HIGHWAY RESEARCH BOARD

Bulletin No. 35

Highways with a Narrow Median

1951

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PUBLICATION OFFICES

2101 Constitution Avenue   Washington 25, D. C.

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HIGHWAYS WITH A NARROW MEDIAN

PRESENTED AT THE THIRTIETH ANNUAL MEETING
1951

HIGHWAY RESEARCH BOARD
DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH
NATIONAL RESEARCH COUNCIL

Washington 25, D. C. May 1951

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SYNOPSIS

D. W. Loutzenheiser, *Chairman, Committee on Geometric Highway Design*
Bureau of Public Roads

It is known that a considerable variation exists across the country in the design of narrow medians. Since the roadside and type of highway conditions vary widely it is to be expected that designs for them will differ. But data are not available to predict traffic patterns and behavior adjacent to a prescribed narrow median for a known general condition In the absence of a large scale research project, this symposium was developed as a form of collective research for examination of resultant operation data with different narrow median sections, related to the conditions for which they were designed.

Through the cooperation of seven State Highway Departments it was possible to obtain reports with information on 23 different narrow median designs for 5 general highway conditions. Narrow medians were considered to be those 8 ft or less in width, of raised curb, rounded or flush section. The general conditions were: (1) rural divided highways, without control of access, (2) major streets through residential or suburban areas, (3) major streets through business areas or with ribbon commercial development, (4) long structures or elevated highways, and (5) expressways. Separate reports for each median include a description of the highway site condition, highway cross section, median details, costs, data on traffic volumes, turning movements, speeds, placement, accident experience, and general conclusions as to suitability of the design.

California reported a narrow median (3) in general suitable but emphasized the need for a wider section to include a median lane. Their long structure report (4) shows need for striping adjustment.

Connecticut reported narrow medians reasonably suitable on residential and business streets, (2) and (3), but find inefficient pavement use because of parallel parking. On long structures (4) there was no significant difference with three types of high narrow medians. Their expressway (5) section appears suitable.

Illinois reported a rural narrow median (1) that was found unsuitable and changed to a flush section. In a second case (2 and 3) local demand resulted in addition of a great many median openings On a Belt Line they used narrow medians over structures (4) as a logical design with wide medians elsewhere on the route.

Michigan reported a 3-ft. bituminous median (1 and 2) being tried as a low cost separator Early experience is favorable.

New Jersey reported use of a high barrier curb (1) on a section with sharp curvature and steep grades to avoid very expensive alignment and profile changes. Also, they reported (2) use of precast reflecting flat curbs as a minimum street section; experience record good.

New York presented a preliminary report of large-scale speed-placement studies on different sections of the Long Island Parkways. Placement data are given but relation of volumes, speeds, etc., have yet to be analyzed.

The following tabulation is a summary of these reports. The condition number is that above indicated. The curb face slope is a ratio of the horizontal to vertical dimensions in inches Where the vertical dimension is less than the curb height there is a bottom vertical section. Placement is the left wheel position measured from the curb face for free-moving vehicles. Accidents are shown as the rate per 100 million vehicle miles; the second value indicates fatalities.

SUMMARY - SYMPOSIUM ON HIGHWAYS WITH A NARROW MEDIAN

State	Condition	Length Miles	Year Built	Median: Width ft	Median: Type Surface	Median: Curb Height, in	Median: Curb Face Slope-H V	Median: Avg Cost per ft	Pavement Lanes ft	ADT Volume thousands	Avg Speed mph	Avg Placement, Left Wheel, ft	Accident Rate		Remarks
Ill	1	1 75	1939	2	Conc	4	3 in ogee	$0 47	10-10-Sh	3 8-5 5	45-50	-	(High)		Removed in 1947
N J	1	2 04	1949	2 5	Conc	16	Concave	5 74	12-11-Sh	8	50 P 16-51T	3±	*		Steep grade section
Mich	1 & 2	10	1950	3	Bit	6	2 in steps	0 82	11-11-Sh	7-12	51 5	4 5	-		Experimental low cost type
Conn	2	3 77	1942	6	Grass	4	1 3	2 40	13 6-12	11	27 3	7 0	690	6 2	2 6 ft gutter pan within inner land
"	2	1 85	1941	6	Grass	4	4 1 3	2 00	13-15	15 5	45 8	5 2	250	8 0	
N J	2	4 0	1949	2	Scored Wh Conc	2 5	12 1	3 90	12-12	18-30	40 0 P 35 7 T	2 1	*		Minimum design example
Ill	2 & 3	1 95	-	4	Conc	6	Vertical	-	10-10-8	25±	30±	-	-	-	Originally 7 median openings changed to 46
Ohio	2 & 3	17 9	1940-50	2 & 4	Conc Block	2 5	6 2	0 33	-	-	-	-	-	-	Blocks 12 by 29 in placed at 45 deg on 12-ft centers
Calif	3	1 0	1946	4	Grass	6	1 6	3 82	11-11-11	28 8-42 2	16 6-21 3	3 4	530	-	Light poles in median
Conn	3	1 50	1940	5	Grass	7	1 7	3 40	31	21	28 5	3 8	540	2 4	No lane lines, parallel parking
"	3	1 85	1940	4	Conc	5	1 4	2 20	11 5-10 5-6	15	35 6	4 3	420	2 7	Parallel parking
Calif	4	0 42	1944	4	Bit	5	6 4 4 8	11 1	13-12	17 8	49 1	4 3	54	-	Double stripe adjacent to median
Conn	4	0 61	1941	4	Metal	21	10 8 14	-	12-12	33	38 6	4 9	210	0	Charter Oak Bridge, Hartford
"	4	1 12	1941	2 5	Conc	19	Two Step	-	12-12	16	35 4	4 8	180	0	Thames R, Groton
"	4	0 34	1939	4	Metal	18	12 18	-	13-13	18	46 0	4 8	970	0	Housatonic R, Merritt Parkway
Ill	4	1 68	1940-44	4	Conc	4	2 5 4	1 25	11-11	4 7	50±	-	-	-	Bloomington Belt Line, median 30-40-ft off structures
Conn	5	1 01	1938	4	Grass	4	4 1 3	3 30	12-12-10	27	40 5	4 6	210	7 2	Riverfront Blvd , Hartford
N Y	5			2 5	Conc	17	Concave	-	10-11	**	**	1 5	-	-	Long Island Parkways, parabolic deflector type curb
"	5			0 5	Stripe	-	-	-	10-11	**	**	1 9	-	-	" " "
"	5			1 0	Conc	12 5	2 7 12	-	10 5-11	**	**	1 9	-	-	" " "
"	5			1 0	Conc & Pipe	15	4 11	-	22	**	**	2 9	-	-	" " " , 5 in pipe on concrete curb
"	5			9	Grass	4	4 3	-	13-12	**	**	3 4	-	-	" " "
	5			42	Grass	None	-	-	12-11	**	**	2 6	-	-	" " "

*Data but rate not given

**Passenger cars, one-way volumes 500 to 2700, legal speeds 35 & 40 mph Data yet to be analyzed Placements at volume of 1500 vph

A STUDY OF HIGHWAYS WITH A NARROW MEDIAN - CALIFORNIA

E. T. Telford, *Engineer of Design, California Division of Highways*

A MAJOR STREET THROUGH A CENTRAL BUSINESS AREA

THE SITE

The location indicated on Figure 1 and covered by the following report is the Street of Broadway in the City of Oakland, California, (State Highway Route Ala-75-Oak), between MacArthur Boulevard and College Avenue, approximately 1 mi. in length. This location was selected as representative of a major street through a central business area.

Development along this section of Broadway is almost continuous and consists of small businesses, automobile sales lots, multiple dwellings and public institutions. (see Figs. 4 to 6). The street is one of the important north and south arterials and is intersected by three State Highway Routes within the City of Oakland. It covers a considerable portion of the intercity traffic between Oakland and Berkley and also is a part of State Highway Route 75 which is the main artery feeding the rapidly developing urban areas of Lafayette and Walnut Creek as well as the expanding industrial areas of Concord, Pittsburgh and Antioch.

THE HIGHWAY

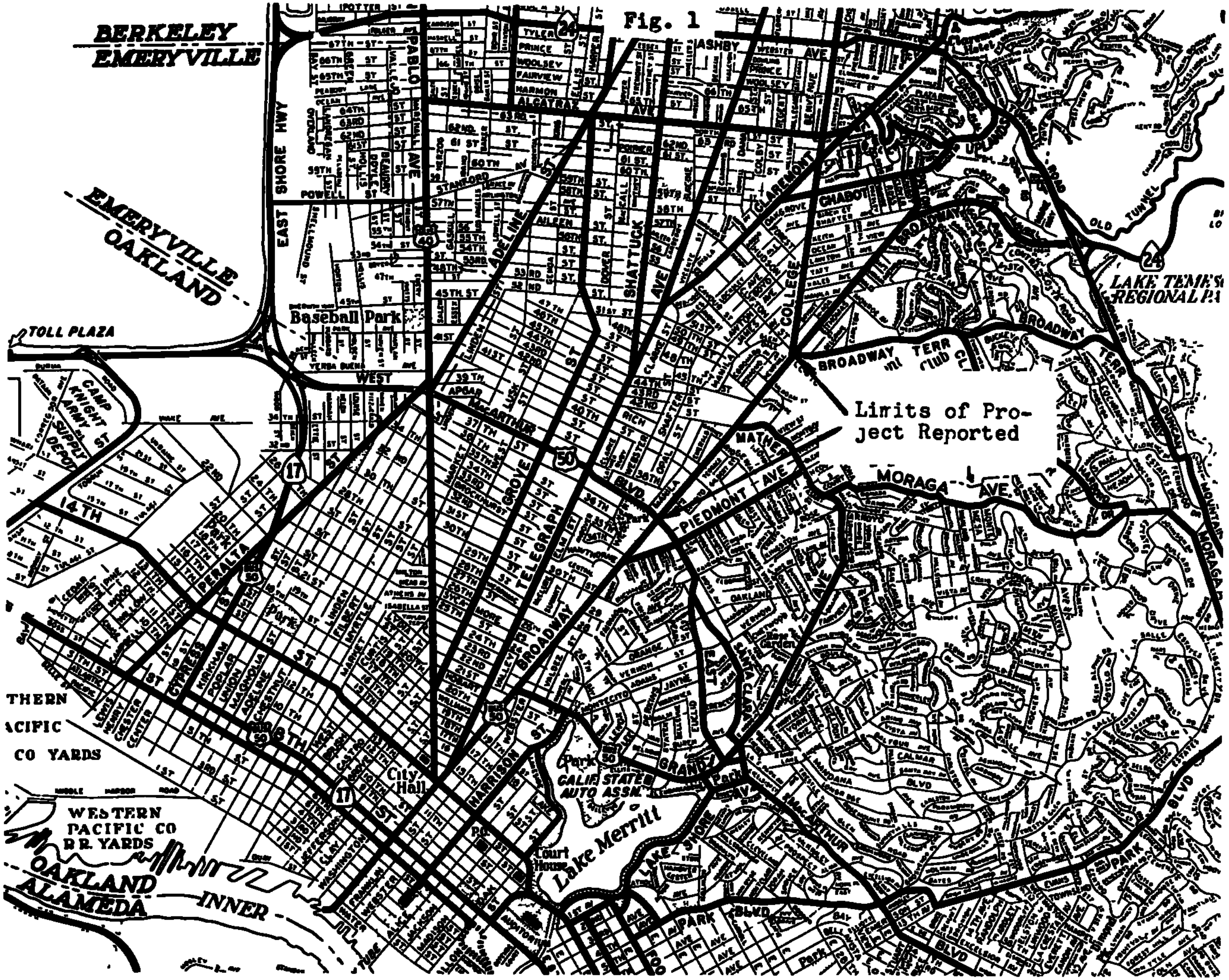
This street originally had double street car tracks occupying the central portion of the traveled way. Subsequent to the substitution of the motor bus for electric street car transportation, the tracks were removed and the resulting 20-ft. width was reconstructed to provide a narrow median and asphaltic concrete pavement to match the existing street.

As shown on the typical cross section Figure 3, the present construction consists of 15 ft. of sidewalk and 33 ft. of asphaltic pavement on each side of a 4-ft. median. This permits two lanes of traffic with parallel parking adjacent to the sidewalk. When permitted, parking is subject to toll collected by parking meters. Several areas at points of congestion are zoned to prohibit parking or stopping at any time. Also, tow-away zones are established on the east side of the street where parking is prohibited between the hours of 4 p.m. and 6 p.m., Sundays and holidays excepted. All vehicles which violate this ordinance are removed from the street and impounded. The purpose is to allow the unobstructed use of the entire three-lane roadway by outbound traffic during "work to home" hours.

The dimensions of the openings in the median are controlled by the width of the intersecting street. They are usually the curb to curb width of the intersecting street plus 4 ft., making a setback of 2 ft. from the face of the curb line projected.

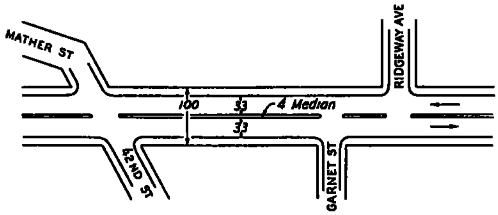
Grade intersections on Broadway are controlled by signals at important intersections as shown in Figure 2, and by arterial "stop" signs at the lesser intersections. Left turns are permitted. Access by means of driveways to business establishments fronting on this street is permitted and regulated by city ordinances concerning length and frequency of openings.

Fig. 1


BERKELEY
EMERYVILLE
EMERYVILLE
OAKLAND
TOLL PLAZA
Baseball Park
CAMP KNIGHT ARMY SUPPLY DEPOT
EAST SHORE HWY
SAN PABLO AVE
ADELINE ST
SHATTUCK AVE
TELEGRAPH
BROADWAY
COLLEGE
CLAREMONT
ASHBY
ALCATRAZ AVE
MacARTHUR
GROVE ST
PIEDMONT AVE
MORAGA AVE
BROADWAY TERR
CHABOT
UPLANDS
OLD TUNNEL RD
LAKE TEMESCAL REGIONAL PARK
Limits of Project Reported
CYPRESS
PERALTA
14TH
WEST ST
HARRISON ST
GRAND
City Hall
Court House
Lake Merritt
CALIF STATE AUTO ASSN.
LAKE SHORE
PARK BLVD
SOUTHERN PACIFIC CO YARDS
WESTERN PACIFIC CO R R YARDS
OAKLAND
ALAMEDA
INNER
MORAGA

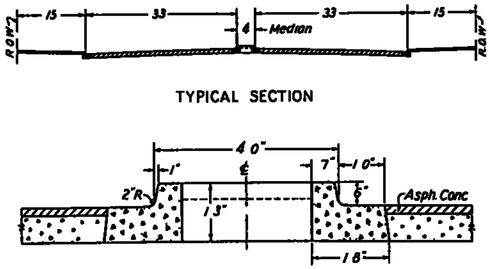
The grade of Broadway between MacArthur Boulevard and College Avenue is slightly rising between MacArthur Boulevard and 45th Street, with a pronounced rise between 45th Street and College Avenue.

Drainage control is of conventional type. Water is interrupted by gutter basins and disposed of into the storm drain system. No water accumulates in the median gutters as the crown of the street slopes towards the gutters adjacent to the sidewalks.



PARTIAL PLAN

Figure 2. Major Street - Broadway Oakland, California



DETAIL OF MEDIAN

Figure 3 Major Street - Broadway Oakland, California

THE MEDIAN

A detailed section of the median is shown in Figure 3. Gutter and curb are of monolithic construction. The intervening space between the curbs was backfilled with selected material for promoting plant growth except at traffic openings in the median where pedestrian refuges about 10 ft. long were paved with concrete (See Fig. 6). Considerable attention is given to the planted areas by the City Park Department. It is planted periodically with seasonable flowers and much favorable comment has been received from the press regarding the aesthetic value of this installation.

Metal electroliers supporting street luminaires are in place at intervals throughout the length of the curbed median (See Figs. 5 and 6). Except at the College Avenue intersections where "3-Way" signals and "No Left Turn" signs are attached to the electroliers, no other signs or devices are installed within the median.

Figure 4.

Figure 5.

THE COST

The over-all highway improvement entailed the expense of removing street car tracks and other work peculiar to this particular street and it is not felt that cost data, aside from the cost of the median, would serve for any basis of comparison.

The cost of constructing this one mile of median in 1946 was as detailed below:

Curb and Gutter at $1.57 per lin. ft.	$16,580
Selected Material (backfill $3.75 per ton)	3,350
Sidewalk at median openings - .25 per sq. ft.	250
Total	$20,180

Figure 6.

TRAFFIC

Traffic volumes are based on 16 hour manual counts supplemented by 24 hour automatic counters at two locations. These data are used to predict average daily traffic by a comparison with the 365 day count available at the adjacent SF-Oakland Bay Bridge. Traffic volumes increase materially from the southerly to the northerly end of the section under study.

(1) Average daily traffic:
South end = 28,773
North end = 42,158

(2) Peak hour traffic volume between 5 and 6 PM, represents 7.41 percent of the 24 hr. total.

(3) Peak hour directional flow:
58.4 percent northbound
41.6 percent southbound

(4) The composition of traffic, 6 AM to 6 PM 12 hr. weekday count:

	Percent
Passenger automobiles	86.85
Busses	2.25
Pickups	5.97
2 Axle Freight Vehicles	3.70
3 " " "	0.70
4 " " "	0.13
5 " " "	0.33
6 and more axle Freight Vehicles	0.07

Turning movement counts were made at the nine intermediate intersections within the limits of the project. Sixteen hour counts were made at two of the intersections to serve as key stations, and four hour counts, two during the AM peak and two during the PM peak, were made at the other intersections. Figure 7 shows AM peak hour, PM peak hour and average daily turning movements at the various intersections.

Turning speeds, signal delays and travel time were determined from data obtained by running test cars in the traffic stream at an average speed. The number of such runs under various traffic conditions were as follows:

Northbound, uncongested	20
Northbound, congested	40
Southbound, uncongested	23
Southbound, congested	42

Table 1 shows average running time, running speed and delay for each of the four segments of the course as well as total time and equivalent gross speed. The same information is expressed graphically in the Time-Distance Diagram, Fig. 8

TABLE 1

Running Speed, Running Time, Delay, Total Time and Equivalent Speed
Broadway, Oakland, California

	MacArt. - 40th St.			40th St. - 42nd St			42nd St - 45th St.			45 th St College				
	Running Time	Running Speed	Delay	Running Time	Running Speed	Delay	Running Time	Running Speed	Delay	Running Time	Running Speed	Delay	Total Time	Gross Speed
Northbound Uncongested	42.5sec	20.4	3.2sec	49.8sec	20.4	5 sec	29.6sec	18.3	0.9sec	36.8sec	20.3		167.8	18.9
Northbound Congested	44.3	19.6	10.5	52.7	19.3	6.6	29.8	18.1	4.2	42.8	17.5		190.9	16.6

	College - 45th St.			45th St. - 42nd St.			42nd St. - 40th St.			40th St. - MacArt.				
	Running Time	Running Speed	Delay	Running Time	Running Speed	Delay	Running Time	Running Speed	Delay	Running Time	Running Speed	Delay	Total Time	Gross Speed
Southbound Uncongested	36.4	20.6	3.4	27.6	19.5	1.7	47.3	21.4	3.0	46.7	18.6	13.4	179.5	17.7
Southbound Congested	34.8	21.5	6.4	23.5	23 0	0 9	44.6	22 7	4.8	45.6	19 0	29 9	190 5	16.6

Vehicle Placement Data - Vehicle placements were obtained for the 11 ft. wide striped inside lanes only, as placements had wide variation over the 22 ft. wide area which accommodated the outer traffic lane plus curb parking.

Placements were obtained by observation, using strips of white plastic tape placed parallel to the median at two-foot intervals. An observer stationed behind a lamp post in the median approximately 300 ft. ahead of the pavement markings could readily estimate the position of the left front wheel to one-half foot intervals. Observations were made of traffic in both directions but statistically, no significant difference was found between the directional samples, so results were averaged.

A breakdown was made, however, between vehicles said to be "free moving" when there was no vehicle in the adjacent lane and vehicles whose course was influenced by a vehicle in the adjacent outside lane. These latter were termed "vehicle in adjacent lane".

The results of this study, shown graphically in Figure 9 are as follows:

	Number of Vehicles recorded	Distance from median curb
Free moving vehicle	170	3.4 ft.
Veh. in adjacent lane	256	3.1 ft.
Computed position of left front wheel for veh. in center of the 11 ft. lane		3.0 ft.

Accident Experience - The accident summary for the 3 year and 9 month period since the median was installed is shown on accident rate report.

Accident records are dependent on the completeness of the reporting. As a check on this feature, we have the National Safety Council Standard for urban reporting of 40 injury accidents and 115 injury plus property damages only per fatal accident. The ratios for reported Broadway accidents are 32 injury accidents and 98 injury plus PDO accidents per fatal accident. Although these figures are of doubtful significance within the limits of the sample, they do indicate fair accident coverage.

Type	PDO	Injury	Fatal	Total
1. Intersectional				
Right turn	6	1	0	7
Left turn	12	6	0	18
Broadside	36	17	0	53
U-turn	1	3	0	4
2. Overtaking				
Sideswipe	27	1	0	28
Rear end	40	22	0	62
3. Approach	1	0	0	1
4. Single Vehicle	9	4	0	13
5. Pedestrian	0	10	2	12
Totals:	132	64	2	198

Accident Rate = 5.30 per million vehicle miles

For a before and after comparison we have available the accident record for a six-month period prior to installation of the median. However, since traffic signals were subsequently added at three intermediate locations and street lights were later placed in the median, it is not possible to isolate the effect of the division strip on the accident record. With these limitations in mind, the before and after accident picture is as follows:

	Accidents per year			Accidents per MVM
	Pedestrian	Auto	Total	
Before	10	44	54	6.60
After	3	50	53	5.30

THE SUMMARY

Reasons for Choice of this Design - Meager data on four-lane highways indicate that accidents involving cars moving in opposite direction are in the ratio of approximately 3 to 1 for the undivided and the double curb median. Accidents involving single cars and cars going in the same direction are slightly higher for the double curb median. The over-all picture would be that there is an advantage of the median in reducing total accidents but most particularly, the more serious kind.

This was the primary purpose of placing this median.

There are two other advantages peculiar to this particular location - the median provides a refuge for pedestrians crossing the wide street and also provides an area in which to place poles for street lighting. This latter advantage would apply in the case when the traffic is of the more slowly moving urban type, but

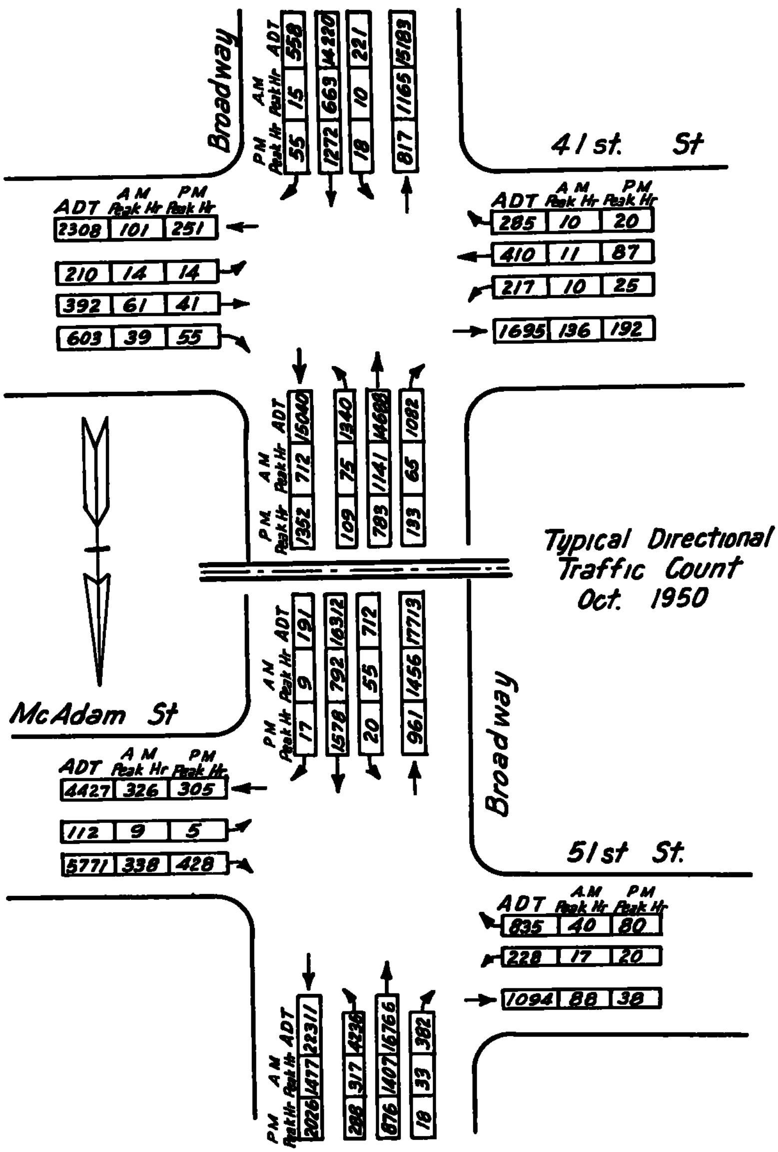


Figure 7.

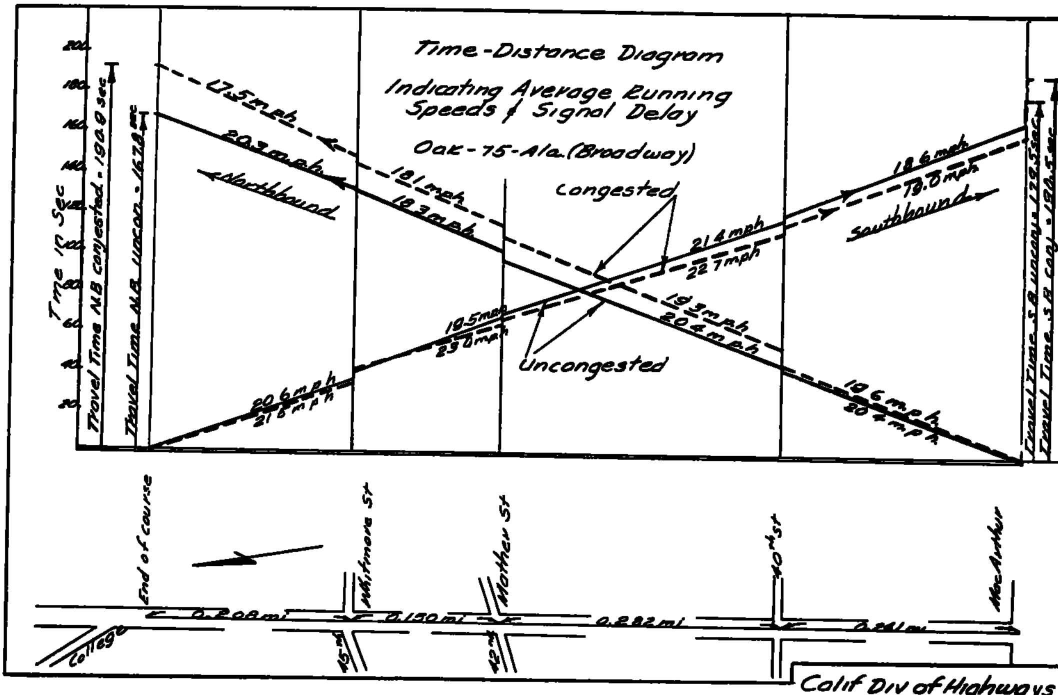


Figure 8.

unless the curbs were definite barriers to cars traversing the median, these obstructions would be a hazard to faster-moving traffic.

The selection of a 4-ft. width for this median was, of necessity, to fit in with future plans which call for reducing the width of each sidewalk by 5 ft., thereby providing space for three 10-ft. lanes and an 8-ft. parking area on each side of the street.

Demonstrated Advantages - Within the limitations noted in the before and after accident study, the improvements have resulted in a fair reduction in the over-all accident rate and a reduction of 70 percent in pedestrian accidents. The improvement in the latter phase of the accident picture is due to the fact that the median provides a safety island for pedestrians, and further, that the pedestrian is concerned at all times with only unidirectional traffic. Thus, in addition to the safety island, the installation has all the demonstrated advantages in pedestrian safety of one-way street operation.

Based on traffic counts made in July 1946, prior to the construction of the median, 1950 traffic counts show a four-year increase of approximately 28 percent. Although this is comparable to normal traffic growth in California over this period, Broadway is now handling a very heavy volume of traffic for a four-lane arterial and this traffic is able to maintain a fair rate of speed even during peak conditions. It is believed that the separation of opposing traffic has increased the traffic capacity of this street.

Suggestions for Future Design -

A suggestion for future narrow median design is that the width of openings in the median at intersections be greater than the present design on this street. Observation indicates that the narrow openings force left turns to be sharp and awkward. As previously stated, the safety islands are an important factor in the low pedestrian accident rate and should the median openings be enlarged, this desirable feature should be maintained by angling pedestrian lanes slightly to intersect the shortened medians.

Physical conditions do not lend themselves for development of a parallel route and hence long-range planning calls for further widening of the present street. The narrow 4-ft. median has not facilitated the making of left turns and the waiting cars necessarily block the inside lane. It has, therefore, been the recommendation of the District Highway Office to establish setback ordinances which insure a median of sufficient width to provide a left-turning median lane along with the necessary number of lanes for future traffic.

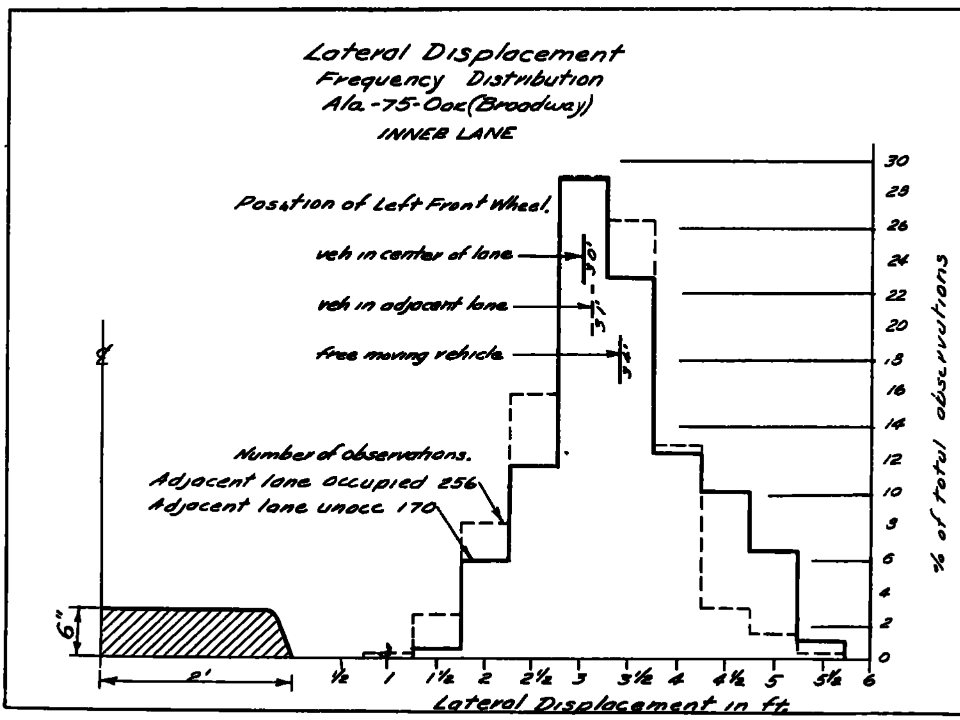


Figure 9.

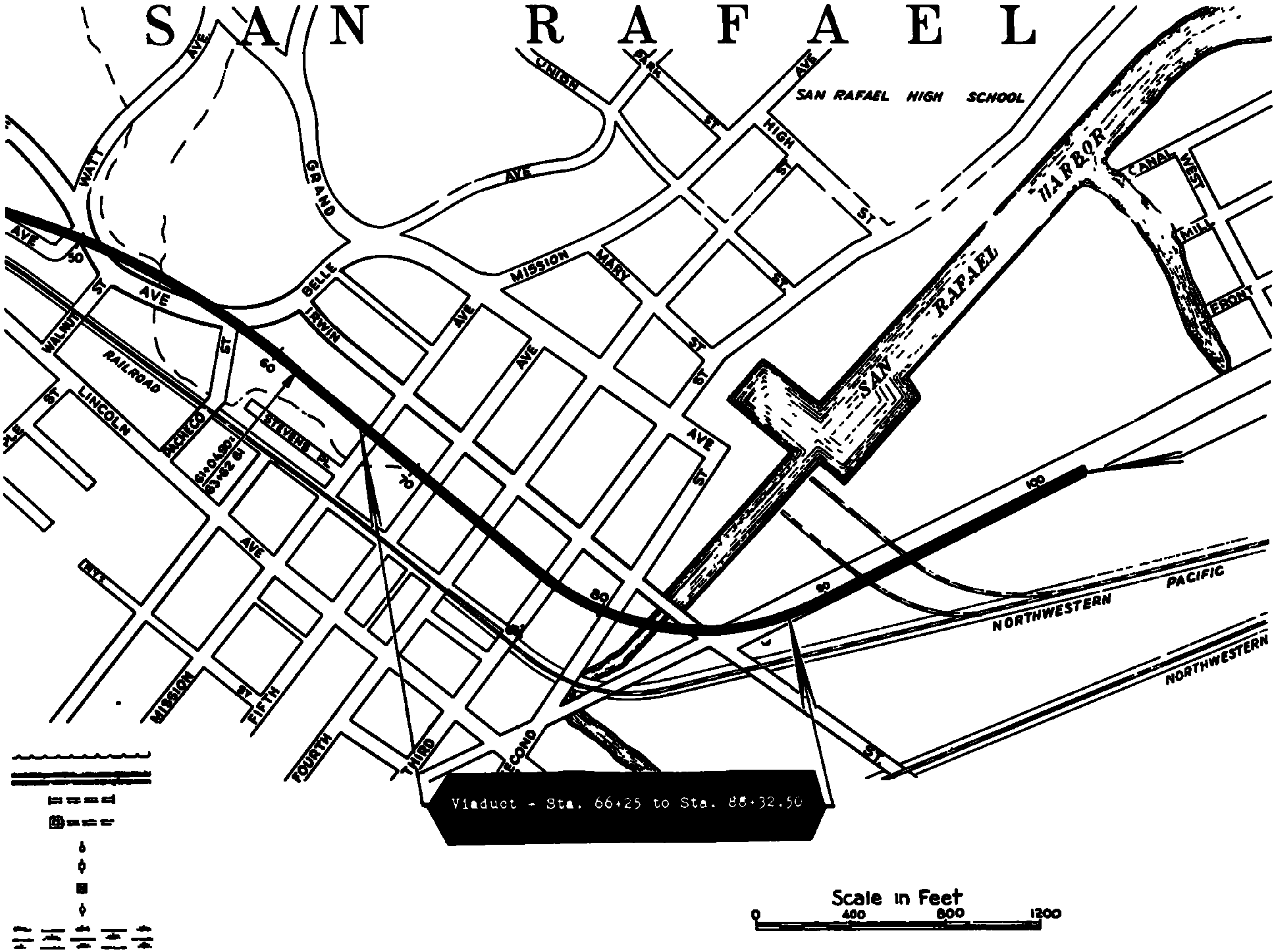

SAN RAFAEL
SAN RAFAEL HIGH SCHOOL
SAN RAFAEL HARBOR
CANAL
WEST
MILL
FRONT
UNION
PARK
AVE
HIGH
ST
GRAND
MISSION
MARY
BELLE
IRWIN
WATT
WALNUT
RAILROAD
LINCOLN
PACHECO
STEVENS PL
FIFTH
FOURTH
THIRD
SECOND
NORTHWESTERN
PACIFIC
50
60
70
80
90
100
Viaduct - Sta. 66+25 to Sta. 88+32.50
Scale in Feet
0
400
800
1200

Figure 10.

Figure 11. Freeway Through San Rafael

A LONG STRUCTURE ON AN ELEVATED HIGHWAY

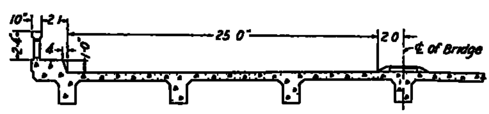
THE SITE

The location shown in Figures 10 and 11, and covered by the following report is the San Rafael Viaduct and approaches in the town of San Rafael, Marin County, California, (State Highway Route Mrn-1-SRF), a length of 0.6 mi. (2,257 ft. of viaduct plus two 500 ft. approaches.) This location was chosen as being representative of a long structure or elevated highway.

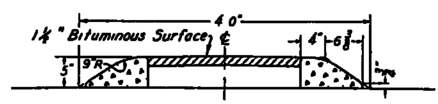
This 0.6 mi. section passes directly through the central business area and a part of the residential area of the town of San Rafael, which has a population of approximately 14,000. It is part of the Redwood Highway which extends from the Oregon State Line near Crescent City to San Francisco. The highway is the main arterial serving all of that portion of Northern California situated west of the Coast Range Mountains. To the north it traverses the highly publicized Redwood Empire that is renowned for recreational facilities and lumbering activities. Upon completion of a six-mile contract now underway, between Ignacio and San Rafael, this road will provide a continuous four-lane limited access freeway from San Francisco to north of Petaluma, a distance of 35 mi. An additional 16 mi. to the north of Petaluma is in the planning stage.

THE HIGHWAY

As shown on the typical cross section, Figure 12, the roadway construction on the viaduct consists of a 4-ft. median, two 25-ft. concrete pavements and two 2-ft. 11-in. sidewalks including the sloping curb and concrete railing. This makes an over-all width of 59-ft. 10-in. for the structure. There are two double stripes immediately adjacent to the median, each double stripe occupying one foot of its respective 25-ft. roadway. The remaining 24-ft. widths are divided into two 12-ft. lanes by a center stripe. (See Figs. 13-15)



TYPICAL SECTION



DETAIL OF MEDIAN

Figure 12. California - Long Structure, San Rafael Freeway

There are no intersections at grade on the viaduct or approaches. With the exception of the crossing of two railroad spur tracks just south of the southerly approach to the viaduct, there are no intersections for the entire two-mile length of freeway through the town of San Rafael. The nominal amount of train movements on these spurs does not warrant separation of grades.

Crossing from one side of the viaduct to the other is accomplished by passing under the viaduct on existing city streets.

On and off ramps are provided at convenient locations along the freeway. There are none on the viaduct proper. On the freeway just north of the viaduct there is an "off ramp" for northbound traffic and an "on ramp" for southbound traffic. Farther north there is an "on ramp" for northbound traffic and an "off ramp" for southbound traffic.

Just off the southerly approach to the viaduct is an "on and off ramp" for traffic in each direction. As can be seen in the map Figure 11, accelerating traffic and decelerating traffic mixes on the freeway. It is intended to rearrange these ramps so that this weaving will take place on the frontage roads rather than on the freeway.

Although provision has been made for lighting installation on the viaduct, at present except for city street lighting at various locations on the frontage roads, no illumination is provided on the viaduct structure.

On the viaduct structure, surface water is collected at frequent intervals with drains along the curbs and disposed of with down-drains emptying into a drainage channel that runs longitudinally beneath the structure.

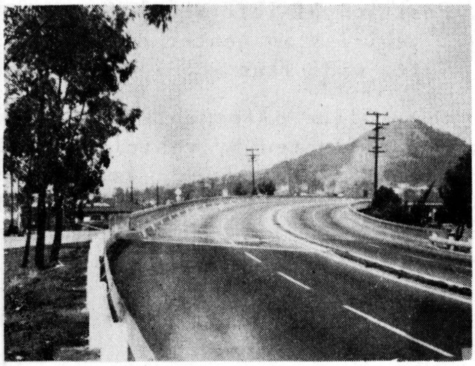


Figure 13.

THE MEDIAN

The median is 4 ft. wide between the outer extremities of the curbs and 5-in. high. A detailed cross-section of the curb is shown in Figures 12 and 14.

The intervening space between the curb is filled with 3½-in. of crusher run base and 1½-in. of plant mix surfacing.

There are no signs or obstructions or openings in the median.

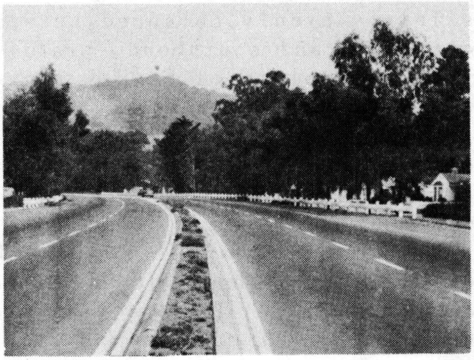


Figure 14.

THE CURB

The total cost of the .42 mi. of viaduct structure was $395,000 in 1939-40.

Approximately $25,000 of the above amount represents the added cost of increasing the width of the structure by 4 ft. to provide for the median.

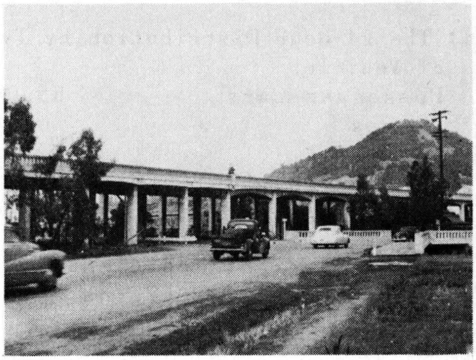


Figure 15.

TRAFFIC

Sunday traffic patterns on this section of highway bear little relation to the weekday traffic.

Sunday traffic volumes, as obtained by the July count, are 70 percent greater than the Monday volume. In addition, although weekday traffic is fairly evenly balanced between northbound and southbound traffic, the heavy volume of Sunday recreational traffic northbound from San Francisco in the morning hours, concentrates in an extremely heavy southbound movement during a few hours in the evening.

Traffic data are based on the July Sunday and Monday 16 hr. counts on the San Rafael Freeway, adjusted through adjacent monthly and 24 hr. stations.

(1) Average Daily Traffic = 17,800

(2) Peak Hour Percentages:
Sunday (8PM to 9PM) =19.4% of the ADT
Weekday (7AM to 8AM)=12.2% of the ADT

(3) Peak Hour Directional Flow:
Sunday - 23 percent northbound
77 percent southbound
Weekday - 50 percent northbound
50 percent southbound

(4) The 24 Hour Distribution by Type of Vehicle:

Passenger Cars	89.05%
Busses	0.05%
Pickups	2.29%
2 Axle Freight Vehicles	3.04%
3 Axle Freight Vehicles	1.30%
4 Axle Freight Vehicles	1.28%
5 Axle Freight Vehicles	1.93%
6 or more Axle Vehicles	1.06%

Speed Data - Vehicle speeds were obtained by use of the Electromatic Speed Meter. 651 vehicles were recorded:

Average speed	=	49.1 mph
85 percentile	=	55.3 mph

Vehicle Placement Data - Vehicle placements for both inner and outer lanes were obtained by the use of strips of white plastic tape on the pavement with the observer stationed some 300 to 400 ft. ahead on the structure sidewalk. Results are plotted in Figures 16 and 17.

A double stripe has been placed adjacent to and on each side of the median curbs providing a neutral area one foot in width on each side. This in effect divides the structure into four 12-ft. traffic lanes and a six-foot median, 4 ft. of which is curbed. However, the double stripe neutral zone is traversable and vehicle placements indicate that drivers utilize this inner lane as though it is 13 ft. in width.

Inner lane placements as measured by distance between left front wheel and face of median curb are as follows:

Adjacent lanes unoccupied	-4.3 ft.
Adjacent lanes occupied	-3.8 ft.
Position of left wheel for vehicles in center of 12 ft. lane offset one foot	-4.5 ft.
Position of left wheel for vehicles in center of 13 ft. wide lane	-4.0 ft.

Outer lane placements were found to be unaffected by vehicles in the adjacent inner lane. Average of outer lane placement as measured by distance of right front wheel from bottom face of 12-in. curbs was 5.6 ft.

Position of right wheel for vehicle in center of lane is 3.5 ft.

Accident Experience - A total of 6 accidents has been reported on the 2257 ft. length of this structure during the 5 year and 3 month period between 6/14/45 and 9/1/50. The accident rate for this full period is computed as 0.54 accidents per million vehicle miles. Although this rate is low, it appears rational when compared with accident rates experienced on other full freeways in this State.

Of the six accidents, three were rear-end collisions, one of which involved a stalled car. The other three were single-car accidents as follows; an intoxicated driver ran into the railing, a blowout threw a car out of control and into the abutment, and one car ran over the median and turned over. Four of the six were injury accidents and two were property damage only.

THE SUMMARY

Reasons for the Choice of this Design- The San Rafael Freeway was constructed during 1939-40 to alleviate a serious bottleneck that had developed in San Rafael due to the increased volume of through traffic using the narrow city streets which were already taxed to capacity by measured local traffic. The viaduct structure was selected to carry the freeway through the more congested part of town, so as to allow a free passage of local traffic under the viaduct on existing city streets. The purpose of the median was, of course, a safety precaution to more effectively separate the opposing fast-moving traffic. The use of a narrow median was an economical expedient resulting in a saving in width of roadway, viaduct structure and right-of-way.

Demonstrated Advantages - The freeway has demonstrated its ability to carry a large amount of through traffic and at the same time provide safe ingress and egress for local traffic.

The median has been efficient in preventing accidents involving opposing traffic as is evident by the absence of accidents of that nature. As there are no left turns permitted and therefore no need for median storage lanes, a wider median would seem to be of no advantage.

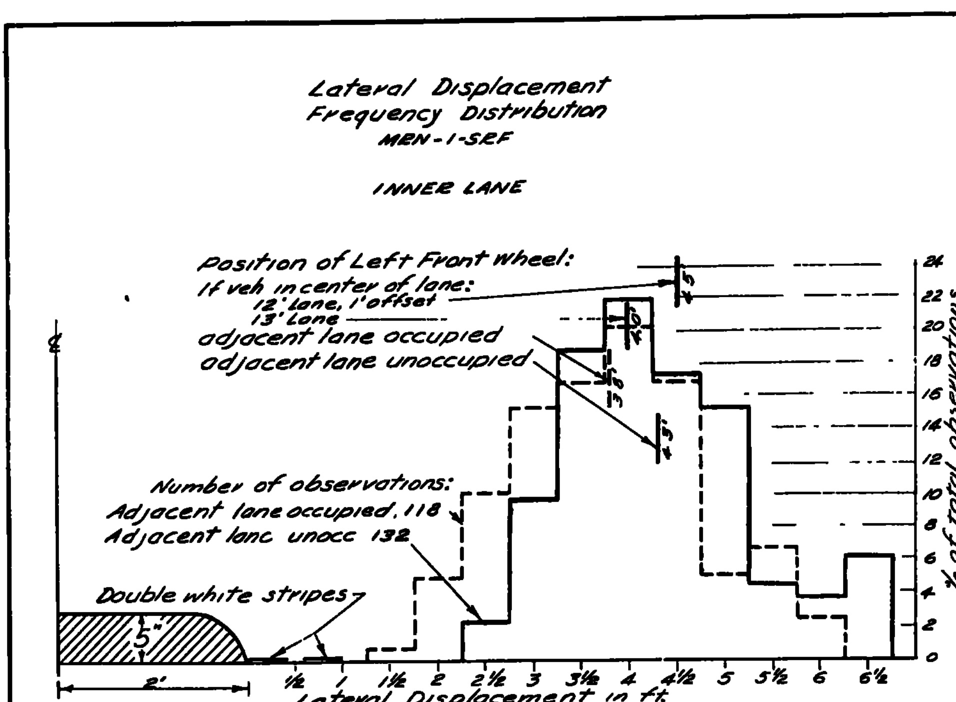


Figure 16.

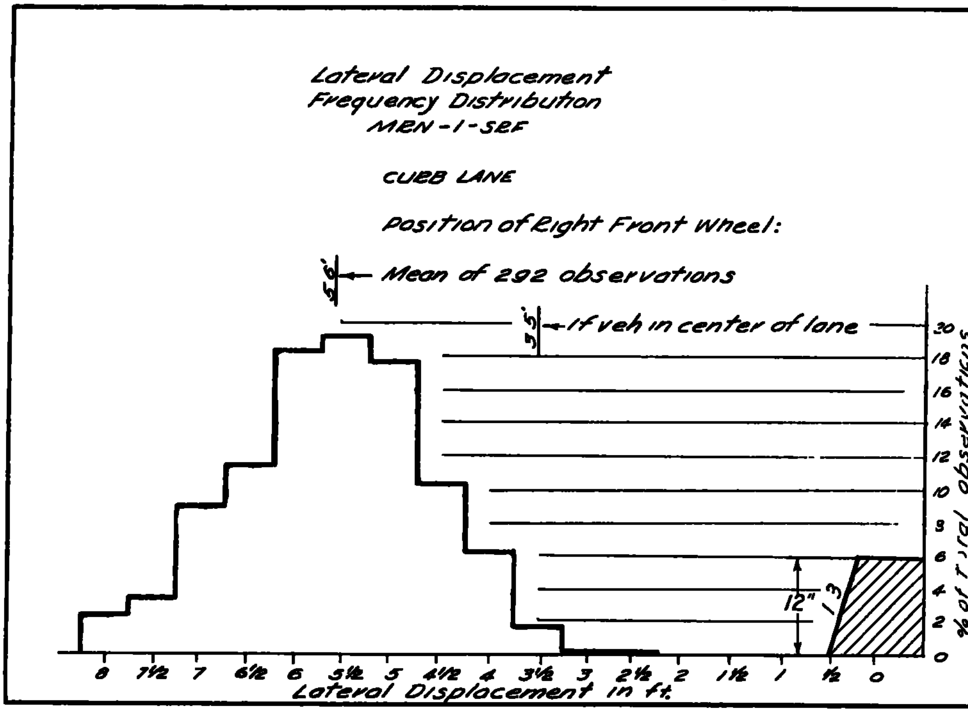


Figure 17.

Suggestions for Future Design - It has been the practice in California to provide 6-ft. medians on long structures. Although the median on the San Rafael Freeway is only 4 ft. curb to curb, there are double stripes immediately adjacent to the curb which makes a total of 6 ft. which may be assigned to the median. However, a study of vehicle placement (see Fig. 16), indicates that traffic in the inside lane ignores the double stripe and treats the area between the center stripe and the curb as a 13-ft. lane. Therefore, it is the recommendation of the Design Department that serious consideration be given to limiting the median on long structures of this type to four feet. Additional structure width can be used to much better advantage as a part of continuous emergency parking shoulders on the right, either full or partial width.

HIGHWAYS WITH A NARROW MEDIAN - CONNECTICUT

Ernest T. Perkins, *Engineer of Survey and Plans, Connecticut State Highway Department*

This paper, being one of several to be given on highways with a narrow median, is intended to present data that can be combined with that contained in other reports. For that reason, there will be no attempt made to elaborate by statistical method nor will conclusions be drawn.

The conditions set up in a proposal for a "Symposium on Highways With a Narrow Median" called for "A median 8 ft. or less in width, of raised curb, rounded or flush section". Elements to be included in the 8-ft. dimension have been defined as follows: The gutter pan is not considered as a part of the traffic lane when the pan is of contrasting color and texture and when used in conjunction with a barrier curb; in which case, the curb and gutter sections are part of the median and its width is measured between the outer edges of gutter pans. If the gutter pan is of the same surface color and texture as the traffic lane, and is not much steeper in cross slope than the adjoining pavement, it is considered as an element separate from the median when the curb is mountable.

Six narrow median conditions were contained in the proposal. The following four are dealt with in this paper: Major street through residential or suburban area, Major street with ribbon commercial development; Long structure; Expressway.

The remaining two conditions, rural divided highway, without control of access and major street through central business or industrial area, are not included in our highway system. From the beginning of our divided highway construction, we have been successful in keeping the median widths to a minimum of 20 ft. in rural areas where access is not controlled. As Connecticut was one of the early areas to be developed in this country, the city streets were generally not established to sufficient widths to permit construction of medians. Then, too, our State laws are such that the State is responsible for but a relatively small mileage of city streets. As late as 1937, the following law was enacted: "Sec. 2240. *Through routes in cities and towns*. One through route extending approximately north and south through each city and town and one through route extending approximately east and west through each city and town shall be included in the Trunk Line System of highways, provided the highway commissioner shall have authority to make agreements with such cities relative to the removal of snow."

The "Proposal" called for the selection of a narrow median section in use that is considered to be good design. Narrow medians, that have been constructed in Connecticut, have been in locations where a downward grading of desirable standards was made necessary because of high property damage that would result, otherwise. Because of the limited number of highways with a narrow median from which to select, the ones treated in this paper are about the only ones in Connecticut that fit into the six suggested groupings.

At the present time, there are 2,948 mi. of State-maintained highways and 11,573 mi. of local roads and streets in Connecticut, making a combined total of 14,521 mi. Of the 11,573 mi. of local roads and streets, 194 mi. are on state-marked routes and, after reconstruction, will become a part of the State highway system.

The speed data, included in this report, were obtained by use of radar equipment. Placement studies were made by setting off lines, from the median curb outward, at one-foot intervals, and vehicular performance was recorded by an observer stationed at the site. Speeds were recorded for those vehicles that were included in the placement observations. Vehicles included in the sample were those which were traveling freely and were not influenced by the actions of other drivers.

Major Street Through Residential or Suburban Area - A section of Route US 5A in the Town of Windsor, and the Saltonstall Parkway, Route US 1 in the Towns of New Haven and East Haven, have been selected for major streets through residential or suburban areas. The Town of Windsor is devoted principally to residential and agricultural use. Industry is beginning to locate along the main line railroad that runs between Springfield, Massachusetts, and Hartford, Connecticut, but there has not been a sufficient movement up to this time to alter the residential and agricultural nature of the Town. The Saltonstall Parkway in New Haven and East Haven was constructed with a narrow median beginning at Townsend Avenue and extending some distance to the east. A narrow median was used because of the closely built-up nature of the area at the beginning of the project, because of the deep swamp that existed beyond the built-up section and because of the Shore Line tracks of The New York, New Haven and Hartford Railroad Company and an adjacent residential area.

Table 1 shows traffic data for all projects. It will be noted that Route US 5A in Windsor carries 11,000 vehicles per day, of which 15 percent is classed commercial. Route US 1 in New Haven and East Haven, has an indicated average daily traffic of 15,500 of which 16 percent is classed as commercial vehicles.

Figure 1 is a view in the Village of Wilson. On the right (east) side of the street there is a group of neighborhood stores and on the left (west) side, in the center of the figure, the local school may be seen. Each roadway is 25 ft. curb to curb. Roadways are separated by a median strip 6 ft. 2-in. wide between curb faces. Figure 2 shows the typical cross section of the roadway. Due to parking that occurs in front of business establishments, there is but one lane available for use by through traffic, and traffic in that lane is hindered by vehicles maneuvering to park.

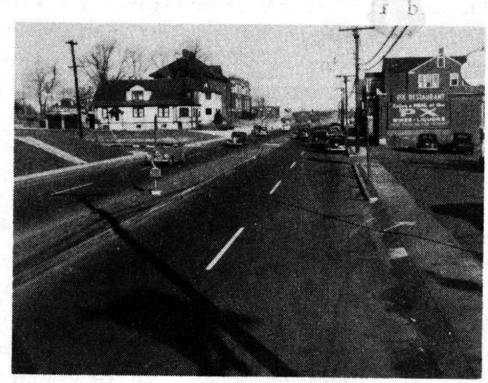
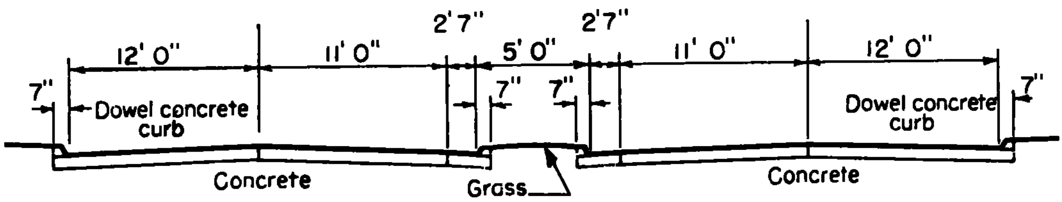
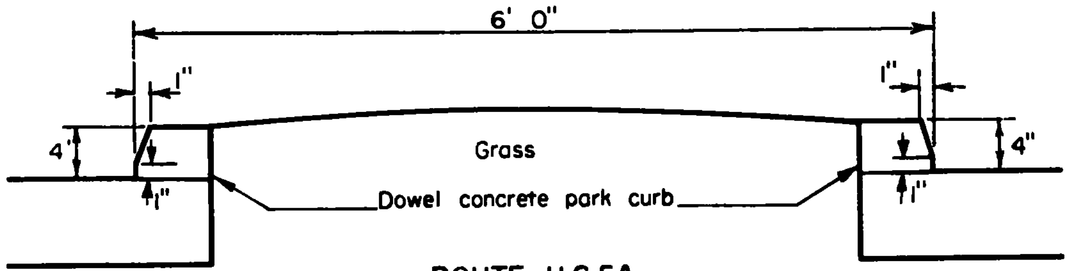


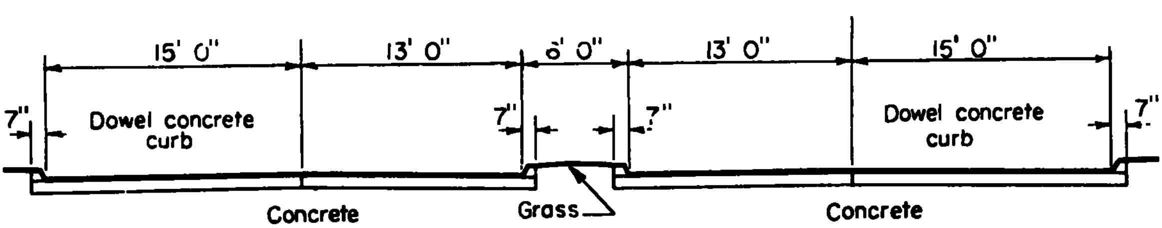
Figure 1. Town of Windsor - Route US 5A

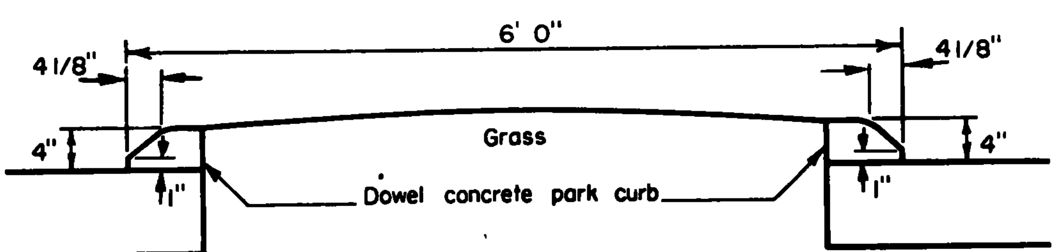
TYPICAL SECTION





ROUTE U S.5A
HARTFORD—WINDSOR ROAD
TOWN OF WINDSOR





ROUTE U.S.I
NEW HAVEN — SAYBROOK ROAD
TOWNS OF NEW HAVEN & EAST HAVEN

Figure 2.

TABLE 1

TRAFFIC DATA

LOCATION	1950 LENGTH (MILES)	AVERAGE DAILY TRAFFIC	30TH HIGHEST HOUR AS % OF A.D.T.	30TH HIGHEST HOUR IN MAJOR DIRECTION AS % OF A.D.T.	VEHICLE MILES 100 MILLION 1946-49	COMPOSITION % PASSENGER	% COMMERCIAL
WINDSOR ROUTE U.S 5A	3.77	11,000	13	8	.482	85	15
NEW HAVEN-EAST HAVEN ROUTE U.S. 1	1.85	15,500	14	8	.377	84	16
BRIDGEPORT ROUTE U.S. 1 FAIRFIELD AVENUE	1.50	21,000	12	6	.418	74	26
FAIRFIELD ROUTE U.S. 1A KINGS HIGHWAY	1.85	15,000	12	6	.366	81	19
HARTFORD RIVER FRONT BOULEVARD	1.01	27,000	15	12	.282	87	13
NEW LONDON-GROTON THAMES RIVER BRIDGE ROUTE U.S. 1	1.12	16,000	12	7	.292	92	8
HARTFORD-EAST HARTFORD CHARTER OAK BRIDGE OVER CONNECTICUT RIVER ROUTE 15	0.61	33,000	12	7	.184	91	9
MILFORD-STRATFORD MERRITT PARKWAY OVER HOUSATONIC RIVER ROUTE 15	0.34	18,000	17	10	.061	100	0

Figure 3 shows a view just beyond the built-up section shown in Figure 1. This section was built as a relocation and has remained rural in character until this year. A housing development is under construction to the left and just out of the view shown. It is expected that this area will build up rapidly now that the first development is under way. Openings were left in the median strip to accommodate future streets.

Figure 4 is a view across the deep swamp in New Haven and East Haven. The better ground to the east is being filled in and a Drive-In Theatre has been constructed within the last two years. We are working on plans, at the present time, that will convert this section of full access highway to a non-access highway. Service roads are planned to provide access to abutting properties.

Figure 2 shows the typical cross section for Route US 1 in New Haven and East Haven. Each roadway is 28 ft. wide between curbs, and the median strip is 6 ft. between curbs.

Figure 3. Town of Windsor - Route US 5A

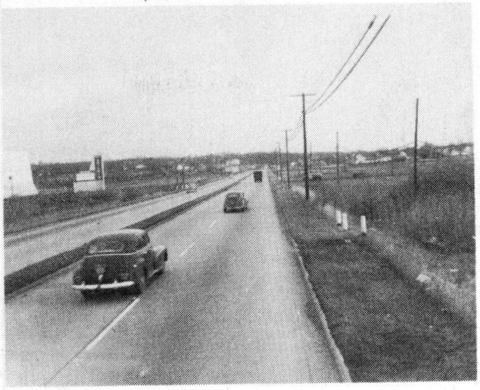


Figure 4. Towns of New Haven and East Haven, Route US 1, (Saltonstall Parkway)

Figure 5 shows a plan and profile for Windsor, Route US 5A. It will be noted that residences, businesses, churches and a school are located within the half-mile section shown. Openings have been provided in the median strip to accommodate side streets and the opening at Station 36 is for the convenience of abutting properties. The minimum length of opening within the area included on the figure, is 69.0 ft. opposite Allen Street and the greatest opening of 164.9 ft. is located at Station 45 to accommodate an offset intersection. Grades for most of the 3.77 mi. of this road are of the order shown on the profile. There is one grade of about 7 percent for a length of possibly 1,000 ft. as the road approaches the Village of Windsor.

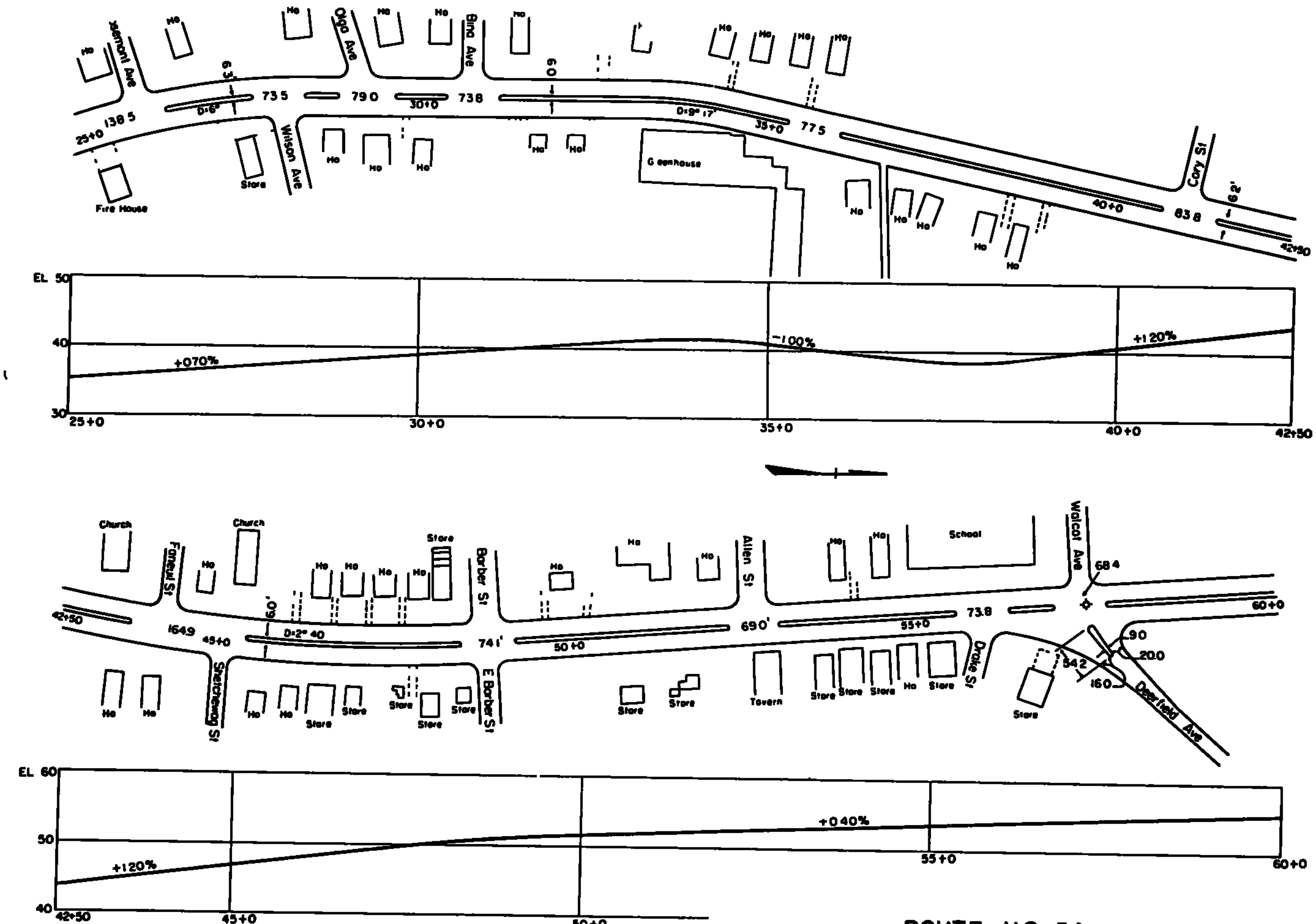
Figure 6 is a plan and profile for the New Haven-East Haven highway. Median openings are well spread due to spacing of the established streets and also because no openings were provided through the swamp area east of Peat Meadow Road. Grades through the remainder of the sections under study are no greater than those shown on the Figure.

Figure 7 shows the speed curves for both Route US 5A in Windsor and Routes US 1 in New Haven and East Haven. The 85 percentile speed for for former is 31.5 M.P.H. whereas the latter has an 85 percentile value of 45.8 M.P.H. The speed differential is due, in part, to the more local nature of traffic on the Windsor section and also because of the frequency of marginal parking which results in one-lane operation with resultant congestion during periods of heavy traffic flow.

Figure 8 shows placement of left wheels in relation to the median curb for the Windsor Section. For the three speed groupings shown, the greatest number of vehicles travel with the left wheel between 6 and 8 ft. from the curb. The majority of drivers seem to stay about 7 or 8 ft. from the curb and there does not appear to be any great difference in the placement between the speed groupings shown.

Figure 9 shows the placement of vehicles on the New Haven-East Haven section. Because of the greater speed range, five groupings are shown. The greatest number of vehicles was observed at an offset of from 4 to 6 ft. from the median. The highest speed groups were about evenly distributed between the 3 and 7 ft. offset with the greatest percent being observed at 6 ft.

Accident data included on Table 2 show a greater accident frequency for Route US 5A in Windsor than for Route US 1 in New Haven and East Haven. It should be noted in Table 1 that the former is 3.77 mi. in length while the latter is 1.85 mi. in length. Accidents per hundred million vehicle miles are 690 for the Windsor section and 250 for the New Haven-East Haven section. Injuries for Windsor are indicated at the rate of 420 per hundred million vehicle miles and 160 for New Haven-East Haven. Property damage is at the rate of $160,000 per hundred million vehicle miles for Windsor, and $65,000 for New Haven-East Haven. The fatality rate is more severe in



ROUTE U.S. 5A
HARTFORD—WINDSOR ROAD
TOWN OF WINDSOR

SCALE
100 0 100 200 FEET

Figure 5.

New Haven-East Haven than in Windsor, the comparison being 6.2 per hundred million vehicle miles for the latter and 8.0 for the former.

Table 3 is a summary of State-wide accident experience for the various classes of highways found in Connecticut. The Windsor road is well above the State average for accidents for divided highways at grade, while the New Haven-East Haven road is below average. Windsor is at about the State average for fatalities while the New Haven-East Haven road is above average. Both injuries and property damage are above average in Windsor and below average in New Haven-East Haven.

Turning movements have not been included as part of the traffic data. There is a considerable difference in use of side streets between the two sections of highway. Streets that intersect Route US 5A in Windsor

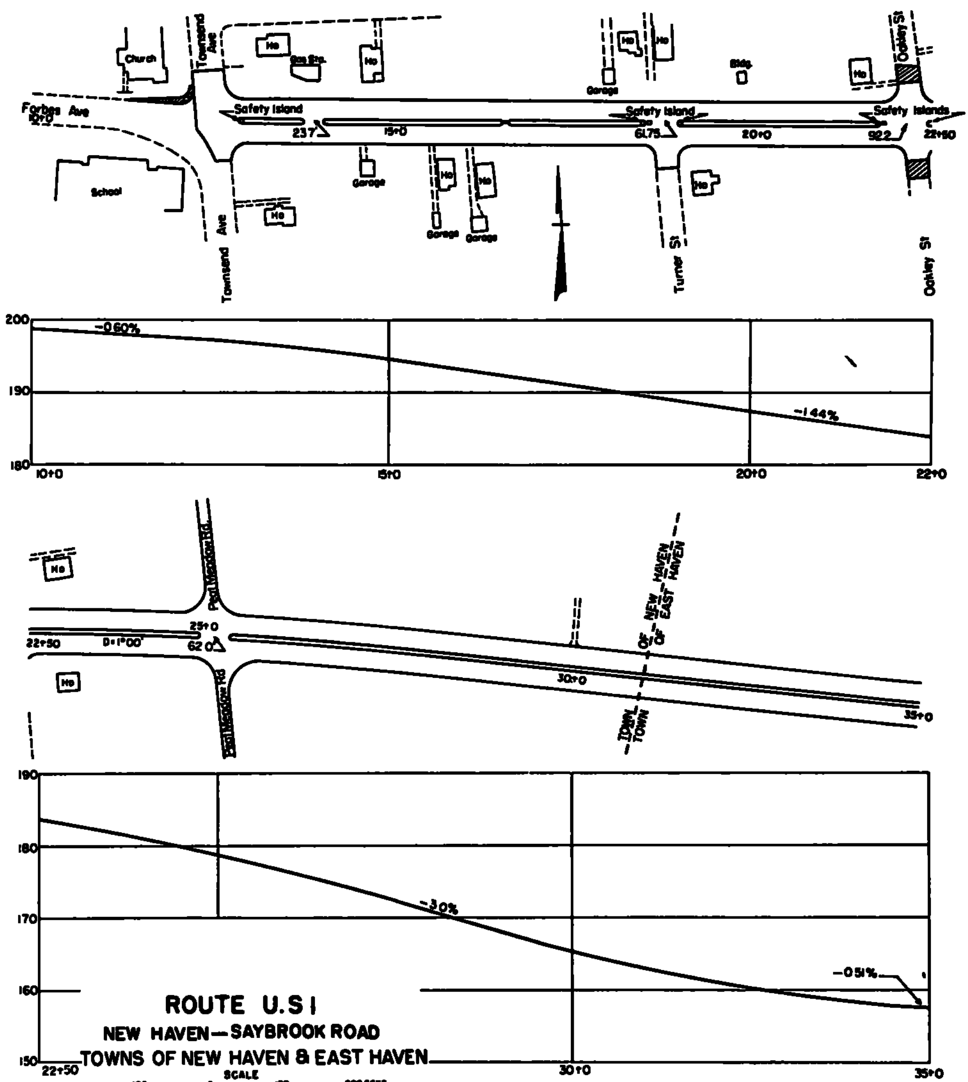


Figure 6.

serve residential areas for a considerable distance on each side with few streets paralleling the main highway. Streets that intersect the New Haven-East Haven highway serve only shallow streets that, in turn, intersect with streets parallel to, and not far from, the main highway. Turning movements along the Windsor road are, therefore, much greater than along the New Haven-East Haven road.

Although traffic volumes on Route US 1 in New Haven-East Haven are 40 percent greater than on Route US 5A in Windsor, there is a much greater freedom of movement on the former. The relative speeds, previously mentioned, also bear out this point.

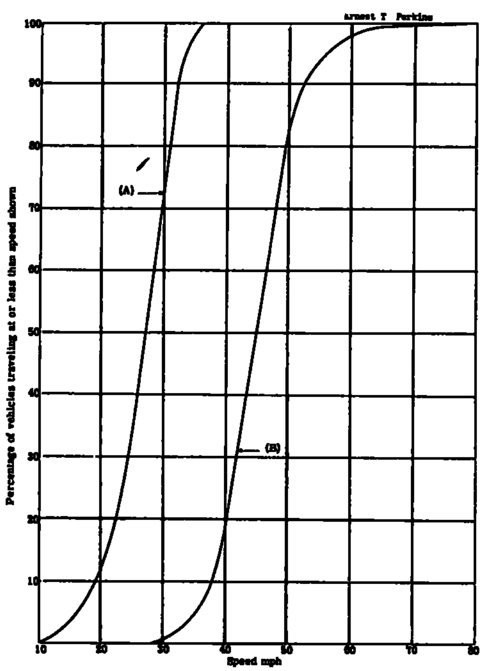


Figure 7. HIGHWAYS
(A) Windsor - Route US 5A Nov. 27, 1950 1.05-1 40 PM 100 OBS S-N AV. SP. 27.3 MPH 85 Percent SP. 31.5 MPH
(B) New Haven and East Haven Route US 1 Nov. 30, 1950 1:20-2 50 PM Dec. 1, 1950 12.05-2:40 PM 100 OBS W-E AV. SP. 45.8 MPH 85 Percent SP. 50.4 MPH

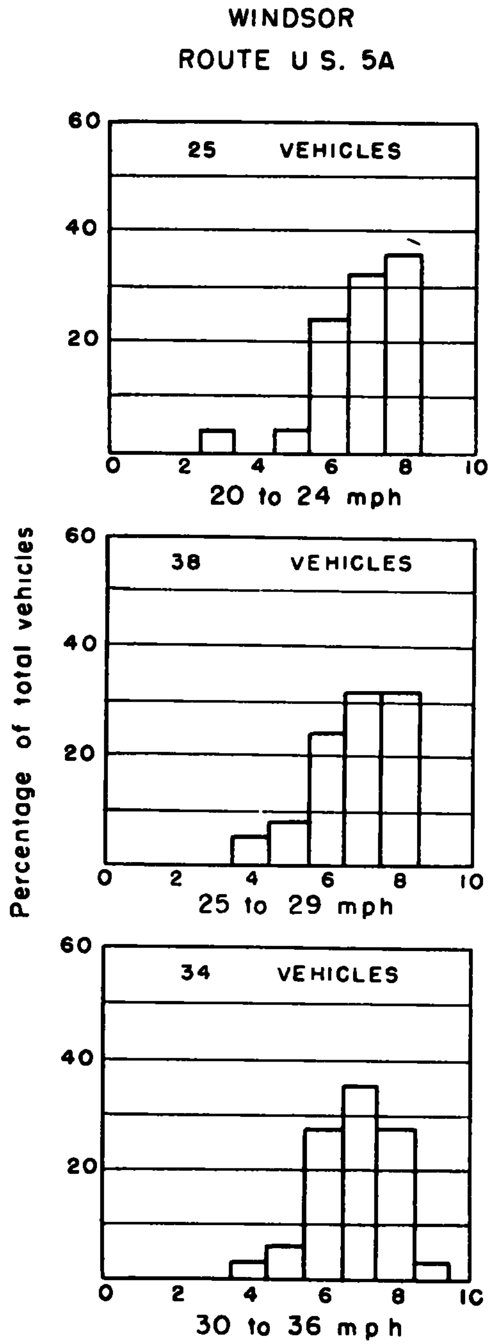


Figure 8. HIGHWAYS - Distance in feet that left wheels were to right of curb

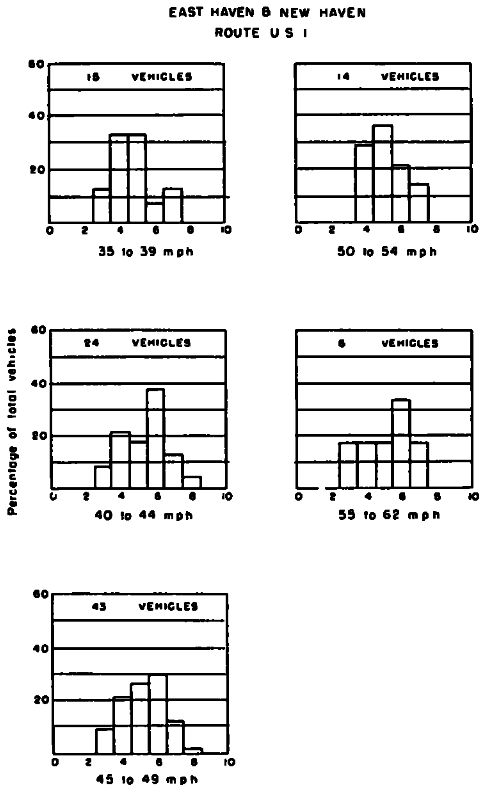


Figure 9. HIGHWAYS - Distance in feet that left wheels were to right of curb

Aside from the frequency of side streets on Route US 5A, there are also drives at closely spaced intervals. The greater turning frequency and marginal parking along Route US 5A, reduces the effective travelway to little more than one lane in each direction. This results in more congestion with the attendant higher accident frequency.

An examination of accident data for Route US 5A in Windsor and that shown in Table 3 for Multiple Lane Undivided Highways at Grade, reveals that the rate for Windsor is higher than the State-wide average for the lower class of highway. It was previously noted that the rate for Windsor was substantially higher than the State-wide average for Divided Highways at Grade. It must be concluded, therefore, that the median strip is more effective on Route US 1 in New Haven-East Haven where two-lane operation is possible and parking and turning movements are light.

The department is developing plans for a non-access expressway that will be located a short distance to the west of Route US 5A between Hartford and Windsor. Property damage would be prohibitive, if alteration of the present highway to higher standards were undertaken. The expressway should divert a sufficiently large volume of traffic that congestion along the present road would be greatly relieved.

Route US 5A in Windsor was constructed in 1942 at a cost of about $467,000 or about $131,000 per mile. Our cost index used 1939 prices as a base of 100. The present index is about 184.15 which means that it would cost about $226,000 per mile to carry out the same construction at the present time. The cost of constructing the median section is estimated at about $2.40 per foot.

Route US 1 in New Haven-East Haven was constructed in 1941 at a cost of about $160,000 per mile. This highway was largely a relocation while the Windsor project was principally along old Route US 5A with only one major cutoff about one-half mile in length. The cost of constructing the median in New Haven-East Haven was about $2.00 per foot.

Major Street With Ribbon Commercial Development - The two streets selected for this grouping are Route 1 (Fairfield Avenue) in the Town of Bridgeport, and Route US 1A (Kings Highway) in the Town of Fairfield. Route US 1 runs directly through the City of Bridgeport while Route US 1A follows a looping, northerly route through outlying residential and neighborhood shopping areas of Bridgeport.

TABLE 2

ACCIDENT DATA

LOCATION	4 YEARS (1946-1949)								
	VEHICLE MILES 100 MILLION	TOTALS				RATES PER 100 MILLION VEHICLE MILES			
		ACCIDENTS	FATALITIES	INJURIES	PROPERTY DAMAGE	ACCIDENTS	FATALITIES	INJURIES	PROPERTY DAMAGE
WINDSOR ROUTE-U S 5A	482	334	3	204	81,530	690	6 2	420	169,000
NEW HAVEN-EAST HAVEN ROUTE U S. 1	377	94	3	62	24,460	250	8 0	160	65,000
BRIDGEPORT ROUTE U S 1 FAIRFIELD AVENUE	418	226	1	102	35,490	540	2 4	240	85,000
FAIRFIELD ROUTE U S 1A KINGS HIGHWAY	366	152	1	63	38,725	420	2 7	170	106,000
HARTFORD RIVER FRONT BOULEVARD	282	60	2	32	19,530	210	7 2	110	69,000
NEW LONDON-GROTON THAMES RIVER BRIDGE ROUTE U S 1	292	52	0	86	11,120	180	0	300	38,000
HARTFORD-EAST HARTFORD CHARTER OAK BRIDGE OVER CONNECTICUT RIVER ROUTE 15	184	39	0	20	5,625	210	0	110	31,000
MILFORD-STRATFORD MERRITT PARKWAY OVER HOUSATONIC RIVER ROUTE 15	061	58	0	30	16,595	970	0	510	272,000

Town of Bridgeport - Route US 1 - (Fairfield Avenue) - Figure 10 shows the plan view and profile for a 3000-ft. length of the street. It can be seen that the street is largely commercial in character. This general pattern is followed throughout the 1.5 mi. involved. The block lengths are short with many of the opposite streets being offset one to another. This has resulted in long openings in the median strip and, in some instances, a short length of median strip was used in order to avoid an excessively long opening in the median strip.

The typical cross section for this street is shown in Figure 11. Roadways were constructed 31 ft. wide each side of a 5-ft. raised median. Barrier curbs were constructed as an aid to pedestrian safety and to channelize, more positively, traffic along this heavily traveled city street. Roadways are sloped each way from the median strip so as to require drainage only along the outside curbs.

Figure 12 is a view of the street. With a constant use of curb space for parking, the 31-ft. width of each roadway provides little more than one lane for through traffic on the lane adjacent to the median. The outside lane is devoted to parking and the frequency of vehicles entering and leaving the curb parking space just about eliminates the middle of the roadway as an additional through lane. It will be noted that a grass plot has been developed in the median area.

This street was reconstructed in 1940 at an average cost of $129,000 per mile. Using the 1950 index, the cost per mile would now be about

$238,000 per mile. The cost of constructing the median strip was about $3.40 per foot.

Data included in Table 1 show average daily traffic on this street to be 21,000 with 26 percent of the total vehicles being of the commercial class. The percent of commercial vehicles appears large because of the Merritt Parkway which runs to the north of, and parallel to, Route US 1 and which allows only passenger vehicles. The Merritt Parkway carries approximately 20,000 vehicles per day as it passes to the north of Bridgeport. Traffic volume for the 30th highest hour is shown as 12 percent of average daily traffic while the 30th highest hour in the major direction is 6 percent of average daily traffic.

Figure 12 is a photo of a section of the street. It will be noticed that curb parking is common and that the remaining apparent width is that of a wide single lane. A good turf has been developed in the median area and an occasional shrub has been planted.

Figure 13 shows the speed graph for the two streets included in this grouping. The 85 percentile speed is 32.5 mi. per hour.

Figure 14 shows the results of the placement study. The greater percentage of vehicles, in the four speed groupings shown, travel with the left wheel four feet from the

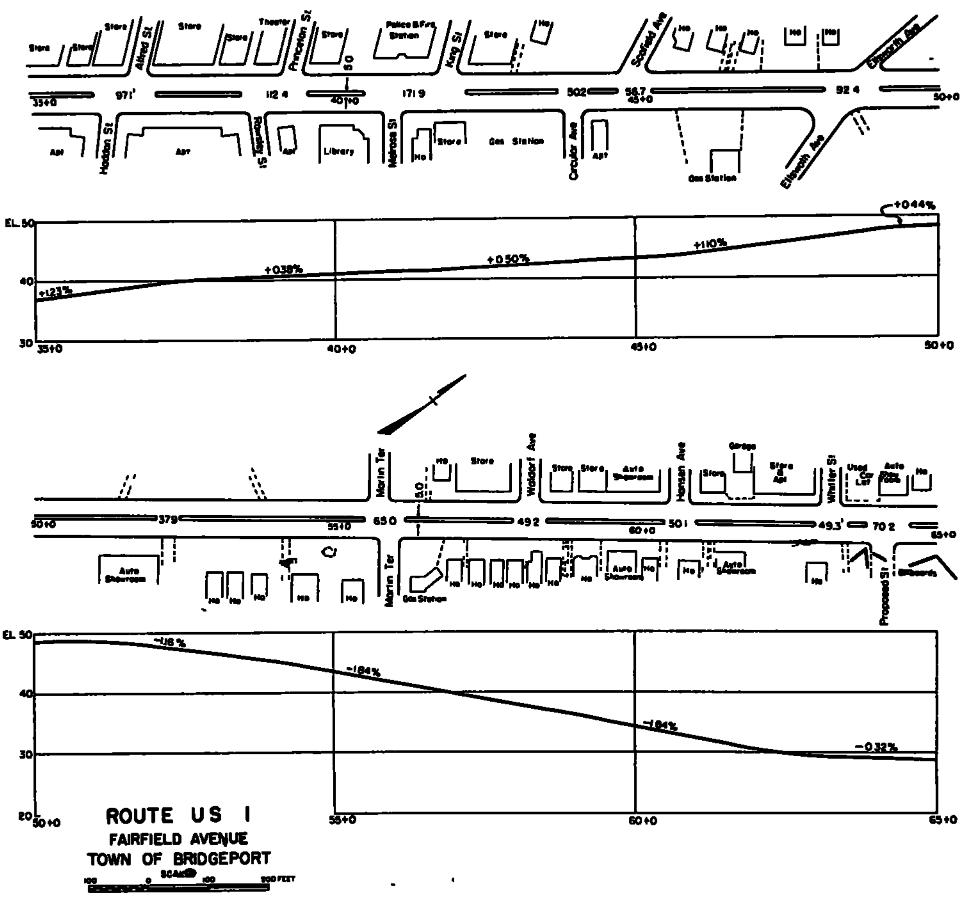
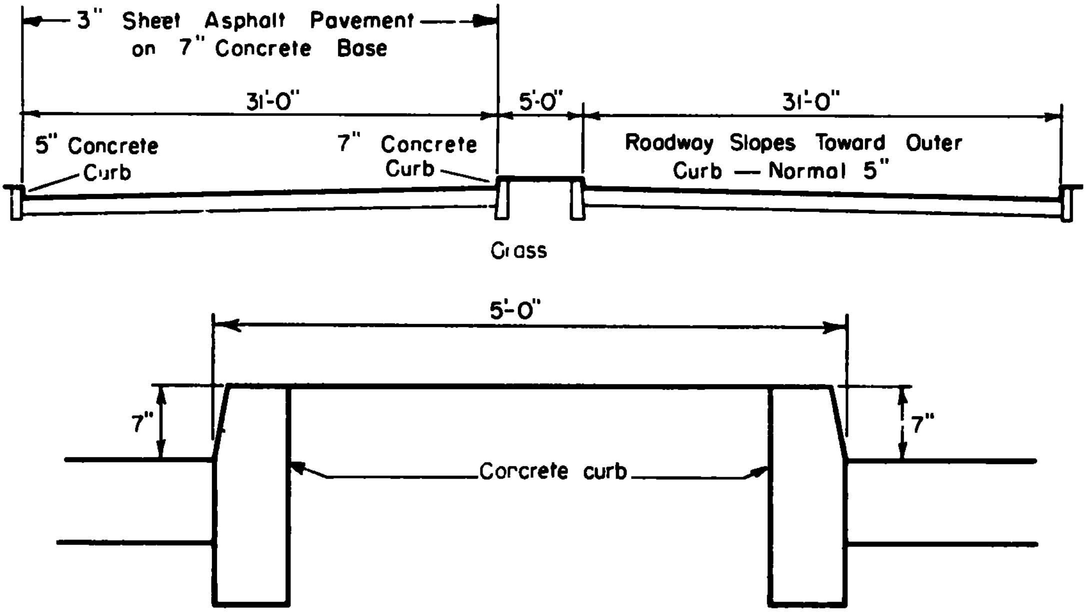
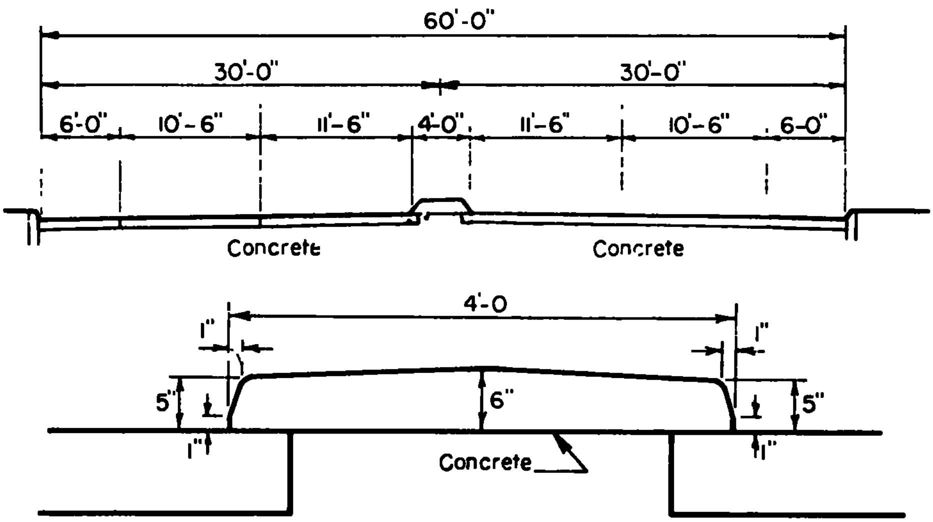


Figure 10.

TYPICAL SECTION



ROUTE U.S 1
FAIRFIELD AVENUE
TOWN OF BRIDGEPORT



ROUTE U S 1A
KINGS HIGHWAY
TOWN OF FAIRFIELD

Figure 11.

curb. The highest speed group, 35 to 39 M.P.H. shows the usual tendency to move away from the curb with about 22 percent of group traveling at 6 ft. from the curb.

Table 2 shows the accident rate to be 540 per hundred million vehicle miles. There is no way of making a close comparison with a State-wide average for similar streets as there are too few on the State highway system. The property damage rate is shown as $85,000 per hundred million vehicle miles, fatalities are at the rate of 2.4 and injuries at the rate of 240 per hundred million vehicle miles.

The design used for this street was the most generous that could be obtained for the location. The closely built-up nature of the street would have made any encroachment on properties a prohibitively costly undertaking. The width of the street and the number of pedestrians involved made the use of a median refuge area mandatory. Barrier curbs were used for added pedestrian protection. It is believed that the median design has served the purpose for which it was designed.

Figure 12. Town of Bridgeport Route US 1, Fairfield Avenue

TABLE 3

AS A COMPARISON OF ACCIDENT RATES THE FOLLOWING ARE THE RATES (PER 100 MILLION VEHICLE MILES) FOUND ON VARIOUS HIGHWAY TYPES IN CONNECTICUT FOR THE FOUR YEARS 1946–1949

	MILES 1-1-'50	RATES PER 100 MILLION VEHICLE MILES			
		ACCIDENTS	FATALITIES	INJURIES	PROPERTY DAMAGE
EXPRESSWAYS	20	240	1.3	140	$ 77,600
PARKWAYS	62	230	3.5	140	81,300
DIVIDED HIGHWAYS AT GRADE	46	430	6.5	230	111,500
MULTIPLE LANE UNDIVIDED HIGHWAYS AT GRADE	78	520	6.0	260	143,600
TWO LANE HIGHWAYS	2742	400	5.4	220	108,600
ALL STATE MAINTAINED HIGHWAYS	2948	400	5.2	210	$109,400

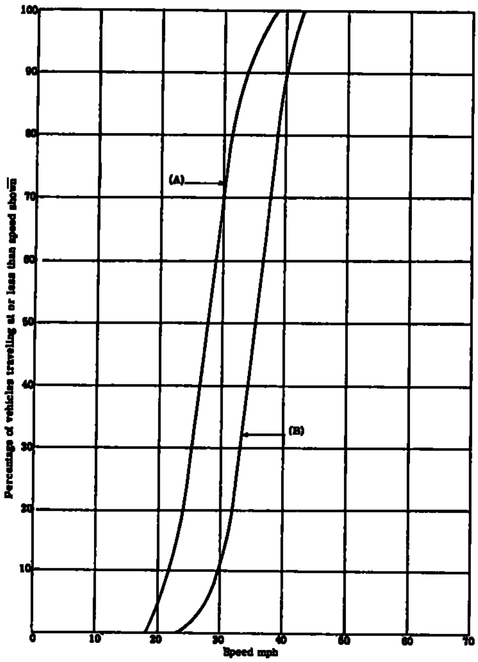


Figure 13. HIGHWAYS
(A) Bridgeport Route US 1 Dec. 1, 1950 10:10-10 45 AM 100 OBS W-E AV. SP. 28.5 MPH 85 Percent 32.5 MPH
(B) Fairfield Route US 1A Nov. 24, 1950 1·00-1·30 PM 100 OBS West Bound AV. SP. 35.6 MPH 85 Percent SP. 39.3 MPH

Town of Fairfield - Route US 1A - Kings Highway - Figure 15 shows the plan and profile for a section of this street. As noted previously, this street passes through an area that is principally residential in character with the usual scattering of neighborhood stores, churches, etc. This street passes through the outlying districts in the north part of the City of Bridgeport whereas the previously described section of Route US 1 leads directly into the center of the city.

Figure 11 shows the typical cross section of the street. Each roadway is 28 ft. in width, curb to curb,

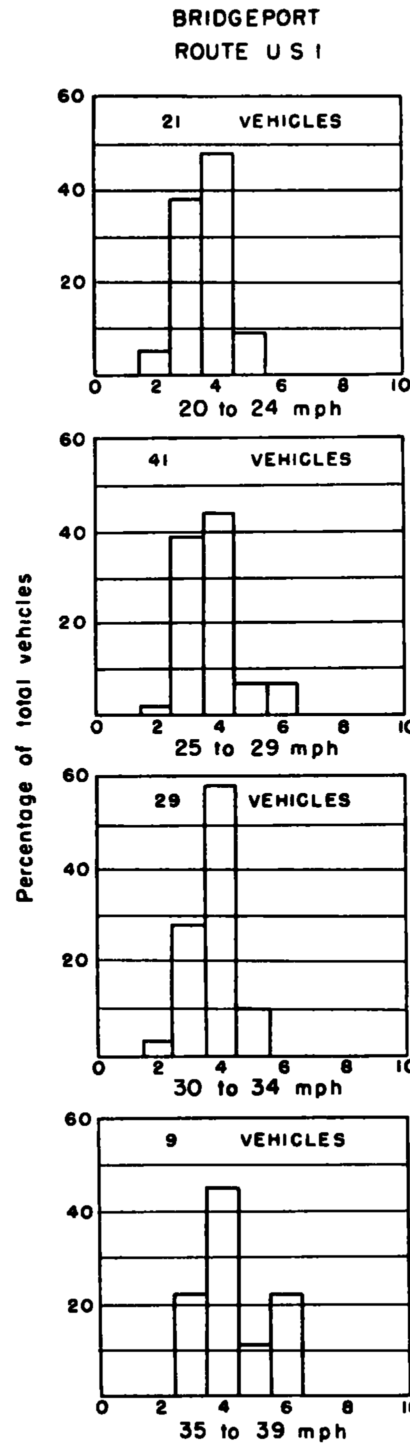


Figure 14. HIGHWAYS - Distance in feet that left wheels were to right of curb

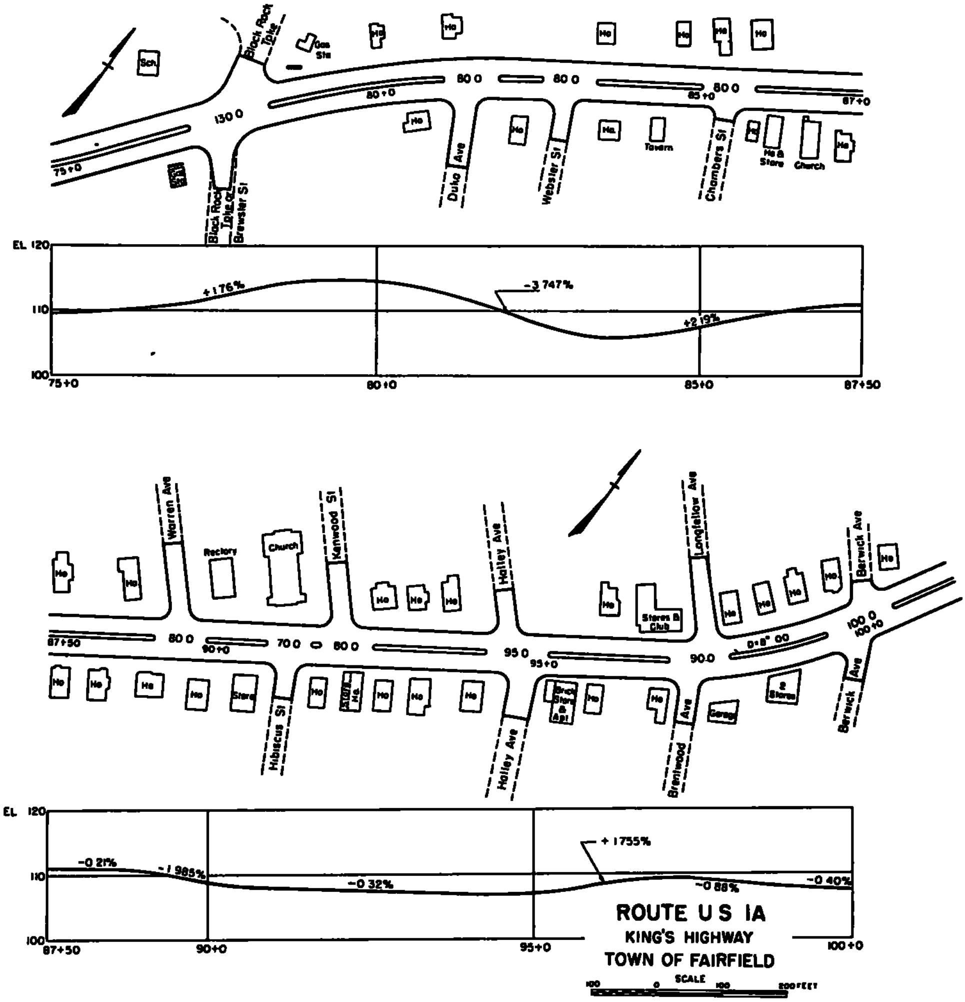


Figure 15.

with a 4-ft. wide median strip. The median was constructed of concrete as integral curb and filler. The pavement is concrete with the inside lane having a width of 11 ft. 6 in. and the outer lane having a width of 10 ft. 6 in. The extra width was built into the inside lane to allow more room for vehicles performing a passing maneuver and for those vehicles traveling at higher speeds. A marginal strip 6 ft. wide was provided for curb parking and for bus stops.

Figure 16 is a photo showing a section of the street. It will be noticed that a center line marking has been applied along the construction joint so as to give greater lane definition. The roadway is sloped away from the median strip, thus requiring drainage pickups at the outer curbs. The four-foot width of median is too narrow for successfully growing grass so an all concrete median was designed.

The street was reconstructed in 1940 and 1941 at a cost of about

$177,000 per mile which would mean $326,000 per mile on the basis of the 1950 index. The median strip was constructed at a cost of about $2.20 per foot.

Traffic data are included on Table 1. These show that the average daily traffic is 15,000 vehicles of which 19 percent is classed as commercial. The 30th highest hour is as 12 percent of A.D.T. and the 30th highest hour in major direction is 6 percent of A.D.T.

Figure 13 shows the speed curve for this street. The 85 percentile value is 39.3 M.P.H. which is 6.5 M.P.H. higher than that shown for Route US 1 in Bridgeport.

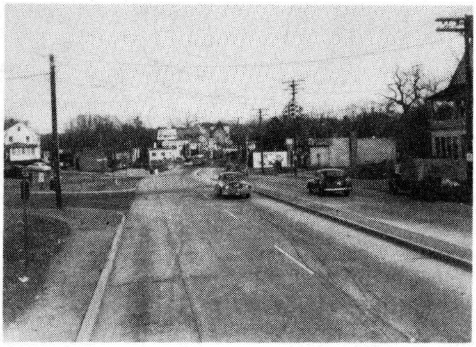


Figure 16.. Town of Fairfield Route US 1, Kings Highway

Figure 17 shows the placement of vehicles with respect to the face of the median curb. It will be noticed that there is a distinct similarity to the placement shown in Figure 14 for Route US 1 in Bridgeport in that the greater percent of vehicles in all speed groupings was traveling with the left wheel at a 4-ft. offset from the median curb. Vehicles in the highest speed grouping showed a tendency to keep farther away from the curb than those in the lower speed groups.

Accident data for this street are shown in Table 2. The accident rate is shown as 420 per hundred million vehicle miles with injuries at the rate of 170 per hundred million vehicle miles. These rates are somewhat lower than for Route US 1 in Bridgeport. The fatality rate is 2.7 and property damage, $106,000 per hundred million vehicle miles. These rates are higher than those for Route US 1 in Bridgeport.

Operations resulting from the design used for the Bridgeport and Fairfield streets are similar in that there are outside parking lanes and two inside lanes for moving traffic. There does not appear to be enough difference in accident data to indicate that performance resulting from one design is better than the other.

As is the case in Bridgeport, it appears that the design is satisfactory for the location. With wider vehicles becoming more common, the 6-ft. parking lane is becoming too narrow and should be increased to a minimum of 8 ft.

Long Structure - The three :tructures selected for this group are the Charter Oak Bridge spanning the Connecticut River in the Towns of Hartford and East Hartford, the bridge on the Merritt Parkway spanning the Housatonic River in the Towns of Stratford and Milford, and the bridge carrying Route US 1 over the Thames River in the Towns of New London and Groton.

The Charter Oak Bridge is a link in Conn. Route 15 which is a cross State highway beginning at the New York State Line and extending across Connecticut to the Massachusetts State Line. The Merritt and Wilbur Cross Parkways, a Section of Route US 5 and the Wilbur Cross Highway, are included in Route 15. The Housatonic River Bridge has been previously mentioned as being on the Merritt Parkway.

Hartford-East Hartford, Charter Oak Bridge, Conn. Route 15 - The Charter Oak Bridge was constructed in 1941.

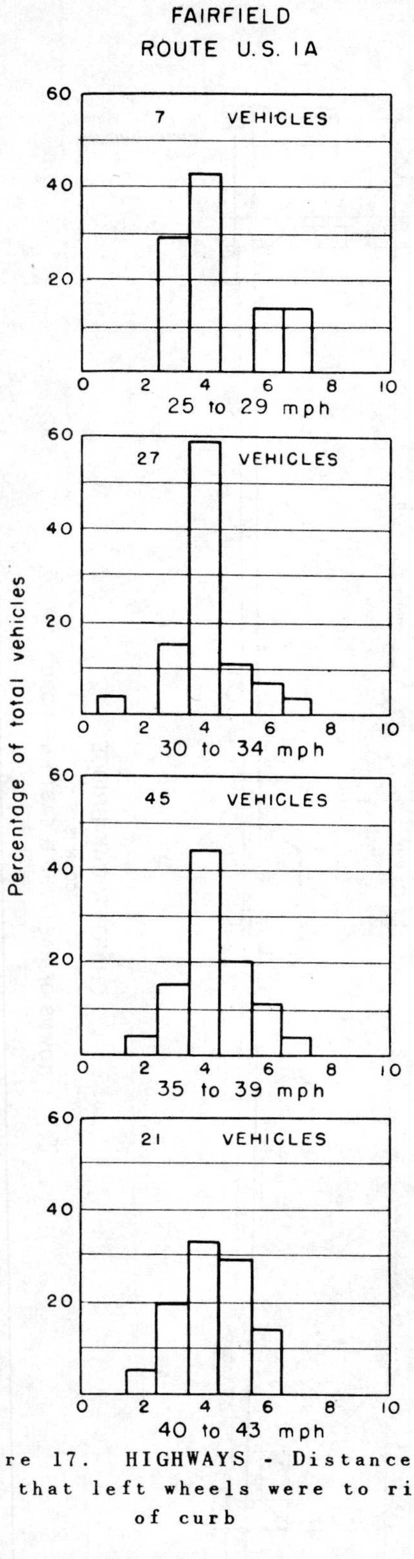


Figure 17. HIGHWAYS - Distance in feet that left wheels were to right of curb

It has a total length of 3,231 ft. between abutments. There is also an exit viaduct to the Riverfront Boulevard that is not included in the length shown. Approach grades on both the east and west portions of the structure are 4 percent.

Figure 18 is a view on the westerly portion of the structure. Sodium vapor lights extend across the entire structure and for some distance on the approaches. There is a toll plaza a few hundred feet beyond the easterly end of the structure.

Figure 19 shows the roadway cross section and an enlarged cross section shows details of the medial divider. The total height of divider is 1 ft. 9 in. with the lower 7 in. having been constructed as a vertical section and the upper 1 ft. 2 in. laid back on a batter. The structure is speed zoned for 25 M.P.H.

Average daily traffic on the structure is shown, on Table 1, as being 33,000 vehicles with 9 percent being of commercial class. The 30th highest hour is 12 percent of A.D.T. and the 30th highest hour in major direction is 7 percent of A.D.T.

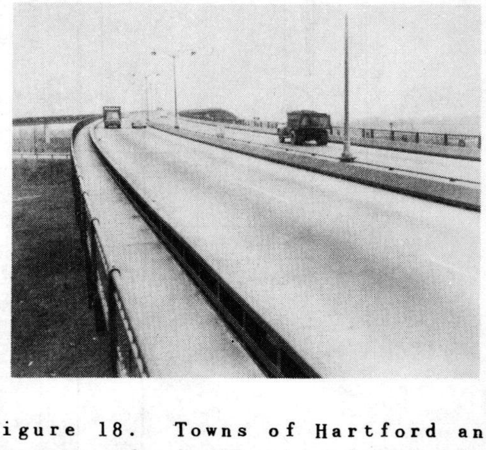
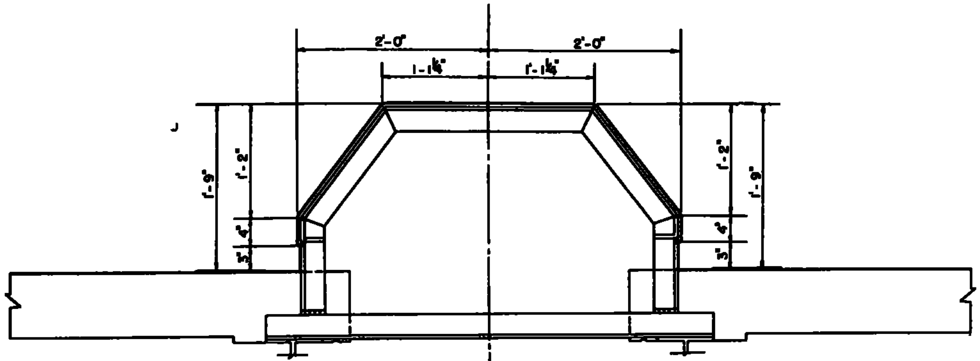
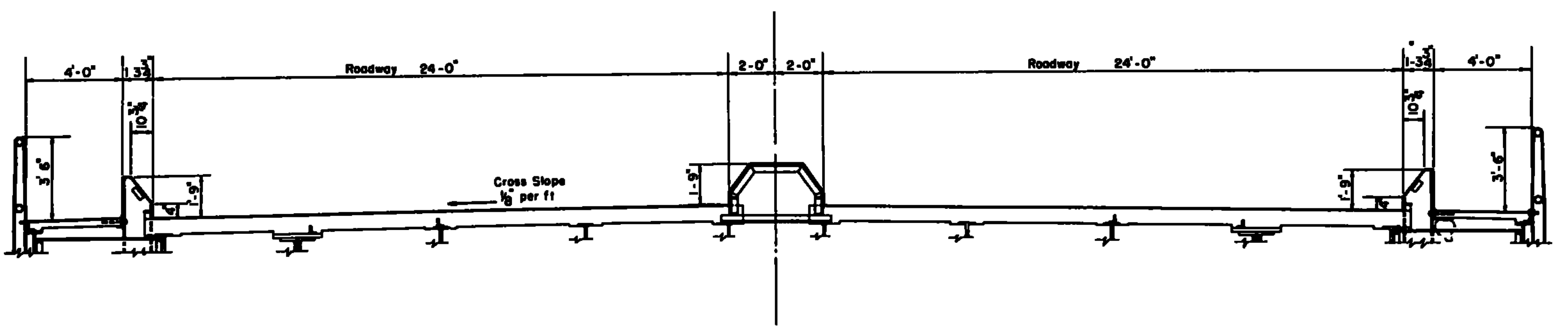


Figure 18. Towns of Hartford and East Hartford, Charter Oak Bridge over Connecticut River, Route 15

Figure 20 shows the speed curves for the three structures included in this study. Observations on the



MEDIAN DETAIL



CHARTER OAK BRIDGE

CONN 15

TOWNS OF HARTFORD & EAST HARTFORD

Figure 19.

Charter Oak Bridge were taken on eastbound vehicles which had been traveling over a non-access highway, and speeds are higher than for westbound vehicles which are required to stop at the toll station at the easterly approach to the bridge. The speed curve indicates that about 60 percent of the vehicles included in the study was traveling in the speed range of about 36 to 42 mi. per hour. The 85 percentile speed value of all vehicles included in the sample, is indicated as 41 M.P.H.

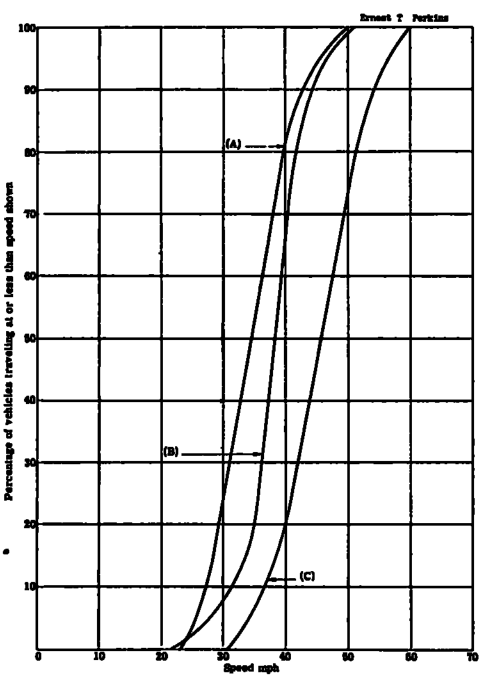


Figure 20. BRIDGES
(A) New London and Groton- Thames River Bridge Route US 1 Dec. 5, 1950 1:30-11·50 PM 100 OBS East Bound AV SP. 35.4 MPH 85 Percent SP. 41.0 MPH
(B) Hartford and East Hartford Charter Oak Bridge-Conn 15 Nov. 27, 1950 11 00-11·15 AM 100 OBS East Bound AV. SP. 38.6 MPH 85 Percent SP. 42.5 MPH
(C) Milford-Housatonic River Bridge Merritt Parkway Nov 29, 1950 10:30-11 15 AM 100 OBS East Bound AV. SP. 46.0 MPH 85 Percent SP. 52.5 MPH

Figures 21 and 22 represent a plot resulting from the placement study. The highest speed grouping shows the previously noted tendency for drivers to maintain a greater offset from the medial divider.

The accident summary shown in Table 2 indicates 39 accidents on the structure during the four periods included. There were no fatalities, and injuries and property damage were light.

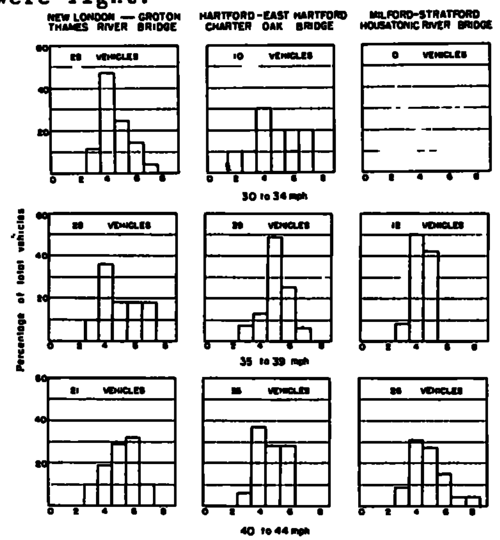


Figure 21. BRIDGES - Distance in feet that left wheels were to right of curb (continued on Figure 22)

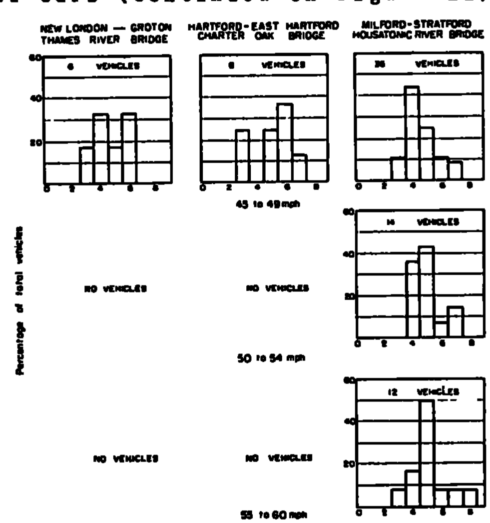


Figure 22. BRIDGES - Distance in feet that left wheels were to right of curb

Towns of Stratford and Milford - Housatonic River Bridge on the Merritt Parkway, Conn. Route 15 - The Housatonic River Bridge on the Merritt Parkway was constructed in 1939. It has a total length of 1,824 ft. between abutments.

Figure 23 shows a view of the structure looking toward the west. The deck was originally constructed of a steel grid which has since been filled with bituminous concrete. The concrete section shown is over railroad tracks and was constructed as a concrete filled grid so as to avoid the smoke nuisance common to steam engine operation. The steel

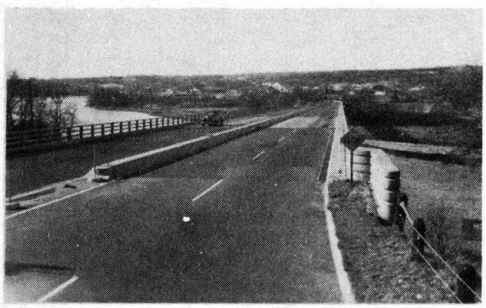


Figure 23. Towns of Stratford and Milford, Housatonic River Bridge on the Merritt Parkway Conn. Route 15

grid produced a swaying motion in moving vehicles and there was a decided rumble as cars rolled over the grid. There were numerous accidents at the westerly end of the structure on the eastbound lane. The Merritt Parkway was posted for a 50 M.P.H. speed for some time and vehicles traveling eastward entered the structure at about that speed. The sudden change from the concrete pavement to a grid, apparently, confused drivers and the result was an unfavorable accident experience. The bituminous surface was applied in an effort to overcome the objectionable grid features and has been partially successful. The toll station is located about 400 ft. beyond the easterly end of the structure.

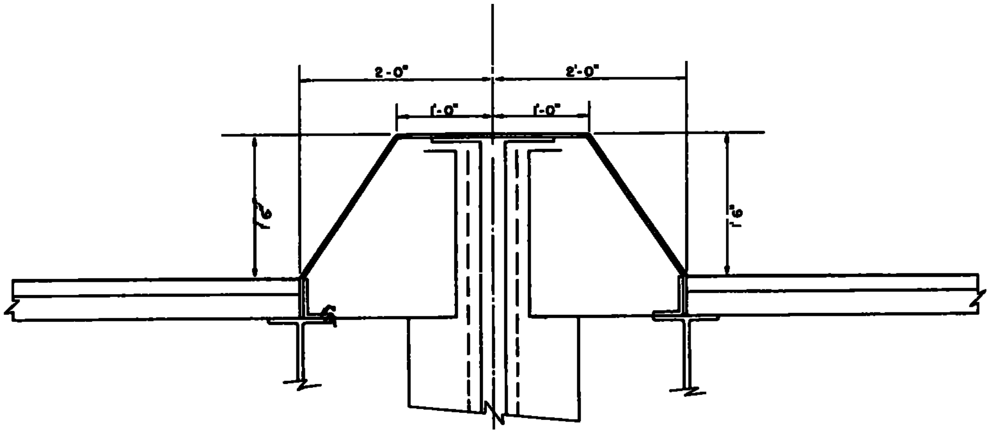
Figure 24 shows the overall roadway typical cross section and also an enlarged section of the medial divider. It will be noted that the medial divider is 1 ft. 6 in. in height and the face adjacent to the travel lane is on a batter for the entire height. A 26-ft. width was used for each roadway. This width is the same as the roadway width between curbs on the Merritt Parkway. The bridge is on a straight 3 percent grade.

Traffic volumes are indicated in Table 1. A.D.T. is 18,000 passenger vehicles. The Merritt Parkway is closed to commercial vehicles of all classes. The 30th highest hour is shown as 17 percent of A.D.T. which is the greatest of all highways included in this study. Travel during a long 4th of July weekend and Labor Day weekend is especially heavy over the Merritt Parkway.

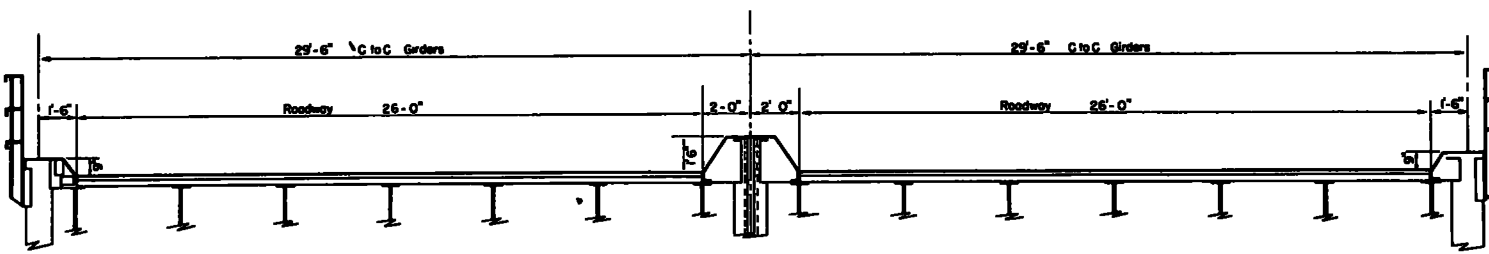
The speed curve for this structure is shown in Figure 20. Observations were made in eastbound roadway because of the influence, on the westbound lane, to vehicles having just left the toll station. The 85 percentile value is 52.5 M.P.H. which is only slightly under the present posted speed of 55 M.P.H. for the Parkway.

Results of the placement study are shown in Figures 21 and 22. For speeds between 35 and 49 M.P.H., the greatest percentage of vehicles was traveling at an offset of 4 and 5 ft. from the median with the greatest percentage being at 4 ft. In the 50 to 60 M.P.H. range, the vehicles shifted slightly to the right with the greatest percent of vehicles included in the sample traveling 5 ft. from the median.

The accident tabulation shown in Table 2 indicates 58 accidents on the structure for the 4-year period shown. There were no fatalities during the same period. The actual



MEDIAN DETAIL



HOUSATONIC RIVER BRIDGE
MERRITT PARKWAY
TOWNS OF MILFORD & STRATFORD

Figure 24.

totals of accidents, injuries and property damage are not great but when translated into terms of the rate per hundred million vehicle miles, seem large because of the relatively short length of structure.

The design of the medial divider was intended to allow vehicles to glance off of the battered section and be returned to their own roadway. Actually, vehicles have run up on the sloping face and have, in some instances, come to rest on top of the divider. The Charter Oak Bridge was constructed two years later and a vertical face of 7 in. at the bottom of curb was used in order to force a glancing movement rather than having vehicles actually mount the divider. It is believed that the Charter Oak medial divider is a better design than the Housatonic River Bridge divider.

New London-Groton - Thames River Bridge - Route US 1 - The Thames River Bridge was constructed in 1941. It is a high-level structure and replaced a low-level, movable span structure. It has a total length of 5931.75 ft. between abutments. The straight grades on both the east and west approach viaducts are 3 percent.

The structure connects New London on the westerly bank of the Thames River with Groton on the easterly side. It is also a major link in Route US 1. A four-lane divided highway by-passing New London and Groton was constructed to provide suitable approach to the structure.

Figure 25 is a view of the easterly portion of the structure. Lighting is provided for the entire length of the structure and for some distance on the approaches. The toll station is several hundred feet beyond the easterly end of the structure.

Figure 26 shows a typical cross section of the roadways and an enlarged section shows details of the medial divider. The divider is in the form of double curbs back to back, the lower barrier curb being 8 in. in height and the upper portion being 10 in. in height. Bottom face of curbs are separated by 2 ft. 6 in. Each directional roadway is 24-ft. wide which width is the same as that on the Charter Oak Bridge.

A.D.T. on this structure is 16,000 vehicles, as may be seen in Table 1. 92 percent of A.D.T. represents passenger vehicles, while 8 percent is classed as commercial. The 30th highest hour is 12 percent of A.D.T. and the 30th highest hour in major direction is 7 percent of A.D.T.

The speed curve is shown in Figure 20. Speeds are lower for this structure than the other two included in the study. The 85 percentile value is shown as 41.0 M.P.H. It will be noted in Figure 25 that the structure is speed zoned for 25 M.P.H. as is the Charter Oak Bridge. General observance of posted speeds seems to be slightly better on the Thames River Bridge but the range of speeds is similar. Observations were taken in the eastbound roadway so as to eliminate the effect of passing through the toll station.

Figures 21 and 22 show the results of placement observations. Vehicles in the 30 to 39 M.P.H. groupings favored a 4-ft. offset from the curb and the 40 to 49 M.P.H. groupings, again, were moving out to a slightly

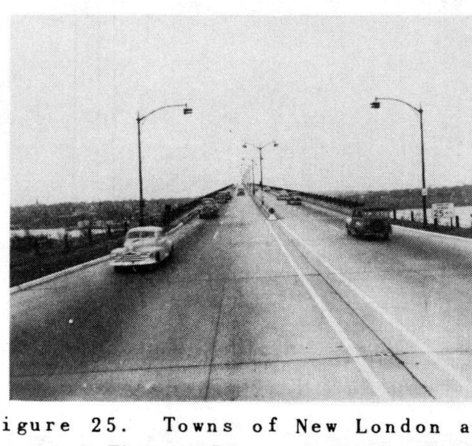


Figure 25. Towns of New London and Groton, Thames River Bridge, Route US 1

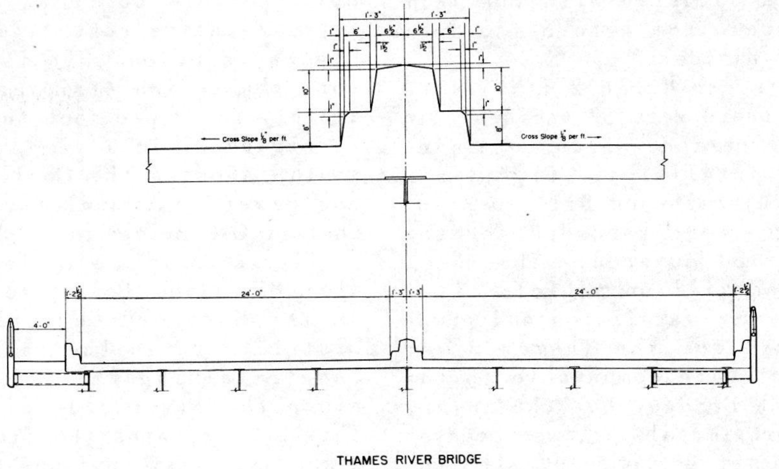


Figure 26.

Figure 27. Town of Hartford, Conland Highway and Riverfront Boulevard with Charter Oak Bridge in background

greater offset. There is a decided preference by drivers at all three structures to drive with the left wheel placed from 4 to 6 ft. from the medial divider.

Referring to Table 2 it will be seen that there were 52 accidents in the 4-year period, which total included no fatalities. Eighty-six personal injuries and $11,120 property damage were recorded for the 4-year period covered. The rates per hundred million vehicle miles for accidents, fatalities and property damage for the Thames River Bridge are quite comparable to the Charter Oak Bridge, but the injury rate is approximately 3 times greater for the former as compared with the latter.

Expressway - Expressways constructed in Connecticut, to the present time, have not included sustained lengths of a narrow median. The Conland Highway and Riverfront Boulevard connect the Charter Oak Bridge and South Meadow Highway with streets adjacent to the center of the City of Hartford. Although there are two designating names for the highways, they form one continuous highway for a length of one mile. The construction of this access road was accomplished in connection with a major flood control project which was undertaken after the disasterous flood of 1936 and the nearly as damaging flood that accompanied the hurricane of 1938. One of the major items in the flood control project was the enclosure of the Park River in a large, twin box culvert. The Conland Highway was constructed on top of the box culvert and, largely, within the limits of the old Park River banks. The Riverfront Boulevard section is adjacent to the Connecticut River from which it is protected by an earth dike. The highway location was planned in conjunction with the dikes. Extensive filling was done by hydraulic methods. Because of the highway and dike work being so closely connected, it is not possible to break out a good representative cost figure for the highway section. It is estimated that the median strip cost approximately $3.30 per foot to construct.

Figure 27 is a view, toward the south, showing the Conland Highway and Riverfront Boulevard with the Charter Oak Bridge in the background.

Figure 28 is a view looking north along Riverfront Boulevard. Buildings in the Hartford Central Business District are in the background. A long retaining wall will be seen along the river side of the road. This wall retains the flood control dike. Industry confines the area to the left of the highway. The median width was kept to a minimum that would include installation of foundation for light standards.

Figure 29 shows a plan and profile for the section of highway shown in Figure 28.

Figure 30 shows the typical cross section of the highway and an enlarged sketch shows details of the median strip. It will be noted that the median strip is 4 ft. wide and that a mountable curb was used. It will be noted that two 12-ft. lanes were constructed for each roadway. The mountable curb was constructed along the edge of the inner 12-ft. lane so as to encourage drivers to make use of the entire inner lane. Inner lanes slope toward the median while the outer lanes slope toward the shoulders. Catch basins are provided along the median curbs to pick up center drainage.

Referring to Table 1, it will be seen that the average daily traffic amounts to 27,000 vehicles. The 30th highest hour is 15 percent of A.D.T. and the 30th highest hour in major direction is 12 percent of A.D.T. Commercial vehicles account for 13 percent of A.D.T.

Results of the speed study are presented in Figure 31. The 85

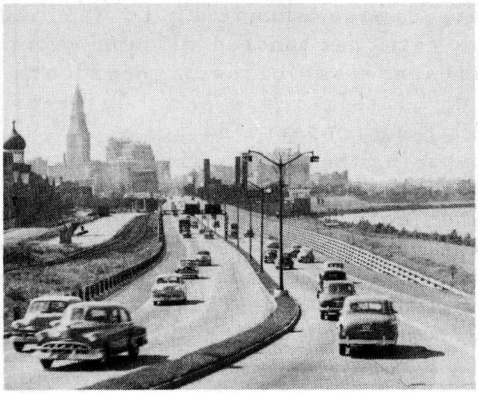


Figure 28. Town of Hartford, Riverfront Boulevard

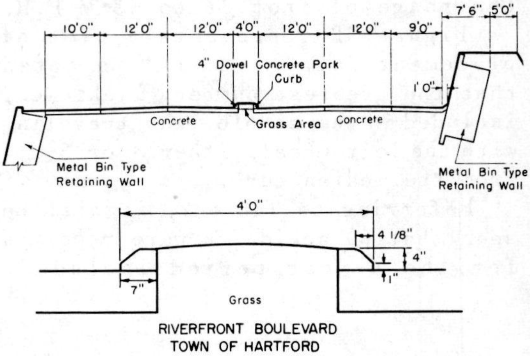


Figure 30. Typical Section

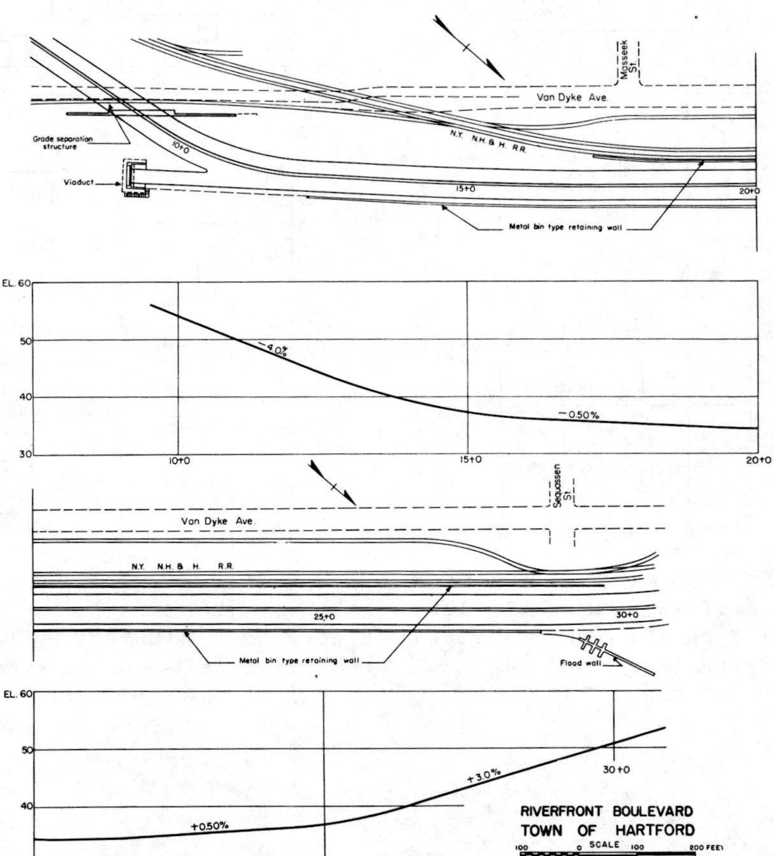


Figure 29.

percentile value is shown as 43.7 M.P.H. The curve is very steep and it will be noted that about 60 percent of the sample was traveling in the range of from 37 to 43 M.P.H.

Figure 32 represents a plot of placement data. It will be noted that the greatest number of vehicles, included in the sample, was traveling with the left wheel either 4 or 5 ft. from the median curb.

Referring to Table 2, it will be seen that 60 accidents were reported for the 4-year period included. Included in the total accidents were two fatalities, 32 injuries and property damage amounting to $19,530. The rates per hundred million vehicle miles are as follows: accidents - 210; fatalities - 7.2; injuries - 110, and property damage - $69,000. Comparing these rates with those shown in Table 3, it will be seen that the rates compare favorably with Statewide average except for fatalities. The two fatalities, on the short section involved, result in a large rate per hundred million miles.

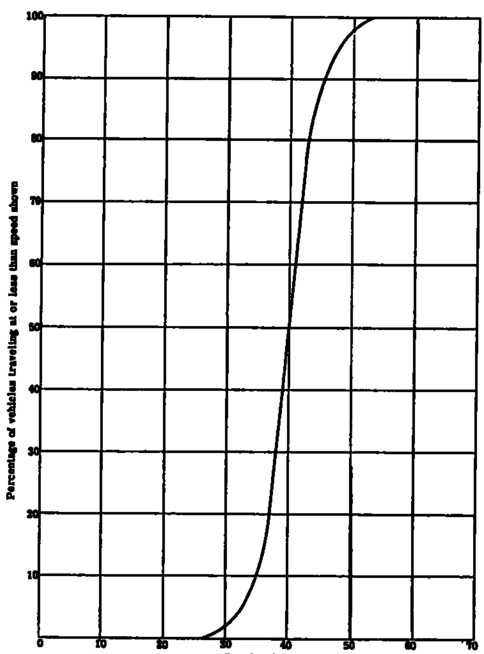


Figure 31 HIGHWAYS - Hartford Riverfront Boulevard Nov. 27, 1950 11:45 AM-12:15 PM 100 OBS Southbound AV. SP. 40.5 MPH 85 Percent SP. 43.7 MPH

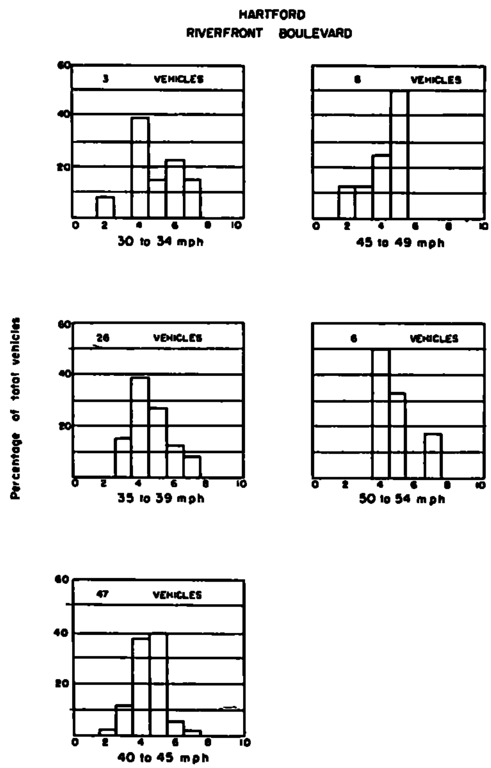


Figure 32 HIGHWAYS - Distance in feet that left wheels were to right of curb

SYMPOSIUM ON HIGHWAYS WITH A NARROW MEDIAN - ILLINOIS

R. J. Furbeck, *Highway Engineer, State of Illinois*

Current design practices in Illinois do not employ the use of narrow curbed medians, except for the channelization of approach pavements to grade separations; the islandization of intersections at grade; and at locations where a reduced cross-section design is economically essential, providing that certain approach conditions are met and cross-conflicts are reduced. Our experience in the past with narrow medians as a separator or physical barrier between dual pavements in rural and in intermediate areas has given us a rather dim view of them, particularly if they are of the curbed type. Perhaps it is unfortunate that the Department of Public Works and Buildings has been criticised, although sometimes with bias by minority groups, for incorporating such design features in our highways. However, in all fairness to the use of narrow medians, the fact should be recognized that such unfavorable criticism has usually been voiced against separated highways in rural and in intermediate areas where operating speeds are high and which are without the benefit of access control. Such adverse criticism can be blamed upon several factors, such as the demand by certain private interests for unrestricted movement; secondly, the driving habits of the mid-western driver; and thirdly, the unfavorable operational accident experience on such constructed highways. In the first instance Illinois abutters hold certain inherent property rights of access to non-controlled highways and consequently many private interests most vehemently oppose any plan which would prohibit, restrict or render circuitous the direct access to their business establishments or services. In the second instance the mid-western driver has, until quite recently, been able to travel in rural areas and even in the majority of urban areas completely free from traffic congestion with its accompanying slower operational speeds and restrictions in turning movements. With the tremendous increase in our post war traffic volumes, our highways, especially in the environs of our larger metropolitan cities, are rapidly becoming more congested but our drivers are still attempting to realize running speeds equal to or higher than those of a decade ago. In brief, they are not yet regimented to the necessity for slower operational speeds; to accept the fact that there are less passing opportunities; to the fact that many turning movements must be restricted; and to the inclusion of adverse travel distance. The third factor, unfavorable accident experience, is to a large degree the consequences of the lack of access control and the driver habits as discussed above and which, together with the inability of the human system to comprehend space interval opportunity, and the distance required for passing in relation to distances covered in split-seconds of travel time constitute the major contributing factors to our increasing accident rate. It is the common butt of jokes that the driver of today - who in the sanctity of his own home is a just man, a loving parent and a considerate neighbor - becomes a veritable maniac and a menace on the highway the moment he gets behind the steering wheel of a car. In any event, there does exist among our drivers of today an increasing lack in the extending of common courtesy as well as an indifference to the rights and the consequential safety of others. It would, therefore, appear that there is as much need for "Human Engineering" as for "Civil Engineering" in the question of median dividers as well as in most other facets of the highway problem.

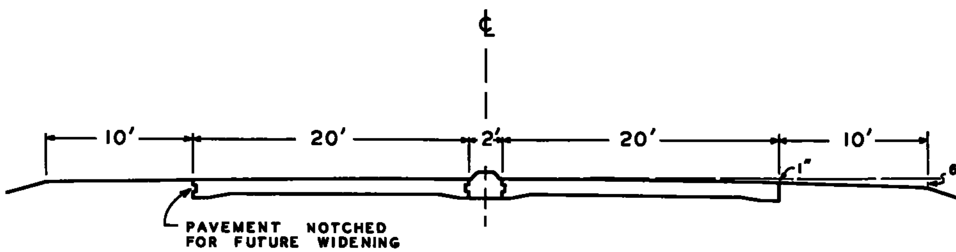
By the early 1930's, Illinois had become fully aware of the desirability of and the necessity for the physical separation of opposing streams of traffic on our more heavily travelled highways. However, at that time, little had been experienced to mold general engineering opinions relative to minimum or to desirable widths for the separating median. As a result, the physical dimensions of such design features were usually the consequences of experimentation and of comparative costs rather than of experience and essentialness. It was with such a background that Illinois prepared a divided pavement design in the late 1930's. US Route 12 was then in the process of being modernized and improved between Chicago and the Wisconsin State line. This was one of the more heavily travelled highways and was subject to considerable one-way congestion during the summer months by week-end vacation travel between Chicago and the Wisconsin lake resort area. In Cook County, this highway had been improved as a solid 40-ft. pavement and it was decided to modernize the highway through Lake County as a divided pavement having a general cross section design of 2 at 22-ft. with a 30-ft. crowned earth median. However, due to right-of-way considerations, a cross section design of 2 at 20-ft. with a 24-in. curbed median and having a height of 4-in. finally appeared to be justified for that portion of the highway which utilized the existing alignment immediately north of the Cook-Lake County line. (Fig. 1A). Where the proposed alignment went into relocation the 24-in. curbed median expanded into the general cross section design. This resulted in a stretch of highway approximately one and three-quarter miles in length which used a narrow curbed median as a physical separator for a divided pavement design.

It was anticipated that at some future time a third lane would have to be added to the Chicago bound pavement in order to provide adequate highway capacity for the concentrated peak period flow of traffic representing the week-end vacationists who usually began returning to the city on Sunday afternoons. Standard 10-ft. earth shoulders were used having a slope of ½-in. per ft. of width and the ditch slopes were 3 to 1. The horizontal alignment was tangential except for one small deflection of 2 degrees and 50 minutes. The maximum grade was 2.38 percent and sight distances were unrestricted.

While the location was through an area generally rural in character, the improvement was fronted by a ribbon development consisting of a rural sub-division, farm units and a small crossroad community. Within the length of this improvement there were 22 homes, one roadhouse or tavern, one shop, two gasoline service stations and five "Bar-B-Q" stands. As this highway was without the benefit of access control, three 12-ft. openings for single entrances and five 30-ft. double entrances were provided in the median for ingress and egress to these properties. Two local roads and a short side street likewise intersected the main highway at grade and one opening in the median of 80-ft. and two openings of 126-ft., the length depending upon the angle of intersection, were provided to serve the interchange needs. All traffic entering the new highway from these intersecting roads were under stop-sign control and there was no restriction in the turning movements.

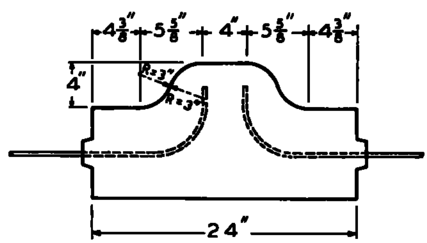
The median was 24-in. in overall

Libertyville, Illinois on August 30, 1938, and was completed and accepted by the Division of Highways on September 5, 1939. The cost of the improvement, including the item of $21,323.25 for additional right-of-way amounted to a total of $187,287.42 for 1.75-mi. of improvement or a cost of $107,021.38 per mi. In order to realize a separation of the opposing streams of traffic, 9,051 lin. ft. of the curbed median were used at a unit price of $0.47 per lin. ft. for a total cost of $4,253.97.



U.S. ROUTE 12

(A) CROSS SECTION FROM COOK-LAKE COUNTY LINE NORTHWEST



(B) DETAIL OF 24" CURBED MEDIAN

Figure 1.

width, 4-in. high and with 4 3/8-in. gutter flags and the sloping faces were readily mountable. The flat width on top was 4-in. (Fig. 1B). The median was joined to the adjacent pavement on either side by means of a longitudinal notch.

The contract for this improvement, designated as S.B.I. Route 60, Section SY-3, was awarded to the Eric Bolander Construction Company of

The magnitude of the average daily traffic volumes on this highway was not startling in itself even for a two-lane highway, amounting in 1938 to 3,800 vehicles and in 1947 to 5,500 vehicles; but it was the peak hour directional traffic conditions related to the recreational characteristics of the road which created an abnormal congestion condition. In 1947 the Chicago outbound recreational traffic, although spread over a two-day period, between the hours of 9:00 and 10:00 A.M. reached peak densities in excess of 1,100 vehicles; while for the return trip, between the hours of 6:00 and 7:00 P.M. peak densities of 1,400 vehicles were realized. The corresponding opposing traffic during these peak hours amounted to only 400 and 300 vehicles respectively. The composition of the traffic using this highway was predominantly passenger car traffic. In 1938, on a normal week day, trucks constituted only eight out of every 100 vehicles. By 1947 this value had increased to 12 percent in contrast to the State-wide average which was in excess of 20 percent. No data were collected relative to speeds on this highway but it is well within reasonable limits to say that on a normal week day the average speed on this highway was from 45 to 50-mi. per hr. with perhaps a small drop in speed for summer week-end outbound traffic. The average speed of the summer week-end inbound traffic was an entirely different matter. During the peak periods of inbound traffic, cars travelled bumper to bumper at snail's pace, and at some locations completely utilized both traffic lanes and some drivers even travelled on the earth shoulders. Due to this "moving barrier" of cars, it was impossible to either enter or cross the existing highway facility for long periods of time. After the completion of this improvement, together with other sections of the highway, the average week-day speed remained at 45 to 50-mi. per hr. and this value held relatively good for the summer week-end outbound traffic. The speed for the corresponding inbound traffic is now in the neighborhood of from 40 to 45-mi. per hr.

The expectation of trouble-free operation on this highway was short lived, for no sooner was it completed and opened to traffic in 1939 than reports began pouring into the Department complaining of the 24-in. curbed median. Vehicles were running into or straddling the nose of the median at its beginning and it was continuously being "side-swiped" through-out its entire length by drivers attempting to overtake and pass vehicles already operating in the second or passing land. (Fig. 2). The low visibility of the median, due to its narrow widths, its low height and its lack of color contrast, undoubledly contributed heavily to the increasing accident record for this section. Adverse criticism by the public against this curb median increased, and in an effort to reduce the accident occurrence, a contract was let on October 11, 1940 for the installation of a Sodium Vapor lighting system at the beginning of the curbed median. Six 10,000 L Sodium Vapor Luminaire units were placed at a total cost of $2,943.85. The results were very disappointing as accidents still continued to occur at this point.

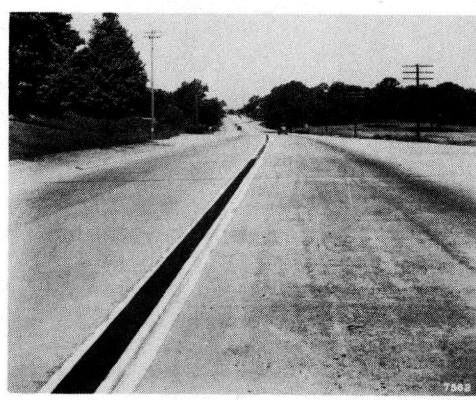


Figure 2. Photo of 24-in. Curbed Median on US Route 12

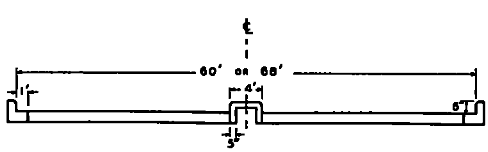
Ultimately the pressure became so great that on September 25, 1947, a contract was awarded to the same Eric Bolander Construction Company for the removal of this controversial 24-in. curbed median and its replacement with a flush type median. The curbed median was not removed in its entirety but only the raised portion and to a depth of from 1-in. to 2½-in. below the surface of the gutter flags. This area was then filled flush with the edge of the two pavements with a ¼-in. crowned bituminous concrete surface course. The total cost of the curb removal and replacement, together with the few accompanying incidental items, amounted to $22,309.25.

The reasons for the decision to use a narrow curbed median at this location were the lack of functional data relative to the use of narrow medians and the attempt to answer the question of justification for the expenditure required versus the comparative worth of the proposed feature. Had all additional right-of-way been secured from one side only of our existing highway, plus enough more to have provided for a 30-ft. earth flush median design, the entire right-of-way cost would have been less than twice the amount actually paid on the basis of the narrow median design. As it was, our so-called experimentation with this narrow median cost the State in actual cash outlay a total of $29,507.07, plus an indeterminate amount to the traveling public in the form of property damage, personal injury and loss of time. From the above, it is evident that there is increasing need for the making of economic analyses to determine the benefits resulting from such an improvement to the cost of that improvement.

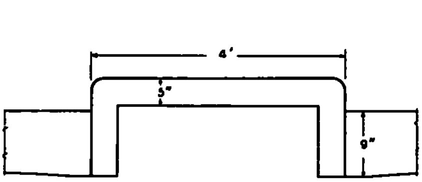
In reviewing our experiences with this narrow curbed median, two very interesting questions were raised. First, what effect would access control have had in regard to the reduction of accidents and second, is it possible for the public to become accustomed to separated highway design where such separation exists only for relatively short distances and as a stage in the ultimate construction of a completed highway? The first is indeed a moot question but the accident reports did not indicate that the accidents were the result of interchange conflicts at the intersecting crossroads or private entrances but rather one of improper highway usage and low visibility. As to the second, it would appear that, if the failure of this narrow mountable curbed median to serve as a traffic control feature in the safe, rapid and efficient movement of traffic was due to the lack of education of the traveling public in the driving of such modernized highways,. certainly such education should have been realized during a decade of time.

The continued accident occurrence over the period of years, in spite of the installation of the Sodium Vapor lighting system as a warning of a potential highwayhazard, forced us to conclude that the use of a narrow curbed median, even though mountable, on sections under high speed operation created a definite travel hazard due primarily to its low shadow visibility and lack of color contrast and to the driving habits of the general public.

Illinois has another condition of a major highway, also without the benefits of access control, which runs through a residential or urban area, an industrial area and finally transforms into a major street running through residential and ribbon commercial developments. One of the first divided highways in the State was the portion of Route 64 on North Avenue extending from the DuPage-Cook County line eastward to Nagle Avenue in Chicago. The cross section design varied materially within these limits. Beginning at the Cook County line and progressing eastward is one section approximately 1.7 mi. in length having a cross section of 2 at 20-ft. with a 52-ft. depressed median. This is followed by a second section of 0.85-mi. in length having a cross section of 2 at 20-ft. with a 32-ft. raised earth median drained by low gutter sections along the median side edge of the pavements. A third section approximately 0.33-mi. in length has a cross section of 2 at 20-ft. with a 12-ft. earth median crowned from 12-in. to 18-in. above a low gutter section, and a fourth section approximately 2.08-mi. in length has a cross section of 2 at 21-ft. with a 12-ft. earth median crowned from 12-in. to 18-in. above a low 2-in. curb and gutter section. Then the section under discussion, lying between Thatcher and Nagle Avenues, has a length of approximately 1.95-mi. and a cross section of 60-ft. or 68-ft. face to face of outside curbs with a 4-ft. curbed median and a curb and gutter section 6-in. in height. (Fig. 3). The area through which this section runs is a combination of residential and ribbon commercial development and there is a considerable amount of pedestrian cross traffic. Within this section and between Thatcher and Harlem Avenues a distance of approximately 0.94-mi., the street is 60-ft. face to face of curbs and it is planned at some future period to



NORTH AVE
CROSS SECTION - THATCHER AVE TO NAGLE AVE



NORTH AVE
DETAIL OF 4-FOOT CURBED MEDIAN

Figure 3.

widen the pavements to provide three lanes of moving traffic in each direction. Major continuous north and south cross-streets intersect North Avenue approximately every quarter of a mile and at these locations openings in the median, varying from 66-ft. to 100-ft. depending upon the importance of the cross-street, are provided for the interchange of traffic. On the north side of North Avenue there are three intermediate intersecting streets between these major cross-streets while on the south side there are only two intermediate intersecting streets within the same limits. (Fig. 4A). The remainder of this section lying between Harlem and Nagle Avenues, a distance of approximately 1.01-mi., has a street width of 68-ft. face to face of curbs. Within these limits, however, there are no continuous intersecting cross streets as the intersecting streets on the north are offset varying distances from the intersecting streets on the south. Openings through the median, varying in length from 140-ft. to 240-ft. depending upon the offset distance between adjacent north and south streets, are provided at approximately each quarter of a mile. (Fig. 4B). All traffic entering from any of these intermediate intersecting streets are required to turn right into North Avenue and in order to cross or to go left, must proceed to the first major cross-street where either a left or a U-turn through the median can be made. The area through which this improvement runs is relatively level and drainage is taken care of by the usual curb inlets and storm sewers. The barrier-type median is 4-ft. in width and has vertical curb faces 6-in. in height.

As this portion of North Avenue was built by agencies other than the State and in various construction stages, no data is available to the writer, as to the cost of the overall

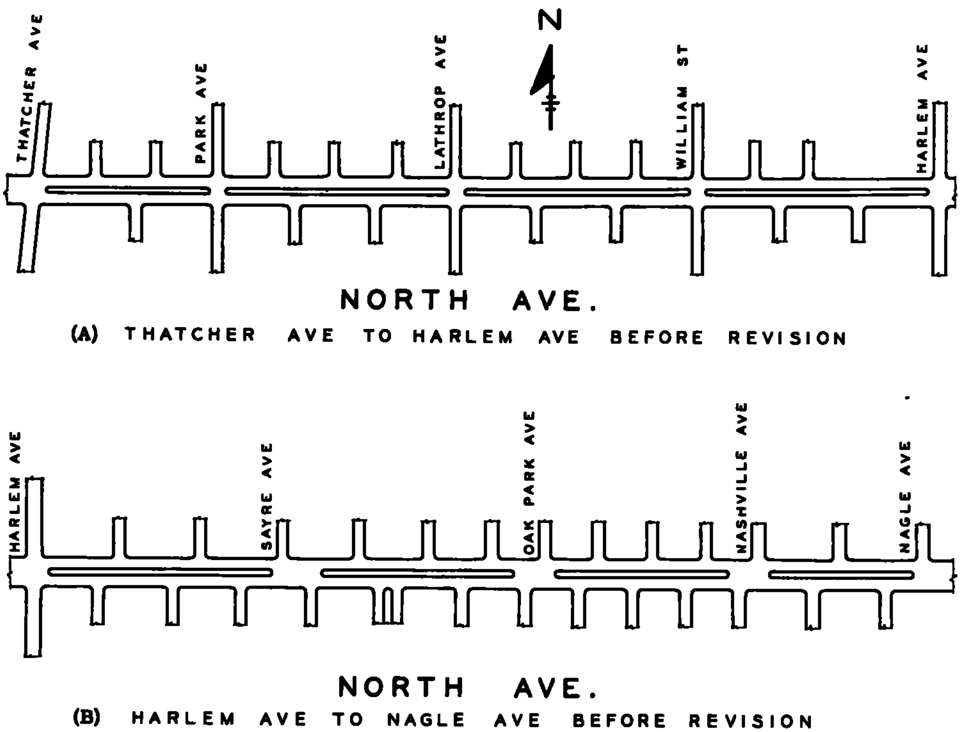


Figure 4.

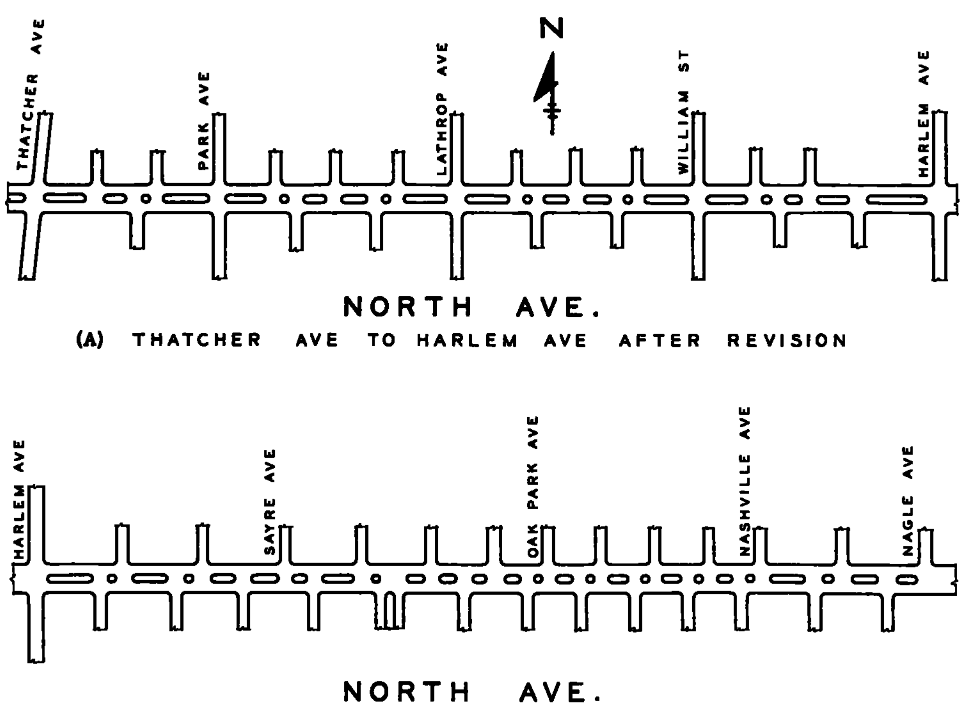
improvement nor of the median.

Due to the importance of this street as a major arterial highway and to the location thereon, a short distance to the west, of several large industrial plants in addition to numerous commercial enterprises the average daily traffic at this time is in the neighborhood of 25,000 vehicles. The average speed within this section approaches 30-mi. per hr. which, together with the multiple-lane width of street, makes pedestrian crossing a hazardous undertaking. For these reasons, if for no other, a barrier-type median is essential to serve as a pedestrian refuge.

For several years pressure had been brought upon the Department to remove entirely the 4-ft. median in this section and also the 12-ft. median in the section to the west and in addition to permit crossovers, wherever desired by private interests, within the sections having the 32-ft. and the 52-ft. parkways. This pressure was not due to an adverse accident record but to the desire by private and commercial interests for unrestricted ingress and egress to their properties. As previously mentioned, this major street was without the benefit of access control and as a compromise between the elements of safety which are believed to result from complete separation and the firmly expressed desires of abutters for unrestricted movement, the Department elected to revise the median design to provide openings at all intersecting cross-streets. (Figs. 5A and 5B). By this compromise, certain elements of safety were sacrificed and others were retained such as a general physical separation of opposing streams of traffic and a pedestrian safety refuge.

One comforting incident was injected into the picture in that after the contract was let a signed petition was received by the Department opposing the removal of the 4-ft. barrier-type median. In this instance, had this major street been protected with the provisions of access control, it would not have been necessary to jeopardize the safe, free flow of traffic by the numerous openings through the median opposite each of the intersecting cross-streets.

Illinois does not wish to leave the impression that it believes narrow medians do not have their place in modern highway design for that is definitely not the case. On the contrary, they serve admirably well for the channelization and islandization of traffic at important grade intersections and also at specific locations in dual-pavement design where a reduced cross section width is economically essential and when conditioned by proper approach design



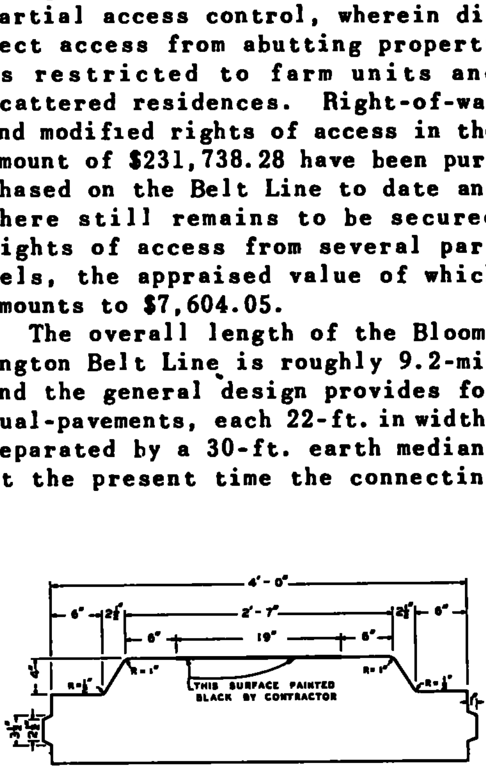
(A) THATCHER AVE TO HARLEM AVE AFTER REVISION

(B) HARLEM AVE TO NAGLE AVE AFTER REVISION

Figure 5.

and the elimination of direct access thereto. An example where such a 4-ft. raised median (Fig. 6) has been used successfully is exemplified on a stretch of US 66 in McLean County known locally as the Bloomington Belt Line. (Fig. 7) This was built during the period from 1939 to 1947 at a total cost of approximately $1,771, 000.00. US 66, except for short local gaps, has been declared a Freeway between St. Louis and Chicago. At this particular location it was designed as a modified freeway with partial access control, wherein direct access from abutting property is restricted to farm units and scattered residences. Right-of-way and modified rights of access in the amount of $231,738.28 have been purchased on the Belt Line to date and there still remains to be secured rights of access from several parcels, the appraised value of which amounts to $7,604.05.

The overall length of the Bloomington Belt Line is roughly 9.2-mi. and the general design provides for dual-pavements, each 22-ft. in width, separated by a 30-ft. earth median. At the present time the connecting



BLOOMINGTON BELT LINE
DETAIL OF 4-FOOT CURBED MEDIAN

Figure 6.

highways at either end of the Belt Line consist of but one pavement of the ultimate dual-pavement construction. These are used for two-lane two-way operation. Where the single pavements transform into the dual Belt Line construction, the design is such that approaching traffic enters its proper one-way pavement either on a straight-line approach or the natural curvature and pavement superelevation is such as to preclude the probability of inadvertent wrong-lane entry.

As this was a modified freeway with partially controlled access, crossovers through the median, varying in length from 10-ft. to 34-ft., were provided at approximately ½-mi. intervals as turn-around facilities. All traffic entering this highway is required to turn right into the one-way pavement and it is necessary that vehicles desiring to go left must proceed in the direction of travel to the first crossover where they can make a U-turn and then proceed in their desired direction.

Within the length of this Belt Line several major highways and important multiple track railroads are crossed where a separation of grades was essential. Other less important highways and a single track local branch railroad were intersected at grade. Due to economic considerations, the median through those portions which included the highway and railroad separations was reduced to a 4-ft. width. Consequently, within the length of this Belt Line we have numerous median designs which include a short stretch of 40-ft. depressed earth section, a 30-ft. depressed earth section; a 30-ft. curbed earth section; sections, both curbed and depressed, varying in width from 30-ft. to 4-ft.; and a 4-ft. curbed median. The use of the 4-ft. median section is quite justified in this particular instance, and due to the restricted entry into the highway at these points and to the design of the approaches thereto, it has functioned very effectively as a positive separator of opposing streams of traffic.

As the construction of this improvement was spread over an elapsed period of eight years during which our national economy passed from a state of emergency into one of full scale warfare and thence into our present inflation period, the cost of similar items in the several portions of this improvement varied materially. In the first contract, awarded in September of 1940, the bid price on 4,501-ft. of Combination Curb and Gutter, Type II was $0.80 per lin. ft. The next contract awarded two months later showed a bid price of $1.05 per lin. ft. for 3,220-ft. of this same type median while in the third contract, awarded in September 1944, the bid price was $3.75 per lin. ft. for 1,059-ft. All told, the overall cost of 8,870-lin. ft. of the 4-ft. curbed median amounted to $10,953.05 for a weighted average of $1.25 per lin. ft.

US 66 is an important component in the national system of interstate highways and is the major highway link between St. Louis and Chicago. Serving in this capacity, it carries a large proportion of through traffic of which approximately 25 percent represents commercial vehicles. The average daily traffic on this Belt Line at the present time exceeds 4,700 vehicles. The operational speed on US 66 is quite high and the average speed will exceed 50-mi. per hr. These values hold true for the section of improvement under discussion. The accident record on this improvement does not indicate any unusual trends from normal dual-pavement operational records and there have been no complaints due to the inclusion of the stretches of narrow median.

As mentioned above, the reason for the inclusion of the narrow median in this Belt Line construction was based entirely on economic considerations due to the excessive costs of the long structures requir-

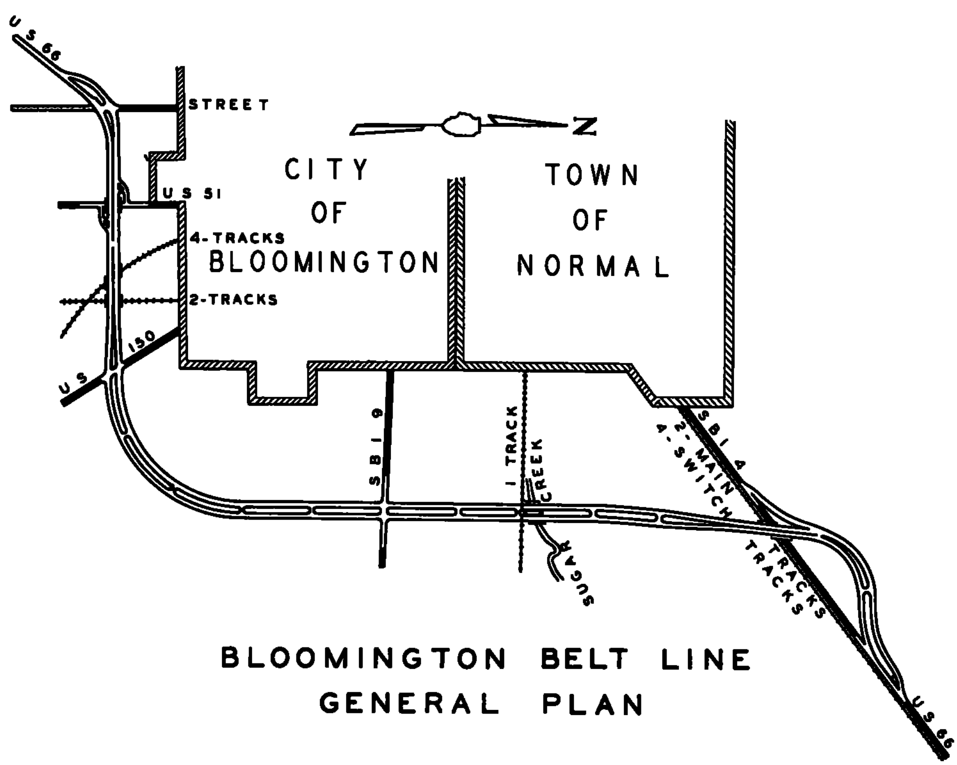


Figure 7.

ed for the various railroad and highway separations. The fact that it has functioned satisfactorily as a physical separator of opposing streams of traffic over the restricted zones of the various separation structures and approaches thereto does not, in itself, necessarily justify its use as a feature of dual-pavement design to the exclusion of wider medians for we have found that they have many objectional shortcomings. The narrow median does not separate opposing streams of traffic sufficiently to eliminate approaching head-light glare. Neither does it relieve the feeling of constriction in multiple-lane highway operation, nor does it eliminate the probability of vehicles figuring in an accident on one highway from ending up in the opposing lanes of traffic. Left turning lanes are precluded and little protection is offered for crossing vehicles. Another limitation of the narrow median is that it does not provide sufficient width for the placement of signs, traffic signals and structural appurtenances. A narrow curbed median, even though mountable, creates a definite travel hazard due primarily to its low shadow visibility and usual lack of color contrast. Another objection to the use of narrow medians is in the matter of maintenance, particularly as regards snow removal or storage.

In conclusion, we wish to reiterate that narrow medians have a definite place in modern highway design especially for the channelization of approach pavements to grade separations; the islandization of traffic at important grade intersections; and at specific locations in dual-pavement design where a reduced cross-section design is economically essential providing that proper approach conditions are met and where cross-conflict or turning movements are limited.

REPORT ON HIGHWAYS WITH A NARROW MEDIAN - MICHIGAN

C. A. Weber, *Road Engineer, Michigan State Highway Department*

Few appreciate the tremendous effect the automobile has had on the American social and economic life. Even fewer realize that a large measure of the automobile industry's development and success is directly attributed to a program of painstaking and intelligent research. The progress of the automobile industry and the story of highway transportation has no parallel in modern history.

The automobile industry, spurred by free enterprise, has poured millions of dollars into experimental and research work which resulted in a continual improvement of its product. During the last decade the industry has reached such phenomenal efficiency in production, that the leaders in the field have become somewhat concerned about possible future curtailment in production, simply because the motoring public have indicated a tendency to shy away from overcrowded highways.

In direct contrast to the auto industry, the highway transportation system has principally been developed and constructed with public funds provided by legislative acts. The Highway Research Board deserves the highest praise for its achievements in national planning and co-ordination of design standards and construction, to meet the ever increasing demand of a fabulously mounting traffic volume.

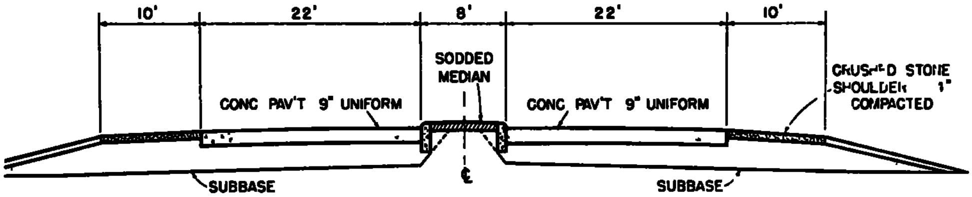
We in Michigan, are fully aware of the importance of careful planning for the future. We also realize that our present rate of highway taxation is not sufficient to meet today's traffic demand. A large percentage of our highways have become inadequate geometrically, principally because of the improved auto design, likewise, the accident rate has risen in proportion to the increased volume of traffic.

While we recognize the desperate need for a radical revision in our design of past years, the magnitude of a complete reconstruction of an already established network, is simply beyond the economic reach of a highly tax conscious public. By careful planning, however, and by special methods of financing, as in the case of the Detroit Crosstown Expressways, we are making some progress in re-designing our major arteries in the state.

Where limited access cannot be provided, it is true that we favor a wide median design in separating opposing traffic lanes of multi-lane highways. These divider strips should be sufficiently wide to allow a safe turning movement and to permit a landscape treatment. We have a standard design for divided highways with 50 ft. between centerlines of roadways and a median width of 26 ft., measured from the inside edges of the pavement. While I frankly admit that our present mileage of this type of construction is rather low, we do have a stage construction policy for our most congested arteries which we have followed during the past 14 years. This policy includes the acquisition of limited access right-of-way of sufficient width to permit the addition of future lanes.

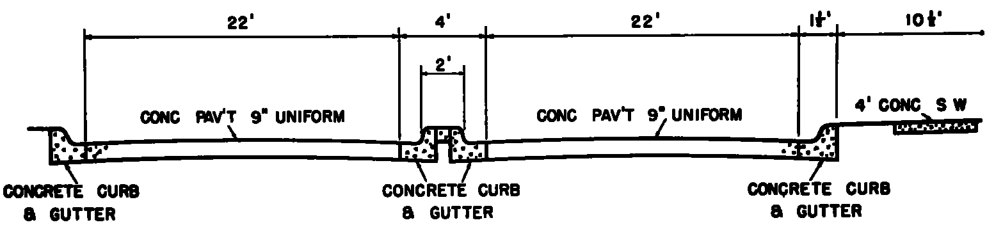
On certain locations, and as an economy measure, we have also constructured some divided highways with a curbed and sodded median from 4 to 8 ft. wide. Throughout interchange areas, and on larger structures, especially within urban limits, we are using a curbed and paved median from 2 to 4 ft. wide. (Figs. 1 to 4).

a narrow divider strip placed directly on the pavement. Two types of design were selected, one of bituminous concrete and one of Portland Cement Concrete construction. This paper will specifically deal with the former type.



TYPICAL SECTION SHOWING
DIVIDED PAVEMENT WITH
8' MEDIAN

Figure 1. Typical Cross Section Primary Trunk Line



TYPICAL SECTION SHOWING
DIVIDED PAVEMENT

Figure 2. Typical Cross Section US 127 Cedar Street, Lansing

Since funds are not adequate to permit a drastic reconstruction of our existing transportation system, we have made a study of what could be accomplished by giving some of our most congested trunklines, a "face lifting", to meet our immediate requirements. It is often too costly to secure more than the original right-of-way along these routes but we do have sufficient room to widen the existing pavement. For the purpose of economy and to increase safety we decided to experiment with

THE HIGHWAY

US-23, a three lane highway from Bay City (Pop. 48,000) and north about 10 miles, and located approximately 100 miles north of Detroit was our first experimental job completed. Most of this location is of a semi-urban nature with a large number of small business establishments such as, grocery stores, restaurants, and gasoline stations adjacent to the project for practically its entire length. (Fig. 7)

This particular trunkline carries a heavy load of local traffic in addition to a tremendous seasonal load of tourist traffic. It is an interstate highway and one of the "Gateways to the North Country" for the population of industrial cities such as Detroit, Flint, Saginaw, and Bay City, combined with an ever increasing influx of tourists from our neighbors south of the border, Ohio, Indiana and Illinois.

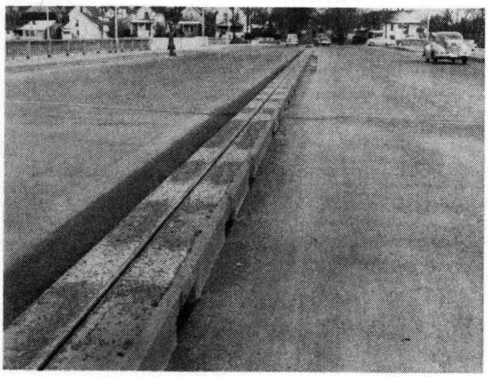


Figure 3. Main Street Bridge, Lansing (US 27 and M-78)

increased percentage of head-on collisions with an unusually high rate of fatalities.

A contract was awarded to widen the original three lane (and a small portion of four lane) pavement with 9 in. uniform concrete pavement to obtain a total overall width of 47 ft. The 3-ft. bituminous concrete divider strip was placed directly on the pavement, thus providing for two separate 22-ft. roadways. (Fig. 8)

The shoulders conform to our standard design for primary trunklines. Our experience has proved that adequate shoulders will greatly add to the safety and feeling of security they give the driver.

It is an extablished fact that a narrow shoulder will decrease the effective driving surface of the highway and seriously hamper the vehicle movement whenever a car breakdown occurs. Consequently, our standard shoulder width on major trunklines is 10 ft. This usually consists of a 2-ft. strip of gravel next to the metal, surfaced with a seal coat mixture, while the remaining 8 ft. are constructed of stabilized earth.

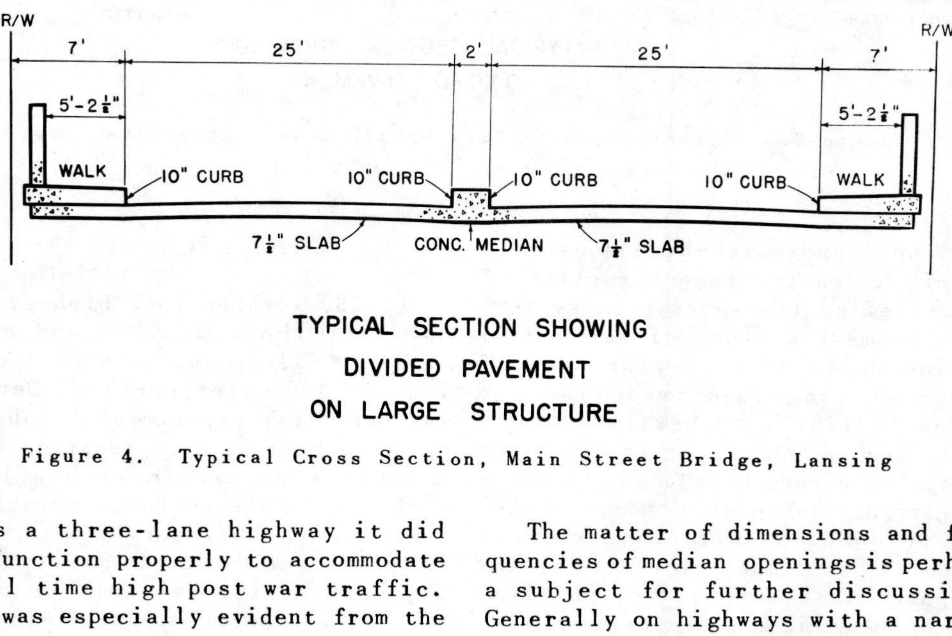


Figure 4. Typical Cross Section, Main Street Bridge, Lansing

As a three-lane highway it did not function properly to accommodate an all time high post war traffic. This was especially evident from the

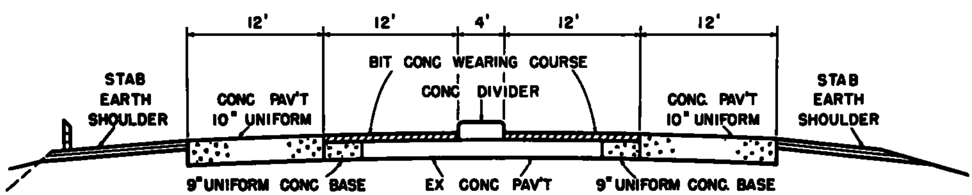
The matter of dimensions and frequencies of median openings is perhaps a subject for further discussion. Generally on highways with a narrow median, openings are restricted to intersections of important roads and approaches.

On this particular location, however, of areas with large numbers of business establishments along the highway, we decided to provide median openings at all approaches and all drives to buildings. Openings were not provided at seldom used field entrances. It was felt that the elimination of all driveway openings would result in a large number of U-turning movements at intersections which would prove extremely hazardous. The theory was to construct a dual highway which would partially retain the turning movements of an undivided four lane highway. While we are not entirely convinced that our spacing of openings is correct, traffic statistics and driver behavior over an extended period of time, will serve as a guide for the future.

It was decided to provide a median opening 95 ft. in length at intersections and 75 ft. at drives. This is generally in accordance with AASHO policy. (Fig. 10)

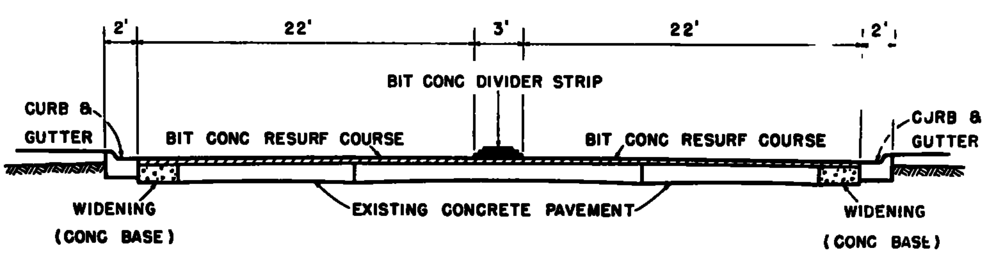
In order to give a feeling of median continuity, the bottom divider layer, 3 ft. wide and 2 in. high was carried across all driveway openings. The median was entirely omitted at intersecting approach roads.

A control speed zone with a 50 m.p.h. limit was established over the entire experimental section in 1947. This was partly due to the proximity of Bay City, and as a precautionary measure to reduce the high rate of accidents. All turning movements are restricted to the designated median openings, while traffic caution lights are placed at important intersecting roads. Because of the high volume of traffic at Linwood Road, at the extreme north end of the



TYPICAL SECTION SHOWING DIVIDED PAVEMENT

Figure 5. Typical Cross Section, US 24 South of Pontiac



TYPICAL SECTION SHOWING DIVIDED PAVEMENT

Figure 6. Typical Cross Section, US 23 Bay City North

initial construction a standard overhead control signal was required to permit crossing with safety.

Approximately one half of the project traverses an old lake bed consisting of wave cut glacial till, while the other half follows a sandy beach left by a former glacial lake. Since the profile of the highway and surrounding terrain is extremely level, the principal drainage problem consisted of the disposal of surface water. Special "scuppers" or openings through the median, were designated to take the surface water across the pavement on superelevated curves. (Fig. 12) All road ditches are emptied into a network of county drains which outlet into Saginaw Bay.

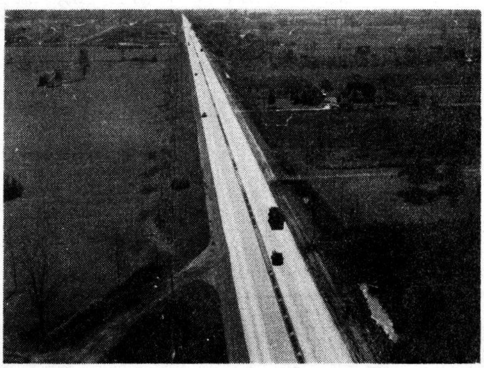


Figure 7. US 23, Bay City North

THE MEDIAN

It has previously been mentioned that the primary reason for selecting a narrow divider construction of bituminous concrete was for the purpose of safety and economy. Although the plan design called for only one type of median throughout the entire 10 mi. experimental section, three different dividers were actually completed on construction.

The major section of approximately 9 mi., has 3 layers, each 2 in. thick. The bottom layer is 36 in. wide, the middle layer 24 in. wide, and the top layer 12 in. wide.

The second section was built in 2-in. layers, 36 in., 30 in. and 24 in. wide respectively. (Figs. 13 to 19)

On the third section only 2 layers were constructed, one 36 in. wide, the other 24 in. wide. Each of the layers were 2½ in. thick.

The actual construction of the median was rather simple. A standard bituminous concrete surfacing mixture consisting of coarse aggregate, fine aggregate, mineral filler and bituminous material were used, while a regular bond coat was applied to the concrete pavement prior to the placing of the bottom course.

All courses were laid by ordinary equipment with adjustable spreader for width and height. Each layer, except the top course, was rolled separately with rollers 36 to 38 in. wide and weighing respectively from 2 to 4 tons. The top layer was rolled by a 15-in. garden roller weighing 350 pounds.

In order to increase visibility of the strip at night, a 4-in. yellow line was painted on each side of the bottom layer of the strip. Also, a white line 2 ft. wide and spaced diagonally every 20 ft. was painted across the median. To further increase the visibility, a reflector type paint containing minute glass beads was used.

THE COST

The contract price of the entire project consisting of 10.3 mi. of grading for widening and surfacing, including the bituminous divider strip was $463,819.00. The cost of the bituminous divider was $34,400.00, or approximately 82 cents per lin. ft. It is estimated that a comparable divider strip constructed of Portland Cement Concrete would cost about $2.00 per lin. ft.

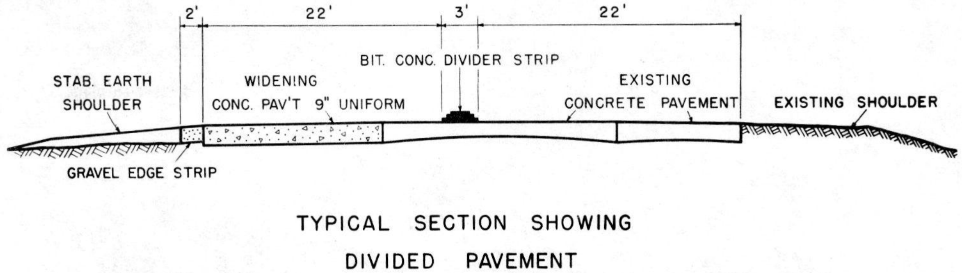


Figure 8. Typical Cross Section US 23 Bay City North

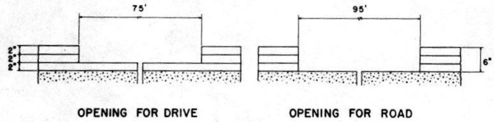


Figure 11. Openings in Median US 23 Bay City North

Figure 9. US 23, North of Bay City

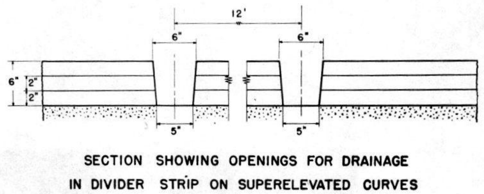


Figure 12. Detail of Median US 23 Bay City North

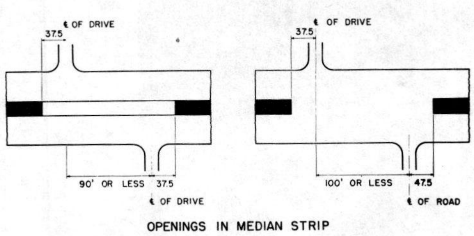


Figure 10. Openings in Median US 23 Bay City North

Figure 13. Three Layer Bituminous Concrete Median

Figure 14. Placing Bottom Median Layer

Figure 15. Placing Second Median Layer

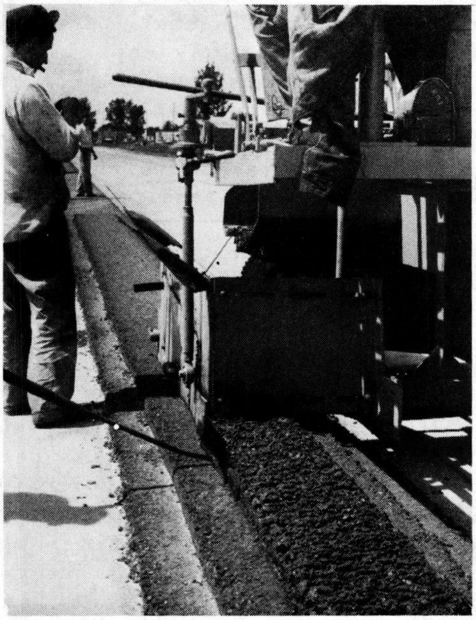


Figure 16. Placing Top Median Layer

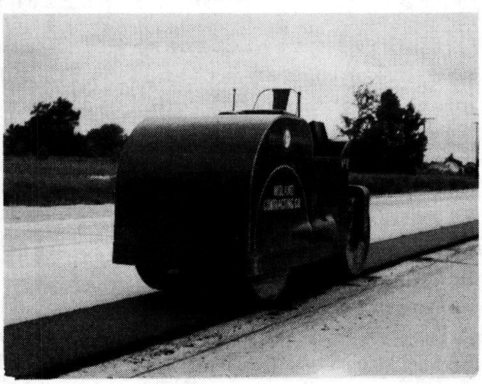


Figure 17. Rolling the Bottom Layer

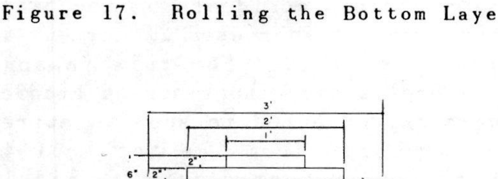


Figure 18. Detail of Median US 23 Bay City North

Figure 19. Two Layer Median

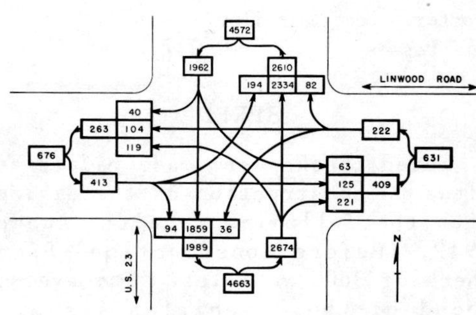


Figure 20. Daily Vehicle Volume Count Intersection US 23 and Linwood Drive - Turning Movements at Intersection with Linwood Road

TRAFFIC

The average daily 24 hour traffic volume is approximately 7,000 vehicles. However, this volume fluctuates sharply as it exceeds 12,000 vehicles on weekends and holidays during recreational seasons. About

20 percent of the traffic consists of commercial vehicles.

The following data has been compiled by our Traffic Engineers: (1) Average Daily Traffic Data - The 1949 average daily traffic on US-23 near Linwood Road was 7,560 vehicles. (2) Peak morning hours are 8 AM to 12 Noon with 25.3% of total traffic. Peak afternoon hours are 1 PM to 5 PM with 28.6% of total traffic. (3) Peak directional hours are the same as listed above with peak
AM Northbound hour 9 AM - 10 AM
PM Northbound hour 1 PM - 2 PM
AM Southbound hour 11 AM - 12 Noon
PM Southbound hour 2 PM - 3 PM
(4) Traffic Composition

	Southbound Percent	Northbound Percent
Passenger cars	75.5	77.5
Passenger cars with trailer	2.9	2.4
Panel or Pickup & Dual rear tire - 2 axle trucks	13.9	13.0
Tractor - Semi & Trailer - Busses	7.7	7.1

SPEED

Speed checks were made before and after the construction of the divider with the following result: August 1949, (Before Construction) Speed check of 3600 vehicles. The average speed of these vehicles was 51.9 m.p.h. 85 percent of the vehicles did not exceed 61.9 m.p.h. November 1950, (After Construction) speed check of 1326 vehicles. The average speed of these vehicles was 51.5 m.p.h. 85 percent of the vehicles did not exceed 59.4 m.p.h. These spot checks were made within the 50 m.p.h. speed zone area.

VEHICLE PLACEMENT STUDY

A study was made by visual observation of vehicle placement by means of paint marks on pavement at one foot intervals from the median edge. The total vehicles shown obviously represent a small percentage of practical roadway capacity for the periods of observation. For this reason, it is reasonable to assume that most of the vehicles observed in the lane adjacent to the median were engaged in a passing maneuver.

Accident Experience - As a three lane highway US-23 had unrestricted sight distance both horizontally and vertically. The accident rate was nevertheless high with a large number of fatalities.

During the tourist season, when the traffic flow reached its peak, the average speed was approximately 45 m.p.h. While the average speeds were normal there were times when drivers were traveling at the rate of 60 to 80 m.p.h., three lanes abreast, forcing the opposing traffic to use the roadway shoulders. Over a 6 months period 1946-1947, three collisions killed 13 persons.

Special precautionary measures were taken in an attempt to reduce the accident rates. Reflectorized lanes were painted twice a year, oversized signs were erected cautioning the motorist that the center lane was for passing only, and a speed limit of 50 m.p.h. was established.

Accident statistics were also recorded for a comparable three months period before and after the median was constructed. During these same periods accidents on the State rural system increased 22 percent in 1950 over 1948. For this reason, the preliminary short period studies were not expected to show an appreciable drop from the total of 40 accidents reported in 1948 within the median section. Classification of these accidents, however, revealed a sharp reduction in opposite direction collisions from 10 to zero after construction of the median.

Likewise, our records indicate a distinct reduction in the number of injuries since construction of the divider. In the three month periods mentioned above, 1 person was killed and 27 injured before placing the median, against no fatalities and 13 persons injured after the median was built.

It may be of interest to note that one of the factors which increases the total reported accidents, is the close proximity of a State Police Post to the area of accident concentration.

It is too early, of course, to form any definite conclusions regarding the accident ratio, the State Police point out, however, that they believe the opposite directional type of collisions will be practically eliminated on this section in the future.

THE SUMMARY

Reason for choice of design - The ideal solution to our transportation problem on this particular highway would, of course, have been to reconstruct the entire section of highway in accordance with the highest standards for divided highways.

As a more realistic approach, economy being one of the primary factors, we attempted to introduce a low cost divider strip with the principal objective of eliminating the high percentage of head-on collisions.

It has already been mentioned that any additional right-of-way would have been difficult to obtain and at a prohibitive cost. Consequently, a process of expensive stage construction would have been

ACCIDENT RECORD BY TYPE AND SEVERITY
FOR
THREE YEARS PRIOR TO MEDIAN CONSTRUCTION

US-23 From N. Union St. Through Linwood Road
Bay County
Years 1946, 1947 and 1948

Type	Accidents Between Intersections No. of Accidents All	Fatal	Injury	Damage	Severity Killed	Injured
Opposite Direction	63	2	26	35	10	65
Sideswipe (Same Direction)	11	0	2	9	0	2
Rear End	85	0	21	64	0	27
Ran Off Road	27	0	9	18	0	10
Pedestrian	4	1	3	0	1	3
U-Turn	6	0	3	3	0	8
Miscellaneous	9	1	2	6	2	8
Sub-Total	205	4	66	135	13	123
Accidents of Intersections						
Sub-Total	76	1	20	55	1	38
TOTAL	281	5	86	190	14	161

exceedingly slow, without any immediate relief for a major part of this congested trunkline.

DEMONSTRATED ADVANTAGES (CONCLUSIONS TO DATE)

While it is too early to form a positive conclusion, after only four months of operation, it is safe to assume that nearly all of the opposite directional type of accidents have been eliminated. The severity of other types of accidents have also been considerably reduced since the installation of the divider strip.

Construction of the bituminous divider strip and the pavement widening can be accomplished without completely disrupting the traffic.

Cost of the bituminous concrete median is considerably less than that of Portland Cement Concrete construction.

Additional openings for future driveways can easily be made.

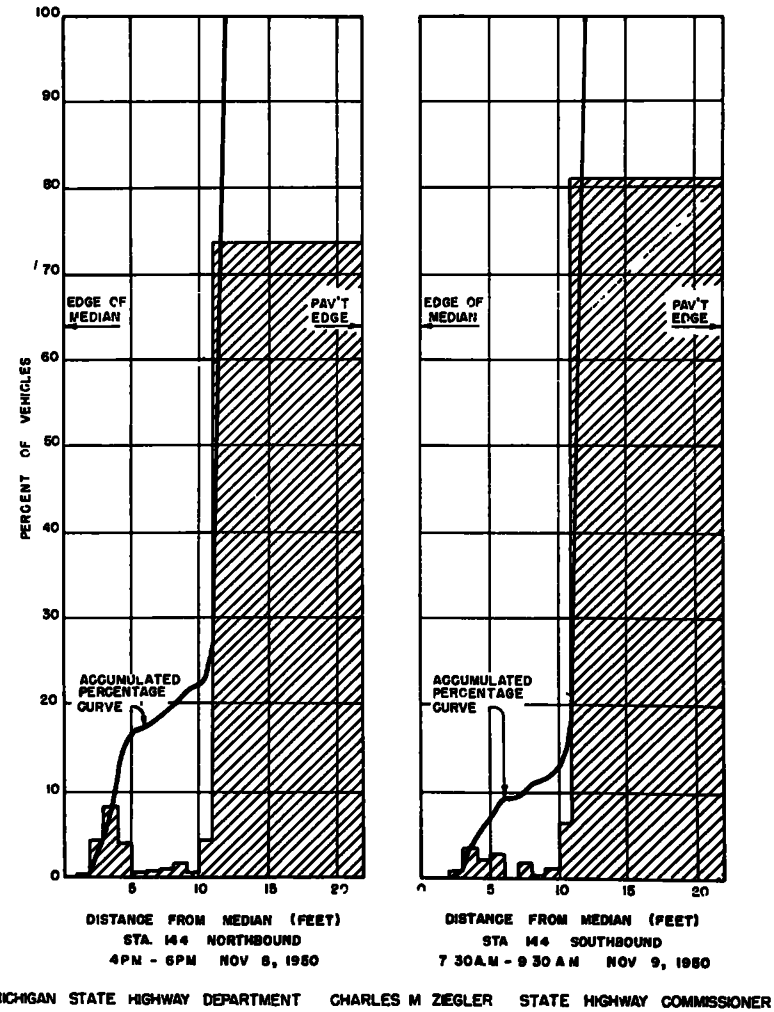


Figure 21 Vehicle Placement Study - US 23 North of Bay City - 4 Lane Divided Highway with 3-in. Bituminous Median

SUGGESTIONS FOR FUTURE DESIGN

From observations made to date, it appears that the two layer divider 36 in. at bottom, 24 in. at top, with each layer 2½ in. thick, will be the choice for a future design. The 24-in. top provides a wider signing surface, which in turn distinctly increases the overall visibility of of the median. To further improve the visibility of the divider at night, it may be advisable to erect reflectorized delineators in the center of the median. Delineators erected, say four feet above the pavement, would also serve as a guide when snow might cover the median for a short period of time.

On future construction special equipment and perhaps a special bituminous mixture will, no doubt be developed to increase efficiency in construction as well as improvement in appearance. Critical shortage of Portland cement may also favor this type of a median.

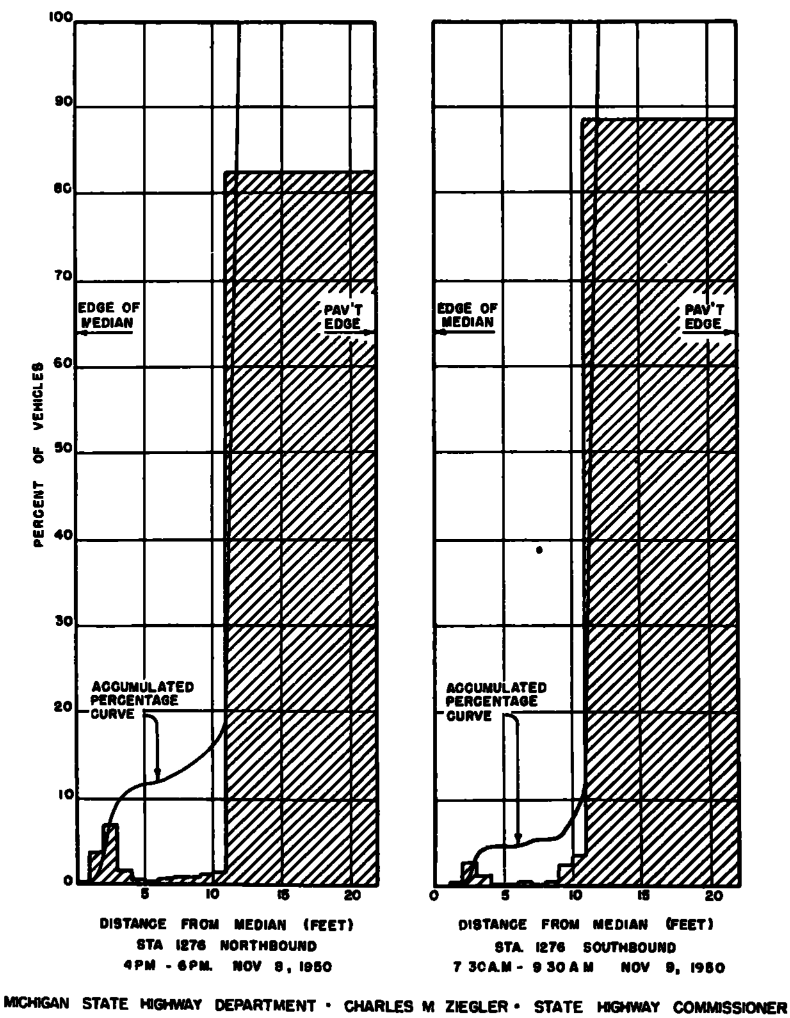


Figure 22. Vehicle Placement Study - US 23 North of Bay City - 4 Lane Divided Highway with 3-in. Bituminous Median

VEHICLE PLACEMENT STUDY

US-23 North of Bay City
4 Lane Divided Highway with 3 Ft Bituminous Median

Station 144 Northbound

Distance - Left Wheels from Median	Number Vehicles	Percent	Accumulated Percent
0 - 1 ft	0	0 00	0 00
1 - 2 ft	2	0 28	0 28
2 - 3 ft	32	4 40	4 68
3 - 4 ft	62	8 53	13 21
4 - 5 ft	29	3 99	17 20
5 - 6 ft	4	0 55	17 75
6 - 7 ft	7	0 96	18 71
7 - 8 ft	8	1 10	19 81
8 - 9 ft	12	1 65	21 46
9 -10 ft	3	0 41	21 87
10 -11 ft	32	4 40	26 27
Over 11 ft	536	73 73	100 00

Station 144 Southbound

Distance - Left Wheels from Median	Number Vehicles	Percent	Accumulated Percent
0 - 1 ft	0	0 00	0 00
1 - 2 ft	0	0 00	0 00
2 - 3 ft	3	0 77	0 77
3 - 4 ft	14	3 60	4 37
4 - 5 ft	8	2 06	6 43
5 - 6 ft	11	2 83	9 26
6 - 7 ft	0	0 00	9 26
7 - 8 ft	7	1 80	11 06
8 - 9 ft	1	0 26	11 32
9 -10 ft	5	1 29	12 61
10 -11 ft	25	6 43	19 04
Over 11 ft	315	80 96	100 00

VEHICLE PLACEMENT STUDY

US-23 North of Bay City
4 Lane Divided Highway with 3 Ft Bituminous Median

Station 1276 Northbound

Distance - Left Wheels from Median	Number Vehicles	Percent	Accumulated Percent
0 - 1 ft	1	0 19	0 19
1 - 2 ft	13	2 56	2 75
2 - 3 ft	34	6 67	9 42
3 - 4 ft	8	1 57	10 99
4 - 5 ft	3	0 59	11 58
5 - 6 ft	2	0 39	11 97
6 - 7 ft	4	0 79	12 76
7 - 8 ft	5	0 98	13 74
8 - 9 ft	5	0 98	14 72
9 -10 ft	6	1 18	15 90
10 -11 ft	7	1 38	17 28
Over 11 ft	421	82 72	100 00

Station 1276 Southbound

Distance - Left Wheels from Median	Number Vehicles	Percent	Accumulated Percent
0 - 1 ft	0	0 00	0 00
1 - 2 ft	1	0 43	0 43
2 - 3 ft	7	2 98	3 41
3 - 4 ft	3	1 28	4 69
4 - 5 ft	0	0 00	4 69
5 - 6 ft	0	0 00	4 69
6 - 7 ft	1	0 43	5 12
7 - 8 ft	0	0 00	5 12
8 - 9 ft	1	0 43	5 55
9 -10 ft	6	2 56	8 11
10 -11 ft	8	3 40	11 51
Over 11 ft	208	88 49	100 00

In conclusion I again want to emphasize that we are experimenting and have not as yet reached conclusive proof that our problem is entirely corrected. We realize that a narrow median has its limitations. We have previously used successfully, a narrow type of a divider when we had limited access and where side friction was practically nonexistent.

Perhaps the success of a narrow divider strip should be judged by the driver behavior. If our statistics over a period of say 2 years, reflect an improved driver behavior, demonstrated by a proportional reduction in accidents, especially head-on collisions, we will feel that our experiment was justified.

APPENDIX

The Michigan State Police have issued the following two statements regarding their observations and experience, while patrolling this highway, since the three foot median was constructed.

MICHIGAN STATE POLICE

Inter-Office Correspondence

Date November 20, 1950

Subject. Observations and Reaction to the Median Divider on US-23 North of Bay City

To Captain William Hansen, Superintendent, Uniform Division, East Lansing

This report is with reference to the request contained in your letter of November 10, 1950, regarding the median divider installed on highway US-23 between Bay City and Linwood, a distance of about twelve miles.

Since the installation of the medial divider on highway US-23, north of Bay City, personnel of the Bay City Post have made daily observations of driver behavior under daytime and night time driving conditions, speed, lane usage and the appearance of the medial divider under adverse weather and driving conditions. From these daily observations, we have noted a marked improvement in driver behavior generally with emphasis on lane usage

The medial divider, we believe from our observations and experience since its installation, has eliminated the wandering lane driver, third lane passing, and head on collisions which were quite frequent and of serious consequences prior to the installation of the medial divider. Since the installation of this divider, we have not experienced a serious accident involving two motor vehicles

We have observed that the medial divider, in our opinion, has created a mental hazard (alertness) which tends to keep the driver alert and attentive to his driving responsibilities.

Public reaction has been very favorable to the divider with exception to the medial divider being fairly difficult to observe under adverse weather conditions especially misty rainy nights Personnel of the Bay City Post concur with the public regarding the difficulty to observe the divider under adverse weather conditions. To correct this condition, we suggest that additional painting would materially improve the drivers problem to observe the divider under adverse weather and driving conditions. It is further suggested that some thought be given the installation of four foot markers with reflector heads every one hundred fifty feet atop the medial divider. Markers of this type, if installed, would not only guide the driver during adverse weather conditions but also during the winter months when snow becomes a problem

Under weather conditions which have prevailed since the installation of the medial divider, the reaction of the personnel assigned to the Bay City Post is very favorable. However, winter driving conditions may create problems which will discredit the medial divider. Answers to drifting snow, ice, snow removal, etc , in relation to the medial divider have yet to be learned. Weather conditions and experience during the winter months will, in my opinion, determine the feasibility of the medial divider.

Respectfully submitted,
/s/ Dan L. Wurzburg
Dan L Wurzburg, Sergeant
Commanding Officer
Bay City Post

cc 3rd Dist Commander

MICHIGAN STATE POLICE

Inter-Office Correspondence

November 21, 1950

Subject Reaction to medial divider on US-23, North of Bay City

To. Captain William D. Hansen, Superintendent of Uniform Division, East Lansing, Michigan

This is with reference to your letter of November 10, pertaining to the above captioned subject.

The medial divider in question is located on US-23 and extends from the north limits of Bay City north to the Linwood Road, a distance of approximately ten and one-half miles.

The highway was formerly a three lane pavement The fourth lane was added and completed for travel on November 13, 1949 From that time on there were occasional accidents of all types. However, undoubtedly fewer than on the standard width four lane pavement, because this highway was built wider to allow the medial divider to be added at a later date

Then on, or about July 3, 1950, the medial divider was completed and since that time the front to front, or head-on accidents have been extinct.

The only accidents on the above mentioned highway since the installation of the medial divider have been rear-end collisions of not too serious a nature, which are caused by drivers stopping suddenly in the inside lane when intending to make a left turn at intersections and regular cross traffic intersection accidents.

The personal injury list has been exceptionally low and of a minor nature up to this time. Of course, hazardous driving conditions have been at a minimum since the installation of the medial divider. Many persons are of the opinion that the medial divider will cause hazardous driving conditions during the winter months, by preventing the water and slush from draining off during the day time, which will naturally freeze during the night.

The outstanding complaint being received from motorists is that they are unable to see the divider at night, especially in rainy, misty, or foggy weather, when traffic is very light.

On Sunday, November 19, between the hours of 2.30 PM and 9·30 PM, during misty weather conditions, the heaviest traffic flow in history traveled south on US-23 and during that time there were just two very minor rear-end property damage accidents on the highway in question.

In our opinion, the medial divider has aided greatly in the reduction of accidents this far and we are anxiously waiting to see what changes winter weather will bring, if any

Respectfully submitted,
/s/ E E. Secrist
Captain E E. Secrist
District Commander
District No 3

EES SJR

SYMPOSIUM ON HIGHWAYS WITH A NARROW MEDIAN - NEW JERSEY

Ralph L. Fisher, *Engineer of Design, New Jersey State Highway Department*

The use of medians for highways of four or more lanes in width has become accepted practice for new facilities and also for modernization of existing roads. The maximum benefits from the use of medians occurs when they are of sufficient width to (1) provide freedom of operation from opposing traffic, (2) provide space for crossing and turning vehicles at intersections or island openings and (3) to minimize headlight glare.

A 16-ft. median is the minimum in which a left turn channel can be constructed. For this reason a median less than 16-ft. in width is not considered good design in New Jersey.

However, the width of median is often limited by available width of right-of-way, economic considerations or other reasons and narrow medians, although not desirable, are sometimes necessary.

The medians on Route 17 and Route 28 in Northern New Jersey are believed to represent what may be considered the minimum in median design.

ROUTE 17

The Site - Figure 1 shows the general location of Route 17 in northern New Jersey. This north-south route crosses 3 major east-west routes (Routes S3, 6 and 4) and thus serves as a connecting road in addition to serving large concentrations of local traffic. Figure 2 shows a section of this route in relation to local streets and highways.

This section of Route 17 may be considered in general as a major street through a residential or suburban area, with some business establishments.

At the time that studies were being made for the improvement of Route 17, the Highway Department had long range plans for the construction of other routes that would relieve traffic conditions on Route 17. Due to the topography, numerous intersecting streets and limited right-of-way, the expense of converting Route 17 to a high capacity route was considered excessive. For these reasons, the improvement of Route 17 was held to what may be considered an absolute minimum for a divided highway.

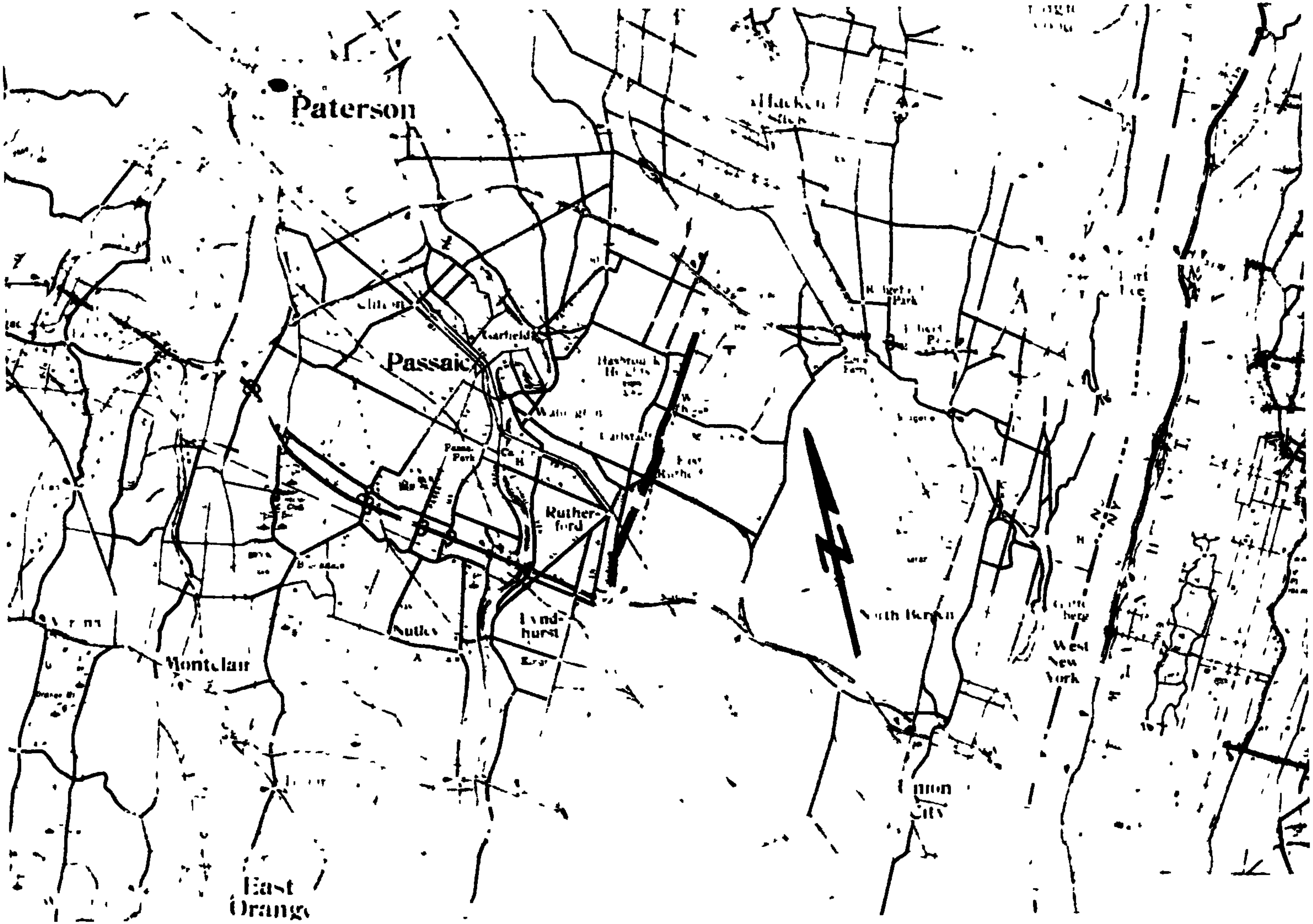
The Highway - Before dualization, Route 17 was a three lane road with 30 ft. of pavement, a 10-ft. shoulder on one side and a 2-ft. shoulder on the other side as shown in Figure 3. The dualization consisted of the installation of a 2-ft. wide low curbed island and two 24-ft. pavements. There are not any shoulders but parking is prohibited.

Figure 4 shows details at one of the major intersections. The 10 ft. of additional pavement on the northeast corner of the intersection was provided in order that thru vehicles could pass vehicles waiting to make a left turn.

Most of the major intersections have traffic signals with all turning movements permitted. These signals are not coordinated.

This section of Route 17 traverses

Figure 1.


Paterson
Passaic
Ruther-
ford
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Montclair
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Union
City

the edge of the marsh area, so that the grades are generally quite flat.

One of the disadvantages of a narrow median is the difficulty of providing adequate drainage. If each roadway has a two way crown, then the curb lines of the median are gutter lines. Vehicles riding close to the curb line throw water or slush across the narrow median onto cars traveling in the opposite direction. One way to remedy this condition is to provide inner shoulders with inlets on each side of the median.

On Route 17 it was not feasible to provide inner shoulders so the roadways were sloped away from the median and inlets were installed at the outside curb lines. This method has the disadvantage of that during periods of freezing and thaw, water from melting snow on the median will run part way across the pavement and then freeze.

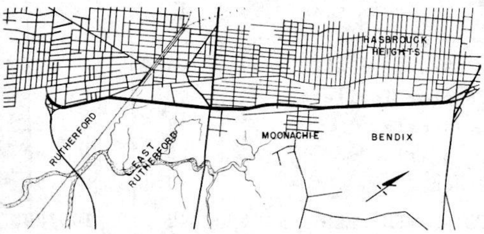


Figure 2.

The Median - Due to the many private driveways and entrances along Route 17, it was felt undesirable to use the usual high median curb with median openings as the numerous openings would practically nullify the benefit of the median. In addition, as the area developed, the Department would be put to the expense and trouble of constantly providing new openings for each new driveway. It was therefore decided to use a low mountable curb continuous between street intersections that could be crossed at any point by traffic desiring to make left turns.

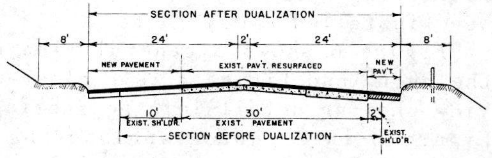


Figure 3. Route 17 - 24-in. Median

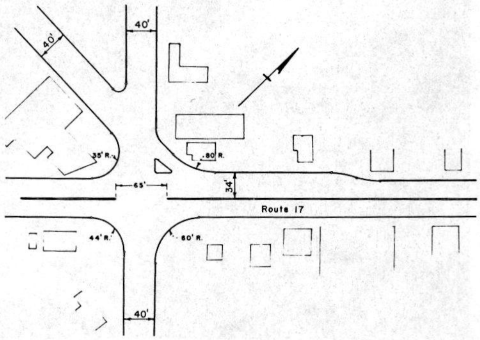


Figure 4.

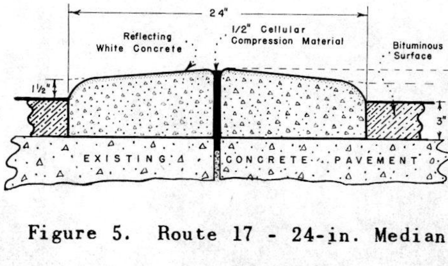


Figure 5. Route 17 - 24-in. Median

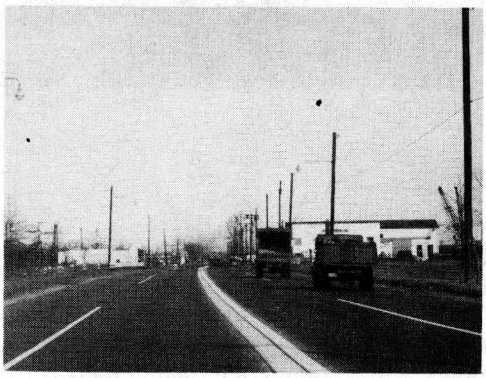


Figure 6.

Details of this curb are shown on Figure 5. The curb is made of cast in place white concrete with a scored reflecting surface. Expansion joints were installed every 12 ft.

Figure 6 shows a general view of the curb, and Figure 7 is a close-up view showing details of the scoring. Figure 8 is a photograph showing a typical section of the highway.

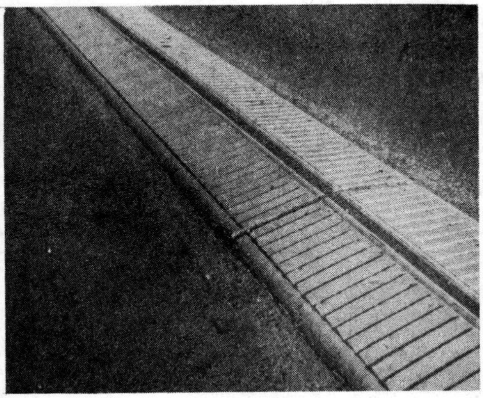


Figure 7.

Figure 8.

The Cost - The length of this project is 4 mi. It was completed in January 1949. The total cost was $822,305.00. This included the conversion from 3 lanes to 4 lanes and the resurfacing of the existing pavement.

The median was constructed at a cost of $3.90 a lin. ft. or a total of $69,759.30 for the 17,887 lin. ft.

The Traffic - Due to the numerous intersecting streets, there is considerable variation in the traffic volumes along the four mile section of highway.

Average daily traffic for 1950 varied from about 18,000 at the southern end to over 30,000 near the center and dropping to about 25,500 near the northern end. The thirtieth peak hour volume is 11 percent of annual average daily traffic, one way.

Table 1 shows a traffic classification based on a count of 1442 vehicles taken on March 14, 1950, near the southern end of the project.

TABLE 1

Type Vehicle	Number	Percent of Total
Passenger Cars	1253	86.89
Trucks		
below 1½ tons	47	3.25
2 axle dual tires	70	4.86
3 axle dual tires	4	.29
Tractor Trailers		
3 axle	42	2.91
4 axle	13	.90
Buses	13	.90
TOTAL VEHICLES	1442	100.00

TABLE 2

ACCIDENT SUMMARY - - ROUTE 17

TYPE	1948	1949	FIRST 6 MONTHS 1950
Right Angle	33	26	12
Same Direction	104	116	69
Left Turn	27	26	15
Pedestrian	6	1	0
Fixed Object	7	11	10
Other	8	5	3
TOTAL	185	185	109
Injuries	82	90	37
Fatalities	3	0	0

NOTE: TRAFFIC INCREASE 8 PERCENT PER YEAR

Table 2 gives the accident summary for the year 1948 (the year before dualization) and for 1949 and the first half of 1950. It is interesting to note that there have been no opposite direction accidents.

The affect of the installation of the median on accidents cannot be determined from the records as other conditions were changed by the dualization.

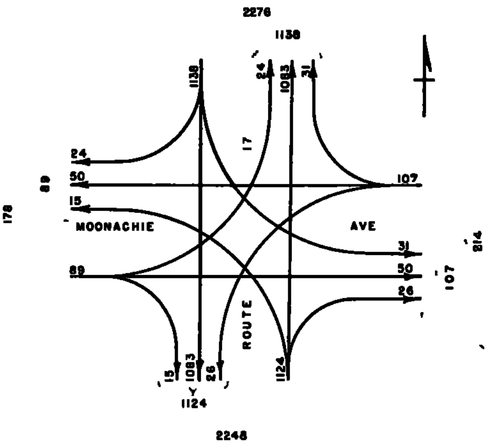


Figure 9.

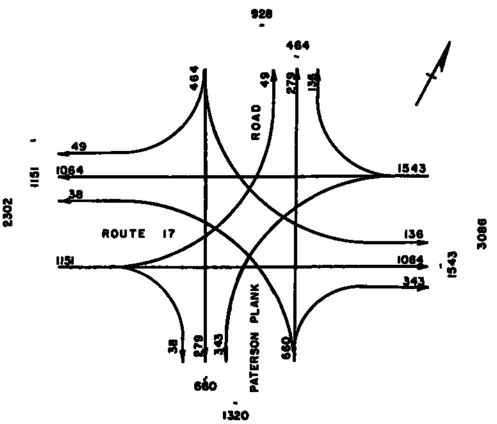


Figure 10.

Figures 9 and 10 show turning movements at two of the major intersections.

Vehicles maintain an average daytime clearance of 1.8 ft. from the edge of the center curb when there is a vehicle on their right and 2.1 ft. when the lane on their right is unoccupied.

Average speeds of vehicles along Route 17 taken during November of 1950 shows an average speed of 40.0 m.p.h. for passenger cars and 35.7 m.p.h. for trucks. The 85 percentile speeds were 46 m.p.h. for trucks and 47 m.p.h. for passenger vehicles.

The Summary - This section of Route 17 presents the rather common problem of improving an old route having limited right-of-way and passing through built up areas. The cost of improving it to modern standards would be prohibitive. It is generally cheaper to build another road on new routes. On the other hand, some improvements should be made as the existing road passes through developed areas and will always carry fairly large volumes of traffic.

The above described improvements to Route 17 may be considered the minimum that can be done for the conversion of an existing 3 lane highway to a 4 lane divided highway.

This median may be considered an experimental type and has not been in use a sufficient length of time to reach final conclusions as to its merits. However it would appear to have the following advantages over the conventional higher type.

(1) Openings for driveways, left turns and "U" turns are not necessary and a continuous median can be used between street intersections. Before construction, some concern was expressed that motorists might not cross this curb for left and "U" turns. However, this has not proved to be the case as motorists do not hesitate to cross this curb in order to make a turning movement.

(2) It gives a positive separation of opposite direction traffic but can be crossed in an emergency (if

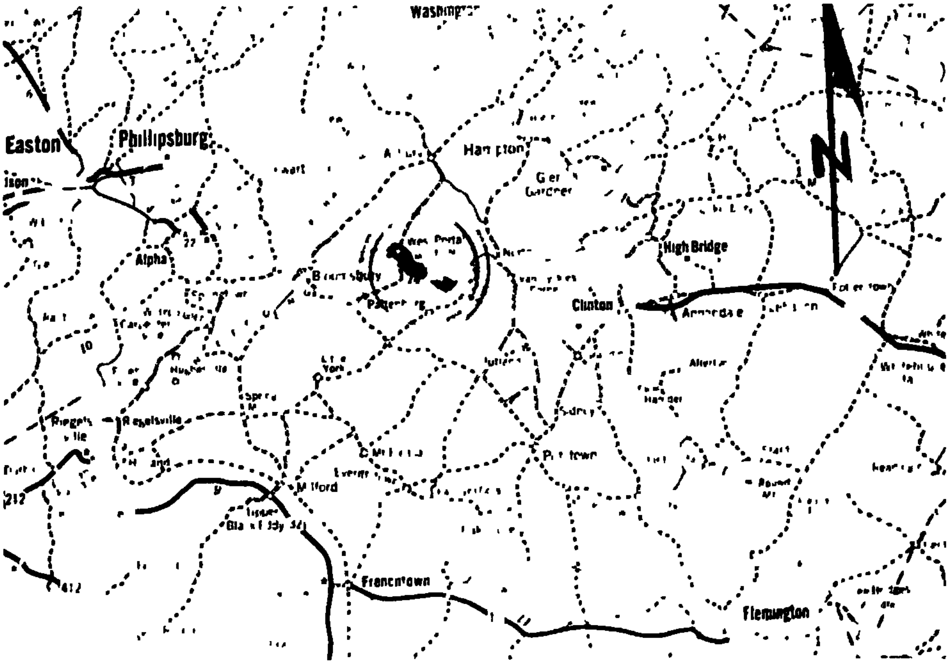


Figure 11.

Figure 12.

the opposite lane is vacant) in order to avoid a collision.

(3) It facilitates the movement of police cars, fire apparatus etc.

(4) In case of fire or accidents, any section of one roadway can be closed off and two way traffic maintained on the other roadway.

(5) This type of curb seems to collect less debris and snow than the conventional higher type. This may be due partially to the fact that vehicles ride closer to it than they would to a higher curb.

ROUTE 28

The Site - Figure 11 shows the general location of Route 28 in relation to other main highways. This route is a direct east-west road across New Jersey from Pennsylvania to Newark and New York.

Figure 12 shows a two mile section of this route. This section is a rural road across a mountain with no intersecting roads of any importance.

The Highway - Before dualization, this section consisted of 20 ft. of pavement with earth shoulders. It has curves as sharp as 10 deg. and grades of 7.2 percent. There were but few sections where it was possible to pass slow moving vehicles.

Due to the topography, construction of a new highway on better alignment and grades would probably necessitate a tunnel. Grading costs would also be high. As money was not available for a new highway, it was decided to dualize the existing road as shown in Figure 13. The dualization consisted of resurfacing and widening the existing road to 23 ft., the construction of 23 ft. of new pavement and a 2 ft. 6 in. curbed median and outer shoulders 10 ft. wide.

The island openings vary from 30 to 50 ft. in length. Figure 14 shows a typical opening. All turns are permitted. Figure 15 shows the

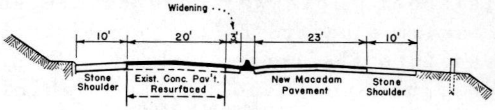


Figure 13. Route 28 - 2-ft. 6-in. Median

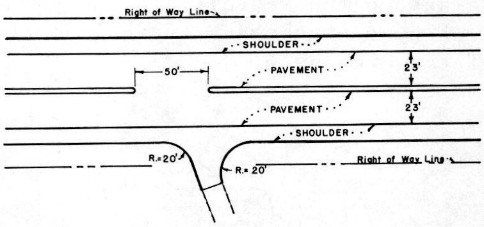


Figure 14.

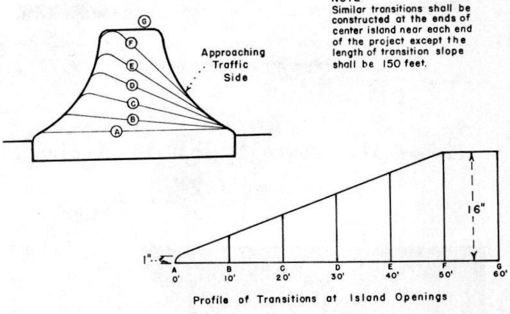


Figure 15.

Figure 16.

transition in curb height at island openings and at the ends of the islands. This was done to present less of a hazard to the motorist who ran into the center island. It was designed to "hand up" the vehicle and cause it to slide along the top of the curb. Vehicles that have run into the ends of the islands come to a sliding stop without injury to the occupants and but little or no damage to the vehicle.

Figure 16 shows a typical section of the highway.

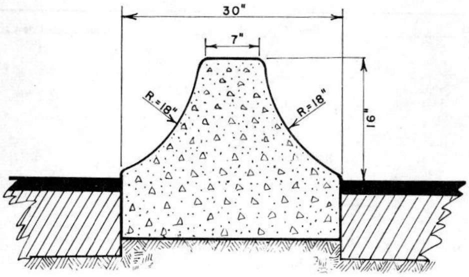


Figure 17. Route 28 - 30-in. Median

Figure 18.

The Median - Figure 17 shows details of the median. The curb was cast in place with expansion joints every 20 ft. The interior consists of grey concrete with a minimum thickness of 2 in. of white concrete on the exposed surfaces. The top of the curb is scored.

Figure 18 shows a close up view of the median.

The Cost - The length of this project is 2.04 mi. and was completed in November of 1949. The total cost was $634,128.

The 7,550 ft. of median as shown in figure 14 was constructed at a cost of $5.74 a lin. ft. or a total of $43,337. In addition there was 1,613 ft. of median doweled to existing pavement at a cost of $5.10 a lin. ft. or a total cost of $8,226.30. The 9,163 lin. ft. cost $51,563.30.

The Traffic - The average daily traffic amounts to 8,000 vehicles. The 30th peak hour factor is 14 percent, giving a peak hour directional flow of 560 vehicles. Thirty percent of the vehicles consist of trucks.

The average speeds upgrade are 50 m.p.h. for passenger cars and 16 m.p.h. for trucks. The corresponding 85 percentile speeds are 56 m.p.h. and 30 m.p.h. The average speeds downgrade are 52 m.p.h. for passenger cars and 51 m.p.h. for trucks. The corresponding 85 percentile speeds are 58 m.p.h. and 60 m.p.h.

Vehicles are reluctant to drive close to this curb. After passing a slower moving vehicle, most cars moved over to the right hand lane. Vehicles maintain an average daytime clearance of 3 ft. from the edge of the center curb when there is a vehicle on their right. On curves to the left, there is some tendency to cut corners and the average clearance from the center curb is about 2.5 ft.

This route has not been open to traffic a sufficient length of time to reach conclusions as to accidents. For the first 8 months of 1950 there were 15 accidents involving 9 injuries and one fatality. Eight of the accidents occurred in clear weather. There were no opposite direction accidents.

In 1948 (the last year before start of construction for the dualization) there were 13 accidents involving 12 injuries. Four of these accidents were opposite direction and 8 occurred in clear weather.

Summary - The cost of installing a wide median on this section of Route 28 would have been prohibitive. On the other hand, a narrow median with a standard 8 in. high curb was not considered adequate because of the sharp curvature, steep grades and high percentage of trucks.

The barrier curb has served its function of preventing crossing of the narrow median. Some high wheeled trucks have managed to straddle it but none have crossed into the opposite lanes.

This curb has probably prevented some accidents from vehicles whose brakes have failed. On several occasions, marks on the curb show that trucks rub against the curb to keep the speed of the vehicle under control. This would not be possible with a lower curb.

THE EFFECT OF VARIOUS TYPES OF MEDIAN DIVIDERS ON THE LATERAL POSITIONING OF CARS

E. B. Shrope, *Principal Civil Engineer, Bureau of Highway Planning New York State Department of Public Works*

One of the generally accepted good design practices in highway engineering is the provision of a median or center divider between opposing lanes of traffic in a multi-lane highway. The most heavily traveled modern highways are being built with these center dividers.

Highways constructed with median dividers reduce the danger of head-on collisions and side-swipes between opposing lanes of traffic. They provide protection for left hand turning movements and a safety zone for pedestrians who must cross the highway.

Among highway engineers there is quite a variance of opinion regarding the effectiveness of the different types and widths of dividers and of the advantages of the curbed vs. non-curbed sections. Technical questions have risen as to the use of the wall type separators and of the proper widths of the two lanes.

In the spring of 1950, the New York State Department of Public Works, in cooperation with the United States Bureau of Public Roads, initiated a research program in an attempt to add to the fund of knowledge on vehicle operation as it relates to highway design. It was agreed that one of the first subjects for investigation would be the study of median dividers in relation to their effect on positioning of free moving passenger cars.

The Long Island Parkway System offered an unusually fertile field for conducting such tests, presenting a variety of highway characteristics and types of medians.

LOCATION PLAN

Representatives of the New York State Department of Public Works and the United States Bureau of Public Roads selected 18 locations for the tests. Each location had a site condition different from the others, some were on tangents and others on curves of varying radii. Six different types of median dividers were represented. Figure 1 shows the general locations of the tests.

Photographs of Test Areas - Photographs of the parkway system in the vicinity of the test locations, (Figs. 2-7), show the character of the roadways and countryside through which the roadways pass. All of the parkways are limited access-ways with no entrance permitted from the adjacent property. Commercial vehicles are prohibited from using the parkway system.

Tests 1, 2, 13, 13A, 14, 15, 16 and 17 were located just inside the New York City corporation line. The remaining tests were located outside the city area in Nassau County. The legal speed limit within the city is 35 m.p.h. and outside 40 m.p.h.

The Parkway System carries heavy traffic to and from New York City with peak hours occurring not only during the normal rush hour periods in the morning and evening, but all during the day, especially in the summer, servicing the millions of people traveling to the Long Island beaches.

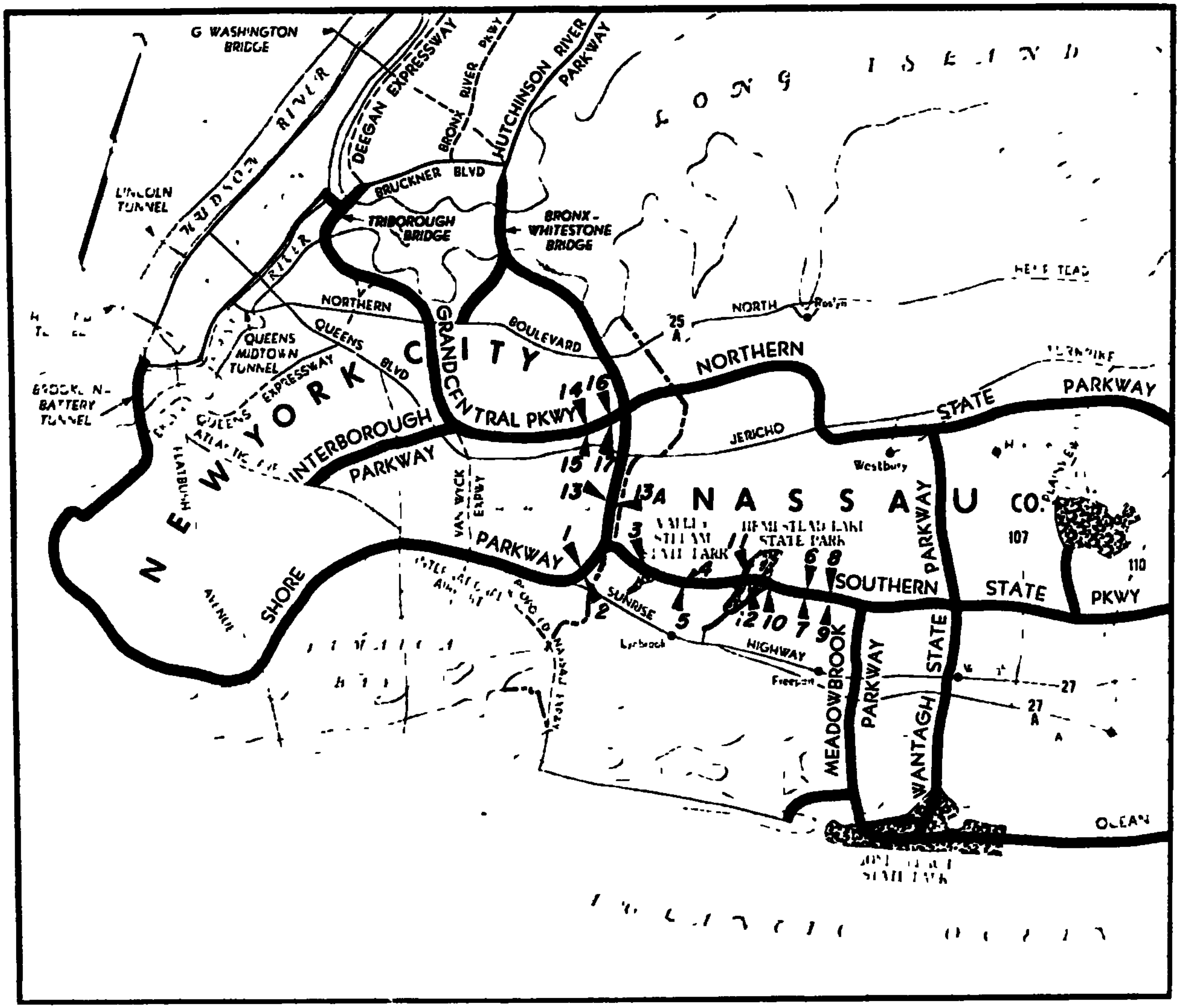


Figure 1. Location of Tests on Median Traffic Dividers

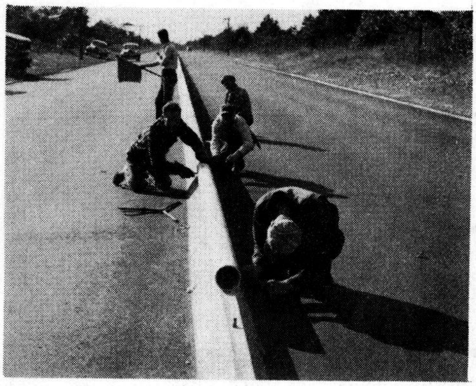


Figure 2. Concrete Wall with Pipe

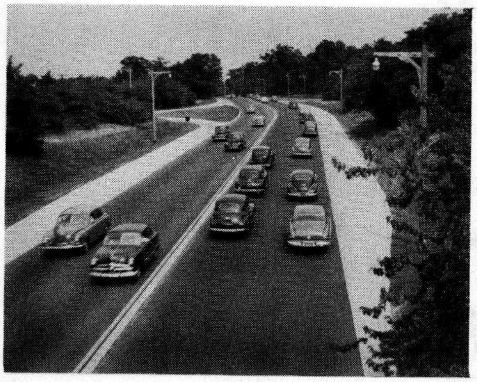


Figure 3. Southern State Parkway
Concrete Wall with Pipe

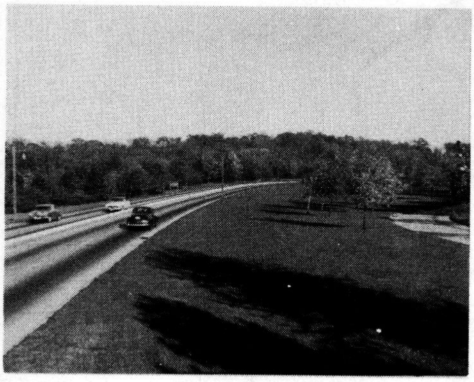


Figure 4. Grand Central Parkway
Concrete Center Divider

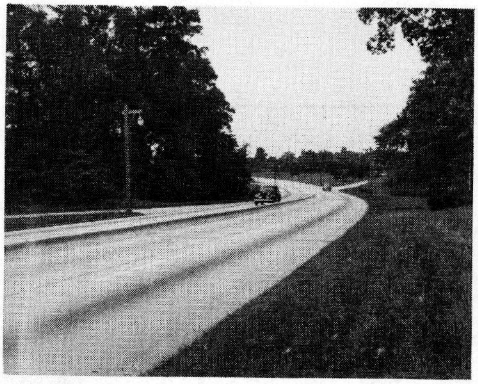


Figure 5. Grand Central Parkway
Concrete Parabolic Divider

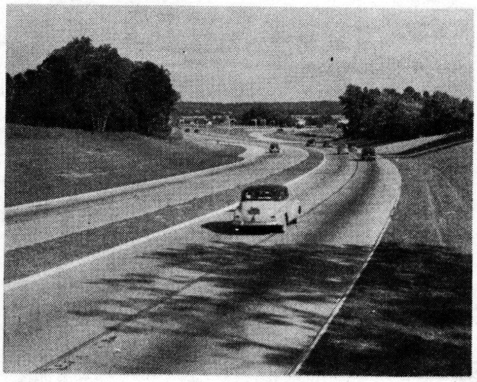


Figure 6. Northern State Parkway
Divided Pavement 9 ft. Center
Mall, 13 ft. Passing Lanes
and 12 ft. Outside Lanes

TYPES OF MEDIAN TRAFFIC DIVIDERS

Figure 8 shows the six types of median traffic dividers in use on the Long Island Parkway System. Some of the highways under test were originally constructed without wall dividers of any type. Subsequently, the narrow-wall type divider was superimposed upon many miles of pavement to afford a physical separator (See 1, 2 & 3, Figure 8). In 1949, the last of the contracts were let for the construction of the narrow concrete wall (See 1, Fig. 8) with pipe mounting, on the remaining portions of the Parkway System where no physical separator of any type existed.

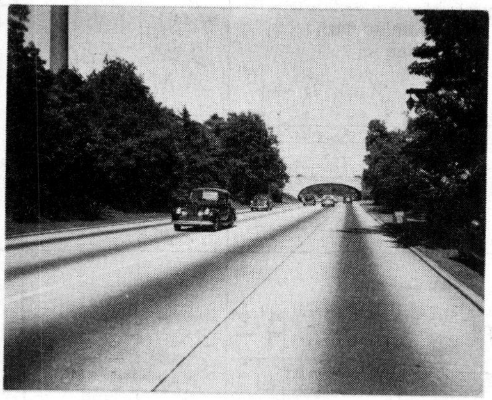


Figure 7. Southern State Parkway 6-in. Paint Line Divider

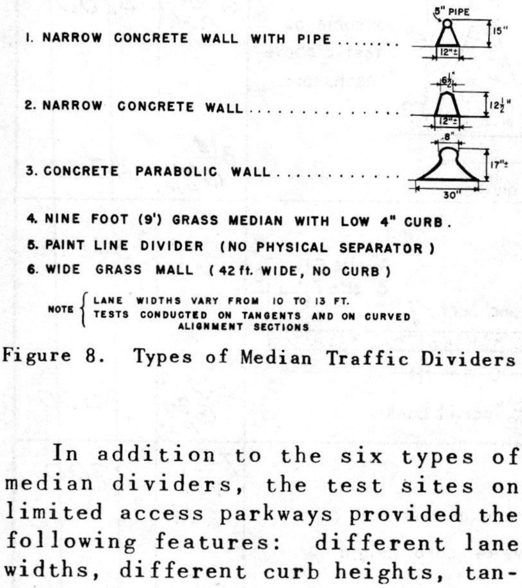


Figure 8. Types of Median Traffic Dividers

In addition to the six types of median dividers, the test sites on limited access parkways provided the following features: different lane widths, different curb heights, tangent and curved roadway alignment, wide variation in traffic volumes, flat grades, elimination of the effects of all type commercial vehicles and marginal interference. These features are shown in detail in Table 1.

CONDUCTING THE TESTS

Tests were conducted during the daylight hours in the month of July 1950, and a record made of approximately 85,000 cars. Each test ran for a period of about 3 hours.

Tests which are grouped together such as 1 and 2, 4 and 5, etc., were taken at the same point on the highway but on the opposing roadway lanes (Table 1). Eight of the tests were taken on curves the sharpest of which was 7.8 deg. (R=735 ft.).

Test equipment was set up in the morning just before the home-to-work movement and data recorded for the 3-hr. period. The equipment was then picked up and set in a new test location later in the day so as to record the work-to-home peak hour movement.

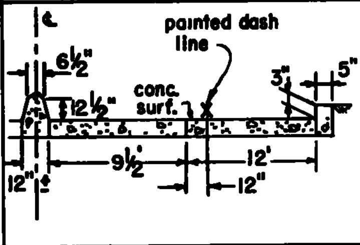
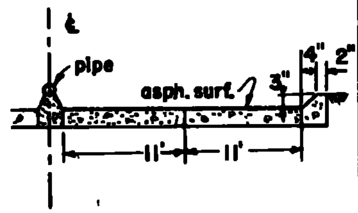
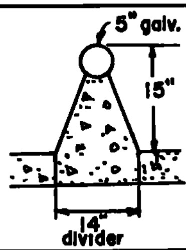
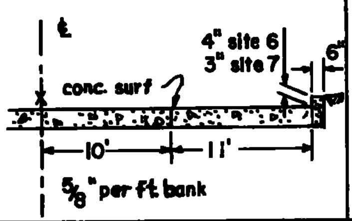
Test Equipment - The portable truck mounted test equipment furnished and operated by the United States Bureau of Public Roads recorded the volume, speed and placement of cars in the two lanes.

A brief description of the equipment and method of recording the data is outlined as follows:

Speed - Rubber air tubes were fastened to the pavement, 20 ft. apart, to record the speeds of vehicles. As the tire passed over the first tube it activated a recording mechanism which was stopped when the tire passed over the second tube. The difference in timing was recorded on an adding machine tape placed in a vehicle which was parked off to one side of the road. In all cases, the location of the equipment and operators in no way influenced the drivers under observation.

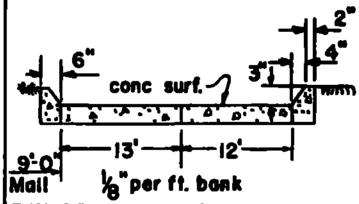
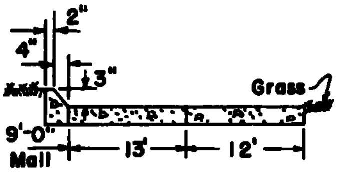
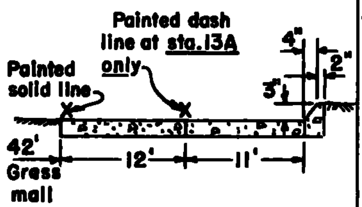
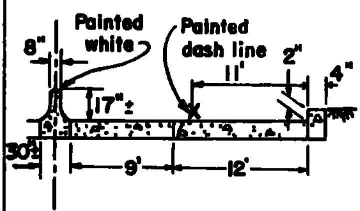
Vehicle Placement - A segmented metal strip in conjunction with a continuous strip was used to determine the lateral position of the vehicle in its lane. Each foot of

TABLE 1
SUMMARY OF FIELD DATA BY TEST SHOWING PAVEMENT CHARACTERISTICS

TEST NO.	ROUTE	NEAR	ALIGNMENT	DIRECT'N TRAFFIC	HALF CROSS-SECTION LANE 2 LANE 1	TIME	TOTAL VOLUME
1 AND 2	Cross Island Pkwy. N.Y C	Merrick Road N Y C	Tangent 1000'± North; 1000'± South	South; North		7^{15} 9^{45} A M; 2^{30} 6^{00} P.M	4200; 5450
3	Southern State Pkwy.	Valley Stream State Park	Curve R=1400'± D=4.1° L=845'	West Rt.		3^{00} 5^{00} P.M.	3800
4 AND 5	Southern State Pkwy.	Hempstead Avenue	Tangent 500' East; 300' West	West; East	 same as test 3 above asph. surf.	2^{15} 6^{00} P.M; 3^{15} 6^{00} P.M.	4200; 4700
6 AND 7	Southern State Pkwy.	Baldwin Road	Curve R=735' D=7.8° L=760'	Rt. West; East Lt.		7^{15} 10^{00} A M; 4^{15} 6^{30} P.M	3400; 3600
8 AND 9	Southern State Pkwy.	Baldwin Road	Tangent 375'± WEST; 325'± EAST	West; East	same as test 6 & 7 above 4" curb height	7^{30}, 9^{30} A M.; 2^{15} 5^{30} P.M.	2700; 3900

ALL TESTS (1-17) WERE TAKEN WEEKDAYS MONDAY THRU FRIDAY DURING JULY 1950.

TABLE 1 (Continued)
SUMMARY OF FIELD DATA BY TEST SHOWING PAVEMENT CHARACTERISTICS

TEST NO.	ROUTE	NEAR	ALIGN-MENT	DIRECT'N TRAFFIC	HALF CROSS-SECTION LANE 2 LANE 1	TIME	TOTAL VOLUME
10	Southern State Pkwy.	Hempstead Park	Curve R=3100' D=1.85° L=1000'	Rt. East		2^{15} 5^{30} P.M.	3500
11 AND 12	Southern State Pkwy.	Hempstead Park	Tangent 600'± EAST 1000'± WEST	West East		7^{00} 10^{00} A.M. 2^{30} 5^{45} P.M.	6800 4000
13 AND 13A	Cross Island Pkwy.	South of Belmont Park	Tangent 3200'± NORTH 3200'± SOUTH	South North		3^{00} 6^{00} P.M. 7^{00} 10^{00} A.M.	4600 4200
14 AND 15	Grand Central Pkwy	Hillside Park N.Y.C.	Curve R=2500 D=2°± L=850'	Rt. West East Lt.		7^{00} 10^{00} A.M. 3^{00} 6^{00} P.M.	6900 5100
16 AND 17	Grand Central Pkwy	Union Turnpke	Curve R=4200' D=1.25°± L=1200'	Rt. West East Lt.	Same as test 14 & 15 above	7^{00} 10^{00} A.M. 3^{00} 6^{00} P.M.	5800 5300

ALL TESTS (1-17) WERE TAKEN WEEKDAYS MONDAY THRU FRIDAY DURING JULY 1950.

the segmented strip contained a 7½ in. "live" or recording section and a 4½ in. "dead" or non-recording section. As the tire passed over the "live" section it made contact with the continuous strip and its position was registered on the adding machine tape located in the nearby recording vehicle. The accuracy of the recordings has been found to be correct within 0.25 ft.

The details of the equipment are described in the Bureau of Public Roads magazine for April, 1940.

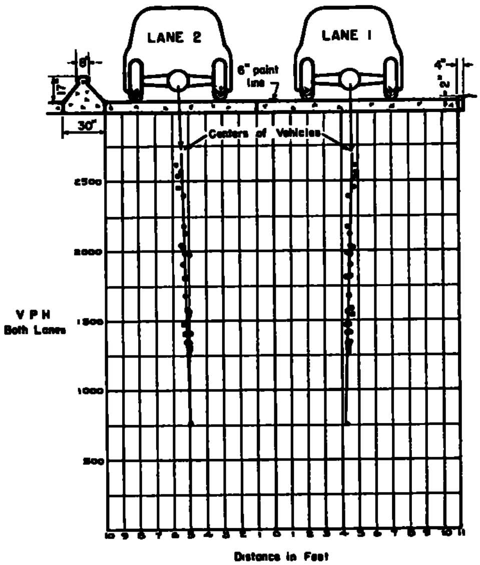


Figure 9. Typical Plotting of Field Data

DEVELOPMENT OF THE BASIC DATA

The field data was sorted out by one tenth of an hour or 6-minute time intervals and the average placement vs. volume for each of these 6-minute periods was plotted on a graph for each lane.

Figure 9 shows a typical pattern of the plottings for a test. Similar plates were prepared for each individual test and in all cases the plotted points were found to follow a straight line variation. The points in the graph were studied and the mean straight line variation between placement and volume drawn.

Referring to Figure 9 it will be noticed that the two lines are not parallel indicating that cars travel further apart or closer to the pavement edges as the volumes increase.

During the tests the volumes in the two lanes ranged from about 500 to 2700 V.P.H. In order to make a comparison of the effect of the different types of medians, it was necessary to make an analysis of the various tests at the same traffic volume. Table 2 shows the tabulation of this analysis. The average position of all cars at 1500 V.P.H. is indicated.

Examination of Table 2 shows the various tests grouped according to type median. Tests 3, 6, and 7 are isolated to show the effect of relatively sharp horizontal curvature. The average positioning of cars by type median are related by the symbol "X", the distance from the edge of the center median to the near side of the cars in lane 2; by the symbol "Y", the lateral distance between cars, and by the symbol "Z", the distance from the outside edge of the cars in lane 1 to the right hand curb or edge of pavement. The width of a car has been taken as 6 ft. 3 in.

It should be noted that for all tests except 3, 4 and 5 some type of lane-line, either a painted line or a longitudinal joint or both existed between lanes 1 and 2. For Tests 3, 4 and 5 the roadway surface consisted of an asphalt surfacing over an existing concrete base and no pavement striping had as yet been provided.

DISTANCE FROM MEDIAN DIVIDER "X"

Referring to Table 2 and considering the distance marked "X" we note that Tests 14 to 17 inclusive, show that cars travel closest (1.5 ft.)

TABLE 2
COLLATION OF TESTS WITH TYPE MEDIAN SHOWING AVERAGE PLACEMENT OF CARS AT 1500 V P H

TEST	CURVE	TOTAL WIDTH LANE 2		TOTAL WIDTH LANE NO 1	MALL TYPE	X (LANE 2)		Y	(LANE 1)	Z	
14	2°	10'	21'	11'	30"	1.45		3.35		3.60	
15	2°	10'	21'	11'	30"	1.65	1.5'	3.35	3.3'	3.40	3.6'
16	1.25°	10'	21'	11'	30"	1.85		3.05		3.50	
17	1.25°	10'	21'	11'	30"	1.15		3.45		3.80	
8		10'	21'	11'	6" line	1.85		3.3		3.25	
9		10'	21'	11'	6" line	2.05	1.95'	3.6	3.45'	2.75	3.2'
1		10½'	21½'	11'		1.55		3.7		3.65	
2		10½'	21½'	11'		2.35		3.2		3.35	
13		12'	23'	11'	42'	2.85	2.65'	4.1	4.4'	3.45	3.35'
13A		12'	23'	11'	42'	2.45		4.7		3.25	
4			22' no lanes			3.05	2.95'	3.2	3.3'	3.15	3.2' no lane line
5			22' no lanes			2.85		3.35		3.20	no lane line
11		13'	25'	12'	9'	3.35	3.4'	5.2	4.9'	3.80	4.1' no curb
12		13'	25'	12'	9'	3.40		4.65		4.35	no curb
6	78°	10'	21'	11'	6" line	2.70		2.95		2.70	
7	78°	10'	21'	11'	6" line	1.65		2.65		4.10	
3	41°		22' no lanes			2.80		2.75		3.85	no lane line
10	1.85°	13'	25'	12'	9'	4.10		4.45		3.80	

to the concrete parabolic wall-type of median. Lane 2 width is 10 ft. These tests were all taken on a curved alignment but it appeared that because of the flatness of the curves no appreciable difference in placement would occur as a result of this curvature. The second grouping combined the 6-in. paint line separator with the narrow concrete wall-type. Lane 2 width is 10 and 10½ ft. This grouping shows an average placement of 1.95 ft. It is to be noted, that for a 10 or 10½-ft. inner lane, cars traveled closer to the concrete parabolic wall-type median than to either the 6-in. paint line or narrow concrete wall-type median. The effect of the gradual curved slope of the concrete parabolic wall-type median apparently influenced the drivers' choice of lateral position.

It should be remembered that in this discussion that distances are related to the edge of and not to the center of the median.

From the other tests it appears that drivers operate somewhat closer (2.65 vs. 2.95 ft.) to a 42-ft. median strip without curbs (Tests 13 and 13A) than to a wall-type (Tests 4 and 5) in spite of the fact that there is a one foot greater width of pavement available on the 42-ft. median section. Going a step further however, it is noted that a decided likeness exists between Tests 1 and 2 and Tests 4 and 5. At these sites there are similar types of dividers with approximately the same roadway widths (21½ vs. 22 ft.). Tests 4 and 5, however, have no lane lines while Tests 1 and 2 do. It is indicated, therefore, that if Tests 4 and 5 had been provided with lane lines, distance "X" would be reduced from 2.95 to 1.95 ft. Based on this indication it can be stated that lane lines apparently cause drivers in Lane 2 to operate their cars closer to a median divider than where no lane lines are provided. (Note different types of curb in test lanes 2, 4 and 5 and variation in 'Z" distances. Effect of type curb not considered here).

Tests 11 and 12 were taken on tangent sections with wide lanes. It is to be expected that this extra space provided by the greater width of lanes and roadway is responsible for the greater distance (3.4 ft.) at which cars travel from the 9-ft. grass mall center divider.

Tests 6 and 7 were taken on a relatively sharp curve (7.8 deg.). If the distance "X" for these two tests is compared with that for Tests 8 and 9, where the conditions are identical except for the alignment, it will be noted that "X" on the section where the alignment curves to the right (Test 6) is 2.7 ft. as compared with 1.95 ft. for the tangent alignment and 1.65 ft. for Test 7 where the alignment curves to the left. Likewise, the distance "Z" is 4.10 ft. where the alignment curves to the left, compared with 2.70 ft. where it curves to the right and 3.0 ft. on tangent sections. It is believed this merely indicates the common tendency of drivers to cut across horizontal curves, and the above recorded distances are a measure of this movement.

LATERAL DISTANCE BETWEEN CARS "Y"

In considering the clearance distance between cars, column Y, Table 2, it is noted that where the roadway widens to 23 and 25 ft., the clearance between bodies of cars is greater than for the relatively narrower pavements. In comparing the tests where pavement widths range from 21 to 22 ft., it will be noted that distance "Y" is slightly less than 3½ ft. For the 23 and 25-ft. pavement sections this distance is 4.4 and 4.9 ft. respectively.

On the relatively sharp curves, represented by Tests 3, 6, and 7, the "Y" distance is less than on similar pavement tangent sections.

A lateral distance of 3 ft. has been determined from previous studies to be the minimum desirable clearance between car bodies of meeting cars.[1] A 3-ft. lateral distance between bodies of cars traveling in the same direction is desirable. This minimum distance was recorded in all tests except Tests 7 and 3. It is thought probable that if the inside lane on Test 7 was increased 1 ft., it would result in a greater lateral distance between the car bodies. No doubt the provision of a lane line in Test 3 would increase the lateral distance between the car bodies to the minimum desirable.

DISTANCE FROM RIGHT EDGE OF ROADWAY "Z"

The distance "Z" remains constant for equal or nearly equal pavement widths regardless of the center median type. In addition, there seems to be no appreciable difference between the "Z" distance on tangent pavement sections with or without lane lines. (Compare "Z" distances for the first four groupings)

The greatest "Z" distance (4.1 ft.) occurs at Test locations 11, 12, and 7. For Tests 11 and 12 this greater distance is undoubtedly caused by the wider lane (12 ft.) and wider pavement width. The 4.1-ft. in Test 7 has been explained above as probably attributable to driver habits

[1]Proceedings of the Highway Research Board, Vol. 27, (1947), pp. 273-280.

on the relatively sharp curves.

INDICATIONS

In running traffic tests, it is usually necessary to accept physical conditions which will not permit an exact evaluation of the unknown factor.

In these tests there were too many variables to permit such a determination of the effect of the six different medians on the placement of vehicles. The variables consist of different widths of roadway and variations in widths and markings between the two lanes of traffic operating in the same direction. An extension of the Long Island tests to other selected locations which would have suitable site conditions would supply necessary data to permit the drawing of more definite conclusions.

From the information available in these tests, however, the following tendencies are indicated:

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-in. paint line divider and the narrow wall-type divider have about the same effect on the positioning of cars in the center lane.
3. Lane lines between two parallel streams of traffic cause motorists in lane 2 (inside lane) to drive closer to the center median than where no lane lines are provided. (Note in the discussion that the effect of type curb is not considered)
4. Medians do not eliminate the common tendency of drivers to cut across horizontal curves.
5. Clearance distance between cars in parallel streams of traffic grow wider as the roadway width increases and as the volume increases.
6. On relatively sharp curves the clearance distance between cars in parallel streams of traffic becomes less than on tangent sections.
7. The distance from the edge of the pavement to cars in Lane 1 (outside 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 Lane 1 (outside lane) for roadways with or without lane lines.

The research section of the Bureau of Highway Planning of the New York State Department of Public Works has inaugurated some studies on the effect of median dividers on the lateral positioning of cars. They are being carried on in cooperation with the United States Bureau of Public Roads.

The procedures for these studies were developed by O. K. Norman and E. B. Shrope and progressed under the direction of Mr. Shrope.

A DISCUSSION OF PRE-CAST CONCRETE TRAFFIC DIVIDERS - OHIO

Ralph J. Lehman, *Ohio Department of Highways*

Of all the frictions that tend to reduce the traffic carrying efficiency of a highway, one of the most important and most deadly is medial friction. The mechanical devices used for reduction of this friction have been subdivided into three progressive types.[1] (1) those providing *visible definition* of medial area. (2) those providing *sensory warning* to vehicles encroaching on medial area. (3) those providing *deflection* and *redirection* of impinging vehicles.

The precast concrete traffic dividers used in Ohio today were developed to supply these three requirements. While providing these qualities the precast traffic divider uses a minimum width of road surface. This feature alone makes this divider most appropriate in many urban and other developed areas. Not only does the divider occupy a minimum of actual roadway width (2 ft.) but it is believed by many traffic engineers that a minimum reduction of effective travel widths on adjacent lanes is caused by use of precast dividers as compared with other raised medial dividers.

In highly developed areas with driveways on both sides of the roadway, the provision of a medial divider, without restriction on mid-block access to the drives, presents a problem. Flush medial strips can be used but these provide little more separation of opposing traffic flows than paint lines. Continuous raised dividers must be broken so often to provide drive openings that they become unsightly and ineffective. The precast concrete divider units, however, serve the dual function required. They provide physical separation of opposing traffic lanes yet their spacing permits the turning cross-movements required for access to drives and the regularity of their spacing throughout the block contributes to the uniform continuity of the medial strip.

In addition to the effect of precast dividers on traffic flow, they have several physical characteristics pertaining to design and construction which merit consideration. Foremost perhaps is the simplicity of installation on both existing pavements and as a part of new construction projects. Installation consists of merely forming or cutting a 2 in. deep opening in the pavement and setting the unit in place with mortar or bitumious filler (see Figs. 1, 2). Economy is an important facet of highway operation and the $4.00 cost per unit in Ohio is an added inducement to their use. For placement at 12-ft. spacings the delivered price of the medial dividers would be less than 33 cents per lin. ft. of pavement. The units also have a high salvage value in that they are easily removed and reset where resurfacing is necessary.

The simplicity of installation and the inherent economy of this type of divider led to numerous early designs. Of these, Mr. R.N. Ricketts Planning Engineer of Division 6, Ohio Department of Highways, developed the standard design now used in Ohio.

[1] "Mechanical Traffic Deflectors" M. McClintock, Highway Research Board, Proceedings, 1938

Cutting an opening in existing pavement

Placing divider

Sealing with bituminous material

Figure 1. Installation of Precast Concrete Traffic Dividers on Bituminous Concrete

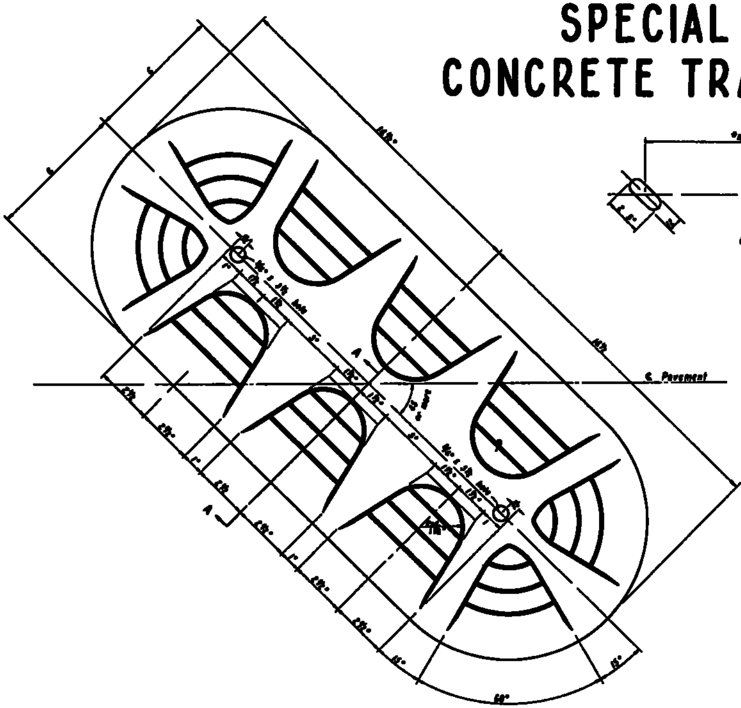
It was first believed that these dividers could be produced by the state personnel, providing an excellent slack-season activity. However, the lack of uniform mix control and the difficulty of compaction in the molds led to such a poor quality product that the production was turned over to commercial concrete manufacturers. Even then, early installations of precast dividers gave very unsatisfactory results since numerous divider units disintegrated rapidly under normal use, creating a traffic hazard and additional expense in replacement. Engineers theorized on numerous explanations concerning impact of heavy vehicles, extensive range of temperature fluctuation, and imperfect seating of units.

Figure 2. Close-up of Precast Concrete Divider Installed Longitudinally in Concrete Pavement

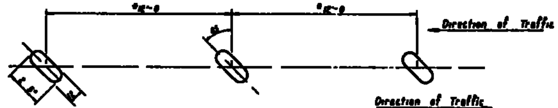
However, rigid specification control of the quality of concrete used and the method of casting brought about satisfactory improvement in the units produced.

They are now made of white cement with an air-entraining agent added to the mixture, and the concrete vibrated in a standard mold. No steel fastening pin or reinforcing steel is used with the concrete. The small size of the individual unit makes reinforcing steel largely unnecessary if the divider is properly bedded. The danger of having steel exposed to the path and contact of vehicle tires in the event that the concrete is chipped or disintegrated, almost prohibits the use of steel pins.

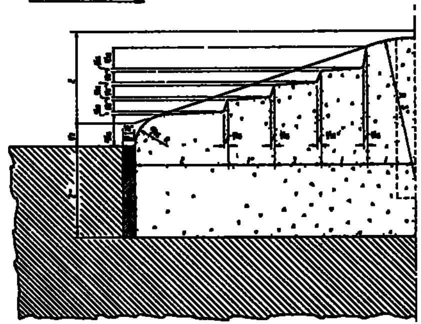
SPECIAL PRECAST CONCRETE TRAFFIC DIVIDERS



PLAN
Scale Half Size



* Note Spacing 12' 0" Ctr to Ctr except where otherwise shown on plans



SECTION A-A
Scale - Full Size

WHEN PLACED IN BITUMINOUS CONCRETE
The dividers shall not be placed until the bituminous concrete surface has been completed The opening remaining between the bituminous concrete and the traffic dividers shall be filled with the same type bituminous material used in the mix, care being exercised to keep the traffic divider free of any material tending to deface them

WHEN PLACED IN PORTLAND CEMENT CONCRETE
Openings into which the traffic dividers are to be set shall be formed by a method acceptable to the Engineer at the time the concrete pavement is placed The opening remaining between the concrete pavement and the traffic dividers shall be filled with 1 2 cement mortar or Sec M-51 bituminous material

Figure 3.

The physical description of the divider is shown in Figure 3. Note the two ¾ by 3½ in. holes in the top of the unit. These are positioned to enable handling of the unit with a pair of specially devised tongs. The holes are then filled and sealed to prevent infiltration of moisture with resultant freezing and cracking of the concrete after installation. As shown in the plan view of Figure 3 the units are usually placed along the centerline of the roadway with their longitudinal axes set at 45 deg. to the centerline in the direction of traffic. This gives them an additional deflective tendency.

according to the character of the section and the degree and type of control desired. In Figure 6 you will note that vehicles are using the bus stop lane for right turning movements. This intersection was designed to provide a bus stop at the terminal of the off ramp. However, driver misuseage of this lane indicates the desirability of having bus stops entirely separate from the natural travel lanes of all through or turning traffic.

Divider units are not recommended on high speed facilities where the velocity of the vehicles is so great as to overcome their deflective

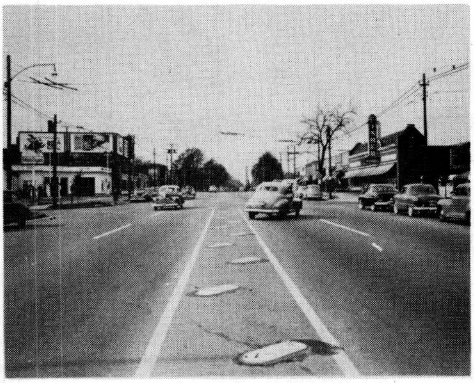


Figure 4. Double Rows of Precast Concrete Traffic Dividers in Urban Sections

Figure 5. Dividers Mounted Longitudinally to Separate Bus Turn-out From Through Traffic Lanes

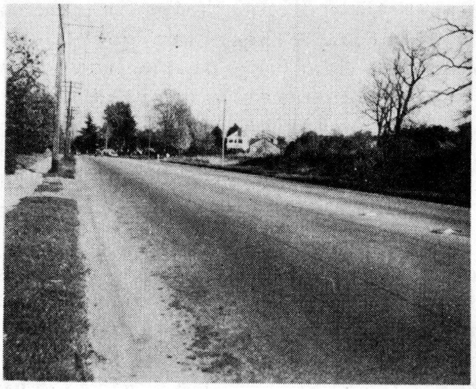
The standard position of the units is at 12-ft. center to center on the centerline of the roadway. Their use, however, is actually almost as versatile as that of paint striping. The units can be staggered in two lines to give a wider effective medial area (see Fig. 4). They can diverge from a single line to two separate lines to form a transitional area approaching a wider median, an underpass center pier, safety island or such. They are effectively used to define bus turn-outs (see Fig. 5) and turning movement lanes (see Fig. 6). Obviously the longitudinal spacing along the roadway may be varied

value, and the striking of the units might cause the driver to lose control of the vehicle.

Ohio has seen an increasing use of precast dividers in the last few years. There are several projects under construction this year that include installation of these dividers. At the present time there are 3.62 mi. of rural state highways divided by precast concrete units and 17.93 mi. of urban (within corporation limits) state routes. Of the rural routes using precast dividers 0.12 mi. or 3.3 percent of these are in developed areas classified as "urban in character". Thus 83.8

percent of the total mileage using precast dividers is in areas of urban development. This bears out the desirability of these units in sections of restricted right-of-way with many mid-block drives.

Another basis for consideration on the use of precast dividers is safety. It was hoped that a "before and after" comparison could be made of accident statistics on a typical section containing precast dividers but such a comparison was inadvisable for several reasons. The continuous sections containing precast dividers were so short that no significant volume of traffic accidents has occured since the installation of the dividers. Ohio, being one of the two states in the Union not having a compulsory accident reporting law, does not have a complete record of the accidents that have occurred, particularly of the minor accidents. No accident record is maintained by the state for highway sections within a municipality. The predominant trend in available accident records however, indicates a definite reduction in head-on and sideswipe collisions with the introduction of these units.



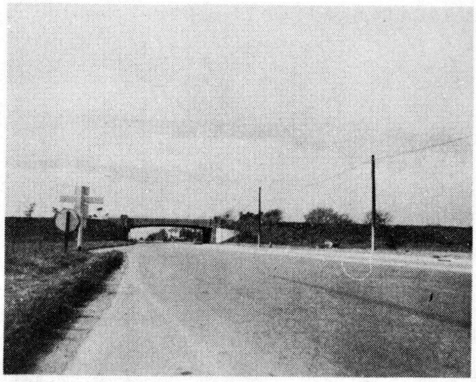


Figure 7. Top: Precast Dividers Used In Residential Section
(S.R. 10, Fairview, Ohio)
Bottom: Precast Dividers Used on Approach To Rural Grade Separation
(S.R. 237 and S.R. 17, Brookpark, O.)

Figure 6. Precast Concrete Traffic Dividers Used to Define Bus Stops on Ramps
(Eddy Road Interchange, Cleveland, Ohio)

Figure 8. Dividers Used on Approach to A Rural Intersection

To summarize on the use of precast dividers we might consider three points:

First, the versatility of the precast dividers almost approaches that of paint-striping, while providing visual and sensory warning, and restraint and redirection of impinging vehicles.

Second, the economy of installation and functional utility in developed areas far exceeds that of any type of continuous divider.

Third, the efficiency of traffic flow and the resultant safety of operation on divided or channelized sections justifies the installation of medial dividers, even in sections of limited width.

Thus it would seem that precast dividers meet a need perhaps not with an ideal solution, but with an economical and efficient design for sections with a definite need and limited opportunity for improvement.

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