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16. Abstract

The bridge railing constructed on the approaches to the US-41 northbound bridge over the Ohio River at Henderson, Kentucky, is not in conformance with specifications. The vertical face was constructed to be an average height of 4 3/4 inches above the pavement surface rather than the specified 3 inches. From the top of the vertical face, the barrier conformed to a standard New Jersey barrier. However, this meant the intersection between the two sloping surfaces was 14 1/2 inches rather than 13 inches above the pavement surface.

An analysis was conducted to ascertain whether the in-place barrier walls (bridge rail) are more or less hazardous than a wall built to specified dimensions. The major negative factor that may be associated with the railing, as constructed, was an increased tendency for vehicle rollovers compared to a rail built with specified dimensions. However, there has not been any substantial differences observed in overall accident severity (using Kentucky or other accident data) between a barrier with dimensions as constructed on US-41 (New Jersey Modified) and the standard New Jersey or General Motors barrier. In addition, potential problems associated with the barrier dimensions will be mitigated by the slope of the roadway cross section and the high probability that collisions will be at low impact angles. In summary, no conclusive evidence was found to show that the overall performance of the barrier (bridge rail), as constructed, will be more or less hazardous than the barrier rail as specified.

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Research Report
UKTRP-83-26

CONCRETE BARRIER GEOMETRICS
(US-41 BRIDGE IN HENDERSON, KENTUCKY)

Kentucky Transportation Research Program
College of Engineering
University of Kentucky
Lexington, Kentucky

in cooperation with
Department of Highways
Commonwealth of Kentucky

and

Federal Highway Administration
US Department of Transportation

October 1983

TABLE OF CONTENTS

INTRODUCTION

Highway barrier systems may be either flexible, semi-rigid, or rigid, depending on the intended function (1). The rigid barrier is constructed of concrete since it is used as a guardrail where no deflection is to be tolerated. That type barrier was developed primarily as a median barrier and is generally referred to as a concrete median barrier, although it may be used at other locations, such as bridge railing, where deflections are not to be tolerated.

Shape configurations of the concrete barriers have been modified since they were first used in an attempt to provide the safest possible design. The general cross section of a concrete barrier is given in Figure 1. Two major designs have been used. One configuration is referred to as the General Motors (GM) Barrier. The significant dimensions to note for the GM barrier are that A is 2 inches and (B - A) is 13 inches, providing a total height of 15 inches (B) from the roadway surface to the intersection of the two sloping surfaces.

The second major shape used is referred to as the New Jersey (NJ) Barrier. Dimensions A and (B-A) are changed to 3 inches and 10 inches, respectively. This results in the lowering of the intersection of the two sloping surfaces to 13 inches (B) above the roadway.

Three different methods of constructing concrete barriers have been used. The three methods include 1) precast, 2) formed, and 3) slipformed. Slipform construction of concrete barriers is a relatively new procedure, only recently used in Kentucky. It was first used as side railing on three bridges on KY 248 in Spencer County near Taylorsville. It has since been used for constructing railing on a bridge on KY 864 (Poplar Level Road) in Louisville and a bridge on US 41 over the Ohio River at Henderson.

A portion of the restoration of the northbound US-41 bridge across the Ohio River at Henderson, Kentucky, involved construction of barrier walls (bridge rails) on each side of the two approach spans (Figure 2). The plans specified construction of approximately 6,000 linear feet of a reinforced concrete barrier wall having a surface profile conforming to the conventional New Jersey configuration with the exception that the total height was 34 rather than 32 inches. The walls were to be a cast-in-place by the use of fixed forms in general compliance with details shown on Kentucky Department of Highways Standard Drawing RBM-001-05 (2). An exception to details shown on that drawing was the vertical reinforcement for the walls. The steel was tied to the deck concrete in an attempt to provide for a composite mass of deck and wall materials.

The subcontractor for the barrier construction requested and was granted permission to slipform the walls. Sometime after completion of the walls, it was discovered that elevations of face intersections of the walls exceeded specified elevations. Actual dimensions of the curb face

(A) ranged from 3 7/8 to 5 1/2 inches in height and averaged 4 3/4 inches. A curb height of 3 inches was specified. The intersection of the sloping faces should have been 13 inches above the deck surface; however, constructed elevations were 14 3/8 to 15 1/8 inches and averaged 14 5/8 inches above the deck.

The basic configuration of the walls, as constructed, comforms to that designated in the contract documents. However, the break points in the barrier cross section (the height of the lower vertical face and the height of the intersection of the two sloped faces) were not within permissible construction tolerances. A task order was issued by the Kentucky Department of Highways authorizing the Kentucky Transportation Research Program to conduct a study in order to ascertain whether the in-place barrier walls (bridge rails) are more or less hazardous than a wall built to specified dimensions.

BACKGROUND

Concrete barrier walls were used in the 1940's in Louisiana and California, providing insight into the performance capabilities of such barriers (3). The basic design was developed in New Jersey. Its height was determined largely by trial and error. Earlier barriers were only 18 inches high, but this height evolved to 32 inches. A height of 32 inches was found to be high enough to restrain vehicles but not so high as to give the driver a feeling of being constricted by the barrier.

Variations have been made in the basic design, mainly by widening the base to provide more clearance for the vehicle body, as in the GM design. Every adaption has retained the basic safety features of the original design. The basic features of concrete barriers that have evolved are:

1) A 2- to 3-inch vertical curb that provides for future pavement overlays and may provide some initial contact resistance with the tires to slow and straighten the vehicle. Crash tests have shown that the vehicle tire readily rides up this small step and little difference in performance results when the 55 degree slope is continued to grade (4).
2. A sloping surface (55 degrees) to allow for vehicles to climb, thus absorbing energy by lifting the vehicle. The energy should be absorbed by the wheels and undercarriage rather than the vehicle body. For shallow angle impacts, this surface is important in minimizing vehicle damage. Crash tests showed little redirection results as a vehicle climbs up this surface (4).
3. A steeply sloping face (84 degrees for the NJ and 80.4 degrees for the GM) to redirect the wheels and straighten the path of the vehicle. This surface provides a barrier for severe impacts and prevents

crossover accidents.

The AASHTO Guide for Selecting, Locating, and Designing Traffic Barriers lists a modification to the standard New Jersey shape to allow for overlays up to 5 inches (5). The modified design provided a 5-inch vertical curb face (A) but maintained the 13-inch height from the initial installation pavement grade to the intersection of the two sloping surfaces (dimension B).

Structurally, barriers should be resistive to impacting heavy trucks at high speeds. Geometrically, barriers should serve to redirect a wide range of vehicle sizes, shapes, weights, and mass distributions. Most traffic streams consist of vehicles ranging from motorcyles to 100,000-pound tractor-trailer trucks. Over the years, legislation has been enacted to allow larger and heavier trucks and because of increasing vehicle and fuel costs, the average size and weight of cars has decreased. High-strength plastic engines are now in the developmental stages and cars will become even lighter.

At present, the average traffic stream in Kentucky consists of approximately 17 percent trucks, 73 percent standard or compact size cars and pickups, and 10 percent subcompact vehicles (6). Subcompact designates vehicles weighing less than 2,500 pounds empty. The increased usage of subcompact vehicles has compounded the barrier profile selection process.

The most extensive research in this area was performed by Southwest Research Institute, and the results were reported in 1976 (4). The investigators used accident data, crash tests, and computer simulation to evaluate concrete barriers.

The accident data summary compared the New Jersey, General Motors, and New Jersey Modified shapes. The New Jersey Modified (NJM) cross section used a 4- to 5-inch height for the initial vertical face instead of the standard 3-inch height. Also, the height of the intersection of the two sloping faces above the road (dimension B) was increased to about 15 inches. The percentage of vehicle rollover accidents of the total was highest for the NJM shape (12 percent), lowest for the NJ shape (3 percent), with the GM shape in between (6 percent). However, the percentage of accidents involving a hospital-type injury was similar (from 21 for the NJM to 25 for the GM).

Crash tests using full-size and subcompact vehicles were conducted at 60 mph with impact angles of 7 and 15 degrees. The NJ, GM, and another shape (called Configuration F) were tested. The "F-shape" used the initial 3-inch step but the 55-degree sloped surface was shorter so that the distance between the pavement surface and the intersection of the two sloped surfaces was 10 inches rather than the 13 inches used in the NJ barrier. The only rollover occurred using the subcompact at the 15-degree test with the GM barrier. The subcompact did not roll over at the 7-degree impact with any barrier shape.

The roll angle was smallest using "F-shape" and highest for the GM. However, vehicle damage was highest for the "F-shape" and lowest for the GM.

The Southwest Research Institute report recommended that the NJ shape be used as a standard. The basis of that recommendation was the conclusion that use of the GM shape should result in an increasing number of vehicle rollovers due to the increasing population of small vehicles. It also was noted that rollover incidence was increased when the initial step height on a basic NJ barrier was increased to 4 to 5 inches instead of the standard 3-inch dimension.

The effect that roadway cross-section slopes have on the tendency of vehicles to roll over after collision with a concrete barrier wall was analyzed (4). When the roadway slopes up to the barrier, vehicle roll angle is increased. Conversely, when the roadway slopes down to the barrier, vehicle roll angle is decreased and there is less chance of a rollover occurrence.

A Federal Highway Administration (FHWA) notice recommended that construction of the GM shape and undesirable modifications to the NJ shape should be phased out (7). This was based on the rollover problem associated with small vehicles when the elevation of the break between the upper and lower shapes is increased to over 13 inches above the pavement surface, as specified for the NJ barrier.

TYPICAL CONCRETE BARRIER CROSS-SECTIONS IN KENTUCKY

As a means of comparing the cross sections and dimensions of concrete barriers in Kentucky, inspections were made at 11 sites. Location of those sites and the average dimensions of the barriers are presented in Figure 3. It can be seen there is some variance in the dimensions of the concrete barriers inspected. With reference to Figure 3, the range of the A dimension was from 1 3/8 to 4 1/8 inches. The other critical dimension was B, with a range from 11 to 14 1/4 inches. With the exception of the barrier on I 75 in Kenton County, all others were built as New Jersey barriers. The concrete barrier on I 75 in Kenton County was one of the first in Kentucky, and it was built to the General Motors specifications.

As noted earlier, slipform paving has been used in the construction of concrete barriers at three locations in Kentucky. Those include the US-41 bridge in Henderson, the KY 864 (Poplar Level Road) bridge in Louisville, and three bridges on KY 248 near Taylorsville in Spencer County. Figure 4 is photographs of the A and B dimensions of the US 41 bridge in Henderson. It can be seen that, at the point where the photographs were taken, the A dimension was approximately 4 7/8 inches and the B dimension was approximately 14 7/8 inches. Similar photographs for the Poplar Level bridge in Louisville and one of the bridges on KY 248 near Taylorsville are shown in Figures 5 and 6, respectively.

The A and B dimensions at the US-41 bridge were further from the specified dimensions than for any other location measured. The first slipform operation on KY 248 resulted in a barrier wall very close to specifications. Dimensions on the next slipform construction on KY 864 (Poplar Level Road in Louisville) were further from specifications but not as much as the US-41 bridge.

Photographs were also taken at other locations included in the accident analysis. The barrier at the combined section of I64-I75 in Fayette County is shown in Figure 7. There was considerable variance from one point to another along the barrier. In the first photograph at Milepoint 116, the A dimension was 2 1/2 inches and the B dimension was 12 1/2 inches. Measurements were also taken at Milepoint 117, where the A dimension was 1 3/4 inches and the B dimension was 14 inches.

CONCRETE BARRIER ACCIDENT HISTORY

Accident data on concrete barriers were available from two sources. From the 1977 report by the Southwest Research Institute (4), accident data from 15 agencies were summarized. Data reflected 552 accidents involving the following three types of concrete barriers: 1) New Jersey, 2) New Jersey Modified, and 3) General Motors. The second source of data was accident records from four sites in Kentucky where concrete barriers had been constructed. A two-year period of data (1981-1982) was analyzed for the sites in Kentucky. Data collected in Kentucky represented 242 accidents and the sites included a range of cross sections, including dimensions representing types similar to those presented in the Southwest Research Institute study (4).

Southwest Research Institute Study

A summary of accident data collected by Southwest Research is presented in Table 1. The sample of accidents was 299 for the General Motors design, 180 for the New Jersey design, and 73 for the New Jersey Modified design. It can be seen that accident severity was not significantly different for the three designs. For example, the percentages of accidents where injuries were sufficient to require hospitalization were 25 percent for the GM design, 21 percent for the New Jersey design, and 20 percent for the New Jersey Modified design. There was only one fatality and this involved a collision with a New Jersey Modified barrier.

One of the most critical aspects of concrete barrier design is the probability of rollover after impact. As shown in Table 1, there were 34 accidents involving rollovers. The highest percentage was for the New Jersey Modified (12 percent). Impacts resulting in rollovers total six percent for the GM barrier and three percent for the New Jersey barrier.

From information presented in an appendix to the

Southwest Research report, a summary of data representing rollover accident statistics was prepared and shown in Table 2. The rollover accident data presented in Table 2 are an expansion of the analysis of the rollover accidents given in Table 1. There is a slight discrepancy in the total number of accident cases between the two tables; however, the data are still very useful. In Table 2, the General Motors Modified design was represented by seven accident cases, that design was apparently grouped with the regular General Motors design in Table 1. As expected, the severity of concrete barrier accidents involving rollover was greater than other types of concrete barrier accidents. Over 50 percent of the rollover accidents involved an injury requiring hospitalization, while only 30 percent of those involved in all types of barrier accidents required hospitalization.

Another critical factor in rollover accidents is the size of the vehicle. As discussed previously, results of crash tests by Southwest Research indicated a higher probability of rollover when subcompact cars impact concrete barrier walls. However, accident data, as shown in Table 2, show only 19 percent of the accidents involved vehicles in the subcompact weight category (1,500 to 2,500 pounds). That shows rollover accidents involving subcompacts as not being much greater than their overall representation in the traffic stream.

Impact speed and impact angle were also summarized for concrete barrier accidents resulting in rollovers. Accidents with impact speeds less than 60 mph comprised 78 percent of the rollovers. Impact angles less than six degrees made up 50 percent of the rollover accidents where impact angle was known.

Kentucky Accident Analysis

Results from the analysis of accident data from four sites in Kentucky are presented in Tables 3 through 7. The site at I 75 in Kenton County represents the GM design. The other three sites were constructed as the New Jersey design. These data can be compared to that given in the Southwest Research Institute report. As noted earlier, when typical cross sections were presented, measurements were taken at 10 sites in Kentucky. In addition, two years of accident data were collected for four sections with concrete barriers. As a means of comparing the Kentucky accident statistics with Southwest Research accident statistics, data for the I 75-Kenton County site were determined to be representative of the GM design and the other three sites were representative of the New Jersey design. Table 3 is a summary of Kentucky accident data in a form similar to the Southwest Research data in Table 1. These data, as shown in Table 3, indicated accident experience in Kentucky was not significantly different from that reported by other agencies in the Southwest Research report. For example, accident severity in terms of the proportion of injuries requiring hospitalization was 18 percent for the GM design as compared to 17 percent for New Jersey design. It should be noted that on sections with the New Jersey design, three percent of the collisions resulted in a fatal injury as compared to only one percent for the section with the GM design.

The problem of rollovers associated with the GM barrier was confirmed with the Kentucky data. As shown in Table 3, the percentage of rollovers on the section with the GM design was seven percent as compared to four percent on sections with the New Jersey design. Neither design showed any problem with vehicles mounting (vaulting) the barrier.

Table 4 is a detailed summary of the accident severity at each of the four sites for collisions involving concrete barriers. Vehicle action after impact with the barrier is summarized for each site in Table 5.

A detailed analysis of accidents involving vehicle rollover was also made. In Table 6 are the numbers of accidents involving rollover by vehicle type. As shown, most vehicles were semi-trailer trucks or large passenger cars. The absence of any small cars was noteworthy.

Severity of injury in rollover accidents was summarized in Table 7. Only one rollover accident resulted in a fatal injury and two resulted in incapacitating injuries. No injuries were sustained in five of the accidents.

SUMMARY

The bridge railing constructed on the approaches to the US-41 northbound bridge over the Ohio River at Henderson, Kentucky, has been shown to not be in conformance with specifications. The vertical face (dimension A) was constructed to be an average height of 4 3/4 inches above the pavement surface rather than the specified 3 inches. From the top of the vertical face, the barrier conformed to a standard New Jersey (NJ) barrier. However, this meant the intersection between the two sloping surfaces was 14 1/2 inches rather than 13 inches above the pavement surface. Measurements taken at other locations showed these dimensions to be unusually high. Dimensions of the first barrier wall constructed using the slipform procedure (KY 248 near Taylorsville) were very close to specifications. It may be seen, therefore, that a barrier wall can be constructed using the slipform procedure to dimensions close to specified values.

Dimensions of the wall, as constructed, have been shown by both accident data (in the Southwest Research Institute report and the Kentucky accident data given in this report) and crash test data to be associated with a higher incidence of rollover accidents than a standard New Jersey barrier. That problem was generally thought to be related to subcompact vehicles, but this has not been substantiated by accident data.

However, there has not been any substantial differences

observed in overall accident severity (using Kentucky or other accident data) between a barrier with dimensions as constructed on US 41 (New Jersey Modified (NJM)) and the standard New Jersey or General Motors barrier. That may be related to the increased vehicle damage and corresponding higher deceleration rates associated with the New Jersey barrier. This may offset the increased tendency for rollover accidents in the NJM and GM barriers, which results in similar overall accident severities.

In 1981 and 1982, there were a total of nine accidents on the US-41 northbound bridge that involved a collision with the bridge railing. Because of the relatively narrow roadway (bridge) width, that type of accident would be associated with a low impact angle. The rollover problem would be less than that associated with higher impact angles. This was demonstrated in the crash tests (4).

Another factor that must be considered is the slope of the roadway cross section. There is a crown of 1/4 inch per foot approaching the concrete barrier on the US-41 bridge. This means that, when a typical subcompact car with a width of about five feet contacts the barrier and the tires on one side of the vehicle ride up the wall, the tires on the opposite side of the vehicle will be about 1 1/4 inches above the elevation of the bottom of the barrier. The effective difference in height between the two tires is, therefore, only 13 1/4 inches, which is close to the 13-inch recommended height of dimension B. Crash tests were conducted on a flat surface, (8) so the crown on the bridge would compensate, in part, for the increased height for dimension B that was related to vehicle rollover.

CONCLUSION

No conclusive evidence was found to show that the overall performance of the barrier (bridge rail) as constructed on the US-41 northbound bridge in Henderson, Kentucky, will be more or less hazardous than the barrier rail as specified.

REFERENCES

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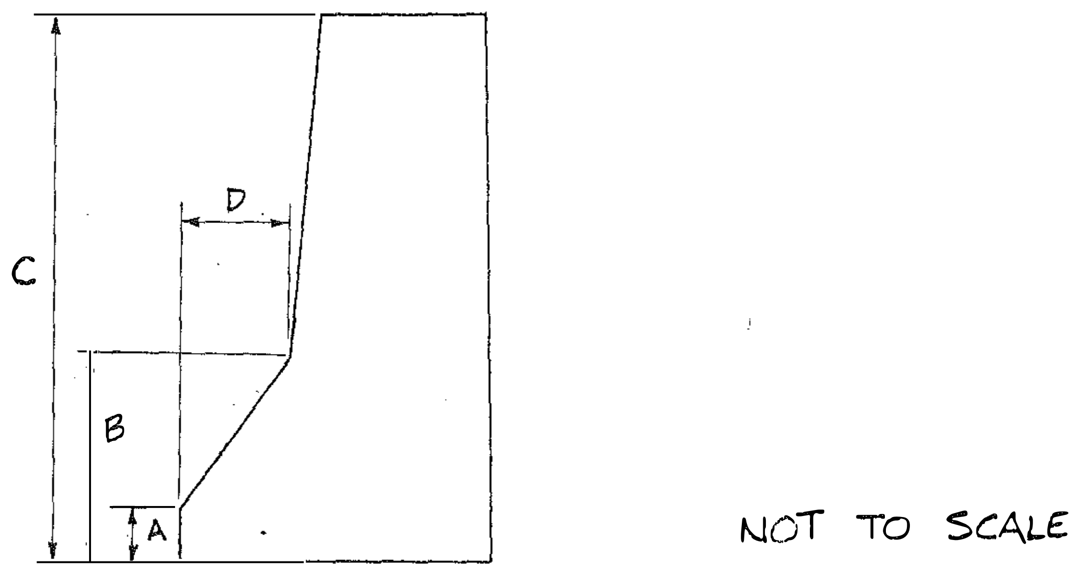
4. Bronstad, M. E.; Calcote, L. R.; and Kimball, C. E.; "Concrete Median Barrier Research," Federal Highway Administration, Report No. FHWA-RD-77-4, March 1976.
5. Guide for Selecting, Locating, and Designing Traffic Barriers, American Association of State Highway and Transportation Officials, 1977.

6. Crabtree, J. D.; "Summary of Vehicle Classification Data," University of Kentucky Transportation Research Program, Report UKTRP-82-10, August 1982.

7. Federal Highway Administration Notice N5040.24, AASHTO Guide for Selecting, Locating, and Designing Traffic Barriers, May 12, 1977.

8. Telephone conversation with M. E. Bronstad, Southwest Research Institute, October 27, 1983.

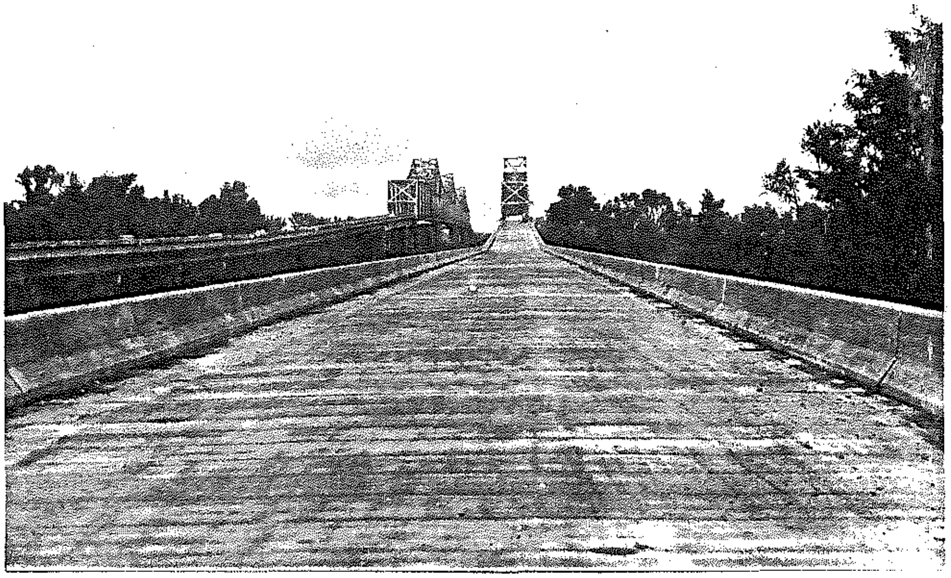
Figure 1. Typical Cross Sections of Concrete Barriers.



Dimensions (Inches)

Type of Barrier	A	B	B-A	C	D
New Jersey	3	13	10	32	7
New Jersey Modified	5	15	10	32	7
General Motors	2	15	13	32	9-1/8

Figure 2. Concrete Barrier on US-41 Bridge across Ohio River in Henderson, Kentucky.



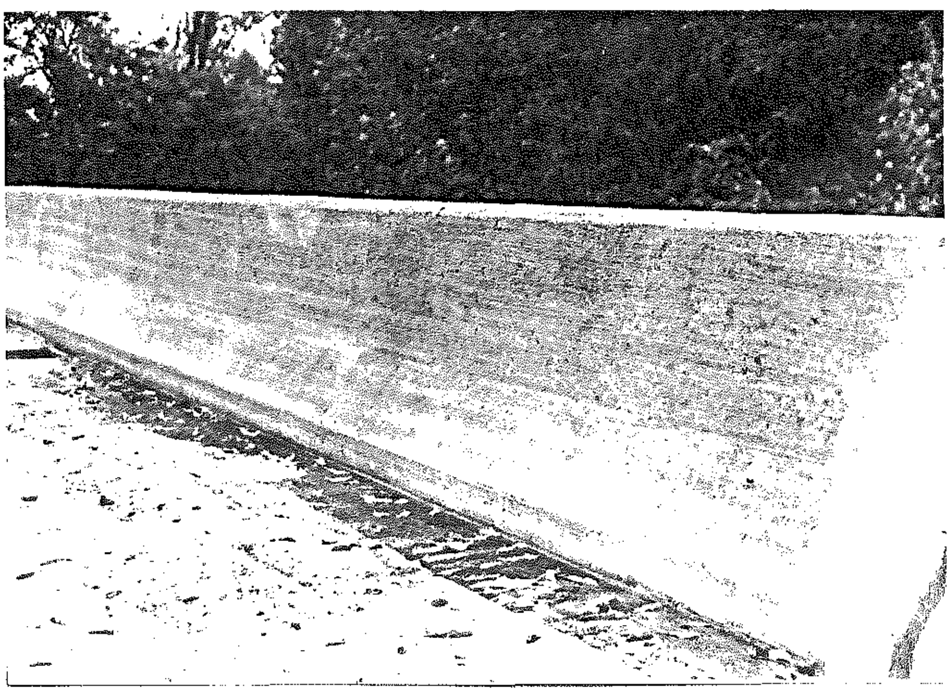
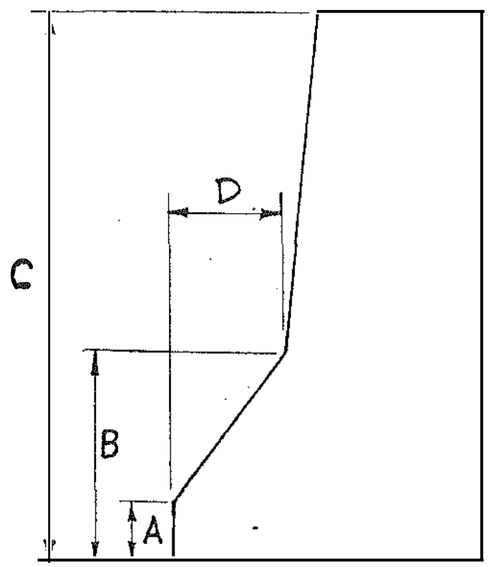


Figure 3. Typical Cross Sections of Concrete Barriers in Kentucky.

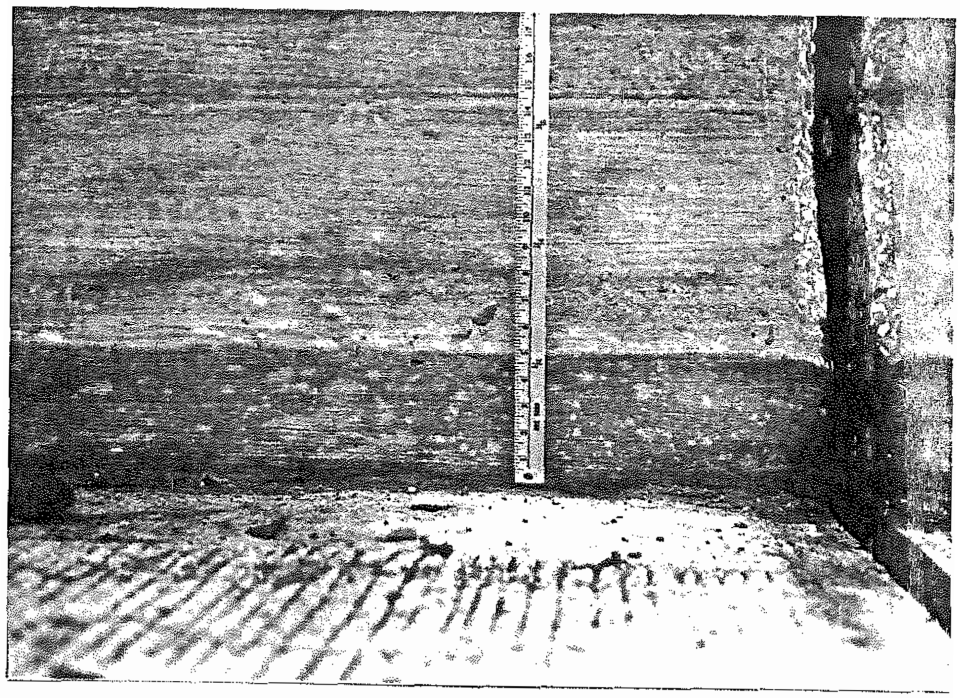


NOT TO SCALE

Dimensions (inches)

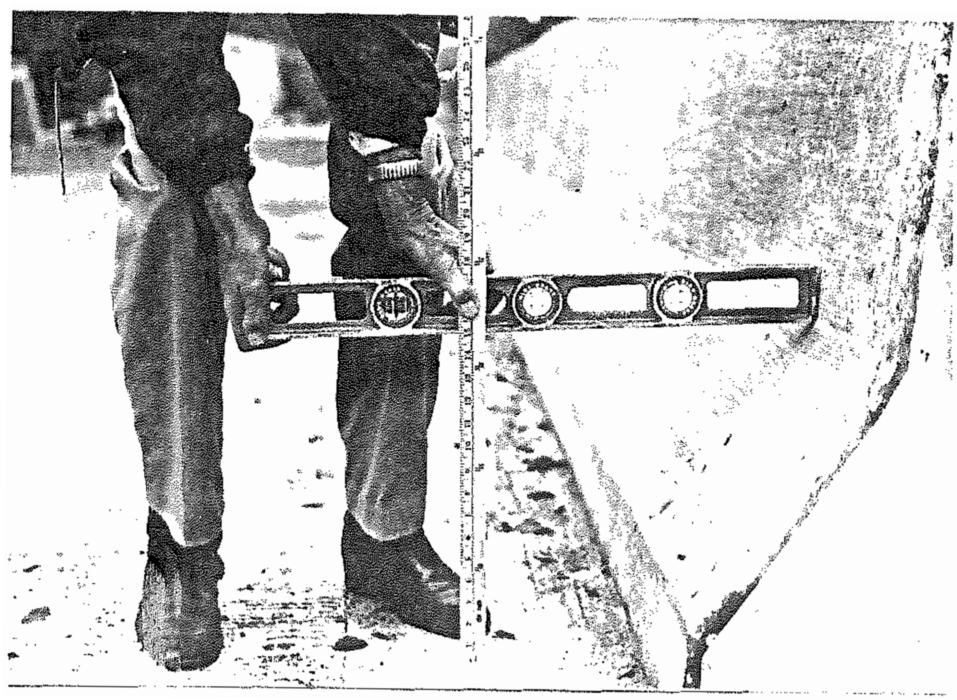
Location	A	B	B-A	C	D
I64-I75, Fayette County (MP 116)	2-1/2	12-1/2	10	31-1/4	7-1/8
I64-I75, Fayette County (MP 117)	1-3/4	14	12-1/4	31-1/2	8-3/8
I65, Louisville (MP 130.8)	1-3/8	11	9-5/8	30-1/8	7-1/8
I65, Louisville (MP 136)	3-1/8	12-7/8	9-3/4	33	7-7/8
I75, Kenton County (MP 187.5)	2-1/2	15-1/2	13	37-3/8	9-1/8
KY 676, Frankfort (near US 60)	2-7/8	13-3/4	10-7/8	31-1/2	7
KY 676, Frankfort (on KY River Bridge)	3	12-7/8	9-7/8	32-3/4	7
KY 248, Spencer County (on two-lane section)	3	13-3/8	10-3/8	34-1/8	7-1/4
KY 248, Spencer County (on four-lane section)	3-1/4	13-3/8	10-1/8	34-1/4	7-1/4
US 41, Henderson	4-3/4	14-5/8	9-7/8	35-3/8	7-1/8
KY 864, Poplar Level Road, Louisville	4-1/8	14-1/4	10-1/8	35	7-3/8

Figure 4. Photographs of A and B Dimensions of Concrete Barrier on US-41 Bridge in Henderson.



A Dimension

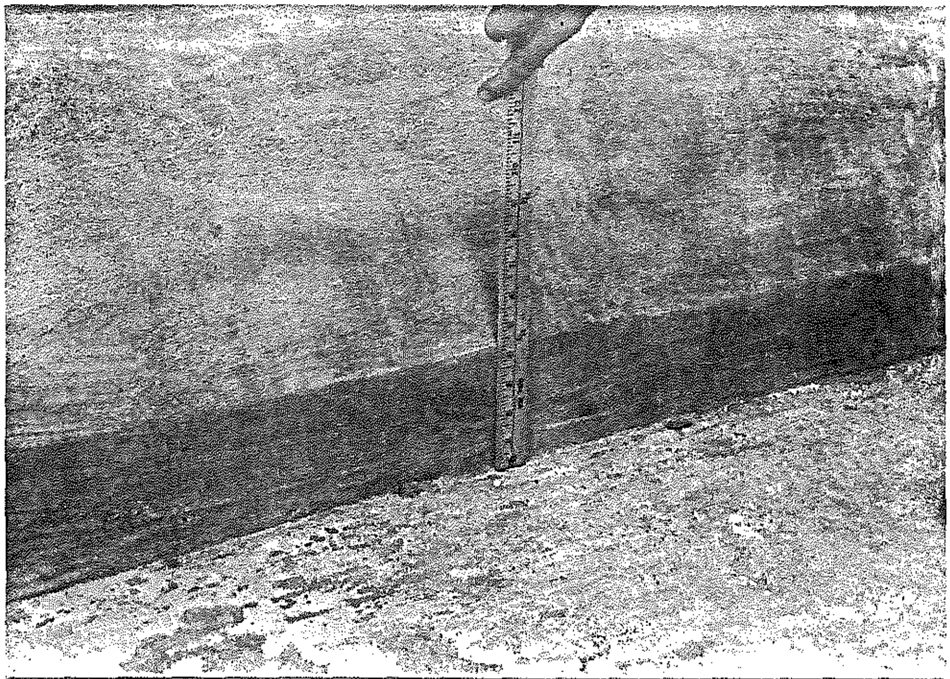
(4 3/4 inches)



B Dimension

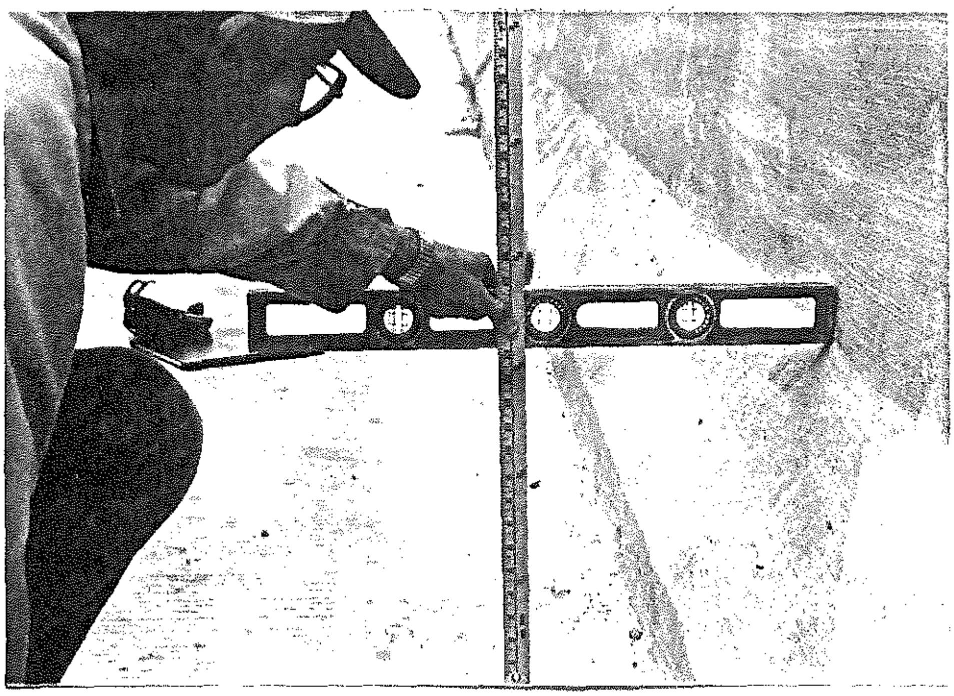
(14 5/8 inches)

Figure 5. Photographs of A and B Dimensions of Concrete Barrier on KY-864 (Poplar Level Road) Bridge in Louisville.



A Dimension

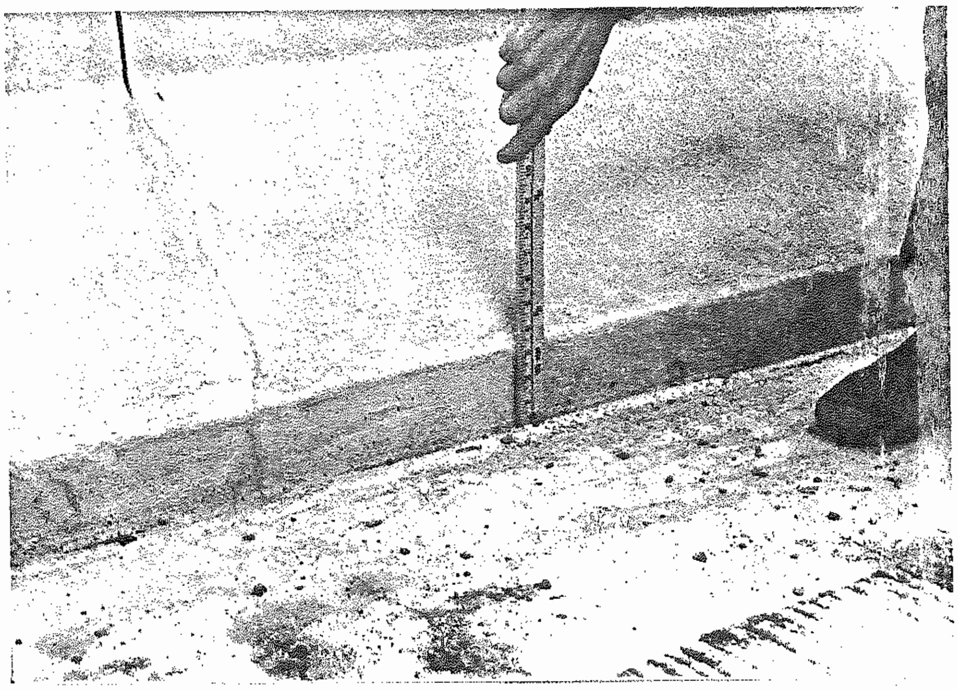
(4 1/8 inches)



B Dimension

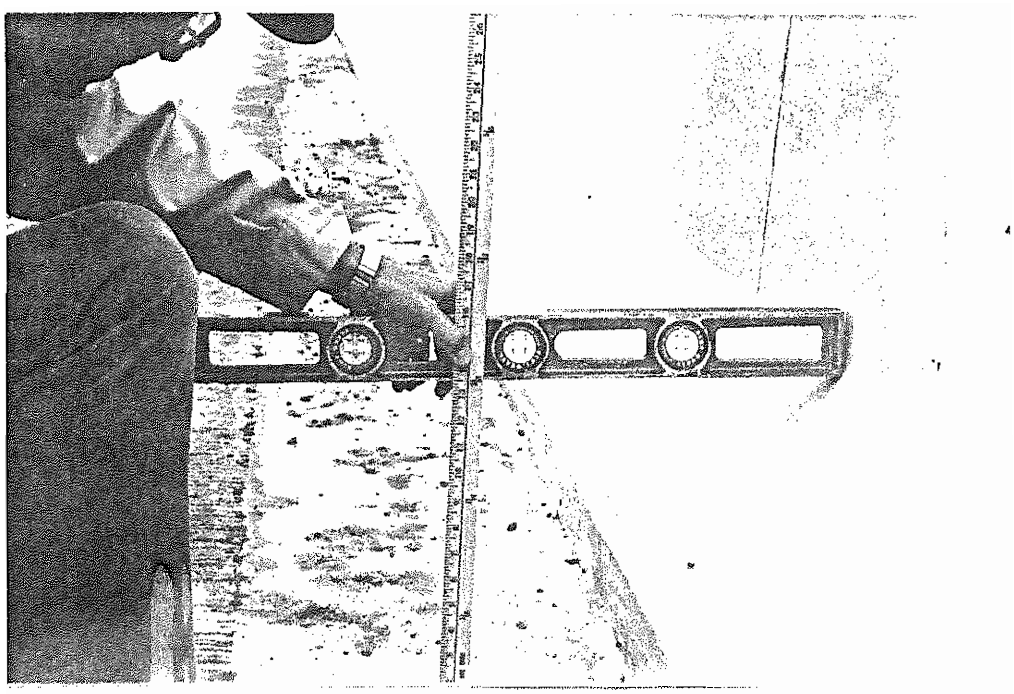
(14 1/4 inches)

Figure 6. Photographs of A and B Dimensions of Concrete Barrier on KY-248 Bridge near Taylorsville.



A - Dimension

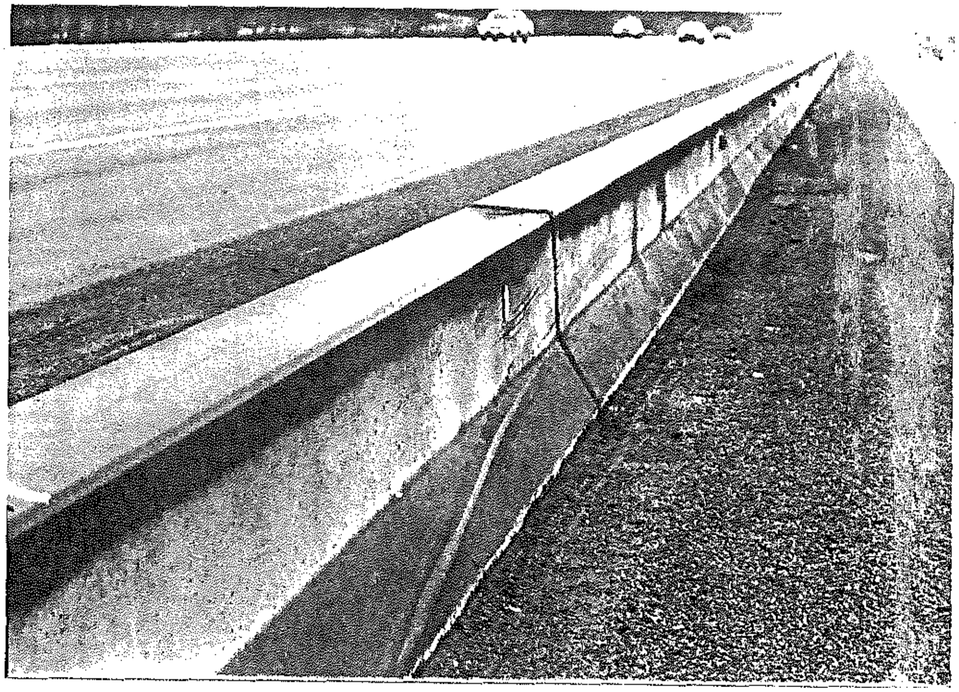
(3 1/4 inches)



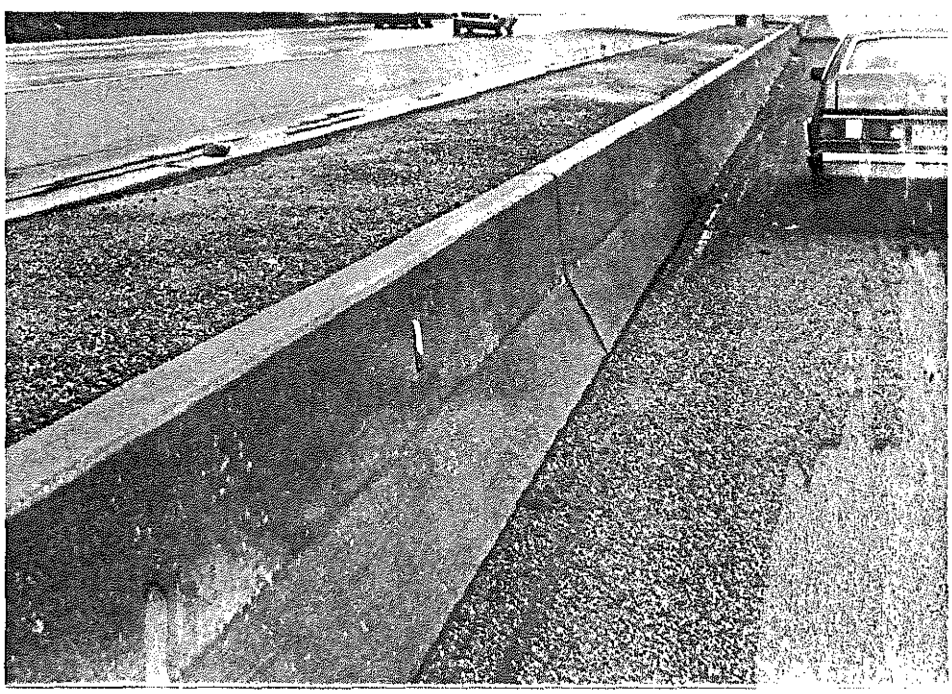
B Dimension

(13 3/8 inches)

Figure 7. Photographs of Concrete Barriers on I 64 - I 75 in Fayette County.



MP 116



MP 117

TABLE 1. SOUTHWEST RESEARCH ACCIDENT DATA SUMMARY (Reference 4)

BARRIER TYPE	NUMBER OF ACCIDENT CASES (a)	ACCIDENT SEVERITY (b) PDO	HOSP INJ	FATAL	VEHICLE (c) ROLLOVERS	MOUNTING
New Jersey	180 (33)	133 (79)	35 (21)	0 (0)	6 (3)	1 (1)
New Jersey (Mod)(d)	73 (13)	58 (77)	15 (20)	1 (1)	9 (12)	0 (0)
General Motors	299 (54)	225 (75)	74 (25)	0 (0)	19 (6)	4 (1)
Total	552	416	124	1	34	5

(a) Numbers in parentheses are percentages of total accident cases with specified barrier profile.
(b) Numbers are number of cases for each category; numbers in parentheses are percentage for that barrier profile.
(c) Numbers are number of vehicle rollovers for each barrier profile; numbers in parentheses represent percentage of total number of accidents for each barrier profile.
(d) New Jersey (Mod) initial step 4-5 in. instead of New Jersey standard 3 inches.

TABLE 2. SUMMARY OF ROLLOVER ACCIDENT DATA FROM SOUTHWEST RESEARCH INSTITUTE REPORT (a)

VARIABLE	CATEGORY	NUMBER
Barrier Profile	New Jersey	6
	New Jersey Modified	9
	General Motors	9
	General Motors Modified	7
Severity	PDO	13
	Hospitalizing Injury	16
	Unknown	2
Vehicle Weight (pounds)	1,500 - 2,500	5
	2,500 - 3,500	9
	3,500 - 4,500	10
	4,500 - 5,500	2
	Unknown	5
Impact Speed (mph)	40 - 49	8
	50 - 59	10
	60 - 69	4
	70 - 80	1
	Unknown	8
Impact Angle (degrees)	0 - 5	6
	6 - 10	1
	11 - 15	1
	16 - 20	1
	21 - 25	1
	26 - 30	2
	Unknown	19

(a) Data obtained from Reference 4.

TABLE 3. KENTUCKY ACCIDENT DATA SUMMARY

BARRIER TYPE	NUMBER OF ACCIDENT CASES (a)	ACCIDENT SEVERITY (b) PDO	HOSP INJ (d)	FATAL	VEHICLE(c) ROLLOVERS	MOUNTING
New Jersey Design	134	74	15	3	5	1
	(55)	(80)	(17)	(3)	(4)	(1)
GM Design	108	55	12	1	8	1
	(45)	(81)	(18)	(1)	(7)	(1)
Total	242	129	27	4	13	2

(a) Numbers in parentheses are percentages of total accident cases for each barrier type.
(b) Numbers in parentheses are percentages of each severity type from the total accident cases where severity was either PDO, hospitalizing injury, or fatal.
(c) Number in parentheses are percentages of total accident cases for each barrier type.
(d) Hospitalizing injury was an A-type (incapacitating) injury.

TABLE 4. SEVERITY OF CONCRETE BARRIER ACCIDENTS

SITE	NUMBER OF ACCIDENTS	MOST SEVERE INJURY(a) NONE	A	B	C	FATAL
I64-I75 Fayette Co.	32	14 (44)(b)	4 (12)	12 (38)	2 (6)	0 (0)
I65 Jefferson Co.	88	55 (61)	8 (9)	16 (18)	8 (9)	3 (3)
I75 Kenton Co.	108	55 (50)	12 (11)	22 (20)	20 (18)	1 (1)
KY 676 Franklin Co.	14	5 (36)	3 (21)	4 (29)	2 (14)	0 (0)
TOTAL	242	129 (52)	27 (11)	54 (22)	32 (13)	4 (2)

(a) A - incapacitating injury
B - non-incapacitating injury
C - possible injury
(b) Number in parentheses are percentages of total number of accidents.

TABLE 5. VEHICLE ACTION AFTER IMPACT WITH BARRIER

SITE	VEHICLE ACTION				
	REBOUNDED OFF BARRIER	SLID TO STOP ALONG BARRIER	ROLLED OVER	VAULTED BARRIER	THROUGH BARRIER
I64-I75 Fayette Co.	26 (18)(a)	4 (12)	2 (6)	0 (0)	0 (0)
I 65 Jefferson Co.	61 (68)	24 (27)	3 (3)	1 (1)	1 (1)
I 75 Kenton Co.	77 (70)	23 (21)	8 (7)	1 (1)	1 (1)
KY 676 Franklin Co.	12 (86)	2 (14)	0 (0)	0 (0)	0 (0)
TOTAL	176 (72)	53 (22)	13 (5)	2 (1)	2 (1)

(a) Numbers in parentheses are percentages of total number of accidents.

TABLE 6. VEHICLE TYPE OF ROLLOVER VEHICLES

VEHICLE TYPE	NUMBER OF ACCIDENTS
Semi-Trailer Truck	6
Large Passenger Car	5
Passenger Car (Unknown Size)	1
Small Truck	1
Jeep	1

TABLE 7. SEVERITY OF ROLLOVER ACCIDENTS

MOST SEVERE INJURY	NUMBER OF ACCIDENTS
Fatal	1
Incapacitating	2
Non-Incapacitating	5
Possible Injury	1
No Injury	5