Research Report
391

BEFORE-AND-AFTER ANALYSIS OF SAFETY IMPROVEMENTS ON I 75 IN NORTHERN KENTUCKY

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Prepared for Presentation to the
44th Annual Meeting
of the
INSTITUTE OF TRAFFIC ENGINEERS
September 15-20, 1974
Detroit, Michigan

May 1974

ABSTRACT

BEFORE-AND-AFTER ANALYSIS OF SAFETY IMPROVEMENTS ON I 75 IN NORTHERN KENTUCKY

In September 1971, the U. S. House of Representatives Subcommittee on Investigations and Oversight met in Covington, Kentucky, to discuss the accident experience and remedial procedures taken to alleviate the frequency of accidents occurring on approximately five miles of I 75 just south of Cincinnati. This section of highway had been and was continuing to be the subject of several safety improvements. The objective of this study was to conduct before-and-after investigations of the effectiveness of the following safety improvement projects: (1) five variable message signs within a two-mile section, (2) a New Jersey-type median barrier wall extending approximately four miles, and (3) a general safety improvement project throughout the study section which included upgrading all guardrail to current safety standards, extension of existing guardrail to fill in gaps, installation of buried end treatments for guardrail, attachment of guardrail to concrete bridge end railings, flattening of side slopes, leveling of gores where feasible, installation of breakaway bases on exposed lighting standards, elimination of butterfly sign supports in gore areas by replacement with new overhead trusses spanning the roadway, and installation of median guardrail at twin bridges.

The before-and-after analyses are based on accident statistics. The "before" statistics are for the 1969 calendar year: the "after" period began after installation of the variable message signs and also encompassed a full year (May 1, 1971, to May 1, 1972). The statistics do not indicate which of the features, singly or collectively, effectively reduced accident rates; the most obvious statistic was the elimination of crossing-the-median head-on collisions. This was the intent and purpose of the concrete barrier.

The variable message signs were used to warn motorists of impending hazardous driving conditions ahead. Displayed messages generally related to accidents, congestion, and poor driving conditions due to adverse weather. Benefits associated with the variable message signs appear to be significant: in the northbound direction (the direction where signs were used), there was a 16.1 percent decrease in the accident rates as compared with only a 1.7 percent reduction in the southbound direction.

Accident rates for the entire study section decreased significantly (95-percent confidence level) between the before and after periods. This is an indication that the combination of safety improvements and corrective design procedures were effective in reducing the accident rate.

BEFORE-AND-AFTER ANALYSIS OF SAFETY IMPROVEMENTS ON I 75 IN NORTHERN KENTUCKY

Jerry G. Pigman[1]

INTRODUCTION

In September 1971, the U. S. House of Representatives Subcommittee on Investigations and Oversight met in Covington, Kentucky, to discuss the accident experience and remedial procedures taken to alleviate the frequency of accidents occurring on approximately five miles of I 75 just south of Cincinnati. This section of highway had been and was continuing to be the subject of several safety improvements. The objective of this study was to conduct before-and-after investigations of the effectiveness of the following safety improvement projects: (1) five variable message signs within a two-mile section, (2) a New Jersey-type median barrier wall extending approximately four miles, and (3) a general safety improvement project throughout the study section which included upgrading all guardrail to current safety standards, extension of existing guardrail to fill in gaps, installation of buried end treatments for guardrail, attachment of guardrail to concrete bridge end railings, flattening of side slopes, leveling of gores where feasible, installation of breakaway bases on exposed lighting standards, elimination of butterfly sign supports in gore areas by replacement with new overhead trusses spanning the roadway, and installation of median guardrail at twin bridges.

Of the several safety improvements implemented on the study section of I 75, only the variable message signing system was considered to be experimental. Other safety improvements had become more - or - less standards for use as recommended by the "yellow look" [(1)]. Arrangements were made for before-and-after evaluation of not only the variable message signs, because of their innovative and experimental status, but also of the New Jersey-type median wall and the various other "hardware" safety features. The study section includes approximately five miles of a six-lane section of I 75 from the Buttermilk Pike interchange in Kenton County (Milepost 187) to the Ohio state line (Milepost 192). The variable message signs were within a section bounded by Mileposts 187.5 and 189.5; the median barrier wall extended from Milepost 187.5 to 191.5; and the general safety improvements extended throughout the study section.

A brief chronology of antecedent events pertaining to the study section is given below:

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Sept 1962	I 75 opened to traffic
Spring 1963	Landslide brought about lane closures
Oct 1964 - Dec 1965	Corrective construction for landslides
1967	Double-beam guardrail median barrier installed on hill*
July 1967 - May 1968	Lighting contract**
March 1968 - June 1968	Pedestrian overpass
March 1970 - Nov 1970	Concrete median barrier construction
Oct 1969 - July 1970	General safety improvements
Sept 1970 - March 1971	Variable message signs

*Six cross-median collisions occurred during the first six months of 1968 where the median barrier was not provided.

**Approximately 20 light poles, not equipped with frangible bases, were being struck each year prior thereto.

PROCEDURE

In February 1971, it was decided that a one-year period of both before and after accidents would be necessary for a reliable evaluation of the aforementioned safety items. The antecedent data, consisting of all 1969 police-reported accidents were collected and summarized. The after data, consisting of all police reported accidents between May 1, 1971 (the day following final inspection of the variable message signs) and May 1, 1972, were collected and summarized. Before and after accident rates and collision diagrams were analyzed. Criteria were developed in conjunction with police agencies responsible for operating the variable message signing system to define traffic conditions under which the various messages were to be used.

FINDINGS

Accident Summaries

From a summary of accident statistics for the before-and-after study periods, Sunday was shown to be the day having the largest number of accidents; there was very little difference between and among the other days of the week. Figure 1 shows the daily variation of before-and-after accident occurrence. No definitive trend in the monthly occurrence of accidents was discernable; this is indicated in Figure 2. The vehicle in 85 percent of the accidents was a passenger car, and the driver in four of five cases

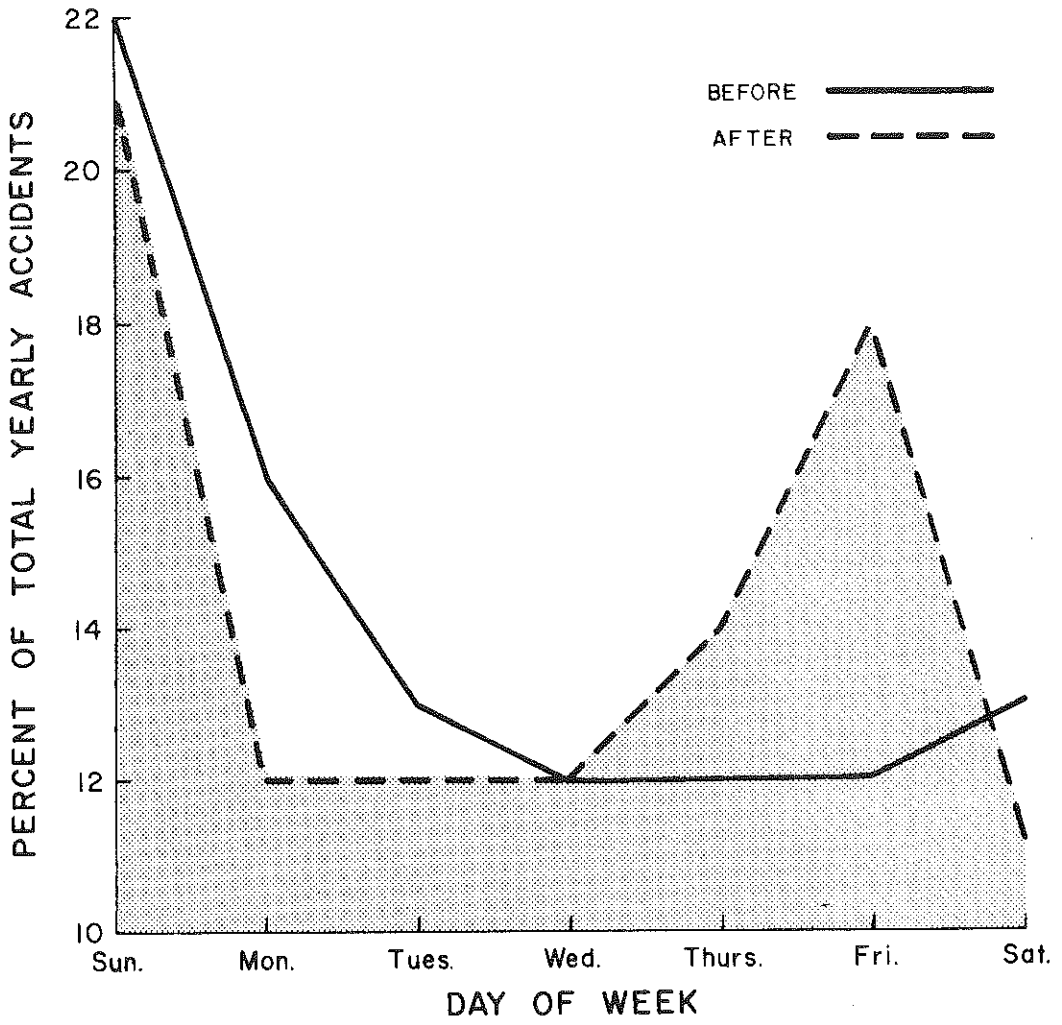

Figure 1. Daily Variation of Accidents

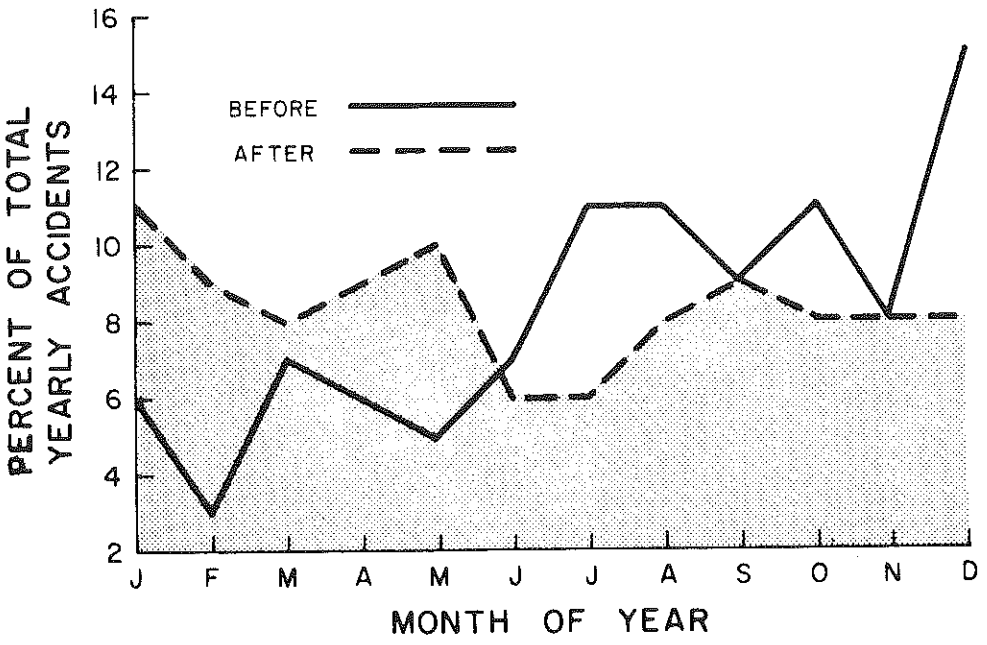

Figure 2. Monthly Variation of Accidents

was male. Approximately half of the drivers were 30 years of age or younger. The driver's residence in a third of the cases was local (Kenton County); about 50 percent of the total were out-of-state drivers.

Of the 416 "before" accidents, there were 149 injuries and no fatalities (Type 'K' injury). Similarly, there were 170 injuries and no fatalities associated with the 455 "after" accidents. Type 'C' injuries (those in which there was no visible injury but the occupant complained of pain or was momentarily unconscious) accounted for 66 percent of the total "before" injuries and 56 percent of the "after" injuries. While the majority of injuries were categorized as Type 'C', a significant percentage of all injuries were Type 'A' and Type 'B'. Type 'A' injuries (those in which there were visible signs of injury such as bleeding, distorted member, or had to be carried away from the scene) increased from 17 percent of the "before" injuries to 26 percent of the "after" injuries. Type 'B' injuries (defined as other visible injury such as bruises, abrasions, swelling, limping, etc.) also increased; this time from 17 percent of the "before' injuries to 18 percent of the "after". Table 1 is a summary of before-and-after injuries classified by severity types.

Table 2 is a summary of before-and-after accidents classified by severity types. This summary differs from the preceding table in that each accident is classified by severity type as compared to each injury being classified by severity in Table 2. In addition, property damage only (PDO) accidents were tabulated for the purpose of showing the number of accidents which involved no injuries. As a means of representing the overall severity of all accidents each year, a severity index (SI) was calculated (Table 2). Severity index is defined as the equivalent property damage only (EPDO) divided by the total number of accidents. EPDO, represented by the expression

$$EPDO = 9.5\ (K+A) + 3.5\ (B+C) + PDO,$$

is a means of weighting all accident severity types in terms of PDO accidents.

Severity indices calculated by this method were tested statistically [2] and it was determined that there was a significant increase in the overall severity (at the 95-percent confidence level) from "before" to "after" improvements.

It is interesting to note that there were no fatalities during either study period as compared to a fatality rate of 2.3 (fatalities/100 million vehicle miles) reported in a summary of accidents on sections of six-lane interstate highways in 40 states [3]. Assuming this rate is applicable to the study section, the expected "before" and "after" fatalities would have been 3 and 4, respectively. From these observations, it would appear that the study section was relatively safe when considering only fatalities.

TABLE 1

INJURIES CLASSIFIED BY SEVERITY

	K	A	B	C	TOTAL
BEFORE					
Number	0	26	25	98	149
Percent	0.0	17.4	16.8	65.8	100.0
AFTER					
Number	0	44	30	96	170
Percent	0.0	25.9	17.6	56.5	100.0

Type K - Fatal
Type A - Visible signs of injury such as bleeding, distorted member or had to be carried away from the scene.
Type B - Other visible injury such as bruises, abrasions, swelling, limping, etc.
Type C - No visible injury but the occupant complained of pain or was momentarily unconscious

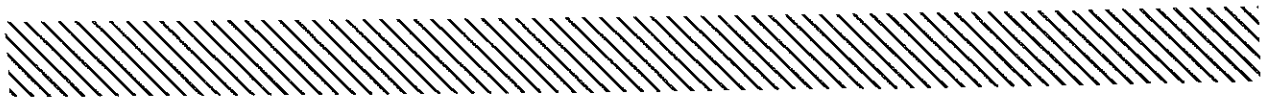

TABLE 2

ACCIDENTS CLASSIFIED BY SEVERITY

	PDO	K	A	B	C	TOTAL	SI*
BEFORE							1.97
Number	309	0	23	21	63	416	
Percent	74.3	0.0	5.5	5.1	15.1	100.0	
AFTER							2.29
Number	317	0	40	33	65	455	
Percent	69.7	0.0	8.8	7.2	14.3	100.0	

*SI (Severity Index) = EPDO/Number of Accidents
where PDO = Property Damage Only
EPDO = Equivalent Property Damage Only
EPDO = 9.5(K + A) + 3.5(B + C) + PDO

However, this presumption tends to indicate that the difference between a fatality and a Type 'A' injury is merely a chance happening.

Weather conditions at the time of before-and-after accidents were predominantly clear (70 percent), but a sizeable number (25 percent) occurred during rainy conditions. Rear-end accidents combined with multiple rear-end accidents accounted for 56 percent of all "before" and "after" accidents. Increases in fixed object accidents (54 percent "before" and 73 percent "after") and decreases in head-on collisions (3 percent "before" and 1 percent "after") are probably attributable to the installation of the New Jersey-type median wall. The single head-on collision after the median wall installation was the result of a wrong-way entrance on an access ramp. Table 3 is a summary of all before-and-after accident types.

The most common category of contributing circumstance which led to an accident was that of "following too closely". Next most common was the "others" category, which was primarily inattentive driving.

From a summary of accident types classified by road surface and visibility conditions, it is apparent that dry-daylight and wet-daylight conditions account for a majority of all accidents. Dry-daylight and wet-daylight conditions also account for the majority of fixed-object accidents involving collisions with guardrails and the concrete median barrier wall. Practically no difference between before-and-after accidents, except for the replacement of guardrail collisions with median wall collisions, was shown by the summary of dry-daylight and wet-daylight fixed-object accidents. This difference was expected, since the concrete median wall was a replacement item for the median guardrail.

Accident Rates

Table 4 is a summary of before-and-after accident rates for 5.15 miles of I 75 from the Buttermilk Pike interchange to the Ohio state line. Rates were calculated as accidents per 100 million vehicle miles. To incorporate specific characteristics of certain portions of the roadway, the total length of 5.15 miles was subdivided into five sections varying from 0.40 - 1.85 miles in length. Section end-points were chosen at intersections for the purpose of simplifying the procedure for handling mainline and ramp accidents. Accident rate categories are: (1) mainline and ramps in both directions, (2) mainline only in both directions, (3) mainline and ramps in northbound direction, and (4) mainline only in northbound direction. Further stratification into four categories was necessary to evaluate the variable message signing system separately from the New Jersey-type median wall and the "hardware" safety improvements. Accident rate Categories I and II were developed as a means of evaluating all safety improvements while Categories III and IV were an attempt to isolate the effects of the variable message signing system.

TABLE 3

ACCIDENT TYPES

	BEFORE		AFTER	
	NUMBER	PERCENT	NUMBER	PERCENT
Rear-End	162	38.9	190	41.8
Multiple Rear-End	71	17.1	60	13.2
Oblique or Sideswipe	78	18.8	99	21.8
Fixed Object	54	13.0	73	16.0
Single Vehicle (Overturn)	8	1.9	1	0.2
Head-On	3	0.7	1	0.2
Miscellaneous	40	9.6	31	6.8

TABLE 4

ACCIDENT RATES
(ACCIDENTS/100 MVM)

SECTION BOUNDARIES	BOTH DIRECTIONS					
	MAINLINE AND RAMPS CATEGORY I			MAINLINE ONLY CATEGORY II		
	BEFORE	AFTER	PERCENT DIFFERENCE	BEFORE	AFTER	PERCENT DIFFERENCE
Buttermilk Pike - Dixie Highway Interchange	103	143	38.8	95	134	41.1
Dixie Highway - Kyles Lane Interchange	193	221	14.5	144	197	36.8
Kyles Lane - 12th Street Interchange	392	324	-17.3	360	268	-25.6
12th Street - 5th Street Interchange	373	304	-18.5	345	280	-18.8
5th Street - Ohio State Line	642	544	-15.3	508	441	- 13.2
Overall Study Section	303	276	8.9	266	238	- 10.5
	NORTHBOUND DIRECTION					
	MAINLINE AND RAMPS CATEGORY III			MAINLINE ONLY CATEGORY IV		
Buttermilk Pike - Dixie Highway Interchange	129	177	37.2	107	165	54.2
Dixie Highway - Kyles Lane Interchange	265	254	- 4.2	193	221	14.5
Kyles Lane - 12th Street Interchange	493	377	-23.5	457	336	- 26.5
12th Street - 5th Street Interchange	486	380	-21.8	452	370	- 18.1
5th Street - Ohio State Line	698	523	-25.1	619	427	- 31.1
Overall Study Section	379	318	-16.1	336	286	- 14.9

Section lengths and section annual average daily traffic volumes (AADT) are presented in Table 5.

As a possible means of resolving the high accident characteristics exhibited throughout the study section, friction measurements were made in October 1971 using a skid-test trailer conforming to ASTM E 274-70. These friction measurements are listed in Table 6. Portions of the pavement had Skid Numbers which fell into the "Slippery" range (between 22 and 30). These data, when grouped with the ratio of wet- to dry-weather accident occurrences, seem to confirm the existence of a skid resistance problem. Based on data from 23 state highway departments [4], the wet-to-dry ratio of 0.269 for the 23 states is considerably less than the ratios of 0.319 "before" and 0.313 "after" improvements.

High accident frequencies throughout the study section may be related to wheel-track wear (rut depths) which has caused the coarse aggregates to become exposed, worn flat, and polished. Studded tires have surely contributed to the abrasion of the pavement. Measurements made in June 1972 revealed that rut depths north of Kyles Lane (Milepost 189.0) generally exceeded those south of this interchange. The southbound lanes from the Ohio state line to Kyles Lane, which is upgrade throughout, have somewhat deeper ruts than the northbound lanes. The maximum was 3/8 inch. Table 7 is a summary of rut-depth measurements throughout the study section.

From Category I in Table 4, overall rates for both directions, including mainline and ramps, indicated a decrease from 303 to 276 accidents/100 million vehicle miles (MVM) from "before" to "after" improvements. These accident rates do not compare favorably with either a statewide average of 98 on four-lane interstates and parkways [5] or with an average of 200 as reported from a summary of accidents on sections of six-lane interstates in 40 states [3]. Application of statiscial tests [6] revealed that this decrease was not significant at the 95-percent confidence level. However, statistical tests at the 90-percent confidence level did reveal a significant decrease. Since no de-slicking treatments have been undertaken, slipperiness has probably increased from those conditions at the time of "before" data collection until "after" data were assembled. Two of the five sections under study, comprising 2.2 miles from Buttermilk Pike to Kyles Lane interchange, did show an increased accident rate. The combined rates for these two sections increased from 146 accidents/100 MVM in 1969 to 180 accidents/MVM in the 1971-1972 data collection period, a 23 percent increase.

Two-directional, before-and-after rates on the mainline only (Category II) gave results similar to those calculated for both mainline and ramps. The most notable difference was a rate decrease of 25.6 percent on the 1.85-mile section from the Kyles Lane interchange to the 12th Street interchange. Total two-directional rates for the mainline indicated that accidents/100 MVM decreased from 266 "before" to 238 "after." This decrease was significant at the 95-percent confidence level.

TABLE 5

SECTION LENGTHS AND AADT'S

SECTION	LENGTH (MILES)	LENGTH (KM)	AADT'S BOTH DIRECTIONS BEFORE	AADT'S BOTH DIRECTIONS AFTER	AADT'S NORTHBOUND BEFORE	AADT'S NORTHBOUND AFTER
Buttermilk Pike - Dixie Highway Interchange	1.20	1.93	60,000	74,800	30,000	37,400
Dixie Highway - Kyles Lane Interchange	1.00	1.61	68,300	82,000	34,150	41,000
Kyles Lane - 12th Street Interchange	1.85	2.98	73,300	87,200	36,650	43,600
12th Street - 5th Street Interchange	0.70	1.13	69,300	82,400	34,650	41,200
5th Street - Ohio State I	0.40	0.64	86,300	99,500	43,150	49,750

TABLE 6

FRICTION MEASUREMENTS

MILEPOST MARKER	SKID NUMBERS (40 MPH)											
	NORTHBOUND LANES						SOUTHBOUND LANES					
	OUTER		MIDDLE		INNER		INNER		MIDDLE		OUTER	
186.5	32		37		39		37		34		30	
186.7	32		34		35							
187.0				(37)			36		32		31	
187.3	32		36									
187.6	34		33	(34)	34		31		28		31	
188.0	31		26		35		30		27		26	
188.2	30		32		27		29		32		23	
188.5	30		33		38		33		33			
188.9	31		33	(33)	37		35		33		29	(33)
189.0	28		29		30		33		34		29	
189.2	29			(35)							28	
189.5	31		29		36		37		33	37	27	(35)
189.6											34	
189.7				(31)							29	
189.8		31										
189.9	29		28		34		33		32	28	27	
190.0			28					33				
190.1												
190.2								38				(33)
190.3	26		24		32	31	32				26	(34)
190.4						27				36		
190.5			22								30	(34)
190.6	28		22		31						27	
190.7	28		26		27		32		29		29	30
190.8			26							28		
190.9	32	29	27		31		32	69	33		28	
191.0		30										
191.1								33				
191.2	33		29		34		33		32		33	
191.3				31								(36)
191.4	30		32		31		35		30		28	30
191.5						30						

Tested October 15, 1971; August 10, 1971; and (November 12, 1969).

TABLE 7

RUT DEPTH IN EACH WHEEL PATH
(ALL MEASUREMENTS ARE IN 32NDS OF AN INCH)
DATE OF MEASUREMENTS: JUNE 20, 1972

MILEPOST MARKER	SOUTHBOUND LANES			NORTHBOUND LANES		
	OUTER	MIDDLE	INNER	INNER	MIDDLE	OUTER
187.7	6-7	7-7				
188.0				4-3	7-7	7-4
189.1	6-6	7-5				
189.5	6-4	9-8			6-9	9-9
190.0					7-11	6-6
190.4	12-6	10-10	6-6		7-9	7-2
190.9	6-5	9-7	7-7			
191.1					2-9	6-6
191.3	3-4	7-7				

Category III in Table 4 presents before-and-after rates for both mainline and ramps in the northbound direction only. The overall accident rate for northbound mainline and ramps decreased 16.1 percent during the before-and-after study period. This decrease (from 379 to 318) was statistically significant at the 95-percent confidence level.

Before-and-after rates from Category IV were for the northbound direction including mainline sections only. Overall rates for this category decreased by 14.9 percent. It was also found that the accident-occurrence rate reduction was statistically significant at the 95-percent confidence level.

In summary, it appears that accident rates for the entire section (mainline and ramps in both directions) have decreased significantly (95-percent confidence level). Likewise, accident rates in the northbound direction have been reduced and the decrease was statistically significant at the 95-percent confidence level. Accidents occurring in the northbound direction were isolated for the purpose of evaluating the variable message signs and it appears that the system was effective when considering there was no other explanation for the greater accident rate reduction in the northbound than in the southbound direction.

From a report prepared for the "hearing..." in September 1971 [7], accident summaries indicated that there was a steady increase in accident rates between 1967 and 1970 on the section under study. These increases took place despite a stepped up enforcement program which employed a relatively new speed measuring device called VASCAR (visual average speed computer and recorder). Conversations with Kentucky State Police officers who were Post Commanders during the two data collection periods indicated their enforcement efforts were approximately equal. Both officers commented on the reduced fatality rate during the years of enforcement. However, with the increased overall severity rate and small number of fatalities, it would appear that the fatalities were chance happenings.

High-Accident Sections

From an analysis of before-and-after collision diagrams, the four highest accident-frequency sections were isolated. For the purpose of this analysis, the entire study area was divided into one-half mile sections. Sections were used rather than discrete locations because it was not possible to isolate high accident-frequency locations along the accident-prone two-mile stretch terminating at the Ohio state line. It was found that these four sections comprised only 40 percent of the total study area length while the percentage of before-and-after accidents represent 62 and 68 percent, respectively. A brief summary of the number and type of accidents on each half-mile section follows. Sections are listed in the order of increasing milepost numbers with the largest number (192.0) ending at the Ohio state line.

Milepost 190.0 to 190.5 This section includes exit and entrance ramps on the southern end of the Jefferson Avenue - Euclid Avenue - I 75 interchange. There were 86 "before" accidents (21 percent of total in the study area) and 65 "after" accidents (14 percent). Wet-weather accidents decreased (from 33 to 26 percent), and nighttime accidents decreased (from 26 to 17 percent). Very little change was noted in the percentages of rear-end accidents. Median-wall accidents, which accounted for 26 percent of the "after" accidents, contributed an unusually large percentage on this section of roadway. Friction values for this section vary from a Skid Number of 24 to 32. These compare with a minimum friction value of 37 as presented in National Cooperative Highway Research Program Report 37 [8]. This minimum value corresponds to the demands for normal driving, cornering, and braking maneuvers by a majority of drivers under normal traffic conditions.

From the beginning of this section (Milepost 190.0) to the Ohio state line (Milepost 192.0), there is a great deal of congestion which probably accounts for the large number of both before and after accidents. There is reason to believe that the variable message signing system is in part responsible for the decrease in percentage of total accidents on this section. The five variable message signs, which were installed in the northbound direction only, are located in a two-and-one-half-mile stretch just to the south of this section under discussion. The criteria defining traffic conditions under which the variable messages are to be used are presented in Table 8.

Milepost 190.5 to 191.0 This section includes the remainder of the Jefferson Avenue - I 75 interchange and extends northward to 12th Street. The accident trend was just opposite that of the previous section; there was an increase in total accidents from 68 "before" (16 percent of the total) to 86 "after" (19 percent). This accounted for only a three-percent increase as compared to a seven-percent decrease in the preceding section. Probable causes for the large number of accidents on this section are heavy congestion, the presence of a large interchange within the limits, and the low friction levels (range from Skid Number of 22 to 32) in both directions throughout the section. A predominance of rear-end collisions (38 percent of the before and 63 percent of the after accidents) is further evidence of a high degree of congestion. Percentages of wet-weather and nighttime accidents also vary considerably between "before" and "after" periods.

Milepost 191.0 to 191.5 The 5th Street northbound exit and southbound entrance ramps account for the majority of accidents within this section. There was practically no difference between the percentage of "before" and "after" total accidents (12 and 11 percent, respectively). Congestion was

TABLE 8

CRITERIA FOR USE OF THE VARIABLE MESSAGE SIGNS

	MESSAGE	WHEN TO USE
1.	ACCIDENT AHEAD -- PREPARE TO STOP	TO BE USED WHEN AN ACCIDENT OCCURS THAT CAUSES A MINOR STOPPAGE OF TRAFFIC ON I 75. (ONE OR LESS LANES OF TRAFFIC BLOCKED)
2.	ACCIDENT AHEAD -- USE MARKED EXIT	TO BE USED WHEN AN ACCIDENT OCCURS THAT CAUSES A MAJOR STOPPAGE OF TRAFFIC ON I 75. (TWO OR MORE LANES OF TRAFFIC BLOCKED)
3.	ACCIDENT AHEAD -- EXIT HERE ↗	AUTOMATICALLY DISPLAYED WITH "ACCIDENT AHEAD -- USE MARKED EXIT."
4.	CONGESTION AHEAD -- PREPARE TO STOP	(A) TO BE USED WHEN VERY HEAVY BUT "MOVING" TRAFFIC OCCURS, SUCH AS ON HOLIDAY WEEKENDS. (B) TO BE USED DURING HEAVY CONGESTION WHEN ONE LANE OF TRAFFIC IS BLOCKED DUE TO ROAD REPAIRS.
5.	CONGESTION AHEAD -- USE MARKED EXIT	(A) TO BE USED WHEN EXTREMELY HEAVY TRAFFIC OCCURS WHICH CAUSES A MAJOR BOTTLENECK ON I 75. (B) TO BE USED IF I 75 IS CLOSED TO TRAFFIC FOR ANY REASON OTHER THAN AN ACCIDENT.
6.	CONGESTION AHEAD -- EXIT HERE ↗	AUTOMATICALLY DISPLAYED WITH "CONGESTION AHEAD -- USE MARKED EXIT."
7.	CURVES HILL -- REDUCE SPEED	TO BE USED WHEN SLICK ROADWAY CONDITIONS EXIST ON I 75, SUCH AS DURING A HEAVY RAINSTORM OR WHEN SNOW OR ICE ARE PRESENT.

again identifiable as the primary causative factor because of the large number of accidents classified as rear-end and multiple rear-end (70 percent "before" and 72 percent "after"). Wet weather and nighttime were apparently the cause for some accidents; however, percentages of accidents occurring under these conditions was considerably less than for the other high-accident sections. Wet-weather conditions accounted for 16 percent of the "before" accidents and 21 percent of "after" accidents. Nighttime accidents were also of minor consequence when compared to the time of occurrence of accidents on the other high-accident sections (14 percent "before" and 8 percent "after"). Skid resistance for this section was somewhat higher than for the two previous sections; skid numbers ranged between 28 and 35.

Milepost 191.5 to 192.0 Included in this section are the southbound 5th Street exit and the northbound 4th Street entrance ramp to the Brent Spence Bridge. Percentages of total accidents occurring in the section remained the same for the two data collection periods (19 percent "before" and 18 percent "after"). Rear-end and multiple rear-end collisions again accounted for a majority of the accidents (58 percent "before" and 63 percent "after"). "Before" and "after" sideswipe accidents were 16 and 17 percent, respectively. An observation worthy of mention was the occurrence of 12 percent of the "after" accidents with a Fitch-type energy absorbing barrier system. The barrier system had not been installed at the beginning of the "before" data collection period. Wet-weather and nighttime conditions, combined with the almost constant state of congestion, resulted in the occurrence of more accidents on this section than any of the other three high-accident sections. Skid-resistance data were not available for this half-mile section.

SUMMARY

A before-after study is usually constrained by the fact that the data base is confined to a few years. In this study, two years of data were collected and analyzed in the form of one year before the improvements were made and one year after. The following is a summary of observations:

1. No fatalities were recorded in either the "before" or "after" study period as compared to an average of 3.8 during each of the five preceding years.
2. There was a significant increase (95-percent confidence level) in accident severity from "before" to "after" periods.
3. Sunday was by far the most accident-prone day of the week in both "before" and "after" periods.

4. Most of the study sections were frequently in a high state of congestion as evidenced by the fact that rear-end and multiple rear-end accidents accounted for approximately 55 percent of all accidents in both periods.
5. Cross-median accidents were eliminated by installation of the median barrier wall. A single, head-on collision resulted from a wrong-way entrance on a ramp.
6. Accident rates for the mainline and ramps in both directions decreased significantly (95-percent confidence level), an indication the overall safety improvement program was effective in reducing the accident rate.
7. Accident rates for the mainline and ramps in the northbound direction decreased significantly (95-percent confidence level) between the "before" and "after" periods. This is an indication that the variable message signing system was a contributive factor in producing a greater accident reduction rate in the northbound direction than in the southbound direction.
8. The four highest accident-frequency, one-half-mile sections were those sections just south of the Ohio state line which had the highest AADT's.
9. Limited time-span studies such as this may not be altogether sufficient for evaluating the effectiveness of overall safety improvements program. While the findings cited here indicate this particular project was somewhat successful from the standpoint of accident abatement, other investigations may be necessary to evaluate improvements more specifically.

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