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16. ABSTRACT

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Three trial projects for concrete median barrier were completed in 1969. Approximately 6-1/2 miles of barrier were constructed on these projects. Early studies of these installations indicated that concrete median barrier was effective in preventing median barrier penetrations and reduced the severity of barrier related collisions.

Late in 1970, concrete median barrier using dimensions developed by the state of New Jersey was adopted as the standard barrier for narrow freeway medians. This choice was based on the results for the three trial installations and performance in other states.

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March 26, 1975

Prepared by:
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Late in 1970, concrete median barrier using dimensions developed by the state of New Jersey was adopted as the standard barrier for narrow freeway medians.[1] This choice was based on the results of the three trial installations and performance in other states.

Warrants

California's present median barrier warrants (Figure 1) have been developed through extensive study of freeway cross-median accidents. The figure shows median barrier warrants as a function of average daily traffic (ADT) and median width.

Barriers are warranted for combination of ADT and median widths that fall within the shaded area of Figure 1. At low ADT's, the probability of a vehicle crossing the median and colliding with a vehicle from the opposite direction is relatively low. Therefore, below 20,000 ADT and within the cross-hatched area of the figure, barriers are warranted only if there has been a history of a high number or rate of cross-median accidents. (Median widths are greater than 20 feet on new construction.)

Concrete median barrier is specified where the freeway median is less than 20 feet wide. This is based on the fact that this barrier does not deflect when struck, and its maintenance requirements are low. Nondeflection, of course, eliminates involvement of vehicles on the other side of the barrier. Low maintenance is important because narrow medians provide insufficient space for maintenance forces to work safely. Usually it is necessary to close off one or more traffic lanes during barrier repairs. Loss

Median Barrier Warrants

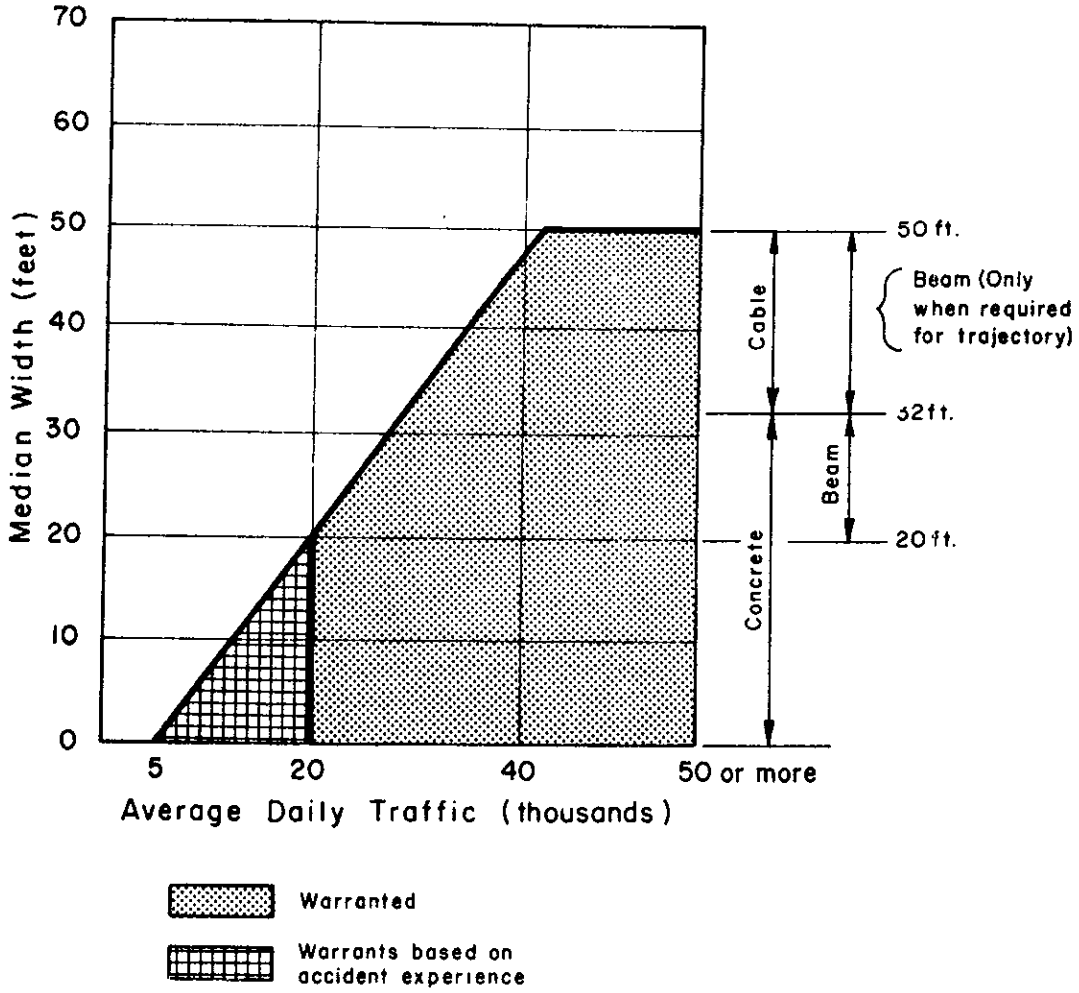

Figure 1

of the lanes has often produced serious congestion and increases accident probability. Either concrete or metal beam barrier is specified in medians between 20 and 32 feet wide. The choice is based on site economics and the result is usually in favor of concrete median barrier. Cable barrier is called for in freeway medians wider than 32 feet. The wider medians accommodate the 10- to 12-foot deflection of the cable barrier without endangering traffic on the far side of the barrier, and the wider medians provide sufficient space to accommodate maintenance forces repairing the barrier. Where the median cross section creates a vehicle trajectory problem, metal beam barrier is used in lieu of the cable barrier.[2] The metal beam barrier is less sensitive to variations in the vehicle approach height created by sawtooth or uneven medians.

Accident Data

By the middle of 1974, sufficient computer file accident data was available for meaningful comparison of barrier experience. The time lag between design and construction, together with a change over in the computerized accident file, brought about the delay in barrier evaluation.

Table 1 shows California State Highway single vehicle collisions with each of the three median barrier types. Data of 1973 only are used for the analyses below, since there were less than 10 miles of concrete barrier in place during 1970 and 1971. Data for 1972 median barrier accidents could not be readily obtained. This is not serious because much of the concrete barrier was under construction during 1972. Note the general downward trend in the accident rate categories from 1970 to 1973.

The 1973 total accident rate for metal beam barrier and concrete barrier are significantly* lower than the similar rate for cable barrier. This can be attributed to the fact that many collisions with metal beam barrier and concrete median barrier are never reported. Frequently, collisions with these barriers result in superficial or no vehicle damage, and the vehicle is driven off. On the other hand, vehicles are often retained by cable barrier or damaged to the point where they cannot be driven away, and the collisions are therefore reported.

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*The differences are highly significant; better than 0.1% level of significance using the Chi-Square test.[3]

MEDIAN BARRIER ACCIDENTS

SINGLE VEHICLE COLLISIONS WITH BARRIERS

TABLE 1

Barrier Type	Accidents				Barrier Miles	Travel (MVM)	Accident Rates		
	Fatal	Injury	PDO	Total			Total Acc/MVM	F+I/MVM	Fatality / 100 MVM
1970									
Cable	56	1,799	3,130	4,985	379	12,956	0.38	0.14	0.43
Beam	20	901	1,056	1,977	245	8,217	0.24	0.11	0.24
Concrete	1	26	23	50	6	225	0.22	0.12	0.44
1971									
Cable	31	1,227	2,918	4,176	403	13,698	0.30	0.09	0.23
Beam	19	675	921	1,615	271	8,859	0.18	0.08	0.21
Concrete	0	24	26	50	7	249	0.20	0.10	0.00
1973									
Cable	36	1,064	2,998	4,098	426	14,773	0.28	0.07	0.24
Beam	18	682	1,170	1,870	344	10,554	0.18	0.07	0.17
Concrete	3	216	431	650	139	3,560	0.18	0.06	0.08

PDO = Property Damage Only Accident

F+I = Fatal plus Injury Accidents
F = Fatal Accidents
MVM = Million Vehicle Miles

There are no differences in the fatal plus injury accident rates in 1973 for the three barrier types. The fatal accident rate, using the 1973 data, indicates a somewhat better experience with concrete barrier.**

In the past, both cable barrier and metal beam barrier have occasionally been penetrated by out-of-control vehicles. The frequency is not large, less than one percent of all barrier collisions, but the results can be most severe. So far, there has been no complete penetration of a concrete median barrier. There have been instances where a vehicle ended up on top of the barrier. Also, one notable collision involved an out-of-control streetsweeper that knocked a sizable section out of a concrete median barrier and ended up straddling the gap in the barrier. In no instance did the offending vehicle get past the barrier to strike traffic going in the opposite direction.

Accident data for all California freeways shows that median (to the drivers' left) accidents make up about 50 percent of single vehicle run-off-road accidents. A notable exception occurs on four-lane rural freeways where the median related accidents make up only one-third of the single vehicle run-off-road accidents. On eight- and ten-lane urban freeways, the median related accidents make up about 60 percent of the single vehicle run-off-road accidents.

Table 2 lists accident data for all California freeways by median width. All accidents, not just median related accidents, are shown in this table. Note that the group of freeways with median widths greater than 30 feet have substantially lower accident rates than the freeways with narrower medians. This should not be construed to mean that these roads are necessarily safer just because they have wider medians. More significant is the fact that these roads represent higher standards associated with more recent construction. The freeways with narrower medians are generally older urban or metropolitan freeways. These have higher traffic volumes and were constructed to standards that date back 15 or more years.

Repair Costs

Median barrier maintenance is a continuing concern to highway engineers. Repair cost is not the only factor considered. Increasing

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**The fatal accident rates are not significantly different at the 5% level using the Chi-Square test. The fatal accident rate on concrete is significantly lower than on cable at the 10% level, however. Additional data is required to reach a more certain conclusion on the significance of fatal accident rates.[3]

TABLE 2

1973 FREEWAY ACCIDENTS								
Median Width Feet	Road Miles	Travel (MVM)	Accidents				Total Accident Rate (Acc/MVM)	Fatal Plus Injury Accident Rate (F+I/MVM)
			Total	Fatal	Injury	PDO		
< 11	176	3,002	6,160	55	1,848	4,257	2.05	0.63
11-20	213	6,954	11,706	89	3,186	8,431	1.68	0.47
21-30	670	17,791	22,391	185	6,495	15,711	1.26	0.38
31-40	429	7,060	7,470	108	2,182	5,180	1.06	0.32
41-50	719	7,765	7,648	162	2,324	5,162	0.98	0.32
> 50	1,587	9,468	9,451	187	3,044	6,220	1.00	0.34

TABLE 3

MEDIAN BARRIER REPAIR COSTS

1973 - 74 FISCAL YEAR

Barrier Type	Inventory Miles	%	Length Repaired Linear Feet	%	Repair Time Man-hours	%	Repair Cost Dollars	%	Repair Cost Per Foot Repaired	Percent Inventory Repaired	Repair Cost Per Inventory Mile
Cable	426	(47)	333,624	(98.3)	56,880	(77)	$719,950	(73)	$ 2.16	14.8	$1,690
Beam	344	(38)	5,516	(1.6)	16,542	(22)	$258,903	(26)	$ 3.75	3.8	$ 753
Concrete	139	(15)	237	(0.1)	738	(1)	8,255	(1)	$34.70	0.03	$ 59
Total	909	(100)	339,377	(100)	74,160	(100)	$987,108	(100)			

importance is given to the hazard to maintenance workers and motorists alike when repair work must be carried out relatively close to large volumes of high-speed traffic.

Table 3 shows costs and man-hours expended during the 1973-74 fiscal year to repair each of the three types of median barrier used in California. The repair costs include salaries, equipment, and material. It can be seen that cable barrier is responsible for the major portion of median barrier repair costs. The percent of inventory repaired each year is by far the largest for cable barrier, as is the repair cost per inventory mile.

Construction Costs

The costs of constructing median barrier have been rising along with other construction costs. The trend in barrier prices from 1972 through 1974 is shown in Table 4. The prices shown are bid averages on State highway projects throughout California. Prices for unique or special designs are not included in these averages.

Table 4

MEDIAN BARRIER AVERAGE BID PRICES, PER LINEAR FOOT

Barrier Type	1972	1973	1974
Cable w/glare screen	$ 3.05	$ 4.02	$ 7.41
Cable w/o glare screen	2.34	2.65	4.32
Metal Beam	11.24	15.73	17.96
Concrete	8.90	8.91	10.86

Cable barrier with glare screen has shown the greatest increase in cost since 1972, some 143 percent. Metal beam barrier experienced a price increase of 60 percent from 1972 to 1974. On the other hand, concrete barrier increased only 22 percent, with all of the increase occurring in 1973 and 1974. These price increases are due to material shortages, in large part, and not just general inflation. The 2-1/4" - 4.1 pound per foot "H" post used for cable

barrier literally disappeared from the market during 1973 as the manufacturer stopped rolling this shape. It became necessary to use round pipe posts, and even square tubular posts, to permit cable barrier construction to proceed. The 6" - 8.2 pound per foot steel channel used on metal beam barrier was in short supply for a brief period in 1973 as production of this item was curtailed by the steel industry.

As noted previously, concrete median barrier construction has experienced the least cost increase. One reason for this is that concrete barriers use little steel. (A single 1/2" continuous reinforcing bar is placed six inches from the top of the barrier.) Construction costs have benefited to some extent from the large quantities constructed. An additional 49 miles of concrete barrier was bid on during 1974. Another important factor in holding the cost of concrete down is the extensive use of slip form barrier machines and the contractors' increasing experience with this type of construction.

Summary

California's median barrier warrants are based on a combination of traffic and median width. (See Figure 1.) For median widths less than 20 feet, warrants are based on accident experience.

Concrete barrier is constructed in medians less than 20 feet in width; either concrete or beam barrier is installed in medians of 20 to 32 feet in width, and cable barrier is installed only in medians greater than 32 feet in width.

Analysis of single vehicle collisions with the three types of median barrier used on California highways shows that total accidents are significantly higher for cable barrier than for metal beam or concrete barrier. This is attributed to the fact that minor collisions with either metal beam or concrete barrier are not reported because the vehicle is able to drive away. On the other hand, minor collisions with cable barrier are often reported because the vehicle is retained by the barrier. Fatal and fatal plus injury accidents are not significantly different between the three barrier types.

Total and fatal plus injury accident rates (all accidents, not just median accidents) decrease with increasing median width. This is more a function of the higher overall standards associated with more recent construction, which uses wider medians, than with the width of the median itself.

Repair costs per inventory mile are substantially higher for cable barrier than for metal beam or concrete barrier. Fifteen percent of the cable barrier inventory is replaced each year at a cost of close to $1,700 per inventory mile. With metal beam barrier, 4 percent

of the inventory is replaced per year at a cost of $750 per inventory mile. Concrete barrier costs about $60 per inventory mile to repair with less than 0.1 percent of the inventory repaired each year.

Construction costs per linear foot for the various barrier types in 1974 were: cable with glare screen - $7.40, cable without glare screen - $4.30, metal beam - $18.00, concrete - $10.90.

There is a continuing trend toward increased use of concrete median barrier. Its first cost is between that of cable and metal beam barrier. Subsequent maintenance cost is substantially lower than either cable or metal beam barrier. Its safety experience is comparable to, or better than, other barriers, and it has definite benefits in narrow medians. Metal beam barrier is a proven design that still has applications. The amount of cable barrier in use in California is expected to decrease. Less is being installed on new construction and substantial lengths of previously constructed cable barrier are being replaced by metal beam or concrete barrier. Replacement results from upgrading the cable barrier in existing medians less than 32 feet in width and when median widths are reduced below 32 feet by the addition of traffic lanes to existing freeways.

Cable barrier is still justified in medians over 32 feet wide because of its lower first cost and because the space available provides adequate safety for maintenance workers and passing traffic.

References:

1. Michie, J. D., and Calcote, L. R., "Location, Selection, and Maintenance of Highway Guardrails and Median Barriers." NCHRP Report 54 (1968) pp. 8-9.

2. Tamburri, T. N., "A Method for Checking the Integrity of Cable and Beam Barriers." California Division of Highways - Traffic Bulletin No. 15, (April 25, 1967), 11 pp.

3. Karr, James Ivil, "Evaluation of Minor Improvements, Grooved Pavements (Part 8)," California Division of Highways, Traffic Department (December 1972), Appendix A, Section D, Significance Testing.