California Median Study: 1958

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This study concerns the relative safety of the various types of median design, including the positive barrier median, on divided highways carrying traffic volumes in excess of 15,000 vehicles per day, and the development of tentative criteria for the installation of positive median barriers. A report covering a previous median study of divided highways which carried volumes up to 25,000 vehicles per day was presented at the HRB Thirty-Second Annual Meeting.

An analysis was made of the approximately 8,000 accidents which occurred in 1956 and 1957 on some 265 mi of divided highway with deterring and non-traversable median designs. Operating conditions, as measured by the average daily traffic (ADT) volume, apparently influenced the relative safety of the deterring and non-traversable medians. In the volume range of up to 130,000 vehicles per day, the deterring-type median had the lower accident and injury rate. In the volume range of 130,000 or more vehicles per day, the advantage shifted to the non-traversable medians which had the lower accident and injury rate.

To emphasize the cross-median fatal head-on-type accident, the 407 fatal accidents which occurred on freeways in 1956, 1957 and 1958 were then analyzed.

During this period, the cross-median collisions accounted for 19 percent of the fatalities on freeways. Freeways carrying more than 60,000 vehicles per day accounted for one-fifth the mileage and two-thirds of the fatal cross-median collisions. Therefore, in order to make a significant attack on the cross-median fatal accident problem, it would be necessary to reach down to the 60,000 ADT level with the installation of median barriers. Past experience indicates that barriers may convert cross-median accidents to other types. However, newly-developed barrier designs may reduce the severity of collisions with the barriers and result in fewer casualties even though the accident rate may rise.

● DIVIDED HIGHWAYS have demonstrated their ability to carry large volumes of traffic efficiently and safely. However, the most modern highway does not prevent all accidents. This results in a continuing demand to improve design and increase safety.

One of the major questions with respect to safety is the type and design of medians for the various conditions under which they must be constructed. Varying terrain in rural areas and high cost of right-of-way in urban areas has led to a variety of median designs.

ACCIDENT RATES AND TYPE AND WIDTH OF MEDIAN

In an effort to evaluate the safety of the various types and designs of medians, a comprehensive study of medians was made in 1952. This study was based on 12,836 reported accidents on 563 mi of 4-lane divided highways with traffic volumes up to 25,000 vehicles per day.

The 1952 study indicated that the type of median influenced the accident rate, and, with respect to those highways within this range of traffic volumes, the traversable and deterring-type medians were superior to the non-traversable group. However, there appeared to be an indication that at higher traffic volumes the non-traversable median might be superior. At that time, there was not much experience with high traffic volumes, and firm conclusions could not be drawn regarding highways in that class.

Since the previous report was made, there has been a tremendous increase, both in traffic volumes and in the mileage of divided highways. For example, a portion of the Hollywood Freeway in Los Angeles carries a traffic volume of 200,000 vehicles per day.

The purpose of the present study is to investigate the effect of median design on accident rates for divided highways carrying traffic volumes in excess of 15,000 vehicles per day and to develop criteria for the use of the various types of median.

DESCRIPTION

A field investigation was made of all divided highways with a 1955 volume of 15,000 or more vehicles per day to establish the location and types of median and to log all features which might affect the accident rate.

To reduce the influence of factors other than median design, only freeways (no intersections), expressways (access rights to adjacent property are severely restricted, but there are intersections), and highways without roadside development were investigated. The study, then, is essentially a comparison of median types as applied to limited-access facilities.

From approximately 530 mi of highway logged in the field, 265.76 mi were selected for detailed study. The remaining mileage was eliminated because of factors other than median design which possibly would influence the accident rate or because of the inability to obtain adequate accident records. All intersection accidents were eliminated.

The median designs were classified in two general categories that were used in the 1952 study, as follows:

1. The deterring type, which, by a physical obstruction, discourages deliberate entrance or crossing of the median. The raised bar or low dike, the mountable double curb, and most of the earth-type medians with flat cross-slopes are in this group.

2. The non-traversable type, which, by a physical obstruction, would presumably prevent crossing from one roadway to another without a reportable accident. Separate roadways; barrier-type medians, including the non-mountable curbs; and earth medians with a continuous obstruction are included in this group. Also included in this group are earth medians with a steep cross-slope. Additionally, all medians greater than 100 ft in width were classified as non-traversable.

The mileage of traversable type medians, such as a paved median or an earth median with a flat, smooth, hard surface, which was available

TABLE 1

Type	Mileage		Accidents	
	1956	1957	1956	1957
Deterring:				
1. Earth median; soft or loose surface, slopes 4 to 1 or flatter	134.80	132.67	1107	1222
2. Double-curbed median with standard curbs less than 6 in. in height	45.34	63.14	1311	1777
3. Miscellaneous features: median with ditch, dike or high raised bars	13.34	14.25	131	175
Sub-total deterring type	193.48	210.06	2549	3174
Non-traversable:				
1. Barrier-type median with guardrailing or concrete wall to prevent crossing	13.78	12.52	367	388
2. Barrier-type median with concrete posts to prevent crossing	18.71	17.78	130	101
3. Barrier-type median with fence to prevent crossing	5.73	3.82	78	57
4. Two separate roadways with slope in median steeper than 4 to 1 or median width greater than 100 ft	13.82	14.66	474	404
5. Miscellaneous features: earth or paved median not crossable because of ditch high curb, or other similar feature	8.87	6.92	140	132
Sub-total non-traversable type	60.91	55.70	1189	1082
Grand total	254.39	265.76	3738	4256

for study was considered too small to draw any conclusions from, because it comprised only two or three short sections of highway.

A summary of the mileage and number of accidents studied in each category is given in Table 1. Examples of the various median types are shown in Figure 1.

Many variables other than median type and design influence the frequency of accidents. Among these are the exposure as measured in vehicle-miles of travel, the design standards and features of a particular facility, traffic density, climatic conditions, speed differentials and many others. Obviously, not all of these variables may be controlled in this kind of study. However, it should be noted that no one section of highway was large enough to bias the over-all results, and in general it was considered fair to assume that variables other than volume were distributed randomly among the median classifications studied, because changes in median type and design occurred frequently along almost all lengths of highway. The 266 mi of highways studied is made up of segments averaging 0.61 mi in length with a maximum length of segment of 5.92 mi.

INFLUENCE OF MEDIAN WIDTH

The accident rates by median width groups are plotted in Figure 2 for the two basic median types. An attempt was made to investigate the effect of the median width for the various median types within each basic group. Whereas the various sub-groups followed the same general pattern as the basic types, the individual samples were too small to correlate the degree of traversability with the accident rates for the various median widths.

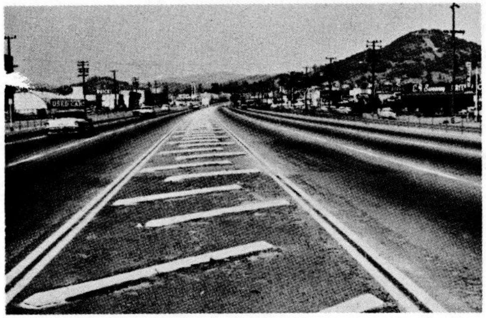
As may be seen in Figure 2, there appears to be no correlation between the accident rates and the width of median for the basic median types. This was also the case in the previous median study (1) and in a study of the accident experience with traversable medians by Hurd (2).

This seems to contradict the hypothesis that, for the same general conditions, the greater the lateral separation, the safer the facility. One explanation for this contradiction is that the median width used in this study (and as generally defined) is the width between the edges of opposing roadways, not the width available for maneuvering or for emergency parking. When a vehicle leaves the roadway, there is a good chance of avoiding a reportable accident if maneuvering room is available. The "width" of median between opposing lanes of traffic is not a direct function of this maneuvering room.

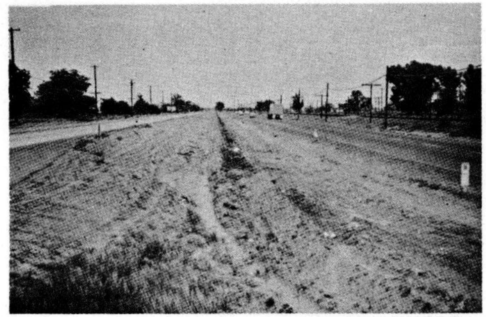
If effective width instead of "median" width were used in constructing Figure 2, a somewhat different picture might have resulted. On the other hand, wide medians (more than 16 ft) of the deterring type are generally earth medians with a slope of 4:1 or flatter. In this case, the effective width would be essentially the same as the actual width. However, this type median shows the same general pattern as the non-traversable median.

INFLUENCE OF TRAFFIC VOLUME

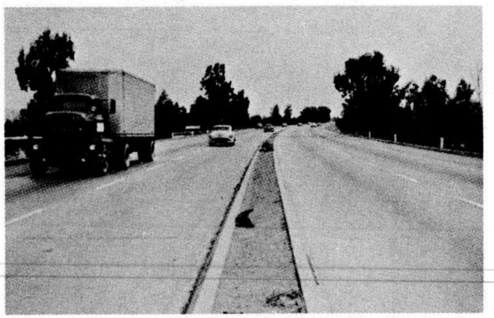
With respect to the over-all safety of a highway, the median types should be investigated for all operating conditions. It is recognized that hourly traffic volumes are a more accurate indication of the oper-



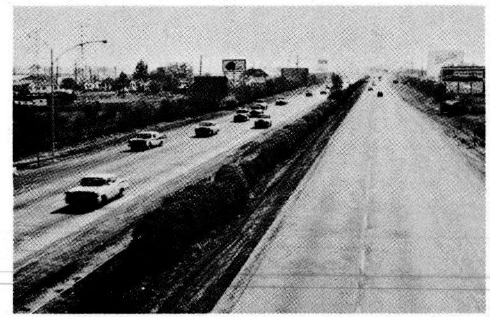
DETERRING-RAISED BARS



DETERRING-EARTH



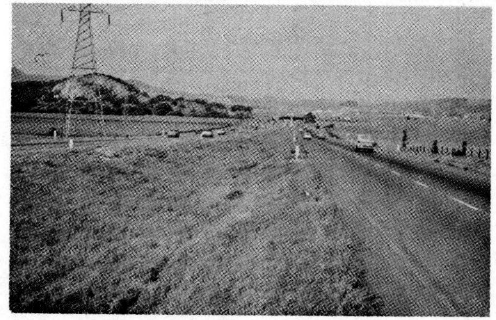
DETERRING-CURBED



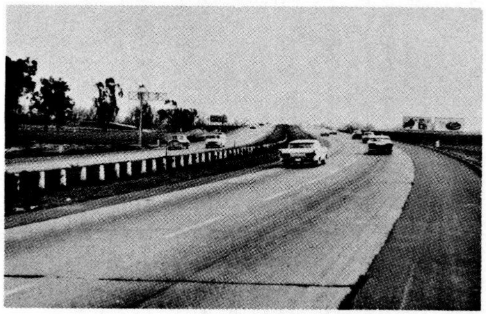
NON TRAVERSABLE-FENCE

Figure 1A.

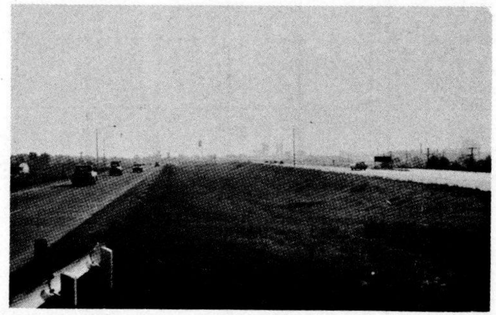
NON TRAVERSABLE-CONCRETE WALL



NON TRAVERSABLE-EARTH



NON TRAVERSABLE-BARRIER POST



NON TRAVERSABLE-SEPARATE ROADWAY

Figure 1B.

ating conditions and degree of congestion than the average daily traffic flow. However, because of obvious difficulties in relating accident rates to hourly flow, the rates were compared by volume groups, using the average daily traffic volume. It is believed that in a large sample such

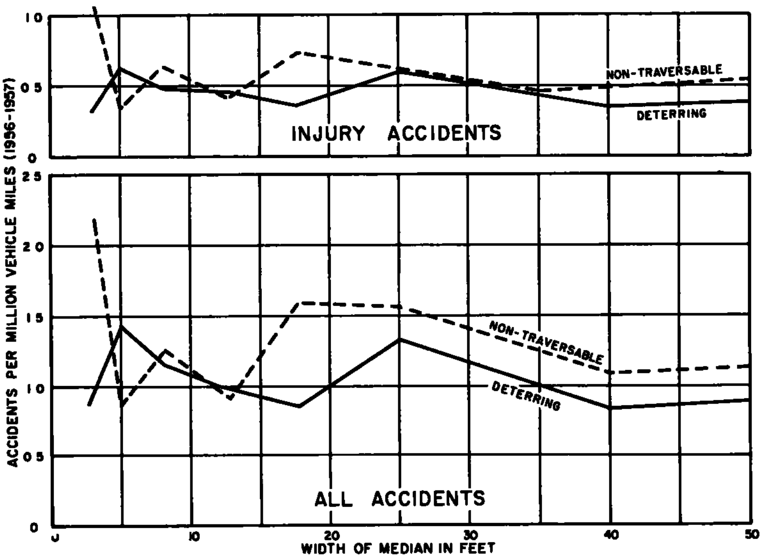


Figure 2. Accidents per million vehicle miles by width of median.

as this, facilities within the same daily volume groups will have similar hourly flow patterns except for the very low volume groups which include facilities in the more rural areas.

The effect of lane volume was also investigated, but no significant difference could be established between the accident rates for facilities carrying the same traffic volumes on different numbers of traffic lanes. However, it should be noted that in this study, there was not enough overlapping of volumes for different widths to form a real basis of comparison. That is to say, in the lower volume groups, almost all the roads were 4-lane, and in the upper volume range there were really not enough mileage of 6- and 8-lane highways carrying equal volume to compare one with the other for the same volume.

Figure 3 shows the accident rates for the two basic types of medians for various daily traffic volumes. The deterring-type median appears to be superior to the non-traversable type until very high volumes are reached. At an average traffic volume of 130,000 vehicles per day, the advantage appears to shift to the non-traversable type. This is illustrated by both the injury and all-accident rates, which follow similar patterns.

The study sections included in volume groups of 130,000 and more vehicles per day are all located in two facilities, the Hollywood and Harbor Freeways in Los Angeles. On these two freeways during the two-year study

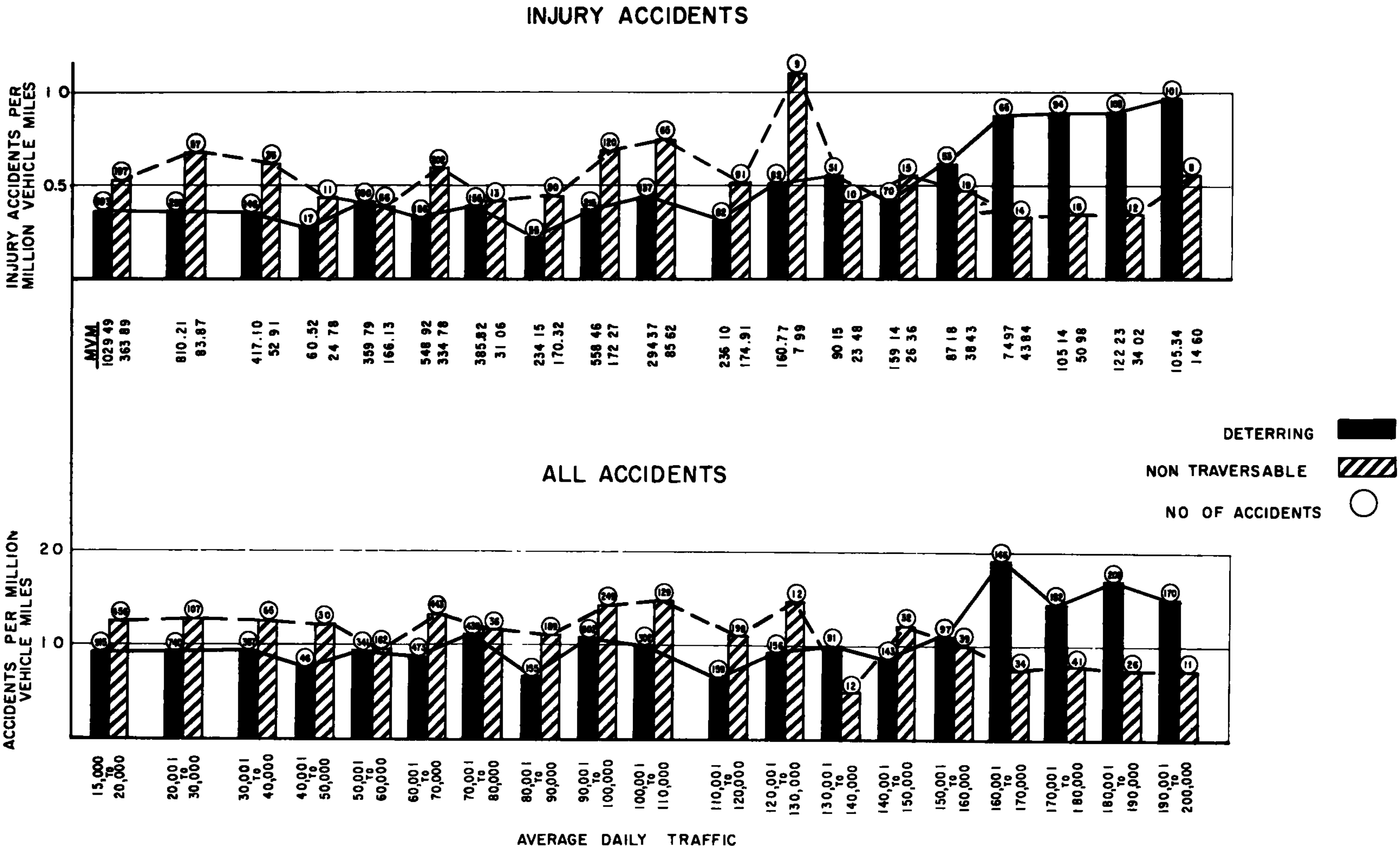


Figure 3. Accidents per million vehicle-miles by 10,000 vehicle per day volume groups.

period, there were 12.48 mile-years of double-curbed deterring type and 3.86 mile-years of non-traversable (separate roadway, guardrail or concrete wall) type. The width of the deterring type varies from 6 to 100 ft, but is typically 12 ft. It is possible that the accident rates in

TABLE 1A

Type of Median	Mileage 1956	Mileage 1957	Million Vehicle-Miles	Accidents 1956	Accidents 1957
	Volume Group I (15,000 - 130,000 ADT)				
All	247.25	256.22	6764.23	3155	3636
Deterring:	188.36	202.41	5095.70	2079	2636
Earth	134.80	132.67	2663.72	1107	1222
Curbed	40.22	55.49	2085.37	841	1239
Misc. features	13.34	14.25	346.61	131	175
Non-Traversable:	58.89	53.81	1668.53	1076	1000
Guardrail or concrete wall	13.28	12.52	534.53	339	388
Barrier post	18.71	17.78	256.55	130	101
Fence	5.73	3.82	110.69	78	57
Two separate roads	12.30	12.77	511.77	389	322
Misc. features	8.87	6.92	254.99	140	132
	Volume Group II (Above 130,000 ADT)				
All	7.14	9.54	975.86	583	620
Deterring:	5.12	7.65	744.15	470	538
Curbed	5.12	7.65	744.15	470	538
Non-Traversable:	2.02	1.89	231.71	113	82
Guardrail or concrete wall	0.50	0.00	26.17	28	0
Two separate roads	1.52	1.89	205.54	85	82

the very high volume groups may reflect accident conditions peculiar to these two freeways, including the fact that reporting is extraordinarily complete. Keeping this in mind, there is nevertheless an indication that at traffic volumes of 130,000 or more vehicles per day, the non-traversable type median is superior. No attempt has been made to derive a statistical measurement of reliability, but the number of accidents and number of vehicle-miles for each plotted point (bar) on the graph are given.

INFLUENCE OF MEDIAN ON TYPE OF ACCIDENT

To investigate the influence of median types on the safety of a facility in more detail, the study mileage was divided into two traffic volume ranges (Table 1A) on the basis of the preceding analysis. Volume Range 1 includes all mileage with traffic volume between 15,000 and 130,000 vehicles per day. Volume Range 2 includes the mileage with a traffic volume of 130,000 or more vehicles per day.

Tables 2A and B give the accident rates per million vehicle-miles by type of accident for the two ranges. Table 2A lists the "all-accident" rates and Table 2B lists the injury-accident rates. In both volume ranges, the overtaking-type accident accounted for the majority of the total accidents. In Volume Range 2, the approach and single-vehicle-type accidents were relatively insignificant.

In the lower volume range, the deterring-type median has the lowest total accident rate. As expected, the approach-type accident rate increases with the degree of traversability. However, in this range of volumes, it is seen that the approach-type accident (head-on) only accounts for 1/25 of all accidents and 1/21 of the injury accidents. Although the non-traversable median has the lowest rate for the approach-type accident, this advantage is more than offset by the higher rate of overtaking and single-vehicle-type accidents.

In the higher volume group, the non-traversable median had lower accident rates for all types of accidents with no approach-type accidents.

INFLUENCE OF MEDIAN ON SEVERITY OF ACCIDENTS

The severity of accidents for the several types of median is given in Table 3 for the two volume groups.

Using the number of injuries per vehicle-mile as an index of severity, it is seen that when the volume was less than 130,000 vehicles per day, the deterring type (whether curbed or earth) had the most favorable record. In fact, the number of injuries per vehicle-mile was 44 percent higher for the non-traversable type than for the deterring type.

On highways having a traffic volume in excess of 130,000 vehicles per day, the injury rate of the deterring type was twice that of the non-traversable type. This may be compared with the fact that the all-accident rate of the deterring type was 1.6 times that of the non-traversable.

MEDIAN ACCIDENTS

A breakdown of median accidents is given in Table 4 for the various median types. As expected, the deterring-type medians had the greater cross-median accident rate per 100 million vehicle-miles in both volume ranges.

On roads carrying between 15,000 and 130,000 vehicles per day, the deterring-type median has the lowest total median-accident rate per million vehicle-miles. On roads with more than 130,000 vehicles per day, the non-traversable median has the lower median-accident rate. However, the percentage of accidents involving the median was higher for the non-traversable type in both volume ranges. This might be expected, because it is known that many vehicles enter the median and recover without having an accident, unless there is something non-traversable to hit.

The severity of the median accidents is given in Table 5. On roads with traffic volumes between 15,000 and 130,000 per day, the deterring-type median had a lower accident severity as measured by the number of injury accidents, injuries, and fatalities per million vehicle-miles than the non-traversable median group. On roads with more than 130,000 vehicles per day, the advantage switched to the non-traversable.

SUMMARY

Operating conditions as measured by the average daily traffic volume apparently influence the relative safety of the deterring and non-traversable medians.

In the volume range between 15,000 and 130,000 vehicles per day, the deterring type median had the lower accident and injury rate. While the non-traversable median had fewer approach-type accidents, the higher rates of overtaking and single-vehicle accidents more than offset this advantage.

In the volume range of 130,000 vehicles or more per day, the advantage shifted to the non-traversable median, which had the lower accident and injury rate.

FATAL ACCIDENTS, FULL FREEWAYS, AND MEDIAN BARRIERS

In the foregoing, it was found that the barrier-type median does not seem to be as good as the curbed or earth type from the standpoint of overall traffic safety or severity of accidents, except on highways carrying extremely high volumes of traffic. However, that analysis did not emphasize the cross-median-, head-on-type accident at the exclusion of fatal or severe accidents of other kinds.

Full freeways (that is, divided highways with no cross traffic and no roadside access) have always had a good record in number of fatal accidents per vehicle-mile, especially when compared with other types of highways or streets. However, even freeways do have fatal accidents, and as the mileage and travel on them has increased, the number of fatal accidents has increased. Perhaps because of their rarity, each of these accidents attracts considerable public attention, especially when it is of the spectacular head-on variety, which frequently (but not always) means that one of the drivers crossed the median.

Ten times as many fatal head-on accidents occur annually on conventional roads and streets in California as occur on freeways. Almost all of these, on both kinds of highway, involve driver error and many of them involve "innocent" victims; that is, the victim was on his own side of

TABLE 2A

ACCIDENT PATTERN AND RATES* BY TYPE OF MEDIAN

Type of Median	Million Vehicle-Miles	Approach	Over-taking	Single Vehicle	All Accidents Including Pedestrian
Volume Group I (15,000 - 130,000 ADT)					
All	6764.23	4	69	23	100
Deterring:	5095.70	5	65	19	92
Earth	2663.72	4	58	22	87
Curbed	2085.37	6	74	16	100
Misc. features	346.61	3	64	16	88
Non-Traversable:	1668.53	3	83	34	124
Guardrail or concrete wall	534.53	4	96	31	136
Barrier post	256.55	3	52	29	90
Fence	110.69	2	77	39	122
Two separate roads	511.77	4	89	42	139
Misc. features	254.99	2	76	25	107
Volume Group II (Above 130,000 ADT)					
All	975.86	4	107	9	123
Deterring:	744.15	6	118	9	135
Curbed	744.15	6	118	9	135
Non-Traversable:	231.71	—	74	8	84
Guardrail or concrete wall	26.17	—	103	4	107
Two separate roads	205.54	—	70	9	81

*Per 100 million vehicle-miles.

the road. While the public attributes the ten-elevenths that happen on ordinary roads to speed, drinking, immaturity, and many other driver factors, the one-eleventh that happen on freeways are attributed to highway design. This is presumably because it looks so simple to erect an unbreakable wall in the middle of a freeway and thus "prevent" the accident

TABLE 2B

INJURY*-ACCIDENT PATTERN AND RATES** BY TYPE OF MEDIAN

Type of Median	Approach	Over-taking	Single Vehicle	All Injury Accs. Including Pedestrian
Volume Group I (15,000 - 130,000 ADT)				
All	2	27	10	42
Deterring:	3	25	8	38
Earth	2	23	9	36
Curbed	4	28	7	41
Misc. features	2	20	6	30
Non-Traversable:	2	36	16	56
Guardrail or concrete wall	2	45	14	64
Barrier post	2	23	13	40
Fence	1	31	9	43
Two separate roads	3	37	22	64
Misc. features	1	29	15	48
Volume Group II (Above 130,000 ADT)				
All	3	56	4	65
Deterring:	4	61	4	73
Curbed	4	61	4	73
Non-Traversable:	—	37	3	41
Guardrail or concrete wall	—	42	—	42
Two separate roads	—	36	4	41

*Includes fatal and non-fatal.
**Per 100 million vehicle-miles.

from happening. The fact that when a car hits a wall there is an accident, possibly fatal and often involving an "innocent victim"; the fact that this same car would stand a good chance of not becoming involved in any accident at all if there were no curb or wall to throw it out of control; and the fact that the cost of the unbreakable wall must be deducted from money available to correct other highway deficiencies, are all overlooked.

ANALYSIS OF FATAL ACCIDENTS ON FREEWAYS

A separate analysis was made of the 407 fatal accidents that happened on freeways in 1956, 1957 and 1958. The purpose of this analysis which follows, is to provide some guidance for determining how far to go in providing median barriers on freeways.

The first thing to look at is the distribution of fatal freeway accidents by type of accident. A breakdown of accidents and fatalities by type for the three years is given in Table 6 and shown in Figure 4.

Figure 5 shows the types of fatal accidents on freeways by hour of occurrence. It may be noted that the majority of all types of fatal accidents occurred in the hours of lighter travel from 7 P. M. to 7 A. M. This part of the day, while accounting for only 28 percent of the travel, accounted for 270 or 66 percent of all fatal freeway accidents.

<u>Single Vehicles</u>

As given in Table 6, the largest percentage of fatalities and fatal accidents involve only one vehicle. Single vehicles accounted for 43 percent of the fatal accidents and 42 percent of the fatalities. In 15 of these accidents, the vehicle crossed the median.

TABLE 3

FATAL AND NON-FATAL ACCIDENTS AND INJURIES

Type of Median	Injury* Accs. Per 100 Million Vehicle-Miles		Injuries* Per 100 Million Vehicle-Miles		Fatalities Per 100 Million Vehicle-Miles	
	Volume Group I (15,000 - 130,000 ADT)					
All	42		71		2.99	
Deterring:	38		64		2.82	
Earth		36		61		2.48
Curbed		41		68		3.12
Misc. features		30		63		3.75
Non-Traversable:	56		92		3.48	
Guardrail or concrete wall		64		105		2.62
Barrier post		40		65		6.24
Fence		43		73		1.81
Two separate roads		64		101		3.91
Misc. features		48		80		2.35
	Volume Group II (Above 130,000 ADT)					
All	65		116		1.33	
Deterring:	73		132		1.48	
Curbed		73		132		1.48
Non-Traversable:	41		65		0.86	
Guardrail or concrete wall		42		92		—
Two separate roads		41		61		0.97

*Includes fatal and non-fatal.

Pedestrians

Seventy-one (14 percent of the fatalities involved pedestrians. The number of pedestrian fatalities is unduly high, considering that most freeways are fenced and pedestrians are prohibited. Fifty-five (78 percent) of these fatalities involved pedestrians who were walking or hitchhiking on the freeway.

Prevention of this type of accident poses interesting questions: First, how shall the transient be informed of this provision of the law? Second, should the law authorize the patrolling officer to arrest a hitchhiker (for example, a young sailor)? If so, what does the officer do with him? Give him a citation, put him in jail, or carry him off the freeway and release him? How does he make the pedestrian stay off? Third, what about the motorist in distress? Should he be encouraged to walk along the freeway by placing telephones for emergency use at intervals along the shoulder?

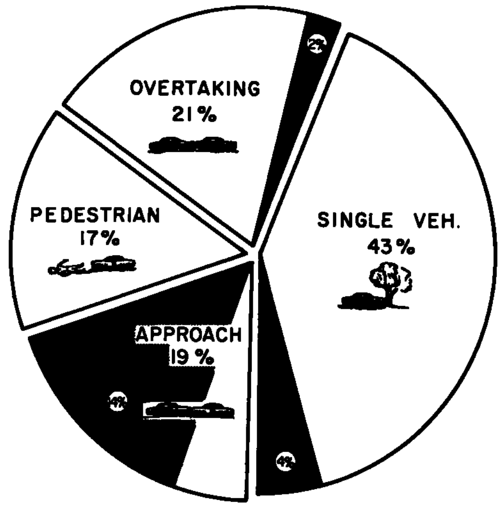


Figure 4. Types of full freeway fatal accidents 1956, 1957, 1958.

Overtaking

Overtaking-type fatal accidents account for 101 (20 percent) of the total fatalities. The overtaking-type fatal accidents, with a description of the accident and the location of the victim with respect to the overtaking or overtaken vehicle, are listed in Appendix A. It is often argued that a driver may adequately protect himself from vehicles traveling in the same direction while it is not possible to protect himself from vehicles traveling in the opposite direction. There is no doubt that, in general, a driver may better avoid vehicles proceeding in the same direction; however, a review of these accidents illustrates the fact that there are many "innocent" victims of overtaking accidents who were unable to avoid the accident. For example, in 22 of these accidents, the victims were struck from the rear by another vehicle.

Approach

Approach, or head-on-type accidents, are the most severe type accident. Fifty-five head-ons were attributable to vehicles crossing the median. The other 22, or 29 percent, involved vehicles driving in the wrong lane opposing traffic for other reason . Generally, it was impossible to determine where or how the vehicle got into the opposing traffic lanes, either because the accident was a fatal one or the driver condition was such that he was unable or unwilling to give this information. With this information unavailable, it is difficult to propose an engineering solution to the problem. As yet, there is no positive solution to the problem of wrong-way movements at off-ramps. It might not be inappropriate to point out that a median barrier would make it more difficult for a car headed the wrong way either to get off the road or to get on the right side of the freeway.

TABLE 4

ACCIDENTS INVOLVING THE MEDIAN

Type of Median	All Cross-Median Accs. Per 100 Million Vehicle-Miles	All Median Accs. Per 100 Million Vehicle-Miles	All Median Accs. as a Percent of All Accs.	Cross-Median Accs. as a Percent of All Accs.
Volume Group I (15,000 - 130,000 ADT)				
All	7	28	28.0	7.2
Deterring:	8	24	25.7	8.4
Earth	6	27	31.2	6.4
Curbed	10	20	19.7	10.2
Misc. features	10	22	25.2	11.1
Non-Traversable:	6	41	33.0	4.6
Guardrail or concrete wall	6	44	32.6	4.8
Barrier post	6	38	42.8	6.9
Fence	6	44	36.3	5.2
Two separate roads	7	49	35.4	5.1
Misc. features	1	19	17.6	0.7
Volume Group II (Above 130,000 ADT)				
All	6	17	14.1	5.1
Deterring:	8	19	13.9	6.0
Curbed	8	19	13.9	6.0
Non-Traversable:	—	13	15.4	—
Guardrail or concrete wall	—	19	17.8	—
Two separate roads	—	12	15.0	—

Cross-Median Accidents

Cross-median accidents accounted for 55 of the approach-type fatal accidents, 7 of the overtaking-type accidents, and 15 of the single-vehicle fatal accidents. It should be explained that the accident classification is determined by the first event. Thus, the cross-median-overtaking accidents involved an overtaking-type collision before the vehicle crossed the median.

The cross-median fatal accidents are listed in Appendix B with a description of the accident. This list illustrates the wide variety of factors associated with cross-median fatal accidents. It may be noted that it is not always a "guilty" party that crosses the median. In 8 fatal-cross-median-approach accidents, the driver of the vehicle crossing the median was not careless or negligent, hence would not be considered "guilty." In 5 of these accidents, the vehicle crossing the median was struck by another vehicle and forced across the median. In an additional 18 accidents, the sequence of events preceding the accident was unknown.

The outstanding statistic here is that cross-median collisions of two or more vehicles accounted for 95, or 19 percent, of all fatalities on freeways in California during 1956, 1957 and 1958. (During the same years there were 11,005 traffic fatalities in the state.)

EXPERIENCE WITH MEDIAN BARRIERS

Grapevine Grade

When the Grapevine Grade on US 99 was converted from a 3-lane to a 4-lane-divided highway, a median barrier was placed on 3.6 mi of it. By 1949, the entire grade, 5.0 mi long, was equipped with a concrete barrier. While it was not possible to make before-and-after comparisons on the whole grade, because of the changes in width and character of the road and influence of the war years, such a comparison was made for the last 1.4 mi that were finished in 1949.

This road is on a 6 percent grade and there were many accidents resulting from cars and trucks losing control going downhill. The accident rate and fatality rate were bad before erection of the barrier, but after erection of the barrier they became worse. On the 1.4-mi section where the before-and-after study was made, the accident rate increased 88 percent and the injury rate increased 53 percent. There was one fatal accident in the "before" period and there were two in the "after" period.

On the entire 5.0 mi of the Grapevine Grade, fatal accidents have continued to be numerous during the succeeding 10 years. The fatality rate is 33 per 100 million vehicle-miles, which is about 4 times the statewide average for rural highways and 10 times the statewide average for freeways. During the years 1951 to 1958, inclusive, 57 people were killed on this 5.0-mi stretch.

San Bernardino Freeway

In 1956, a median guardrail-type barrier was installed on a 1 3/4-mi section of the San Bernardino Freeway in Los Angeles. The results were disappointing. A comparison of the records for 22 months before and 22 months after the installation showed that the all-accident rate increased three-fourths and the injury accident rate increased by 116 percent (more than double). While cross-median accidents were almost eliminated, the median accident rates increased by two-thirds and the number of persons injured per accident increased 30 percent. This comparison is based on a total of 167 accidents before and 338 accidents after.

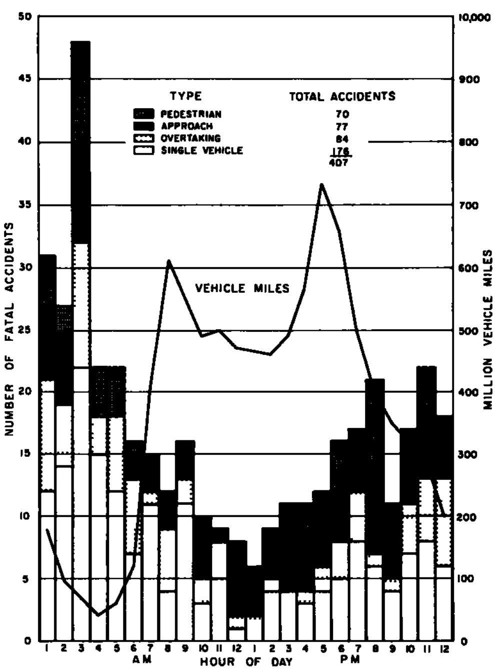


Figure 5. Freeway fatal accident summary by type for hour of day 1956, 1957, 1958.

Bayshore Freeway

In 1957, a median guardrail was installed on a 1.07-mi section of the Bayshore Freeway in San Francisco. In contrast to the Grapevine and San Bernardino Freeway experience, the results here are favorable, to date.

A comparison of accidents 12 months before and after the installation revealed that the total accident rate and the injury accident rate decreased approximately 40 percent after the barrier was installed. Cross-median accidents were eliminated and the median injury accident rate decreased 45 percent after the installation. The number of persons injured per accident decreased 16 percent. These observations are based on a total of 141 accidents before and 88 accidents after.

In evaluating the results of these studies, it must be noted that there has been considerable variation in the rates for segments of these freeways from year to year, presumably by chance.

TABLE 5

FATAL AND NON-FATAL MEDIAN ACCIDENTS AND INJURIES

Type of Median	Injury* Accs. Per 100 Million Vehicle-Miles		Injuries* Per 100 Million Vehicle-Miles		Fatalities Rate Per 100 Million Vehicle-Miles	
Volume Group I (15,000 - 130,000 ADT)						
All	14		25		1.27	
Deterring:	12		23		1.18	
Earth		14		25		1.28
Curbed		10		19		1.00
Misc. features		12		28		1.73
Non-Traversable:	20		31		1.56	
Guardrail or concrete wall		19		26		1.68
Barrier post		17		31		2.73
Fence		20		33		0.90
Two separate roads		24		38		1.37
Misc. features		16		26		0.78
Volume Group II (Above 130,000 ADT)						
All	10		19		0.82	
Deterring:	11		23		0.94	
Curbed		11		23		0.94
Non-Traversable:	5		6		0.43	
Guardrail or concrete wall		—		—		—
Two separate roads		6		7		0.49

*Includes fatal and non-fatal.

POSSIBLE REASONS FOR UNFAVORABLE RECORD OF BARRIERS

In view of the unfavorable record of barriers in two of the before-and-after studies and in the 265-mi study, it would be in order to discuss what factors are associated with barriers that might affect accident rates unfavorably. A Texas study (3) indicated that barriers in narrow medians have little influence on the placement of vehicles in the median lane. Opposing traffic appeared to have exerted a similar influence on vehicle placement. This study did note that the barrier appeared to provide a better reference point for driving in the median lane than a low curb.

On the other hand, the introduction of a physical barrier in a traversable or deterring median reduces the usable width of the median. If this usable width of the median is a factor in the over-all safety of a

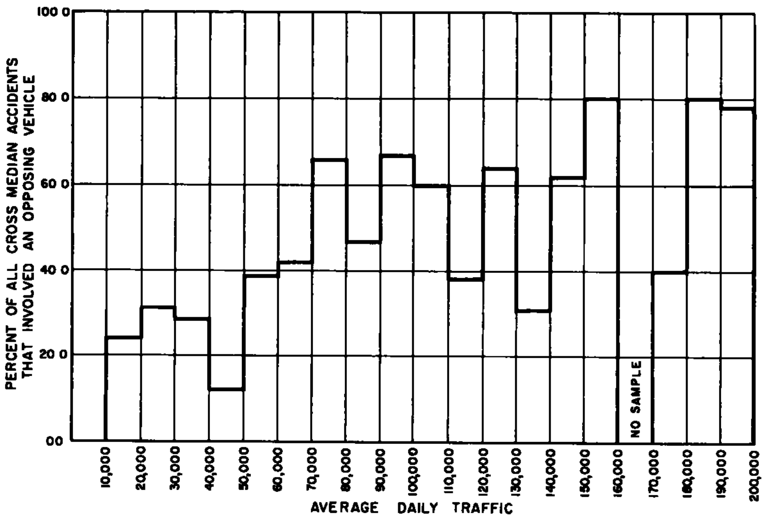


Figure 6. Proportion of all cross-median accidents that involved opposing vehicles, as a function of traffic volume.

freeway, it would be a rational explanation of the noted increase in the accident rates with the installation of a barrier. A driver's freedom to maneuver to avoid collision with other vehicles is reduced by a median barrier. There are undoubtedly vehicles which enter and in some cases cross the median and recover without a reportable accident when no barrier is present. More important, perhaps, is the fact that stalled vehicles are observed daily in median areas.

It is frequently taken for granted that if a car crosses the median of a heavily-traveled freeway, it is bound to collide with a car proceeding in the opposite direction. This is not true. Even during daytime hours, there are many long spaces between vehicles, and during the hours from midnight to 5 A. M., when the fatal accident problem is the greatest, most of the spaces between vehicles are several hundred feet long.

TABLE 6

FULL FREEWAY FATAL ACCIDENTS BY TYPE (1956, 1957 and 1958)

Item	Approach		Overtaking		Single Vehicle		Pedestrian		
	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total	Total
1956 Fatal accs.	17	16.5	25	24.3	42	40.8	19	18.4	103
Persons killed	22	18.8	29	24.8	46	39.4	19	16.2	116
1957 Fatal accs.	27	18.3	28	18.9	69	46.6	24	16.2	148
Persons killed	46	24.1	34	17.8	87	45.5	24	12.6	191
1958 Fatal accs.	33	21.2	31	19.9	65	41.6	27	17.3	156
Persons killed	50	26.0	38	19.8	76	39.6	28	14.6	192
Total for Period of Study									
All fatal accs.	77	18.9	84	20.6	176	43.3	70	17.2	407
Persons killed	118	23.7	101	20.3	209	41.9	71	14.2	499
Persons killed per accident	1.53		1.20		1.19		1.01		1.23
Cross-Median: Fatal accs.	55	13.5	7	1.7	15	3.7	0	0	77 (18.9%)
Persons killed	88	17.6	7	1.4	17	3.4	0	0	112 (22.5%)

There are no data to indicate how many vehicles enter or cross the median without having an accident, but a clue may be had by examining the accidents that involve cars crossing the median.

For this purpose, the data on the 7,994 accidents of the basic study were used because there was a better chance of discerning a pattern by examining them than there was in the 407 accidents of the corollary study.

Figure 6 shows, by daily traffic volume groups, the chances of involvement with a vehicle traveling in the opposite direction when one vehicle crosses the median and is involved in an accident. Even when the car that crosses the median has an accident, the chance of colliding with an opposing vehicle varied from 12 percent to a maximum of 80 percent of the cases, depending on traffic volume.

DISTRIBUTION OF FATAL CROSS-MEDIAN ACCIDENTS

In the basic study it was seen that if past experience is a guide, the installation of positive barriers in "deterring-type" medians, when the volume is less than about 130,000 vehicles per day, would increase not only the total number of accidents, but the number of injuries and fatalities. On the other hand, the fact that, in three years, 19 percent of all fatalities on freeways were caused by cross-median collisions is extremely serious. The question is: would a reduction in the cross-median fatalities, accomplished by installing positive barriers, be accompanied by a rise in other types of fatalities that would more than offset the benefit?

To provide some guidance in resolving this dilemma, the geographic distribution of cross-median fatal accidents on freeways was examined.

The San Francisco and Los Angeles metropolitan areas accounted for 55 (89 percent) of the fatal cross-median accidents that involved more than one vehicle. The large majority of this type of accident have occurred on sections of a relatively few heavily-traveled freeways. Table 7 gives these freeways and their record of fatal cross-median accidents.

Figure 7 is a plot of the cumulative number of full freeway fatal cross-median accidents involving opposing vehicles against the cumulative miles of freeway in ascending order of traffic volume. From this figure we may read the percent of this type accident occurring on any given amount or percent of the freeway mileage. For example, 80 percent of the

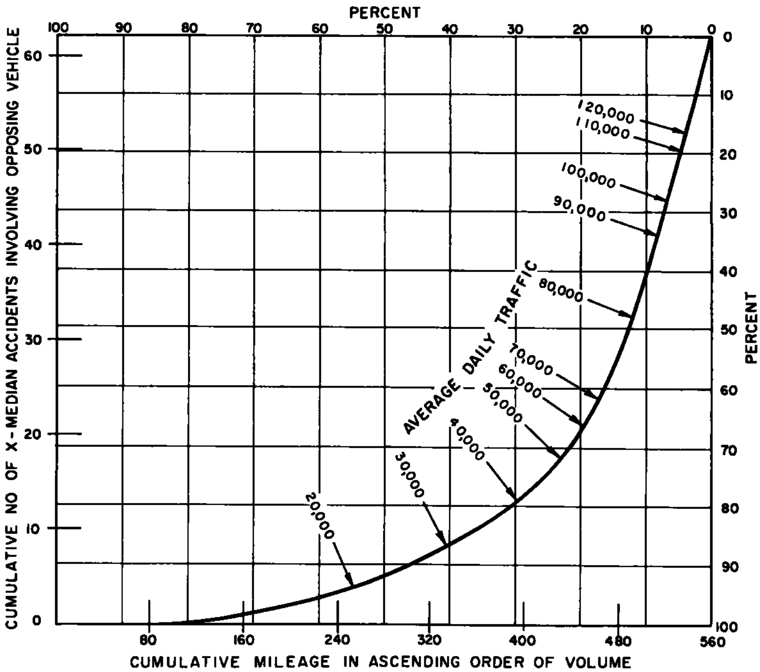


Figure 7. Fatal cross-median collisions by miles of freeway.

accidents occurred on the 32 percent of the mileage that had traffic volume exceeding 38,999 vehicles per day. Conversely, 382 mi, or 68 percent of the mileage, had traffic volumes of less than 38,000 vehicles per day and accounted for only 20 percent of the accidents. There is a "break" in the curve in the vicinity of 60,000 ADT. Below this point, 4/5 of the mileage accounts for only 1/3 of the accidents, and above this point, one-fifth of the mileage accounts for 2/3 of the accidents. At the time of the study, 1/5 of the mileage amounted to about 110 mi.

Figure 8 shows, as a function of traffic volume, the rate per mile for cross-median accidents that involve opposing vehicles for the deterring-type median. The rate varied from 0.1 to 9.0 accidents per mile-year for the period of the study.

Referring to Figure 7, 2/3 of fatal cross-median collisions would have been converted to some other type of accident by installation of an effective barrier on approximately 110 (as of 1958) mi of full freeway with traffic volumes in excess of 60,000 vehicles per day. However, the reported descriptions of these accidents, coupled with observation of full-scale crash tests (4) of median barriers, led to an inescapable conclusion that a rigid barrier seldom would have obviated a serious and possibly fatal accident. Further, it would appear that the injuries and fatalities in other types of accidents would be increased by the introduction of a barrier except for those highways carrying extremely high volumes of traffic.

MEDIAN BARRIER DESIGN

The relative effectiveness of various types of barriers may provide a solution to the dilemma. As may be seen in the table showing the severity of median accidents (Table 5), the barriers presently in place on those facilities with traffic volumes below 130,000 vehicles per day are not effective in reducing the severity of accidents involving the median. If these barriers were more effective in reducing the severity of these accidents, then possibly the volume at which barriers would be effective in reducing the over-all casualty rate would be considerably lower than the 130,000 vehicles per day indicated in this study.

For a barrier to be effective in reducing the severity of accidents, it must:

1. Prevent the vehicles from crossing the median.
2. Minimize the possible injury to occupants of the vehicle striking the barrier.
3. Prevent the vehicle from reflecting back into the traffic stream.

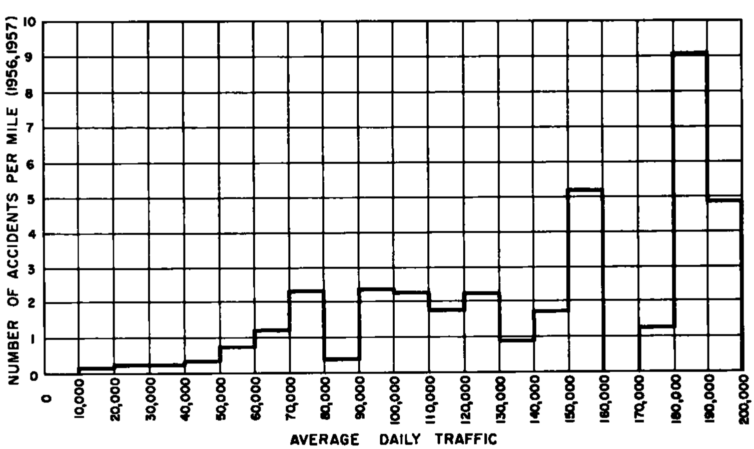


Figure 8. Cross-median accidents on deterring-type medians which involved opposing vehicles as a function of traffic volume, expressed in accidents per mile.

TABLE 7

FATAL CROSS-MEDIAN COLLISIONS ON SELECTED FULL FREEWAYS (1956, 1957 and 1958)

Freeway	Limits	Length (Mi) (1958)	No. of Fatal Cross-Median Accidents	Percent of Statewide Total
Los Angeles Area:				
San Bernardino Rte. 26	Santa Ana Freeway to Rte. 62 (West Covina)	18.5	7	11.3
Hollywood Rte. 2	Four Level to Lankershim	8.7	5	8.0
Santa Ana Rte. 2, 166, 174	Four Level to Rte. 175 (Orangethorpe Avenue)	21.7	12	19.4
Pasadena Rte. 165, 205	Four Level to Pasadena	8.2	3	4.8
Harbor Rte. 165	Four Level to Rte. 174 (Manchester)	7.8	4	6.5
	Sub-total	64.9	31	50.0
San Francisco Area:				
Eastshore Rte. 69	Fallon to Rte. 105 (Jackson)	14.5	7	11.3
Bayshore Rte. 68	Central Freeway (Rte. 2) to S.C.L. San Mateo	18.1	6	9.7
	Sub-total	32.6	13	21.0
	Total	97.5	44	71.0
Total in Los Angeles & San Francisco areas:		306.3	55	88.7
All other freeways:		252.2	7	11.3
	Grand total	558.5	62	100%

With the above criteria in mind, full-scale tests were made of 15 different designs for a barrier (4). In these tests, cars were driven into the rail at high speeds. Some of the designs failed (that is, the cars went over or through the railing) and most of the designs resulted in severe damage to the car and serious "injury" to the dummy occupant. However, three basic designs showed promise of fulfilling, to varying degrees, all of the criteria.

From the standpoint of over-all safety, a flexible-type barrier with chain link fence, light steel posts, and three 3/4-in. cables is the most effective. This barrier was the only type tested in which the deceleration within the test vehicle was tolerable to human occupants. However, if the median is narrow, deflection during the collision presents a problem. The minimum median width required for this type barrier would be in the range of 12 to 16 ft.

For median widths between 3 and 12 ft, either a steel rail system or a concrete wall would be effective.

The steel rail system consists of two W-section beam-type guardrails, blocked out 8 in. from douglas fir posts, together with supplemental channels 12 in. from the ground. The purpose of these channels and the blocking out is to prevent autos from "hooking" into the posts which causes a crash to be extremely severe.

For median widths less than 3 ft, a concrete wall would be the most effective type barrier in the space available.

With the use of one of these newly-developed designs, there is reason to hope that past unfavorable experience with guardrailing in medians can be reversed, at least on high volume roads. The question now becomes, what volume to use as the cut-off point?

Referring again to Figure 7, it is seen that if barriers were used only on highways with traffic volumes exceeding 100,000 vehicles per day, only about 27 percent of the cross-median fatal accidents would have been converted to other types of accident. In other words, it is necessary to include all highways where traffic exceeds a relatively low volume—60,000 vehicles per day—in order to effect a substantial reduction in the total number of this kind of accident (Fig. 7), and before the point of diminishing returns is reached.

The problem has two subdivisions: (1) installation of barriers on existing freeways, and (2) inclusion of barriers in plans for freeways yet to be constructed. On existing freeways, it would seem prudent to start at the top and work down, observing results as the work progresses. Before the 80,000 level is reached, there should be more actual field experience to use as a guide for further installations.

For future freeways, it appears that barriers should be provided whenever the initial volume is estimated at 60,000 ADT or more. It is not recommended that the design-year (20 years hence) volume be used for this purpose, because the barriers can be installed after the freeway is built if and when the volume builds up. An exception to this might be found where the design-year volume appears to warrant barriers, and installation of barriers would change the width otherwise required. It should be noted that if a barrier is used, there is not much to be gained by going beyond about 22 ft in total width, which would provide space for stalled vehicles and considerable maneuvering area on each side of the barrier.

SUMMARY OF FINDINGS AND CONCLUSIONS

The purpose of this study was to investigate the relative safety of various existing types of median designs, and to provide criteria for installation of positive median barriers on divided highways.

No attempt was made to evaluate the many factors other than safety which would influence the selection of a median type for a particular segment of highway.

Within the limitations of the data available, the following findings and conclusions appear to be warranted:

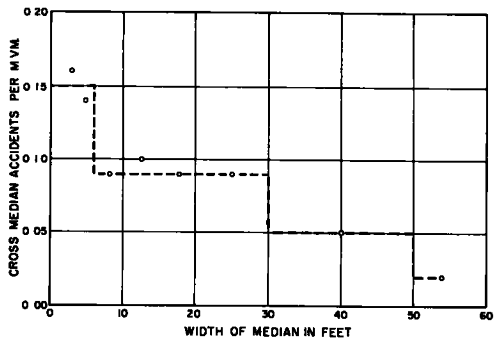


Figure 9. Cross-median accident rate by width of median for deterring-type medians.

1. The type of median influences the number of accidents on divided highways. On highways with traffic volume between 15,000 and 130,000 vehicles per day, the accident rate was 92 accidents per hundred-million vehicle-miles for earth and low-curb medians, and 136 accidents per hundred-million vehicle-miles for the guardrail or concrete-wall-type median. Separate roadways had a rate of 139 in this volume range.

2. Traffic volume appears to be a factor in the relative safety of the various types of medians. Where traffic volumes were between 15,000 and 130,000 vehicles per day, the non-barrier-type median was superior. Where traffic volumes exceeded 130,000 vehicles per day, the advantage shifted to the non-traversable barrier-type median.

3. The cross-median accident rate goes down as the median width goes up. However, there was no apparent relationship between the width of median and the all-accident rate in this study.

4. Widths of less than 50 ft will not prevent vehicles from crossing the median, although the probability is greatly reduced when that width (50 ft) is exceeded. A vertical barrier will prevent nearly all vehicles from crossing the median.

5. Cross-median accidents, although important, are only one phase of the traffic safety problem. Cross-median fatal collisions on freeways comprised 0.9 percent of traffic fatalities in California during the three years 1956, 1957 and 1958.

6. Traffic volumes appear to be the major criterion for the installation of median barriers. At volumes of 130,000 or more vehicles per day, it is indicated that median barriers will add to the safety of a divided highway.

7. Cross-median accidents can be converted to other kinds by the construction of vertical barriers. Because this kind of accident is responsible for 19 percent of fatalities on freeways, and because of compelling public demand, it is considered essential to convert them.

In order to make a significant attack on this problem, it is necessary to reach down to the 60,000 ADT level. Freeways carrying more than 60,000 vehicles per day accounted for 20 percent of the mileage and 67 percent of the cross-median collision-type fatal accidents during the 3 years 1956, 1957 and 1958.

8. If past experience continues into the future, going down to the 60,000 ADT level would result in an increase in accidents, injuries, and possible fatalities. However, newly-developed barrier designs hold promise of resulting in fewer casualties even though the accident rate may rise.

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APPENDIX A

Overtaking Fatal Accidents on Full Freeways

No.	No. Killed	Victim Over-taking	Victim Over-taken	Description	Victim Innocent
1.	1	1		Truck stalled in traffic lane, hit by car	No
2.	1	1		Truck sideswiped by car	No
3.	1		1	Car hit in the rear by other car, lost control	Yes
4.	1		1	Car hit in the rear by other car, overturned	Yes
5.	1		1	Truck hit by truck-trailer, lost control	Yes
6.	1	1		Driver had been drinking, hit other car in rear & lost control	No
7.	1		1	Car stopped on freeway to secure hood, hit by other car	Yes
8.	1	1		Truck hit by speeding car	No
9.	1	1		Car making U-turn, hit by other car	Yes
10.	1		1	Car making U-turn, hit by other car	No
11.	1	1		Car speeding, making unsafe lane change, hit pickup and lost control	No
12.	1	1		Car struck by motorcycle	No
13.	2	2		Car made unsafe lane change, bumped by other car and lost control	No
14.	1		1	Car stopping without lights, hit in rear by truck-trailer	No
15.	1	1		Pickup made unsafe lane change, hit other car and lost control	No
16.	1		1	Car struck in the rear by pickup, lost control	Yes
17.	1	1		Car hit rear of other car stopped in traffic lane	No
18.	1	1		Car made unsafe lane change, struck other car	No
19.	1		1	Car lost control when struck by pickup traveling at excessive speed	Yes
20.	2	2		Car failed to make turn onto freeway on-ramp, struck by truck-trailer	No
21.	1	1		Car was struck when driver cut in front of other car to enter off-ramp	No
22.	1		1	Truck-trailer ran into rear of slow-moving car	Yes
23.	3	2	1	Car struck other car in rear when attempting to pass at excessive speed	No
24.	1		1	Car lost control when struck by other car making unsafe lane change	Yes
25.	1		1	Car stopping in traffic lane, hit by truck trailer	No
26.	1	1		Driver asleep at wheel, drifted off road, over-corrected and struck pickup and trailer	No
27.	1		1	Car struck by car in the rear, lost control and struck bridge rail	Yes
28.	1	1		Pickup pushing car, hit by other pickup going 70 mph	No
29.	2	2		Truck parked on shoulder, hit by speeding vehicle	No
30.	1	1		Truck parked on traveled lane, driver asleep, hit by car in the rear	Yes
31.	1		1	Car slowing for accident ahead in fog, struck by truck-trailer	Yes
32.	1	1		Car driven by drunk driver at excessive speed hit truck-trailer in the rear	No
33.	1		1	Car ran over passenger fallen from motorcycle	Yes
34.	1		1	Car hit by truck-trailer in the rear	Yes
35.	1	1		Truck stopped behind stalled vehicle, hit in the rear by car	No
36.	2		2	Driver had been drinking, struck motorcycle stopped on shoulder	Yes

No.	No. Killed	Victim Over-taking	Victim Over-taken	Description	Victim Innocent
37.	1		1	Truck stopped in traveled lane, hit by car	Yes
38.	1	1		Slow-moving truck-trailer hit by car	No
39.	1	1		Truck-trailer entering highway from shoulder hit by car	No
40.	1	1		Motorcycle made unsafe lane change, hit by car	No
41.	2		2	Car slowed suddenly, hit by truck-trailer, caught fire	No
42.	1	1		Truck-trailer going upgrade, struck by car	No
43.	1	1		Car improperly parked, hit by car	Yes
44.	1		1	Truck-trailer hit pickup pushing other car	No
45.	1	1		Truck-trailer hit by car making unsafe turning movement	No
46.	2	2		Car speeding, making unsafe lane change, hit other car and lost control	No
47.	1	1		Truck-trailer hit in rear by car	No
48.	1	1		Car hit by other car which was speeding and making unsafe lane change	No
49.	1		1	Car stopped to pick up hitchhiker, struck by other car	Yes
50.	3	3		Car stalled on highway, struck by other car at high rate of speed	No
51.	1	1		Driver had been drinking, speeding, hit other car in rear	No
52.	1		1	Driver had been drinking, hit other car, causing it to lose control	Yes
53.	1	1		Car making U-turn through median, hit in rear by other car	Yes
54.	1		1	Vehicle lost control and struck concrete abutment when hit in the rear by speeding truck	Yes
55.	1		1	Driver had been drinking, made sudden stop to discharge passenger, struck in rear by truck	No
56.	1		1	Car stopped on shoulder, struck by speeding vehicle, overturned and burned	Yes
57.	1	1		Driver of motorcycle under influence of alcohol, struck car in the rear	No
58.	1		1	Car exceeded safe speed on wet pavement, hit car in rear	Yes
59.	2		2	Vehicle made unsafe lane change, knocked car across divider into path of oncoming car	Yes
60.	3	3		Vehicle traveling at excessive speed, struck rear of parked dumptruck	No
61.	1	1		Car following too close, struck car which was slowing for traffic ahead, then jumped divider & struck opposing car head-on	No
62.	1	1		Truck stopped due to accident ahead, struck in rear by car	No
63.	1	1		Driver had been drinking and speeding, struck truck-trailer	No
64.	1	1		Driver fell asleep, struck pole and bounced into other car	No
65.	1	1		Car made unsafe entry onto highway from shoulder, struck by other car	Yes
66.	1	1		Car made unsafe lane change, struck other car in rear and lost control	No
67.	1	1		Driver obviously drunk, made unsafe lane change, struck by other car, lost control	No
68.	1	1		Car traveling at excessive speed, struck other car in the rear, lost control	No
69.	1	1		Driver intoxicated, stopped on freeway without lights. struck by other car	Yes
70.	1	1		Car went across on-ramp to the right, struck pickup parked off road, then struck concrete wall	No
71.	1		1	Driver obviously drunk, going over 70 mph. struck other car in rear, causing it to catch on fire, and lost control	Yes
72.	1	1		Driver obviously drunk, speeding, struck car ahead slowing due to traffic congestion	No
73.	1	1		Car following too closely, struck other car in the rear which was slowing for traffic ahead	No
74.	1	1		Truck-trailer struck from behind by truck-trailer exceeding safe speed	No
75.	1	1		Driver had been drinking, exceeded safe speed, struck bus which was stalled on freeway	No
76.	1	1		Car exceeded safe speed, struck slow-moving truck in rear	No
77.	3	3		Driver apparently fell asleep, struck truck-trailer parked on shoulder. (Part of trailer was on roadway.)	No
78.	2	2		Car speeding, struck truck-trailer in rear-skidded sideways and was struck by other truck-trailer	No
79.	2		2	Driver apparently fell asleep, ran into car parked on traveled way	Yes
80.	1	1		Driver apparently asleep at wheel, struck truck-trailer in rear	No
81.	1	1		Car struck other car in rear which was slowing due to traffic ahead	No
82.	1		1	Car slowing for traffic ahead in heavy fog, struck in rear by speeding car	Yes
83.	1		1	Car stopping on freeway, struck by other car	No
84.	1	1		Car speeding at 90 mph, overtook and struck other car in rear	No

APPENDIX B

Cross-Median Fatal Accidents on Full Freeways

No.	Med. Width	Volume ADT	No. Killed	Victim: X-Median Vehicle	Victim: Other Vehicle	Description	X-Med Vehicle Innocent	No. of Vehicles Involved
1.	36'	65,000	1		Ped.	Driver under influence of alcohol, speeding, lost control of veh. Pedestrian on roadway rendering help to injured when hit by 4th car.	No	4
2.	6'	100,000	1		Pass.	Car leaped over divider, landed on hood of oncoming vehicle, cause unknown	Unk.	2
3.	36'	65,000	1	Dr.		Car traveling at very high rate of speed, lost control at curve, crossed median, hit fence	No	1
4.	6'	76,000	1	Dr.		Car wheels came in contact with curb on the right, lost control	No	1
5.	6'	34,000	1		Dr.	Car traveling at excessive speed, made unsafe lane change, lost control	No	2
6.	30'	13,000	2	Dr., Pass.		Dr., possibly intoxicated, hooked bumper in attempt to pass, lost control	No	2
7.	30'	13,000	1		Dr.	Driver of pickup under influence of alcohol, asleep at wheel	No	2
8.		12,000	3		Dr., 2 Pass.	Truck-trailer blew front tire, lost control	No	3
9.	6'	165,000	1		Dr.	Driver under influence of alcohol, lost control	No	2
10.	22'	57,000	1	Dr.		Reason unknown	Unk.	2
11.	8'	95,000	1	Dr.		Car coming up too fast on car ahead, applied brakes, lost control	No	4
12.	8'	95,000	1	Pass.		Pickup traveling at excessive speed, struck & pushed car across median	Yes	4
13.	8'	95,000	1	Dr.		Car at excessive speed, avoiding collision with car ahead, swerved across median	No	2
14.	22'	57,000	1		Dr.	Truck blew tire, lost control	No	2
15.	10'	132,000	1		Pass.	Pickup at excessive speed, struck and pushed car across divider	Yes	4
16.	32'	25,000	1		Pass.	Driver lost control of car when avoiding collision with car making unsafe lane change from the right	Yes	3
17.	12'	66,000	1	Dr.		Hood of veh. blew up, obscured vision of driver	No	2
18.	12'	66,000	1		Pass.	Car speeding, swerved left to avoid rear-end collision, hit curb, lost control	No	5
19.	12'	66,000	2	2 Pass.		Unknown	Unk.	3
20.	12'	66,000	3	Dr. Pass.	Dr.	Unknown	Unk.	2
21.	12'	66,000	1	Dr.		Unknown	Unk.	2
22.	40'	25,000	2	2 Pass.		Driver had been drinking, traveling at estimated speed of 85 mph, lost control	No	1
23.	6'	100,000	1	Dr.		Driver made unsafe lane change, locked bumpers, both cars lost control	No	2
24.	6'	100,000	6	Dr.	Dr., 4 Pass.	Car traveling at excessive speed, struck slow veh. ahead & lost control	No	4
25.	10'	127,000	4	Dr.	Dr., 2 Pass.	Driver had been drinking, avoiding collision with car changing lanes, lost control	No	4
26.	10'	127,000	1	Dr.		Unknown	Unk.	2
27.	10'	55,000	3	Dr.	Dr., Pass.	Car at excessive speed, attempting to slow for traffic ahead, wheel hit med. curb, lost control	No	4
28.	8'	55,000	1	Dr.		Unknown	Unk.	2
29.	35'	90,000	1		Dr.	Truck exceeded safe speed, swerved left to avoid truck changing lanes ahead, lost control	No	2
30.	16'	62,000	1		Dr.	Driver had been drinking, exceeded safe speed, lost control	No	4

No.	Med. Width	Volume ADT	No. Killed	Victim: X-Median Vehicle	Victim: Other Vehicle	Description	X-Med. Veh. Innocent	No. of Vehicles Involved
31.	16'	62,000	2	Dr., Pass.		Driver asleep at wheel, ran off onto shoulder, over-corrected and lost control	No	2
32.	16'	32,000	3	Dr.	Dr., Pass.	Unknown	Unk.	4
33.	12'	106,000	2		2 Pass.	Car speed racing with motorcycle, struck car ahead & pushed it across median	Yes	5
34.	32'	65,000	1	Pass.		Pickup swerved left to avoid car cutting in from the right, lost control	Yes	2
35.	32'	32,000	1	Dr.		Unknown	Unk.	3
36.	10'	153,000	1		Dr.	Car attempting to slow for traffic ahead, went into skid, lost control	No	3
37.		21,000	2	2 Pass.		Driver had been drinking, being pursued by police, going over 100 mph, lost control	No	1
38.		11,000	1	Dr.		Motorcycle made U-turn across median without stop, hit broadside by truck	No	2
39.	14'	30,000	1	Dr.		Unknown	Unk.	1
40.	14'	30,000	1		Dr.	Driver had been drinking, excessive speed, struck vehicle ahead and lost control	No	2
41.	14'	22,000	1	Pass.		Driver apparently asleep at wheel, skidded on wet pavement and lost control	No	1
42.	36'	80,000	1	Dr.		Driver obviously drunk, traveling at high speed, went onto shoulder, lost control, overturned	No	1
43.	36'	80,000	1	Dr.		Driver under influence of alcohol, speeding and lost control	No	3
44.	36'	80,000	1	Dr.		Driver had been drinking, estimated speed over 70 mph, lost control	No	1
45.	32'	80,000	1	Pass.		Car blew rear tire, lost control	Yes	1
46.	36'	72,000	1	Dr.		Unknown	Unk.	2
47.	16'	82,000	2	Dr.	Dr.	Driver under influence of alcohol, crossed med. & continued for 1 mile, hit car head-on	No	2
48.	36'	75,000	2	Dr.	Pass.	Driver obviously drunk, drove across median	No	2
49.	12'	82,000	1	Dr.		Car exceeded safe speed, lost control on wet pavement	No	2
50.		82,000	1	Dr.		Car exceeded safe speed, hit other car slowing for traffic ahead, lost control	No	3
51.	12'	41,000	1	Pass.		Car exceeded safe speed, swerved left to avoid slow traffic ahead, lost control	No	2
52.	12'	38,000	2	Dr., Pass.		Car made unsafe lane change, knocked other car across median	Yes	3
53.	12'	38,000	1		Dr.	Car traveling at 90 mph speed, wheel went onto shoulder, lost control	No	2
54.	10'	183,000	2	Dr.	Dr.	Speeding at over 70 mph, lost control	No	3
55.	10'	140,000	1	Dr.		Car in avoiding collision with slowing veh. ahead, ran onto median, lost control on wet pavement	No	2
56.	10'	130,000	2	Dr., Pass.		Excessive speed, had been drinking, driver in avoiding slow veh. ahead, swerved left into median	No	2
57.	22'	130,000	1	Dr.		Car struck by other car when making unsafe lane change, lost control on wet pavement	No	3
58.	12'	125,000	4	Dr.	Dr., 2 Pass.	Unknown	Unk.	3
59.		40,000	1	Dr.		Driver under influence of alcohol, going 80 mph, on lane to off-ramp, swerved left to keep on freeway, & lost control	No	1
60.	10'	64,000	1		Dr.	Driver obviously drunk, speeding, lost control	No	3
61.	11'	47,000	1	Dr.		Driver lighting a cigarette, wheel hit median curb, lost control	No	3
62.		47,000	1	Pass.		Car traveling at excessive speed, hit car in front & lost control	No	3

No.	Med. Width	Volume ADT	No. Killed	Victim: X-Median Vehicle	Victim: Other Vehicle	Description	X-Med. Veh. Inno-cent	No. of Vehicles Involved
63.	32'	81,000	1	Dr.		Driver had been drinking, speeding, suddenly swerved across median	No	1
64.	12'	130,000	1	Dr.		Driver had been drinking, made unsafe lane change, lost control	No	2
65.	6'	130,000	1	Dr.		Raining, car slowing for traffic ahead was struck from behind and jumped divider	Yes	7
66.	6'	97,000	1		Dr.	Car blew right rear tire, lost control	No	2
67.		12,000	1	Dr.		Car going over 70 mph, weaving in and out, lost control	No	1
68.	34'	85,000	1	Dr.		Unknown	Unk.	3
69.	12'	103,000	1	Pass.		Exceeded safe speed, applied brakes due to traffic congestion ahead, lost control	No	4
70.	12'	103,000	4	Dr.	Dr.,2 Pass.	Unknown	Unk.	2
71.	12'	103,000	1	Dr.		Unknown	Unk.	1
72.		66,000	1	Dr.		Unknown	Unk.	5
73.		30,000	3		Dr., 2 Pass.	Unknown	Unk.	2
74.	30'	31,000	1	Pass.		Driver obviously drunk, going over 80 mph, hit median curb and lost control	No	1
75.	30'	31,000	1	Dr.		Unknown	Unk.	1
76.	16'	23,000	1	Dr.		Car at excessive speed, jumped divider	No	2
77.	6'	23,000	1	Dr.		Driver lost control on wet pavement (raining)	No	4