Cross-Median Accident Experience on the New Jersey Turnpike

JOHN R. CROSBY, Traffic Engineer
New Jersey Turnpike Authority, New Brunswick

● THE cross-median collision, of all accident types, probably holds the greatest promise of prevention. Initial highway design with inclusion of adequate median widths between opposing roadways can almost completely prevent the sensational head-on motor-vehicle accident. This, of course, is an impossibility on many of our existing highways where cross-sectional design cannot be improved substantially within existing right-of-way. The highway operating agency may, therefore, turn to other means of physically separating the opposing vehicular streams in an attempt to control these higher than normal fatal injury-producing collisions. The economic consideration of barrier erection may appear prohibitive and many questions remain unanswered as to the best design for a barrier and where and under what conditions a barrier should be erected.

The purpose of this study is to present the cross-median accident experience on the New Jersey Turnpike for the 7-yr period 1952 through 1958. This period constitutes the "before" accident experience, as during 1958 eighteen miles of medial guardrail were constructed on medians varying in width from 6 to 26 ft. It is hoped that the presentation of these data will assist highway and safety officials by answering some of the many questions that still remain about the frequency of cross-median collisions.

To assist in the proper evaluation of the total accident problem, data will be presented on the over-all accident experience of the highway so that areas of similar geometric design carrying dissimilar traffic volumes may be compared. Cross-median accidents will be analyzed with respect to severity, median width and type, and annual average traffic volumes. No attempt will be made to present data on the effectiveness of median barriers in this study, as insufficient time has elapsed to develop a pattern of accident types and severity since the erection of the barriers.

SITE DESCRIPTION

The New Jersey Turnpike is a 131-mi full-controlled-access toll highway interconnecting the Delaware Memorial Bridge and Pennsylvania Turnpike on the south and west with the three major Hudson River crossings on the north. This highway serves one of the heaviest traffic corridors in the east between such traffic generators as New York, Philadelphia, Baltimore, and the New England industrial area. Due to its proximity to the densely populated New York and North Jersey metropolitan areas, the northerly 42 mi of the highway is a primary commuter route in addition to carrying a heavy volume of transient vehicles.

The average trip length per vehicle currently is just under 30 mi. Trip length has consistently decreased since 1952, at which time it was

42 mi. Commercial traffic during the first year of operation amounted to 7.8 percent of the total traffic. This type of vehicle use has steadily increased amounting to 11 percent in 1958.

During the period of this study vehicular use of the Turnpike has more than doubled while miles traveled have increased more than sixty percent. These annual statistics as well as the yearly accident statistics are given in Table 1. It is noted that with the great increase in vehicle use the total accident experience has remained nearly constant during the 7-yr period. Injury accidents, however, have failed to follow any consistent pattern with respect to either vehicle exposure or total accident experience. They have varied from a low of 25 percent of all accidents in 1954 to a high of 37 percent in 1957 and averaged 31 percent during the 7-yr period. Personal injuries averaged 2.3 per injury accident varying from a low of 2.0 in 1956 to a high of 2.5 in both 1952 and 1953. It is interesting to note that this figure checks closely to the vehicle occupancy surveys that have been taken from time to time on the Turnpike.

The original project of the New Jersey Turnpike Authority was a 118-mi facility with 17 interchanges. This portion of the project was opened to traffic in January 1952. During 1956 two extensions were completed and opened to traffic. These added approximately 14 mi to the system and four additional interchanges. For the purpose of this study, detailed analysis of cross-median and head-on accidents will be limited to the through roadways of the initial 118-mi project. Accidents occurring within service areas, interchanges and their interconnecting roadways and ramps have been deleted.

The toll feature of this highway aids materially in an accident study of this type. This is particularly true for the calculation of vehicle mileage rates and daily traffic volumes. The daily auditing of every toll ticket (representing a vehicle) and the weekly, monthly and yearly summarization of the daily audits yield a wealth of extremely accurate information. This includes origin and destination by interchanges, daily volume by direction between successive pairs of interchanges, vehicle-miles of travel, average trip length by vehicle types, ramp volumes and many other useful details of great interest to the traffic engineer.

CRITIQUE

The Turnpike study site may not be typical of experience recorded on controlled-access freeways. The fact that toll booths are located at each interchange adds a degree of control that does not exist on public and some partial toll highways. At these points, vehicles are scrutinized as to loading and superficial mechanical condition including tires and lights. Drivers suspected of excessive alcoholic indulgence or fatigue may be detected, and if so, appropriate action is taken. During periods of brisk winds, house trailers are banned as this vehicle combination has had unfavorable accident experience.

A total of 63 weather and roadway condition warning signs are spaced at 5-mi intervals along the highway. These are used to caution drivers in advance of areas where a hazardous condition exists. In addition, when hazardous weather conditions prevail or the roadway is partially blocked due to construction, the normal posted speed limit of 60 mph is reduced to 35 mph. Officer enforcement is generally increased under these conditions although it is believed to be at a relatively high level during all periods with respect to other comparable facilities.

Even with these unique standard operating procedures, accidents continue to occur. The adoption of these procedures, however, probably accounts for the fact that total annual accidents have remained relatively stable during the 7-yr period, resulting in a rate reduction per one hundred million-vehicle-miles of 130.9 in 1952 to 81.0 in 1958. This trend in total accident rate is also given in Table 1, together with the trend of injury accidents and fatal accidents. The year 1955 would appear as an exception to the general trend of total accidents as well as injury accidents as portrayed by this figure. During 1955, 64 mi of the Turnpike were widened from a 4-lane divided highway to a 6-lane divided facility. Since early 1956, 84 mi of the Turnpike have had a 6-lane divided cross-section while the southern 34 mi remain unchanged. With one minor exception, all the widening took place beyond the existing traveled roadway without change in the median cross-section. The distraction of such a length of construction activity may account for the increased incident of accidents during 1955.

CROSS-MEDIAN FATAL ACCIDENTS

During the period 1952 through 1958, 48 of the 158 fatal accidents involved a vehicle crossing the median into the opposing trafficway. This amounts to 30.4 percent of the fatal accident experience on the Turnpike. Table 2 indicates the distribution of the fatal accidents under the four major collision types and one miscellaneous classification. A perusal of the yearly tabulations indicates an apparent instability in accident types resulting in fatal collisions. The fatal accident is apparently such a rarity that it lacks the stability needed for proper analysis and formulation of sound conclusions unless a large sample is available. In this particular study the yearly sample size is obviously too small for independent analysis.

An interesting comparison is presented in Table 3 between the Turnpike fatal accident types and those reported in the California Freeway

TABLE 1

N. J. TURNPIKE ACCIDENT STATISTICS (1952 THROUGH 1958)

	1952	1953	1954	1955	1956[a]	1957	1958	Total 1952-1958
Total accidents[b]	1,007	896	946	1,145	1,009	1,045	1,004	7,052
Accidents/100 motor vehicle-miles	130.9	102.9	101.8	121.6	94.3	86.6	81.0	100.4
Injuries	851	681	533	722	588	798	708	4,881
Injury accidents	340	277	233	312	287	385	327	2,166
Injuries/100 motor vehicle-miles	110.6	78.2	57.4	76.7	54.9	66.1	57.1	69.5
Fatalities	47	36	23	26	25	24	30	211
Fatal accidents	33	26	18	25	18	20	24	164
Fatalities/100 motor vehicle-miles	6.11	4.14	2.47	2.76	2.34	1.99	2.42	3.00
Vehicles in millions	18.2	22.2	24.7	26.1	31.8	39.5	41.8	204.3
Vehicle-miles in millions	769.1	870.4	929.3	941.9	1,070.3	1,206.4	1,238.9	7,026.5

[a]During 1956 nearly 14 mi of new highway were added to the original 118-mi system.

[b]Accidents include all types even those with negligible property damage. Accidents at service areas and interchanges also included.

Median Study 1958 (1). The proximity of the approach and pedestrian-type fatal accident percentages between the two studies is startling. Such a comparison must, however, be tempered as 22 of the approach-type accidents or 5.4 percent in the California Study did not involve a crossing of the median but rather head-on collisions between vehicles, one of which was driving against the normal flow of traffic. Taking this into account, the Turnpike actually had a higher percentage of out-of-control head-on collisions than were recorded in the California Study. Their comparable total was 55 accidents representing 13.5 percent of the total accidents.

TABLE 2

ANALYSIS OF FATAL ACCIDENT TYPES (1952 THROUGH 1958)

	1952	1953	1954	1955	1956	1957	1958	Total	Percent
Overtaking	14	5	7	2	5	8	7	48	30.4
Overtaking (cross-median)	2	-	-	1	-	1	-	4	2.5
Pedestrian	4	4	2	9	3	3	2	27	17.1
Head-on[1]	2	6	1	5	3	3	7	27	17.1
Single vehicle	10	4	4	5	4	2	4	33	20.9
Single vehicle (cross-median)	1	5	3	3	2	2	1	17	10.7
Miscellaneous (passenger fell from vehicle)	-	1	-	-	-	-	1	2	1.3
Total[2]	33	25	17	25	17	19	22	158	

1/ Two accidents in 1955 initiated as a rear-end collision and a sideswipe but resulted in head-on collisions.

2/ Total of annual fatal accidents does not always agree with those recorded in Table 1, as fatal accidents which occurred within interchange areas or on extensions have been deleted.

There is no apparent reason for the wide percentage spread noted between the two studies in overtaking and single-vehicle-type fatal accidents. The balance of the Turnpike fatal accidents or some 64.5 percent are nearly equally divided between the overtaking (32.9 percent) and single-vehicle (31.6 percent) accidents. These accident types constituted 63.9 percent of the freeway accident study and single-vehicle-type fatal collisions exceeded the overtaking type by a factor of in excess of 2 to 1.

No detailed information was available as to hourly traffic flow characteristics when the accidents occurred in the freeways studied, but it was reported that 66 percent of the fatal accidents occurred during the hours between 7 p.m. and 7 a.m. Although a similar hourly breakdown has not been undertaken, it is known that 55 percent of the Turnpike fatal accidents occurred during the hours of darkness. On a yearly average basis, the period of darkness might compare reasonably close to the 7 p.m. to 7 a.m. period. Assuming this to be true, there are at least two possible reasons to explain the difference in frequency of the two fatal-accident types apparent between the two studies: (1) Turnpike fatal accidents occur during periods of higher traffic density; (2) nighttime freeway traffic density is below that experienced on the Turnpike. Either of these statements may partially explain the noted difference, but are considered inconclusive. Further investigation to determine the true reasons for such an apparent difference in these fatal-accident types could prove worthwhile.

Table 3 further indicates close agreement between the two studies on both average fatalities per fatal accident and average fatalities per head-on-type accident the most significant factor to be noted here is with

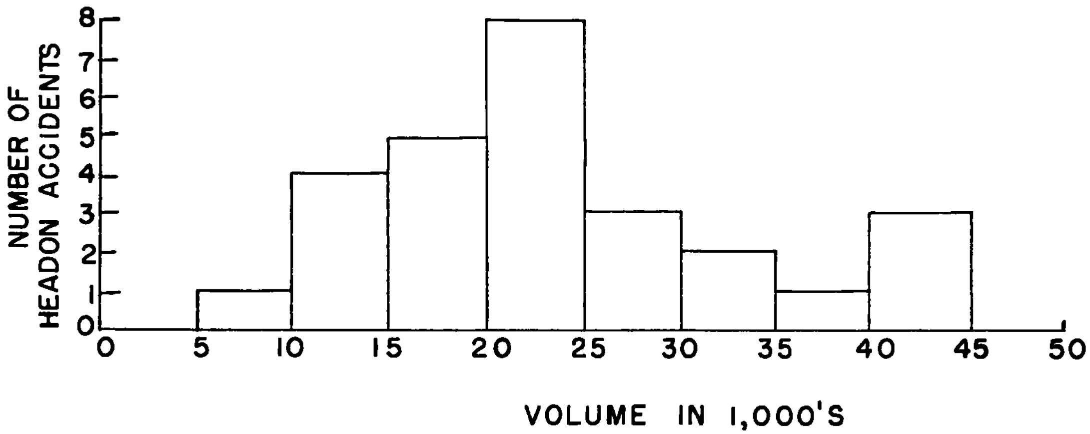

Figure 1. Number of head-on accidents as a function of two-way daily volume at the time of occurrence.

regard to the severity of the head-on collision. This collision type is more apt to produce two fatalities than one, while the probability for all types is reversed. This is certainly one reason why highway officials should be concerned with the prevention of head-on collisions even though they represent one of the lesser fatal-accident types.

A further comparison of the two studies shows a wide variation in the cross-median fatal accident percentages. The Turnpike which recorded a 30.3 percent figure has had considerably worse experience when compared with the 18.9 percent recorded on the Freeways. The reasons for this difference is unknown but may be partially attributable to differences in median cross-section and width as well as traffic densities and normal vehicle speeds.

Table 4 gives a further analysis of the cross-median head-on fatal accidents during the 7-yr study period. In this tabulation the two-way traffic volume recorded on the day of the accident at point of occurrence is recorded as is the design width of the median crossed. The median widths shown as 18, 20 and 26 ft consist of a slightly mounded earth median with grass cover and penetration-type inner shoulders 5 ft in width on each side. The inner shoulders, which have a different texture from the bituminous roadway but are today nearly the same in color, are delineated by a well-maintained 6-in. reflectorized white paint line placed on the left edge of the inner traffic lane. The 6-ft median is a raised steel median with 9-in. barrier curbing immediately adjacent to the inner 12-ft traffic lanes. It is difficult to draw any conclusions from this tabulation as the mileage of the various median cross-sectional widths is of such unequal length and the annual average daily traffic volume varies so widely that they cannot be satisfactorily compared. The frequency of fatal crossings of the 26-ft designed width median makes it apparent that such a width is insufficient design to prevent the spectacular head-on collision.

Figure 1 shows the percentage of the fatal head-on accidents that occurred within certain daily volume ranges. Low or moderate opposing traffic volumes may reduce the statistical probability of a head-on collision but gives little, if any, assurance that they will not occur. The dynamics of vehicular movement are such that low probabilities of head-on occurrences may not be realistic as they are unable to cope with the defensive maneuvers that may be taken by either or both drivers. Detailed in-

TABLE 3

COMPARISON OF FATAL ACCIDENT TYPES ON TURNPIKE WITH CALIFORNIA FREEWAY EXPERIENCE

Accident Type	New Jersey Turnpike Study			California Freeway Median Study		
	No.	Percent of Total	Fatality Rate[c]	No.	Percent of Total	Fatality Rate[c]
Approach	27	17.1		77[a]	18.9[a]	
Overtaking	52	32.9		84	20.6	
Single vehicle[b]	50	31.6		176	43.3	
Pedestrian	27	17.1		70	17.2	
Total fatal accds.	158			407		
Total fatalities	205			499		
All accidents			1.30			1.23
Head-on accidents			1.66			1.53
Cross-median fatal accidents	48	30.3		77	18.9	

[a] These figures include accidents involving vehicles driving against the normal flow of traffic. Deleting such incidents results in 55 approach cross-median accidents or 13.5 percent of total.

[b] Single-vehicle-type fatal accidents include two miscellaneous types as presented in Table 2.

[c] Fatalities per accident.

TABLE 4

RESUME OF HEAD-ON FATAL ACCIDENTS ON N. J. TURNPIKE (1952 THROUGH 1958)

No.	Date	Milepost Location	Two-Way Daily Volume on Day of Accident	Median Width Including Inside Shoulders (ft)	Number Killed
1.	2/28/52	89	12,227	26	2
2.	11/30/52	110	44,706	6	1
3.	4/ 3/53	75	29,227	26	2
4.	5/15/53	22	14,004	26	1
5.	7/18/53	84	43,370	26	1
6.	8/14/53	34	24,020	26	1
7.	9/ 5/53	24	24,146	26	1
8.	11/ 6/53	50	12,782	26	5
9.	2/21/54	76	24,074	26	2
10.	4/ 3/55	67	26,931	26	2
11.	5/29/55	81	24,629	26	1
12.	7/22/55	66	25,213	26	1
13.	8/12/55	30	15,979	26	1
14.	11/10/55	89	24,019	26	1
15.	3/ 8/56	13	9,635	26	2
16.	3/16/56	63	16,267	26	1
17.	8/ 2/56	100	42,859	18	3
18.	4/29/57	39	19,772	26	3
19.	6/ 8/57	29	22,232	26	1
20.	7/13/57	40	31,869	26	2
21.	2/ 1/58	41	13,162	26	1
22.	4/26/58	50	23,072	26	1
23.	7/22/58	116	30,285	20	2
24.	9/21/58	56	37,542	26	2
25.	9/21/58	4	17,468	26	1
26.	10/15/58	61	22,981	26	1
27.	11/16/58	14	15,674	26	3

Note: 45 fatalities, 27 fatal accidents, 24 over 26-ft median, 1 over 20-ft median, 1 over 18-ft median, and 1 over 6-ft median.

vestigation into a number of these collisions gave an indication that in some cases the chosen defensive action actually was a primary contributing factor to the event.

FREQUENCY OF HEAD-ON ACCIDENTS AS RELATED TO VOLUME AND ROADWAY CROSS-SECTION

In an attempt to keep the head-on accident in the proper perspective to the over-all highway accident picture, Tables 5 and 6 are presented. The accident experience between successive pairs of interchanges by accident type for a recent 3-yr period are given in Table 5. The average daily traffic volume between the successive interchanges is noted. Where it became necessary to combine areas to yield a satisfactory sample size, the appropriate volumes are noted for the combined areas.

Overtaking accidents account for more than 60 percent of the total accidents, but vary from a low of 45 percent between interchanges 2 and 4 to a high of 79 percent between 15 and 16. There is undoubtedly a strong tendency for this percentage to vary directly with the traffic volume.

Single-vehicle accidents are classified under three sub-headings and are also summarized. Collisions of this type account for over 30 percent of the total accidents. Considering the twelve locations separately, it

TABLE 5

N. J. TURNPIKE ACCIDENT TYPES BY LOCATION (1956 THROUGH 1958)

Between Interchange Number	Roadway Mileage	Average Daily Volume	Total All Accidents	Overtaking Accidents		Single-Vehicle Accidents					Head-on Accidents		Misc. or Unclassified 2/	
				No.	%	Out-of-Control Left	Out-of-Control Right	Other Types 1/	Total Number	7.1	No.	%	No.	%
1 - 2	12	14,476	114	61	54	16	23	7	46	40	3	3	4	3
2 - 3	13	14,946	110	50	45	20	24	6	50	45	6	6	4	4
3 - 4	8	16,490	130	58	45	21	30	5	56	43	12	9	4	3
4 - 5	10	20,152	177	101	57	20	36	7	63	36	5	3	8	4
5 - 7	9	(20,411 (26,515	129	69	53	15	23	7	45	35	6	5	9	7
7 - 8	15	26,527	275	161	58	20	47	13	80	29	5	2	29	11
8 - 9	15	26,154	280	161	57	23	50	13	86	31	5	2	28	10
9 - 10	7	32,630	122	73	60	13	19	10	42	35	3	2	4	3
10 - 13	10	(25,587 (38,003 (41,656	267	166	63	19	46	13	78	29	1	0	22	8
13 - 15	7	(40,761 (41,708	220	143	65	16	24	21	61	28	5	2	11	5
15 - 16	5	45,907	327	258	79	21	12	13	46	14	6	2	17	5
16 - 18	6	(26,212 (28,346	101	60	59	13	12	6	31	31	4	4	6	6
Total	117		2,252	1,361		217	346	121	684		61		146	
Percentage of total accidents				60.4		9.7	15.4	5.4	30.5		2.7		6.4	
Percentage of fatal accidents				36.2					39.7		22.4		1.7	

1/ Includes overturned on roadway, pedestrian and collision with other objects on roadway accidents.
2/ Includes unusual accident types such as unattended vehicles leaving roadway, jackknifing of utility trailer, chain broke on lumber truck striking adjacent car, wheel broke free and struck passing vehicle, etc.

is found that the percentage varies from a low of 12 percent between interchanges 15 and 16 to a high of 45 percent between 2 and 3. When the percentages are reviewed with respect to traffic volumes, the tendency for this accident type to increase with decreasing traffic volumes is apparent. This tendency is probably a direct result of the higher speeds and decrease in driver attentiveness associated with low traffic density.

Head-on accidents constitute the smallest portion of the accident experience, accounting for 2.7 percent of the total. The range for this collision type varies from 0 percent between interchanges 10 through 13 to a high of 9 percent between 3 and 4. The former percentage is relatively easy to explain as 8.5 mi of this 10-mi area has a median width of 94 ft. This analysis fails to reveal any accident pattern with respect to volume which possibly may be due to the infrequency of head-on accidents. In the earlier discussions, however, it was pointed out that the roadway cross-section was identical between interchanges 1 and 10, except that only four lanes are paved between 1 and 4 with six lanes from 4 to

10. In the 34-mi four-lane divided area 5.9 percent of the collisions have been head-on, while only 2.4 percent were of this type in the 56-mi six-lane section. This suggests the possibility that roadway width may be a modifying factor as it affects the total maneuvering width available to drivers. This theory was also suggested in the California Median Study 1958.

EFFECTIVE MEDIAN WIDTH VS ACTUAL MEDIAN WIDTH

A recent study (2) of lane volumes and speed presented a typical distribution of vehicles by traffic lanes for a three-lane one-way roadway. It was reported in the study that during periods when the roadway volume is below 500 vehicles per hour, the right lane carries more vehicles than either the center or left lanes. Above this figure, the center lane carries a volume in excess of the right lane but the left lane volume does not exceed the right lane volume until the total one-directional volume exceeds approximately 1,800 vehicles per hour. Furthermore, the volume carried by the left lane remains below the center lane volume until the roadway volume exceeds 3,600 vehicles per hour. This description of lane use partially illustrates the variability of "effective median width" as it may be applied to various hourly or daily roadway volumes. (Effective median width for purpose of this study is assumed to be the lateral distance from a vehicle traveling in any lane in one roadway to the nearest possible vehicle traveling the opposing roadway of a divided highway having a traversable median.)

Using further data from this study, it was reported that for a particular day when traffic flow for a short period of time approached the basic capacity, the left lane carried 33 percent, the center lane 40 percent and the right lane 27 percent of the total daily flow. These lane volume percentages may be restated in terms of "effective median width" for the vehicles occupying each of the three lanes in one roadway with respect to the inside lane of the opposing roadway as follows:

TABLE 6

N. J. TURNPIKE ACCIDENT FREQUENCY AND VEHICLE MILEAGE RATES FOR VARIOUS ACCIDENT TYPES BY LOCATION (1956 THROUGH 1958)

Between Interch. Number[a]	Roadway Mileage	Typical Median Cross-Section (ft)	Average Daily Volume	Vehicle-Miles (in millions)	Accident Frequency (per mi)	Accident Rate (per 100 million veh-mi)	Overtaking Accidents (per 100 million veh-mi)	Single-Vehicle Accidents (per 100 million veh-mi)	Head-On Accidents (per 100 million veh-mi)	Misc. Accidents (per 100 million veh-mi)
1 - 2	12	26	14,476	190.4	9.5	59.9	32.0	24.2	1.6	2.1
2 - 3	13	26	14,946	212.9	8.5	51 6	23.5	23.5	2.8	1.9
3 - 4	8	26	16,490	144.6	16.3	89.9	40.1	38.7	8.3	2.8
4 - 5	10	26	20,152	220.9	17.7	80.1	45.7	28.5	2.3	3.6
5 - 7	9	26	(20,411 (26,515	214.7	14.3	60.1	32.1	21.0	2.8	4.2
7 - 8	15	26	26,527	436.1	18.3	63.0	36.9	18.3	1.1	6.6
8 - 9	15	26	26,154	430.0	18.7	65.1	37.4	20.0	1.2	6.5
9 - 10	7	26	32,630	250.3	17.4	48.7	29.2	16.8	1.2	1.6
10 - 13	10	94[b]	(25,587 (38,003 (41,656	418.9	26.7	63.7	39.6	18.6	0.2	5.2
13 - 15	7	20[c]	(40,761 (41,708	314.8	31.4	69.9	45.4	19.4	1.6	3.5
15 - 16	5	20[d]	45,907	251.6	65.4	130.0	102.5	18.2	2.4	6.8
16 - 18	6	20	(26,212 (28,346	184.1	16.7	54.9	32.5	16.8	2.2	3.2
Total	117			3,269.3	19.2	68.9	41.6	20.9	1.9	4.5

a/ The roadway cross-section between interchanges 1 through 4 is 4-lane divided with 6-lane divided elsewhere with one exception (Note b).

b/ Includes 0.7 mi of 20-ft and 0.8 mi of 8-lane dual-dual with 20-ft medians.

c/ Includes 1.4 mi of 18-ft median with 9-in. barrier curbs.

d/ Includes 1.0 mi of 6-ft median with double guardrail and 2.4 mi on bridges with 6-ft steel median with 9-in. barrier curbs and no outer shoulder.

1. Thirty-three percent of the vehicles had an "effective median width" equal to the median width.
2. Forty percent of the vehicles had an "effective median width" equal to the median width plus 12 ft (1 lane width).
3. Twenty-seven percent of the vehicles had an "effective median width" equal to the median width plus 24 ft (2 lane widths).

From the foregoing it is apparent that the designed median width is not a good base for evaluation of its effectiveness. The "effective median width" is a better measurement as it takes into account lane placement of vehicles. It is also obvious that a six-lane divided facility will have a greater "effective median width" for all conditions of traffic flow than a four-lane facility with identical median width. The cross-median accident experience of two facilities having equal or nearly equal design median width cannot be directly compared with any reasonable reliability unless the "effective median width" (that is, roadway cross-section and annual hourly lane volumes) are similar. Further investigation, beyond the scope of this study, is needed to better identify the relationships that may exist between these factors.

There would appear to be a direct application of this theory to traffic operations. Some states have eradicated the "keep right except to pass" rule, which formerly, when adequately enforced, tended to keep the practical maximum number of vehicles away from the roadway centerline. The relaxation of this regulation has resulted in a reduced "effective median width" and may increase the frequency of both cross-median and head-on-type accidents. This regulation is well posted and enforced on the Turnpike and may in part explain the fact that 60 percent more out-of-control single-vehicle accidents involved vehicles leaving the roadway to the right rather than the left. The tendency to keep right results in greater maneuvering area to the left with a lesser area on the right. This area on the right, for a vehicle traveling the right lane, includes only the 10- or 12-ft paved shoulder plus approximately 6 ft of berm. The area beyond this to the base of the ditch cannot be considered maneuver area as it is generally a 1 on 4 slope. Such a slope tends to "roll" vehicles traveling at the usual roadway speed.

Table 6 gives the accident rate experience between successive pairs of interchanges by accident type for the same period as in Table 5. Accident frequency per mile averaged 19.2 with a range of 8.5 to 65.4 There is a definite trend for this value to increase with volume although minor exceptions are noted. The peak frequency of 65.4 does not necessarily give a true picture of the conditions of operation between interchanges 15 and 16. This particular area has been approaching saturation during the morning and afternoon peak commuter period. A total length of 2.4 mi of high bridge structure of six-lane divided cross-section without breakdown shoulder and lengthy 3.0 percent grades has certainly exerted a great deal of influence on the over-all frequency experience of this 5-mi section of roadway. (Ultimate design of the area between interchanges 15 and 16 will result in twin structures of identical cross-section, each carrying one-way traffic flow on dual-dual roadways with full breakdown shoulder.)

With respect to the overtaking and single-vehicle accident rates per 100 million vehicle-miles, the rates tend to equalize in the lower volume areas. With increasing volume the overtaking accident rates generally tend to increase with a resulting decrease in single-vehicle accidents.

TABLE 7

SUMMARY OF CROSS-MEDIAN AND HEAD-ON ACCIDENTS AND ACCIDENT RATES FOR MAJOR AREAS OF SIMILAR CROSS-SECTION AND TRAFFIC VOLUMES (1952 THROUGH 1958)

Section	Between Interchanges or Mile	Mileage	Roadway Lanes	Median Cross-Section (ft)	Minimum and Maximum ADT[a]	Number Cross-Median Accids.	No. Cross-Median Accidents (per mi)	Cross-Median Rate (per 100 million veh-mi)	Number Head-On Accidents	Number Head-On Accidents (per mi)	Head-On Rate (per 100 million veh-mi)	Fatal Accids.	Vehicle-Miles (in millions)
A	1 and 4	33	4	5-16-5	13,400 14,800	127	3.8	10.8	44	1.3	3.7	7	1,178.0
B	4 and 10	56	4-1952-55 6-1956-58	5-16-5	18,300 21,400	231	4.1	7.3	62	1 1	2 0	17	3,144.1
C	10 and Mile 98	8	6	5-84-5	23,100 36,900	3	0.4	0.4	1	0.1	0.1	0	683.1
D	Mile 101 and Mile 107	6	6	5-10-5	36,000 37,600	35	5.8	6.2	11	1.8	2.0	0	560.5
E	16 and 18	5.6	4-1952-55 6-1956-58	5-10-5	23,600 24,400	19	3.4	5.5	4	0.7	1.1	1	346 8
Total	Interchange 1 to 18					455	3.9	6.8	134	1.1	2.0	27	6,706.4

[a] The minimum ADT is the average daily volume for the 7-yr period in the section of any area carrying the least amount of traffic. The maximum ADT is the similar figure for the section carrying the heaviest volume.

The head-on accident rate again yields no recognizable pattern. The low rate shown for the area between interchanges 10 and 13 speaks well for the safety of the 94-ft median through most of this area. Referring to Table 5, only one cross-median head-on occurrence was recorded on this 10-mi section for the 3-yr period, and was of minor consequence. However, such a width will not completely eradicate the head-on accident problem as during 1959 a vehicle involved in a minor sideswipe collision completely crossed this area striking an opposing vehicle and resulted in two fatalities.

CROSS-MEDIAN AND HEAD-ON ACCIDENT FREQUENCY

During the study period from January 1952 through December 1958, there were recorded 455 cross-median accidents, 134 of which resulted in a head-on collision. The total open highway experience for the same period resulted in 5,473 collisions of all types including those of negligible property damage. Cross-median accidents constitute 8.3 percent of all accidents and head-on collisions 2.4 percent. However, 29.5 percent of the cross-median accidents resulted in a head-on accident. These statistics would appear to minimize the importance of this accident type; except for the fact that a prior analysis indicates that over 30 percent of the fatal accident experience was a direct result of a cross-median accident and 17 percent involved a head-on impact. While highway officials have a difficult time justifying the expenditure of a very large sum of money to prevent 8.3 percent of the highway accidents, public sentiment appears to be more concerned with the prevention of the smaller number, but considerably higher percentage of fatal accidents.

Appendix A (an expansion of a similar tabulation included in a 1957 supplemental unpublished report to the Median Accident Report, December 1954, submitted to the New Jersey Turnpike Authority by Fred W. Hurd, Yale Bureau of Highway Traffic) is a log of cross-median and head-on accident frequency by 1-mi sections for the entire study area. The occurrence rates per 100 million vehicle-miles are presented as well as other pertinent information, including median cross-section and the average daily traffic for each 1-mi section. This detailed analysis is summarized in Table 7 by areas of similar roadway cross-section and traffic volume range. Very short areas of unusual cross-section have not been summarized in this tabulation due to the obvious statistical deficiencies associated with such analyses.

Several sections worthy of mention, which were discussed in an earlier study (3), are in the area between mile 107.2 and 110.6 detailed in the

Appendix. These consist of three median locations having back-to-back beam-type guardrail. The first section of 0.15 mi and last section of 0.25 mi are placed continuously through the transition from the 6-ft raised steel median to the beginning of the 20-ft standard cross-section. The middle section which has a length of 0.7 mi is positioned in the center of a 6-ft slightly depressed bituminous concrete surfaced median. During the 7-yr study period there is no record of a cross-median accident at either of these locations. The over-all experience with this barrier has been good as compared to the steel-curbed medians on the bridge structures.

A review of Table 7 reveals two significant items related to both median width and traffic volumes. Section C with its 94-ft median and carrying close to the highest average daily traffic volumes has what might be considered almost a perfect cross-median accident record. Section A which carries the lowest volumes of the entire study area has produced the worst cross-median and head-on accident statistics of any of the five sections with one minor and relatively unimportant exception. It may be directly compared to Section B which has an identical median cross-section but traffic volumes varying from 40 percent to more than 80 percent in excess of those carried in Section A. This comparison reveals that the cross-median and head-on rates are 48 percent and 85 percent, respectively, above the rates in Section B. Here again traffic volumes appear to have little relationship to this accident type. Design median width can also be ruled out as they are identical in both areas. The difference in "effective median width," which was earlier discussed, appears to be at least a partial explanation.

Sections D and E may also be directly compared as the roadway cross-sections are identical although the former section carried more than 50 percent higher daily volumes. At these locations, which have almost equal lengths, volume alone would appear to explain the higher cross-median and head-on accident rates. If, however, volume is assumed to be the major factor here, it becomes impossible to explain the fact that both Sections A and B have had considerably poorer experience with both lower volumes and wider medians.

SUMMARY AND CONCLUSIONS

The purpose of this study was to present the cross-median accident experience on the New Jersey Turnpike. This information, in addition to several other pertinent analyses, has been presented for evaluation of the subject.

In recognition of this evaluation it should be understood that the New Jersey Turnpike was constructed in conformance to high design standards. All opposing roadways were separated by reservations which were generally considered, in the highway field at that time, to be wide medians. Experience has proven that serious head-on collisions will occur across these slightly raised deterring-type earth medians having a cross-sectional width of 26 ft or less. On the other hand, the 94-ft deterring-type earth median of either slightly raised or depressed design, has proved adequate to prevent almost all cross-median accidents. Furthermore, medians of this cross-sectional design add valuable maneuver area permitting an errant driver to recover control of a vehicle without damage or injury. Highly raised or deeply depressed designs may be effective in preventing cross-median accidents with a lesser width, but tend to roll, deflect or trap vehicles that may have recovered without incident. A flat slope, of 1 on 6 or less, is equally important to median and drainage slope design beyond the outside shoulders. Further study of similar designs having widths between the range of 26 to 94 ft should prove of value in the determination of optimum width.

The following conclusions appear warranted as a result of the findings of this study:

1. Head-on collisions represent less than 3 percent of the total accident experience on the Turnpike but cannot be neglected from the engineering standpoint as they account for more than 17 percent of the fatal accidents and 22 percent of the fatalities.

2. There is no apparent relationship between total accident rates and roadway volumes for sections of road with comparable design features operating at or below their design capacity.

3. Overtaking and single-vehicle accidents (excluding pedestrian accidents) account for over 85 percent of the total accident experience on the Turnpike and nearly 65 percent of the fatal accidents. The former accident type exhibit a tendency to increase in frequency with increasing volume, whereas the latter diminish in frequency with increase in volume.

4. Pedestrian accidents, although constituting less than 5 percent of the accident experience, are responsible for 17 percent of the fatal accidents. More stringent controls and increased enforcement are deemed essential to prevent hitch-hiking which was responsible for more than one-third of these fatalities. The balance of the fatalities were motorists who were outside of their vehicles and in many cases legally parked on the shoulder due to vehicle disablement. A standardized pattern of rear lighting to specifically identify a stopped vehicle appears necessary, as in many cases a vehicle drove onto the shoulder striking the vehicle and motorist. Increased motorist education pointing out the hazard of leaving the vehicle under these conditions may be helpful.

5. There is no apparent relationship between design median width and total accident rate. Furthermore, there is little, if any, relationship between median width and cross-median accidents for designed widths varying from 6 to 26 ft. Available data at the lower extreme, however, were very limited and are, therefore, believed to be inconclusive. Within this range of median width several other factors including pavement cross-section and character, and driver attitude and attention may be controlling factors exerting a greater influence than physical median width itself.

6. For design median widths of 20 to 26 ft there appears to be little relationship between either cross-median or head-on collisions and roadway volumes experienced during the study period. A need for further study is indicated to develop the relationships suggested in the study between roadway cross-section, traffic volumes and cross-median accidents.

REFERENCES

1. "Median Accident Study: 1958." Traffic Department, California Division of Highways.

2. Ricker, E. R., "Monitoring Traffic Speed and Volume." Traffic Quarterly, Eno Foundation for Highway Traffic Control, Saugatuck, Conn. (Jan. 1959).

3. Hurd, F. W., "Accident Experience with Traversable Medians of Different Widths." HRB Bull. 137, pp. 18-26 (1956).

Appendix

CROSS-MEDIAN AND HEAD-ON ACCIDENTS AND ACCIDENT RATES BY 1-MI SECTIONS
(CROSS-MEDIAN TOTALS INCLUDE HEAD-ON ACCIDENTS) (1952 THROUGH 1958)

Mile	Median Cross-Section (ft)	Number Cross-Median Accid.	Cross-Median Rate (per 100 million veh-mi)	Number Head-On Accid.	Head-On Rate (per 100 million veh-mi)	Fatal Accidents and Fatalities	Average Daily Traffic1/
Inter. 1							
1 - 2	5-16-5	-	-	-	-		13,400
2 - 3		2	6	-	-		
3 - 4		-	-	-	-		
4 - 5		3	9	1	3	(1)	
5 - 6		3	9	-	-		
6 - 7		1	3	-	-		
7 - 8		4	12	1	3		
8 - 9		6	18	2	6		
9 - 10		2	6	1	3		
10 - 11		8	24	3	9		
11 - 12		4	12	1	3		
12 - 13		4	12	-	-		
Inter. 2							
13 - 14	5-16-5	9	26	3	9	(2)	13,900
14 - 15		6	17	3	9	(3)	
15 - 16		2	6	-	-		
16 - 17		1	3	-	-		
17 - 18		-	-	-	-		
18 - 19		3	9	-	-		
19 - 20		3	9	-	-		
20 - 21		2	6	-	-		
21 - 22		2	6	1	3		
22 - 23		4	12	1	3	(1)	
23 - 24		3	9	-	-		
24 - 25		6	17	4	12	(1)	
25 - 26		-	-	-	-		
Inter. 3							
26 - 27	5-16-5	3	8	-	-		14,800
27 - 28		4	11	2	5		
28 - 29		4	11	1	3		
29 - 30		9	24	6	16	(1)	
30 - 31		7	19	3	8	(1)	
31 - 32		4	11	1	3		
32 - 33		7	19	4	11		
33 - 34		11	30	6	16		
Inter. 4							
34 - 35	5-16-5	3	7	1	2	(1)	18,800
35 - 36		10	21	2	4		
36 - 37		2	4	-	-		
37 - 38		6	13	1	2		
38 - 39		2	4	1	2		
39 - 40		3	6	1	2	(3)	
40 - 41		4	9	1	2	(2)	
41 - 42		5	11	1	2	(1)	
42 - 43		6	13	-	-		
43 - 44		5	11	2	4		
Inter. 5							
44 - 45	5-16-5	4	8	1	2		19,100
45 - 46		4	8	-	-		
46 - 47		3	6	-	-		
47 - 48		4	8	3	6		
48 - 49		4	8	1	2		
49 - 50		2	4	1	2		
50 - 51		4	8	2	4	(1) (5)	
Inter. 6							
51 - 52	5-16-5	8	15	2	4		21,800
52 - 53		6	11	-	-		
Inter. 7							
53 - 54		3	5	-	-		
54 - 55		6	11	-	-		
55 - 56		1	2	-	-		
56 - 57		5	9	3	5	(2)	
57 - 58		1	2	1	2		
58 - 59		1	2	-	-		
59 - 60		4	7	1	2		
60 - 61		4	7	-	-		
61 - 62		3	5	1	2	(1)	
62 - 63		3	5	1	2		
63 - 64		6	11	2	4	(1)	
64 - 65		4	7	1	2		
65 - 66		9	16	2	4		
66 - 67		3	5	1	2	(1)	
67 - 68		6	11	3	5	(2)	

CROSS-MEDIAN AND HEAD-ON ACCIDENTS AND ACCIDENT RATES BY 1-MI SECTIONS (CROSS-MEDIAN TOTALS INCLUDE HEAD-ON ACCIDENTS) (1952 THROUGH 1958) (Continued)

Mile	Median Cross-Section (ft)	Number Cross-Median Accid.	Cross-Median Rate (per 100 million veh-mi)	Number Head-On Accid.	Head-On Rate (per 100 million veh-mi)	Fatal Accidents and Fatalities	Average Daily Traffic[1]
Inter. 8							
68 - 69	5-16-5	10	18	2	4		22,500
69 - 70		5	9	1	2		
70 - 71		7	12	1	2		
71 - 72		2	4	-	-		
72 - 73		3	5	1	2		
73 - 74		2	3	-	-		
74 - 75		9	16	4	7		
75 - 76		5	9	2	4	(2)	
76 - 77		3	5	1	2	(2)	
77 - 78		2	3	1	2		
78 - 79		4	7	-	-		
79 - 80		4	7	-	-		
80 - 81		7	12	3	5		
81 - 82		3	5	1	2	(1)	
82 - 83		5	9	2	4		
Inter. 9							
83 - 84	5-16-5	4	6	2	3		27,400
84 - 85		3	4	1	2	(1)	
85 - 86		2	3	1	2		
86 - 87		1	2	-	-		
87 - 88		3	4	2	3		
88 - 89		1	2	-	-		
89 - 90		2	3	1	2	(1) (2)	
Inter. 10							
90 - 91	5-84-5	1	2	-	-		23,100
Inter. 11							
91 - 92	5-84-5	-	-	-	-		34,100
92 - 93		1	2	1	2		
93 - 94		-	-	-	-		
94 - 95		-	-	-	-		
95 - 96		1	2	-	-		
Inter. 12							
96 - 97	5-84-5	-	-	-	-		36,900
97 - 98		-	-	-	-		
98.5	5-10-5						
98 - 99		3	3	1	1		
99.2	Dual-dual						
99 - 100		4	4	1	1		
100 - 101	5-8-5	7	8	2	2	(3)	36,000
101.4							
101 - 102	5-10-5	6	7	2	2		
102-103		7	8	3	3		
103 - 104		7	8	1	1		
104 - 105		7	8	2	2		
Inter. 14							
105 - 106	5-10-5	5	5	-	-		37,600
106 - 107		3	3	3	3		
Inter. 15							
107 - 107.2	5-10-5	5	24	1	5		40,100
107.2 - 107.35	Guardrail	-	-	-	-		
107.35-108.65	6-ft steel	10	7	5	4		
108.65-109.25	Guardrail	-	-	-	-		
109.25-110.35	6-ft steel	6	5	1	1	(1)	
110.35-110.6	Guardrail	-	-	-	-		
110.6 - 111	5-10-5	2	5	-	-		
111 - 112		3	3	1	1		
Inter. 16							
112 - 113	5-10-5	1	1	1	1		23,600
Inter. 17							
113 - 114	5-10-5	4	7	-	-		24,400
114 - 115		2	3	-	-		
115 - 116		3	5	-	-		
116 - 117		8	13	2	3	(2)	
117 - 117.6		1	2	1	2		
Inter. 18							

[1] Average daily traffic volume shown is the average for the 7 years (1952 through 1958) and may be converted directly to vehicle-miles of exposure for any 1-mi section using an expansion factor of 2557.