# Effectiveness of Median Barriers

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More than 200 mi of median barrier have been installed on the highest volume freeways in California since 1959. The two types of median barrier are cable chain link barrier and double blocked-out median barrier. They were installed to prevent cross-median head-on accidents. This study was initiated to determine the effect of the installation on all types of accidents. The construction and maintenance costs of the two barriers were also studied.

Cross-median head-on accidents have been eliminated by barrier installation, but property damage accidents and injury accidents have increased. Fatal accidents have decreased at barrier locations in spite of a few accidents involving the barriers which resulted in fatalities. The cost analysis revealed that the beam barrier is more expensive to install and that the cable barrier is more expensive to maintain.

•THIS IS a report on the effectiveness of median barriers on California freeways. An interim report on this study was published in December 1962. A before-and-after study was made of 26.6 mi of cable chain link barrier (Fig. 1) and 27.6 mi of double blocked-out metal beam barrier (Fig. 2). The various sections of each type of barrier have at least 1 yr each of before-and-after experience. The construction period was omitted from the study.

The remaining miles of median barrier had less than 1 yr of before or after experience and were, therefore, excluded from the before-and-after study. However, they are included in the statewide barrier study.

Median barriers are normally installed on freeways and expressways when one or more of the following conditions exist:

1. The traffic volume exceeds 60,000 veh/day;
2. The number or rate of cross-median accidents is high (0.46 cross-median accidents involving opposing vehicles per mile per year or 0.12 fatal cross-median accidents per mile per year); and
3. With initial, 8-lane construction the median is 22 ft wide or less.

The cable barrier is normally installed in medians with a width of 16 ft or more, and the beam barrier is normally installed in medians having a width of less than 16 ft. This is because the cable barrier will normally deflect up to approximately 8 ft when struck and also because 8 ft is the minimum clearance practical for parking a vehicle to repair damaged areas.

The status of the median barrier program as of January 1, 1964, was:

Paper sponsored by Committee on Operational Effects of Geometrics.

Figure 1. Cable chain link median barrier.

Figure 2. Double blocked-out metal beam barrier.

| Status | Net Miles of Barrier | | |
|---|---|---|---|
| | Cable | Beam | Total |
| Constructed | 152.6 | 51.5 | 204.1 |
| Under construction | 69.7 | 22.0 | 91.7 |
| Total | 222.3 | 73.5 | 295.8 |

## BEFORE-AND-AFTER STUDY

### Effect of Median Barrier Installation on All Accidents

The effect of median barrier installation on accident rates is indicated by Table 1. Sections of highway where the beam barrier was installed had higher rates in both the before and after periods. Generally the beam barrier has been installed on freeways with narrower medians (less than 16 ft) which also tend to be the older freeways with higher volumes and lower geometric standards with an adverse effect on accident rates.

The rise in accident rates can be attributed primarily to the median barrier installation. The accident rate on all urban freeways has increased slightly during the past few years. However, the accident rate on urban freeways with median barriers has increased more than the statewide average for urban freeways. It is believed that the primary reason for the increase in accident rates is that the median barrier is a fixed object struck by out-of-control vehicles that might have recovered without incident if the barrier had not been installed.

### Effect of Median Barrier Installation on Injury and Fatal Accidents

Injury and fatal accidents combined increased after median barrier installation (Table 1). The beam barrier increases injury and fatal accidents approximately twice as much as does the cable barrier. The beam barrier is considerably more rigid than the cable barrier and it is believed that this is the reason for the increased severity.

The ratio of the all accident rate to the injury and fatal accident rate is given in Table 1. The ratios in the before period are almost equal (2.2:1) and are normal for California freeways. In the after period, the ratio for the beam barrier is considerably lower than that for the cable, which is further evidence that the beam barrier increases the severity of accidents more than the cable barrier.

TABLE 1

EFFECT OF MEDIAN BARRIER INSTALLATION ON ACCIDENTS

| Barrier Type | Length (mi) | MVM | All Accidents | | | | Injury and Fatal Accidents | | | | Ratio[a] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. | Rate | Rate Change Abs. | Rate Change Percent | No. | Rate | Rate Change Abs. | Rate Change Percent | |
| (a) Before Installation | | | | | | | | | | | |
| Cable | 26.6 | 1,195.6 | 1,586 | 1.33 | – | – | 713 | 0.60 | – | – | 2.22:1 |
| Beam | 27.6 | 1,633.8 | 2,690 | 1.65 | – | – | 1,204 | 0.74 | – | – | 2.23:1 |
| Total | 54.2 | 2,829.4 | 4,276 | 1.51 | – | – | 1,917 | 0.68 | – | – | 2.22:1 |
| (b) After Installation | | | | | | | | | | | |
| Cable | 26.6 | 1,277.8 | 2,231 | 1.75 | +0.42 | +32 | 904 | 0.71 | +0.11 | 18 | 2.46:1 |
| Beam | 27.6 | 1,608.5 | 3,330 | 1.98 | +0.33 | +20 | 1,612 | 0.96 | +0.22 | 30 | 2.06:1 |
| Total | 54.2 | 2,958.3 | 5,561 | 1.88 | +0.37 | +25 | 2,516 | 0.85 | +0.17 | 25 | 2.21:1 |

[a]Of all accident rate to injury and fatal accident rate.

## Effect of Median Barrier Installation on Fatal Accidents

Both types of median barrier have been successful in preventing cross-median head-on fatal accidents. As indicated by Table 2, this resulted in a reduction in the number of fatal accidents and fatal accidents per 100 million veh-mi (MVM) in spite of an increase in non-cross-median fatal accidents. Chance variation could have accounted for part of the decrease in fatal accidents. However, there were almost 3 billion veh-mi of travel in each of the before-and-after periods.

There were 15 fatal accidents involving the barrier in the after period. There have been several other fatal accidents involving median barriers. However, these occurred in sections outside the limits of the before-and-after portion of this study.

In 10 of the 12 fatal accidents involving the cable barrier, a vehicle struck the barrier and spun, ejecting one or more persons; in the other, the vehicle involved went through the barrier. In 2 of the 3 beam barrier fatal accidents, there were ejections.

## Accidents Involving Median

An accident involving the median is defined as an accident in which one or more cars enter the median. Table 3 indicates the effect of barrier installations on median accidents. Approximately 90 to 95 percent of the median accidents in the after period involved the barrier. Accidents involving the median increased by 88 percent where the cable barrier was installed, and at the beam barrier locations they increased 11 percent. This lends support to a widely expressed hypothesis that drivers would rather collide with the cable barrier than another object (fixed or moving) and that they are willing to take their chances with some other object or vehicle rather than collide with the beam barrier. In other words, drivers may be deliberately striking the cable barrier much more often than the beam barrier to avoid striking another object or vehicle. There is no way to prove this. On the contrary, according to the drivers' accounts of what they did, 7 percent of those hitting the cable barrier and 6 percent of those hitting the beam implied that it was deliberate.

Where cable barrier was installed, the rate for accidents involving the median increased 0.23 and the rate for accidents not involving the median increased 0.18 (Table 4). This tends to support the conjecture that drivers are now more willing to drive into the median to avoid another object or vehicle, provided a "soft" barrier is there to prevent contact with opposing traffic.

TABLE 2

EFFECT OF MEDIAN BARRIER INSTALLATION ON FATAL ACCIDENTS, 1959-1963

| Barrier Type | Length (mi) | 100 MVM | No. Fatal Accidents: All | Cross-Median | Non-Cross-Median | Involving Barrier | Rate | Rate Change: Abs. | Percent |
|---|---|---|---|---|---|---|---|---|---|
| (a) Before Installation | | | | | | | | | |
| Cable | 26.6 | 11.96 | 31 | 9 | 22 | (0) | 2.59 | – | – |
| Beam | 27.6 | 16.34 | 31 | 13 | 18 | (0) | 1.90 | – | – |
| Total | 54.2 | 28.30 | 62 | 22 | 40 | (0) | 2.19 | – | – |
| (b) After Installation | | | | | | | | | |
| Cable | 26.6 | 12.78 | 21 | 1 | 20 | (12) | 1.64 | -0.95 | -37 |
| Beam | 27.6 | 16.81 | 27 | 0 | 27 | ( 3) | 1.61 | -0.29 | -15 |
| Total | 54.2 | 29.59 | 48 | 1 | 47 | (15) | 1.62 | -0.57 | -26 |
| All Calif. urban freeways, 1960-1962: | | | | | | | | | |
| With barriers | | 32.88 | 54 | – | – | – | 1.64 | – | – |
| Without barriers | | 182.50 | 481 | – | – | – | 2.64 | – | – |

TABLE 3

EFFECT OF MEDIAN BARRIER INSTALLATION ON ACCIDENTS INVOLVING MEDIAN

| Barrier Type | Length (mi) | Before | | | After | | | Change in Rate | |
|---|---|---|---|---|---|---|---|---|---|
| | | No. Accidents | MVM | Rate | No. Accidents | MVM | Rate | Abs. | Percent |
| Cable | 26.6 | 308 | 1,195.6 | 0.26 | 629 | 1,277.8 | 0.49 | +0.23 | +88 |
| Beam | 27.6 | 443 | 1,633.8 | 0.27 | 511 | 1,680.5 | 0.30 | +0.03 | +11 |
| Total | 54.2 | 751 | 2,829.4 | 0.27 | 1,140 | 2,958.3 | 0.39 | +0.12 | +44 |

TABLE 4

EFFECT OF MEDIAN BARRIER INSTALLATION ON ACCIDENTS NOT INVOLVING MEDIAN

| Barrier Type | Length (mi) | Before | | | After | | | Change in Rate | |
|---|---|---|---|---|---|---|---|---|---|
| | | No. Accidents | MVM | Rate | No. Accidents | MVM | Rate | Abs. | Percent |
| Cable | 26.6 | 1,278 | 1,195.6 | 1.07 | 1,602 | 1,277.8 | 1.25 | +0.18 | +17 |
| Beam | 27.6 | 2,247 | 1,633.8 | 1.38 | 2,819 | 1,680.5 | 1.68 | +0.30 | +22 |
| Total | 54.2 | 3,525 | 2,829.4 | 1.25 | 4,421 | 2,958.3 | 1.49 | +0.24 | +19 |

Where the beam was installed, the rate for accidents not involving the median increased 0.30, whereas the rate for accidents involving the median rose only 0.03. This indicates that drivers are reluctant to hit the beam barrier. However, proof of this may be difficult, if not impossible, to obtain.

### Median Width

After barriers are installed, 90 to 95 percent of the accidents involving the median also involve the median barrier. It would be logical to assume that the wider the median, the less the barrier would be struck. Figure 3 indicates that this is true for the beam barrier. However, there are only two points with a sizable amount of experience, not enough to establish a trend. The cable barrier seems to be struck just as often in a wide as in a narrow median.

Regardless of the median width, the beam barrier is struck less often than the cable, indicating that the type of barrier rather than the median width determines how frequently the barrier is struck. This also indicates that drivers may be striking the beam barrier, doing very little damage to the barrier and driving away without reporting the accident. Because the cable barrier is relatively soft, vehicles may strike it and become entangled in the barrier or damage the barrier enough to result in a reported accident.

## STATEWIDE BARRIER STUDY

### All Accident Rates and Fatal Accident Rates

Figure 4 and Table 5 present the accident rate in each traffic volume range for freeways with and without median barriers. The freeways with barriers had higher rates, except at two points which represent less than 20 mi of median barrier. This is to be expected after noting the before-and-after portion of this study.

Figure 5 shows the fatal accident rates in each traffic volume range for freeways with and without median barriers. Generally, the freeways with median barriers had lower fatal accident rates. This is also to be expected after noting the before-and-after portion of this study. However, since fatal accidents are a relatively rare occurrence, chance variation could have accounted for part or all of the difference.

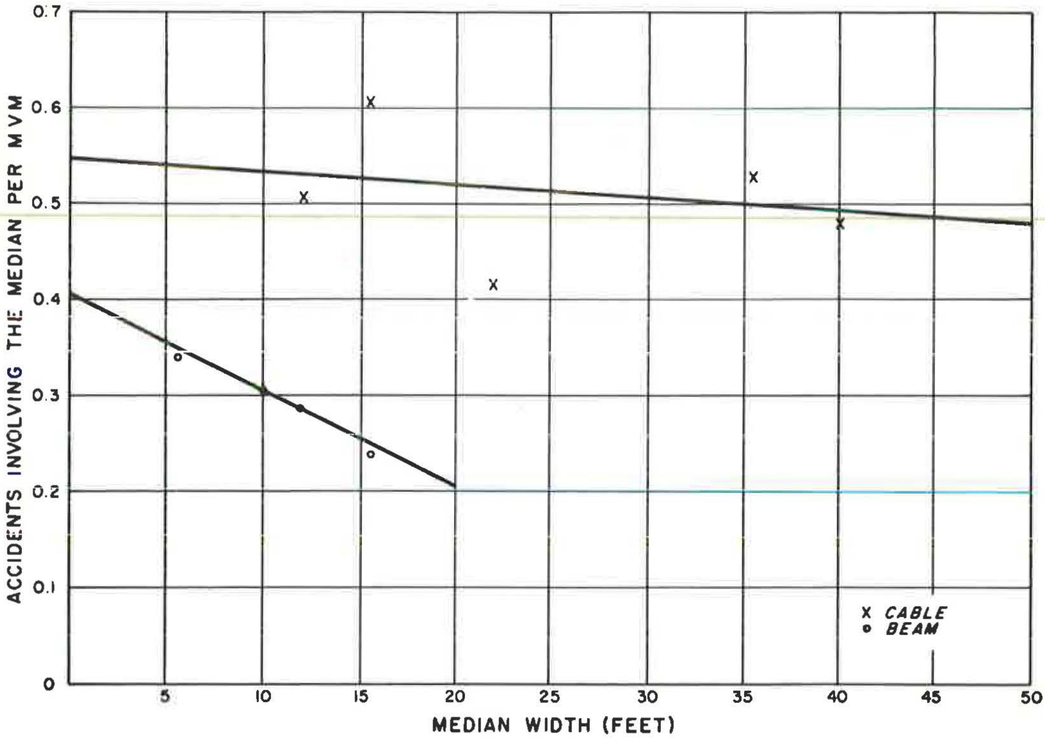


Figure 3. Accidents involving median vs median width.

## Cross-Median Fatal Accidents

As indicated in Tables 6 and 7, median barriers have been effective in reducing cross-median fatal accidents. Almost all California freeways with traffic volumes of 60,000 veh/day or more now have median barriers in place or under construction. At the end of 1963, there were 24.5 mi of barrier on freeways carrying less than 60,000 veh/day but which had, before the barriers were installed, a high incidence of cross-median accidents. In spite of this, there are still about 20 cross-median fatal accidents per year on remaining freeways in California where the volume is less than 60,000 ADT. Approximately 7 of these 20 accidents are occurring on freeways with volumes between 40,000 and 60,000 ADT, and another 6 are occurring at volumes of 30,000 to 40,000 ADT.

## Median Barrier Failures

Since median barriers were first installed, there have been 38 known instances where the barrier did not perform exactly as it should have and a vehicle came to rest partially or completely on the wrong side of the barrier. Only one of these instances involved the beam barrier and 37 involved the cable barrier. Five of the 38 were fatal accidents and three of the five involved vehicles in the opposing lanes.

Many different median widths and shapes are found on California freeways because of factors such as land values, curvature, and drainage. One of the situations conducive to vehicles going over or under the cables is shown in Figure 6 (sawtooth section). Vehicles hitting the barrier from the upper side tend to go over the cables and vehicles from the lower side tend to go under. The reason for constructing freeways in this manner on horizontal curves is to provide a channel for the drainage runoff from 48 ft of pavement. There are about 11.7 mi of freeway constructed in this manner in the Los Angeles area alone.

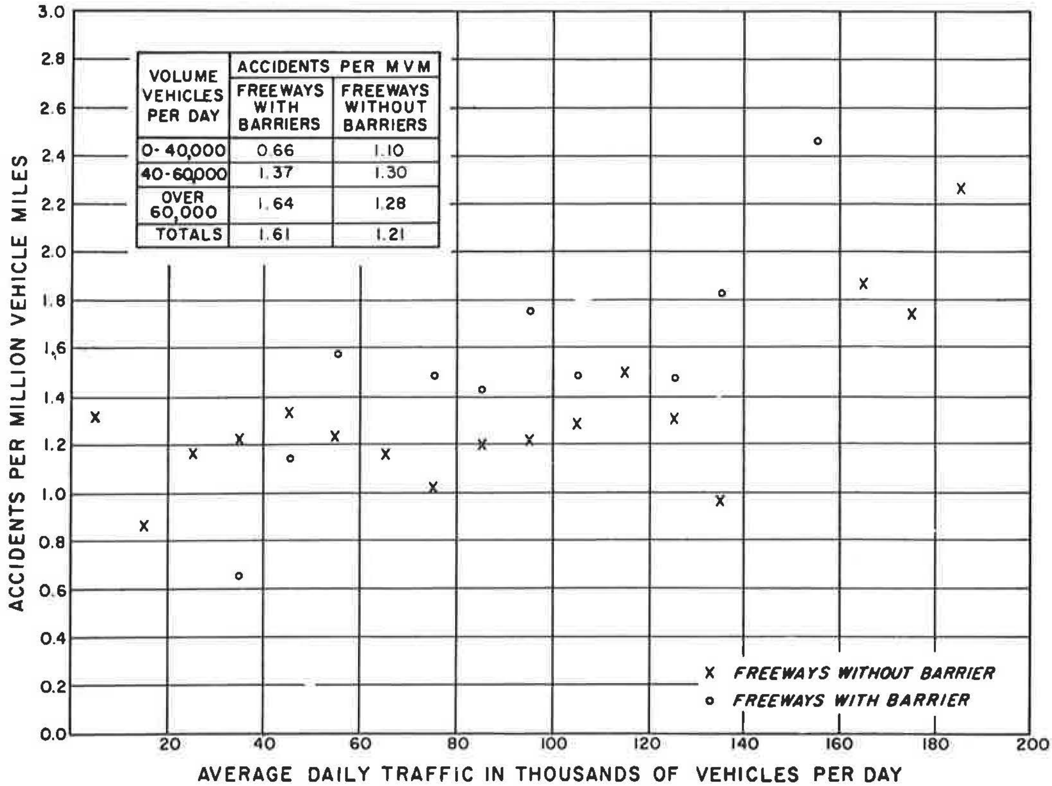


Figure 4. Accident rates vs average daily traffic, California urban freeways, 1960-1962.

TABLE 5

ACCIDENTS ON URBAN FREEWAYS IN CALIFORNIA WITH AND WITHOUT MEDIAN BARRIERS, 1960-1962

| Freeways | Veh/Day | No. Accidents | | MVM | Acc./MVM | Fatal Acc./100 MVM |
|---|---|---|---|---|---|---|
| | | All | Fatal | | | |
| With barrier | 0-40,000 | 25 | 0 | 38 | 0.66 | — |
| Without barrier | 0-40,000 | 7,898 | 255 | 7,178 | 1.10 | 3.55 |
| With barrier | 40-60,000 | 384 | 8 | 279 | 1.37 | 2.87 |
| Without barrier | 40-60,000 | 4,739 | 91 | 3,638 | 1.30 | 2.50 |
| With barrier | >60,000 | 4,885 | 46 | 2,971 | 1.64 | 1.55 |
| Without barrier | >60,000 | 9,522 | 135 | 7,434 | 1.28 | 1.82 |
| Total | | | | | | |
| With barrier | | 5,294 | 54 | 3,288 | 1.61 | 1.64 |
| Without barrier | | 22,159 | 481 | 18,250 | 1.21 | 2.64 |

Since the cable height appears to be very critical, it seems reasonable to place the beam barrier in the sawtooth sections as shown in Figure 7. The beams can be placed at the proper elevations on each side of the barrier. Full-scale impact tests are under way to see if the cable barrier can be modified at sawtooth sections to prevent barrier failures.

As of January 1964, there were 22 fatal accidents in which a vehicle struck the barrier but did not go over or through the barrier. Five involved the beam barrier, and 17 involved the cable. When a vehicle strikes the cable barrier, it is slowed down

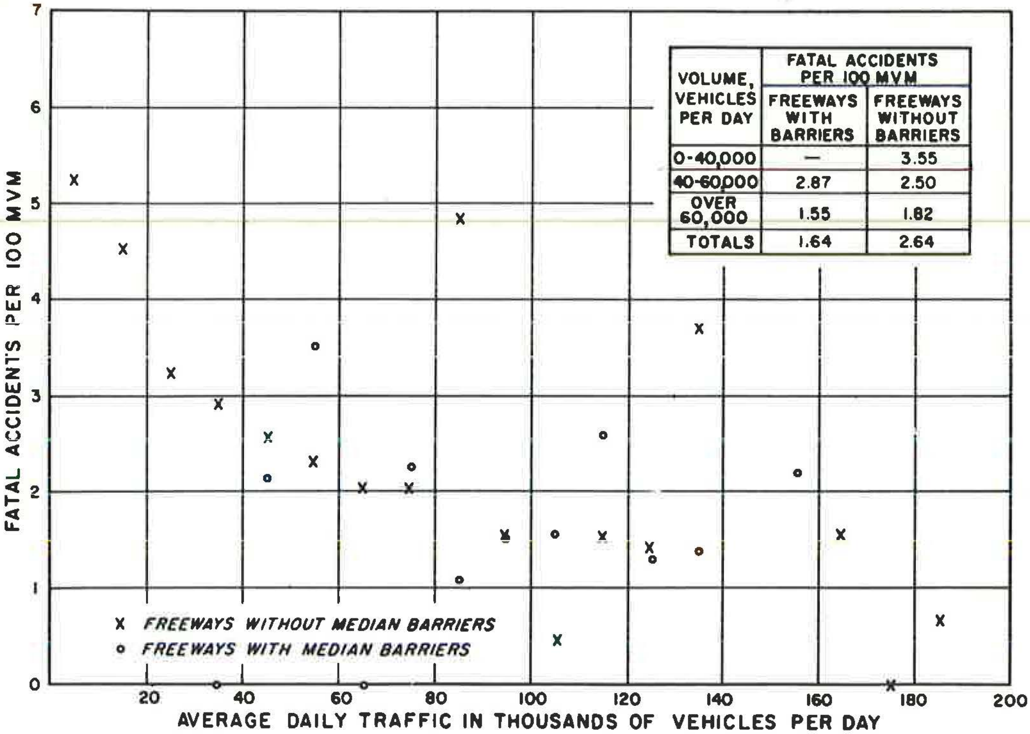


Figure 5. Fatal accident rates vs average daily traffic, California urban freeways, 1960-1962.

TABLE 6

CROSS-MEDIAN FATAL ACCIDENTS

| Year | No. Acc. | Acc./Mi | Acc./100 MVM | Mi Barrier Completed |
|---|---|---|---|---|
| 1959 | 45 | 0.065 | 0.51 | 0 |
| 1960 | 28 | 0.036 | 0.27 | 36 |
| 1961 | 33 | 0.038 | 0.28 | 33 |
| 1962 | 35 | 0.030 | 0.24 | 107 |
| 1963 | 41 | 0.031 | 0.25 | 29 |

primarily by friction between the cable and the left front of the vehicle. This imparts a moment to the vehicle and it tends to spin counterclockwise as it comes to a stop. The vehicles usually spin 90 to 270 deg. As they spin, occupants of the vehicles quite often are ejected and suffer fatal injuries. In 15 of the 17 cable barrier fatal accidents, the persons killed were ejected. This type of fatal accident could be almost completely eliminated by the use of seat belts.

TABLE 7

CROSS-MEDIAN FATAL ACCIDENTS, CALIFORNIA FREEWAYS, 1961-1963[a]

| Veh/Day | Mi of Freeway | | No. Accidents | |
|---|---|---|---|---|
| | Per Year | Cumul. | Per Year | Cumul. |
| 0-10,000 | 225 | 225 | 3 | 3 |
| 10-20,000 | 293 | 518 | 3 | 6 |
| 20-30,000 | 158 | 676 | 15 | 21 |
| 30-40,000 | 119 | 795 | 17 | 38 |
| 40-50,000 | 56 | 851 | 14 | 52 |
| 50-60,000 | 55 | 906 | 11 | 63 |
| 60-70,000 | 39 | 945 | 10 | 73 |
| 70-80,000 | 16 | 961 | 6 | 79 |
| 80-90,000 | 25 | 986 | 5 | 84 |
| 90-100,000 | 20 | 1,006 | 3 | 87 |
| 100-110,000 | 26 | 1,032 | 5 | 92 |
| 110-120,000 | 14 | 1,046 | 2 | 94 |
| 120-130,000 | 14 | 1,060 | 6 | 100 |
| 130-140,000 | 20 | 1,080 | 1 | 101 |
| 140-150,000 | 2 | 1,082 | 1 | 102 |
| 150-160,000 | 6 | 1,088 | 2 | 104 |
| 160-170,000 | 3 | 1,091 | 4 | 108 |
| 170-180,000 | 11 | 1,102 | 1 | 109 |
| 180-190,000 | 3 | 1,105 | 0 | 109 |

[a]Freeways with traffic volumes >60,000 veh/day had median barriers in place during part or all of the 3-yr period; accidents took place before erection of barriers.

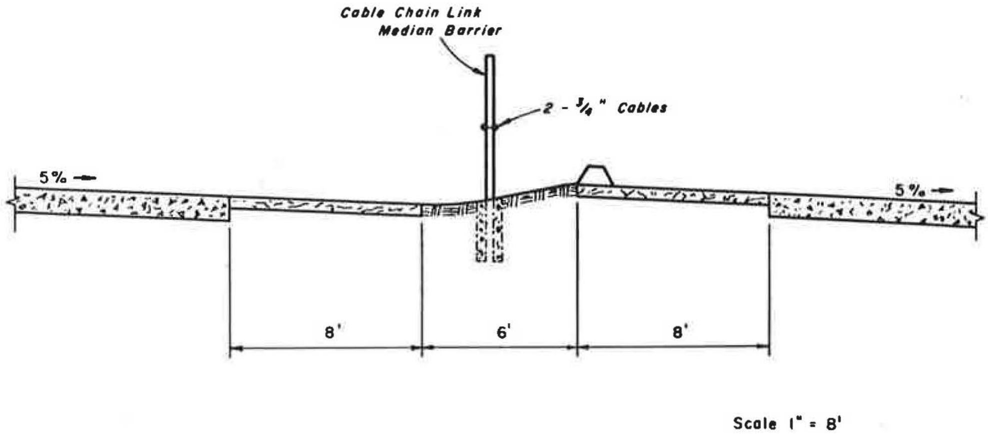


Figure 6. Existing sawtooth median.

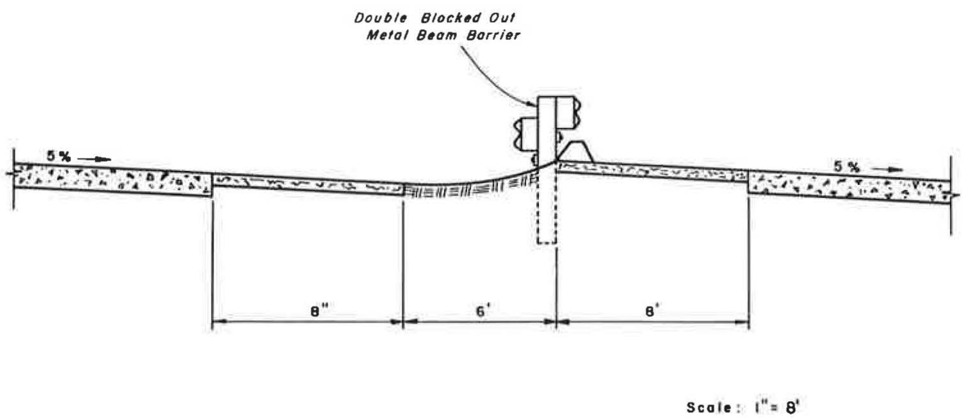


Figure 7. Proposed sawtooth median.

## Concrete Median Barrier (Santa Monica Freeway)

The Santa Monica Freeway is an 8-lane elevated viaduct between the Harbor Freeway and the Santa Ana Freeway. It has 10 ft shoulders on the right of traffic and 8 ft on the left. The median width is 16 ft. The median is narrow because of the high cost of construction. A concrete median barrier was installed which would not deflect and involve cars in the opposing lanes (Fig. 8). The average daily traffic during the study period was 45,000, giving a total of 48.39 MVM. The accident record for this 2.48-mi section with barrier is as follows:

All accidents, 46 (0.95/MVM);
Accidents involving injury, 27 (0.56/MVM);
No fatal accidents; and
Accidents involving median, 10 (0.21/MVM).

Of the 10 accidents in which the barrier was struck, two involved property damage only and eight involved minor injuries.


Figure 8. Concrete median barrier with headlight glare screen.

The accident experience with this type of barrier is limited. The freeway has a low accident rate and the rate of accidents involving the median is low. Drivers may tend to avoid the median because of the concrete median barrier. If they are avoiding the median, they do not seem to be causing a lot of accidents on the traveled way.

The ADT (45,000) during the study period is extremely low for an 8-lane freeway, permitting a great deal of freedom and maneuverability in a crisis. This probably accounts for the low rates.

TABLE 8

MEDIAN BARRIER MAINTENANCE COSTS, 1959-1963

| Freeway | Barrier Type | Length (mi) | MVM | Maintenance Cost ($) | Period (mo) | $/Mi/Yr | $/MVW |
|---|---|---|---|---|---|---|---|
| Nimitz | Cable | 3.9 | 489.0 | 29,393 | 45 | 2,010 | 60 |
| Nimitz | Beam | 2.9 | 374.3 | 9,918 | 45 | 912 | 26 |
| Santa Ana | Cable | 3.3 | 271.0 | 25,116 | 27 | 3,383 | 93 |
| Santa Ana | Beam | 4.1 | 336.7 | 9,624 | 27 | 1,043 | 29 |
| Hollywood | Cable | 3.2 | 87.4 | 8,680 | 6 | 5,425 | 99 |
| Hollywood | Beam | 5.0 | 136.5 | 820 | 6 | 328 | 6 |
| San Bernardino | Cable | 3.8 | 38.0 | 4,611 | 6 | 2,427 | 121 |
| San Bernardino | Cable | 7.4 | 202.6 | 53,425 | 18 | 4,813 | 264 |
| Total | Cable | 36.65[a] | 1,088.0 | 121,225 | | 3,308 | 114 |
| | Beam | 26.70[a] | 847.5 | 20,262 | | 759 | 24 |

[a]Miles/year.

Maintenance and Construction Costs

The latest available median barrier maintenance costs are given in Table 8. Median barrier construction costs for 1962 were as follows:

Single blocked-out metal beam, $5.84/lin ft or $30,800/mi;
Double blocked-out metal beam, $8.66/lin ft or $45,700/mi; and
Cable chain link, $2.59/lin ft or $13,700/mi.

Consideration is being given to revising the design of the beam barrier slightly to reduce the construction costs.

The beam barrier costs $32,000/mi more than the cable barrier to install and the cable barrier costs $2,549/mi/yr more than the beam barrier to maintain. At these rates, the cable and beam expenditures per mile of barrier will be equal at the end of 13 yr. If 60 percent of the damages continue to be recovered by the state, the two expenditures would be equal at the end of 31 yr, with the cost being in favor of the cable barrier for the first 31 yr and in favor of the beam barrier thereafter. Any increase in the rate of recovery of damages could increase the time required to equalize the cost of the two types.

## SUMMARY OF FINDINGS

1. Median barriers are effective in preventing cross-median accidents.
2. Fatalities due to cross-median accidents have been practically eliminated where barriers have been installed.
3. Although the barriers themselves, especially the cable barrier, cause an occasional fatality, the total number of fatal accidents (due to all causes) has been reduced at barrier locations by 23 percent.
4. The number of accidents per MVM has increased 32 percent in the case of the cable barrier and 20 percent in the case of the beam barrier.
5. The combined number of injury and fatal accidents per MVM have increased 18 percent at cable barrier locations and 30 percent at beam barrier locations.
6. Accidents involving the median have increased 88 percent at cable barrier locations and 11 percent at beam barrier locations.
7. The rate of accidents involving the median decrease substantially with increasing median width in the case of the beam barrier and decreases slightly with increasing width in the case of the cable barrier.
8. For the median width where data are available (6 to 16 ft), the beam barrier has a substantially lower median accident rate than the cable barrier.
9. In 15 collisions with the cable barrier, persons were ejected and killed when the vehicle spun to a stop. These fatalities might have been prevented if the vehicle occupants had worn seat belts.
10. Cable barriers installed in medians with sawtooth sections (horizontal curves) or containing dikes are being penetrated under the cable or are being overtopped by catapulting vehicles. Further full-scale impact tests are under way in an effort to see if the cable barrier can be modified at sawtooth sections to prevent barrier failures.
11. Cable barriers are very expensive to maintain. If no cost of repair is recovered by the state from the party responsible for the damage, 13 yr are required for the added maintenance costs to counteract its initial lower construction costs. However, since approximately 60 percent of the repair costs are recovered, 31 yr are required for the total costs to balance.

## APPENDIX A

| Section Number | Type of Barrier | Freeway Name | Location | Length in Miles | Median Width | Before Period MVM | Total Acc's. | Rate | Injury Acc's. | Rate | Fatal Acc's. | X-Med. Fat. Acc's. | Acc'ts. Involv. Med. | Rate | After Period MVM | Total Acc's. | Rate | Injury Acc's. | Rate | Fatal Acc's. | X-Med. Fat. Acc's. | Acc's. Involv. Med. | Rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cable | Santa Ana | Buhman Ave. Ped. O.C. to Simmons U.C. (A.T. & S.F.) | 3.20 | 12' | 202.8 | 231 | 1.14 | 98 | 0.48 | 5 | 1 | 46 | 0.23 | 236.4 | 322 | 1.36 | 116 | 0.49 | 3 | 1 | 80 | 0.34 |
| 2 | Beam | Santa Ana | Simmons U.P. (A.T. & S.F.) to Long Beach Fwy. | 2.58 | 12' | 156.7 | 137 | 0.87 | 48 | 0.31 | 3 | 1 | 42 | 0.27 | 168.6 | 266 | 1.58 | 105 | 0.62 | 2 | 0 | 46 | 0.27 |
| 3 | Guard Rail | Santa Ana | Lorena St. to Soto St. | 0.73 | 10' | | | | | | | | | | 95.6 | 144 | 1.51 | 71 | 0.74 | 1 | 0 | 24 | 0.25 |
| 4 | Beam | Santa Ana | Soto St. to San Bernardino Fwy. | 1.47 | 12' | 109.8 | 198 | 1.80 | 92 | 0.84 | 3 | 2 | 43 | 0.39 | 99.4 | 181 | 1.82 | 71 | 0.71 | 1 | 0 | 28 | 0.28 |
| 5 | Beam | Santa Ana | San Bernardino Fwy. to Alameda St. | 0.70 | 6-8' | 60.9 | 141 | 2.31 | 78 | 1.28 | 0 | 0 | 11 | 0.18 | 63.2 | 199 | 3.15 | 105 | 1.66 | 4 | 0 | 25 | 0.40 |
| 6 | Beam | Hollywood | 4-Level Str. to 500' N. of Alvarado St. | 1.20 | 12' | 192.3 | 403 | 2.10 | 231 | 1.20 | 2 | 1 | 52 | 0.27 | 212.4 | 533 | 2.51 | 294 | 1.38 | 2 | 0 | 41 | 0.19 |
| 7 | Beam | Hollywood | 500' N. of Avarado St. to 1300' N. of Silver Lake Blvd. | 1.11 | 8' | 92.9 | 148 | 1.59 | 82 | 0.88 | 1 | 0 | 8 | 0.09 | 88.0 | 117 | 1.33 | 52 | 0.59 | 1 | 0 | 11 | 0.13 |
| 8 | Beam | Hollywood | Melrose Ave. to Highland Ave. | 2.96 | 12' | 170.4 | 287 | 1.68 | 148 | 0.87 | 2 | 1 | 39 | 0.23 | 164.2 | 269 | 1.64 | 143 | 0.87 | 2 | 0 | 34 | 0.21 |
| 9 | Cable | Hollywood | Highland Ave. to 500' N. of Barham Blvd. | 1.34 | 22-40' | 73.9 | 239 | 3.24 | 121 | 1.64 | 2 | 0 | 34 | 0.46 | 84.6 | 236 | 2.79 | 123 | 1.45 | 1 | 0 | 62 | 0.73 |
| 10 | Cable | Hollywood | 1300' N. of Lankershim Blvd. to 700' S. of Riverside Dr. | 0.86 | 22' | 46.0 | 77 | 1.67 | 43 | 0.93 | 1 | 0 | 16 | 0.35 | 45.4 | 80 | 1.76 | 42 | 0.93 | 0 | 0 | 22 | 0.51 |
| 11 | Cable | Ventura | Kraft Ave. to Laurel Canyon Rd. | 0.91 | 22' | | | | | | | | | | 74.9 | 122 | 1.63 | 62 | 0.83 | 0 | 0 | 23 | 0.31 |
| 12 | Cable | Ventura | Laurel Canyon Rd. to Sepulveda Blvd. | 4.27 | 22' | | | | | | | | | | 497.5 | 599 | 1.20 | 313 | 0.63 | 4 | 1 | 194 | 0.39 |
| 13 | Cable | Ventura | Haskell Ave. to Encino Ave | 2.36 | 22' | | | | | | | | | | 226.7 | 267 | 1.18 | 211 | 0.93 | 3 | 0 | 97 | 0.43 |
| 14 | Cable | Ventura | Encino Ave. to Reseda Blvd. | 1.31 | 22' | | | | | | | | | | 78.1 | 84 | 1.08 | 53 | 0.68 | 0 | 0 | 36 | 0.46 |
| 15 | Cable | Golden State | 6th St. to Alleje St. | 2.30 | 22' | | | | | | | | | | 222.0 | 171 | 0.77 | 88 | 3.96 | 0 | 0 | 32 | 0.14 |
| 16 | Beam | San Bernardino | Indiana St. to Long Beach Fwy. | 1.83 | 4-6' | 117.6 | 288 | 2.45 | 81 | 0.69 | 4 | 1 | 58 | 0.49 | 135.2 | 344 | 2.54 | 171 | 1.27 | 2 | 0 | 51 | 0.38 |
| 17 | Cable | San Bernardino | Baldwin Ave. to Puente Ave | 3.20 | 40' | 274.8 | 290 | 1.06 | 105 | 0.38 | 1 | 0 | 52 | 0.19 | 288.3 | 362 | 1.26 | 144 | 0.50 | 4 | 0 | 128 | 0.44 |
| 18 | Cable | San Bernardino | Puente Ave. to Holt Ave. | 5.64 | 16' | 212.5 | 222 | 1.05 | 133 | 0.63 | 8 | 3 | 63 | 0.30 | 189.4 | 338 | 1.79 | 123 | 0.65 | 1 | 0 | 89 | 0.47 |
| 19 | Cable | Bayshore | Sierra Pt. O.H. to Blanken Ave. | 2.72 | 36' | 84.9 | 84 | 0.99 | 40 | 0.47 | 1 | 1 | 27 | 0.32 | 106.8 | 104 | 0.97 | 43 | 0.40 | 1 | 0 | 39 | 0.37 |
| 20 | Beam | Bayshore | Blanken Ave. to Paul Ave. | 0.86 | 6-12' | 41.7 | 60 | 1.44 | 26 | 0.62 | 1 | 0 | 12 | 0.29 | 47.2 | 121 | 2.56 | 56 | 1.19 | 1 | 0 | 18 | 0.38 |
| 21 | Beam | Bayshore | Powhatten Ave. to Army St. | 0.61 | 6' | 57.8 | 89 | 1.54 | 34 | 0.59 | 1 | 0 | 9 | 0.16 | 61.7 | 142 | 2.30 | 61 | 0.99 | 1 | 0 | 16 | 0.26 |
| 22 | Guard Rail | Bayshore | Army St. to 17th St. | 1.10 | 6' | | | | | | | | | | 174.4 | 552 | 3.16 | 254 | 1.46 | 1 | 0 | 66 | 0.38 |
| 23 | Cable | Nimitz | Washington Ave. to 98th Ave. | 3.80 | 12' | 192.5 | 247 | 1.28 | 100 | 0.52 | 6 | 4 | 44 | 0.23 | 222.8 | 474 | 2.13 | 181 | 0.81 | 5 | 0 | 120 | 0.54 |
| 24 | Beam | Nimitz | 98th Ave. to High St. | 2.90 | 12' | 149.6 | 233 | 1.56 | 58 | 0.38 | 3 | 3 | 35 | 0.23 | 173.8 | 398 | 2.29 | 173 | 1.00 | 4 | | 70 | 0.40 |
| 25 | Beam | Nimitz | 5th Ave. to Adeline St. | 1.53 | 4-16' | 61.4 | 83 | 1.35 | 32 | 0.52 | 1 | 0 | 16 | 0.26 | 66.8 | 111 | 1.66 | 48 | 0.72 | 0 | 0 | 12 | 0.18 |
| 26 | Beam | Eastshore | Distribution Structure to El Cerrito O.H. | 3.87 | 12' | 154.1 | 239 | 1.55 | 105 | 0.68 | 4 | 3 | 47 | 0.30 | 162.0 | 269 | 1.66 | 117 | 0.72 | 3 | 0 | 46 | 0.28 |
| 27 | Cable | San Diego | Ventura Blvd. to Burbank St. | 1.27 | Interchange traffic; adjacent area under construction. Data considered unreliable. | | | | | | | | | | | | | | | | | | |
| 28 | Cable | Harbor | 190th St. to 120th St. | 4.36 | 22' | | | | | | | | | | 269.0 | 428 | 1.59 | 229 | 0.85 | 2 | 0 | 169 | 0.63 |
| 29 | Beam | Pasadena | U.P.R.R. to Glenarm St. | 5.58 | 6' | 237.1 | 318 | 1.34 | 162 | 0.68 | 4 | 0 | 64 | 0.27 | 205.1 | 330 | 1.61 | 167 | 0.81 | 4 | 0 | 83 | 0.41 |
| 30 | Concrete | Santa Monica | Grand Ave. to Noomi | 1.35 | 22' | | | | | | | | | | 21.4 | 16 | 0.75 | 9 | 0.42 | 0 | 0 | 3 | 0.14 |
| 31 | Concrete | Santa Monica | Noomi to Los Angeles Riv. | 1.13 | 21' | | | | | | | | | | 27.0 | 30 | 1.11 | 18 | 0.67 | 0 | 0 | 7 | 0.26 |
| 32 | Beam | Bayshore | Southern Fwy. to Powhatten Ave. | 0.40 | 6' | 31.5 | 66 | 2.10 | 27 | 0.86 | 2 | 1 | 7 | 0.22 | 32.8 | 88 | 2.68 | 31 | 0.95 | 0 | 0 | 12 | 0.37 |
| 33 | Beam | Harbor | 7th St. to Santa Monica Fwy. | 0.68 | 16-22' | | | | | | | | | | 42.3 | 80 | 1.89 | 49 | 1.16 | 0 | 0 | 10 | 0.24 |
| 34 | Cable | Harbor | Imperial Hwy. to Santa Monica Fwy. | 8.51 | 16-22' | | | | | | | | | | 458.8 | 1048 | 2.28 | 625 | 1.36 | 9 | 0 | 215 | 0.47 |
| 35 | Cable | San Bernardino | Holt Ave. to Jct. Rte. 77 (Arroyo Ave.) | 3.84 | 16' | 108.2 | 196 | 1.81 | 73 | 0.67 | 7 | 0 | 26 | 0.24 | 104.2 | 315 | 3.02 | 132 | 1.27 | 6 | 0 | 89 | 0.85 |
| | Total Before and After Study | | | | | | | | | | | | | | | | | | | | | | |
| | Cable | | | 26.60 | | 1195.6 | 1586 | 1.32 | 713 | 0.60 | 31 | 9 | 308 | 0.26 | 1277.9 | 2231 | 1.75 | 904 | 0.71 | 21 | 1 | 629 | 0.49 |
| | Beam | | | 27.60 | | 1633.8 | 2690 | 1.65 | 1204 | 0.74 | 31 | 13 | 443 | 0.27 | 1680.4 | 3330 | 1.93 | 1612 | 0.96 | 27 | 0 | 511 | 0.30 |

APPENDIX B

## MEDIAN BARRIER FAILURES AND PARTIAL PENETRATIONS 1959 THROUGH 1963

| FREEWAY | SEV-ERITY | VEHICLE | MEDIAN WIDTH | MEDIAN TYPE | BARRIER TYPE | REMARKS |
|---|---|---|---|---|---|---|
| 1. Santa Ana | PDO | Chevrolet Flatbed | 12' | "B" Curb-Paved | Cable | Truck over cables |
| 2. Ventura | PDO | 55 Oldsmobile | 22' | Dirt | Cable | Vehicle straddled cables |
| 3. Golden State | PDO | 53 Ford | 22' | Dirt | Cable | 8" berm - 3' from barrier-curve-cable 28" above ground |
| 4. San Bernardino | Injury | 58 Lincoln | 16' | "C" Curb-Paved | Cable | Veh. over cables-cables did not strip. Cable ht. = 30". |
| 5. Ventura | Injury | 62 Chevrolet Pickup | 22' | Dirt | Cable | 8" berm - 3' from barrier-curve-veh. over cables. Cable ht. = 30" above ground - 17" above berm. |
| 6. Ventura | PDO | 62 Pontiac Coupe | 22' | Dirt | Cable | 6" berm-3' from barrier-curve. Cable ht.= 33" above ground - 24" above berm. |
| 7. San Diego | PDO | 58 Mercury | 22' | Dirt & Oleanders | Cable | 2" berm - 1½' from barrier-pillbox at point of impact. |
| 8. Ventura | PDO | 52 Pontiac | 22' | Dirt | Cable | Pontiac went partially under cables. |
| 9. Golden State | PDO | 55 Ford | 22' | Dirt | Cable | Ford over cables-cables did not strip. |
| 10. Harbor | PDO | 53 Chevrolet | 22' | Dirt | Cable | Chevrolet hit barrier and rolled over-cables did not strip. |
| 11. Harbor | Injury | Austin-Healy Sprite | 16' | "C" Curb-Paved | Cable | Raised median - Sprite under cables. Cable ht. = 31". |
| 12. Ventura | Injury | 59 Ford Sta. Wagon | 22' | Paved | Cable | Ford Sta. Wagon went over cables - 6" berm - 3' from barrier. Cable ht. = 30" above ground - 18" above berm. |
| 13. Ventura | PDO | * | 22' | Dirt | Cable | Vehicle straddled cables. |
| 14. Ventura | PDO | * | 22' | Dirt | Cable | Vehicle over barrier. |
| 15. Golden State | Injury | 62 MG Conv. | 22' | Dirt | Cable | MG under cables - scene is a superelevation transition. |
| 16. Golden State | Injury | 61 Austin-Healy | 22' | Dirt | Cable | Vehicle under cables. |
| 17. Ventura | Injury | 1 Sedan 2 Trucks | 22' | Dirt | Cable | Ford changed lanes and forced the trucks into barrier. All 3 came to rest on top of barrier. Pill box at point of impact. |
| 18. Santa Ana | PDO | 61 Ford | 12' | "B" Curb-Paved | Cable | Hood of Ford went under cables. Impact ∢ = 30°±. |
| 19. Santa Ana | Injury | 63 Oldsmobile | 12' | "B" Curb-Paved | Cable | Olds under cable. Cable ht. = 33" above ground. |
| 20. San Bernardino | PDO | 55 Buick | 16' | "C-2" Curb-Paved | Cable | Buick over cable - mesh acted as a ramp. |
| 21. San Bernardino | Injury | Trac. & Semi. | 16' | "C" Curb-Paved | Cable | Truck over cables. |
| 22. San Bernardino | Fatal | 60 Corvette | 16' | Flat & Paved | Cable | Corvette under cables - driver decapitated. |
| 23. San Bernardino | PDO | 57 Ford | 16' | "C" Curb-Paved | Cable | Ford over cables. |
| 24. Bayshore | Injury | 61 T-Bird | 36' | Dirt-Fairly Flat | Cable | Hood of T-Bird under cables. |
| 25. Bayshore | Injury | 62 T-Bird | 36' | Dirt-Flat | Cable | T-Bird under cables (envelope). Cable ht. = 35" |
| 26. Bayshore | Fatal | 55 Corvette | 36' | Dirt-Flat | Cable | Corvette under cables (envelope). |
| 27. Bayshore | Injury | 57 Buick Hardtop | 36' | Dirt | Cable | Buick under cables - top of car torn off. |
| 28. Nimitz | Injury | Alpha-Romeo | 12' | "B" Curb-Paved | Cable | Car under cables. |
| 29. Santa Ana | Fatal | Panel-Truck | 12' | * | Cable | Truck over barrier (head-on). |
| 30. Harbor | * | Car | 22' | Paved | Cable | Car over cables on a curve. Cable ht. < 30". |
| 31. Harbor | Fatal | Car | 12' | Curbed | Beam | Car jumped beam. |
| 32. Bayshore | Injury | Austin-Healy | 36' | Dirt-Flat | Cable | Car under cables. |
| 33. Ventura | Fatal | 60 Cadillac | 22' | Paved | Cable | Cad. over cables hit a 1951 Chevrolet head-on. |
| 34. San Bernardino | PDO | 60 Ford | 16' | "C" Curb-Paved | Cable | Ford got on top of cables and vaulted. |
| 35. San Bernardino | Injury | 59 Chevrolet Sta. Wagon | 16' | "C-2" Curb-Paved | Cable | Chevrolet station wagon over cables. |
| 36. San Diego | Injury | 57 Ford | 22' | Dirt | Cable | Ford over cables. Berm - 3' from cables - cable was 36" above ground and 26" above berm. |
| 37. Bayshore | Fatal | 62 Pontiac | 36' | Dirt | Cable | Cable ht. = 18". Grade had been raised but cable had not. Pontiac hit a Karmen Ghia head-on. |
| 38. Bayshore | Injury | 63 Lincoln Conv. | 30' | Ice Plant | Cable | Ht. = 31-33". Lincoln went under cables and across opposing lanes. Took the top off. Speed about 75 M.P.H. |

** Not readily available*

APPENDIX C

# FATAL ACCIDENTS INVOLVING MEDIAN BARRIERS 1959 THROUGH 1963

| FREEWAY | SEVERITY | VEHICLE | MEDIAN WIDTH | MEDIAN TYPE | BARRIER TYPE | REMARKS |
|---|---|---|---|---|---|---|
| 1. Harbor | Fatal | 1950 Crosley Sta. Wagon | 22' | Paved | Cable | Passenger ejected and killed. |
| 2. San Bernardino | Fatal | Buick | 16' | 'C' Curb-Paved | Cable | Driver ejected and pinned under Buick which rolled 1 1/2 times. |
| 3. Ventura | Fatal | 58 Talbot | 22' | Paved | Cable | Talbot hit barrier and spun, ejecting driver. |
| 4. Golden State | Fatal | 51 Chevrolet | 22' | Dirt | Cable | Driver found in back seat with head injury. 6" berm 3' from barrier. |
| 5. Golden State | Fatal | 57 Volkswagon | 22' | Dirt-Oleanders | Cable | Wheel came off - V.W. hit barrier and spun, ejecting 2 passengers. |
| 6. Bayshore | Fatal | 57 Volkswagon | 36' | Dirt | Cable | Driver and passengers ejected and killed. |
| 7. Nimitz | Fatal | Sedan | 12' | 'D' Curb-Paved | Cable | Car struck cable and ejected passenger. |
| 8. Nimitz | Fatal | Motorcycle | 12' | Curbed | Cable | Motorcycle struck barrier and ejected driver. |
| 9. San Bernardino | Fatal | Car | 16' | 'C' Curb-Paved | Cable | Car struck barrier and ejected driver. |
| 10 Nimitz | Fatal | Car | 12' | * | Beam | Suicide - Driver left a note - Bounced off beam into bridge rail |
| 11. Nimitz | Fatal | Truck | 12' | Curb-Paved | Beam | Truck struck beam and ejected driver. |
| 12. Bayshore | Fatal | 52 Plym. | 36' | Paved | Beam | Plymouth struck end of beam. No ejections. |
| 13. Ventura | Fatal | 61 Falcon | 22' | Paved | Cable | Falcon struck barrier - Driver ejected. |
| 14. Santa Ana | Fatal | Ford | 6'-8' | Curb-Paved | Beam | Ford struck beam-Passenger ejected. |
| 15. Bayshore | Fatal | Kaiser | 36' | Dirt | Cable | Kaiser was knocked into barrier - Driver ejected. |
| 16. San Bernardino | Fatal | Oldsmobile | 16' | 'C' Curb-Paved | Cable | Olds struck cable rail and spun around - Driver ejected. |
| 17. Harbor | Fatal | 50 De Soto | 22' | Paved | Cable | De Soto hit barrier and overturned. |
| 18. San Bernardino | Fatal | Pontiac Conv. | 16' | 'C' Curb-Paved | Cable | Pontiac lost wheel, hit barrier and overturned - Driver ejected. |
| 19. Golden State | Fatal | 52 Chrysler | 22' | Paved | Cable | Crysler hit barrier and spun - Driver ejected |
| 20. San Bernardino | Fatal | 58 T-Bird | 16' | 'C' Curb-Paved | Cable | T-Bird hit barrier and spun - Driver ejected. |
| 21. San Bernardino | Fatal | 55 Buick | 16' | 'C' Curb-Paved | Cable | Buick hit barrier and rolled 1 1/2 times - Driver and passenger ejected. |
| 22. Santa Ana | Fatal | 52 Ford | 6'-8' | Curb-Paved | Beam | Ford hit beam - Passenger ejected and run over. |

*Not readily available*