89E+02	507.79048	2.38E+01	3.31E+01	40.772035
CALLOWAY	KY94		11.07	4	C	4.0	3	C	21.50	4.00E+00	4.00E+00	4.61E+05	3.68	1.31	3.67E+03	2.60E+03	4504.0546	1.71E+02	2.42E+02	296.47031
CALLOWAY	KY94		11.30	5	C	4.0	3	C	23.50	4.00E+00	4.00E+00	4.61E+05	4.03	1.43	3.37E+03	2.39E+03	4126.7560	1.43E+02	2.03E+02	248.51749
CALLOWAY	KY94		11.44	4	C	4.0	4	C	22.00	4.00E+00	4.00E+00	4.61E+05	3.10	1.10	2.95E+03	2.09E+03	3618.2394	1.34E+02	1.90E+02	232.75051
CALLOWAY	KY94		17.10	2	C	1.0	1	C	20.00	6.21E+03	4.04E+01	4.61E+05	2.64	0.70	3.07E+04	1.25E+06	1252150.6	1.54E+03	6.26E+04	62607.530
CALLOWAY	KY94		23.03	3	C	1.0	1	C	10.00	2.22E+03	2.86E+01	4.61E+05	0.71	0.70	2.34E+04	1.79E+06	1789766.5	2.34E+03	1.79E+05	178976.65
CALLOWAY	US641		1.15	4	C	1.0	1	C	17.00	2.28E+04	1.02E+02	4.61E+05	0.70	0.70	2.85E+04	6.36E+06	6359710.2	1.67E+03	3.74E+05	374100.60
CALLOWAY	US641		5.66	3	C	10.0	1	C	20.75	6.45E+03	2.30E+01	4.61E+05	0.70	0.70	1.72E+04	9.67E+06	9665369.8	1.66E+03	1.86E+06	1863201.6
CALLOWAY	US641		8.92	3	C	10.0	6	C	44.00	1.54E-01	1.54E-01	4.61E+05	11.84	4.20	4.34E+02	3.08E+02	532.35116	1.97E+01	2.80E+01	34.244557
CALLOWAY	US641	TB	15.65	3	C	10.0	15	C	32.00	1.54E-01	1.54E-01	4.61E+05	6.99	2.48	4.84E+02	3.43E+02	593.75839	3.03E+01	4.29E+01	52.517713
CALLOWAY	US641	TB	15.81	3	C	10.0	8	C	33.00	1.54E-01	1.54E-01	4.61E+05	7.13	2.53	4.65E+02	3.29E+02	569.79495	2.82E+01	3.99E+01	48.870938
CARLISLE	KY121		9.38	5	D	10.0	7	C	37.00	9.10E-02	9.10E-02	4.61E+05	14.09	4.99	4.32E+02	3.06E+02	529.18791	2.33E+01	3.31E+01	40.481278
CARLISLE	US62		3.88	3	C	4.0	2	C	37.00	6.75E+00	6.75E+00	4.61E+05	4.92	1.74	2.79E+03	1.98E+03	3423.9790	7.55E+01	1.07E+02	130.96202
CHRISTIAN	KY91		4.43	3	B	1.0	1	C	19.00	1.52E+03	6.40E+00	4.61E+05	3.79	0.70	7.74E+03	3.40E+05	339772.46	4.08E+02	1.79E+04	17882.761
CHRISTIAN	KY91		11.26	2	B	1.0	1	C	15.00	4.39E+03	5.85E+01	4.61E+05	0.70	0.70	2.10E+04	1.58E+06	1575632.7	1.40E+03	1.05E+05	105042.18
CHRISTIAN	KY91		13.07	2	B	1.0	1	C	20.00	8.19E+03	7.20E+01	4.61E+05	0.70	0.70	1.45E+04	1.65E+06	1652287.8	7.26E+02	8.26E+04	82614.390
CHRISTIAN	US41		15.33	3	A	1.0	1	C	20.00	1.33E+04	2.86E+01	4.61E+05	0.70	0.70	5.77E+03	2.67E+06	2672567.2	2.88E+02	1.34E+05	133628.36
CHRISTIAN	US41		29.51	2	B	10.0	5	C	35.00	4.20E-01	4.20E-01	4.61E+05	2.95	1.05	4.66E+02	3.31E+02	571.70333	2.67E+01	3.78E+01	46.232641
CHRISTIAN	US41		30.88	5	B	2.0	3	C	31.00	6.75E+00	6.75E+00	4.61E+05	1.36	0.70	1.10E+03	1.13E+03	1576.4996	3.54E+01	7.31E+01	81.254773
CHRISTIAN	US41A		10.87	2	B	2.0	4	C	14.00	3.25E+00	3.25E+00	4.61E+05	1.01	0.70	1.94E+03	2.68E+03	3302.4095	1.38E+02	3.82E+02	406.45273
CHRISTIAN	US41A	TB	4.43	2	A	4.0	4	C	23.00	1.46E+01	1.46E+01	4.61E+05	1.56	0.70	4.96E+03	4.46E+03	6673.8667	2.16E+02	3.88E+02	443.98212
CHRISTIAN	US41A		13.44	2	A	2.0	6	C	33.00	6.75E+00	6.75E+00	4.61E+05	12.15	4.30	8.68E+03	6.15E+03	10633.295	2.63E+02	3.73E+02	456.00539
CHRISTIAN	US68/KY80		3.56	3	A	2.0	3	C	25.00	1.91E+00	1.91E+00	4.61E+05	10.16	3.60	3.58E+03	2.54E+03	4387.7378	1.43E+02	2.03E+02	248.38004
CHRISTIAN	US68/KY80		4.68	3	A	2.0	1	C	18.50	5.93E+03	6.00E+00	4.61E+05	1.80	0.70	3.65E+03	2.80E+06	2796578.5	1.97E+02	3.02E+05	302332.62
CHRISTIAN	US68/KY80		10.76	3	A	1.0	1	C	22.00	7.32E+03	1.49E+02	4.61E+05	1.19	0.70	4.23E+04	1.22E+06	1220409.4	1.92E+03	5.54E+04	55473.158
CHRISTIAN	US68/KY80		11.20	2	A	2.0	7	C	18.00	9.29E+00	9.29E+00	4.61E+05	1.37	0.70	4.52E+03	4.63E+03	6466.0948	2.51E+02	5.14E+02	572.03361
CHRISTIAN	US68/KY80		18.18	3	B	1.0	1	C	20.00	4.52E+03	1.76E+01	4.61E+05	0.70	0.70	3.56E+03	9.11E+05	911432.74	1.78E+02	4.56E+04	45571.637
CRITTENDEN	US60		22.99	3	C	2.0	2	C	55.00	6.59E+02	1.25E+03	4.61E+05	0.75	0.70	3.57E+04	3.52E+04	50072.049	6.48E+02	1.28E+03	1433.2348
DAVIESS	KY1554		0.90	2	B	2.0	4	C	16.50	8.44E-01	8.44E-01	4.61E+05	4.06	1.44	1.45E+03	1.03E+03	1778.2778	8.79E+01	1.25E+02	152.52172
DAVIESS	KY1554		1.42	3	B	4.0	1	C	25.50	1.73E+03	9.00E+00	4.61E+05	3.44	0.70	5.49E+03	4.29E+05	429061.10	2.15E+02	3.36E+04	33649.785
DAVIESS	US231		3.76	5	B	10.0	5	C	27.00	2.48E-01	2.48E-01	4.61E+05	3.07	1.09	4.82E+02	3.42E+02	590.95186	3.57E+01	5.06E+01	61.949009

THE EARHTQUAKE MOMENTS AND SHEAR FORCES
IN PIER COLUMNS AND INTERMEDIATE BENTS

GENERAL INFORMATION						PIER INFORMATION				MOMNET OF INERTIA		E	MAXIMUM DISPL.		SEISMIC MOMENTS			SEISMIC SHEAR FORCES		
COUNTY	ROUTE		MILE POST	No. SPAN	SPC	PIER TYPE	No. COL.	MAT	HEIGHT H (FT)	IX (FT-4)	IY (FT-4)	E (KSF)	DXma (	DYmax	Mx (KIPS-FT)	My (KIPS-FT)	M total (KIPS-FT)	Vx (KIPS)	Vy (KIPS)	V total (KIPS)
DAVIESS	US231		3.91	5	B	10.0	5	C	45.00	2.48E-01	2.48E-01	4.61E+05	10.95	3.88	6.18E+02	4.38E+02	757.57542	2.75E+01	3.89E+01	47.649613
DAVIESS	US231		4.03	5	B	10.0	5	C	45.00	2.48E-01	2.48E-01	4.61E+05	26.89	10.44	1.52E+03	1.18E+03	1922.5344	6.75E+01	1.05E+02	124.67185
DAVIESS	US231		4.18	5	B	10.0	5	C	45.00	2.48E-01	2.48E-01	4.61E+05	26.89	10.44	1.52E+03	1.18E+03	1922.5344	6.75E+01	1.05E+02	124.67185
DAVIESS	US231		4.29	5	B	10.0	5	C	45.00	2.48E-01	2.48E-01	4.61E+05	9.78	3.47	5.52E+02	3.91E+02	676.86142	2.45E+01	3.48E+01	42.572903
DAVIESS	US231		8.84	3	B	2.0	1	C	42.00	4.33E+03	5.90E+01	4.61E+05	5.57	0.70	2.15E+04	3.96E+05	396821.96	5.11E+02	1.89E+04	18875.520
DAVIESS	US231		8.94	7	B	10.0	6	C	50.00	2.48E-01	2.48E-01	4.61E+05	11.89	4.21	5.44E+02	3.85E+02	666.25253	2.17E+01	3.08E+01	37.715068
DAVIESS	US231		9.22	4	B	10.0	6	C	50.00	2.48E-01	2.48E-01	4.61E+05	11.30	4.00	5.17E+02	3.66E+02	633.30291	2.07E+01	2.93E+01	35.849863
DAVIESS	US231	TB	11.29	4	B	2.0	3	C	30.00	6.18E+00	7.75E+00	4.61E+05	4.47	1.86	4.44E+03	2.97E+03	5339.0008	1.48E+02	1.98E+02	247.12683
FULTON	KY166		2.09	3	D	10.0	5	C	40.00	2.50E-01	2.50E-01	4.61E+05	7.02	2.49	5.06E+02	3.58E+02	619.60530	2.53E+01	3.58E+01	43.843090
FULTON	KY166		9.03	3	D	10.0	5	C	40.00	2.50E-01	2.50E-01	4.61E+05	6.87	2.43	4.95E+02	3.51E+02	606.59279	2.47E+01	3.51E+01	42.922329
FULTON	KY166	TB	12.71	3	D	4.0	3	C	28.00	6.75E+00	6.75E+00	4.61E+05	2.68	0.95	2.66E+03	1.69E+03	3263.4930	9.51E+01	1.35E+02	164.94558
FULTON	KY94		17.85	2	D	3.0	1	C	19.00	2.68E+03	1.07E+02	4.61E+05	0.70	0.70	2.39E+04	5.99E+05	599394.05	1.26E+03	3.15E+04	31547.055
FULTON	US51		1.16	2	D	4.0	6	C	19.00	9.88E+00	9.88E+00	4.61E+05	1.15	0.70	3.62E+03	4.42E+03	5708.0726	1.90E+02	4.65E+02	502.30072
GRAVES	KY121		7.96	7	C	10.0	5	C	32.00	2.50E-01	2.50E-01	4.61E+05	5.08	1.80	5.71E+02	4.05E+02	700.11031	3.57E+01	5.06E+01	61.924502
GRAVES	KY121		8.14	4	C	10.0	5	C	30.00	2.50E-01	2.50E-01	4.61E+05	3.73	1.32	4.77E+02	3.38E+02	585.09521	3.18E+01	4.51E+01	55.201555
GRAVES	KY121		8.27	6	C	10.0	5	C	30.00	2.50E-01	2.50E-01	4.61E+05	3.62	1.28	4.64E+02	3.29E+02	568.36887	3.09E+01	4.38E+01	53.625374
GRAVES	KY121		8.75	2	C	1.0	1	C	11.00	1.07E+04	7.88E+01	4.61E+05	0.70	0.70	5.25E+04	7.15E+06	7146731.3	4.78E+03	6.50E+05	649702.84
GRAVES	KY121		11.73	4	C	4.0	2	C	26.00	6.75E+00	6.75E+00	4.61E+05	3.90	1.38	4.49E+03	3.18E+03	5506.8772	1.73E+02	2.45E+02	299.74232
GRAVES	KY121		20.19	5	C	2.0	3	C	40.00	6.75E+00	6.75E+00	4.61E+05	9.26	3.28	4.50E+03	3.19E+03	5516.4935	1.13E+02	1.59E+02	195.17273
GRAVES	KY58		0.51	3	C	2.0	2	C	40.00	6.75E+00	6.75E+00	4.61E+05	6.78	2.40	3.30E+03	2.34E+03	4041.3994	8.24E+01	1.17E+02	142.98412
GRAVES	KY58		2.83	2	C	3.0	1	C	12.00	1.71E+03	1.28E+02	4.61E+05	0.70	0.70	7.17E+04	9.60E+05	962930.53	5.98E+03	8.00E+04	80244.211
GRAVES	KY58		5.27	2	C	4.0	3	C	19.00	9.88E+00	9.88E+00	4.61E+05	1.67	0.70	5.25E+03	4.42E+03	6862.8085	2.76E+02	4.65E+02	540.84811
GRAVES	KY58		6.68	3	C	10.0	14	C	35.00	1.55E-01	1.55E-01	4.61E+05	7.35	2.60	4.29E+02	3.04E+02	525.42532	2.45E+01	3.47E+01	42.490220
GRAVES	KY58/KY80		12.25	3	C	3.0	1	C	40.00	2.66E+03	5.00E+01	4.61E+05	2.88	0.70	1.04E+04	1.34E+05	134624.10	2.60E+02	3.36E+03	3365.6026
GRAVES	KY94		2.00	4	C	10.0	5	W	35.00	4.00E-02	4.00E-02	1.00E+06	4.99	1.77	1.63E+02	1.15E+02	199.77260	9.31E+00	1.32E+01	16.155258
GRAVES	KY94	TB	2.96	3	C	10.0	5	W	35.00	4.00E-02	4.00E-02	1.00E+06	4.94	1.75	1.61E+02	1.14E+02	197.66143	9.22E+00	1.31E+01	15.984531
GRAVES	US45		1.68	3	C	2.0	3	C	29.00	1.69E+00	1.69E+00	4.61E+05	7.40	2.62	1.72E+03	1.22E+03	2103.4408	5.92E+01	8.39E+01	102.64749
GRAVES	US45		17.80	3	C	2.0	3	C	29.00	6.75E+00	6.75E+00	4.61E+05	7.25	2.57	6.71E+03	4.75E+03	8222.5881	2.31E+02	3.28E+02	401.26064
GRAVES	US45		17.86	3	C	2.0	4	C	29.00	6.75E+00	6.75E+00	4.61E+05	2.06	0.73	1.90E+03	1.35E+03	2331.6798	6.56E+01	9.30E+01	113.78550
GRAVES	US45/KY58		10.54	4	C	4.0	8	C	35.00	1.54E-01	1.54E-01	4.61E+05	25.61	9.71	3.71E+02	2.81E+02	465.60051	1.06E+01	1.61E+01	19.254113
GRAVES	US45/KY58		12.20	3	C	1.0	1	C	22.00	2.73E+03	2.67E+00	4.61E+05	10.75	0.70	6.82E+03	4.55E+05	455198.17	3.10E+02	2.07E+04	20690.828
HENDERSON	A-PKY		15.78	4	C	1.3	1	C	119.00	6.05E+04	4.83E+02	4.61E+05	26.57	0.78	1.05E+05	3.84E+05	397736.31	8.78E+02	3.22E+03	3342.3219
HENDERSON	KY351		8.59	4	C	10.0	6	C	38.00	1.54E-01	1.54E-01	4.61E+05	6.63	2.35	3.26E+02	2.31E+02	399.56244	1.72E+01	2.43E+01	29.760970
HENDERSON	KY351	TB	1.40	3	C	4.0	3	C	24.00	2.73E+00	2.73E+00	4.61E+05	6.00	2.12	3.28E+03	2.32E+03	4015.2737	1.37E+02	1.93E+02	236.76633
HENDERSON	KY416		16.88	2	C	4.0	5	C	20.00	7.70E+00	7.70E+00	4.61E+05	1.81	0.70	4.01E+03	3.11E+03	5070.2363	2.00E+02	3.11E+02	369.62403
HENDERSON	US41		0.65	3	C	10.0	5	C	34.00	2.50E-01	2.50E-01	4.61E+05	4.48	1.59	4.46E+02	3.16E+02	547.07891	2.63E+01	3.72E+01	45.542522
HENDERSON	US41		6.20	3	C	10.0	6	C	56.00	2.50E-01	2.50E-01	4.61E+05	11.98	4.24	4.40E+02	3.12E+02	539.49186	1.57E+01	2.23E+01	27.267347
HENDERSON	US41		6.32	3	C	10.0	6	C	48.00	2.50E-01	2.50E-01	4.61E+05	8.72	3.09	4.36E+02	3.09E+02	534.55140	1.82E+01	2.58E+01	31.520584
HENDERSON	US41		11.27	3	C	1.0	1	C	40.00	1.06E+04	3.20E+01	4.61E+05	6.10	0.70	1.41E+04	5.33E+05	533295.88	3.52E+02	1.33E+04	13332.397
HENDERSON	US41		12.65	3	C	10.0	5	C	51.00	2.50E-01	2.50E-01	4.61E+05	9.61	3.40	4.26E+02	3.02E+02	521.67870	1.67E+01	2.37E+01	28.952025
HENDERSON	US60		0.01	13	C	1.3	1	C	28.00	1.30E+04	1.66E+02	4.61E+05	0.81	0.70	1.99E+04	1.34E+06	1335185.7	7.11E+02	4.77E+04	47685.203
HENDERSON	US60		10.00	3	C	10.0	11	S	79.00	6.10E-03	1.90E-02	4.18E+06	28.35	29.57	3.61E+02	2.42E+02	434.17567	9.13E+00	1.22E+01	15.266250
HENDERSON	US60		10.57	3	C	4.0	3	C	28.00	4.39E+00	5.85E+00	4.61E+05	9.22	4.05	7.93E+03	5.23E+03	9497.8207	2.83E+02	3.73E+02	468.64441
HENDERSON	US60		10.64	3	C	4.0	3	C	26.00	4.39E+00	5.85E+00	4.61E+05	4.04	1.77	4.03E+03	2.66E+03	4824.7938	1.55E+02	2.04E+02	256.37927
HICKMAN	KY58		19.82	5	D	1.1	1	C	38.00	3.80E+03	5.08E+01	4.61E+05	3.91	0.70	1.59E+04	2.12E+05	212949.28	4.17E+02	5.59E+03	5603.9286
HICKMAN	KY58		19.82	5	D	10.1	4	S	60.00	6.10E-03	1.90E-02	4.18E+06	30.14	30.48	6.65E+02	4.32E+02	792.84179	2.22E+01	2.88E+01	36.331002
HICKMAN	KY94		0.24	3	D	10.0	8	S	60.00	2.10E-02	5.92E-01	4.18E+06	0.70	2.06	4.81E+02	1.00E+02	491.51961	1.60E+01	6.69E+00	17.378417
HICKMAN	KY94		2.01	2	D	4.0	3	C	19.00	8.00E+00	8.00E+00	4.61E+05	1.84	0.70	4.69E+03	3.58E+03	5899.7722	2.47E+02	3.76E+02	450.18481

THE EARHTQUAKE MOMENTS AND SHEAR FORCES
IN PIER COLUMNS AND INTERMEDIATE BENTS

------------ GENERAL INFORMATION --------------						---- PIER INFORMATION ----				- MOMNET OF INERTIA -		-- E --	- MAXIMUM DISPL. -		--- SEISMIC MOMENTS ---			--- SEISMIC SHEAR FORCES ---		
COUNTY	ROUTE		MILE POST	No. SPAN	SPC	PIER TYPE	No. COL.	MAT	HEIGHT H (FT)	IX (FT-4)	IY (FT-4)	E (KSF)	DXma (	DYmax	Mx (KIPS-FT)	My (KIPS-FT)	M total (KIPS-FT)	Vx (KIPS)	Vy (KIPS)	V total (KIPS)
HOPKINS	KY109		3.81	4	B	2.0	2	C	22.00	6.75E+00	6.75E+00	4.61E+05	3.07	1.09	4.93E+03	3.49E+03	6044.4992	2.24E+02	3.18E+02	388.82454
HOPKINS	KY109		4.50	3	B	2.0	3	C	31.00	1.05E+01	7.34E+00	4.61E+05	4.13	1.12	3.64E+03	2.82E+03	4605.1942	1.17E+02	1.82E+02	216.62289
HOPKINS	KY109		6.49	3	B	2.0	3	C	35.00	7.83E+00	6.30E+00	4.61E+05	6.44	1.94	3.82E+03	2.86E+03	4768.3687	1.09E+02	1.63E+02	196.34843
HOPKINS	KY109		7.24	5	C	10.0	5	C	40.00	2.50E-01	2.50E-01	4.61E+05	7.86	2.79	5.68E+02	4.02E+02	695.81063	2.84E+01	4.02E+01	49.235357
HOPKINS	KY109		14.74	11	C	10.0	5	C	50.00	2.50E-01	2.50E-01	4.61E+05	12.43	4.40	5.73E+02	4.06E+02	702.37429	2.29E+01	3.25E+01	39.759839
HOPKINS	KY109		16.39	5	C	10.0	5	C	50.00	2.50E-01	2.50E-01	4.61E+05	12.47	4.42	5.75E+02	4.07E+02	704.40604	2.30E+01	3.26E+01	39.874852
HOPKINS	KY1751		1.14	3	C	1.0	1	C	38.00	7.66E+03	1.02E+02	4.61E+05	2.78	0.70	2.27E+04	4.28E+05	428668.85	5.97E+02	1.13E+04	11280.759
HOPKINS	US41		6.13	4	C	10.0	5	C	47.00	2.50E-01	2.50E-01	4.61E+05	10.86	3.85	5.66E+02	4.01E+02	694.16668	2.41E+01	3.42E+01	41.803431
HOPKINS	US41A		0.49	3	C	10.0	10	C	46.00	1.55E-01	1.55E-01	4.61E+05	11.08	3.93	3.74E+02	2.65E+02	458.64326	1.63E+01	2.31E+01	28.220403
HOPKINS	US41A		0.62	3	C	10.0	10	C	46.00	2.63E-01	2.63E-01	4.61E+05	7.51	2.66	4.30E+02	3.05E+02	527.30984	1.87E+01	2.65E+01	32.445470
HOPKINS	US41A		3.42	7	C	3.0	3	C	27.00	1.25E+01	1.25E+01	4.61E+05	1.83	4.16	3.61E+03	8.21E+03	8971.1444	1.34E+02	3.04E+02	332.26480
HOPKINS	US41A		6.59	9	C	2.0	3	C	39.00	6.91E+00	9.50E+00	4.61E+05	6.48	2.92	4.67E+03	3.05E+03	5577.1403	1.20E+02	1.57E+02	197.05783
HOPKINS	US41A		9.00	3	B	4.0	4	C	33.00	6.58E+01	6.58E+01	4.61E+05	1.20	0.70	8.35E+03	9.74E+03	12832.952	2.53E+02	5.90E+02	642.38620
HOPKINS	US41A		13.11	2	B	1.0	1	C	21.00	3.64E+03	1.26E+02	4.61E+05	0.70	0.70	2.31E+04	6.66E+05	665924.59	1.10E+03	3.17E+04	31710.694
HOPKINS	US41A		15.33	6	B	2.0	2	C	29.00	4.80E+01	4.80E+01	4.61E+05	1.38	0.70	9.06E+03	9.21E+03	12916.991	3.12E+02	6.35E+02	707.75200
HOPKINS	US41A	TB	5.30	6	C	4.0	3	C	35.00	6.75E+00	6.75E+00	4.61E+05	16.89	5.98	1.07E+04	7.60E+03	13142.937	3.06E+02	4.34E+02	531.42309
HOPKINS	US62		0.23	3	B	3.0	1	C	11.00	8.00E+03	3.94E+01	4.61E+05	0.70	0.70	2.63E+04	5.33E+06	5333948.9	2.39E+03	4.85E+05	484904.45
LIVINGSTON	US60		12.37	15	C	1.3	1	C	165.00	1.60E+04	3.25E+02	4.61E+05	29.90	5.27	4.11E+04	3.57E+05	359812.93	2.49E+02	2.17E+03	2180.6844
LIVINGSTON	US62/US641		0.64	10	C	2.1	5	C	33.00	1.03E+01	1.03E+01	4.61E+05	4.21	1.49	4.58E+03	3.25E+03	5618.3414	1.39E+02	1.97E+02	240.94072
LIVINGSTON	US62/US641		0.64	10	C	10.2	6	S	50.00	6.10E-03	1.90E-02	4.18E+06	29.62	26.13	9.41E+02	5.33E+02	1081.3588	3.76E+01	4.26E+01	56.877150
LIVINGSTON	US62/US641		0.97	3	C	4.0	5	C	31.00	6.75E+00	6.75E+00	4.61E+05	10.44	3.70	8.45E+03	5.99E+03	10354.470	2.73E+02	3.86E+02	472.69632
LIVINGSTON	US62/US641		2.78	12	C	2.0	2	C	108.00	1.65E+01	1.65E+01	4.61E+05	22.52	28.43	3.67E+03	9.27E+03	9970.6933	3.40E+01	1.72E+02	175.00214
LIVINGSTON	US62/US641	TB	1.20	3	C	4.0	3	C	26.00	6.75E+00	6.75E+00	4.61E+05	3.90	1.36	4.49E+03	3.18E+03	5506.8772	1.73E+02	2.45E+02	299.74232
LOGAN	US431		20.31	3	B	2.0	3	C	27.00	2.75E+00	2.75E+00	4.61E+05	5.85	2.07	2.54E+03	1.80E+03	3117.4023	9.42E+01	1.34E+02	163.39739
LOGAN	US431		27.41	5	B	1.3	1	C	36.00	3.04E+03	5.18E+01	4.61E+05	3.36	0.70	1.55E+04	1.89E+05	189979.93	4.29E+02	5.26E+03	5277.2204
LOGAN	US431		27.73	3	B	3.0	1	C	20.00	1.31E+03	3.85E+00	4.61E+05	4.89	0.70	5.43E+03	2.65E+05	264802.70	2.71E+02	1.32E+04	13240.135
LOGAN	US431		28.91	2	B	3.0	1	C	17.00	1.31E+03	3.85E+00	4.61E+05	2.95	0.70	4.53E+03	3.66E+05	366460.01	2.67E+02	2.16E+04	21556.471
LOGAN	US68/KY80		2.80	2	A	1.0	1	C	25.00	4.29E+02	5.25E+00	4.61E+05	6.54	0.70	6.33E+03	5.53E+04	55704.407	2.53E+02	2.21E+03	2228.1763
LOGAN	US68/KY80		9.64	7	A	2.0	3	C	37.00	3.46E+01	2.42E+01	4.61E+05	4.10	1.11	8.37E+03	6.49E+03	10590.536	2.26E+02	3.51E+02	417.31667
LOGAN	US68/KY80		20.94	2	B	1.0	1	C	16.00	3.62E+04	1.18E+02	4.61E+05	0.70	0.70	3.72E+04	1.14E+07	11400377.	2.33E+03	7.13E+05	712523.56
LOGAN	US68/KY80		21.91	3	A	2.0	3	C	39.00	1.25E+01	1.25E+01	4.61E+05	8.15	2.89	7.72E+03	5.47E+03	9460.2255	1.98E+02	2.80E+02	343.28348
LOGAN	US79		2.91	3	A	1.0	1	C	15.00	6.91E+03	7.23E+01	4.61E+05	0.70	0.70	2.59E+04	2.48E+06	2476858.2	1.73E+03	1.65E+05	165123.88
LOGAN	US79		4.64	3	A	1.0	1	C	23.00	5.85E+03	4.34E+01	4.61E+05	1.36	0.70	1.29E+04	8.92E+05	892246.10	5.61E+02	3.88E+04	38793.309
LOGAN	US79		5.93	2	A	1.0	1	C	19.00	6.26E+03	5.37E+01	4.61E+05	1.00	0.70	1.72E+04	1.40E+06	1397950.5	9.03E+02	7.36E+04	73576.345
LYON	US62		11.60	3	B	4.0	5	C	33.00	5.12E+00	5.12E+00	4.61E+05	6.46	2.29	3.50E+03	2.48E+03	4291.1585	1.06E+02	1.50E+02	184.02492
LYON	US62	TB	12.20	4	C	4.0	3	C	23.00	6.75E+00	6.75E+00	4.61E+05	2.69	0.95	3.95E+03	2.80E+03	4839.7376	1.72E+02	2.43E+02	297.78993
LYON	US62/US641		3.65	4	C	3.0	1	C	49.00	7.81E+03	4.50E+02	4.61E+05	2.04	0.70	4.40E+04	2.62E+05	266157.78	8.99E+02	5.36E+03	5431.7914
LYON	US62/US641	TB	6.80	4	C	4.0	4	C	27.00	6.75E+00	6.75E+00	4.61E+05	2.61	0.93	2.79E+03	1.97E+03	3415.9764	1.03E+02	1.46E+02	179.04703
MARSHALL	KY408		8.82	3	C	10.0	3	C	30.00	2.50E-01	2.50E-01	4.61E+05	3.39	1.20	4.35E+02	3.08E+02	532.86374	2.90E+01	4.11E+01	50.254840
MARSHALL	KY408		8.92	3	C	3.0	1	C	20.00	3.91E+03	1.90E+01	4.61E+05	0.89	0.70	4.87E+03	7.88E+05	787806.42	2.43E+02	3.94E+04	39390.321
MARSHALL	KY408		9.34	5	C	10.0	3	C	30.00	2.50E-01	2.50E-01	4.61E+05	4.10	1.45	5.25E+02	3.72E+02	643.70744	3.50E+01	4.96E+01	60.731401
MARSHALL	KY408		9.73	21	C	10.0	3	C	30.00	2.50E-01	2.50E-01	4.61E+05	3.94	1.40	5.05E+02	3.58E+02	619.05844	3.37E+01	4.77E+01	58.405859
MARSHALL	KY58/KY80		1.12	3	C	1.0	1	C	24.00	2.64E+03	3.37E+01	4.61E+05	2.10	0.70	1.42E+04	3.69E+05	369499.35	5.90E+02	1.54E+04	15395.806
MARSHALL	KY80		8.72	2	C	1.0	1	C	14.00	2.58E+03	3.14E+01	4.61E+05	0.70	0.70	1.29E+04	1.06E+06	1060090.6	9.23E+02	7.57E+04	75720.761
MARSHALL	KY80		9.67	10	C	1.0	1	C	12.00	3.22E+03	6.28E+01	4.61E+05	0.70	0.70	3.52E+04	1.81E+06	1806846.3	2.93E+03	1.51E+05	150570.52
MARSHALL	KY80		9.86	17	C	1.0	1	C	23.00	3.31E+03	6.64E+01	4.61E+05	0.70	0.70	1.01E+04	5.04E+05	504129.83	4.40E+02	2.19E+04	21918.688
MARSHALL	KY80		12.52	7	C	4.0	4	C	17.00	3.36E-01	3.36E-01	4.61E+05	4.60	1.63	6.16E+02	4.36E+02	754.42646	3.62E+01	5.13E+01	62.803524
MARSHALL	US62		9.48	5	C	10.0	7	C	45.00	9.00E-02	9.00E-02	4.61E+05	16.54	5.86	3.39E+02	2.40E+02	415.32740	1.51E+01	2.13E+01	26.123062
MARSHALL	US62		10.87	3	C	10.0	9	C	50.00	2.50E-01	2.50E-01	4.61E+05	11.95	4.23	5.51E+02	3.90E+02	675.28148	2.20E+01	3.12E+01	38.226176

THE EARHTQUAKE MOMENTS AND SHEAR FORCES
IN PIER COLUMNS AND INTERMEDIATE BENTS

GENERAL INFORMATION						PIER INFORMATION				MOMNET OF INERTIA		E	MAXIMUM DISPL.		SEISMIC MOMENTS			SEISMIC SHEAR FORCES		
COUNTY	ROUTE		MILE POST	No. SPAN	SPC	PIER TYPE	No. COL.	MAT	HEIGHT H (FT)	IX (FT-4)	IY (FT-4)	E (KSF)	DXma (	DYmax	Mx (KIPS-FT)	My (KIPS-FT)	M total (KIPS-FT)	Vx (KIPS)	Vy (KIPS)	V total (KIPS)
MARSHALL	US62		2.47	4	C	10.0	9	C	45.00	9.00E-02	9.00E-02	4.61E+05	16.14	5.72	3.31E+02	2.34E+02	405.39380	1.47E+01	2.08E+01	25.498264
MARSHALL	US62 (I24)	TB	8.81	4	C	4.0	2	C	25.00	4.20E+00	4.20E+00	4.61E+05	12.52	4.43	9.70E+03	6.86E+03	11878.867	3.88E+02	5.49E+02	672.14784
MARSHALL	US641		9.40	3	C	3.0	1	C	16.00	1.85E+04	9.50E+01	4.61E+05	0.70	0.70	2.99E+04	5.84E+06	5837039.0	1.87E+03	3.65E+05	364814.94
MARSHALL	US641		9.83	4	C	3.0	1	C	16.00	1.85E+04	9.50E+01	4.61E+05	0.70	0.70	2.99E+04	5.84E+06	5837039.0	1.87E+03	3.65E+05	364814.94
MARSHALL	US641		9.87	4	C	10.0	11	C	25.00	9.10E-02	9.10E-02	4.61E+05	4.71	1.74	3.16E+02	2.34E+02	393.07419	2.53E+01	3.74E+01	45.126709
MARSHALL	US641	TB	0.24	3	C	10.0	11	C	34.00	9.00E-02	9.00E-02	4.61E+05	2.69	0.95	9.65E+01	6.84E+01	118.29194	5.68E+00	8.05E+00	9.8474157
MARSHALL	US68		22.48	5	C	4.0	2	C	38.00	1.56E+01	1.24E+01	4.61E+05	6.78	2.03	6.73E+03	5.05E+03	8412.7607	1.77E+02	2.66E+02	319.21759
MARSHALL	US68	TB	9.43	2	C	4.0	3	C	19.00	1.25E+01	1.25E+01	4.61E+05	1.26	0.70	5.04E+03	5.59E+03	7522.7151	2.65E+02	5.88E+02	645.10081
MARSHALL	US68/KY80		27.8	27	C	1.0	1	C	90.00	7.88E+03	1.07E+02	4.61E+05	30.12	5.23	4.59E+04	5.86E+05	587812.30	5.10E+02	6.51E+03	6531.2478
McCRACKEN	US60		6.69	3	C	2.0	2	C	31.00	6.75E+00	6.75E+00	4.61E+05	6.45	2.28	5.22E+03	3.70E+03	6398.3163	1.68E+02	2.39E+02	292.09225
McCRACKEN	US60		8.30	5	C	1.0	1	C	26.00	3.91E+03	5.63E+01	4.61E+05	1.56	0.70	1.49E+04	4.66E+05	466388.09	5.75E+02	1.79E+04	17938.003
McCRACKEN	US60		11.09	3	C	10.0	24	C	60.00	9.00E-02	9.00E-02	4.61E+05	28.98	11.68	3.34E+02	2.69E+02	428.95357	1.11E+01	1.79E+01	21.119130
McCRACKEN	US60		11.76	3	C	2.0	4	C	35.00	8.20E+00	8.20E+00	4.61E+05	2.79	0.99	2.15E+03	1.52E+03	2635.4913	6.14E+01	8.71E+01	106.56377
McCRACKEN	US60		18.64	4	C	4.0	2	C	43.00	5.21E+01	5.21E+01	4.61E+05	10.64	3.78	3.46E+04	2.46E+04	42386.703	8.04E+02	1.14E+03	1396.2865
McCRACKEN	US60	TB	10.80	3	C	4.0	3	C	21.00	6.75E+00	6.75E+00	4.61E+05	2.02	0.72	3.57E+03	2.53E+03	4374.9892	1.70E+02	2.41E+02	294.83139
McCRACKEN	US62	TB	12.95	3	C	4.0	4	C	35.00	6.75E+00	6.75E+00	4.61E+05	4.59	1.63	2.92E+03	2.07E+03	3575.7777	8.34E+01	1.18E+02	144.58342
McCRACKEN	US62		13.06	5	C	4.1	3	C	30.00	6.75E+00	6.75E+00	4.61E+05	4.87	1.73	4.21E+03	2.98E+03	5160.3897	1.40E+02	1.99E+02	243.43178
McCRACKEN	US62		13.06	5	C	10.4	10	C	40.00	9.00E-02	9.00E-02	4.61E+05	18.22	6.45	4.72E+02	3.35E+02	578.97115	2.36E+01	3.35E+01	40.967830
McCRACKEN	US62		13.91	3	C	4.0	2	C	26.00	6.75E+00	6.75E+00	4.61E+05	5.39	1.91	6.21E+03	4.40E+03	7605.1686	2.39E+02	3.38E+02	413.95347
McCRACKEN	US62		12.98	5	C	2.0	2	C	35.00	1.13E+01	1.46E+01	4.61E+05	5.45	2.35	7.49E+03	4.97E+03	8993.4130	2.14E+02	2.84E+02	355.79587
McCRACKEN	US68	TB	1.01	2	C	4.0	3	C	25.00	6.75E+00	6.75E+00	4.61E+05	3.35	1.19	4.17E+03	2.96E+03	5115.0149	1.67E+02	2.37E+02	289.54957
McLEAN	KY136		19.17	3	B	3.0	1	C	18.00	1.93E+03	2.73E+01	4.61E+05	0.70	0.70	6.81E+03	4.80E+05	480462.87	3.78E+02	2.67E+04	26692.381
McLEAN	KY136		20.88	7	B	3.1	1	C	18.25	3.81E+03	3.80E+01	4.61E+05	0.70	0.70	9.20E+03	9.22E+05	922426.55	5.04E+02	5.05E+04	50543.921
McLEAN	KY136		20.88	7	B	10.3	4	C	40.00	2.48E-01	2.48E-01	4.61E+05	8.99	3.19	6.42E+02	4.55E+02	787.32569	3.21E+01	4.55E+01	55.710936
MUHLENBERG	KY176		4.29	9	B	10.0	5	C	40.00	2.50E-01	2.50E-01	4.61E+05	7.22	2.56	5.20E+02	3.68E+02	636.96368	2.60E+01	3.68E+01	45.071364
MUHLENBERG	US431		3.45	7	B	10.0	4	C	35.00	2.50E-01	2.50E-01	4.61E+05	5.00	1.77	4.70E+02	3.33E+02	576.63685	2.69E+01	3.81E+01	46.631605
MUHLENBERG	US431		12.45	7	B	10.0	7	C	43.00	1.55E-01	1.55E-01	4.61E+05	9.98	3.54	3.86E+02	2.73E+02	472.77361	1.79E+01	2.54E+01	31.119370
MUHLENBERG	US431		17.48	4	A	2.0	3	C	21.00	1.25E+01	1.25E+01	4.61E+05	1.56	0.70	5.10E+03	4.57E+03	6847.3513	2.43E+02	4.36E+02	498.60242
OHIO	KY136		1.06	4	B	10.0	4	C	45.00	2.48E-01	2.48E-01	4.61E+05	8.89	3.15	5.02E+02	3.56E+02	615.42663	2.23E+01	3.16E+01	38.706807
OHIO	KY136		3.34	5	B	10.0	4	C	40.00	4.40E-01	4.40E-01	4.61E+05	4.44	1.57	5.64E+02	3.99E+02	690.62468	2.82E+01	3.99E+01	48.868400
OHIO	KY136		5.67	2	B	1.0	1	C	16.00	3.43E+03	3.80E+01	4.61E+05	0.70	0.70	1.20E+04	1.08E+06	1080039.9	7.48E+02	6.75E+04	67502.495
OHIO	US231		11.46	4	B	2.0	6	C	18.00	3.81E+00	8.88E-01	4.61E+05	3.95	0.70	1.25E+03	1.90E+03	2271.7154	6.94E+01	2.11E+02	221.98769
OHIO	US231		11.95	4	B	10.0	5	C	40.00	2.48E-01	2.48E-01	4.61E+05	7.03	2.49	5.02E+02	3.56E+02	615.69807	2.51E+01	3.56E+01	43.566616
OHIO	US231		13.32	3	B	1.0	1	C	35.00	7.50E+03	9.53E+01	4.61E+05	1.96	0.70	1.76E+04	4.94E+05	494505.83	5.03E+02	1.41E+04	14128.738
OHIO	US231		13.49	6	B	10.0	5	C	46.00	2.48E-01	2.48E-01	4.61E+05	8.18	2.90	4.42E+02	3.13E+02	541.97792	1.92E+01	2.72E+01	33.347999
OHIO	US231		13.88	6	B	10.0	5	C	46.00	2.48E-01	2.48E-01	4.61E+05	8.18	2.90	4.42E+02	3.13E+02	541.97792	1.92E+01	2.72E+01	33.347999
OHIO	US231		14.12	3	B	10.0	8	S	53.00	1.00E-02	2.00E-02	4.18E+06	26.39	17.05	7.85E+02	5.08E+02	935.03331	2.96E+01	3.83E+01	48.430522
OHIO	US231		15.80	3	B	2.0	5	C	20.00	2.48E-01	2.48E-01	4.61E+05	22.13	7.87	1.58E+03	1.12E+03	1940.4795	7.91E+01	1.12E+02	137.48020
OHIO	US231		20.30	4	B	10.0	6	C	50.00	2.48E-01	2.48E-01	4.61E+05	8.66	3.07	3.96E+02	2.81E+02	485.49084	1.58E+01	2.25E+01	27.482552
OHIO	US231	TB	6.70	3	B	2.0	3	C	23.00	6.75E+00	6.75E+00	4.61E+05	2.16	0.76	3.17E+03	2.25E+03	3888.5549	1.38E+02	1.95E+02	239.26348
TODD	US68/KY80		9.10	2	B	1.0	1	C	15.00	5.49E+03	6.30E+01	4.61E+05	0.70	0.70	2.26E+04	1.97E+06	1967882.5	1.51E+03	1.31E+05	131192.16
TODD	US79		1.95	3	A	2.0	2	C	30.00	2.76E+00	2.76E+00	4.61E+05	8.87	3.14	3.13E+03	2.22E+03	3840.2926	1.04E+02	1.48E+02	181.15865
TODD	US79		7.61	4	A	1.0	1	C	18.00	1.07E+03	1.23E+01	4.61E+05	1.81	0.70	7.96E+03	2.66E+05	266545.55	4.42E+02	1.48E+04	14808.066
TRIGG	US68/KY80		3.11	3	C	2.0	4	C	46.00	6.75E+00	6.75E+00	4.61E+05	8.34	2.95	3.07E+03	2.17E+03	3757.2854	6.66E+01	9.44E+01	115.59322
TRIGG	US68/KY80		8.27	32	C	1.0	1	C	160.00	3.81E+04	2.83E+03	4.61E+05	30.94	5.98	3.94E+05	1.03E+06	1099675.3	2.46E+03	6.42E+03	6872.9710
TRIGG	US68/KY80		10.94	3	C	10.0	7	C	70.00	9.00E-02	9.00E-02	4.61E+05	30.43	15.57	2.58E+02	2.64E+02	368.67790	7.36E+00	1.51E+01	16.771469
TRIGG	US68/KY80		17.89	6	C	1.0	1	C	46.00	8.10E+03	1.17E+02	4.61E+05	3.05	0.70	1.94E+04	3.09E+05	309427.88	4.21E+02	6.71E+03	6726.6932

THE EARHTQUAKE MOMENTS AND SHEAR FORCES
IN PIER COLUMNS AND INTERMEDIATE BENTS

GENERAL INFORMATION					PIER INFORMATION				MOMNET OF INERTIA		E	MAXIMUM DISPL.		SEISMIC MOMENTS			SEISMIC SHEAR FORCES		
COUNTY	ROUTE	MILE POST	No. SPAN	SPC	PIER TYPE	No. COL.	MAT	HEIGHT H (FT)	IX (FT-4)	IY (FT-4)	E (KSF)	DXma (	DYmax	Mx (KIPS-FT)	My (KIPS-FT)	M total (KIPS-FT)	Vx (KIPS)	Vy (KIPS)	V total (KIPS)
UNION	KY130	12.54	3	C	3.0	1	C	16.00	2.60E+03	1.70E+01	4.61E+05	0.70	0.70	5.36E+03	8.21E+05	820633.50	3.35E+02	5.13E+04	51289.593
UNION	KY130	13.47	3	C	10.0	5	C	47.00	2.50E-01	2.50E-01	4.61E+05	9.86	3.49	5.14E+02	3.65E+02	630.53277	2.19E+01	3.10E+01	37.971331
UNION	US60	3.66	3	C	10.0	6	S	40.00	6.10E-03	1.90E-02	4.18E+06	14.36	11.91	7.13E+02	3.60E+02	807.73962	3.56E+01	3.80E+01	52.076941
UNION	US60	5.20	3	C	10.0	9	C	40.00	9.00E-02	9.00E-02	4.61E+05	19.41	6.88	5.03E+02	3.57E+02	616.83944	2.52E+01	3.57E+01	43.647379
UNION	US60	6.48	3	C	10.0	9	C	40.00	9.00E-02	9.00E-02	4.61E+05	18.40	6.52	4.77E+02	3.38E+02	584.82122	2.39E+01	3.38E+01	41.381778
UNION	US60	13.06	3	C	10.0	9	C	40.00	9.00E-02	9.00E-02	4.61E+05	14.65	5.19	3.80E+02	2.69E+02	465.49406	1.90E+01	2.69E+01	32.938224
WARREN	US231	15.43	4	A	2.0	6	C	30.00	6.75E+00	6.75E+00	4.61E+05	4.05	1.44	3.50E+03	2.48E+03	4291.1399	1.17E+02	1.65E+02	202.42654
WARREN	US231	21.53	3	A	2.0	3	C	25.00	2.68E+03	5.56E+00	4.61E+05	2.28	0.70	2.33E+03	6.93E+05	692569.76	9.34E+01	5.54E+04	55405.345
WARREN	US231	22.61	3	A	1.0	1	C	25.00	3.33E+02	2.50E+01	4.61E+05	2.84	0.70	1.31E+04	4.30E+04	44935.128	5.24E+02	1.72E+03	1797.4051
WARREN	US68/KY80	8.2	4	A	2.0	3	C	26.00	1.92E+00	1.92E+00	4.61E+05	11.57	4.10	3.78E+03	2.68E+03	4634.7645	1.45E+02	2.06E+02	252.29065
WEBSTER	KY109	7.33	5	C	2.0	1	C	12.00	6.75E+00	6.75E+00	4.61E+05	0.72	0.70	3.90E+03	7.56E+03	8508.0049	3.25E+02	1.26E+03	1301.6971
WEBSTER	KY109	10.72	4	C	1.0	1	C	28.00	2.66E+03	4.95E+01	4.61E+05	3.10	0.70	2.26E+04	2.74E+05	274851.78	8.06E+02	9.78E+03	9816.1351
WEBSTER	US41	6.86	3	C	2.0	3	C	31.00	6.75E+00	6.75E+00	4.61E+05	5.86	2.08	4.75E+03	3.36E+03	5818.4184	1.53E+02	2.17E+02	265.61909
WEBSTER	US41	11.68	4	C	2.0	3	C	25.00	1.09E+01	1.09E+01	4.61E+05	1.70	0.70	3.41E+03	2.81E+03	4418.2873	1.37E+02	2.24E+02	262.74101

APPENDIX I

SUMMARY REPORT OF ALL SEISMIC ANALYSIS RESULTS

SUMMARY REPORT OF SEISMIC ANALYSIS

------- GENERAL INFORMATION -------						------ SEISMIC ANALYSIS RESULTS ------									R E T
							------ INTERMEDIATE SUBSTRUCTURE ------				------ END SUBSTRUCTURE ------				
						SINGLE	PIER & COLUMN		PILE BENT		SOLID ABUTMENT		END BENT & OPEN ABUT.		
COUNTY	ROUTE	TB	MILEPOST	NO.SPANS	SPC	SPAN	SPAN-LOSS	ATC	SPAN-LOSS	ATC	SPAN-LOSS	ATC	SPAN-LOSS	ATC	
BALLARD	KY121		0.00	21	D					•	•				YES
BALLARD	KY121		3.15	9	D					•					YES
BALLARD	KY121		5.30	3	D					•					YES
BALLARD	US60		1.94	2	D										NO
BALLARD	US60		2.50	2	D										NO
BALLARD	US60		3.93	1	D	S.S.									NO
BALLARD	US60		5.32	1	D	S.S.						•			YES
BALLARD	US60		5.74	1	D	S.S.								•	YES
BALLARD	US60		10.23	1	D	S.S.									NO
BALLARD	US60		11.51	3	D										NO
BALLARD	US60		11.81	3	D										NO
BUTLER	US231		4.63	5	B										NO
BUTLER	US231		8.00	1	B	S.S.									NO
BUTLER	US231	TB	8.80	2	B										NO
BUTLER	US231		9.92	1	B	S.S.									NO
BUTLER	US231		12.26	10	B										NO
BUTLER	US231		16.32	6	B				•				•		YES
BUTLER	US231		17.11	5	B				•	•			•		YES
BUTLER	US231		17.76	2	A			•				•			YES
CALDWELL	KY672		14.08	4	C									•	YES
CALDWELL	KY91		7.79	1	C	S.S.									NO
CALDWELL	KY91		12.24	4	B										NO
CALDWELL	KY91		13.92	1	B	S.S.									NO
CALDWELL	KY91		14.57	1	C	S.S.									NO
CALDWELL	US62		18.38	1	B	S.S.									NO
CALDWELL	US641		1.43	1	B	S.S.									NO
CALDWELL	US641		4.62	1	C	S.S.									NO
CALLOWAY	KY121		21.57	8	C					•				•	YES
CALLOWAY	KY94		1.77	1	C	S.S.									NO
CALLOWAY	KY94		5.15	1	C	S.S.									NO
CALLOWAY	KY94		6.44	1	C	S.S.									NO
CALLOWAY	KY94		11.07	4	C									•	YES
CALLOWAY	KY94		11.30	5	C										NO
CALLOWAY	KY94		11.44	4	C										NO
CALLOWAY	KY94		16.49	1	C	S.S.									NO
CALLOWAY	KY94		17.10	2	C						•				YES
CALLOWAY	KY94		23.03	2	C						•				YES
CALLOWAY	US641		1.15	4	C										NO
CALLOWAY	US641		5.49	1	C	S.S.									NO
CALLOWAY	US641		5.66	3	C								•	•	YES
CALLOWAY	US641		8.92	3	C					•					YES
CALLOWAY	US641	TB	15.65	3	C									•	YES
CALLOWAY	US641	TB	15.81	3	C										NO
CARLISLE	KY121		9.10	1	D	S.S.									NO
CARLISLE	KY121		9.38	5	D				•	•					YES
CARLISLE	US62		3.88	3	D							•			YES
CARLISLE	US62		6.04	1	D	S.S.									NO

SUMMARY REPORT OF SEISMIC ANALYSIS

GENERAL INFORMATION						SEISMIC ANALYSIS RESULTS									R
						INTERMEDIATE SUBSTRUCTURE					END SUBSTRUCTURE				E
COUNTY	ROUTE	TB	MILEPOST	NO.SPANS	SPC	SINGLE SPAN	PIER & COLUMN SPAN-LOSS	PIER & COLUMN ATC	PILE BENT SPAN-LOSS	PILE BENT ATC	SOLID ABUTMENT SPAN-LOSS	SOLID ABUTMENT ATC	END BENT & OPEN ABUT. SPAN-LOSS	END BENT & OPEN ABUT. ATC	T
CHRISTIAN	KY91		2.16	1	A	S.S.									NO
CHRISTIAN	KY91		4.43	3	B										NO
CHRISTIAN	KY91		11.26	2	B										NO
CHRISTIAN	KY91		13.07	2	B										NO
CHRISTIAN	US41		15.33	3	A						•				YES
CHRISTIAN	US41		29.51	2	B										NO
CHRISTIAN	US41		30.88	5	B									•	YES
CHRISTIAN	US41A	TB	4.43	2	A										NO
CHRISTIAN	US41A		8.74	3	A										NO
CHRISTIAN	US41A		8.74	2	A										NO
CHRISTIAN	US41A	TB	10.87	2	B										NO
CHRISTIAN	US41A	TB	13.44	2	A										NO
CHRISTIAN	US68/KY80		3.56	3	A										NO
CHRISTIAN	US68/KY80		4.68	3	A										NO
CHRISTIAN	US68/KY80		10.76	3	A						•				YES
CHRISTIAN	US68/KY80		11.20	2	A										NO
CHRISTIAN	US68/KY80		18.16	3	B										NO
CRITTENDEN	US60		8.37	1	B	S.S.									NO
CRITTENDEN	US60		10.76	1	B	S.S.									NO
CRITTENDEN	US60		12.40	1	C	S.S.									NO
CRITTENDEN	US60		14.69	1	C	S.S.									NO
CRITTENDEN	US60		15.79	1	C	S.S.									NO
CRITTENDEN	US60		17.22	1	C	S.S.									NO
CRITTENDEN	US60		20.32	1	C	S.S.									NO
CRITTENDEN	US60		22.99	3	C								•	•	YES
CRITTENDEN	US641		5.36	1	C	S.S.									NO
DAVIESS	KY1554		0.90	2	B										NO
DAVIESS	KY1554		1.42	3	B									•	YES
DAVIESS	US231		3.76	5	B										NO
DAVIESS	US231		3.91	5	B										NO
DAVIESS	US231		4.03	5	B				•						YES
DAVIESS	US231		4.18	5	B				•						YES
DAVIESS	US231		4.29	5	B										NO
DAVIESS	US231		8.84	3	B										NO
DAVIESS	US231		8.94	7	B										NO
DAVIESS	US231		9.22	4	B										NO
DAVIESS	US231	TB	11.29	4	B										NO
FULTON	KY166		2.09	3	D					•				•	YES
FULTON	KY166		9.03	3	D					•				•	YES
FULTON	KY166	TB	12.71	3	D									•	YES
FULTON	KY94		15.87	1	D	S.S.									NO
FULTON	KY94		17.22	1	D	S.S.									NO
FULTON	KY94		17.85	2	D										NO
FULTON	KY94		24.04	1	D	S.S.									NO
FULTON	KY94		24.22	1	D	S.S.									NO
FULTON	KY94		25.52	1	D	S.S.									NO
FULTON	US51		1.16	2	D										NO

SUMMARY REPORT OF SEISMIC ANALYSIS

------- GENERAL INFORMATION -------						------------------------------- SEISMIC ANALYSIS RESULTS -------------------------------									
						------------ INTERMEDIATE SUBSTRUCTURE ------------					--------- END SUBSTRUCTURE ---------				RET
						SINGLE	PIER & COLUMN		PILE BENT		SOLID ABUTMENT		END BENT & OPEN ABUT.		
COUNTY	ROUTE	TB	MILEPOST	NO.SPANS	SPC	SPAN	SPAN-LOSS	ATC	SPAN-LOSS	ATC	SPAN-LOSS	ATC	SPAN-LOSS	ATC	
GRAVES	KY121		7.96	7	C									•	YES
GRAVES	KY121		8.14	4	C									•	YES
GRAVES	KY121		8.27	6	C					•				•	YES
GRAVES	KY121		8.75	2	C					•					YES
GRAVES	KY121		11.73	4	C					•					YES
GRAVES	KY121		20.19	5	C							•			YES
GRAVES	KY58		0.51	3	C			•				•			YES
GRAVES	KY58		2.83	2	C							•			YES
GRAVES	KY58		5.27	2	C			•							YES
GRAVES	KY58		7.90	1	C	S.S.									NO
GRAVES	KY58/KY80		6.68	3	C					•					YES
GRAVES	KY58/KY80		12.25	3	C										NO
GRAVES	KY58/KY80		12.44	1	C	S.S.									NO
GRAVES	KY94		0.20	1	C	S.S.									NO
GRAVES	KY94		2.00	4	C					•				•	YES
GRAVES	KY94		2.90	1	C	S.S.							•	•	YES
GRAVES	KY94	TB	2.96	3	C					•				•	YES
GRAVES	US45		1.68	3	C			•							YES
GRAVES	US45		1.80	1	C	S.S.						•			YES
GRAVES	US45		6.09	1	C	S.S.									NO
GRAVES	US45		7.80	1	C	S.S.									NO
GRAVES	US45		7.86	1	C	S.S.									NO
GRAVES	US45		17.80	3	C			•				•			YES
GRAVES	US45		17.86	3	C							•			YES
GRAVES	US45/KY58		10.54	4	C		•	•					•	•	YES
GRAVES	US45/KY58		12.20	3	C										NO
GRAVES	US45/KY58		13.10	1	C	S.S.									NO
HENDERSON	A-PKY		15.78	4	C		•	•							YES
HENDERSON	KY351	TB	1.40	3	C									•	YES
HENDERSON	KY351		8.59	4	C					•				•	YES
HENDERSON	KY416		16.88	2	C			•							YES
HENDERSON	US41		0.65	3	C										NO
HENDERSON	US41		6.20	3	C					•			•	•	YES
HENDERSON	US41		6.32	3	C					•				•	YES
HENDERSON	US41		11.27	3	C									•	YES
HENDERSON	US41		12.65	3	C					•				•	YES
HENDERSON	US60		0.01	1	C	S.S.									NO
HENDERSON	US60		0.01	13	C										NO
HENDERSON	US60		10.00	3	C				•	•			•	•	YES
HENDERSON	US60		10.57	3	C			•							YES
HENDERSON	US60		10.64	3	C										NO
HICKMAN	KY58		19.82	5	D				•	•			•	•	YES
HICKMAN	KY94		0.24	3	D										NO
HICKMAN	KY94		2.01	2	D			•							YES
HOPKINS	KY109		3.81	4	B										NO
HOPKINS	KY109		4.50	3	B										NO
HOPKINS	KY109		6.49	3	B										NO

SUMMARY REPORT OF SEISMIC ANALYSIS

GENERAL INFORMATION						SEISMIC ANALYSIS RESULTS									
						INTERMEDIATE SUBSTRUCTURE					END SUBSTRUCTURE				
							PIER & COLUMN		PILE BENT		SOLID ABUTMENT		END BENT & OPEN ABUT.		
COUNTY	ROUTE	TB	MILEPOST	NO.SPANS	SPC	SINGLE SPAN	SPAN-LOSS	ATC	SPAN-LOSS	ATC	SPAN-LOSS	ATC	SPAN-LOSS	ATC	RET
HOPKINS	KY109		7.24	5	C					•				•	YES
HOPKINS	KY109		14.74	11	C					•				•	YES
HOPKINS	KY109		16.39	5	C					•				•	YES
HOPKINS	KY1751		1.14	3	C										NO
HOPKINS	US41		6.13	4	C					•				•	YES
HOPKINS	US41A		0.49	3	C									•	YES
HOPKINS	US41A		0.82	3	C					•				•	YES
HOPKINS	US41A		3.42	7	C							•			YES
HOPKINS	US41A	TB	5.30	6	C			•					•	•	YES
HOPKINS	US41A		6.59	9	C										NO
HOPKINS	US41A		9.00	3	B										NO
HOPKINS	US41A		12.65	1	C	S.S.									NO
HOPKINS	US41A		13.11	2	B						•				YES
HOPKINS	US41A		15.33	6	B										NO
HOPKINS	US41A		15.73	1	C	S.S.									NO
HOPKINS	US62		0.23	3	B										NO
LIVINGSTON	US60		12.37	15	C		•	•			•				YES
LIVINGSTON	US60		16.66	1	C	S.S.									NO
LIVINGSTON	US60		21.31	1	C	S.S.									NO
LIVINGSTON	US60		25.96	1	C	S.S.									NO
LIVINGSTON	US60		29.06	1	C	S.S.									NO
LIVINGSTON	US62/US641		0.31	3	C										NO
LIVINGSTON	US62/US641		0.64	10	C				•				•	•	YES
LIVINGSTON	US62/US641		0.97	3	C								•		YES
LIVINGSTON	US62/US641		2.78	12	C		•	•			•	•			YES
LIVINGSTON	US62/US641	TB	1.20	3	C								•		YES
LOGAN	US431		20.31	3	B										NO
LOGAN	US431		27.41	5	B										NO
LOGAN	US431		27.73	3	B										NO
LOGAN	US431		28.91	2	B										NO
LOGAN	US68/KY80		2.80	2	A						•				YES
LOGAN	US68/KY80		9.64	7	A										NO
LOGAN	US68/KY80		10.38	1	B	S.S.									NO
LOGAN	US68/KY80		20.94	2	B						•				YES
LOGAN	US68/KY80		21.91	3	A										NO
LOGAN	US79		2.91	3	A										NO
LOGAN	US79		4.64	3	A										NO
LOGAN	US79		5.93	2	A										NO
LOGAN	US79		9.43	1	B	S.S.									NO
LYON	US62		11.60	3	B										NO
LYON	US62	TB	12.20	4	C									•	YES
LYON	US62/US641		2.78	12	C										NO
LYON	US62/US641		3.65	4	C										NO
LYON	US62/US641	TB	6.80	4	C			•							YES
MARSHALL	KY408		8.10	1	C	S.S.									NO
MARSHALL	KY408		8.82	3	C					•				•	YES
MARSHALL	KY408		8.92	3	C							•			YES

SUMMARY REPORT OF SEISMIC ANALYSIS

GENERAL INFORMATION						SEISMIC ANALYSIS RESULTS									
							INTERMEDIATE SUBSTRUCTURE				END SUBSTRUCTURE				RET
							PIER & COLUMN		PILE BENT		SOLID ABUTMENT		END BENT & OPEN ABUT.		
COUNTY	ROUTE	TB	MILEPOST	NO.SPANS	SPC	SINGLE SPAN	SPAN-LOSS	ATC	SPAN-LOSS	ATC	SPAN-LOSS	ATC	SPAN-LOSS	ATC	
MARSHALL	KY408		9.34	5	C					•				•	YES
MARSHALL	KY408		9.73	21	C					•				•	YES
MARSHALL	KY408		10.87	1	C	S.S.									NO
MARSHALL	KY58/KY80		1.12	3	C										NO
MARSHALL	KY80		8.72	2	C										NO
MARSHALL	KY80		9.67	10	C										NO
MARSHALL	KY80		9.86	17	C										NO
MARSHALL	KY80		12.52	7	C										NO
MARSHALL	KY80		15.06	1	C	S.S.									NO
MARSHALL	US62		2.47	4	C					•				•	YES
MARSHALL	US62	TB	8.81	4	C			•							YES
MARSHALL	US62		9.48	5	C									•	YES
MARSHALL	US62		10.87	3	C								•	•	YES
MARSHALL	US62		11.94	30	C										NO
MARSHALL	US641	TB	0.24	3	C					•				•	YES
MARSHALL	US641	TB	7.94	1	C	S.S.								•	YES
MARSHALL	US641		9.40	3	C										NO
MARSHALL	US641		9.83	4	C										NO
MARSHALL	US641		9.87	4	C										NO
MARSHALL	US68	TB	9.43	2	C										NO
MARSHALL	US68		22.48	5	C			•						•	YES
MARSHALL	US68/KY80		27.80	27	C						•				YES
McCRACKEN	US60		4.10	1	C	S.S.									NO
McCRACKEN	US60		4.96	1	C	S.S.						•			YES
McCRACKEN	US60		6.69	3	C										NO
McCRACKEN	US60		8.30	5	C						•	•			YES
McCRACKEN	US60	TB	10.80	3	C										NO
McCRACKEN	US60		11.09	3	C				•	•				•	YES
McCRACKEN	US60		11.76	3	C										NO
McCRACKEN	US60		18.64	3	C										NO
McCRACKEN	US60		19.86	24	C										NO
McCRACKEN	US62	TB	12.95	3	C			•				•			YES
McCRACKEN	US62	TB	13.06	5	C				•	•					YES
McCRACKEN	US62		13.91	3	C										NO
McCRACKEN	US62		12.98	5	C										NO
McCRACKEN	US68	TB	1.01	2	C										NO
McLEAN	KY136		17.13	1	B	S.S.									NO
McLEAN	KY136		19.17	3	B										NO
McLEAN	KY136		20.88	7	B										NO
MUHLENBER	KY176		4.29	9	B										NO
MUHLENBER	KY176		6.60	1	A	S.S.									NO
MUHLENBER	US431		3.45	7	B					•					YES
MUHLENBER	US431		3.63	1	B	S.S.									NO
MUHLENBER	US431		12.45	7	B									•	YES
MUHLENBER	US431		13.31	1	B	S.S.									NO
MUHLENBER	US431		17.48	4	A						•				YES

SUMMARY REPORT OF SEISMIC ANALYSIS

GENERAL INFORMATION						SEISMIC ANALYSIS RESULTS										R E T
							INTERMEDIATE SUBSTRUCTURE				END SUBSTRUCTURE					
						SINGLE	PIER & COLUMN		PILE BENT		SOLID ABUTMENT		END BENT & OPEN ABUT.			
COUNTY	ROUTE	TB	MILEPOST	NO.SPANS	SPC	SPAN	SPAN-LOSS	ATC	SPAN-LOSS	ATC	SPAN-LOSS	ATC	SPAN-LOSS	ATC		
OHIO	KY136		1.06	4	B											NO
OHIO	KY136		3.34	5	B											NO
OHIO	KY136		5.67	2	B											NO
OHIO	KY136		6.01	1	B	S.S.										NO
OHIO	US231	TB	6.70	3	B											NO
OHIO	US231		11.46	4	B											NO
OHIO	US231		11.95	4	B											NO
OHIO	US231		12.30	1	B	S.S.										NO
OHIO	US231		13.32	3	B											NO
OHIO	US231		13.49	6	B											NO
OHIO	US231		13.88	6	B											NO
OHIO	US231		14.12	3	B				•				•	•		YES
OHIO	US231		15.80	3	B		•						•			YES
OHIO	US231		20.30	4	B											NO
TODD	US68/KY80		1.55	1	B	S.S.										NO
TODD	US68/KY80		3.15	1	A	S.S.										NO
TODD	US68/KY80		9.10	2	B											NO
TODD	US79		1.95	3	A											NO
TODD	US79		7.61	4	A											NO
TRIGG	US68/KY80		3.11	3	C			•								YES
TRIGG	US68/KY80	TB	8.27	32	C			•			•					YES
TRIGG	US68/KY80		10.94	3	C									•		YES
TRIGG	US68/KY80		17.89	6	C								•	•		YES
TRIGG	US68/KY80	TB	24.50	1	C	S.S.										NO
UNION	KY130		12.54	3	C			•								YES
UNION	KY130		13.47	3	C					•				•		YES
UNION	US60		3.66	3	C					•				•		YES
UNION	US60		5.20	3	C				•					•		YES
UNION	US60		6.48	3	C				•	•				•		YES
UNION	US60		9.94	1	C	S.S.										NO
UNION	US60		13.06	3	C					•				•		YES
UNION	US60		14.78	1	C	S.S.										NO
WARREN	US231		15.43	4	A											NO
WARREN	US231		21.53	3	A									•		YES
WARREN	US231		22.61	3	A											NO
WARREN	US68/KY80	TB	8.20	4	A											NO
WEBSTER	KY109		1.03	1	B	S.S.										NO
WEBSTER	KY109		7.33	5	C							•				YES
WEBSTER	KY109		10.72	4	C							•				YES
WEBSTER	US41		6.86	3	C											NO
WEBSTER	US41		11.68	4	C											NO

APPENDIX J

RETROFITTING PRIORITY ORDER FOR BRIDGES IN PRIORITY ROUTE SYSTEM

PRIORITY ORDER OF RETROFITTING NEEDS FOR BRIDGES

PRIORITY ORDER	------ GENERAL INFORMATION ------						SEISMIC	RETROF. ? SEISMIC
	COUNTY	ROUTE	T	MILE POST	No.OF SPANS	SPC	RATING	ANALYSIS
1	HICKMAN	KY94		2.01	2	D	96.5	YES
2	CARLISLE	KY121		9.38	5	D	96.5	YES
3	FULTON	KY166	T	12.71	3	D	95.5	YES
4	FULTON	KY166		2.09	3	D	95.5	YES
5	GRAVES	US45/KY58		10.54	4	C	94	YES
6	BALLARD	KY121		0.00	21	D	92.5	YES
7	BALLARD	KY121		5.30	3	D	92.5	YES
8	BALLARD	KY121		3.15	9	D	92.5	YES
9	McCRACKEN	US62		13.06	5	C	91.5	YES
10	HICKMAN	KY58		19.82	5	D	91.5	YES
11	GRAVES	US45		17.80	3	C	91.5	YES
12	FULTON	KY166		9.03	3	D	90.5	YES
13	CARLISLE	US62		3.88	3	D	90.5	YES
14	MARSHALL	US68/KY80		27.80	27	C	89.5	YES
15	MARSHALL	US641	T	0.24	3	C	89.5	YES
16	LIVINGSTON	US62/US641		0.97	3	C	89.5	YES
17	GRAVES	KY121		11.73	4	C	89	YES
18	TRIGG	US68/KY80	T	8.27	32	C	87.5	YES
19	LYON	US62	T	12.20	4	C	87.5	YES
20	CRITTENDEN	US60		22.99	3	C	87.5	YES
21	CALLOWAY	KY121		21.57	8	C	87.5	YES
22	LIVINGSTON	US60		12.37	15	C	87	YES
23	CALLOWAY	KY94		11.07	4	C	86.5	YES
24	HOPKINS	US41		6.13	4	C	85.5	YES
25	GRAVES	KY58		5.27	2	C	85.5	YES
26	BALLARD	US60		5.74	1	D	85	YES
27	LIVINGSTON	US62/US641		2.78	12	C	84.5	YES
28	HOPKINS	US41A	T	5.30	6	C	83	YES
29	LYON	US62/US641	T	6.80	4	C	82.5	YES
30	CALLOWAY	US641		5.66	3	C	82.5	YES
31	BALLARD	US60		5.32	1	D	82.5	YES
32	HENDERSON	A-PKY		15.78	4	C	80.5	YES
33	GRAVES	US45		17.86	3	C	79	YES
34	HENDERSON	KY416		16.88	2	C	78	YES
35	GRAVES	KY121		7.96	7	C	76.5	YES
36	GRAVES	KY94		2.00	4	C	75.5	YES
37	MARSHALL	US62		2.47	4	C	74.5	YES
38	MARSHALL	US62		10.87	3	C	74.5	YES
39	MARSHALL	US62	T	8.81	2	C	74.5	YES
40	MARSHALL	KY408		8.92	3	C	74.5	YES
41	MARSHALL	KY408		8.82	3	C	74.5	YES
42	LIVINGSTON	US62/US641		0.64	10	C	74.5	YES
43	LIVINGSTON	US62/US641	T	1.20	3	C	74.5	YES
44	GRAVES	KY121		20.19	5	C	74	YES
45	GRAVES	KY58		0.51	3	C	73	YES
46	GRAVES	KY94		2.90	1	C	73	YES
47	TRIGG	US68/KY80		10.94	3	C	72.5	YES
48	TRIGG	US68/KY80		3.11	3	C	72.5	YES
49	CALLOWAY	US641	T	15.65	3	C	72.5	YES
50	McCRACKEN	US60		8.30	5	C	71.5	YES
51	GRAVES	KY58/KY80		6.68	3	C	71.5	YES
52	GRAVES	KY121		8.14	4	C	71.5	YES
53	GRAVES	US45		1.68	3	C	71.5	YES
54	GRAVES	KY121		8.27	6	C	71.5	YES
55	GRAVES	KY121		8.75	2	C	71.5	YES
56	HENDERSON	US41		12.65	3	C	70.5	YES
57	HENDERSON	KY351		8.59	4	C	70.5	YES
58	HENDERSON	US41		6.20	3	C	70.5	YES
59	GRAVES	KY58		2.83	2	C	70.5	YES
60	GRAVES	KY94	T	2.96	3	C	70.5	YES
61	MARSHALL	KY408		9.34	5	C	69.5	YES
62	MARSHALL	KY408		9.73	21	C	69.5	YES
63	MARSHALL	US68		22.48	5	C	69.5	YES
64	HOPKINS	KY109		7.24	5	C	69.5	YES
65	UNION	KY130		12.54	3	C	68	YES
66	HOPKINS	US41A		3.42	7	C	68	YES

PRIORITY ORDER OF RETROFITTING NEEDS FOR BRIDGES

PRIORITY ORDER	------ GENERAL INFORMATION ------ COUNTY	ROUTE	T	MILE POST	No.OF SPANS	SPC	SEISMIC RATING	RETROF. ? SEISMIC ANALYSIS
67	HENDERSON	KY351	T	1.40	3	C	68	YES
68	UNION	US60		6.48	3	C	67.5	YES
69	UNION	US60		13.06	3	C	67.5	YES
70	UNION	US60		3.66	3	C	67.5	YES
71	UNION	US60		5.20	3	C	67.5	YES
72	TRIGG	US68/KY80		17.89	6	C	67.5	YES
73	McCRACKEN	US62	T	12.95	3	C	67.5	YES
74	CALLOWAY	US641		8.92	3	C	67.5	YES
75	McCRACKEN	US60		11.09	3	C	66.5	YES
76	CALDWELL	KY672		14.08	4	C	66.5	YES
77	UNION	KY130		13.47	3	C	65.5	YES
78	HOPKINS	US41A		0.82	3	C	65.5	YES
79	HOPKINS	US41A		0.49	3	C	65.5	YES
80	HENDERSON	US41		6.32	3	C	65.5	YES
81	HENDERSON	US41		11.27	3	C	65.5	YES
82	WEBSTER	KY109		7.33	5	C	64.5	YES
83	WEBSTER	KY109		10.72	4	C	64.5	YES
84	MARSHALL	US62		9.48	5	C	64.5	YES
85	HOPKINS	US41A		13.11	2	B	64.5	YES
86	HOPKINS	KY109		14.74	11	C	64.5	YES
87	HOPKINS	KY109		16.39	5	C	64.5	YES
88	MARSHALL	US641	T	7.94	1	C	62	YES
89	McCRACKEN	US60		4.96	1	C	61.5	YES
90	GRAVES	US45		1.80	1	C	61.5	YES
91	CALLOWAY	KY94		17.10	2	C	61.5	YES
92	HENDERSON	US60		10.57	3	C	60.5	YES
93	HENDERSON	US60		10.00	3	C	60.5	YES
94	BUTLER	US231		17.76	2	A	60.5	YES
95	CALLOWAY	KY94		23.03	3	C	57.5	YES
96	CHRISTIAN	US41		30.88	5	B	55.5	YES
97	LOGAN	US68/KY80		20.94	2	B	53.5	YES
98	DAVIESS	KY1554		1.42	3	B	53.5	YES
99	DAVIESS	US231		4.18	5	B	48.5	YES
100	DAVIESS	US231		4.03	5	B	48.5	YES
101	OHIO	US231		15.80	3	B	46.5	YES
102	MUHLENBERG	US431		12.45	7	B	46.5	YES
103	MUHLENBERG	US431		3.45	7	B	46.5	YES
104	BUTLER	US231		16.32	6	B	46.5	YES
105	BUTLER	US231		17.11	5	B	46.5	YES
106	MUHLENBERG	US431		17.48	4	A	45.5	YES
107	CHRISTIAN	US41		15.33	3	A	40.5	YES
108	CHRISTIAN	US68/KY80		10.76	3	A	40.5	YES
109	LOGAN	US68/KY80		2.80	2	A	38.5	YES
110	WARREN	US231		21.53	3	A	36.5	YES
111	OHIO	US231		14.12	3	B	35.5	YES
112	BALLARD	US60		1.94	2	D	97.5	NO
113	HICKMAN	KY94		0.24	3	D	96.5	NO
114	BALLARD	US60		2.50	2	D	92.5	NO
115	BALLARD	US60		11.51	3	D	92.5	NO
116	McCRACKEN	US62	T	13.06	5	C	91.5	NO
117	BALLARD	US60		11.81	3	D	90	NO
118	McCRACKEN	US60	T	10.80	3	C	89	NO
119	FULTON	US51		1.16	2	D	89	NO
120	FULTON	KY94		17.85	2	D	89	NO
121	LYON	US62/US641		2.78	12	C	87.5	NO
122	MARSHALL	KY80		12.52	7	C	87	NO
123	McCRACKEN	US60		11.76	3	C	86.5	NO
124	McCRACKEN	US60		18.64	4	C	86.5	NO
125	CALLOWAY	KY94		11.44	4	C	86.5	NO
126	CALLOWAY	US641	T	15.81	3	C	85	NO
127	MARSHALL	KY80		9.86	17	C	84.5	NO
128	CALLOWAY	US641		1.15	4	C	82.5	NO
129	CALLOWAY	KY94		11.30	5	C	81.5	NO
130	McCRACKEN	US62		13.91	3	C	76.5	NO
131	McCRACKEN	US62		12.98	5	C	76.5	NO
132	WEBSTER	US41		6.86	3	C	75.5	NO

PRIORITY ORDER OF RETROFITTING NEEDS FOR BRIDGES

PRIORITY ORDER	GENERAL INFORMATION COUNTY	ROUTE	T	MILE POST	No.OF SPANS	SPC	SEISMIC RATING	RETROF. ? SEISMIC ANALYSIS
133	MARSHALL	US62		11.94	30	C	74.5	NO
134	LYON	US62/US641		3.65	4	C	72.5	NO
135	MARSHALL	US641		9.83	4	C	72	NO
136	MARSHALL	US68	T	9.43	2	C	72	NO
137	McCRACKEN	US68	T	1.01	2	C	71.5	NO
138	McCRACKEN	US60		6.69	3	C	71.5	NO
139	McCRACKEN	US60		19.86	24	C	71.5	NO
140	GRAVES	US45/KY58		12.20	3	C	71.5	NO
141	GRAVES	KY58/KY80		12.25	3	C	71.5	NO
142	WEBSTER	US41		11.68	4	C	70.5	NO
143	OHIO	US231		13.32	3	B	70.5	NO
144	HOPKINS	US41A		6.59	9	C	70.5	NO
145	HENDERSON	US60		0.01	13	C	70.5	NO
146	BUTLER	US231		12.26	10	B	70.5	NO
147	MARSHALL	KY80		9.67	10	C	69.5	NO
148	MARSHALL	KY80		8.72	2	C	69.5	NO
149	MARSHALL	KY58/KY80		1.12	3	C	69.5	NO
150	HENDERSON	US41		0.65	3	C	65.5	NO
151	HENDERSON	US60		10.64	3	C	65.5	NO
152	LOGAN	US68/KY80		21.91	3	A	62.5	NO
153	MARSHALL	US641		9.40	3	C	62	NO
154	MARSHALL	US641		9.87	4	C	62	NO
155	CALDWELL	KY91		12.24	4	B	61.5	NO
156	HOPKINS	KY1751		1.14	3	C	60.5	NO
157	CHRISTIAN	US41		29.51	2	B	58	NO
158	LYON	US62		11.60	3	B	57.5	NO
159	HOPKINS	US41A		15.33	6	B	55.5	NO
160	HOPKINS	US41A		9.00	3	B	55.5	NO
161	CHRISTIAN	US41A	T	10.87	2	B	55.5	NO
162	HOPKINS	KY109		6.49	3	B	54.5	NO
163	HOPKINS	KY109		4.50	3	B	54.5	NO
164	DAVIESS	US231		8.84	3	B	53.5	NO
165	OHIO	US231		11.46	4	B	51.5	NO
166	McLEAN	KY136		20.88	7	B	51.5	NO
167	LOGAN	US431		20.31	3	B	51.5	NO
168	DAVIESS	US231		3.91	5	B	51	NO
169	DAVIESS	US231	T	11.29	4	B	51	NO
170	HOPKINS	US62		0.23	3	B	50.5	NO
171	CHRISTIAN	KY91		13.07	2	B	50.5	NO
172	CHRISTIAN	KY91		11.26	2	B	50.5	NO
173	CHRISTIAN	KY91		4.43	3	B	50.5	NO
174	CHRISTIAN	US68/KY80		18.18	3	B	50.5	NO
175	LIVINGSTON	US62/US641		0.31	3	C	49.5	NO
176	OHIO	US231	T	6.70	3	B	49	NO
177	TODD	US68/KY80		9.10	2	B	48.5	NO
178	DAVIESS	US231		8.94	7	B	48.5	NO
179	DAVIESS	US231		9.22	4	B	48.5	NO
180	DAVIESS	US231		3.76	5	B	48.5	NO
181	DAVIESS	US231		4.29	5	B	48.5	NO
182	HOPKINS	KY109		3.81	4	B	47	NO
183	OHIO	US231		11.95	4	B	46.5	NO
184	OHIO	US231		20.30	4	B	46.5	NO
185	OHIO	US231		13.88	6	B	46.5	NO
186	OHIO	US231		13.49	6	B	46.5	NO
187	MUHLENBERG	KY176		4.29	9	B	46.5	NO
188	McLEAN	KY136		19.17	3	B	46.5	NO
189	LOGAN	US431		27.73	3	B	46.5	NO
190	LOGAN	US431		28.91	2	B	46.5	NO
191	LOGAN	US431		27.41	5	B	46.5	NO
192	BUTLER	US231	T	8.80	2	B	46.5	NO
193	BUTLER	US231		4.63	5	B	46.5	NO
194	DAVIESS	KY1554		0.90	2	B	46	NO
195	CHRISTIAN	US41A		8.74	2	A	45.5	NO
196	CHRISTIAN	US41A		8.74	3	A	45.5	NO
197	CHRISTIAN	US41A	T	13.44	2	A	45.5	NO
198	CHRISTIAN	US41A	T	4.43	2	A	45.5	NO

PRIORITY ORDER OF RETROFITTING NEEDS FOR BRIDGES

PRIORITY ORDER	------ GENERAL INFORMATION ------ COUNTY	ROUTE	T	MILE POST	No.OF SPANS	SPC	SEISMIC RATING	RETROF. ? SEISMIC ANALYSIS
199	OHIO	KY136		5.67	2	B	44.5	NO
200	OHIO	KY136		1.06	4	B	44.5	NO
201	OHIO	KY136		3.34	5	B	44.5	NO
202	LOGAN	US68/KY80		9.64	7	A	43.5	NO
203	CHRISTIAN	US68/KY80		11.20	2	A	43	NO
204	TODD	US79		7.61	4	A	42.5	NO
205	LOGAN	US79		2.91	3	A	42.5	NO
206	WARREN	US68/KY80	T	8.20	4	A	41.5	NO
207	WARREN	US231		15.43	4	A	41.5	NO
208	CHRISTIAN	US68/KY80		4.68	3	A	40.5	NO
209	CHRISTIAN	US68/KY80		3.56	3	A	40.5	NO
210	TODD	US79		1.95	3	A	37.5	NO
211	LOGAN	US79		4.64	3	A	37.5	NO
212	LOGAN	US79		5.93	2	A	37.5	NO
213	WARREN	US231		22.61	3	A	36.5	NO
214	BALLARD	US60		3.93	1	D	87.5	NO
215	FULTON	KY94		25.52	1	D	86.5	NO
216	FULTON	KY94		24.04	1	D	86.5	NO
217	CALDWELL	US641		4.62	1	C	82.5	NO
218	BALLARD	US60		10.23	1	D	82.5	NO
219	FULTON	KY94		24.22	1	D	81.5	NO
220	CARLISLE	KY121		9.10	1	D	81.5	NO
221	CARLISLE	US62		6.04	1	D	80.5	NO
222	FULTON	KY94		17.22	1	D	79	NO
223	FULTON	KY94		15.87	1	D	79	NO
224	TRIGG	US68/KY80	T	24.50	1	C	75	NO
225	LIVINGSTON	US60		16.66	1	C	68.5	NO
226	GRAVES	US45		7.86	1	C	66.5	NO
227	GRAVES	US45		7.80	1	C	66.5	NO
228	GRAVES	US45/KY58		13.10	1	C	66.5	NO
229	CALDWELL	US62		18.38	1	B	66.5	NO
230	MARSHALL	KY408		8.10	1	C	64.5	NO
231	McCRACKEN	US60		4.10	1	C	61.5	NO
232	GRAVES	KY58/KY80		12.44	1	C	61.5	NO
233	HENDERSON	US60		0.01	1	C	60.5	NO
234	GRAVES	KY58		7.90	1	C	60.5	NO
235	GRAVES	KY94		0.20	1	C	60.5	NO
236	MARSHALL	KY80		15.06	1	C	59.5	NO
237	MARSHALL	KY408		10.87	1	C	59.5	NO
238	CRITTENDEN	US60		14.69	1	C	57.5	NO
239	CALLOWAY	US641		5.49	1	C	57.5	NO
240	CALDWELL	KY91		7.79	1	C	57.5	NO
241	CALLOWAY	KY94		1.77	1	C	56.5	NO
242	CALLOWAY	KY94		5.15	1	C	56.5	NO
243	CALLOWAY	KY94		16.49	1	C	56.5	NO
244	CALLOWAY	KY94		6.44	1	C	56.5	NO
245	HOPKINS	US41A		15.73	1	C	55.5	NO
246	HOPKINS	US41A		12.65	1	C	55.5	NO
247	CRITTENDEN	US60		20.32	1	C	55	NO
248	CALDWELL	KY91		14.57	1	C	53.5	NO
249	LIVINGSTON	US60		25.98	1	C	50.5	NO
250	LIVINGSTON	US60		21.31	1	C	50.5	NO
251	GRAVES	US45		6.09	1	C	50	NO
252	CRITTENDEN	US641		5.36	1	C	48.5	NO
253	CRITTENDEN	US60		12.40	1	C	46	NO
254	WEBSTER	KY109		1.03	1	B	44.5	NO
255	CRITTENDEN	US60		10.76	1	B	42.5	NO
256	CRITTENDEN	US60		8.37	1	B	42.5	NO
257	CALDWELL	US641		1.43	1	B	42.5	NO
258	OHIO	US231		12.30	1	B	41.5	NO
259	UNION	US60		14.78	1	C	40	NO
260	UNION	US60		9.94	1	C	40	NO
261	CRITTENDEN	US60		17.22	1	C	40	NO
262	CRITTENDEN	US60		15.79	1	C	40	NO
263	TODD	US68/KY80		1.55	1	B	38.5	NO
264	LOGAN	US68/KY80		10.38	1	B	38.5	NO

PRIORITY ORDER OF RETROFITTING NEEDS FOR BRIDGES

PRIORITY ORDER	------ GENERAL INFORMATION ------						SEISMIC	RETROF. ? SEISMIC
	COUNTY	ROUTE	T	MILE POST	No.OF SPANS	SPC	RATING	ANALYSIS
265	LOGAN	US79		9.43	1	B	37.5	NO
266	MUHLENBERG	US431		3.63	1	B	36.5	NO
267	McLEAN	KY136		17.13	1	B	36.5	NO
268	BUTLER	US231		9.92	1	B	36.5	NO
269	BUTLER	US231		8.00	1	B	36.5	NO
270	LIVINGSTON	US60		29.06	1	B	36	NO
271	OHIO	KY136		6.01	1	B	34.5	NO
272	MUHLENBERG	US431		13.31	1	B	34	NO
273	CALDWELL	KY91		13.91	1	B	34	NO
274	CHRISTIAN	KY91		2.16	1	A	30.5	NO
275	TODD	US68/KY80		3.15	1	A	28.5	NO
276	MUHLENBERG	KY176		6.60	1	A	18	NO

APPENDIX K

RETROFITTING PRIORITY ORDER FOR BRIDGES IN EACH COUNTY

PRIORITY ORDER OF BRIDGE RETROFITTING NEEDS
FOR EACH COUNTY

-- PRIORITY ORDER --		-------- GENERAL INFORMATION --------						SEISMIC	RETROF. ?
COUNTY	SYSTEM	COUNTY	ROUTE	TB	MILE POST	No.OF SPANS	SPC	RATING	SEISMIC ANALYSIS
1	6	BALLARD	KY121		0.00	21	D	92.5	YES
2	7	BALLARD	KY121		5.30	3	D	92.5	YES
3	8	BALLARD	KY121		3.15	9	D	92.5	YES
4	26	BALLARD	US60		5.74	1	D	85	YES
5	31	BALLARD	US60		5.32	1	D	82.5	YES
6	112	BALLARD	US60		1.94	2	D	97.5	NO
7	114	BALLARD	US60		2.50	2	D	92.5	NO
8	115	BALLARD	US60		11.51	3	D	92.5	NO
9	117	BALLARD	US60		11.81	3	D	90	NO
10	214	BALLARD	US60		3.93	1	D	87.5	NO
11	218	BALLARD	US60		10.23	1	D	82.5	NO
1	94	BUTLER	US231		17.76	2	A	60.5	YES
2	104	BUTLER	US231		16.32	6	B	46.5	YES
3	105	BUTLER	US231		17.11	5	B	46.5	YES
4	146	BUTLER	US231		12.26	10	B	70.5	NO
5	192	BUTLER	US231	TB	8.80	2	B	46.5	NO
6	193	BUTLER	US231		4.63	5	B	46.5	NO
7	268	BUTLER	US231		9.92	1	B	36.5	NO
8	269	BUTLER	US231		8.00	1	B	36.5	NO
1	76	CALDWELL	KY672		14.08	4	C	66.5	YES
2	155	CALDWELL	KY91		12.24	4	B	61.5	NO
3	217	CALDWELL	US641		4.62	1	C	82.5	NO
4	229	CALDWELL	US62		18.38	1	B	66.5	NO
5	240	CALDWELL	KY91		7.79	1	C	57.5	NO
6	248	CALDWELL	KY91		14.57	1	C	53.5	NO
7	257	CALDWELL	US641		1.43	1	B	42.5	NO
8	273	CALDWELL	KY91		13.91	1	B	34	NO
1	21	CALLOWAY	KY121		21.57	8	C	87.5	YES
2	23	CALLOWAY	KY94		11.07	4	C	86.5	YES
3	30	CALLOWAY	US641		5.66	3	C	82.5	YES
4	49	CALLOWAY	US641	TB	15.65	3	C	72.5	YES
5	74	CALLOWAY	US641		8.92	3	C	67.5	YES
6	91	CALLOWAY	KY94		17.10	2	C	61.5	YES
7	95	CALLOWAY	KY94		23.03	3	C	57.5	YES
8	125	CALLOWAY	KY94		11.44	4	C	86.5	NO
9	126	CALLOWAY	US641	TB	15.81	3	C	85	NO
10	128	CALLOWAY	US641		1.15	4	C	82.5	NO
11	129	CALLOWAY	KY94		11.30	5	C	81.5	NO
12	239	CALLOWAY	US641		5.49	1	C	57.5	NO
13	241	CALLOWAY	KY94		1.77	1	C	56.5	NO
14	242	CALLOWAY	KY94		5.15	1	C	56.5	NO
15	243	CALLOWAY	KY94		16.49	1	C	56.5	NO
16	244	CALLOWAY	KY94		6.44	1	C	56.5	NO
1	2	CARLISLE	KY121		9.38	5	D	96.5	YES
2	13	CARLISLE	US62		3.88	3	D	90.5	YES
3	220	CARLISLE	KY121		9.10	1	D	81.5	NO
4	221	CARLISLE	US62		6.04	1	D	80.5	NO
1	96	CHRISTIAN	US41		30.88	5	B	55.5	YES
2	107	CHRISTIAN	US41		15.33	3	A	40.5	YES
3	108	CHRISTIAN	US68/KY80		10.76	3	A	40.5	YES
4	157	CHRISTIAN	US41		29.51	2	B	58	NO
5	161	CHRISTIAN	US41A	TB	10.87	2	B	55.5	NO
6	171	CHRISTIAN	KY91		13.07	2	B	50.5	NO
7	172	CHRISTIAN	KY91		11.26	2	B	50.5	NO
8	173	CHRISTIAN	KY91		4.43	3	B	50.5	NO
9	174	CHRISTIAN	US68/KY80		18.18	3	B	50.5	NO
10	195	CHRISTIAN	US41A		8.74	2	A	45.5	NO
11	196	CHRISTIAN	US41A		8.74	3	A	45.5	NO
12	197	CHRISTIAN	US41A	TB	13.44	2	A	45.5	NO
13	198	CHRISTIAN	US41A	TB	4.43	2	A	45.5	NO

PRIORITY ORDER OF BRIDGE RETROFITTING NEEDS
FOR EACH COUNTY

-- PRIORITY ORDER --		-------- GENERAL INFORMATION --------						SEISMIC	RETROF. ?
COUNTY	SYSTEM	COUNTY	ROUTE	TB	MILE POST	No.OF SPANS	SPC	RATING	SEISMIC ANALYSIS
14	203	CHRISTIAN	US68/KY80		11.20	2	A	43	NO
15	208	CHRISTIAN	US68/KY80		4.68	3	A	40.5	NO
16	209	CHRISTIAN	US68/KY80		3.56	3	A	40.5	NO
17	274	CHRISTIAN	KY91		2.16	1	A	30.5	NO
1	20	CRITTENDEN	US60		22.99	3	C	87.5	YES
2	238	CRITTENDEN	US60		14.69	1	C	57.5	NO
3	247	CRITTENDEN	US60		20.32	1	C	55	NO
4	252	CRITTENDEN	US641		5.36	1	C	48.5	NO
5	253	CRITTENDEN	US60		12.40	1	C	46	NO
6	255	CRITTENDEN	US60		10.76	1	B	42.5	NO
7	256	CRITTENDEN	US60		8.37	1	B	42.5	NO
8	261	CRITTENDEN	US60		17.22	1	C	40	NO
9	262	CRITTENDEN	US60		15.79	1	C	40	NO
1	98	DAVIESS	KY1554		1.42	3	B	53.5	YES
2	99	DAVIESS	US231		4.18	5	B	48.5	YES
3	100	DAVIESS	US231		4.03	5	B	48.5	YES
4	164	DAVIESS	US231		8.84	3	B	53.5	NO
5	168	DAVIESS	US231		3.91	5	B	51	NO
6	169	DAVIESS	US231	TB	11.29	4	B	51	NO
7	178	DAVIESS	US231		8.94	7	B	48.5	NO
8	179	DAVIESS	US231		9.22	4	B	48.5	NO
9	180	DAVIESS	US231		3.76	5	B	48.5	NO
10	181	DAVIESS	US231		4.29	5	B	48.5	NO
11	194	DAVIESS	KY1554		0.90	2	B	46	NO
1	3	FULTON	KY166	TB	12.71	3	D	95.5	YES
2	4	FULTON	KY166		2.09	3	D	95.5	YES
3	12	FULTON	KY166		9.03	3	D	90.5	YES
4	119	FULTON	US51		1.16	2	D	89	NO
5	120	FULTON	KY94		17.85	2	D	89	NO
6	215	FULTON	KY94		25.52	1	D	86.5	NO
7	216	FULTON	KY94		24.04	1	D	86.5	NO
8	219	FULTON	KY94		24.22	1	D	81.5	NO
9	222	FULTON	KY94		17.22	1	D	79	NO
10	223	FULTON	KY94		15.87	1	D	79	NO
1	5	GRAVES	US45/KY58		10.54	4	C	94	YES
2	11	GRAVES	US45		17.80	3	C	91.5	YES
3	17	GRAVES	KY121		11.73	4	C	89	YES
4	25	GRAVES	KY58		5.27	2	C	85.5	YES
5	33	GRAVES	US45		17.86	3	C	79	YES
6	35	GRAVES	KY121		7.96	7	C	76.5	YES
7	36	GRAVES	KY94		2.00	4	C	75.5	YES
8	44	GRAVES	KY121		20.19	5	C	74	YES
9	45	GRAVES	KY58		0.51	3	C	73	YES
10	46	GRAVES	KY94		2.90	1	C	73	YES
11	51	GRAVES	KY58/KY80		6.68	3	C	71.5	YES
12	52	GRAVES	KY121		8.14	4	C	71.5	YES
13	53	GRAVES	US45		1.68	3	C	71.5	YES
14	54	GRAVES	KY121		8.27	6	C	71.5	YES
15	55	GRAVES	KY121		8.75	2	C	71.5	YES
16	59	GRAVES	KY58		2.83	2	C	70.5	YES
17	60	GRAVES	KY94	TB	2.96	3	C	70.5	YES
18	90	GRAVES	US45		1.80	1	C	61.5	YES
19	140	GRAVES	US45/KY58		12.20	3	C	71.5	NO
20	141	GRAVES	KY58/KY80		12.25	3	C	71.5	NO
21	226	GRAVES	US45		7.86	1	C	66.5	NO
22	227	GRAVES	US45		7.80	1	C	66.5	NO
23	228	GRAVES	US45/KY58		13.10	1	C	66.5	NO
24	232	GRAVES	KY58/KY80		12.44	1	C	61.5	NO
25	234	GRAVES	KY58		7.90	1	C	60.5	NO
26	235	GRAVES	KY94		0.20	1	C	60.5	NO
27	251	GRAVES	US45		6.09	1	C	50	NO

PRIORITY ORDER OF BRIDGE RETROFITTING NEEDS
FOR EACH COUNTY

-- PRIORITY ORDER --		-------- GENERAL INFORMATION --------						SEISMIC	RETROF. ?
COUNTY	SYSTEM	COUNTY	ROUTE	TB	MILE POST	No.OF SPANS	SPC	RATING	SEISMIC ANALYSIS
1	32	HENDERSON	A-PKY		15.78	4	C	80.5	YES
2	34	HENDERSON	KY416		16.88	2	C	78	YES
3	56	HENDERSON	US41		12.65	3	C	70.5	YES
4	57	HENDERSON	KY351		8.59	4	C	70.5	YES
5	58	HENDERSON	US41		6.20	3	C	70.5	YES
6	67	HENDERSON	KY351	TB	1.40	3	C	68	YES
7	80	HENDERSON	US41		6.32	3	C	65.5	YES
8	81	HENDERSON	US41		11.27	3	C	65.5	YES
9	92	HENDERSON	US60		10.57	3	C	60.5	YES
10	93	HENDERSON	US60		10.00	3	C	60.5	YES
11	145	HENDERSON	US60		0.01	13	C	70.5	NO
12	150	HENDERSON	US41		0.65	3	C	65.5	NO
13	151	HENDERSON	US60		10.64	3	C	65.5	NO
14	233	HENDERSON	US60		0.01	1	C	60.5	NO
1	1	HICKMAN	KY94		2.01	2	D	96.5	YES
2	10	HICKMAN	KY58		19.82	5	D	91.5	YES
3	113	HICKMAN	KY94		0.24	3	D	96.5	NO
1	24	HOPKINS	US41		6.13	4	C	85.5	YES
2	28	HOPKINS	US41A	TB	5.30	6	C	83	YES
3	64	HOPKINS	KY109		7.24	5	C	69.5	YES
4	66	HOPKINS	US41A		3.42	7	C	68	YES
5	78	HOPKINS	US41A		0.82	3	C	65.5	YES
6	79	HOPKINS	US41A		0.49	3	C	65.5	YES
7	86	HOPKINS	KY109		14.74	11	C	64.5	YES
8	85	HOPKINS	US41A		13.11	2	B	64.5	YES
9	87	HOPKINS	KY109		16.39	5	C	64.5	YES
10	144	HOPKINS	US41A		6.59	9	C	70.5	NO
11	156	HOPKINS	KY1751		1.14	3	C	60.5	NO
12	159	HOPKINS	US41A		15.33	6	B	55.5	NO
13	160	HOPKINS	US41A		9.00	3	B	55.5	NO
14	162	HOPKINS	KY109		6.49	3	B	54.5	NO
15	163	HOPKINS	KY109		4.50	3	B	54.5	NO
16	170	HOPKINS	US62		0.23	3	B	50.5	NO
17	182	HOPKINS	KY109		3.81	4	B	47	NO
18	245	HOPKINS	US41A		15.73	1	C	55.5	NO
19	246	HOPKINS	US41A		12.65	1	C	55.5	NO
1	16	LIVINGSTON	US62/US641		0.97	3	C	89.5	YES
2	22	LIVINGSTON	US60		12.37	15	C	87	YES
3	27	LIVINGSTON	US62/US641		2.78	12	C	84.5	YES
4	42	LIVINGSTON	US62/US641		0.64	10	C	74.5	YES
5	43	LIVINGSTON	US62/US641	TB	1.20	3	C	74.5	YES
6	175	LIVINGSTON	US62/US641		0.31	3	C	49.5	NO
7	225	LIVINGSTON	US60		16.66	1	C	68.5	NO
8	249	LIVINGSTON	US60		25.98	1	C	50.5	NO
9	250	LIVINGSTON	US60		21.31	1	C	50.5	NO
10	270	LIVINGSTON	US60		29.06	1	B	36	NO
1	97	LOGAN	US68/KY80		20.94	2	B	53.5	YES
2	109	LOGAN	US68/KY80		2.80	2	A	38.5	YES
3	152	LOGAN	US68/KY80		21.91	3	A	62.5	NO
4	167	LOGAN	US431		20.31	3	B	51.5	NO
5	189	LOGAN	US431		27.73	3	B	46.5	NO
6	190	LOGAN	US431		28.91	2	B	46.5	NO
7	191	LOGAN	US431		27.41	5	B	46.5	NO
8	202	LOGAN	US68/KY80		9.64	7	A	43.5	NO
9	205	LOGAN	US79		2.91	3	A	42.5	NO
10	211	LOGAN	US79		4.64	3	A	37.5	NO
11	212	LOGAN	US79		5.93	2	A	37.5	NO
12	264	LOGAN	US68/KY80		10.38	1	B	38.5	NO
13	265	LOGAN	US79		9.43	1	B	37.5	NO

PRIORITY ORDER OF BRIDGE RETROFITTING NEEDS
FOR EACH COUNTY

-- PRIORITY ORDER --		-------- GENERAL INFORMATION --------						SEISMIC	RETROF. ?
					MILE	No.OF		RATING	SEISMIC
COUNTY	SYSTEM	COUNTY	ROUTE	TB	POST	SPANS	SPC		ANALYSIS
1	19	LYON	US62	TB	12.20	4	C	87.5	YES
2	29	LYON	US62/US641	TB	6.80	4	C	82.5	YES
3	121	LYON	US62/US641		2.78	12	C	87.5	NO
4	134	LYON	US62/US641		3.65	4	C	72.5	NO
5	158	LYON	US62		11.60	3	B	57.5	NO
1	14	MARSHALL	US68/KY80		27.80	27	C	89.5	YES
2	15	MARSHALL	US641	TB	0.24	3	C	89.5	YES
3	37	MARSHALL	US62		2.47	4	C	74.5	YES
4	38	MARSHALL	US62		10.87	3	C	74.5	YES
5	39	MARSHALL	US62	TB	8.81	2	C	74.5	YES
6	40	MARSHALL	KY408		8.92	3	C	74.5	YES
7	41	MARSHALL	KY408		8.82	3	C	74.5	YES
8	61	MARSHALL	KY408		9.34	5	C	69.5	YES
9	62	MARSHALL	KY408		9.73	21	C	69.5	YES
10	63	MARSHALL	US68		22.48	5	C	69.5	YES
11	84	MARSHALL	US62		9.48	5	C	64.5	YES
12	88	MARSHALL	US641	TB	7.94	1	C	62	YES
13	122	MARSHALL	KY80		12.52	7	C	87	NO
14	127	MARSHALL	KY80		9.86	17	C	84.5	NO
15	133	MARSHALL	US62		11.94	30	C	74.5	NO
16	135	MARSHALL	US641		9.83	4	C	72	NO
17	136	MARSHALL	US68	TB	9.43	2	C	72	NO
18	147	MARSHALL	KY80		9.67	10	C	69.5	NO
19	148	MARSHALL	KY80		8.72	2	C	69.5	NO
20	149	MARSHALL	KY58/KY80		1.12	3	C	69.5	NO
21	153	MARSHALL	US641		9.40	3	C	62	NO
22	154	MARSHALL	US641		9.87	4	C	62	NO
23	230	MARSHALL	KY408		8.10	1	C	64.5	NO
24	236	MARSHALL	KY80		15.06	1	C	59.5	NO
25	237	MARSHALL	KY408		10.87	1	C	59.5	NO
1	9	McCRACKEN	US62		13.06	5	C	91.5	YES
2	50	McCRACKEN	US60		8.30	5	C	71.5	YES
3	73	McCRACKEN	US62	TB	12.95	3	C	67.5	YES
4	75	McCRACKEN	US60		11.09	3	C	66.5	YES
5	89	McCRACKEN	US60		4.96	1	C	61.5	YES
6	116	McCRACKEN	US62	TB	13.06	5	C	91.5	NO
7	118	McCRACKEN	US60	TB	10.80	3	C	89	NO
8	123	McCRACKEN	US60		11.76	3	C	86.5	NO
9	124	McCRACKEN	US60		18.64	4	C	86.5	NO
10	130	McCRACKEN	US62		13.91	3	C	76.5	NO
11	131	McCRACKEN	US62		12.98	5	C	76.5	NO
12	137	McCRACKEN	US68	TB	1.01	2	C	71.5	NO
13	138	McCRACKEN	US60		6.69	3	C	71.5	NO
14	139	McCRACKEN	US60		19.86	24	C	71.5	NO
15	231	McCRACKEN	US60		4.10	1	C	61.5	NO
1	166	McLEAN	KY136		20.88	7	B	51.5	NO
2	188	McLEAN	KY136		19.17	3	B	46.5	NO
3	267	McLEAN	KY136		17.13	1	B	36.5	NO
1	102	MUHLENBERG	US431		12.45	7	B	46.5	YES
2	103	MUHLENBERG	US431		3.45	7	B	46.5	YES
3	106	MUHLENBERG	US431		17.48	4	A	45.5	YES
4	187	MUHLENBERG	KY176		4.29	9	B	46.5	NO
5	266	MUHLENBERG	US431		3.63	1	B	36.5	NO
6	272	MUHLENBERG	US431		13.31	1	B	34	NO
7	276	MUHLENBERG	KY176		6.60	1	A	18	NO
1	101	OHIO	US231		15.80	3	B	46.5	YES
2	111	OHIO	US231		14.12	3	B	35.5	YES
3	143	OHIO	US231		13.32	3	B	70.5	NO
4	165	OHIO	US231		11.46	4	B	51.5	NO
5	183	OHIO	US231		11.95	4	B	46.5	NO

PRIORITY ORDER OF BRIDGE RETROFITTING NEEDS
FOR EACH COUNTY

-- PRIORITY ORDER --		-------- GENERAL INFORMATION --------						SEISMIC	RETROF. ?
					MILE	No.OF		RATING	SEISMIC
COUNTY	SYSTEM	COUNTY	ROUTE	TB	POST	SPANS	SPC		ANALYSIS
6	184	OHIO	US231		20.30	4	B	46.5	NO
7	185	OHIO	US231		13.88	6	B	46.5	NO
8	186	OHIO	US231		13.49	6	B	46.5	NO
9	199	OHIO	KY136		5.67	2	B	44.5	NO
10	200	OHIO	KY136		1.06	4	B	44.5	NO
11	201	OHIO	KY136		3.34	5	B	44.5	NO
12	258	OHIO	US231		12.30	1	B	41.5	NO
13	271	OHIO	KY136		6.01	1	B	34.5	NO
14	176	OHIO	US231	TB	6.70	3	B	49	NO
1	177	TODD	US68/KY80		9.10	2	B	48.5	NO
2	204	TODD	US79		7.61	4	A	42.5	NO
3	210	TODD	US79		1.95	3	A	37.5	NO
4	263	TODD	US68/KY80		1.55	1	B	38.5	NO
5	275	TODD	US68/KY80		3.15	1	A	28.5	NO
1	18	TRIGG	US68/KY80	TB	8.27	32	C	87.5	YES
2	47	TRIGG	US68/KY80		10.94	3	C	72.5	YES
3	48	TRIGG	US68/KY80		3.11	3	C	72.5	YES
4	72	TRIGG	US68/KY80		17.89	6	C	67.5	YES
5	224	TRIGG	US68/KY80	TB	24.50	1	C	75	NO
1	65	UNION	KY130		12.54	3	C	68	YES
2	68	UNION	US60		6.48	3	C	67.5	YES
3	69	UNION	US60		13.06	3	C	67.5	YES
4	70	UNION	US60		3.66	3	C	67.5	YES
5	71	UNION	US60		5.20	3	C	67.5	YES
6	77	UNION	KY130		13.47	3	C	65.5	YES
7	259	UNION	US60		14.78	1	C	40	NO
8	260	UNION	US60		9.94	1	C	40	NO
1	110	WARREN	US231		21.53	3	A	36.5	YES
2	206	WARREN	US68/KY80	TB	8.20	4	A	41.5	NO
3	207	WARREN	US231		15.43	4	A	41.5	NO
4	213	WARREN	US231		22.61	3	A	36.5	NO
1	82	WEBSTER	KY109		7.33	5	C	64.5	YES
2	83	WEBSTER	KY109		10.72	4	C	64.5	YES
3	132	WEBSTER	US41		6.86	3	C	75.5	NO
4	142	WEBSTER	US41		11.68	4	C	70.5	NO
5	254	WEBSTER	KY109		1.03	1	B	44.5	NO

APPENDIX L

BRIDGE DATABASE

COUNTY	ROUTE	MILEPT	S_P_C	NO_S	FOUNDATION	ABUTMENT	HEIGHTABUT	LT_SP_ABUT	HEIGHTPIER	WIDTH_PIER	HT_PIER_SL	NO_PIERS	NO_C	HEIGHTPILE	HT_PILE_SL	CATA
BALLARD	US 60	1.940	D	2	14".R.C.PILES.FRICTION	PILE WW RIPRAP.2:1SLOPE	42'FRICTION PILES	50"	18.6'FROM PILE TO B.SEAT	40"	8.6'FROM SOIL TO B.SEAT	1 (OPEN)	4	30'TO BOTTOM OF PIER	N/A	Y
BALLARD	US 60	3.930	D	1	??. SPREAD FOOTER ROCK	WINGWALL	11'FOOT ABUTMENT	18"	N\A	N\A	N\A	N\A	0	N/A	N/A	Y
BALLARD	US 60	5.320	D	0	?	?	?		?		?	?		?	?	
BALLARD	US 60	5.740	D	0	?	?	?		?		?	?		?	?	
BALLARD	US 60	2.500	D	0	?	?	?		?		?	?		?	?	
BALLARD	US 60	10.230	D	0	?	?	?		?		?	?		?	?	
BALLARD	US 60	11.810	D	0	?	?	?		?		?	?		?	?	
BALLARD	US 60	11.510	D	3	14"R.C.PILES.FRICTION	E.B.PILES BERM 2:1 SLOPE	29'FRICTION PILES	B/24"	10.6'P.BENT W/SOLID WEBWA	B/36"	8.8'FROM SOIL TO B.SEAT	//4 BENTS	B/7	28'TIP P.TO TOP SOLID BEN	N/A	Y
BALLARD	KY 121	0.100	D	21	FRICTION PILES. QUICKSAND	E.B. RIPRAP OR CONC SLOPE	?	B/32"	N\A	B/32"	N\A	//22 BENTS	B/5	25'	9'	Y
BALLARD	KY 121	3.150	D	9	FRICTION PILES.STF.SAND	E.B. RIPRAP OR CONC SLOPE	?	B/33"	N\A	B/33"	N\A	//10 BENTS	B/5	35'	10'	Y
BALLARD	KY 121	5.270	D	3	FRICTION PILES,QUICK SAND	E.B. RIPRAP OR CONC SLOPE	?	B/32"	N\A	B/32"	N\A	//4 BENTS	B/5	40'	11.2'	Y
BUTLER	US 231	9.920	B	0	?	?	?		?		?	?		?	?	
BUTLER	US 231	12.260	B	10	SPREAD FOOTING ON R.&PILE	WINGWALL 2:1 SLOPED ROCK	19.25' BOT FT TO BRG SEAT	30"	128' BOT FT TO BRG SEAT	48.102.72"	86' FROM BRIDGES SEAT	9 (SOLID)	1	APPROX. 75'	N\A	N
BUTLER	US 231	17.110	B	5	18" RC FRICTION PILES	E.B.2:1 SLOPE RIPRAP	? (PILE AT E.B)	B/15"	N\A	B/30"	?	//6 BENTS	B/5	?	?	Y
BUTLER	US 231	16.320	B	6	FRICTION PILES. GRAVEL	E.B. 2:1 SLOPE & RIPRAP	?	B/25"	N\A	B/32"	?	//7 BENTS	B/5	APPROX. 28FEET ABOVE SOIL	?	Y
BUTLER	US 231	17.110	B	5	FRICTION PILE.SAND OR GRA	E.B. 2:1 SLOPE. RIPRAP	?	B/15"	N\A	B/30"	N\A	//6 BENTS	B/5	27.6	?	Y
BUTLER	US 231	17.760	A	2	SPREAD FOOTER. ROCK.SH&SS	WINGWALL BERM 2:1 CON SLP	7' BOT OF FT TO BRG SEAT	36" (12")	16' BOT OF FT TO BRG SEAT	16" (12")	N\A	1 (OPEN)	7	N\A	N\A	Y
CALDWELL	KY 672	14.080	C	4	14" RC PILES. P.BEARING	END BENTS W/ROCK FILL	40'@ BENT1 26'@ BENT5	B/29"	N/A	B/36"	N\A	//5 BENTS	B/5	38'@B1,23'@B5,43'@B2-B4	"20' FROM B.SEAT	Y
CALDWELL	US 641	4.620	C	1	SPREAD FOOTINGS ON ROCK	WINGWALLS W/2:1 SLOPE	12'BOT OF FOOT TO B.SEAT	24"	N\A	N\A	N\A	N\A	0	N\A	N\A	N
CALLOWAY	KY 94	6.440	C	0	?	?	?		?		?	?		?	?	
CALLOWAY	KY 94	16.490	C	0	?	?	?		?		?	?		?	?	
CALLOWAY	KY 94	23.030	C	0	?	?	?		?		?	?		?	?	
CALLOWAY	KY 94	5.150	C	0	?	?	?		?		?	?		?	?	
CALLOWAY	KY 94	17.100	C	0	?	?	?		?		?	?		?	?	
CALLOWAY	KY 94	1.770	C	0	?	?	?		?		?	?		?	?	
CALLOWAY	US 641	5.490	C	1	SPREAD FOOT. ON MH	WINGWALLS W/RIPRAP	16' BOT. OF FOOT. TO SEAT	20"	N\A	N\A	N\A	N\A	0	N\A	N\A	Y
CALLOWAY	US 641	1.100	C	4	SPREAD FOOTING	SOLID ABUTMENT	17.5' BOT FT TO BRG SEAT	17"	17'FROM BOT. OF FOOTING	37"	7' BOT FT TO BRG SEAT	3 (OPEN)	1	N\A	N\A	Y
CALLOWAY	KY 94	11.440	C	4	14" CONCRETE PILES	W.W BERM 2:1 SLOPE RIPRAP	38' TIP OF PILE TO SEAT	19"	22'TOP OF PILE TO PIERCAP	38"	11'FROM BRG SEAT	3 (OPEN)	4	34'@ ENDS.35' INTERMEDIAT	N\A	Y
CALLOWAY	KY 94	11.070	C	4	14" CONC. PILES	W.W BERM 2:1 PERP.TO STEA	47' TIP OF PILE TO SEAT	23"	21.5' TOP OF PILE TO CAP	36"	10'FROM BRG SEAT	3 (OPEN)	3	42'@ ENDS. 45' INTERMED.	N\A	Y
CALLOWAY	KY 94	11.300	C	5	14" CONC. PILES	W.W BERM 2:1 SLOPE. STONE	34.6'TIP OF PILE TO CAP	29"	23'TOP OF PILE TO PIERCAP	52"	11'FROM BRG SEAT	4 (OPEN)	3	30'@ ENDS, 32' INTERMED.	N\A	Y
CALLOWAY	KY 121	21.570	C	8	FRICTION RC PILES	EB.WW.BM.2:1 SLOPE RIPRAP	?	B/18"	?	B/31"	?	//7 BENTS	B/8	APPROX. 35'	?	Y
CALLOWAY	US641WB	15.810	C	3	14" FRICTION R.C. PILES	EB. WW. BM. 2:1 SLP STONE	26' TIP OF PILE TO CAP	B/18	N\A	B/37"	N\A	//2*2 BENT	B/2	20'@ ENDS.33'@ INTERMED.	10'@ INTERIOR BENTS	Y
CALLOWAY	US641WB	15.650	C	3	14" FRICTION R.C. PILES	EB. WW. BM. 2:1 STONESLOP	30' TIP OF PILE TO CAP	B/28"	N\A	B/39"	N\A	//2*2 BENT	B/2	25'@ ENDS, 32' INTERMED.	10'MAX	Y
CALLOWAY	US 641	8.920	C	3	14" R.C. FRICT. PILES	EB. BM. 2:1 SLOPE STONE	44' TIP OF PILE TO SEAT	B/14"	N\A	B/36"	N\A	//2 BENTS	B/6	40'	6'FROM BRG SEAT	Y
CALLOWAY	US 641	5.660	C	3	HP 12x53 FRICTION STEEL P	EB. WW. BM. 2:1 SLOPE	30'TIP OF PILE TO CAP	B/42"	20.75'TIP OF PILE TO CAP	B/39"	12'	//2 BENTS	B/3	28'@ ENDS. 15'@ PIERS	0	Y
CARLISLE	KY121	9.380	D	5	14"RC SOIL FRICTION PILES	END BENT 2:1 STONE SLOP	25'TIP OF PILE TO BG SEAT	B/28"	N\A	B/28"	N\A	//6 BENTS	B/7	23'B1,6/36'B2,5/40'B3,4	15' FROM BRG SEAT(B3,4)	Y
CHRISTIAN	US 68	11.270	A	2	SPREAD FOOTINGS ON ROCK	WW.ROCK BERM 1:20 SLOPE	"2'BOT. OF FOOT.TO B.SEAT	25"	19'BOT.OF FOOT. TO B.SEAT	50"	13'FROM BRG SEAT	1 (OPEN)	7	N\A	N\A	N
CHRISTIAN	US41A/P	6.850	?	2	STEEL R.P.B.PILE & S.FT.R	WINGWALLS S.PILE BM SLOPE	"44'TIP OF PILE TO B.SEAT	34"	"33'BOT.OF FOOT.TO B.SEAT	36"	"14' FROM B.SEAT	1 (OPEN)	6	34'	N\A	Y
CHRISTIAN	US 41A	15.390	?	4	SPREAD FOOTINGS ON ROCK	WINGWALLS	11' (?FROM BOT FT TO B.S)	10"	25' BOT OF FOOT TO B.SEAT	13"	23' FROM BRG SEAT	3 (B OPEN)	?	N\A	N\A	Y
CHRISTIAN	US 41A	14.190	?	3	SPREAD FOOTINGS ON ROCK	WINGWALLS	17' BOT OF FOOT TO B.SEAT	15"	20' NOTE TWIN BRIDGES	40"	20'	2 (SOLID)	1	N\A	N\A	Y
CHRISTIAN	US 41A	10.870	?	2	SPREAD FOOTINGS ON ROCK	WINGWALLS	13' BOT OF FOOT TO B.SEAT	11"	14' BOT OF FOOT TO B.SEAT	28"	9' FROM B.SEAT	1 (OPEN)	4	N\A	N\A	Y
CHRISTIAN	SNKFORK	4.430	?	3	SPREAD FOOTINGS ON ROCK	WINGWALLS	19' BOT OF FOOT TO B.SEAT	17"	19' BOT OF FOOT TO B.SEAT	32"	"17'	2 (?SOLID)	1	N\A	N\A	Y
CHRISTIAN	KY91	2.160	A	1	SPREAD FOOTINGS ON ROCK	WINGWALLS	16'BOT OF FOOT TO B.SEAT	19"	N\A	N\A	N\A	N\A	0	N\A	N\A	Y
CHRISTIAN	US41AWB	85.560	?	2	STEEL PILES 12BP@53	WINGWALLS 2:1SLOPE.S.PILE	36'PILES AT ABUTMENT	58"	'23' TOP PILE TO B.SEAT	32"	"16' FROM B.SEAT	1 (OPEN)	4	"44'AVG..10'R.TO BTTMPIER	N\A	Y
CHRISTIAN	US68	4.680	A	3	SPREAD FOOTINGS ON ROCK	BERM W/2:1 SLOPE	19'BOT OF FOOT TO B.SEAT	18"	19'BOT OF FOOT TO B.SEAT	29"	"10' FROM B.SEAT	2 (OPEN)	3	N\A	N\A	Y
CHRISTIAN	US68	3.560	A	3	S.PILE . ABUT & SF.R.PIER	END BENT BERM 2:1 SLOPE	43'TIP OF PILE TO B SEAT	B/26"	25'BOT OF FT TO BRG SEAT	35"	N\A	2 (OPEN)	3	42' AT END BENT	N\A	Y
CHRISTIAN	US41	30.880	B	5	SPREAD FOOTING ON ROCK	SLOP 2:1. ABUT.	21' BOT OF FT TO BRG SEAT	20"	31' BOT OF FT TO BRG SEAT	35"	23' FROM BRG SEAT	4 (OPEN)	3	N\A	N\A	Y
CHRISTIAN	US41	15.330	A	3	SPREAD FOOTING ON ROCK	WINGWALLS	20' BOT OF FT TO BRG SEAT	13"	20' BOT OF FT TO BRG SEAT	24"	12'FROM BRG SEAT	2 (SOLID)	1	N\A	N\A	Y

COUNTY	ROUTE	MILEPT	S_P_C	NO_S	FOUNDATION	ABUTMENT	HEIGHTABUT	LT_SP_ABUT	HEIGHTPIER	WIDTH_PIER	HT_PIER_SL	NO_PIERS	NO_C	HEIGHTPILE	HT_PILE_SL	CATA
CHRISTIAN	US68	18.180	B	3	SPREAD FOOTING ON ROCK	WINGWALLS	17' BOT OF FT TO BRG SEAT	18"	20' BOT OF FT TO BRG SEAT	37"	15' FROM BRG SEAT	2 (SOLID)	1	N\A	N\A	Y
CRITTENDEN	US 60	10.760	B	1	SPREAD FOOTER. ROCK	WINGWALLS	13'BOT. OF FOOT. TO SEAT	17"	N\A	N\A	N\A	N\A	0	N\A	N\A	Y
CRITTENDEN	US 60	22.990	C	3	HP12x53 STELPILE & S.FT.R	EB. WW. BM. 2:1 STONE SLP	55' TIP OF PILE TO B.SEAT	B/32"	55' TIP OF PILE TO B.SEAT	56"	28' FROM B. SEAT	2 (OPEN)	2	~53' TIP TO TIP	N\A	N
CRITTENDEN	US 60	10.760	B	1	SPREAD FOOTINGS ON ROCK	WING WALLS	13'BOT.OF FOOT.TO B.SEAT	20"	N\A	N\A	N\A	N\A	0	N\A	N\A	Y
CRITTENDEN	US 60	8.370	B	1	SPREAD FOOTINGS ON ROCK	WINGWALLS	17'BOT.OF FOOT.TO B.SEAT	19"	N\A	N\A	N\A	N\A	0	N\A	N\A	Y
DAVIES	KY 54 ?	1.420	?	3	14" RC FRICTION PILES	WINGWALL 2:1 SLOPE RIPRAP	"75' TIP OF PILE TO SEAT	13"	25.5' TOP OF PILE TO SEAT	35"	15'	2 (OPEN)	2	~50'@ PIER, ~70'@ ABUT.	N\A	Y
DAVIESS	KY1554	0.800	B?	2	14" FRICTION RC PILES	WINGWALL 2:1 SLOPE	60' TIP OF PILE TO B.SEAT	20"	69' TIP OF PILE TO B.SEAT	33"	18'	1 (OPEN)	4	50'@ PIER&ABUT.60'@ WINGS	N\A	Y
DAVIESS	US231WB	11.290	B	4	14" RC PILES & S.FT.CLAY	EB. BERM 2:1 SLOPE RIPRAP	30' TIP OF PILE TO B.SEAT	29"	30' BOT OF FOOT TO B.SEAT	37"	15'NOTE:(TWIN BRIDGES)	2 (OPEN)	3	~28'@ ABUT.'S ONLY	N\A	Y
DAVIESS	US 231	9.220	B	4	18" RC FRICTION PILES	EB.2:1 SLOPE RIPRAP OR CO	~52'TIP OF PILE TO B.SEAT	B/18"	N\A PILE BENTS USED ~52'	B/36"	N\A	//3 BENT	B/6	~50'	N\A	Y
DAVIESS	US 231	8.940	B	7	18" RC FRICTION PILES	EB.2:1 SLOPE RIPRAP OR CO	~65' TIP PILE TO B.SEAT	B/27"	N\A ~64' PILE BENTS	B/40"	N\A	//8 BENTS	B/6	~65'	~20'@ CHANNEL	Y
DAVIESS	US 231	8.840	B	3	R.P.B.RC.PILE & S.FT.R.	END BENTS	52'& 26'TIP TO SEAT@ ENDS	B/25"	42' & 33'	40"	~17'	2 (N.OPEN)	3	50'@ ABUT.1. 24'@ ABUT.2	N\A	Y
DAVIESS	US 231	4.290	B	5	30-RC 18" PILES	END BENT 2:1 SLOPE RIPRAP	~47'PILE AT END BENT	B/22"	N\A ~47' PILE BENTS	B/31"	N\A	//6 BENTS	B/5	~45'	N\A	Y
DAVIESS	US 231	4.180	B	5	RC FRICTION PILES	END BENT 2:1 SLOPE RIPRAP	~56' TIP OF PILE TO SEAT	B/31"	~50' TIP OF PILE TO SEAT	B/31"	N\A	//6 BENT	B/5	54'@ END, ~50'@ OTHERS	N\A	Y
DAVIESS	US 231	4.030	B	5	18" RC R.P.B. PILES	EB. BERM 2:1 SLOPE RIPRAP	47' TIP OF PILE TO B.SEAT	B/31"	N\A	B/31"	N\A	//6 BENTS	B/5	AQV. 45'	N\A	Y
DAVIESS	US231	3.910	B	5	18" RC PILE FRICTION	END BENT SLOP 2:1	? 52'TIP OF PILE TO BSEAT	B/19"	N\A	B/48"	N\A	//6 BENTS	B/5	? AVERAGE 60'	15' FROM BRG SEAT (BENT3)\	N
DAVIESS	US231	3.760	B	5	18" P-C RC PILE P.BEARING	END B 2:1 SLOP RIPRAP	40'TIP OF P TO B SEAT B6	B/31"	N\A	B/31"	N\A	//6 BENTS	B/5	38'-18'/AVERAGE 27'	6'FROM BS FOR ALL INTER B	Y
FULTON	KY166WB	0.910	?	3	14"RC FRICTION PILES	END B.&W-WALL BERM 2:1 SL	40' PILE AT END BENT	B/26"	28' BOT OF FT TO BRG SEAT	34"	6' FROM BRG SEAT	2*2 OPEN P	3	AV.40'END B. 14' AT PIERS	N\A	Y
FULTON	US51	1.160	D	2	14"RC FRICTION PILE	PILE WINGWALL BERM&SLOP	19'BFT-BS/37' PILE AT AB	23"	19' FROM BOT PILE TO B.S	40"	16' FROM BRG SEAT	1 (OPEN P)	6	AV.34',23' AB . 23' PIERS	N\A	Y
FULTON	KY166	2.090	D	3	18"RC P-C FRICTION PILES	END BENT & BERM 2:1 SLOPE	40' PILE AT END BENT	B/28"	N\A	B/34"	N\A	//4 BENTS	B/5	AV. 40' AT EACH BENT	7' FROM TOP OF PILES	Y
FULTON	KY166	9.030	D	3	18-20"PRERC FRICTION PILE	END BENT 2:1 SLOPE RIPRAP	40' PILE AT END BENT	B/28"	N\A	B/30"	N\A	//4 BENTS	B/5	AV. 40' AT EACH BENT	5' FROM BRG BEAT	Y
GRAVES	KY 58	5.270	C	2	CONCRETE FRICTION PILES	PILE W-WALL BERM 2:1SLOPE	17'BFT-BS/39' PILE AT AB	21"	19'FROM BOT OF FT TO B.S.	28"	14' FROM THE BRG SEAT	1 (OPEN P)	3	AV.19',35'AT AB/19' PIERS	N\A	Y
GRAVES	KY121	20.190	C	5	SPREAD FOOTING ON GREVEL?	2:1 SLOPE FULL ABUTMENT	16' BOT OF FT TO BRG BEAT	14"	40' BOT OF FT TO BRG BEAT	41"	32' FROM BRG SEAT	4 (OPEN)	3	N\A	N\A	Y
GRAVES	KY121	11.730	C	4	14"RC FRICTION PILES	END BENT BERM 2:1 SLOPE	50'(?) END BENT	B/17"	26'BOT OF PIER FT TO B.S.	36"	20' FROM BRG SEAT	3 (OPEN P)	2	50'(?)END BENT >20'PIERS	N\A	Y
GRAVES	KY121	8.750	C	2	SPREAD FOOTING ON (?)	WINGWALL	11' BOT OF FT TO BRG SEAT	18"	11'BOT OF FT TO BRG SEAT	36"	N\A	1 (SOLID)	1	N\A	N\A	Y
GRAVES	KY121	7.960	C	7	18"RC PRECAST PILES	END BENT&RIPRAP 1.5:1 SLP	32' END BENT PILE	B/17"	N\A	B/29"	N\A	//8 BENTS	B/5	AV. 32' AT EACH BENT	15, FROM BRG SEAT	Y
GRAVES	KY121	8.140	C	4	18"RC PRECAST PILES	END BENT&RIPRAP 1.5:1 SLP	30'(?) END BENT PILE	B/12"	N\A	B/30"	N\A	//5 BENTS	B/5	AV. 30'(?) AT EACH BENT	8' FROM BRG SEAT	Y
GRAVES	KY121	8.270	C	6	18'RC PILES	END BENT RIPRAP 1.5:1 SLP	30'(?) END BENT PILE	B/20"	N\A	B/29"	N\A	//6 BENTS	B/5	AV. 30'(?)	9' FROM BRG SEAT	Y
GRAVES	KY94 WB	2.960	C	3	FRIC.CREOSOTED TIMBER PIL	END BENT & 1.5:1 SLOPE	35'END BENT PILE (30')	B/13"	N\A	/20"	N\A	//4 BENTS	B/5	AV. 35' (30')	3' FROM BRG SEAT	Y
GRAVES	KY94	2.000	C	4	FRIC.CREOSOTED TIMBER PIL	END BENT RIPRAP 1.5:1 SLP	35' END BENT PILE	B/11"	N\A	B/19"	N\A	//5 BENTS	B/5	AV. 35'	5' FROM BRG SEAT	Y
GRAVES	KY58	12.440	C	1	SPREAD FOOTING ON SAND	WINGWALL	20'BOT OF FT TO TOP OF FT	22"	N\A	N\A	N\A	N\A	0	N\A	N\A	Y
GRAVES	KY58	6.680	C	3	RC FRICTION PILES	E.B.BERM 2:1 SLP RIPRAP	35' END BENT PILL/42'TEST	B/23"	N\A	B/36"	N\A	//4 BENTS	B/14	AV. 35' E.BENT 42' INT.B	20' FROM BG SEAT	Y
GRAVES	US45	17.770	?	3	SPREAD FOOTING ON GRAVEL	WINGWALLS	28' BOT OF FT TO BRG SEAT	16"	29' BOT OF FT TO BRG SEAT	30"	22' FROM BRG SEAT	2 (OPEN)	3	N\A	N\A	Y
HENDERSON	US41	6.320	C	3	18"RC ROCK POINTBEAR PILE	END BENT (? SLOPE)RC PILE	48' PILE AT END BENT	B/28"	N\A	B/35'	N\A	//4 BENTS	B/6	AV.48' AT EACH BENT	5' FROM BRG SEAT	Y
HENDERSON	US41	6.200	C	3	18"RC PILE POINT B SANDST	END BENT RC PILE	55' PILE AT END BENT	B/17"	N\A	B/36"	N\A	//4 BENTS	B/6	53',54',56',55'-B1,2,3,4	4' FROM BRG SEAT	Y
HENDERSON	US41	0.650	C	3	18"RC PILE POINTBEAR ROCK	END BENT & BERM 2:1 SLOPE	40' PILE AT END BENT4	B/30"	N\A	B/35"	N\A	//4 BENTS	B/5	27',31',34',40'-B1,2,3,4	12' FROM BRG SEAT	Y
HENDERSON	US.KY41	12.600	?	3	18"RC ROCK POINT BEAR PIL	END BENTS	51'END BENT PILE	B/29"	N\A	B/29"	N\A	/4 OF BENT	B/5	AV.51' AT EACH BENT	25' FROM BRG SEAT	Y
HENDERSON	US.KY41	11.270	C	3	18"RC R.P.B.PILE & S.FT.R	END BENT	42' END BENT 1 PILE	B/19"	40' BOT OF FT TO BRG SEAT	40"	12' FROM BRG SEAT	2 SOLID/2B	1	42' E.B.1 34' E.B.2	N\A	Y
HENDERSON	US41 WB	14.170	?	3	RC ROCK POINT BEAR. PILES	END BENT 4"CONC SLOPEWALL	52' END BENT PILE	B/18"	24' BOT OF FT TO BRG SEAT	36"	20' FROM BRG SEAT	2 (OPEN)	3	AV.48' E.B.1, 50' E.B.2	16' FROM BRG SEAT	Y
HENDERSON	US60	0.010	C	13	TREOPED TIMBER PILES	END BENT & WINGWALL	18'BOT OF W.W.TO B.S/40'P	B/30"	28' B.FT TO B.S.	40" B/31"	21' FROM BRG SEAT	2 SOL/12SB	1	AV.40'E.B 32'PIER 20'I.B.	N\A	Y
HENDERSON	US60 *	0.010	C	1	14" RC PRECAST PILES	END BENT WINGWALL	50' E.B.PILE /14'HT OF WW	B/24"	N\A	N\A	N\A	N\A	0	AV. 44'	10' FROM BRG SEAT	N
HENDERSON	US60	10.040	?	3	HP 12*53 STEEL PILE	END BENT & BERM (SLOPE)	80' END BENT PILE	B/25"	N\A	B/32"	N\A	//4 S.BENT	B/11	AV. 79'AT EACH BENT	//23' FROM BRG SEAT	Y
HENDERSON	US60	10.570	C	3	14".16" RC PILES	E.B. W.W.+BM 3:1 SLP+CSW	51' END BENT PILE	B/30"	28' BOT OF FT TO BRG SEAT	36"	20' FROM BRG SEAT	2(OPEN P.)	3	AV. 51' AT E.B.40'AT PIER	N\A	Y
HENDERSON	US60	10.640	C	3	14".16" RC PILES	END BENT 2:1 FULL SLOPE	56' END BENT PILE	B/30"	26' BOT OF FT TO BRG SEAT	36"	21' FROM BRG SEAT	2 (OPEN P)	3	AV.56' AT E.B. 40'AT PIER	N\A	Y
HENDERSON	KY351	8.590	C	4	14"RC PILES (?)	END BENT BERM 2:1 SLOPE	40' END BENT PILE	B/25"	N\A	B/29"	N\A	/5 OF BENT	B/6	AV.38'AT EACH BENT	14' FROM BRG SEAT	Y
HENDERSON	KY416	10.180	?	2	12PB53 STELL R.P.B. PILES	S. PILE /W.W. BM. 2:1 SLP	53' LONGEST PILE AT ABUT1	35"	20' BOT OF FT TO BRG SEAT	35"	14' FROM BRG SEAT	1 (OPEN P)	5	AV.23'ABUT1,35'ABUT2.14'P	N\A	Y
HENSERSON	?9005	15.780	?	4	STEEL R.P.B.P & S.FT.R.	STEEL.P. BERM 2:1 SLOPE	120' LONGEST PILE AT ABUT	24"	119' BOT OF FT TO B.SEAT	36"	50' FROM BRG SEAT	3 (SOLID)	1	AV.115' AT ABUT 60' PIER1	N\A	Y
HICKMAN	KY94	2.010	D	2	14"RC FRICTION PILES	PILE/WINGWALL/BERM 2:1SLP	18'B.FT-B.S/42'PILE AT AB	26"	19' BOT OF FT TO BRG SET	32"	11' FROM BRG SEAT	1 (OPEN.P)	3	AV.22'AB1 28'AB2 13'PIER	N\A	Y
HICKMAN	HWY58	19.820	D	5	STEEL H PILES & SPREAD FT	END BENT 2:1 SLOPE	60' END BENT PILE	B/21"	38' BOT OF FT TO BRG SEAT	26" B/21"	25' FROM BRG SEAT	2(SL.)4S.B	B/4	AV. 60' AT EACH BENT	10' FROM BRG SEAT	Y

COUNTY	ROUTE	MILEPT	S_P_C	NO_S	FOUNDATION	ABUTMENT	HEIGHTABUT	LT_SP_ABUT	HEIGHTPIER	WIDTH_PIER	HT_PIER_SL	NO_PIERS	NO_C	HEIGHTPILE	HT_PILE_SL	CATA
HOPKINS	US41(A)	0.490	C	3	16"RC FRICTION PILES	END BENT BERM 2:1 SLOPE	43' END BENT PILE	B/21	N\A	B/39"	N\A	//4 BENTS	B/10	AV. 43' END B 46' INT. B.	9' FROM BRG SEAT	Y
HOPKINS	US41	6.130	C	4	18"RC R.POINT BEAR. PILES	END BENT	47' END BENT PILE	B/19"	N\A	B/28"	N\A	// 5 BENTS	B/5	47'AT EACH BENT	12' FROM BRG SEAT	Y
HOPKINS	US62	0.230	B	3	RC PILE (END BENT)	EB.WW.BERM 2:1 SLP RIPRAP	42'END BENT PILE (60'TEST	B/25"	11' BOT STEM TO TOP CAP	B/36"	8' FROM TOP OF CAP	2(SOLID P)	1	AV. 50' AT E.B AND PIERS	N\A	Y
HOPKINS	KY109	3.810	B	4	SPREAD FOOTING ON ROCK	WINGWALL 2:1 SLP&C.SLP W.	20' BOT OB FT TO BRG SEAT	27"	22' BOT OF FT TO BRG SEAT	36" (24")	15' FROM BRG SEAT	3 (OPEN)	2	N\A	N\A	Y
HOPKINS	US41A	6.590	?	9	S.FT ON CLAY(AB1) & SHALE	FILL SLOP 2:1	19' BOT OF FT TO BRG SEAT	22"	39' BOT OF FT TO BRG SEAT	44"	30' FROM BRG SEAT	6(OP.2COMB	3 (5)	N\A	N\A	Y
HOPKINS	US41	0.820	C	3	16"RC FRICTION PILES	E.B WINGWALL BERM 2:1 SLP	43'END BENT PILE (45'TEST	B/15"	N\A	B/35"	N\A	//4 BENTSB	B/10	AV. 43' E.B. 46' INTER B.	6' FROM BRG SEAT	Y
HOPKINS	KY109	16.390	C	5	18"RC R.POINT BEAR. PILES	END BENT 1.5:1 SLP RIPRAP	63' TIP OF PILE TO B.SEAT	B/30"	N\A	B/30"	N\A	//6 BENTS	B/5	AV. 50'	10' FROM BRG SEAT	Y
HOPKINS	KY109	14.740	C	11	RC ROCK POINT BEAR PILES	END BENT 1.5:1 SLP RIPRAP	63' TIP OF PILT TO B.SEAT	B/30"	N\A	B/30"	N\A	//12 BENTS	B/5	AV. 50'	18'FROM BRG SEAT	Y
HOPKINS	KY109	7.240	C	5	18"RC ROCK POINTBEAR PILE	E.B. W.W.1.5:1 SLP RIPRAP	40' END BENT PILE	B/22"	N\A	B/22"	N\A	//6 BENTS	B/5	AV. 40'	11' FROM BRG SEAT	Y
HOPKINS	KY109	6.490	B	3	SPREAD FOOTING ON ROCK ..	FULL ABUT EXCAVATION SLOP	12' BOT OF FT TO BRG SEAT	21"	35' BOT OF FT TO BRG SEAT	42"	23' FROM B.S.(27'TO EXC.S	2 (OPEN)	3	N\A	N\A	Y
HOPKINS	KY109	4.500	B	3	SPEAD FOOTING ON ROCK	FULL ABUTMENT	9' BOT OF FT TO BRG SEAT	21"	31' BOT OF FT TO BRG SEAT	42"	29' FROM BRG SEAT	2 (OPEN)	3	N\A	N\A	Y
HOPKINS	US41A	9.000	B	3	HP 12*53 R.POINT BEAR PIL	E.B.+ W.WALL BERM 2:1 SLP	46' END BENT PILES	B/72"	33' BOT OF FT TO BRG SEAT	96"	28' FROM BRG SEAT	2(OPEN P)	4	AV. 44' E.B. 16' PIERS	N\A	N
HOPKINS	US41A	12.650	C	1	SPREAD FOOTING ON ROCK	WING WALL	13' BOT OF FT TO BRG SEAT	39"	N\A	N\A	N\A	N\A	0	N\A	N\A	N
HOPKINS	US41A	13.110	B	2	SPREAD FOOTING ON ROCK	WINGWALL	20' BOT OF FT TO BRG SEAT	21"	21' BOT OF FT TO BRG SEAT	60"	N\A	1 (SOLID)	1	N\A	N\A	N
HOPKINS	KY1751	1.140	C	3	SPREAD FOOTING ON S.STONE	WINGWALL	5' BOT OF FT TO BRG SEAT	22"	38' BOT OF FT TO BRG SEAT	46"	33' FROM BRG SEAT	2 (SOLID)	1	N\A	N\A	N
HOPKINS	US41A	15.330	B	6	OP.SPREAD FOOTING ON ROCK	BERM 1.5:2 SLOPE	29' BOT OF FT TO BRG SEAT	26"	29' BOT OF FT TO BRG SEAT	45"	21' FROM BRG SEAT	5 (OPEN)	2	N\A	N\A	N
HOPKINS	9001 WB	36.900	?	6	RC.ROCK POINT BEAR PILES	EB. W.WALL BERM 1.5:1 SLP	W-58'.E-60' END BENT PILE	26"	W-35'.E-35' B.FT TO B.S.	36"	W-28'.E-28' FROM BRG.SEAT	5 (OPEN P)	3	AV.55' AT E.B 23' AT PIER	N\A	Y
HOPKINS ?	US41A	13.110	B	11	ROCK POINT BEARING PILES	PILE / BERM 2:1 SLOPE	30' END BENT PILE	B/5"	BENT WITH FT 27'FT TO B.S	7"	BENT WITH FT 16'FROM B.S.	12B(5+FT)	B/	30',20'E.B 20',25',30'I.B	16' FROM BRG SEAT	Y
LIVINGSTON	US62	2.780	C	12	FP A1/SFR.A2/F-RPBP+SFR P	AB1 PILE 2:1 SLOP AB2 FAB	50' PILE AB1/5'BF-BS AB2	44"	109'BOT FT-BS/85'TOP.P-BS	44"	62' FROM BS/50' AT BENT	4(OP.)/7 B	2	45'-50'	N\A	Y
LIVINGSTON	US60	12.370	C	15	SF.ON GRAV-S.CLAY OR ON P	FULL ABUTMENT	8'(17) B.FT TO B.S. SEAT	26"	165'BOT OT FT TO BRG SEAT	42",54"	38' FROM BRG SEAT	14 (SOLID)	1	25',40',50'	N\A	Y
LIVINGSTON	KY453NB	2.810	?	3	STEEL 12BP53 PILES	END BENT BERM 2"1 SLOPE	40' END BENT PILE	B/28"	26' BOT OF FT TO BRG SEAT	36"	21' FROM BRG SEAT	2 (OPEN P)	3	AV.40'AT E.B. 60'AT PIER	N\A	Y
LIVINGSTON	US62	0.970	C	3	STEEL PILES	E.B.WINGWALL BERM 2:1 SLP	45' END BENT PILES	B/29"	31' BOT FT TO BRG SEAT	38"	25' FROM BRG SEAT	2 (OPEN P)	5	AV. 45'AT E.B. 25'AT PIER	N\A	Y
LIVINGSTON	US62	0.640	C	10	STEEL 12"@53"FRICTION PIL	END BENT 2:1 SLOPE	50' END BENT PILE (TEST)	B/16"	33' BOT OF FT TO BRG SEAT	54" B/33"	27' FROM BRG SEAT	2(OP.)/9B.	4 B/7	AV.50'AT E.B. 50'AT I.B.	N\A	Y
LOGAN	US79	5.930	A	2	SPREAD FOOTING ON ROCK	WINGWALL	16' BOT OF FT TO BRG SEAT	18"	19' BOT OF FT TO BRG SEAT	40"	10' FROM BRG SEAT	1 (SILID)	1	N\A	N\A	Y
LOGAN	US79	2.910	A	3	SPREAD FOOTING ON ROCK	WINGWALL	16' BOT OF FT TO BRG SEAT	16"	15' BOT OF FT TO BRG SEAT	37"	6' FROM BRG SEAT	2 (SOLID)	1	N\A	N\A	Y
LOGAN	US431	27.730	B	3	UNTREATED TIMBER PILES	WINGWALL	21' BOT OF FT TO BRG SEAT	20"	20' BOT OF FT TO BRG SEAT	36"	11' FROM BRG SEAT	2(SOLID P)	1	AV. 30'	N\A	Y
LOGAN	US431	28.910	B	2	UNTREATED TIMBER PILES	WINGWALL	17' BOT OF FT TO BRG SEAT	17"	17' BOT OF FT TO BRG SEAT	36"	6' FROM BRG SEAT	1(SOLID P)	1	AV. 20'	N\A	Y
LOGAN	US68	20.940	B	2	SPREAD FOOTING ON ROCK	WINGWALL	14' BOT OF FT TO BRG SEAT	18"	16' BOT OF FT TO BRG SEAT	39"	10' FROM BRG SEAT	1 (SOLID)	1	N\A	N\A	Y
LOGAN	US68	9.640	A	7	SPREAD FOOTING ON ROCK	OPEN ABUT 1.5:1 SLOPE	35' BOT OF FT TO BRG SEAT	29"	37' BOT OF FT TO BRG SEAT	41"	23' FROM BRG SEAT	6 (OPEN)	2	N\A	N\A	Y
LOGAN	US68	21.910	A	3	STEEL R.P.B.PILE & S.FT.R	E.B. W.WALL BERM 2:1 SLOP	38' PILE AT END BENT	36"	39' BOT OF FT TO BRG SEAT	45"	25' FROM BRG SEAT	2 (OPEN)	3	AV. 38'	N\A	N
LOGAN	US431	27.410	B	5	S.FT ON ROCK & ON TIMB.P	WINGWALL	26' BOT OF FT TO BRG SEAT	15"	36' BOT OF FT TO BRG SEAT	34"	12' FROM BRG SEAT	4(SL.2P.)	1	AV.26' (?)	N\A	Y
LOGAN	US431	20.310	B	3	SPREAD FOOTING ON ROCK	SLOPE 1.5:1	16' BOT OF FT TO BRG SEAT	23"	27' BOT OF FT TO BRG SEAT	36"	19' FROM BRG SEAT	2 (OPEN)	3	N\A	N\A	Y
LOGAN	US79	4.640	A	3	SPREAD FOOTING ON ROCK	WINGWALL	21' BOT OF FT TO BRG SEAT	16"	23' BOT OF FT TO BRG SEAT	33"	19' FROM BRG SEAT	2 (SOLID)	1	N\A	N\A	Y
LOGAN	US68	2.800	A	2	SPREAD FOOTING ON ROCK	WINGWALL	20' BOT OF FT TO BRG SEAT	18"	25' BOT OF FT TO BRG SEAT	40'	N\A	1 (SOLID)	1	N\A	N\A	Y
LYON	US62	2.780	?	12	TIMBER R.P.B PILE & S.F.R	TIMBER PILE 2:1 SLOPE	50'PILE AB1/5'B.F-B.S AB2	?	109 BOT OF FT TO B. SEAT	40"	81' FROM BRG SEAT	4(SL)/9 B.	1	AV.50'AT AB1,45' AT INT.B	N\A	Y
LYON	9010 WB	3.700	?	4	CONCRETE PILES	E.B. W.W. BERM 2:1 SLOPE	40' END BENT PILE (TEST)	B/32"	23' BOT OF FT TO BRG SEAT	36"	20' FROM BRG SEAT	3 (OPEN P)	3	AV.29'AT E.B. 24'AT PIER	N\A	Y
LYON (WB)	US62/24	39.510	?	4	14"CONCRETE FRICTION PILE	E.B. W.W. BERM C.A.SLOPE	45'END BENT PILE (TEST)	B/28'	27'N.B.29'S.B. B.FT-B.S.	34"	19' FROM BRG SEAT	3 (OPEN P)	4	AV.38'AT E.B. 19'AT PIER	N\A	Y
LYON TW	US62/24	39.510	?	4	CONCRETE PILES	E.B. W.WALL BERM C.A.SLP	40' END BENT PILES (TEST)	B/26"	29' BOT OF FT TO BRG SEAT	40"	24' FROM BRG SEAT	3 (OPEN P)	4	AV.40'AT EB.20-25'AT PIER	N\A	Y
LYON*	US62	3.670	?	4	12BP53 STEEL BEARING PILE	S.P. W.W.BERM 1.5:1 SLOPE	6'B.FT-B.B.//81'ABUT.PILE	40"	49' BOT OF FT TO BRG SEAT	64"	40' FROM BRG SEAT	3(SOLID P)	1	16',13',33',34',81',EACH	N\A	N
LYON*	US62	11.600	B	3	STELL.R.P.B.PILE&S.FT.ROC	E.B. BERM 1.5:1 SLOPE	30' END BENT PILE	B/27"	33' BOT OF FT TO BRG SEAT	34"	23' FROM BRG SEAT	2 (OPEN)	5	26' AT B.1 30' AT B.2	N\A	Y
MARSHALL	US62	9.480	C	5	14"RC FRICTION PILES	END BENT 2:1 SLOPE	45' END BENT PILE	B/30"	N\A	B/40"	N\A	//6 BENTS	B/5	AV. 45 AT EACH BENT	14' FROM BRG SEAT	Y
MARSHALL	US62	8.670	?	3	18"RC PILE--SPREAD FOOTER	N.B.2:1 SLOPE--2:1 SLOPE	52'E.B.P.--37'B.FT.TO B.S	B/27"	N\A	B/39"	N\A	//3 BENTS	B/9	AV. 51'AT E.B. 50'AT I.B.	17' FROM BRG SEAT	Y
MARSHALL	US62	2.470	C	4	14"RC FRICTION PILES	END BENT SLOPE PROTECTION	46' END BENT PILE	B/36"	N\A	B/36"	N\A	//5 BENTS	B/9	AV. 46'AT E.B. 45'AT I.B.	23' FROM BRG SEAT	Y
MARSHALL	US68/58	1.120	C	3	SPREAD FOOTING ON ROCK	WINGWALL	23' BOT OF FT TO BRG SEAT	19"	24' BOT OF FT TO BRG SEAT	38"	13' FROM BRG SEAT	2 (SOLID)	1	N\A	N\A	Y
MARSHALL	US68	22.480	C	5	PRECAST RC. PILES	END BENT 3:1 SLOPE	55'LOGEST PILE AT E.B.	B/28"	38' BOT OF FT TO BRG SEAT	B/34"	33' FROM BRG SEAT	//6 BENTS	B/16	35'37'27'28'39'49' B.1-5	N\A	Y
MARSHALL	KY408	9.730	?	21	18"RC FRICTION PILES	N.B.RIPRAP STONE(EXIST AB	30' END BENT PILE	B/19"	N\A	B/31"	N\A	//21 BENTS	B/3	AV. 30' AT EACH PILE	6' FROM BRG SEAT	Y
MARSHALL	KY408	9.340	C	5	18"PREC-RC FRICTION PILE	END BENT DRY RIPRAP	30' END BENT PILE	B/21"	N\A	B/31"	N\A	//6 BENTS	B/3	AV. 30' AT EACH BENT	5' FROM BRG SEAT	Y
MARSHALL	KY408	8.820	C	3	18"PREC-RC FRICTION PILES	END BENT DRY RIPRAP	30' END BENT PILES	B/21"	N\A	B/31"	N\A	//4 BENTS	B/3	AV. 30' AT EACH BENT	6' FROM BRG SEAT	Y

COUNTY	ROUTE	MILEPT	S_P_C	NO_S	FOUNDATION	ABUTMENT	HEIGHTABUT	LT_SP_ABUT	HEIGHTPIER	WIDTH_PIER	HT_PIER_SL	NO_PIERS	NO_C	HEIGHTPILE	HT_PILE_SL	CATA
MARSHALL	KY80	15.060	C	1	SPREAD FOOTING ON SOIL ?	WINGWALL	19' BOT OF FT TO BRG SEAT	25"	N\A	N\A	N\A	N\A	0	N\A	N\A	N
MARSHALL	KY80(?)	9.860	C	17	S.FT ON STONE-GRAVEL-SAND	WINGWALL	18' BOT OF FT TO BRG SEAT	19"'	23' BOT OF FT TO BRG SEAT	54"(L=18")	7' FROM BRG SEAT	16 (SOLID)	1	N\A	N\A	Y
MARSHALL	KY80	9.670	C	10	SPREAD FOOTING ON GRAVEL	WINGWALL	12' BOT OF FT TO BRG SEAT	17"	12' BOT OF FT TO BRG ESAT	40"	7' FROM BRG SEAT	9 (SOLID)	1	N\A	N\A	Y
MARSHALL	KY80	8.720	C	2	SPREAD FOOTING ON SOIL ?	WINGWALL	14' BOT OF FT TO BRG SEAT	18"	14' BOT OF FT TO BRG SEAT	36"	8' FROM BRG SEAT	1 (SOLID)	1	N\A	N\A	Y
MARSHALL	US641WB	0.240	C	3	14"PRECAST RC PILES	E.B.W.W.BM.2:1 SLP RIPRAP	34' END BENT PILE(42'TEST	B/36"	N\A	B/36"	N\A	//4 BENTS	B/2	AV. 34' AT EACH BENT	13' FROM BRG SEAT	Y
MARSHALL	US 641	7.950	?	1	SP.FT ON UNT.TIMBER PILES	WINGWALL	17' BOT OF FT TO BRG SEAT	17"	N\A	N\A	N\A	N\A	0	AV. 25' EACH	N\A	Y
MARSHALL	US641	7.940	?	1	14"TREATED TIMBER PILES	E.B. BERM 1.5:1 SLOPE	30' END BENT PILE (TEST)	B/30"	N\A	N\A	N\A	N\A	0	?30'	N\A	N
MARSHALL?	US68 WB	9.430	C	2	14"RC PILES	PILE W.W. BERM 2:1 SLOPE	18' PILE AT ABUT (17'AB.)	26"	19' BOT OF FT TO BRG SEAT	41"	13' FROM BRG SEAT	1 (OPEN P)	3	AV. 15'AT ABUT 13'AT PIER	N\A	Y
MUHLENBERG	US431	3.450	B	7	S.FT ON ROCK OR R.P.RC.P.	END BENT BERM 2:1 SLOPE	15'B.FT TO B.S.OR 38'E.B	12"	N\A	B/20"	N\A	//7 BENTS	B/4	AV. 35' AT EACH BENT	13' FROM BRG SEAT	Y
MUHLENBERG	KY176	4.290	B	9	RC PRECAST PILES	E.B. 1.5:1 SLOPE RIPRAP	40' END BENT PILES	B/36"	N\A	B/36"	N\A	//10 BENTS	B/74	AV. 40' AT EACH BENT	10' FROM BRG SEAT	Y
MUHLENBERG	US431	12.450	B	7	16"RC PILES	E.B.BERM 2:1 ROCKFILL SLP	43' END BENT PILE	B/36'	N\A	B/36"	N\A	//8 BENTS	B/7	AV. 43 AT E.B. 45'AT I.B.	20' FROM BRG SEAT	Y
McCRACKEN	US60 WB	4.330	?	3	14" RC PILES	PILE/W.W. BERM 2:1 SLOPE	51'ABT.PILE.(19'B.FT-B.S)	36"	21' BOT OF TF TO BRG SEAT	36"	16' FROM BRG SEAT	1 (OPEN)	3	AV. 42'AT ABT.38' AT PIER	N\A	Y
McCRACKEN	US60	4.100	C	1	SPREAD FOOTING ON GRAVEL	WINGWALL	15' BOT OF FT TO BRG SEAT	16"	N\A	N\A	N\A	N\A	0	N\A	N\A	Y
McCRACKEN	US60	6.690	?	3	SPREAD FOOTING	BERM SLOPE (?)	23' BOT OF FT TO BRG SEAT	25"	31' BOT OF FT TO BRG SEAT	47"	24' FROM BRG SEAT	2 (OPEN)	2	N\A	N\A	N
McCRACKEN	US60	8.300	C	5	SPREAD FOOTING ON (ROCK?)	WINGWALL	23' BOT OF FT TO BRG SEAT	15"	26' BOT OF FT TO BRG SEAT	42"	16' FROM BRG SEAT	4 (SOLID)	1	N\A	N\A	Y
McCRACKEN	US60	11.090	C	3	14"RC PRECAST PILES	E.B. W.W. BERM 2:1 SLOPE	60' END BENT PILES	B/26"	N\A	B/25"	N\A	//4 BENTS	B/24	AV. 60'END BENT AND INT.B	6' FROM BRG SEAT	Y
McCRACKEN	US60	11.760	C	3	SPREAD FOOTING ON ROCK	BERM 2:1 SLOPE	27' BOT OF FT TO BRG SEAT	24"	35' BOT OF FT TO BRG SEAT	37"	26' FROM BRG SEAT	2 (OPEN)	8	N\A	N\A	Y
McCRACKEN	US62 ?	12.980	?	5	SPREAD FOOTING ON GRAVEL	WINGWALL (?)	25' BOT OF FT TO BRG SEAT	23"	35' BOT OF FT TO BRG SEAT	51"	30' FROM BRG SEAT	2 (OPEN)	2	N\A	N\A	N
McCRACKEN	US60	19.860	C	0	?	?	?		?		?	?		?	?	
McCRACKEN	US62	13.060	C	5	14"RC PREC.FRICTION PILES	END BENT & BERM & SLOPE	40' END BENT PILE	B/20"	30' BOT OF FT TO BRG SEAT	36" B/36"	25' FROM BRG SEAT	2 OP.P/4B.	2 B/9	AV. 40' BENT 30' AT PIERS	13' FROM BRG SEAT	Y
McCRACKEN	US68 WB	1.010	C	2	14"RC PRECAST PILE	PILE WINGWALL BERM 3:1 SL	20' B.FT TO B.S.//45'PILE	20"	25' BOT OF FT TO BRG SEAT	36"	14' FROM BRG SEAT	2(SOLID.P)	1	AV.35' AT ABUT.25'AT PIER	N\A	Y
McCRACKEN	US68	6.160	?	3	14"RC PILES	E.B. W.W BERM 2:1 SLOPE	45' END BENT PILES	B/31"	26' BOT OF FT BRG SEAT	36"	14' FROM BRG SEAT	2 (OPEN P)	2	45' AT E.B. 30' AT PIERS	N\A	Y
McCRACKEN	US60I24	4.330	?	0		WINGWALL	?		?		?	?		?	?	
McCRACKEN	US62I24	4.330	?	4	PILES	WINGWALL	?		?		?	3		?	?	
McLEAN	KY 136	17.129	B	1	14'' R.C. PILES	WINGWALLED	16.8 FEET	20"	N\A	N\A	N\A	N\A	N\A	APPROX. 30 FEET	N\A	Y
McLEAN	KY 136	19.160	B	3	R.P.B.18" PILES (E.B.& P)	E.B.PRE-PILE 1.5:1 RIPRAP	PILES FROM ROCK 39.22'	B/ 16"	18.3 FROM PILE TO B.SEAT	40"	15.5 FEET	2 (SOLID)	1	15.26 FROM ROCK TO PIER	N/A	Y
McLEAN	KY 136?	20.880	B	7	14"PRE PILES (E.B.& PIER)	E.B.PILES W/ RIPRAP	35 TO 40 FOOT PILES	B/?	18'FROM PILE TO B.SEAT	31" B/25"	10.2'	2(SOL)/6 B	1	35' TO 40'	5'	Y
McLEAN	KY 136	20.880	B	7	PRECAST CONCRETE PILES	END BENT RIPRAP	40' END BENT PILE	B/14"	18' BOT OF FT TO BRG SEAT	31" B/26"	11' FROM BRG SEAT	2(SOL P)5B	1 B/4	AV.40'AT BENT.35'AT PIER	5' FROM BRG SEAT	Y
McLEAN	KY 136	19.170	B	3	PREC-RC ROCK P.B.PILES	E.B. 1.5:1 SLOPE RIPRAP	39' END BENT PILES	B/20"	18' BOT OF FT TO BRG SEAT	34"	11' FROM BRG SEAT	2(SOLID P)	1	AV.33'AT E.B.14'AT PIERS	N\A	Y
McLEAN	KY 136	17.130	B	1	S.FT.ON 14"RC PILES	PILES WINGWALL	17' BOT OF FT TO BRG SEAT	17"	N\A	N\A	N\A	N\A	0	AV. 30'	N\A	Y
OHIO	KY 136	1.060	B	4	??.R.C. PRECAST PILES	E.B. 1.5:1 SLOPE RIPRAP	45' PRECAST PILES	B/20"	N\A	B/40"	N\A	//5 BENTS	B/4	45' 43' 35'	7'FROM SOIL TO B.SEAT	Y
OHIO	KY 136	3.340	B	5	??.R.C.PRECAST PILES	E.B 1.5:1 SLOPE RIPRAP	40' PRECAST PILES AT E.B.	B/14"	N\A	B/29"	N\A	//6 BENTS	B/4	APPROX. 40 '	7'FROM SOIL TO B.SEAT	Y
OHIO	KY 136	5.600	B	2	SPREAD FOOTING ON ROCK	WINGWALL	17.61' BOT OF FT TO BRG S	17"	16.0 FROM ROCK TO B.SEAT	36"	10.4'FROM BRG SEAT	1 (SOLID)	1	N\A	N\A	Y
OHIO	KY 136	6.000	B	0	?	?	?	?	?	?	?	?	?	?	?	
OHIO	US 231	11.460	B	4	SPR.FOOTER ROCK. SHALE	WINGWALL	20' BOT FT TO BRG SEAT	18"	18'FROM ROCK TO B.SEAT	30"	10.6' FROM SOIL TO B.SEAT	3 (OPEN)	6(?)	N/A	N/A	Y
OHIO	US 231	11.950	B	4	18" R.C. PILES. FRICTION	E.B.PILE 2:1 SLOPE RIPRAP	40' PILES AT END BENT	B/15"	N\A	B/32"	N\A	//5 BENTS	B/5	APPROX. 40 FOOT	10.0' FROM SOIL TO B.SEAT	Y
OHIO	US 231	12.300	B	1	??. SPREAD FOOTER	WINGWALL	18' BOT OF FT TO BRG SEAT	15"	N\A	N\A	N\A	N\A	N\A	N\A	N\A	Y
OHIO	US 231	13.320	B	3	3 SPR. ROCK. 1 P.BEARING	WINGWALL.1 SPR.R.1 P.BEAR	SPR.20'ROCK,17'P.+16'ABUT	20"	35'FROM ROCK TO B.SEAT	42" (17")	30'FROM SOIL TO B.DECK	2 (SOLID)	1	17.0 FROM ROCK TO WING	N/A	Y
OHIO	US 231	13.490	B	6	SOIL. FRICTION PILES	E.B. SLOPE CONCR RIPRAP	46'R.C.PILES	B/18"	N/A	B/30"	N/A	//7 BENTS	B/5	46'FRICTION PILES	8.8'FROM SOIL TO B.SEAT	Y
OHIO	US 231	13.880	B	6	ROCK. P.BEARING PILES	E.B.PILES W/RIPRAP OR CON	46'R.C.PILES FROM ROCK	B/16"	N/A	B/31"	N/A	//7 BENTS	B/5	46'FROM ROCK TO B.SEAT	10.4'FROM SOIL TO B.SEAT	Y
OHIO	US 231	14.120	B	3	SHALE. P.BEARING PILES	53 FOOT PILES W/ROCK BERM	53 FOOT PILES	B/18"	11'P.BENT W SOLID WEBBWAL	B/36"	8.5'FROM SOIL TO B.SEAT	2	B/8	53'FROM ROCK TO B.SEAT	42'FROM ROCK TO SOL.P.BEN	Y
OHIO	US 231	15.800	B	0	?	?	?		?		?	?		?	?	
OHIO	US 231	20.300	B	4	18".R.C.PRE.PILE.FRICTION	E.B. PILES W/ 2:1 SLOPE	50'PILES	B/31"	N\A	B/29"	N\A	//5 BENTS	B/6	50'FRICTION PILES	25'FROM SOIL TO B.SEAT	Y
OHIO	KY136	5.670	B	2	SPREAD FOOTING ON ROCK	WINGWALL	18' BOT OF FT TO BRG SEAT	17"	16' BOT OF FT TO BRG SEAT	36"	10' FROM BRG SEAT	1 (SOLID)	1	N\A	N\A	Y
OHIO	KY136	3.340	B	5	RC PRECAST PILES	END BENT 1.5:1 SLP RIPRAP	40' END BENT PILE	B/14"	N\A	B/29"	N\A	//6 BENTS	B/4	AV. 40' AT EACH BENT	7' FROM BRG SEAT	Y
OHIO	KY136	1.060	B	4	RC PRECAST PILES	E.B. 1.5:1 SLOPE RIPRAP	42' END BENT PILE	B/20"	N\A	B/40"	N\A	//5 BENTS	B/4	AV. 42' AT EACH BENT	6' FROM BRG SEAT	N
OHIO	US231	11.950	?	4	18"PREC-RC FRICTON PILE	E.B.2:1 SLP DRY RIPRAP	40' END BENT PILE	B/15"	N\A	B/32"	N\A	//5 BENTS	B/5	AV. 40' AT EACH BENT	10' FROM BRG SEAT	Y
OHIO	US231	11.460	B	4	SPREAD FOOTING ON ROCK	WINGWALL	20' BOT OF FT TO BRG SEAT	18"	18' BOT OF FT TO BRG SEAT	30"	11' FROM BRG SEAT	3 (OPEN)	6	N\A	N\A	Y

COUNTY	ROUTE	MILEPT	S_P_C	NO_S	FOUNDATION	ABUTMENT	HEIGHTABUT	LT_SP_ABUT	HEIGHTPIER	WIDTH_PIER	HT_PIER_SL	NO_PIERS	NO_C	HEIGHTPILE	HT_PILE_SL	CATA
OHIO	US231	12.300	B	1	SPREAD FOOTING ON ROCK	WINGWALL	16' BOT OF FT TO BRG SEAT	15"	N\A	N\A	N\A	N\A	0	N\A	N\A	Y
OHIO	US231	13.880	B	6	18"RC R.P.B. PILES	END BENT RIPRAP STONE SLP	46' END BENT PILE	B/16"	N\A	B/31"	N\A	//7 BENTS	B/5	AV. 46' AT EACH BENT	11' FROM BRG SEAT	Y
OHIO	US231	13.490	B	6	18"RC FRICTION PILES	END BENT RIPRAP STONE SLP	46' END BENT PILE	B/18"	N\A	B/30"	N\A	//7 BENTS	B/5	AV. 46' AT EACH BENT	9' FROM BRG SEAT	Y
OHIO	US231	13.320	B	3	SPREAD FOOTER	WINGWALL	22' BOT OF FT TO BRG SEAT	20"	37' BOT OF FT TO BRG SEAT	42"(L=17")	31' FROM BRG SEAT	2 (SOLID)	1	N\A	N\A	Y
OHIO	US231	14.120	B	3	12HP53 STEEL PILES	END BENT BERM 2:1 SLOPE	53' END BENT PILE	B/18"	N\A	B/36"	N\A	//4 BENTS	B/8	AV. 52' AT EACH BENT	9' FROM BRG SEAT	Y
OHIO	US231	20.300	B	4	18"PREC-RC FRICTION PILE	E.B BERM 2:1 SLOPE	51' END BENT PILE	B/31"	N\A	B/29"	N\A	//5 BENTS	B/6	AV. 50' AT EACH BENT	12' FROM BRG SEAT	Y
OHIO WD	9001	74.560	?	3	SPREAD FOOTING ON ROCK	WINGWALL	9' BOT OF FT TO BRG SEAT	18"	23'BOT OF FT TO BRG SEAR	36"	16' FROM BRG SEAT	2 (OPEN)	3	N\A	N\A	Y
TODD	US68	3.150	A	1	SPREAD FOOTING ON ROCK	WINGWALL (RC & MASONRY)	12' BOT OF FT TO BRG SEAT	16"	N\A	N\A	N\A	N\A	0	N\A	N\A	Y
TODD	US68	1.550	B	1	SPREAD FOOTING ON ROCK	WINGWALL	11' BOT OF FT TO BRG SEAT	16"	N\A	N\A	N\A	N\A	0	N\A	N\A	Y
TODD	US79	7.610	A	4	SPREAD FOOTING ON ROCK	WINGWALL	17' BOT OF FT TO BRG SEAT	17"	18' BOT OF FT TO BRG SEAT	34"	16' FROM BRG SEAT	3 (SOLID)	1	N\A	N\A	Y
TODD	US79	1.940	A	3	SPREAD FOOTING ON ROCK	1.5:1 SLOPE	19' BOT OF FT TO BRG SEAT	23"	30' BOT OF FT TO BRG SEAT	35"	22' FROM BRG SEAT	2 (OPEN)	2	N\A	N\A	Y
TRIGG	US68	10.940	C	3	14'RC & 12BP53 PILES	END BENT 2:1 SLOPE	70' END BENT PILE	B/15"	N\A	B/40"	N\A	//4 BENTS	B/7	AV. 70 AT EACH BENT	20, FROM BRG SEAT	Y
TRIGG	US68	17.890	C	6	S.FT.SOIL + 10BP42 PILE	END BENT 2:1 SLOPE	12'B.FT-B.S AB1/48'E.B.P	14" B/27"	46' BOT OF FT TO BRG SEAT	44"	30' FROM BRG SEAT	5 (SOLID)	1	AV. 48' AT END BENT	N\A	Y
TRIGG WD	US68/24	65.350	?	1	16"RC FRICTION PILES ?	PILE W.W. BERM 2:1 SLOPE	24' B.FT-B.S./60'AB.PILE	17"	N\A	N\A	N\A	N\A	0	AV. 48'	N\A	Y
UNION	US60	3.660	C	3	12BP53 STEEL FRICTION PIL	E.B. W.W. BERM 2:1 SLOPE	40' END BENT PILE	B/32"	N\A	B/32"	N\A	//4 BENTS	B/6	40'E.B1,38'I.B,36'E.B2	23' FROM BRG SEAT	Y
UNION	US60	5.200	C	3	RC PRECAST FRICTION PILE	E.B. W.W. BERM 2:1 SLOPE	40' END BENT PILE	B/19"	N\A	B/38"	N\A	//4 BENTS	B/9	40' AT E.B. 45' AT I.B.	20' FROM BRG SEAT	Y
UNION	US60	6.480	C	3	RC PRECAST FRICTION PILE	E.B. W.W. BERM 2:1SLOPE	40' END BENT PILE	B/19"	N\A	B/35"	N\A	//4 BENTS	B/9	40' AT E.B. 45' AT I.B.	15' FROM BRG SEAT	Y
UNION	US60	13.060	C	3	RC PRECAST FRICTION PILE	E.B. W.W. BERM 2:1 SLOPE	40' END BENT PILE	B/19"	N\A	B/33"	N\A	//4 BENTS	B/9	40' AT E.B. 45' AT I.B.	13' FROM BRG SEAT	Y
UNION	KY13	13.470	C	3	RC PRECAST FRICTION PILE	E.B. BERM 2:1 SLOPE	52' END BENT PILE	B/31"	N\A	B/31"	N\A	//4 BENTS	B/5	47' AT E.B. 56' AT I.B.	13' FROM BRG SEAT	Y
WARREN	US231	15.430	A	4	S.R.P.B.P-E.B/S.FT.R-PIER	E.B. W.W. BERM 2:1 SLOPE	26' END BENT PILE	B/24"	30' BOT OF FT TO BRG SEAT	40"	19' FROM BRG SEAT	3 (OPEN)	6	26'	N\A	Y
WARREN	US231	21.530	A	3	SPREAD FOOTING ON ROCK	WINGWALL BERM SLOPE	20' BOT OF FT TO BRG SEAT	27"	25' BOT OF FT TO BRG SEAT	48"	16' FROM BRG SEAT	2 (OPEN)	3	N\A	N\A	Y
WEBSTER	US41	6.860	C	3	SPREAD FOOTING ON ROCK	WINGWALL BERM 2:1 SLOPE	34' BOT OF FT TO BRG SEAT	22"	31' BOT OF FT TO BRG SEAT	41"	13' FROM BRG SEAT	2 (OPEN)	3	N\A	N\A	Y
WEBSTER	KY109	1.030	B	1	HP12*53 STEEL PILES	END BENT STONE SLOPE PROT	36' LONGEST PILE AT E.B.	B/24"	N\A	N\A	N\A	N\A	0	AV.33'AT EB.1 31'AT EB.2	N\A	N
WEBSTER	US41	11.680	C	4	SPREAD FOOTING ON STONE	WINGWALLS	22' BOT OF FT TO BRG SEAT	26"	25' BOT OF FT TO BRG SEAT	39"	22' FROM BRG SEAT	3 (OPEN)	3	N\A	N\A	Y

APPENDIX M

STATISTICAL AND PROBABILISTIC ANALYSIS FOR ESTIMATING THE SOIL FRICTION ANGLES

SEP. 27, 1989

BALLARD COUNTY
STATISTICAL ANALYSIS OF SOIL PROPERTIES
FREQUENCY DISTRIBUTION AND PROBABILITY DESITY
FOR FRICTION ANGLES

n	93
N	8
MAX VALUE	44.7
MIN VALUE	26.477832
INTERVAL	2.2777709

PROB DEN		0.057	0.137	0.085	0.076	0.019	0.033	0.024	0.009
INTV PROP		0.129	0.312	0.194	0.172	0.043	0.075	0.054	0.022
FREQUEN		12	29	18	16	4	7	5	2
CUM FRE		12	41	59	75	79	86	91	93
		1	2	3	4	5	6	7	8
SAMPLE		28.755603	31.033374	33.311145	35.588916	37.866687	40.144458	42.422229	44.7
1	32.203287	0	0	1	1	1	1	1	1
2	34.558823	0	0	0	1	1	1	1	1
3	37.475280	0	0	0	0	1	1	1	1
4	29.934612	0	1	1	1	1	1	1	1
5	30.586904	0	1	1	1	1	1	1	1
6	28.590927	1	1	1	1	1	1	1	1
7	29.636729	0	1	1	1	1	1	1	1
8	30.250560	0	1	1	1	1	1	1	1
9	30.946463	0	1	1	1	1	1	1	1
10	31.332679	0	0	1	1	1	1	1	1
11	30.586904	0	1	1	1	1	1	1	1
12	30.250560	0	1	1	1	1	1	1	1
13	29.354956	0	1	1	1	1	1	1	1
14	28.833368	0	1	1	1	1	1	1	1
15	26.477832	1	1	1	1	1	1	1	1
16	30.250560	0	1	1	1	1	1	1	1
17	32.203287	0	0	1	1	1	1	1	1
18	38.974544	0	0	0	0	0	1	1	1
19	29.636729	0	1	1	1	1	1	1	1
20	31.749825	0	0	1	1	1	1	1	1
21	33.249089	0	0	1	1	1	1	1	1
22	37.475280	0	0	0	0	1	1	1	1
23	33.249089	0	0	1	1	1	1	1	1
24	31.749825	0	0	1	1	1	1	1	1
25	31.332679	0	0	1	1	1	1	1	1
26	32.7	0	0	1	1	1	1	1	1
27	37.475280	0	0	0	0	1	1	1	1
28	34.558823	0	0	0	1	1	1	1	1
29	32.203287	0	0	1	1	1	1	1	1
30	29.636729	0	1	1	1	1	1	1	1
31	44.7	0	0	0	0	0	0	0	1
32	41.087640	0	0	0	0	0	0	1	1
33	38.974544	0	0	0	0	0	1	1	1
34	34.558823	0	0	0	1	1	1	1	1
35	38.974544	0	0	0	0	0	1	1	1
36	30.250560	0	1	1	1	1	1	1	1
37	38.974544	0	0	0	0	0	1	1	1
38	29.636729	0	1	1	1	1	1	1	1
39	29.636729	0	1	1	1	1	1	1	1
40	38.974544	0	0	0	0	0	1	1	1
41	28.590927	1	1	1	1	1	1	1	1
42	28.590927	1	1	1	1	1	1	1	1
43	27.334103	1	1	1	1	1	1	1	1

THE PROBABILITY ANALYSIS OF FRICTION ANGLES

IN BALLARD COUNTY

No. SAMPLE 92

NORMAL DISTRIBUTION			LOGNORMAL DISTRIBUTION		
MEAN= 32.	X=m - S.D.	X=m - 2 S.D.	MEAN= 3.4 (32.52)	X=m - S.D.	X=m - 2 S.D.
VARIANCE= 17.	28.	24.408144	VARIANCE= 0.0	3.3	3.2367260
STD DEV= 4.1	u=1	u=2	STD DEV= 0.1	u=1	u=2
COEF V= 0.1	F(u)=15.87%	F(u)=2.28%	COEF V= 0.0	F(u)=15.87%	F(u)=2.28%
WITH 95% CONFIDENCE	F(u) = 0.05		WITH 95% CONFIDENCE	F(u) = 0.05	
	u= -1.645			u= -1.645	
	X = 25.894910 DEGREES			X= 3.2803161	
				Y = 26.584175 DEGREES	

PHI = 44.7 - 12*(LOG PI)

P.I. X	PHI Y	(Y-m)^2	LN(PHI) LN(Y)	(LN(Y)-M)^2	phi	Ln(phi)	LOGNORMAL DISTR.	NORMAL DISTR.
11	32.203287	0.3375671	3.4720685	0.0001047	20	2.996	0.0000632	0.0009026
7	34.558823	3.1489583	3.5426629	0.0036432	21	3.045	0.0002886	0.0018183
4	37.475280	22.005359	3.6236815	0.0199876	22	3.091	0.0009215	0.0034599
17	29.934612	8.1206767	3.3990154	0.0069369	23	3.135	0.0026166	0.0062189
15	30.586904	4.8285147	3.4205719	0.0038108	24	3.178	0.0062854	0.0105583
22	28.590927	17.584311	3.3530894	0.0166963	25	3.219	0.0130125	0.0169323
18	29.636729	9.9071536	3.3890144	0.0087029	26	3.258	0.0235929	0.0256495
16	30.250560	6.4198021	3.4095147	0.0052982	27	3.296	0.0379852	0.0367012
14	30.946463	3.3776172	3.4322587	0.0025045	28	3.332	0.0549678	0.0496044
13	31.332679	2.1071811	3.4446616	0.0014169	29	3.367	0.0722526	0.0633288
15	30.586904	4.8285147	3.4205719	0.0038108	30	3.401	0.0870736	0.0763697
16	30.250560	6.4198021	3.4095147	0.0052982	31	3.434	0.0969988	0.0869923
19	29.354956	11.760347	3.3794614	0.0105765	32	3.466	0.1006114	0.0936009
21	28.833368	15.609805	3.3615333	0.0145855	33	3.497	0.0977983	0.0951304
33	26.477832	39.771442	3.2763076	0.0424343	34	3.526	0.0896018	0.0913268
16	30.250560	6.4198021	3.4095147	0.0052982	35	3.555	0.0777748	0.0828165
11	32.203287	0.3375671	3.4720685	0.0001047	36	3.584	0.0642543	0.0709374
3	38.974544	38.319218	3.6629087	0.0326181	37	3.611	0.0507353	0.0573949
18	29.636729	9.9071536	3.3890144	0.0087029	38	3.638	0.0384315	0.0438643
12	31.749825	1.0701240	3.4578872	0.0005961	39	3.664	0.0280222	0.0316656
9	33.249089	0.2160360	3.5040273	0.0004719	40	3.689	0.0197282	0.0215926
4	37.475280	22.005359	3.6236815	0.0199876	41	3.714	0.0134478	0.0139079
9	33.249089	0.2160360	3.5040273	0.0004719	42	3.738	0.0086960	0.0084617
12	31.749825	1.0701240	3.4578872	0.0005961	43	3.761	0.0057281	0.0048629
13	31.332679	2.1071811	3.4446616	0.0014169	44	3.784	0.0035952	0.0026398
10	32.7	0.0071053	3.4873750	0.0000257	45	3.807	0.0022043	0.0013535
4	37.475280	22.005359	3.6236815	0.0199876				
7	34.558823	3.1489583	3.5426629	0.0036432				
11	32.203287	0.3375671	3.4720685	0.0001047				
18	29.636729	9.9071536	3.3890144	0.0087029				
1	44.7	141.98407	3.7999735	0.1009139				
2	41.087640	68.945571	3.7157073	0.0544771				
3	38.974544	38.319218	3.6629087	0.0326181				
7	34.558823	3.1489583	3.5426629	0.0036432				
3	38.974544	38.319218	3.6629087	0.0326181				
16	30.250560	6.4198021	3.4095147	0.0052982				
3	38.974544	38.319218	3.6629087	0.0326181				
18	29.636729	9.9071536	3.3890144	0.0087029				
18	29.636729	9.9071536	3.3890144	0.0087029				

44	33.862920	0	0	0	1	1	1	1	1
45	34.558823	0	0	0	1	1	1	1	1
46	35.362184	0	0	0	1	1	1	1	1
47	33.249089	0	0	1	1	1	1	1	1
48	38.974544	0	0	0	0	0	1	1	1
49	33.249089	0	0	1	1	1	1	1	1
50	33.862920	0	0	0	1	1	1	1	1
51	33.862920	0	0	0	1	1	1	1	1
52	34.558823	0	0	0	1	1	1	1	1
53	32.203287	0	0	1	1	1	1	1	1
54	36.312359	0	0	0	0	1	1	1	1
55	32.203287	0	0	1	1	1	1	1	1
56	30.946463	0	1	1	1	1	1	1	1
57	30.250560	0	1	1	1	1	1	1	1
58	27.720319	1	1	1	1	1	1	1	1
59	34.558823	0	0	0	1	1	1	1	1
60	30.946463	0	1	1	1	1	1	1	1
61	29.934612	0	1	1	1	1	1	1	1
62	26.803659	1	1	1	1	1	1	1	1
63	28.359265	1	1	1	1	1	1	1	1
64	29.934612	0	1	1	1	1	1	1	1
65	41.087640	0	0	0	0	0	0	1	1
66	34.558823	0	0	0	1	1	1	1	1
67	33.862920	0	0	0	1	1	1	1	1
68	34.558823	0	0	0	1	1	1	1	1
69	38.974544	0	0	0	0	0	1	1	1
70	32.7	0	0	1	1	1	1	1	1
71	33.862920	0	0	0	1	1	1	1	1
72	33.249089	0	0	1	1	1	1	1	1
73	34.558823	0	0	0	1	1	1	1	1
74	33.862920	0	0	0	1	1	1	1	1
75	41.087640	0	0	0	0	0	0	1	1
76	41.087640	0	0	0	0	0	0	1	1
77	41.087640	0	0	0	0	0	0	1	1
78	31.749825	0	0	1	1	1	1	1	1
79	44.7	0	0	0	0	0	0	0	1
80	31.332679	0	0	1	1	1	1	1	1
81	26.803659	1	1	1	1	1	1	1	1
82	29.354956	0	1	1	1	1	1	1	1
83	29.354956	0	1	1	1	1	1	1	1
84	28.833368	0	1	1	1	1	1	1	1
85	29.934612	0	1	1	1	1	1	1	1
86	26.974544	1	1	1	1	1	1	1	1
87	28.833368	0	1	1	1	1	1	1	1
88	29.636729	0	1	1	1	1	1	1	1
89	30.586904	0	1	1	1	1	1	1	1
90	28.590927	1	1	1	1	1	1	1	1
91	27.523634	1	1	1	1	1	1	1	1
92	29.636729	0	1	1	1	1	1	1	1
93	29.636729	0	1	1	1	1	1	1	1

3	38.974544	38.319218	3.6629087	0.0326181
22	28.590927	17.584311	3.3530894	0.0166963
22	28.590927	17.584311	3.3530894	0.0166963
28	27.334103	29.704564	3.3081351	0.0303347
8	33.862920	1.1634364	3.5223206	0.0016013
7	34.558823	3.1489583	3.5426629	0.0036432
6	35.362184	6.6455268	3.5656430	0.0069454
9	33.249089	0.2160360	3.5040273	0.0004719
3	38.974544	38.319218	3.6629087	0.0326181
9	33.249089	0.2160360	3.5040273	0.0004719
8	33.862920	1.1634364	3.5223206	0.0016013
8	33.862920	1.1634364	3.5223206	0.0016013
7	34.558823	3.1489583	3.5426629	0.0036432
11	32.203287	0.3375671	3.4720685	0.0001047
5	36.312359	12.447255	3.5921581	0.0120679
11	32.203287	0.3375671	3.4720685	0.0001047
14	30.946463	3.3776172	3.4322587	0.0025045
16	30.250560	6.4198021	3.4095147	0.0052982
26	27.720319	25.643824	3.3221657	0.0256442
7	34.558823	3.1489583	3.5426629	0.0036432
14	30.946463	3.3776172	3.4322587	0.0025045
17	29.934612	8.1206767	3.3990154	0.0069369
31	26.803659	35.767975	3.2885384	0.0375450
23	28.359265	19.580864	3.3449538	0.0188650
17	29.934612	8.1206767	3.3990154	0.0069369
2	41.087640	68.945571	3.7157073	0.0544771
7	34.558823	3.1489583	3.5426629	0.0036432
8	33.862920	1.1634364	3.5223206	0.0016013
7	34.558823	3.1489583	3.5426629	0.0036432
3	38.974544	38.319218	3.6629087	0.0326181
10	32.7	0.0071053	3.4873750	0.0000257
8	33.862920	1.1634364	3.5223206	0.0016013
9	33.249089	0.2160360	3.5040273	0.0004719
7	34.558823	3.1489583	3.5426629	0.0036432
8	33.862920	1.1634364	3.5223206	0.0016013
2	41.087640	68.945571	3.7157073	0.0544771
2	41.087640	68.945571	3.7157073	0.0544771
2	41.087640	68.945571	3.7157073	0.0544771
12	31.749825	1.0701240	3.4578872	0.0005961
1	44.7	141.98407	3.7999735	0.1009139
31	26.803659	35.767975	3.2885384	0.0375450
19	29.354956	11.760347	3.3794614	0.0105765
19	29.354956	11.760347	3.3794614	0.0105765
21	28.833368	15.609805	3.3615333	0.0145855
17	29.934612	8.1206767	3.3990154	0.0069369
30	26.974544	33.753173	3.2948936	0.0351226
21	28.833368	15.609805	3.3615333	0.0145855
18	29.636729	9.9071536	3.3890144	0.0087029
15	30.586904	4.8285147	3.4205719	0.0038108
22	28.590927	17.584311	3.3530894	0.0166963
27	27.523634	27.674525	3.3150450	0.0279755
18	29.636729	9.9071536	3.3890144	0.0087029
18	29.636729	9.9071536	3.3890144	0.0087029

APPENDIX N

MODIFIED MERCALLI INTENSITY SCALE

Table 1: MODIFIED MERCALLI INTENSITY SCALE

Modified Mercalli Intensity Scale, 1956 Version

The following comments by Dr. Richter precede the published statement of the intensity scale:

...Each effect is named at the level of intensity at which it first appears frequently and characteristically. Each effect may be found less strongly, or in fewer instances, at the next lower grade of intensity; more strongly or more often at the next higher grade. A few effects are named at two successive levels to indicate a more gradual increase.

Masonry A, B, C, D. To avoid ambiguity of language, the quality of masonry, brick or otherwise, is specified by the following lettering.

Masonry A. Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.

Masonry B. Good workmanship and mortar, reinforced by not designed in detail to resist lateral forces.

Masonry C. Ordinary workmanship and mortar; no extreme weakness like failing to tie corners, but neither reinforced nor designed against horizontal forces.

Masonry D. Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

The following list represents the twelve grades of the scale.

I. Not felt. Marginal and long-period effects of large earthquakes.

II. Felt by persons at rest, on upper floors, or favorable placed.

III. Felt indoors, Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.

IV. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV wooden walls and frame creak.

V. Felt outdoors; direction estimated. Sleepers awakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.

VI. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken, Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken.

VII. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices. Same cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.

VIII. Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundation if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.

IX. General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. Frame structures, if not bolted, shifted off foundations. Frames cracked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake fountains, sand crater.

X. Most masonry and frame structures destroyed with their foundations. Some will-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large land slides. Water thrown on banks of canals, river, lakes, etc. Sand and mud shifted horizontally on beaches and flat lands. Rails bent slightly.

XI. Rails bent greatly. Underground pipelines completely out of service.

XII. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown in the air.

APPENDIX O

RETROFITTING PRIOIRY ORDER FOR BRIDGES IN EACH CORRIDOR