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Bulletin 137

Median Design: Effect on Traffic Behavior

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Median Design: Effect on Traffic Behavior

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Contents

Effect of Median Dividers on Driver Behavior

C. E. BILLION, Principal Civil Engineer,
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There is quite a difference of opinion among highway engineers regarding the relative merits and effectiveness of the different types and widths of median dividers. Technical questions have been raised as to whether or not the wall type median is desirable and as to the proper width of each of the two lanes for one direction of travel on a 4-lane divided highway. A study was conducted in New York in an attempt to obtain factual information on the subject.

Vehicle speeds and placements were recorded in 1950 during daylight hours at 18 sites on the Long Island Parkway System, a 4-lane divided parkway, carrying volumes as high as 2,800 vehicles per hour in one direction of travel. Six types of median traffic dividers were studied and the results were the basis of the preliminary report. (1) Additional data were recorded in 1951 at four of the original sites and at four other sites on rural 4-lane divided highways near Albany. The 1951 study included both day and night observations.

●THE preliminary report was based on driver behavior studies, during July 1950, on the Long Island Parkway System. This system, serving the millions of motorists traveling to the Long Island beaches, carries heavy traffic to and from New York City not only during the morning and evening rush-hour periods but all during the day, especially in the summer. All the parkways on the system are limited access with commercial vehicles prohibited. Figure 1 shows the general locations of the sites studied.

This system offered an unusually fertile field in the variety of highway characteristics and types of medians. Included in the eighteen sites at the ten locations selected for study, were the six different types of median dividers shown in Figure 2. The photographs in Figure 2 show, in the vicinity of the study sites, the character of the roadways and countryside through which the roadways pass. Some type of lane line, either painted or a construction joint or both, separated the two lanes of traffic at all the study sites except three which had asphaltic surfaces without any lane lines.

Equipment furnished and operated by the United States Bureau of Public Roads (2) was used to record in code on adding machine tapes, the time to the ten-thousandths of an hour, the speed, and the placement of all cars in the two lanes. At some of the sites, only placement data were recorded using a placement detector in combination with a 20-pen recorder. Data for approximately 48,000 cars observed, during daylight hours, were used as a basis for the report.

The field data were arranged in 6-minute time periods and placement-volume graphs were plotted, for both lanes of traffic, for each of these 6-minute periods. Figure 3 shows a typical pattern of the plotted data recorded at one study site. Similar graphs were prepared for each study site, and a linear relation was found to exist between the average lateral position of cars and hourly volume. Referring to Figure 3, it is noted that the two lines are not parallel indicating that as the volume increases cars in the right lane, on an average, travel closer to the curb and those in the left lane travel closer to the median.

The critical distances studied were: 1. the average distance from the edge of the median to the near side of the cars in the left lane, indicated by the symbol "X"; 2. the average lateral distance between the bodies of cars, indicated by the symbol "Y"; and 3. the average distance from the outside edge of the cars to the curb, indicated by the symbol "Z." The average overall width of the cars observed was estimated to be 6 feet 3 inches. These dimensions are illustrated at the top of Figure 3.

The average position of cars at a volume of 1,500 vehicles per hour in one direction of travel was selected for analysis in the preliminary report because comparable data were available for all sites only at this traffic volume. The average values of the dimensions "X," "Y," and "Z" were then determined for each study site and grouped by median type.

TABLE 1
NUMBER OF VEHICLES STUDIED

Type of Median Traffic Divider	Location	Number of Vehicles Observed				Total Vehicles Observed
		Day		Night		
		Left Lane	Right Lane	Left Lane	Right Lane	
	LONG ISLAND PARKWAY SYSTEM SITES (all passenger car traffic)					
12-inch Narrow Concrete Median with Pipe	Southern State	2108	2001	651	637	5397
12-inch Narrow Concrete Median	Southern State	4522	4073			8595
30-inch Concrete Parabolic Median	Grand Central	6813	4833			11646
9-ft. Grass Median	Southern State	5198	5396	1036	1282	12912
6-inch Paint Line Divider Median (No physical separator)	Southern State	2399	3651			6050
42-ft. Grass Median	Cross Island	3439	2678			6117
	ALBANY AREA SITES (Mixed traffic)					
4-ft. Reflecting Concrete Median	Routes U.S. 9 and N.Y.S. 7	657	2034	144	379	3214 1/
Totals		25136	24666	1831	2298	53931

Note 1/ - 8% of the vehicles were trucks

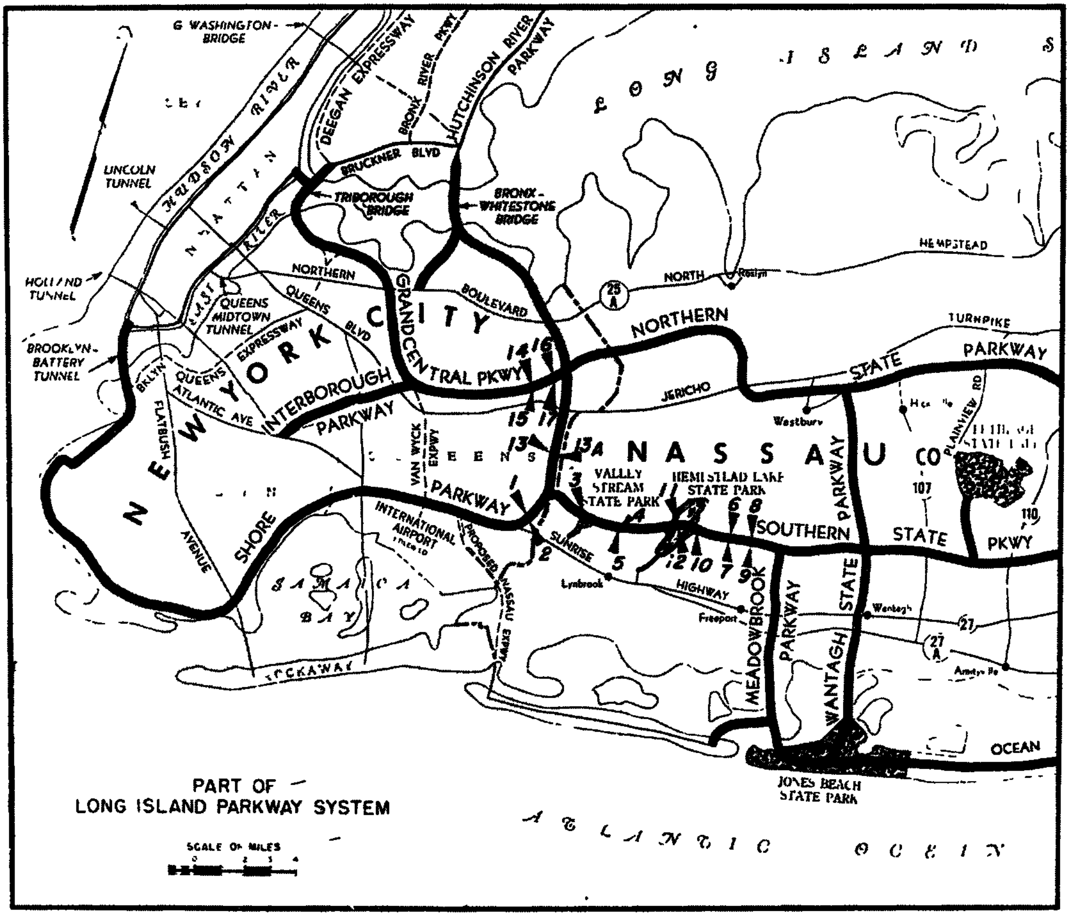


Figure 1. Location of Long Island area sites for study of median traffic dividers.

TABLE 2

COMPARISON BETWEEN DAY AND NIGHT OPERATIONS (1951 DATA ONLY), AVERAGE SPEEDS

Hourly Volume Both Lanes	Type of Median Divider											
	Concrete Wall With Pipe				9-Ft. Grass				4-Ft. Reflecting Concrete			
	Left Lane		Right Lane		Left Lane		Right Lane		Left Lane		Right Lane	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
	Mph	Mph	Mph	Mph	Mph	Mph	Mph	Mph	Mph	Mph	Mph	Mph
Below 500	- -	- -	- -	- -	- -	- -	- -	- -	51.8	51.6	46.1	44.7
500-999	44.7	46.1	39.0	40.3	- -	- -	- -	- -	- -	- -	- -	- -
1000-1499	44.8	44.4	38.3	39.1	46.8	41.8	40.8	41.2	- -	- -	- -	- -
1500-1999	- -	- -	- -	- -	43.4	46.7	41.1	38.8	- -	- -	- -	- -

TABLE 3

COMPARISON BETWEEN DAY AND NIGHT OPERATIONS (1951 DATA ONLY), LATERAL POSITIONS, DISTANCES FROM EDGE OF MEDIAN TO NEAR SIDE OF VEHICLE IN THE LEFT LANE, (X)

Hourly Volume Both Lanes	Type of Median Divider					
	Concrete Wall With Pipe		9-Ft. Grass		4-Ft. Reflecting Concrete	
	Day	Night	Day	Night	Day	Night
	Feet	Feet	Feet	Feet	Feet	Feet
Below 500	- -	- -	- -	- -	4.53	4.38
500-999	2.88	2.98	- -	- -	- -	- -
1000-1499	2.83	2.85	4.08	4.16	- -	- -
1500-1999	- -	- -	4.13	4.63	- -	- -

The preliminary report lists the following indications:

"1. Drivers ride closer to the edge of the concrete parabolic wall-type divider than to any of the other types of medians tested.

2. The 6-inch paint line divider and the narrow wall-type divider have about the same effect on the positioning of cars in the left lane.

3. Lane lines between two parallel streams of traffic cause motorists in the left lane to drive closer to the center median than where no lane lines are provided.

4. Clearance distance between cars in parallel streams of traffic grow wider as the roadway width increases and as the volume increases.

5. On relatively sharp curves the clearance distance between cars in parallel streams of traffic becomes less than on tangent sections.

6. The distance from the edge of the pavement to cars in the right lane is the same or about the same for equal pavement widths, regardless of the type of center median. On tangent sections there is no measurable difference between the positions of cars in the right lane for roadways with or without lane lines."

EXTENSION OF STUDY DATA

Combining the data from the 1950 and 1951 studies, provided information for approxi-

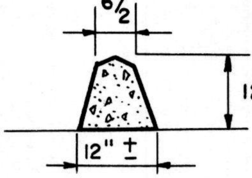
TABLE 4

COMPARISON BETWEEN DAY AND NIGHT OPERATIONS (1951 DATA ONLY), LATERAL CLEARANCES, DISTANCES BETWEEN BODIES OF VEHICLES, (Y)

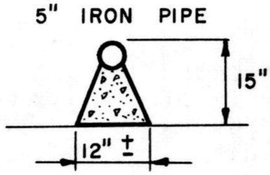
Hourly Volume Both Lanes	Type of Median Divider					
	Concrete Wall With Pipe		9-Ft. Grass		4-Ft. Reflecting Concrete	
	Day	Night	Day	Night	Day	Night
	Feet	Feet	Feet	Feet	Feet	Feet
Below 500	- -	- -	- -	- -	3.74	4.27
500-999	4.10	3.41	- -	- -	- -	- -
1000-1499	3.95	3.85	4.65	4.57	- -	- -
1500-1999	- -	- -	4.65	4.20	- -	- -

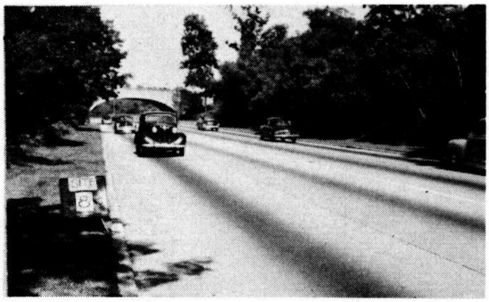
CROSS SECTION OF MEDIAN

SITE NO.2 — SHORE PARKWAY — NARROW CONCRETE MEDIAN

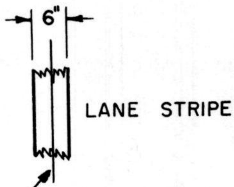


SITE NO. 5 — SOUTHERN STATE PARKWAY NARROW CONCRETE MEDIAN WITH PIPE





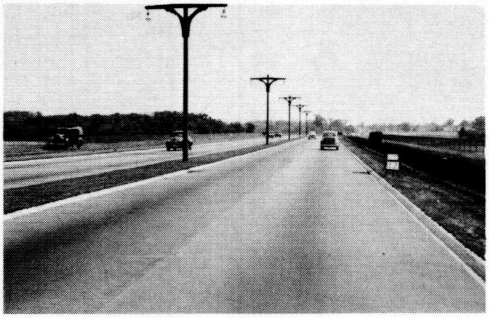
SITE NO.8 — SOUTHERN STATE PARKWAY — 6-INCH WHITE SOLID PAINT LANE STRIPE

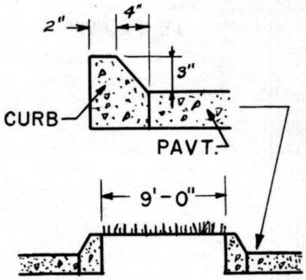


— PLAN —

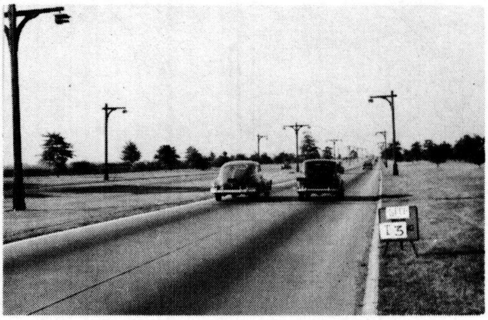
Figure 2 (continued). Typical study sites and types of medians.

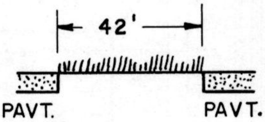
CROSS- SECTION OF MEDIAN



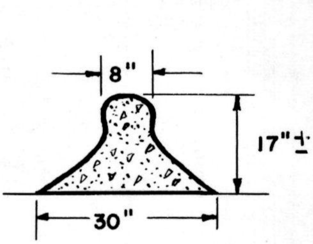


SITE NO. 12 — SOUTHERN STATE PARKWAY—
9 FT. WIDE GRASS MEDIAN WITH 3-INCH
HIGH CURB.





SITE NO. 13 — CROSS ISLAND PARKWAY
42 FT. WIDE GRASS MEDIAN — NO CURB



SITE NO. 17 — GRAND CENTRAL PARKWAY—
CONCRETE PARABOLIC MEDIAN.

Figure 2. Typical study sites and types of medians.

TABLE 5

AVERAGE SPEEDS OF VEHICLES BY TYPE MEDIAN DIVIDER DURING DIFFERENT TRAFFIC VOLUMES

Traffic Volume Vehicles Per Hour Both Lanes	Type of Median Divider													
	30-Inch Concrete Parabolic		12-Inch Concrete Wall		42-Foot Grass		6-Inch Paint Line		12-Inch Concrete Wall With Pipe		9-Foot Grass		4-Foot Reflecting Concrete	
	Left[1]	Right[2]	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
	LONG ISLAND PARKWAY SYSTEM - (Passenger Cars Only) - NEW YORK CITY						NASSAU COUNTY						ALBANY AREA SITES (Mixed Traffic)	
	Mph	Mph	Mph	Mph	Mph	Mph	Mph	Mph	Mph	Mph	Mph	Mph	Mph	Mph
500 and Under	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	53 0	45.7
800 - - - - - -	- -	- -	44.7	38.0	- -	- -	46.3	40.4	45.6	40.3	45.3	39.7	- -	- -
1200 - - - -	41.6	35.6	44.1	37.2	52.0	43.2	44.5	39.3	44.8	38.4	45.0	38.9	- -	- -
(1500) - - -	(43 2)	(36 3)	(44.0)	(36.8)	(52.3)	(45.1)	(43.1)	(39.7)	(44.0)	(36 9)	(46.5)	(39.5)	- -	- -
1600 - - - -	43 3	36.0	43.6	36.3	52.5	46.3	43.0	39.7	- -	- -	49 4	39.6	- -	- -
2000 - - - -	41.1	35.1	41 5	34.6	47.8	42 2	- -	- -	- -	- -	40.5	36.7	- -	- -
2400 - - - -	32.3	28.8	32 1	28.1	46.9	40.0	- -	- -	- -	- -	31.0	30.5	- -	- -

Note 1/ Left lane in direction of traffic.
Note 2/ Right lane in direction of traffic.

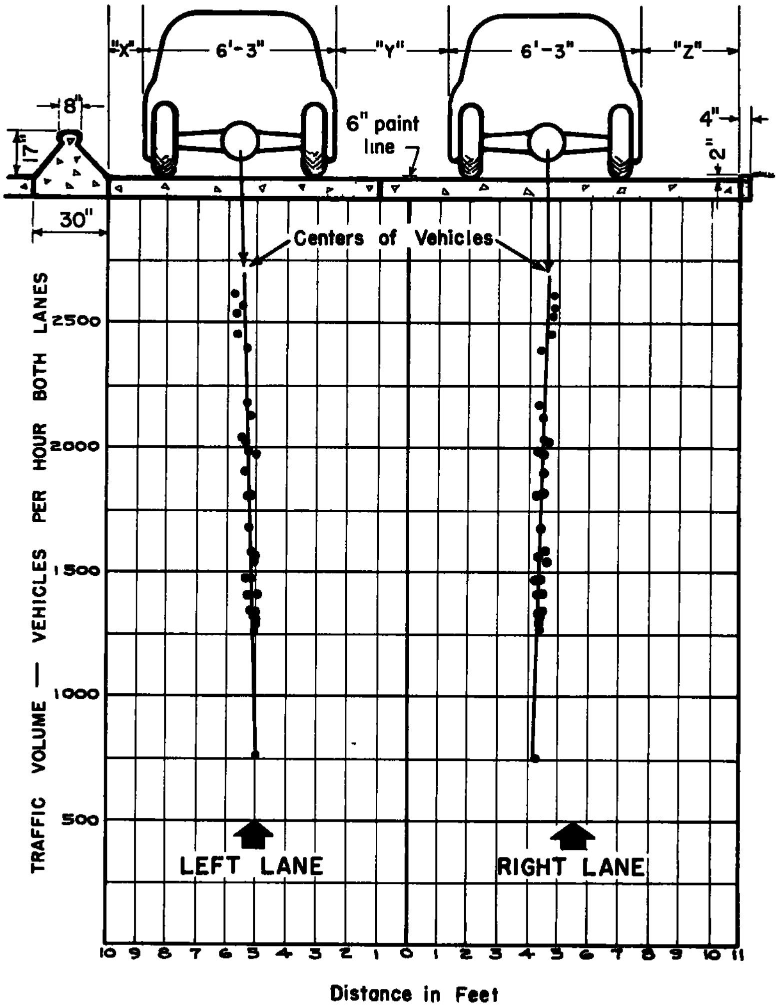


Figure 3. Typical plotting of field data.

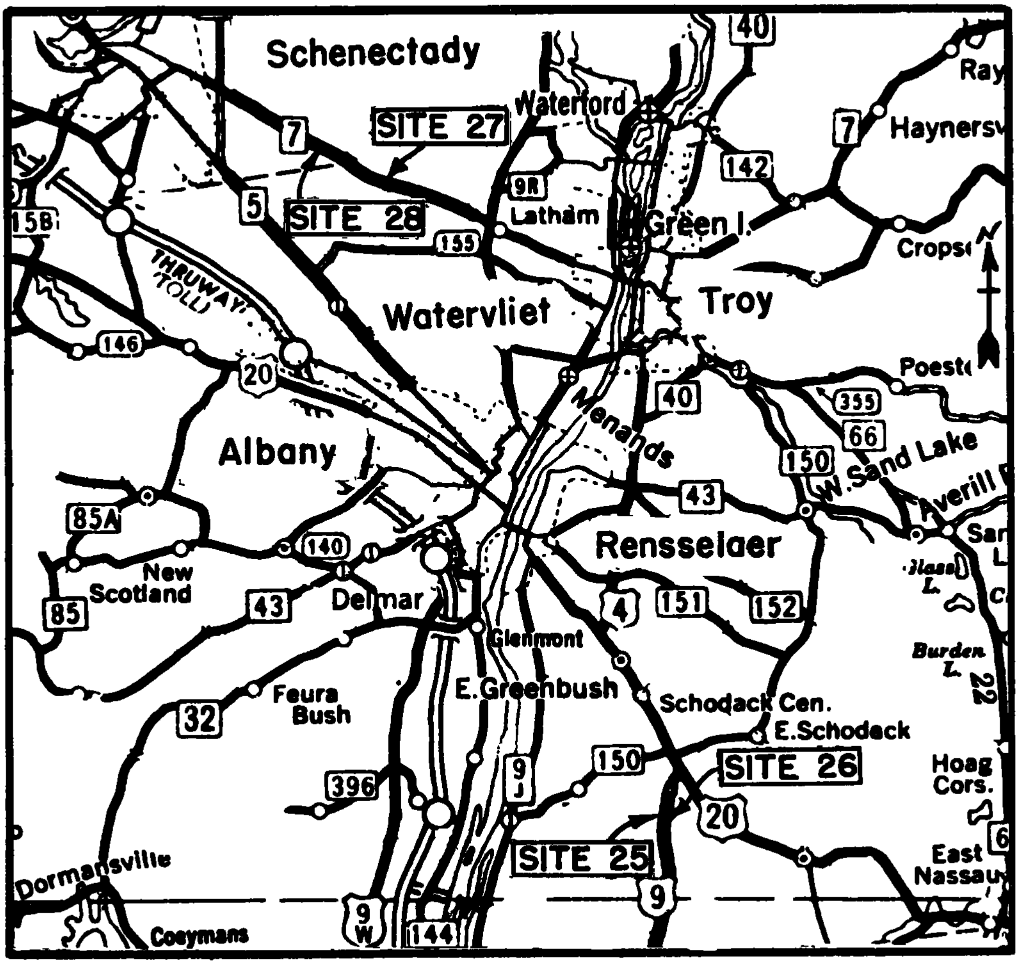


Figure 4. Location of Albany area sites for study of median traffic dividers.

TABLE 6

OBSERVED LATERAL PLACEMENT DIMENSIONS, AVERAGE "X", "Y", "Z", VALUES, FOR VARIOUS TRAFFIC VOLUMES BY TYPE MEDIAN DIVIDER

Type of Median	Vehicles Per Hour in One Direction									Lane Width	
	"X"			"Y"			"Z"				
	1200	2000	2800	1200	2000	2800	1200	2000	2800	Left	Right
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
30-Inch Concrete Parabolic	1.6	1.4	1.2	3.2	3.6	4.0	3.7	3.5	3.3	10	11
12-Inch Concrete Wall	2.0	1.8	1.6	3.4	3.8	4.2	3.6	3.4	3.2	10.5	11
42-Feet Grass	2.8	2.5	2.2	4.3	4.6	4.9	3.4	3.4	3.4	12	11
12-Inch Concrete Wall With Pipe	2.9	2.8	2.8	3.7	3.8	3.8	2.9	2.9	2.9	11	11
4-Feet Reflecting Concrete	4.0	- -	- -	4.5	- -	- -	4.0	- -	- -	13	12
9-Feet Grass	4.0	3.7	3.4	4.6	5.0	5.5	3.9	3.8	3.6	13	12
6-Inch Paint Line	1.9	2.1	2.3	3.5	3.5	3.5	3.1	2.9	2.7	10	11

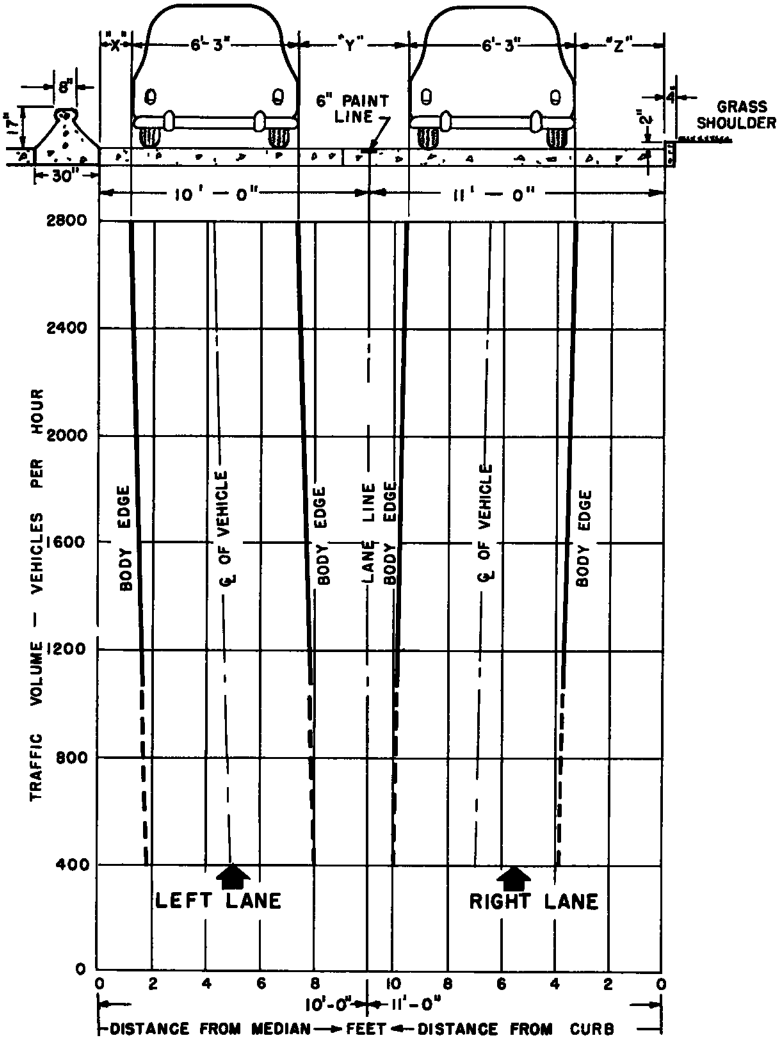


Figure 5. Average position of passenger cars, traveling in one direction on the four-lane Grand Central Parkway divided with a 30-inch wide concrete parabolic median, during different traffic volumes.

mately 54,000 vehicles at 22 sites for seven types of median dividers (Table 1) and permitted an analysis of the speed-placement data over a range in traffic volumes from 400 to 2,800 vehicles per hour in one direction of travel. The locations of the four sites studied in the Albany area are shown in Figure 4.

The analysis procedure for the extended study was similar to the procedure used in the 1950 study and is described in the first part of the paper. The linear relation between lateral positions of vehicles and hourly volumes was found to hold true for all the sites studied and for day and night observations.

Comparison Between Day and Night Operations

Comparable data for day and night operations were recorded only during 1951 and then only at four sites having three different kinds of median dividers. Only these data were used, therefore, to compare the differences between day and night driver behavior.

Table 2 shows the comparison of speeds. It will be noted that in nearly all cases the

TABLE 7

CALCULATED LATERAL PLACEMENT DIMENSIONS, AVERAGE "X","Y","Z", VALUES, FOR VARIOUS TRAFFIC VOLUMES BY TYPE MEDIAN DIVIDER AND ASSUMED 11-FT. LEFT AND RIGHT LANES

Type Of Median	Vehicles Per Hour In One Direction									Lane Width (Assumed)	
	"X"			"Y"			"Z"			Left	Right
	1200	2000	2800	1200	2000	2800	1200	2000	2800		
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
30-Inch Concrete Parabolic	2.0	1.8	1.5	3.8	4.2	4.7	3.7	3.5	3.3	11	11
12-Inch Concrete Wall	2.2	2.0	1.8	3.7	4.1	4.5	3.6	3.4	3.2	11	11
42-Feet Grass	2.3	2.1	1.8	3.8	4.0	4.3	3.4	3.4	3.4	11	11
12-Inch Concrete Wall With Pipe	2.9	2.8	2.8	3.7	3.8	3.8	2.9	2.9	2.9	11	11
4-Feet Reflecting Concrete	2.8	- -	- -	3.4	- -	- -	3.3	- -	- -	11	11
9-Feet Grass	2.8	2.6	2.4	3.5	3.8	4.1	3.2	3.1	3.0	11	11
6-Inch Paint Line	2.4	2.7	2.9	3.9	3.9	3.9	3.2	2.9	2.7	11	11

average speeds at night were about 1 mile per hour different from the speeds during daytime at comparable traffic volumes. Furthermore, the speeds were sometimes higher at night than during the day and at other times they were lower at night than during the day. On the average, therefore, there does not appear to be a very significan difference between day and night speeds.

Similarly, a comparison of the average lateral positions of vehicles during the day with the values recorded during the night (Table 3) shows that distances from the edge of the median to the near side of the car were substantially the same for day and night operations. Table 4 also shows that there was an insignificant difference between the clearances of cars for day and night operations. Because of these findings, the day and night observations have been combined in the ensuing analysis.

Effect of Median Divider on Speeds

As mentioned earlier there was a range in volume from about 400 to 2,800 vehicles

TABLE 8

COMPARISON OF 1950 WITH 1952 ACCIDENT DATA FOR SECTIONS OF THE LONG ISLAND PARKWAY SYSTEM WHERE THE MEDIAN TYPE REMAINED UNCHANGED

Year	Section	Type Median	Miles	Annual Traffic Millions	MVM	Total Accidents Number	Total Accidents Rate Per MVM	Injury Number	Injury Rate Per MVM	Property Damage Number	Property Damage Rate Per MVM
1950	Glencove Road to Wantagh Parkway 1/	10'-60' Grass	3.1	7.8	24.2	35	1.44	11	0.45	24	0.99
	City Line to Hempstead Lake 2/	Pipe	4.5	15.0	67.5	164	2.43	39	0.58	124	1.84
	Hempstead Lake 3/	9'-Grass	1.5	13.0	19.5	39	2.00	13	0.67	26	1.33
	Totals				111.2	238	2.14	63	0.57	174	1.56
1952	Glencove Road to Wantagh Parkway	10'-60' Grass	3.1	11.9	36.9	64	1.74	19	0.51	44	1.20
	City Line to Hempstead Lake	Pipe	4.5	21.9	98.6	204	2.07	52	0.53	151	1.53
	Hempstead Lake	9'-Grass	1.5	19.0	28.5	41	1.44	13	0.46	28	0.98
	Totals				164.0	309	1.88	84	0.51	223	1.36
Percentage Changes 1952 vs. 1950 on unchanged Sections					+47.5%	+30%	-12.1%	+33%	-10.5%	+28.1%	-12.8%

Note 1/ - Portion of Northern State Parkway. No fatalities in 1950 and one in 1952.
Note 2/ - Portion of Southern State Parkway. One fatality in 1950 and one in 1952.
Note 3/ - Portion of Southern State Parkway. No fatalities in 1950 and 1952.

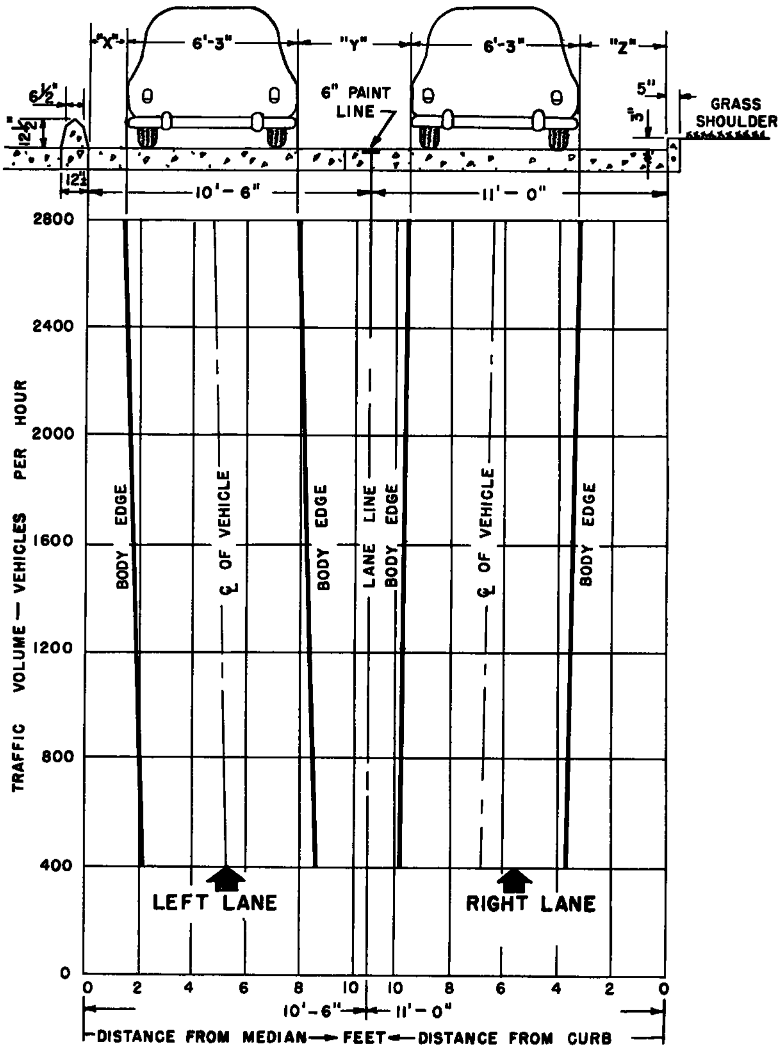


Figure 6. Average position of passenger cars, traveling in one direction on the four-lane Southern State Parkway divided with a 12-inch wide concrete wall median, during different traffic volumes.

per hour at the sites selected for study. The hourly volume being one of the most important influential factors on operating speeds, a study of the effect on speeds of any highway design feature must of necessity take into account the hourly volume. Table 5 has been arranged, therefore, to permit a comparison of speeds between the several types of median dividers at an hourly volume common to all sections of 1, 500 vehicles in one direction of travel. With the exception of the section with the 42-foot grass median divider, the speeds at this volume were about the same for all the other types of median dividers, being about 45 miles per hour for cars traveling in the left lane and about 37 miles per hour for cars traveling in the right lane.

The somewhat higher speeds on the section with the 42-foot grass divider cannot readily be explained. Certainly this wide grass median could not alone be responsible. One other possible explanation could be that this section of highway was on a straight tangent with un-restricted sight distances while the other sections were on alignment with curves. In any event, it is not feasible to state that vehicle speeds are affected by one type of divider any differently than by any other of the median dividers studied. This result is not surprising, because a number of other studies have shown that speeds

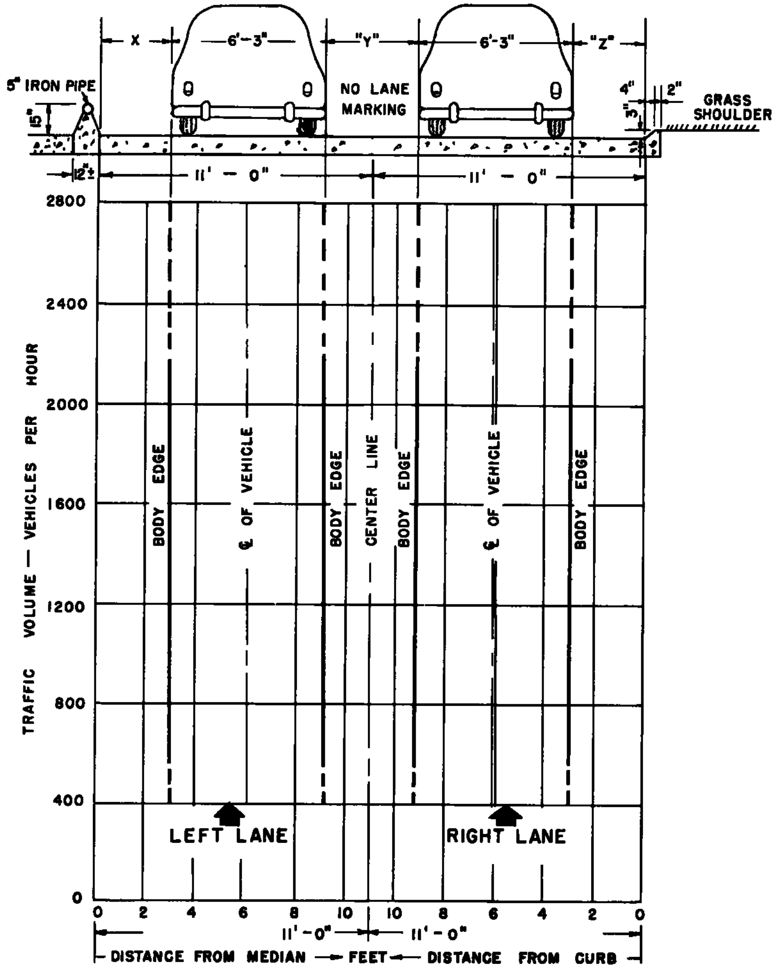


Figure 7. Average position of passenger cars, traveling in one direction on the four-lane Southern State Parkway divided with a 12-inch wide concrete wall with pipe median, during different traffic volumes.

are not reduced as one would expect by unusual conditions.

The Albany area sites were characteristic of free-access rural four-lane highways, the directions of travel being divided by a 4-foot reflecting concrete median with a limited number of breakthroughs for left turns, and was posted for a 50-mph. speed limit. For volumes below 500 vehicles-per-hour in one direction, vehicles traveled at an average speed of about 53 miles per hour in the left lane and about 46 miles per hour in the right lane.

Effect of Median Divider on Lateral Positions of Vehicles

In order to compare the effects of the seven types of medians on the lateral positions of vehicles, at the same hourly volume, it was necessary to determine graphically the average lateral placements for each type of median against the recorded volumes. For the Long Island sites, the desired data were thus obtained for each 400 vehicle-per-hour increment within the range of the observed volume. Figures 5 to 10 show these data and the critical distances studied, for each of the six types of medians, as defined by the symbols "X," "Y," and "Z." Figure 11 shows similar data for the median studied at the Albany area sites, in 200 vehicle-per-hour increments of volume.

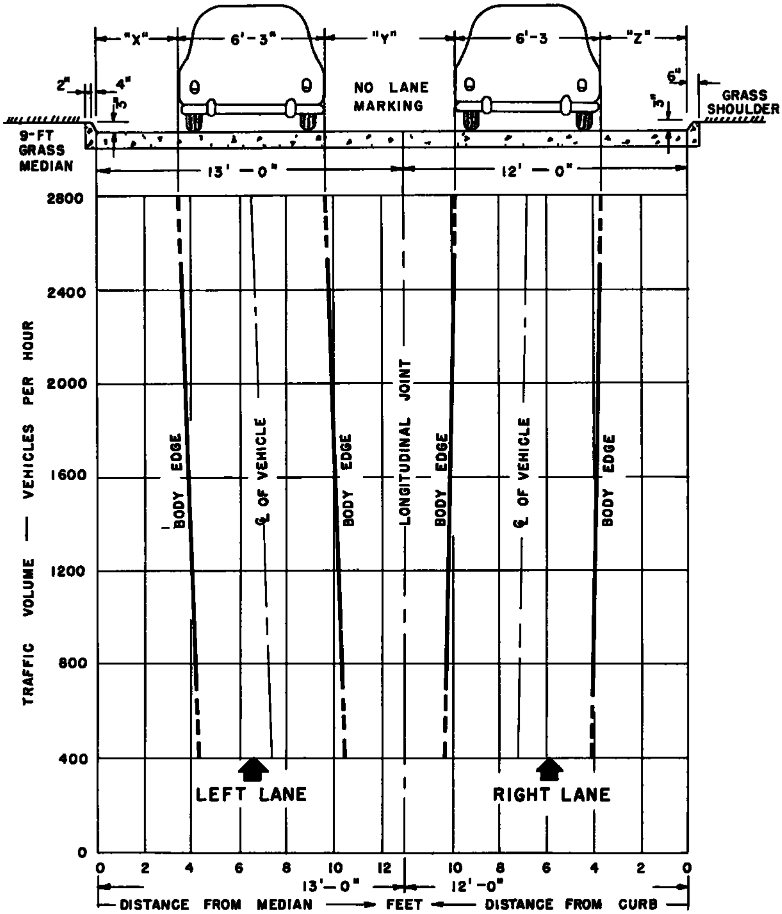


Figure 8. Average position of passenger cars, traveling in one direction on the four-lane Southern State Parkway divided with a 9-ft. wide grass median, during different traffic volumes.

Examination of Figures 5 to 11 shows the variety of highway characteristice mentioned earlier. Represented are pavement widths of 21, 21½, 22, 23 and 25 feet with left lanes of 10, 10½, 11, 12 and 13 feet wide respectively. The right lanes were 11 feet wide for five of the median types studied and 12 feet wide for two of the median types studied. (Table 6).

Average "X," "Y," and "Z" values from Figures 5 to 11 have been arranged in Table 6 by type median for traffic volumes of 1,200, 2,000, and 2,800 vehicles-per-hour in one direction of travel. It is to be noted that the types of median have been arranged in order of the average distance from the edge of the median to the near side of the vehicles in the left lane, "X" dimension. Disregarding the width of left lane, these data indicate that at all volumes, vehicles traveled closer to the concrete parabolic type of median than to the other types of median studied. The effect of the gradual curved slope of the parabolic median apparently influenced the drivers' choice of lateral position.

The average distances from the outside edge of the vehicles to the curb, "Z" dimensions, show little variation, by median type, for the same width of right lane, at any of the volumes. Apparently the type of median had little if any effect on the positioning of vehicles in the right lane. With a constant pavement width and the little variations in the average "Z" distances for the various types of median, the choice of a median type, as it affects the average "X" distance becomes important in providing desirable clear-

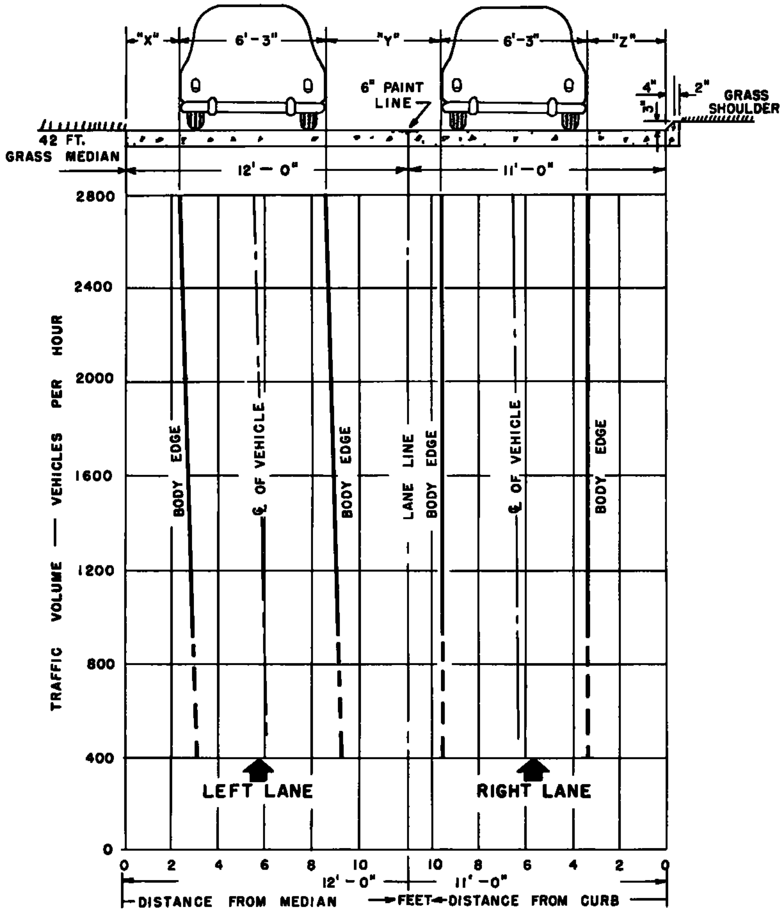


Figure 9. Average position of passenger cars, traveling in one direction on the four-lane Cross Island Parkway divided with a 42-ft. wide grass median, during different traffic volumes.

TABLE 9

COMPARISON OF 1950 WITH 1952 ACCIDENT DATA FOR SECTIONS OF THE LONG ISLAND PARKWAY SYSTEM WHERE THE PAINT LINE WAS REPLACED BY A BARRIER TYPE MEDIAN DIVIDER

Year	Section	Type Median	Miles	Annual Traffic Millions	MVM	Total Accidents Number	Total Accidents Rate Per MVM	Injury Number	Injury Rate Per MVM	Property Damage Number	Property Damage Rate Per MVM
1950	City Line to Glencove Road 1/	Paint Line	6.5	12.9	83.8	132	1.58	49	0.59	82	0.98
	Hempstead Lake to Broadway 2/	Paint Line	8.2	10.0	82.0	151	1.84	36	0.44	115	1.40
	Totals				165.8	283	1.71	85	0.51	197	1.19
1952	City Line to Glencove Road	Concrete Parabolic	6.5	19.8	128.7	206	1.61	54	0.42	151	1.18
	Hempstead Lake to Broadway	Pipe	8.2	14.5	118.9	120	1.01	34	0.29	85	0.71
	Totals				247.6	326	1.32	88	0.36	236	0.95
Percentage Changes 1952 vs. 1950 in Changed Sections					+49.2%	+15.2%	-22.8%	+3.5%	-29.5%	+19.8%	-20.2%
Percentage Reduction in Rates Due to Median Dividers 1952 vs 1950							10.7%		19.0%		7.4%

Note 1/ - Portion of Northern State Parkway. One fatality in 1950 and one in 1952.
Note 2/ - Portion of Southern State Parkway. No fatalities in 1950 and one in 1952.

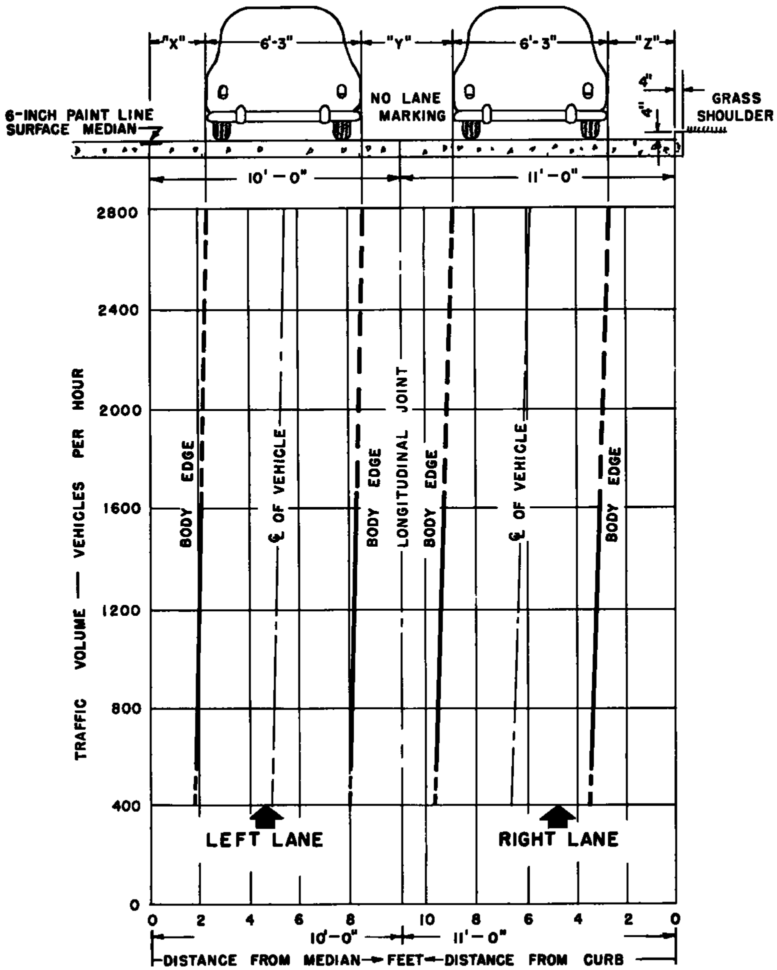


Figure 10. Average position of passenger cars, traveling in one direction on the four-lane Southern State Parkway divided with a 6-inch wide paint line surface median, during different traffic volumes.

ances between vehicles.

Except for the 6-inch paint line and the 12-inch concrete wall with pipe medians, the average clearances between vehicles by type median shown in Table 6, "Y" dimensions, increased with volume. As would be expected, the wider pavements provided the greater clearance between vehicles at all volumes. In the case of the 6-inch paint line divider, the average clearance distance between vehicles remained about the same at all volumes. This was due primarily to the positioning of vehicles in the left lane away from the paint line as the volume increased and apparently causing vehicles in the right lane to position closer to the curb, by about the same amounts, thus resulting in the same clearances between vehicles at all volumes.

The foregoing analysis is based on lateral placements of vehicles by median type for the various widths of lanes and pavement.[1]

[1] It is to be noted that a longitudinal joint exists about one foot to the left of the lane line for both the 30-inch concrete parabolic median and the 12-inch concrete wall median, Figures 5 to 6. In both cases, the lane widths used in the analyses were measured from the paint line.

In order to examine only the effect of median divider on the lateral positions of vehicles, the average "X," "Y," and "Z" values for the various types of medians, have been calculated for assumed 11-foot left and right lanes. This procedure tends to eliminate the effect of lane widths on lateral placement of vehicles. For this purpose, it would appear logical to assume that the "X," or "Z" placement values for two different widths of lanes are directly proportioned to the unoccupied widths of lane.

These calculated lateral placement dimensions, average "X," "Y," and "Z" values, have been arranged in Table 7 by type median for traffic volumes of 1,200, 2,000, and 2,800 vehicles-per-hour in one direction. Again it is found that at all traffic volumes: 1. Vehicles travel closer to the parabolic type of median than to the other median types; 2. There is little variation in the lateral placement from the curb, "Z" dimension by median type; and 3. The clearance between vehicles remains about the same for the 6-inch paint line and 12-inch concrete wall with pipe median. The parabolic median provides the greatest clearance distances between vehicles at all volumes.

Effect of Barrier Type Median Divider on Accident Rates

Two of the heaviest traveled sections of the Parkway System under the jurisdiction of the Long Island State Park Commission are the Northern State Parkway, from the New York City limits to the Wantagh Parkway and the Southern State Parkway from the city limits to the Broadway interchange, all in Nassau County (Figure 1). These two sections of the Parkway contained several sustained lengths with the various types of median dividers observed in the 1950 and 1951 placement studies and there were in-

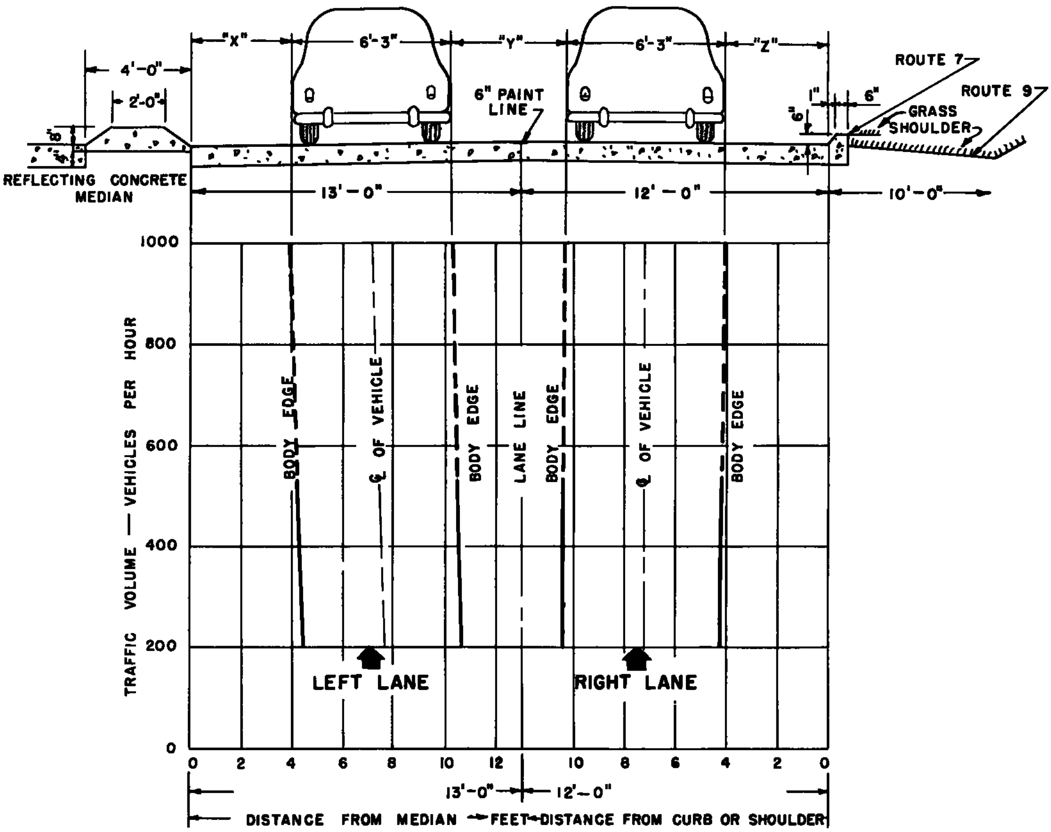


Figure 11. Average position of vehicles traveling in one direction on the four-lane portions of State Route 7 and US 9, near Albany, divided with a 4-ft. wide reflecting concrete median, during different traffic volumes.

stalled within their limits, in the 1951 construction season, the concrete parabolic wall and the narrow concrete wall with pipe types of median dividers replacing paint line dividers replacing paint line dividers which presented no physical separation.

Accident records for 1950 and 1952 for 23.8 miles of the Northern and Southern State Parkways were examined. In 1950, opposing lanes of traffic on 14.7 miles were separated by a 6-inch paint line on the pavement. During 1951, the paint line was replaced with the concrete parabolic and pipe types of median dividers. The balance of the mileage, 9.1 miles, represented pavements with the pipe type and 9-foot to 60-foot wide grass median dividers which remained unchanged from 1950 thru 1952.

Table 8 shows a comparison of traffic and accident data for 1950 and for 1952 on the sections where the median type remained unchanged during this period. Table 9 shows similar data on the sections where the paint line divider was replaced by the concrete parabolic or pipe type median divider.

For the "unchanged" sections, (Table 8) the rates per MVM for total, injury and property damage accidents decreased about 10 to 13 percent from 1950 to 1952.

For the "changed" sections (Table 9) the rates per MVM decreased 23 percent for total accidents, 30 percent for injury accidents and 20 percent for property damage accidents from 1950 to 1952.

The rates for the "changed" sections show a further decrease over the "normal trend" indicated for the "unchanged" sections. The additional reductions in the accident rates appear to be due to the barrier type median dividers which were installed. The additional reductions amounted to 11 percent for the total accident rate, 19 percent for the injury accident rate and 7 percent for the property damage accident rate.

The statewide fatality rate for the period from 1950 thru 1952 was about 6 deaths per 100,000,000 vehicle miles while for the Long Island Parkway System, this rate was about 1 death per 100,000,000 vehicle miles.

Effect of Barrier Type Median on the Reduction of Head-on Collisions

In 1950, for the total accidents on the Parkway System under jurisdiction of the Long Island Park Commission, 4 percent of the accidents, 19 percent of the injuries and 5 percent of the cars damaged were caused by the head-on collision type of accident. In 1952 these corresponding figures were reduced to 0.7 percent, 2.5 percent, and 0.7 percent respectively. The principal contributing cause to the head-on collision type of accident was crossing the center line. In 1950, 24 cars crossed the center line resulting in collisions while in 1952 this was reduced to two cars, indicating the effectiveness of the 15 miles of barrier type median divider installed on the system.

SUMMARY OF CONCLUSIONS

Comparison between Day and Night Operations

Speed. In nearly all cases the average speeds at night were about one mile per hour different from the speeds suring daytime at comparable traffic volumes. Furthermore, the speeds were sometimes higher at night than during the day and vice verse. On the average, therefore, there does not appear to be a very significant difference between day and night speeds.

Placement. Similarly, a comparison of the average lateral positions of vehicles during the day with the values recorded during the night shows that distances from the edge of the median to the near side of the car was substantially the same for day and night operations. Also, there was an insignificant difference between the clearances of cars for day and night operations.

Effect of Median Divider on Speeds

It appears that the average speeds of vehicles are not affected by one type of median any differently than by any other of the medians studied. At an hourly volume of 1,500 vehicles in one direction of travel, the average speeds were about 45 miles per hour for cars traveling in the left lane and about 37 miles per hour for cars traveling in the right lane.

Effect of Median Divider on Lateral Positions of Vehicles

From a study of the lateral positions of vehicles, it is indicated that at all volumes, vehicles travel closer to the concrete parabolic type of median than to the other types of median studied and the clearances between vehicles are greatest for the concrete parabolic type of median than for any other barrier type median studied.

There is a linear relation between the average lateral position of vehicles and the hourly volume. As the volume increases, vehicles in the right lane, on an average, travel closer to the curb and those in the left lane travel closer to the median.

Effect of Barrier Type Median Divider on Accident Rates

The accident rates for the years 1950 and 1952 were examined, by type median, for several sections of the Long Island Parkway System which remained unchanged during these years and for other sections on which barrier type medians were installed in 1951. These data show that the installation of the barrier type median reduced the injury rate 19 percent, the property damage rate 7 percent, and the total accident rate 11 percent.

ACKNOWLEDGMENTS

The work described in this report was done for the New York State Department of Public Works, with the cooperation of the Bureau of Public Roads. The work was done under the general direction of B. A. Lefeve, Director of Highway Planning (now Deputy Chief Engineer for Highways). The procedure for analysis was developed in collaboration with O. K. Normann and A. Taragin of the Highway Transport Research Branch, Bureau of Public Roads.

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1. Highways with a Narrow Median, Bulletin No. 35, Highway Research Board, 1951.
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Accident Experience with Traversable Medians Of Different Widths

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● THIS study is concerned with the accident experience of traversable medians of various widths on limited access, high speed highways. It was sponsored by the New Jersey Turnpike Authority and was conducted by the Yale Bureau of Highway Traffic during the summer of 1954.

Since the study pertains only to limited access facilities, the factors which often determine median design on highways with intersections at grade, such as, the "shadowing" of crossing and turning vehicles, as well as pedestrian protection were not considered in the accident analysis.

Source and Nature of Data

Data for this report were obtained through the cooperation of state highway departments and turnpike authorities. Accident and physical data for limited access facilities such as, Merrit and Wilbur Cross Parkways, DuPont and Shirley Highways, Queen Elizabeth Way, the New Jersey Turnpike, etc., were submitted by the departments in charge of their operations.

To increase the number of samples, state highway departments were requested to select and submit data for sections of rural, divided, high speed highways having limited access characteristics with few intersections and little, or no, roadside development. It was assumed that the operations of these roads were comparable with those of the parkways and turnpikes.

All pedestrian and intersection accidents were excluded from the accident data used in the analysis.

The total mileage of highways analyzed for this study consists of 245 miles of limited access facilities and 181 miles of divided highways with limited access operational characteristics. This mileage fell into 22 sections of high speed highways with traversable median widths varying from 2 ft to 94 ft. Some of the medians are mounded, with or without lip curb, and some are depressed.

The amount of slope in the median cross section is three (horizontal) to one (vertical), or less, in every case. Most of the narrow medians have lip curb up to 7½ in. in height. Neither the lip curb nor median slopes could be classed as barriers according to their accident experience. In fact, it was concluded during the study that the amount of kinetic energy to be controlled at high speeds is so great that nothing short of a substantial physical barrier could prevent the crossing of narrow medians by out-of-control vehicles.

All of the sample facilities operate at high speed except one which has a 45 mph speed limit. While this particular section of road has a good median accident experience, the evidence is not sufficient to attribute this favorable record directly to the speed limit.

None of the sample facilities are lighted except a few which have occasional lighting at special locations. All of the facilities accommodate trucks except Merritt and Wilbur Cross Parkways. One sample facility has a single cable guard rail in the center of its 48 ft median to prevent "U" turns. This semi-barrier makes no significant difference in the median accident experience of this facility.

The medians of all samples, except one, are relatively clear of barriers. In this exception the median is heavily planted with trees. Its extension to the north has a median width of three ft less but it is sparsely planted and provides an ideal basis for a comparison of median operations. The fatal and injury median accident rate for the section planted with trees was higher than that for the unplanted section based on accident records covering a recent three year period. This difference was mostly caused by an average of 50 accidents per year when vehicles struck trees in the median. While it may be believed that the trees prevented "crossed median" accidents, the percents of "crossed median" and "hit tree" accidents which produce fatal and injury accidents

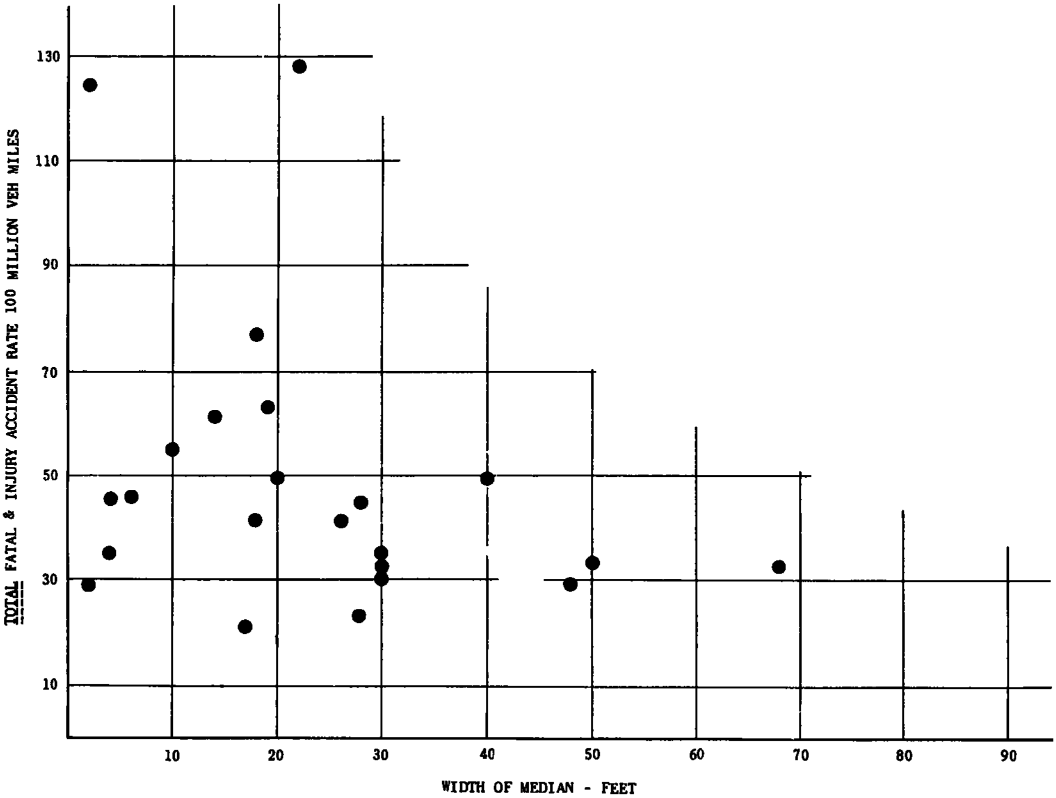


Figure 1. Fatal and injury accident rates by width of median.

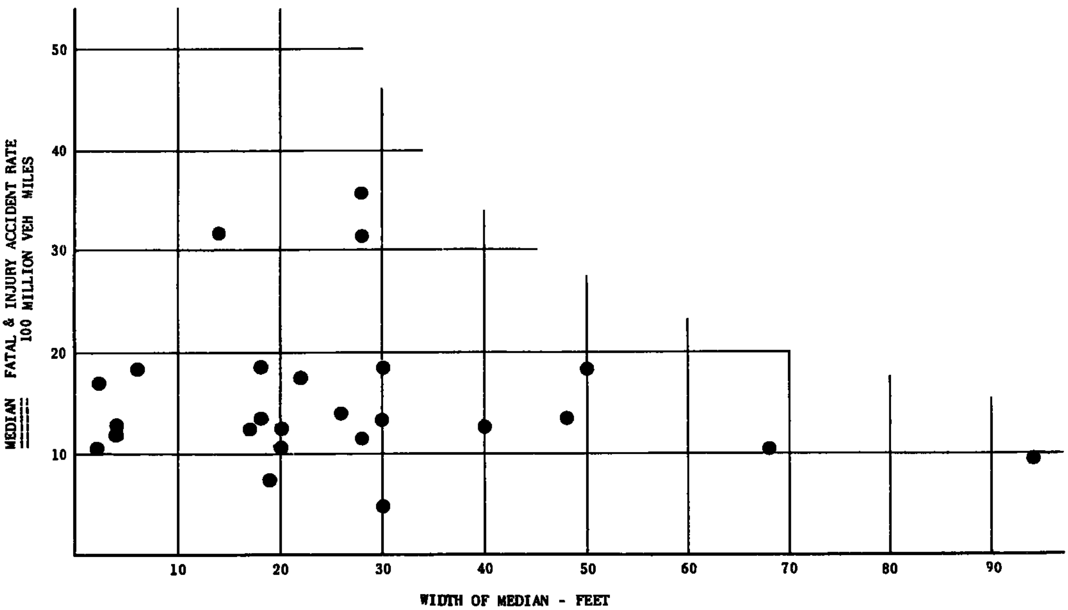


Figure 2. Median fatal and injury accident rate by width of median.

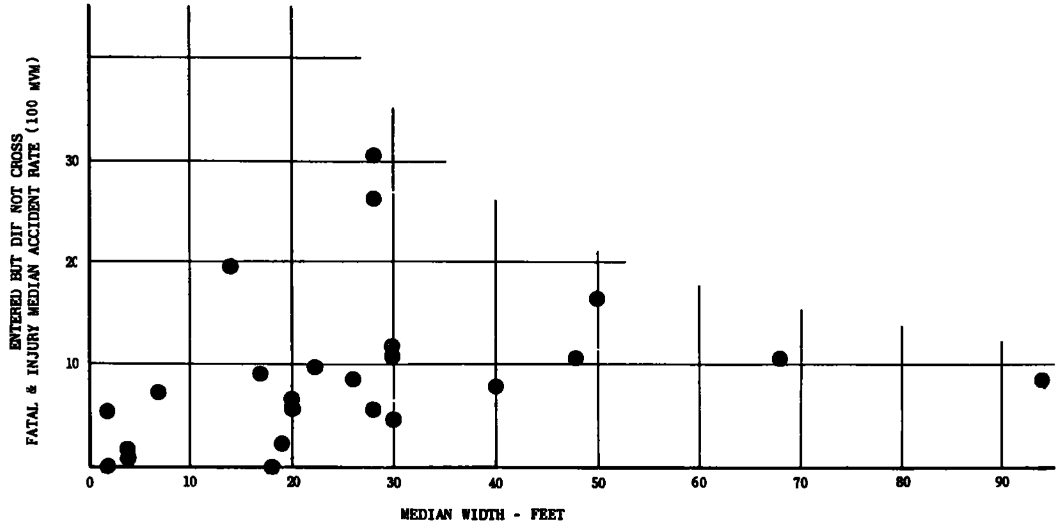


Figure 3. Fatal and injury accident rate for entered but did not cross by width of traversable median.

were about 50 percent in both cases and, obviously, the trees caused many accidents which would not otherwise have occurred.

Total Accident Rates

Figure 1 shows the total, fatal and injury (combined) accident rates by width of median for the 22 facilities studied in this report.

The coverage of accident reporting varies with different highways and highway systems. Injury and fatal accidents are nearly always called to the attention of the police whereas property damage accidents may not be reported. To minimize the differences in accident coverage, only fatal and injury accidents are shown in this figure.

It is clear from Figure 1 that there is no correlation between the overall accident rates of the 22 sample facilities and the width of their traversable median.

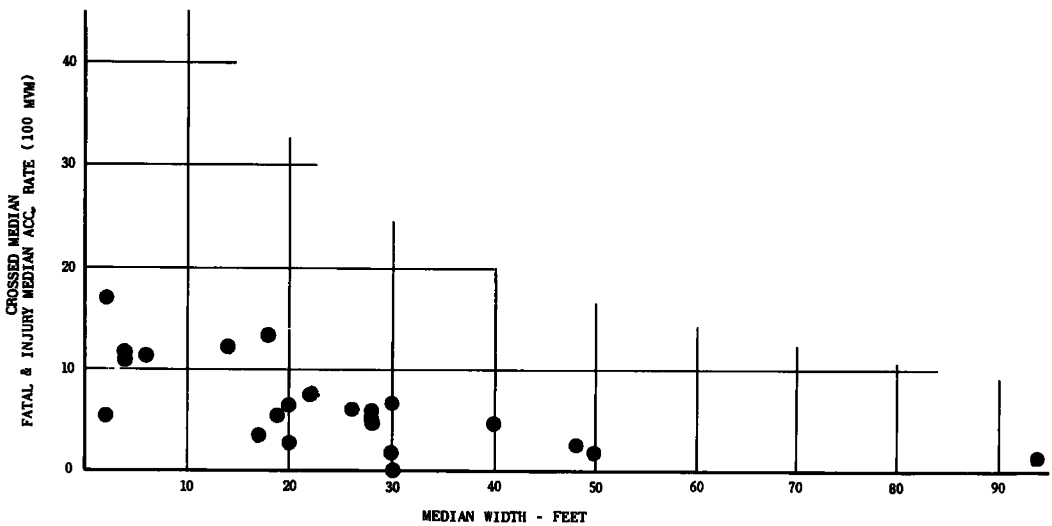
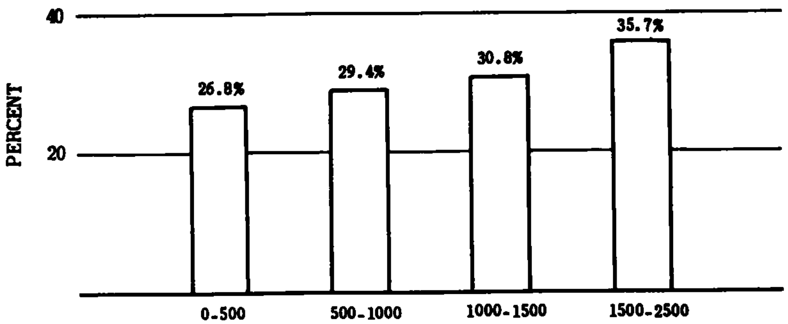


Figure 4. Fatal and injury accident rate for vehicles that crossed median by width of traversable median.



ACCIDENTS FOR ALL HOURS TRAFFIC IN BOTH DIRECTION FELL WITHIN THE ABOVE HOURLY GROUPS.

	0-500	500-1000	1000-1500	1500-2500
NUMBER OF HEAD-ON	19	15	8	10
NUMBER OF CROSS MED. ACC.	71	51	26	28

Figure 5. Percent of cross median accidents which were head-on. Accidents during hours of certain traffic volumes (Jan. 1, 1952 to June 30, 1954). New Jersey Turnpike.

Study of individual accident occurrences on the sample facilities implied that there are many different factors, other than median design, which affect accident rates. Some of these factors are: (1) the overall standards of design. (2) road user velocitation. (3) climatic environment, fog, ice, etc. (4) differentials in vehicle speeds.

The combination of these factors produced rates ranging mostly between 30 to 60 fatal and injury accidents per 100 million vehicle miles. Of the two facilities with highest rates, one does not provide right hand shoulders and the other had a high number

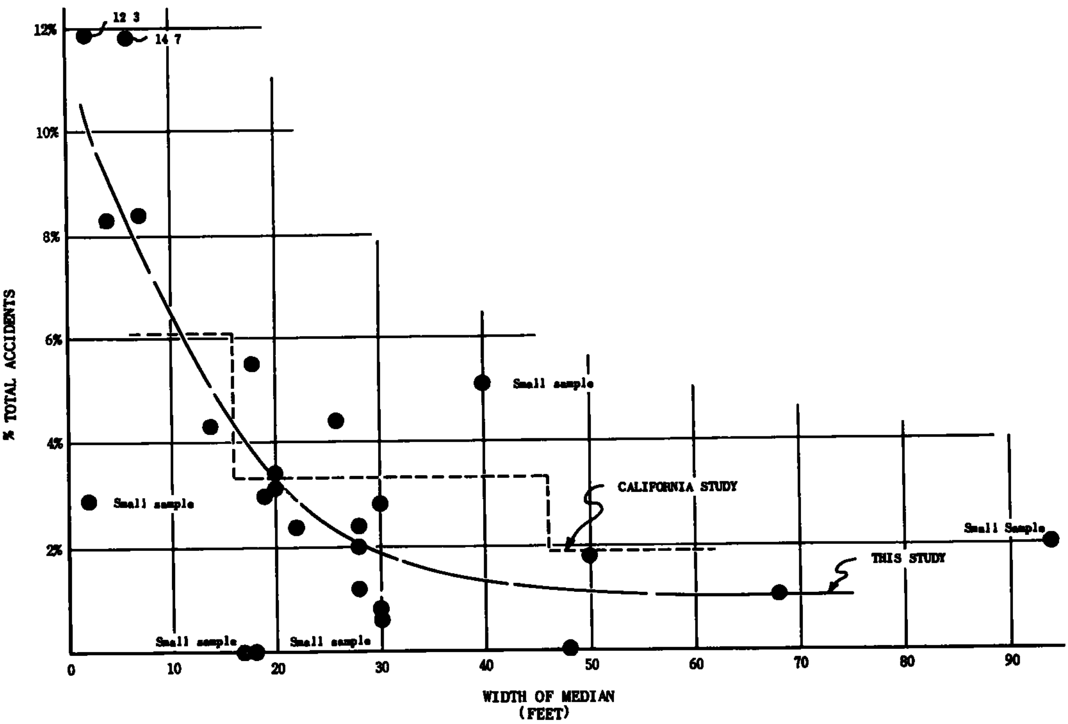


Figure 6. Head-on accidents as percent of total accidents by median width.

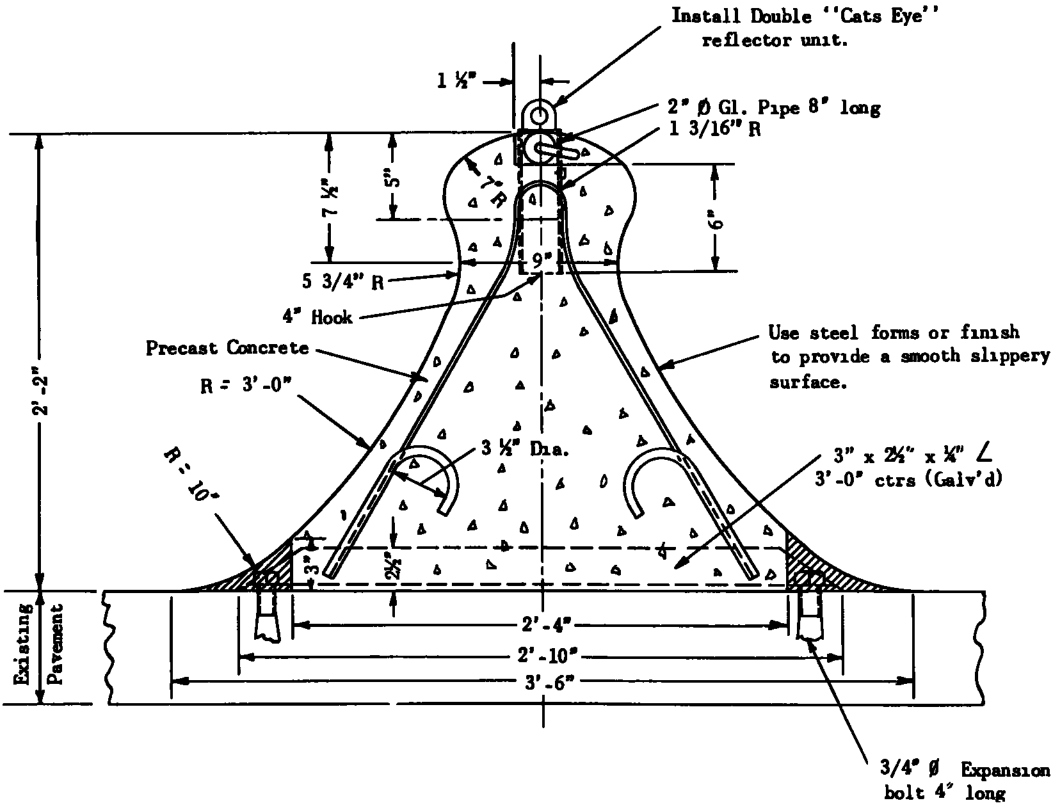


Figure 7. Detail of California parabolic divider.

of intersection accidents which, although excluded from this study, suggests large differentials in speeds.

Median Accident Rates

Figure 2 is concerned with median accident rates only. It shows the injury and fatal

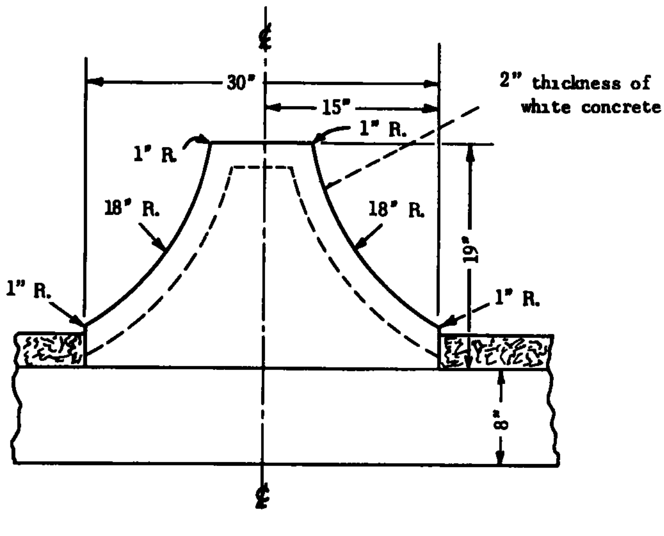


Figure 8. Detail of parabolic divider. US 22, New Jersey.

accident rate, combined, for only those accidents which involved the median by width of median.

Again, there appears to be no correlation between the accident rates and width of median. This phenomenon is difficult to rationalize because greater safety with wider medians would be expected. Perhaps, drivers are more alert when the median is narrow and top speeds are higher on roads with medians of more generous design.

The range of accident rates including the majority of samples shown by Figure 2 is from 10 to 20 injury and fatal accidents per 100 million vehicle miles. Median accidents therefore account for about ⅓ of the total accidents on these facilities, since their total accident rate ranged between 30 and 60. (see Figure 1)

Figure 3 shows the fatal and injury accident rate for only those vehicles that entered the median but did not cross it.

In the analysis of accident records for this study median accidents were clauses as those which occurred either: (a) When the vehicle struck, entered or encroached upon the median but did not cross it, or (b) when the vehicle crossed the median and entered lanes for the opposed flow.

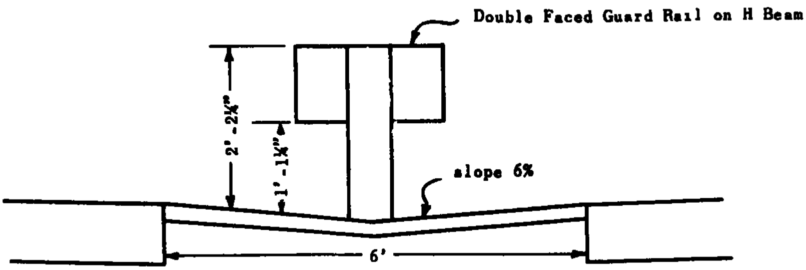


Figure 9. Cross section between Hackensack and Passaic R.R. bridges New Jersey Turnpike.

Figure 3 shows the fatal and injury accident rate for the first classification of median accidents. The three facilities with highest rates on this figure are ones with highest rates on the previous figure. This indicates that the median itself is the cause of an unusual number of accidents. Detailed data are not yet available to determine the exact cause of these median accidents. The medians of all three of these facilities are relatively free of obstructions and are of depressed design but so are some of the other samples with favorable accident records.

Figure 4 shows the fatal and injury accident rate for vehicles that crossed the median by width of median. This figure shows a good correlation between "crossed median" accident rates and width of traversable median. As might be expected, the rate for this type of accident is reduced with increased median width.

Head-on Accidents

There is no reason why the width of traversable median should influence the accident rate except in the case of head-on collisions with vehicles in the opposed flow. In other words, except for head-on collisions, a traversable median without trees, bridge piers, or other obstructions, offers no greater hazard than the right side road margin so long as physical obstructions are equal distances from the right and left edges of the pavement. Therefore, the objective of median design on limited access facilities is to prevent head-on collisions.

Head-on collisions are a small percent of total accidents but they are extremely severe accidents. Totals of the accident data for this study show that 6 out of 10 head-on accidents are personal injury or fatal accidents. While they accounted for $\frac{1}{25}$ of all injury accidents they were responsible for ⅕ of all fatal accidents.

In addition, because of the lethal nature of head-on accidents, they are considered very unfavorably by the public. Only one of the drivers is usually in error when a head-on collision occurs and public criticism is "leveled" at lack of protection for the innocent driver.

Figure 10. Steel guard rail on US 101 in California.

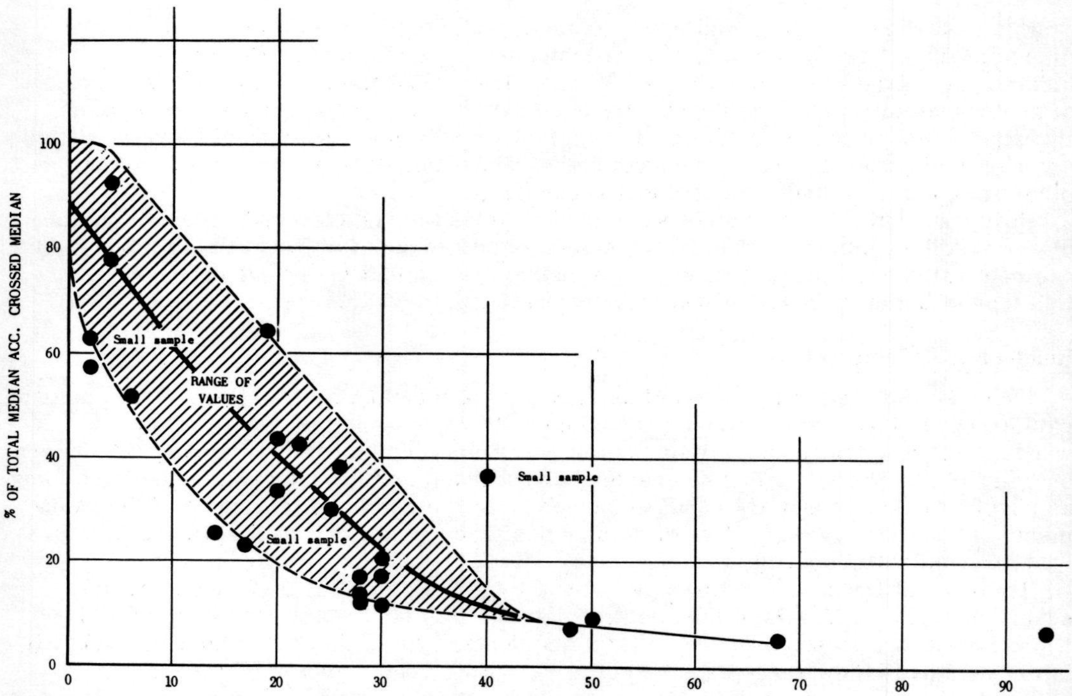


Figure 11. Percent total median accident crossed median by median width (traversable medians).

Logic dictates that the probability of a "crossed median" accident becoming a head-on collision will depend upon the density of traffic. To study the effect of traffic volume on head-on accidents a detailed analysis of traffic accident experience and volume was made for the New Jersey Turnpike. Results of this study are shown on Figure 5. This particular accident analysis covered the 30 month period from January 1, 1952 to July 1, 1954 and hourly volume data were obtained from the Turnpike's toll records.

The percent of "crossed median" accidents on the Turnpike which produced head-on accidents increased from 26.8 percent for the 0-500 vehicles per hour group to 37.7 percent for the 1,500-2,500 vehicles per hour group. While the sample is small, a definite relationship between increased traffic density and head-on collisions was found but the increase of 8.9 percent is less than would be expected. Apparently, drivers are more cautious and alert when operating under high volume conditions but more data are required to prove this reasoning.

Figure 6 shows head-on accident experience as a percentage of total accidents by median width for the 22 samples. It was assumed that head-on accidents expressed as a percent of total accidents would be reliable in spite of differences in accident reporting for the various facilities. The curve superimposed on this figure is an "average" of the data with consideration made of sample size. The curve shows that the percents of total accidents which are head-on accidents range from 1 percent for the wider medians to 14.7 percent for the narrow medians. The percent reduces rapidly with increased width of median up to 40 feet. For median widths greater than 50 feet the reduction is small.

In cooperation with this study, the California Division of Highways made a special analysis of median accidents on all rural high speed highways having limited access characteristics within that state. These facilities were not included in the 22 samples shown on Figure 6. All head-on accidents were expressed as a percent of total accidents by widths of median grouped for medians 6 to 16 feet wide, 16 to 46 feet wide and wider than 46 feet.

The California study results are shown by the dotted lines on Figure 6. The difference for the wider medians of about 2 percent between the two studies cannot be precisely explained but in both cases substantial reductions in head-on accident experience with increased width of median up to 50 feet are shown. Apparently, a 50 foot traversable median width offers sufficient "skid or roll over room" and recovery time to contain most out-of-control vehicles. A median width of several hundred feet would probably be required to contain all median accidents.

Barrier Medians

As a part of this study of traversable medians, exploratory accident investigations were made of the operational characteristics of barrier medians now employed on rural high speed highways. Physical barrier medians are most warranted when highways pass through areas of restricted rights-of-way where traversable medians of adequate width would be very costly.

Figure 7 shows the design detail of the parabolic divider located on the famous Grapevine Grade of US 91 in California. It is 26 in. high, 42 in. wide at its base and is of concrete construction. During three recent years of operations, 50 percent of the accidents caused by hitting the divider involved severe property damage, 32 percent were injury and 11 percent were fatal accidents. In 39 percent of these accidents, the vehicle rolled over after striking the median. However, none of the vehicles crossed or straddled the divider.

Figure 8 shows the design detail of another parabolic divider for which accident experience was studied located in New Jersey on US 22 at Jugtown Mountain. It is 19 in. high, 30 in. wide at its base and is of concrete construction. During the years 1950 through 1953, 77 accidents occurred within the two mile section having this divider and 22 of these could be directly attributed to the median. 44 percent of the accidents caused by hitting the median were property damage accidents and 56 percent involved personal injury. In 5 of these accidents, the vehicle jumped the median and in 5 of them the median was straddled. In six cases, the vehicle swerved across the right lane after contact with the median.

These two accident investigations indicate that a low parabolic divider is too easily mounted and a high one tends to "roll" the vehicle. Apparently, a divider of this type, when designed to prevent crossing, transmits a vertical acceleration to the vehicle, which, under high speed conditions, tends to "roll" it or catapult it into the air.

Figure 9 shows the details of an installation of beam type guard rail placed back-to-back in the median of a one mile section of the New Jersey Turnpike. The barrier is in the center of a six foot slightly depressed section.

Accident records for this section of median were available for the years 1952, 1953 and eight months of 1954. The reportable accidents produced by contact with the guard rail consisted of 10 property-damage-only accidents, 1 injury and 1 fatal accident. The fatal and injury accidents could not properly be charged to the guard rail because the injury accident occurred when a vehicle struck the end of the rail at an opening and the fatal accident occurred when a vehicle skidded along the guard rail into a vehicle parked alongside the rail. In the 12 accidents, one vehicle straddled the rail and another rolled over it. The accident reports indicated in at least two cases that the guard rail caused the vehicle to bounce off and cross to the outside of the road. In most of the accidents, restricted clearance distance between the edge of pavement and guard rail was a causative factor.

Figure 10 shows the installation of Tuthill guard rail on 1.5 miles of highway US 101 in California. As shown by the photograph, the installation was made to protect traffic from the row of large trees in the median. During a period of two years prior to the installation 20 median accidents occurred when vehicles hit trees. These accidents consisted of 3 property-damage-only accidents, 14 injury accidents and 3 fatal accidents. During a period of one year after installation of the guard rail there were 4 accidents consisting of 3 property damage and 1 injury accident. In the case of at least two of these accidents, the vehicle was bounced off the guard rail and crossed over the right hand lane.

These studies of the accident experience of different types of physical barriers now employed in the medians of high speed, rural roads are limited in scope and size of sample. In addition to limitations in accident data, higher than normal accident experience may be expected for the barriers studied because they are employed mostly at "accident prone" locations where physical limitations such as, long grades, horizontal curves and limited right-of-way occur. However, it is apparent that none of the barriers have ideal performance characteristics, especially for high speed roads, and all of those studied introduce added hazard when compared with accident experience where traversable medians of adequate width are employed.

Figure 11 shows the percent of total median accidents that crossed the median for the 22 sample facilities with traversable medians of various widths. The "cross hatched" area indicates the range of values found in the data. The curve shown by the heavy line is drawn in the center of the range for median widths.

This curve provides a means of estimating the increased number of accidents which may be produced if a given traversable median is divided with a physical barrier. For example, with a 26 ft traversable median, about 30 percent of the median accidents may be expected to cross the median. But, when the median "recovery" width is reduced ½ by a physical barrier, this figure becomes 55 percent; or 25 percent higher. This increase does not include those vehicles which enter or cross a traversable median and recover control without accident but would be "tripped up" by a physical divider.

The severity of accidents caused by a physical divider depends upon its design. More research in the design of physical dividers, under high speed conditions employing both trucks and passenger cars, is required to solve this problem.

The superiority of a traversable median 40, or more, feet wide over any type of existing physical barrier employed to prevent head-on accidents on high speed, limited access facilities is demonstrated in this study.

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The NATIONAL RESEARCH COUNCIL was established by the ACADEMY in 1916, at the request of President Wilson, to enable scientists generally to associate their efforts with those of the limited membership of the ACADEMY in service to the nation, to society, and to science at home and abroad. Members of the NATIONAL RESEARCH COUNCIL receive their appointments from the president of the ACADEMY. They include representatives nominated by the major scientific and technical societies, representatives of the federal government designated by the President of the United States, and a number of members at large. In addition, several thousand scientists and engineers take part in the activities of the research council through membership on its various boards and committees.

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The HIGHWAY RESEARCH BOARD was organized November 11, 1920, as an agency of the Division of Engineering and Industrial Research, one of the eight functional divisions of the NATIONAL RESEARCH COUNCIL. The BOARD is a cooperative organization of the highway technologists of America operating under the auspices of the ACADEMY–COUNCIL and with the support of the several highway departments, the Bureau of Public Roads, and many other organizations interested in the development of highway transportation. The purposes of the BOARD are to encourage research and to provide a national clearinghouse and correlation service for research activities and information on highway administration and technology.