A STUDY OF HIGHWAYS WITH A NARROW MEDIAN - CALIFORNIA

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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

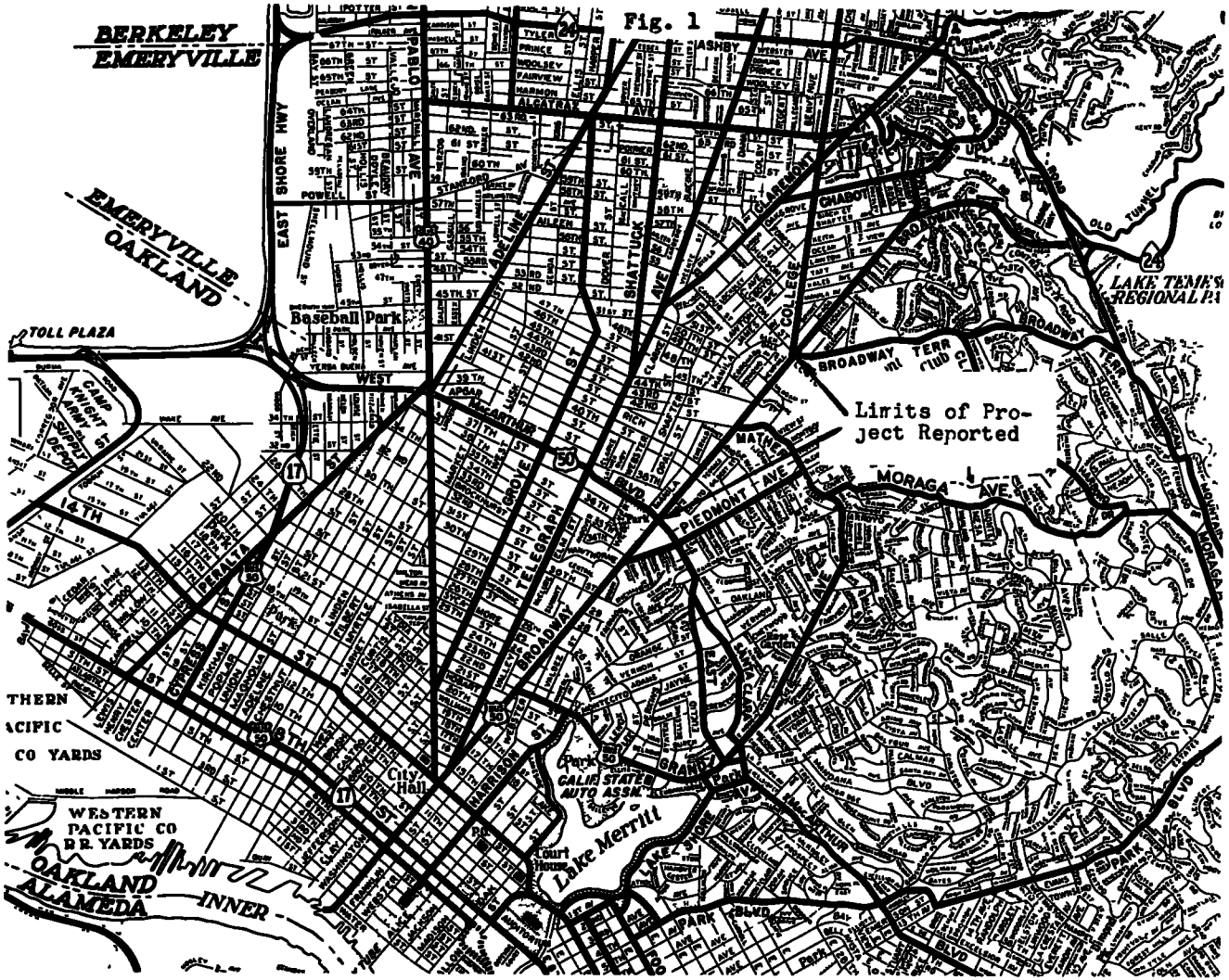
This street originally had double street car tracks occupying the central portion of the traveled way. Subsequent to the substitution of the motor bus for electric street car transportation, the tracks were removed and the resulting 20-ft. width was reconstructed to provide a narrow median and asphaltic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

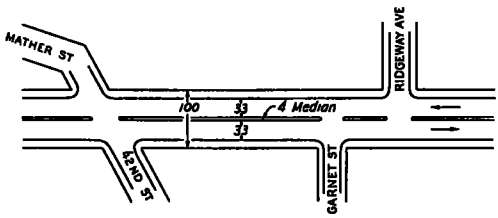
Grade intersections on Broadway are controlled by signals at important intersections as shown in Figure 2, and by arterial "stop" signs at the lesser intersections. Left turns are permitted. Access by means of driveways to business establishments fronting on this street is permitted and regulated by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

Fig. 1


BERKELEY
EMERYVILLE
EMERYVILLE
OAKLAND
TOLL PLAZA
EAST SHORE HWY
Baseball Park
CAMP KNIGHT ARMY SUPPLY DEPOT
Limits of Project Reported
MORAGA AVE
PIEDMONT AVE
BROADWAY
BROADWAY TERR
LAKE TEMESCAL REGIONAL PA
City Hall
Court House
Lake Merritt
Park
CALIF STATE AUTO ASSN
WESTERN PACIFIC CO R.R. YARDS
OAKLAND
ALAMEDA
INNER
THERN
ACIFIC
CO YARDS
14TH
PERALTA
TELEGRAPH
SHATTUCK
ALCATRAZ
ASHBY
POWELL
PARK BLVD

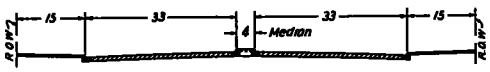
The grade of Broadway between MacArthur Boulevard and College Avenue is slightly rising between MacArthur Boulevard and 45th Street, with a pronounced rise between 45th Street and College Avenue.

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.

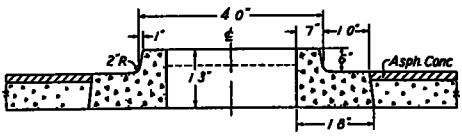


PARTIAL PLAN

Figure 2. Major Street - Broadway Oakland, California



TYPICAL SECTION



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

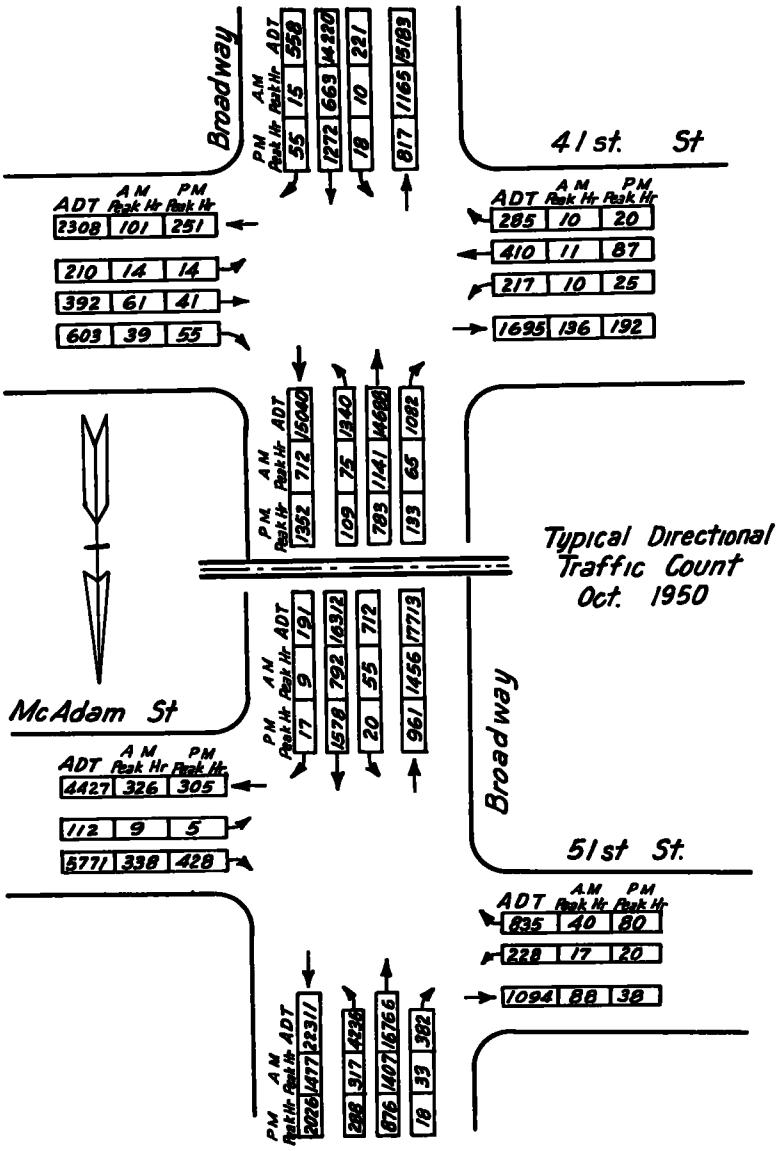


Figure 7.

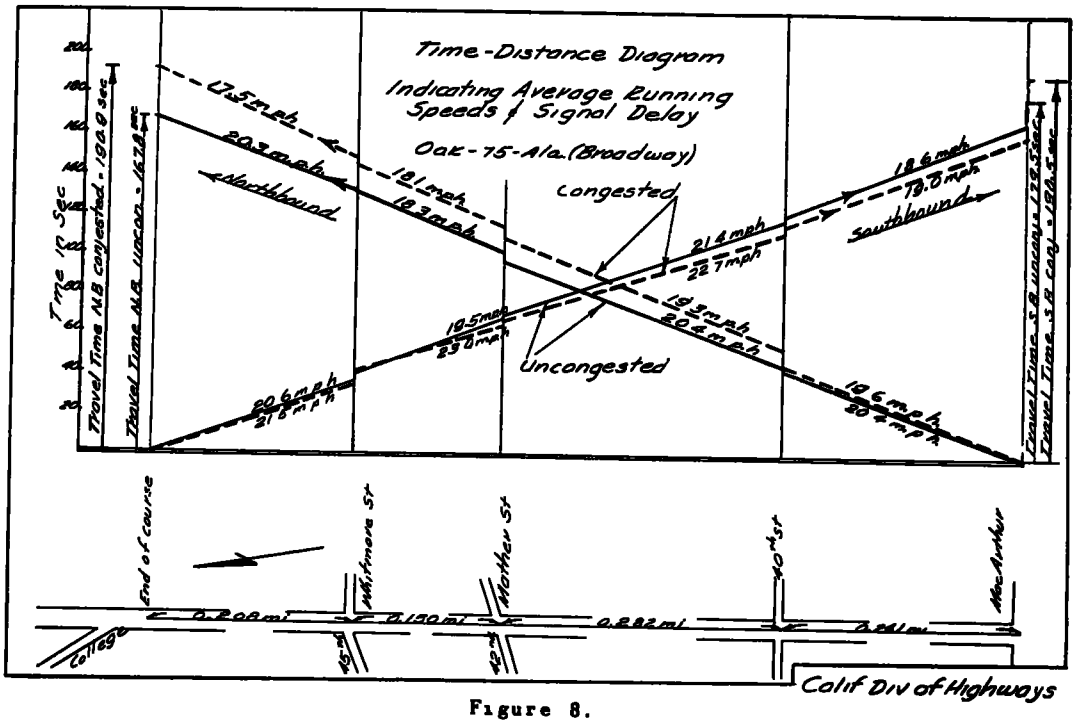


Figure 8.

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.

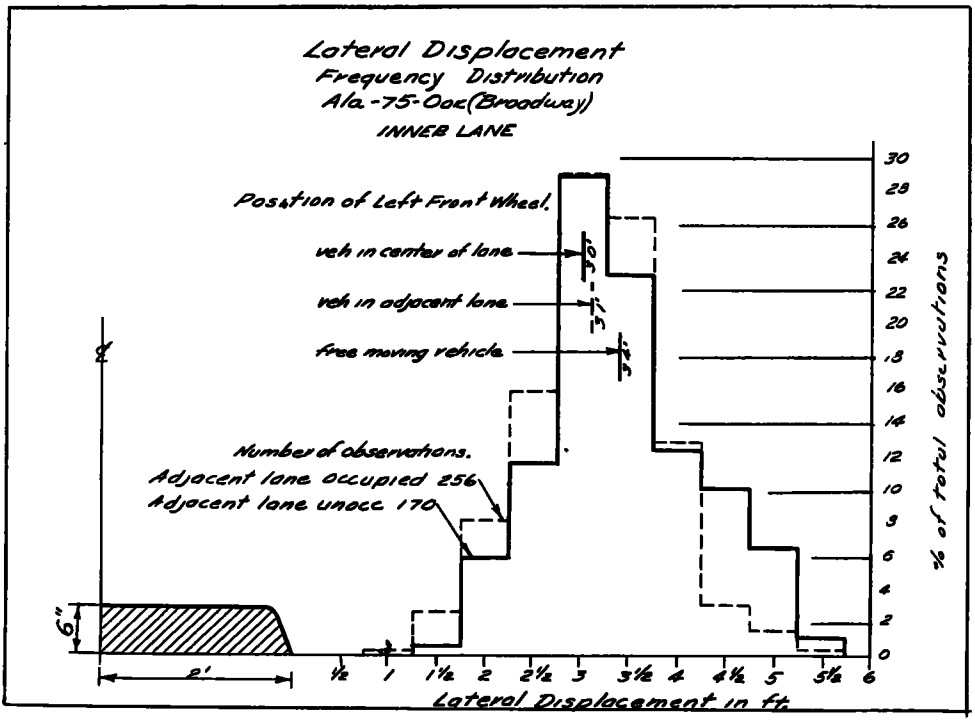
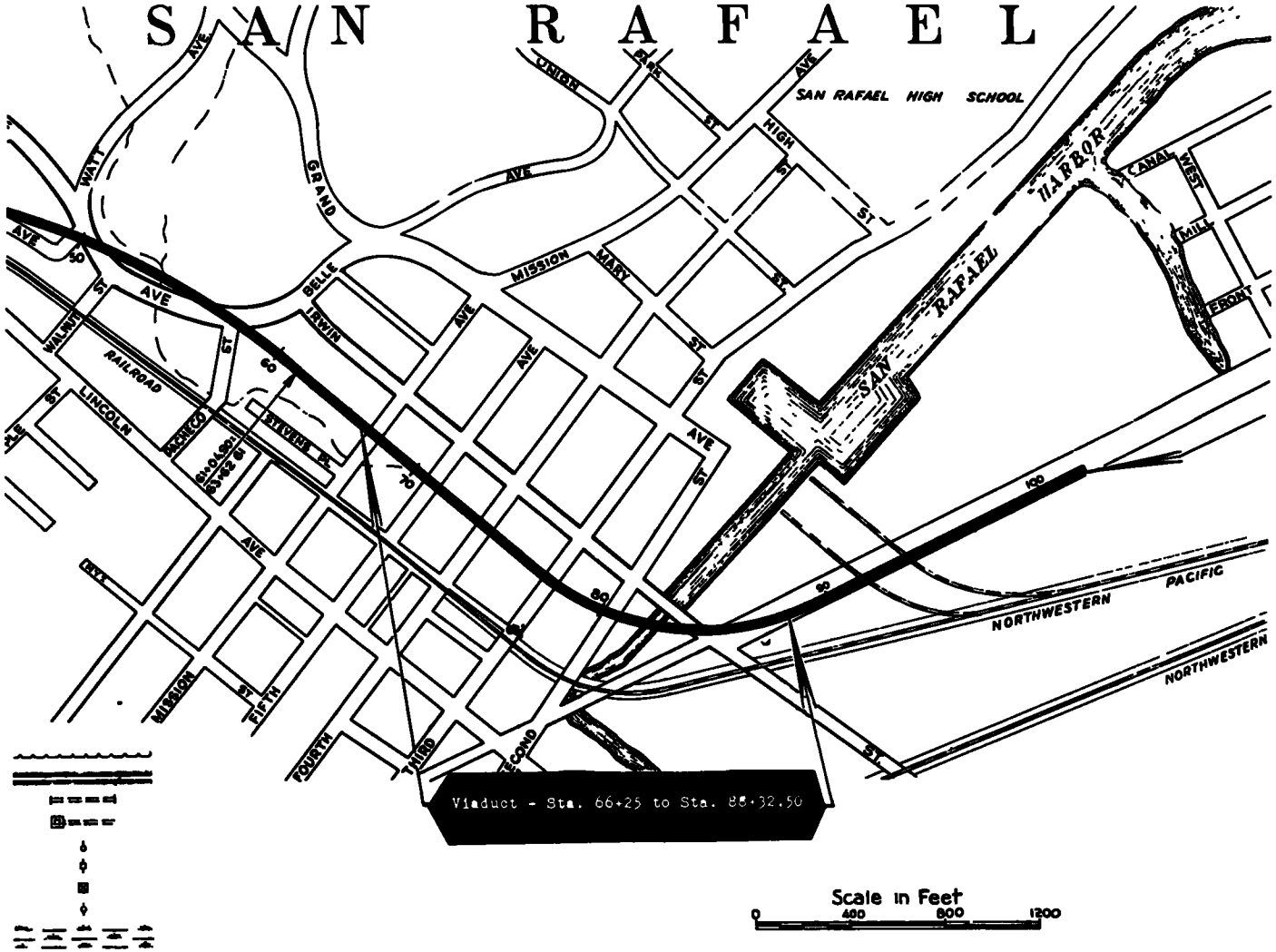


Figure 9.


SAN RAFAEL
SAN RAFAEL HIGH SCHOOL
UNION
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LINCOLN
RAILROAD
MACHECO
RIVERS PL
SAN RAFAEL HARBOR
CANAL
WEST
MILL
LEBONT
NORTHWESTERN
PACIFIC
MISSION
FIFTH
FOURTH
THIRD
SECOND
Viaduct - Sta. 66+25 to Sta. 88+32.50
Scale in Feet
0
400
800
1200

Figure 10.

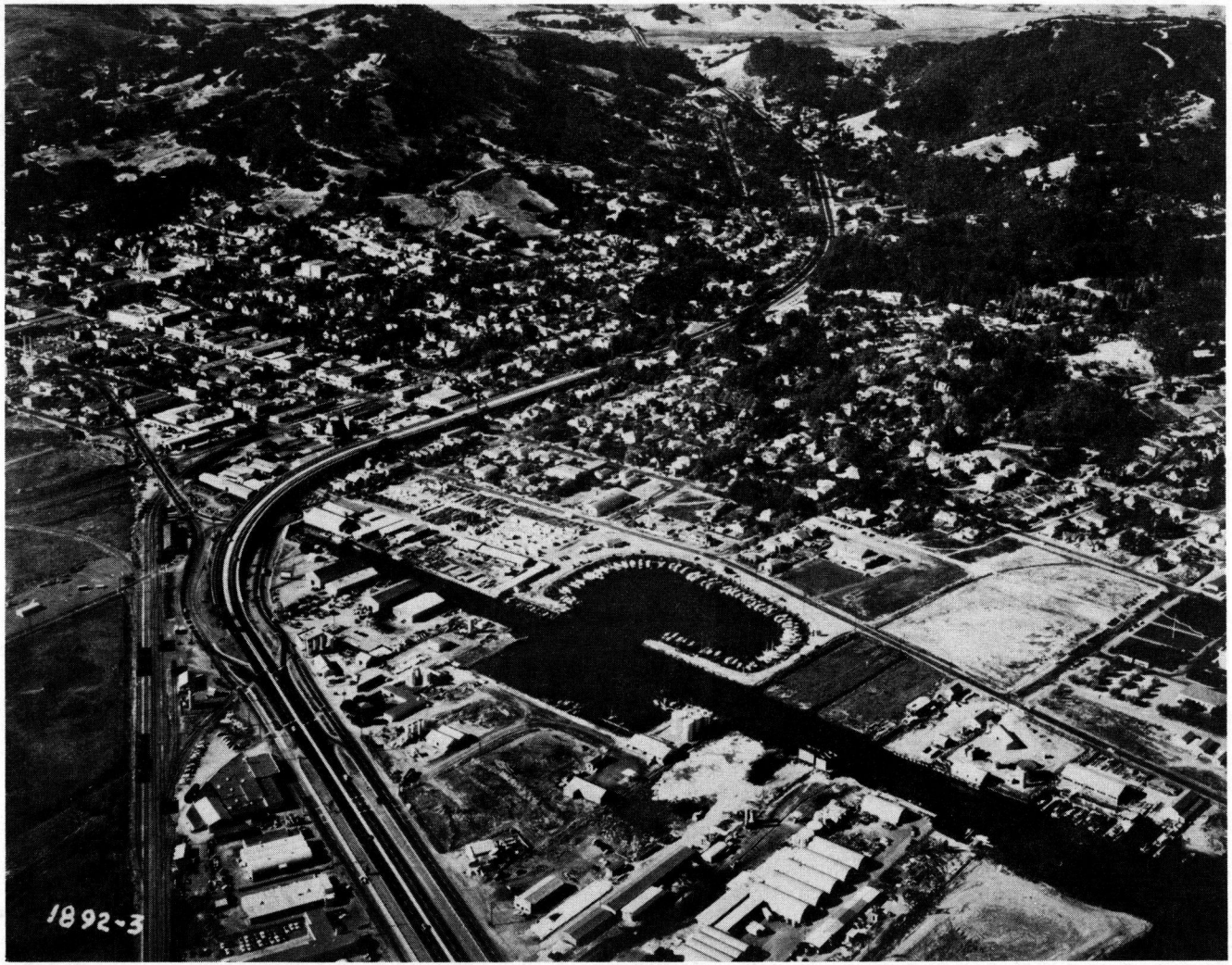

Figure 11. Freeway Through San Rafael

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)

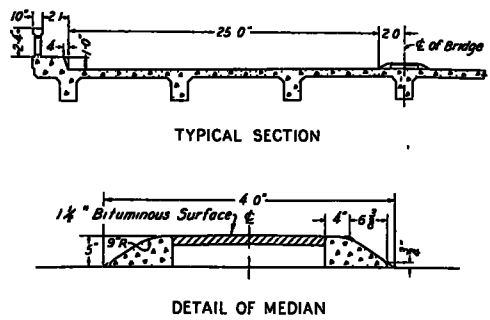

Figure 12. California - Long Structure, San Rafael Freeway

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.

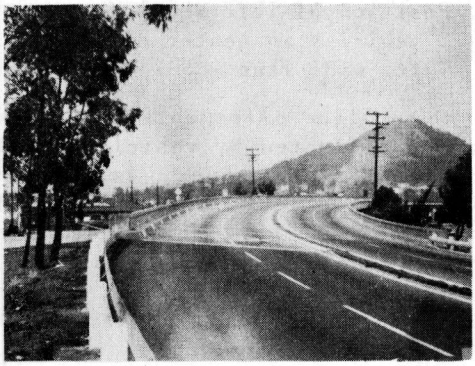

Figure 13.

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.

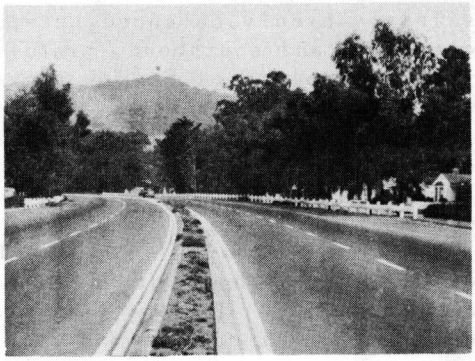

Figure 14.

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.

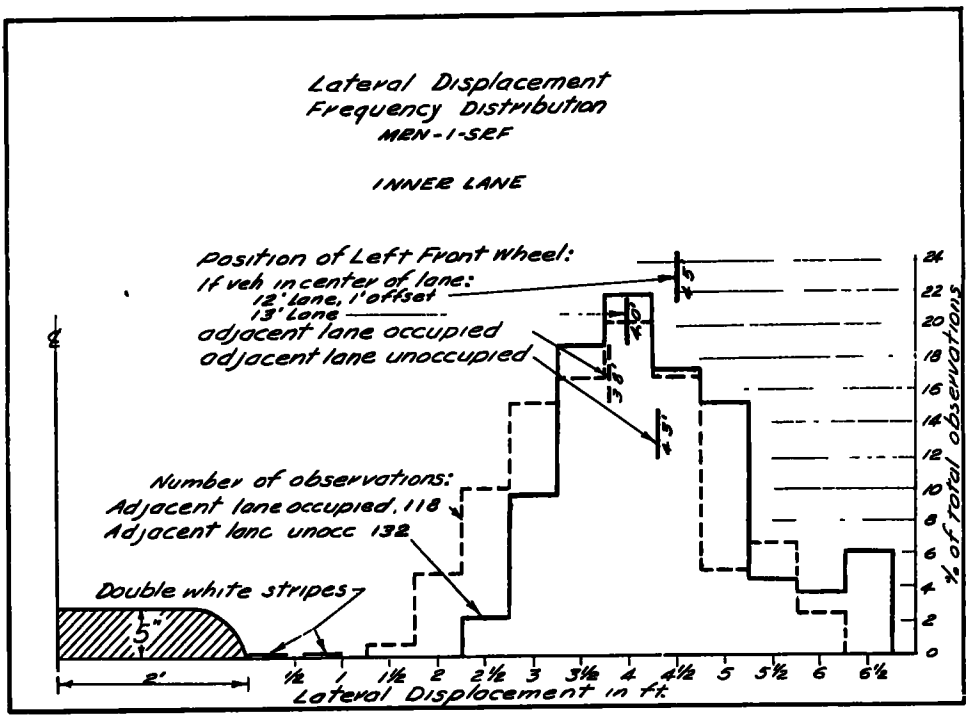

Figure 16.

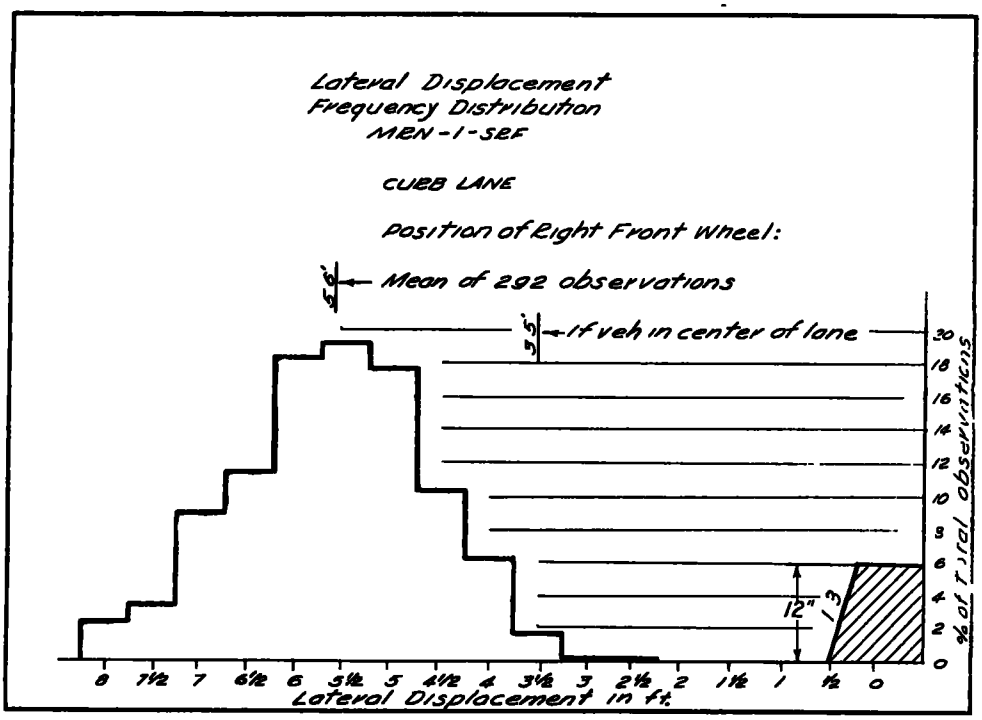

Figure 17.

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.