Assessment of Median Barriers

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16. Abstract

Over the last 10 years passenger cars have become smaller, and the percentage of smaller cars in the traffic stream nation-wide, has increased dramatically, while trucks have become heavier and longer. Concern has been expressed that current median barriers used on the nation's highways may prove to be inadequate and that this fact may lead to higher severity rates of injuries and fatalities. Based on an extensive literature review the following recommendations are made:

1. Without specifics regarding individual site configuration and corresponding accident data, it is not possible to generalize what action should be taken on a state-wide basis. Obviously, action may be needed after due evaluation of specific sites, based on cross median accident data.
2. Crash tests have shown that the New Jersey type and configuration 'F' type of concrete median barriers are capable of dealing with a wide range of vehicles and are recommended for adoption in the future in sections that may have obsolete barriers and are in need of replacement, on a case-by-case basis.
3. Inexpensive modifications to existing median barriers and adoption of new proven methods such as the SERB (Self-Restoring Traffic Barrier), may be considered when appropriate and warranted, on a case-by-case basis.

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ASSESSMENT OF MEDIAN BARRIERS

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ABSTRACT

Over the last 10 years passenger cars have become smaller, and the percentage of smaller cars in the traffic stream nation-wide, has increased dramatically, while trucks have become heavier and longer. Median barriers, like most other roadside hardware, were developed and installed before these changes in traffic composition started. Concern has been expressed that current median barriers used on the nation's highways may prove to be inadequate and that this fact may lead to higher severity rates of injuries and fatalities. Based on an extensive literature review the following recommendations are made:

1. The fleet size composition of passenger cars and the weight size range of heavy vehicles using the highway system has changed over the last 10 years. However, without specifics regarding individual site configuration and corresponding accident data, it is not possible to generalize what action should be taken on a state-wide basis. Obviously, action may be needed after due evaluation of a specific site based on cross median accident data.
2. Crash tests have shown that the New Jersey type and configuration 'F' type of concrete median barriers are capable of dealing with a wide range of vehicles and are recommended for adoption in the future in sections that may have obsolete barriers and are in need of replacement, on a case-by-case basis.
3. Inexpensive modifications to existing median barriers and adoption of new proven methods such as the SERB (Self-Restoring Traffic Barrier), may be considered when appropriate and warranted, on a case-by-case basis.

SUMMARY

Substantial changes in the composition of highway traffic has been experienced over the last decade. Passenger cars are becoming smaller and lighter with the result that accidents involving compacts and subcompacts overturning after colliding with median barriers is reported to be progressively rising. At the same time dramatic increases in the length, width and weight of trucks over the last few years have raised questions regarding the effectiveness of median barriers to contain and redirect heavy vehicles. There is evidently a need for effective median barriers and the problem continues to receive attention with the development of new median barrier systems and improvement of old ones in response to a changing vehicle fleet.

The objectives of the study are: to collect recent reports and articles on the developments in the design, testing, application and evaluation of median barrier systems; to contact state DOTs on their experiences with median barrier problems; and to synthesize this information in a state-of-the-art report.

Definitions, functions and descriptions of operational median barriers as per AASHTO are presented, including current warrants for median barriers in Washington State. The performance of several median barriers (flexible, semi-rigid and rigid) based on accident studies is also presented and discussed. While cable median barriers are the most forgiving they are evidently more expensive to maintain. On the other hand concrete median barriers need little attention and are generally maintenance free. The New Jersey type concrete barrier is superior to the GM type.

With the rapid change in fleet composition leaning toward the smaller and lighter car indicates that design and maintenance of median barriers may have to adapt to this change in the future. The level of maintenance for median barriers may be higher in the future. The New Jersey type and configuration 'F' type of concrete barrier have proven successful and are recommended for installation.

As a result of the Surface Transportation Assistance Act of 1982, heavier, wider and longer trucks are being increasingly used on the highway system. The heavy vehicle poses a different set of problems for median barriers. As a result of a steady increase in bus and truck traffic there is some concern regarding upgrading existing median barriers. However, this question of upgrading of safety hardware for trucks will have to be resolved simultaneously by evolving a special softening feature to safely accommodate the small car on impact also. In view of conflicting reports on the performance of median barriers it would be premature to recommend what ought to be done even in the short term.

Realizing the rapid changes in fleet size composition (weight, size, width, distribution) there has been some progress in on-going research to design median barriers to meet these changes. Current trends in new designs such as the introduction of the Self-Restoring Traffic Barrier (SERB) the International Barrier Corporation Median Barrier, and the Tall Wall design indicate that there is room for adapting to new conditions.

Also, revision of AASHTO's "Guide for Selecting, Locating and Designing Traffic Barriers" is currently underway and is likely to be completed in the near future. This revised guide will present the

results of a synthesis of current information on the various elements of traffic barrier systems, including warrants, structural and strength characteristics, maintenance characteristics, selection criteria, and placement data. It is therefore suggested to await results contained in the forthcoming AASHTO Guide*.

The bottom line is that without specifics regarding individual site configurations and corresponding accident data it is not possible to generalize what action should be taken on a state-wide basis.

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* personal conversation with Mr. James F. Roberts of Missouri, Chairman of the AASHTO Task Force for Traffic Barrier Systems.

CONCLUSIONS

1. Most of the existing median barriers on the highway system were designed and installed two to three decades ago when the passenger car size ranged between 2,000 and 4,500 lbs. There is some concern that existing median barriers may not perform properly with vehicles that weigh less than 2,000 lbs. At the same time, as a result of the increase in bus and truck traffic and the higher frequency of heavy trucks in the traffic stream, there is concern that existing median barriers may prove to be inadequate. Crash tests have, however, shown that the New Jersey type and Configuration F type of concrete median barrier have proven successful for small-sized cars and are recommended for future use.
2. Without specifics regarding individual site configuration and corresponding accident data it would not be possible to recommend a common strategy of dealing with median barriers. In fact the cause for the accident and its severity may be a function entirely disconnected with the median barrier at that location.
3. As a result of the Surface Transportation Assistance Act of 1982 the highway system will be increasingly used by heavy trucks. It appears that the heavy vehicle (80,000 lbs) needs median barriers substantially stronger than the ones currently in use in order to contain and redirect them. However, current ongoing research has not yet conclusively resolved the issue, but the results of a 2-year TRB study will indicate what is needed to be done, at least in the short-term.

4. Current trends in new designs such as the introduction of the self-restoring traffic barrier, the IBC median barrier and the "Tall Wall" barrier indicate that the room for adaptations is readily available.

RECOMMENDATIONS

1. Monitor the fleet size composition of passenger cars using the highway system in Washington state to establish trends and compare with national figures.
2. Monitor the weight and dimension range of heavy vehicles using the highway system in Washington state to establish trends, and compare with national figures.
3. On a case by case basis, sections of highways may be examined to detect any trend connecting accidents with specific site conditions. This examination may indicate that there may be some existing operational median barriers that require only minimum adjustment, while others may prove to be functionally inadequate.
4. Since the New Jersey type and configuration F type of median concrete barriers have proven successful in handling a wide range of vehicles it is suggested that in the future these types be considered when replacement of existing sections appear necessary, on a case by case basis.
5. As and when the newer traffic median barriers are considered operational, they may be considered for adoption on a case by case basis.

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1 - INTRODUCTION

1.1 - Purpose of the Study

There have been substantial changes in the technology of safety hardware used on highways within the past fifteen years. Review of field installations such as median barriers, has revealed that in many cases the conditions under which they were originally developed, tested, and intended to perform has altered as a result of changes in vehicle size and weight now using the highway network. This report is an assessment of median barrier systems currently in use as well as the newer systems proposed and tested by researchers. A synthesis of the most recent work in this area is presented in this report.

1.2 - Problem Statement

Median barriers can be both useful and cost-effective in eliminating or reducing the severity of vehicular accidents, especially head-on collisions. Numerous types of median barrier systems have been designed, tested, evaluated, and implemented over the years. One type of rigid median barrier for example, which has gained popularity across the country is the New Jersey Concrete type. Since the development and widespread use of this type of median barrier, however, cars have become progressively smaller and lighter, with the result that accidents involving compact or subcompact cars overturning on to the roadway are increasing. At the same time, dramatic changes created by the permissive Surface Transportation Assistance Act, 1982 (PL 97-424), have resulted in increases in the length, width, and weight

of trucks, raising serious questions regarding the effectiveness of these N.J. type barriers. The service performance of median barrier systems with respect to the changing characteristics of the current vehicle fleet using the highway is not known.

There have been some recent developments in the design of median barrier sytems that need to be investigated urgently. Several governmental agencies, universities, and private consultants have been working on problems connected with median barrier systems over the last decade, but the results are at best scattered in reports and journal articles. Also, the current problems pertaining to small cars and large trucks with roadside hardware (such as guardrails, median barriers, bridge railings, crash cushions, and break away sign supports) is a comparatively new phenomenon. Reports regarding the inadequacies of median barriers for automobile vehicles weighing less than 2000 lbs. and heavy trucks are now coming in.

1.3 - Objectives of the Study

The objectives of the study are as follows:

1. To collect recent reports, vendor literature, and articles on developments in the design, testing, application, and evaluation of median barrier systems;
2. to contact other State DOT's on their experiences with median barrier problems;
3. to synthesize this information into a useable summary report (State-of-the-Art Report).

1.4 - Scope of the Study

This research is basically a synthesis of the most recent work done in the area of median barrier safety. The emphasis of this state-of-the-art investigation is on the effects of recent changes in the composition of highway traffic on median barrier safety and performance.

2 - BACKGROUND

2.1 - Definition

"A median barrier is a longitudinal system used to prevent an errant vehicle from crossing the portion of a divided highway separating the travelled ways for traffic in opposite directions" (1). In many respects, median barriers are similar to roadside barriers except that they must be designed for impacts from both travel directions. Hence, many of the factors that affect performance of roadside barriers apply equally well to median barriers.

2.2 - Functions of Median Barriers

If impacted under anticipated operating conditions, a median barrier should function as follows:

1. It should prevent an out-of-control vehicle from crossing the median of a divided highway.
2. It should prevent an out-of-control vehicle from impacting a fixed hazard in the median that it is shielding.
3. It should redirect the out-of-control vehicle without allowing the vehicle to penetrate, vault, or snag, and without creating an undue hazard to other traffic.
4. It should accomplish the above with acceptable levels of impact forces to the occupants of the vehicle so that serious injury is not expected. The nationally recognized impact performance standards are presented in an NCHRP report #230.(2)

2.3 - Warrants for Median Barriers in Washington State (3)

Median barriers are normally used on access-controlled high speed, high traffic density facilities (design speed 50 mph or greater). A median barrier is not normally placed on a facility that:

1. is a low speed highway (design speeds less than 50 mph),
2. has no access control,
3. has raised medians,
4. is classified as a collector highway,
5. has numerous openings, or
6. has a median less than 4 feet wide.

Warrants for median barriers on access controlled, high speed, high-traffic-density facilities which have relatively flat unobstructed medians have been established.

Median barrier warrants are based on a combination of average daily traffic (ADT), (design year for new alignment, current for existing alignment), and median widths. At low ADTs, the probability of a vehicle crossing the median is relatively low. Thus, for ADTs less than 20,000 and median widths less than 20 feet, median barrier use is optional. Likewise, for relatively wide medians, the probability of a vehicle crossing the median is also relatively low. Medians that are wider than 50 feet do not warrant a barrier unless there is a history of across-the-median accidents.

When a median barrier is warranted for a median of less than 4 feet on an existing facility, median widening is required so as

to provide a minimum 4 foot median with 6 feet being the desirable minimum.

A concrete barrier having the standard double-faced New Jersey shape is the preferred median barrier except for wide medians (greater than 30 feet). The concrete barrier can be precast or cast-in-place. The cast-in-place barrier is most suitable for differential vertical and horizontal alignment situations where stepped medians are required.

2.4 - Operational Median Barriers

"Operational barriers", by AASHTO definition, include those barriers that have performed satisfactorily in full-scale crash tests and have demonstrated satisfactory in-service performance. The median barriers that have been classified "operational" are identified in Part IV of the AASHTO Barrier Guide.(1)

Other classificatons include "research and development" barriers and "experimental" barriers. "Research and development" barriers are those that have performed satisfactorily in full-scale crash tests but have not been in service long enough to evaluate their performance. "Experimental" barriers are those that have not been fully crash tested yet but are being studied for possible use. Operational barriers can be used without further testing and barriers being replaced should be of this type to avoid possible tort liability at a later date.

Operational barriers, identified according to their deflection characteristics, are listed.

FLEXIBLE BARRIERS

Two operational median barriers are considered to be flexible barriers:

1. Cable (2 or 3 strand cable on steel posts)
2. W-beam, steel weak posts

SEMI-RIGID BARRIERS

The AASHTO Barrier Guide lists seven operational median barriers that are considered to be semi-rigid:

1. Box Beam, Steel Posts
2. Blocked-out W-Beam, Wood Posts
3. Blocked-out W-Beam, Steel Posts
4. Aluminum Strong Beam, Aluminum Posts
5. Aluminum Balanced Beam, Aluminum Posts
6. Blocked-out Thrie Beam, Steel Posts
7. Unblocked W-Beam, Steel Breakaway Posts

RIGID BARRIERS

The concrete safety shaped barrier is the only operational rigid median barrier.

2.5 - Factors that Affect Performance of the Standard Section (1)

Selection of a median barrier will depend on a number of factors including:

1. Median width
2. Deflection characteristics
3. Barrier to hazard distance

4. Maintenance characteristics
5. Cost

Maintenance requirements include consideration of personnel safety, and cost to install and maintain the barriers.

2.6 - Width of Median

The primary purpose of a median barrier is to prohibit an out-of-control vehicle from entering the travel lanes for opposing traffic on the other side of the median. If a median barrier deflects more than the distance to the other traffic lane, obviously this function is not satisfied.

Table 2-1 presents deflections for the operational median barriers listed previously. A particular barrier should not be used when the distance behind it to the opposite travel lane is less than the deflection distance.

Table 2-1

MEDIAN BARRIER DEFLECTIONS (1)

System	Maximum Dynamic Deflection (ft)	Impact Angle
Flexible Systems		
MB1	17.0	25
MB2	7.0	25
Semi-Rigid Systems		
MB3	5.5	25
MB4W	2.0	25
MB4S	1.5	16
MB7	7.2	26.6
MB8	unavailable	--
MB9	3.2	25
MB10	1.5	25
Rigid System		
MB5	0	--

References

1. "Guide for Selecting, Locating, and Designing Traffic Barriers", American Association of State Highway and Transportation Officials, 1977.
2. "Recommended Procedures for the Safety Performances Evaluation of Highway Appurtenances", NCHRP Report #230, Transportation Research Board, March 1981.
3. Design Manual M22-01 (HR), Washington State Department of Transportation, Olympia, WA.

3 - PERFORMANCE OF MEDIAN BARRIERS

3.1 - Introduction

Traffic median barriers are used to redirect and attentuate the impact of vehicles. They are generally installed when it is not feasible to remove existing hazardous conditions by any other means. However, their overuse can constitute a major roadside hazard (1,2).

3.2 - General Performance

Over the years, numerous types of roadside barriers and medians have been designed, tested, evaluated and implemented. Table 3-1 gives an indication of the relative safety performance of various kinds of roadside barriers and medians that are used. The two-strand and three-strand cable type are evidently much more forgiving as compared to the blocked W-Beam type.

The most common rigid barrier system is constructed in concrete and these barriers are used for both medians and bridge parapets. Concrete barriers (as well as some other type barriers) while similar in appearance often perform quite differently because of many facts, e.g., vehicle weight, approach speed, impact angle, presence of superelevation, physical barrier shape, etc. Both simulation and full-scale crash studies have been performed to evaluate and assess the safety performance of various concrete barrier shapes. For example, in 1977, Bronstad, et al. reported the results of simulation tests on eight concrete barrier shapes including the two most commonly used designs, those developed by New Jersey and General Motors. Both designs

Table 3-1

TYPE AND PERCENT OF DRIVER INJURY

Guardrail Type	Number Observed	Percent Injury	Percent Killed	Percent Not Injured
Blocked W-Beam (Steel Post)	64	47	3	50
Blocked W-Beam (Light Steel Post)	7	29	0	71
Blocked-W-Beam (Wood Post)	71	28	1	71
Parapet (Concrete)	11	27	0	73
Nonblocked W-Beam	30	27	7	66
Wood Post	4	25	0	75
Box Beam	14	21	0	75
Three-Strand Cable	17	18	0	82
Two-Strand Cable	13	8	0	92
TOTAL	231	31	2	67

SOURCE: K. Perchonock, et al., Hazardous Effects of Highway Features and Roadside Objects, Vol. 2, Findings Report #FHWA-RD-78-202, Federal Highway Administration, Sept. 1978.

use an overall height of 32 inches and a lower impact slope of 55 degrees. The New Jersey design has a somewhat longer and steeper stem-wall which deters mounting, vaulting, and rolling. These crash tests by Bronstad have shown that the General Motors (GM) shape is more likely to cause small cars to roll over. Therefore, installation of the GM shape is no longer recommended. (3)

According to Table 3-2, developed by Tye (4), the repair cost for concrete barriers is considerably less than for other barrier systems.

3.3 - Accident Findings

VanZweden and Bryden (5) 1977 evaluated the performance of both light-post and heavy-post barriers in a 2-year study of 4,213 accidents. They found that the light-post designs resulted in less severe injuries than the heavy-post designs erected through 1965. They also reported on the effectiveness of box-beam barriers used on the Taconic State Parkway in New York. During the 29-month study, 286 median barrier accidents were recorded. Of 234 midsection accidents, 228 vehicles were contained by the box-beam barrier, while 1 vehicle penetrated the barrier and 5 overturned. They reported that 22 of 31 end section accidents were also contained. They concluded that box-beam median barriers on light-posts provided excellent performance even for the very narrow Parkway Median.

Single vehicle collisions with median barriers were investigated by the California Department of Transportation (4). Accident data were available for meaningful comparison of barrier

Table 3-2

BARRIER REPAIR COSTS

Barrier Type	Inventory Miles	Inventory %	Repair Cost Dollars	Repair Cost %	Percent Inventory Repaired	Repair Cost Per Inventory Mile
Cable	426	47	$719,950	73	14.8	$ 1,690
Beam	344	38	258,903	26	3.8	753
Concrete	139	15	8,255	1	0.03	59
Total	909	100	$987,108	100		

SOURCE: Reference 4.

experience. Barrier type and associated single vehicle collisions are shown in Table 3-3. A general downward trend in the accident rate is indicated for each barrier type. The 1973 total accident rate for metal beam barrier and concrete barrier was found to be significantly lower than a similar rate for cable barriers. Although there was no difference in the fatal-plus-injury accident rates for the three barrier types, the fatal accident rate on the concrete type is significantly lower than on cable barriers.

Bronstad et al. (3) described the accident experience of concrete barrier shapes used by 15 agencies. The data shown in Table 3-4 only reflects reported accidents and not "brush" impacts that also occur. No fatalities were reported for either type of barrier. The NJ type is undoubtedly superior to the GM type.

Research reported in 1973 by Garner and Deen (6) 1973 conducted in Kentucky involved studying a variety of median types on 420 miles of toll road and interstate system opened prior to 1966. This research has shown that both the total median accident rate and the accident severity rate decline with increasing median width. A breaking point or "leveling off" seems to occur for median widths between 30 and 40 feet. They found, however, that other elements of the median, such as cross slopes and presence of obstructions and irregularities, can have a greater effect on safety of the median than width. The beneficial effect of wide medians can be completely negated by steep slopes. The Garner and Deen study in Kentucky showed that

Table 3-3

SINGLE VEHICLE COLLISIONS WITH BARRIERS

Year/ Barrier Type	Barrier Miles	Travel (MVM)	Accident Rates: Total Acc/MVM	F + I MVM	Fatal/ 100 MVM
1970					
Cable	379	12,956	0.38	0.14	0.43
Beam	245	8,217	0.24	0.11	0.24
Concrete	6	225	0.22	0.12	0.44
1971					
Cable	403	13,698	0.30	0.09	0.23
Beam	271	8,859	0.18	0.08	0.21
Concrete	7	249	0.20	0.10	0.00
1973					
Cable	426	14,773	0.28	0.07	0.24
Beam	344	10,554	0.18	0.07	0.17
Concrete	139	3,560	0.18	0.06	0.08

PDO = Property Damage Only Accidents
F+I = Fatal Plus Injury Accidents
F = Fatal Accidents
MVM = Million Vehicle Miles

SOURCE: Reference (4)

Table 3-4

CONCRETE BARRIER ACCIDENT DATA

Barrier Type	Total Accidents	Barrier Performance[a]		Accident Severity[b]		
		Vehicle Rollovers	Vehicle Mountings	PDO	Hospital	Total & Property Damage
New Jersey	180	6 (3)	1 (1)	133 (79)	35 (21)	168 (100)
General Motors	299	19 (6)	4 (1)	255 (79)	74 (25)	299 (100)

(a) Numbers in ( ) are percentage of total accidents.
(b) Numbers in ( ) are percentage of total property damage only (PDO) and injury accidents

Source: (3)

4:1 and 3:1 cross slopes of the 35-foot deeply depressed medians have high median accident rates. The cross slopes of the 20-, 30-, and 60-foot medians were relatively mild when compared to the 36-foot medians. The steep slopes do not provide reasonable recovery areas and are often a hazard in themselves.

Foody and Culp (7) reported in 1974 on their study of the safety benefits associated with 84-foot-wide medians as to mound type (raised) versus swale type (depressed) for interstate highways in Ohio. About 130 miles of each median type for four-lane divided highways were studied and the accident data from 1969 through 1971 were analyzed. The results indicated that either type provides a generally adequate recovery area for encroaching vehicles although the swale median appears to provide more opportunity for encroaching vehicles to regain control and return to their roadway. The swale type median had 8:1 slopes to a 4-foot-deep ditch in the center. The mound type had 8:1 slopes down to 1.6-foot ditch with a 30-foot-wide, 5-foot-high mound in the center which had 3:1 slopes.

Traffic barriers such as guardrails, bridge rails, and median barriers, now on highways have been developed for passenger vehicles. It is not uncommon for large trucks, because of their weight and high center of gravity, either to penetrate a traffic barrier or to overturn upon impact rather than be redirected upright on a noncollision course. In a limited sample (68 cases) of truck accidents involving guardrails, Vallette et al. (8), found 36 percent of the trucks striking guardrails mounted on wooden posts penetrated or vaulted the guardrail

compared to 19 percent for guardrails with steel posts. VanZweden and Bryden (5) found vehicle penetration of weak-post guardrail and median barrier designs occurring in 16 percent (57 of 347 cases) of impacts by vehicles weighing less than 5,000 pounds. The sample did not include impacts within 50 feet of either end of the railing. Other evidence of the inadequacy of guardrails and barriers for trucks is cited by Post et al. (9) reporting the number of trucks involved in traffic barrier fatal accidents in Texas increasing from 16 to 21 percent over a 2-year period in the early 1970s.

This concern has prompted impact testing of large trucks into these protective devices. Post et al. (9) did preliminary testing by running a loaded combination truck weighing 48,000 pounds into a concrete safety-shaped barrier (commonly referred to as the New Jersey barrier) at speed and approach angle combinations of 35 mph and 19 degrees, 34 mph and 15.5 degrees, and 45 mph and 15 degrees. The barrier proved effective for all three tests, and only minor damage occurred to both truck and barrier.

Research by Dynamic Science, Inc. (10) established the upper performance limit of N.J. concrete safety-shaped barriers. In a 40,000-pound, cab-over-engine combination truck impact at 55 mph and 15 degrees, the tractor and the front of the trailer climbed the top of the barrier. The position of the vehicle after the crash suggested complete vaulting of the tractor, and possibly the trailer could be expected in a collision with a barrier longer than the section employed in the test.

FHWA research underway at the Texas Transportation Institute (TTI) in 1982 on barrier systems for heavier vehicles has primarily concentrated on school buses and intercity buses because of the consequence of serious injuries and fatalities to a large number of people when such vehicles penetrate or vault a traffic barrier. Problems associated with the difficulty of containing combination trucks and of stable redirection (e.g., truck load shift, fully loaded combination trucks and rollover) have not yet been rigorously addressed.

FHWA has a program to develop improved bridge railing systems for heavier vehicles. One project evaluated an energy absorbing system which used the deformation of steel rings as the primary energy absorber. Kimball et al. (11) conducted three crash tests using combination trucks weighing 40,000 and 70,000 pounds. Although the vehicle was contained and redirected in each test, it overturned.

3.4 - Summary

While cable medians are the most forgiving type, they are evidently the most expensive to maintain. Concrete median barriers on the other hand need little attention and are almost maintenance free. The NJ type concrete median barrier appeared definitely superior to the GM type.

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4 - IMPLICATIONS OF SMALL PASSENGER CARS IMPACTING MEDIAN BARRIERS

4.1 - Statistics on Small Cars

The necessity for greater fuel economy has generated many vehicle changes, one of them being in downsizing the automobile. This progressive change in fleet composition has occurred mainly in the last ten years (1975-85). Vehicle weights, which were averaging near 3,500 lbs. in 1983 are now averaging just over 3,000 lbs., and are likely to go down to 2500 lbs. by 1990. Nearly two-thirds of current car sales are now small cars. Table 4-1 provides a summary of the trend toward more small cars in the traffic stream.

Major autombile manufacturers are expected to introduce a two passenger urban vehicle with a weight between 1,000 and 1,500 lbs. in a couple of years (1).

4.2 - Safety Implications

The severity of vehicle-vehicle collision and vehicle-roadside hardware collision accidents are the two major accident categories that have been adversely affected by passenger car downsizing. Probably an area of concern with smaller vehicles is with the safety hardware along the roadside, such as median barriers. Ivey (2) illustrated that roadside hardware according to present design guide lines are only marginally adequate for the 2,250 lbs. design vehicle and that vehicles under 2,000 lbs. cannot be safely accommodated. Figure 4-1 illustrates the

Table 4-1. Large Car-Small Car Fleet Composition

Year	Large Cars*	Small Cars**
1975	75%	25%
1980	55%	45%
1985	25%	75%

* over 3,000 lbs.

** under 3,000 lbs.

Source (1)

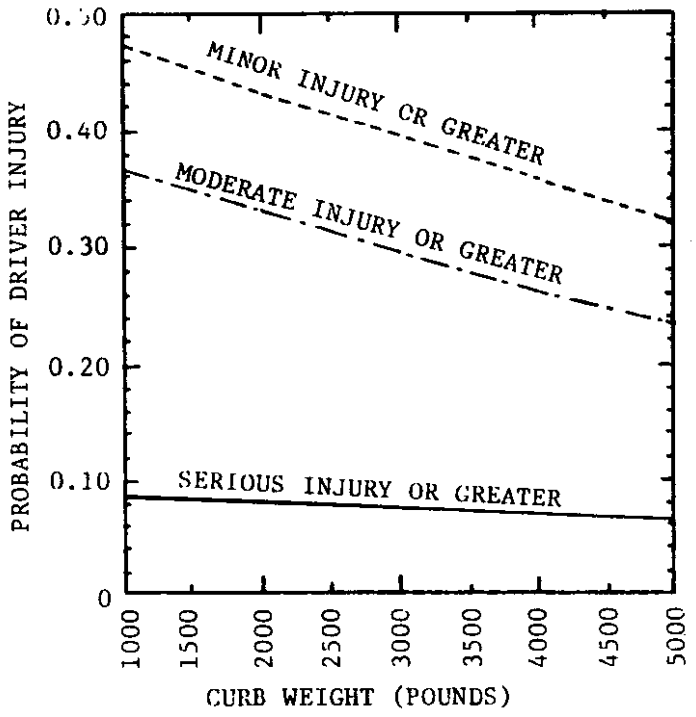

Figure 4-1. Curb Weight and Relative Safety of Guard Rails. Source (1)

probability of driver injury increasing as vehicle weight decreases in collisions with guardrails and median barriers.

With the current trend, it would appear that all hardware designs should be predicated on a 1,600 lbs. vehicle to insure some degree of compatability in the future (1).

4.3 - Median Barrier and Guardrail Implications

For shaped concrete median barriers, the effects of passenger vehicle size on the likelihood of vehicle overturn has been questioned. An earlier study has shown that variations in concrete median barrier profile affect overturn potential and that 2,250 lb (1.02 Mg) vehicles are more prone to overturn than 4,500 lb (2.04 Mg) vehicles in impacts with these barriers (3) Table 4-2 lists the overturn outcome of all 1979 police-reported median barrier accidents for the three most common barrier designs used on California freeways. Passenger vehicle overturns from impacting the shaped concrete barrier occurred at 1.9 times the rate of the cable median barrier and at 3.8 times the rate of the metal beam barrier. For all vehicle classes, overturns occurred from impacting the shaped concrete barrier at 2.5 times the rate of the metal beam barrier. 51 percent of the overturned vehicles weighed less than 2,250 lbs., although these vehicles only account for 24 percent of the passenger vehicle registrations (4).

Figure 4-2 shows the weight distribution of vehicles that overturned on impact with each of the three California freeway median barrier designs. The cable median barrier also shows a vehicle size effect--50 percent of overturns occurred at weights

Table 4-2

MEDIAN BARRIER ACCIDENTS ON CALIFORNIA FREEWAYS, 1979

Accident type	Concrete (MB5)		Median Barrier Type Cable (MB1)		Metal W beam (MB4W)	
	Number	Percent	Number	Percent	Number	Percent
Total accidents	1,796	100.0	2,305	100.0	2,004	100.0
Total overturn	177	9.9	143	6.2	78	3.9
Passenger vehicle overturn	123	6.8	83	3.6	37	1.8
Non-passenger vehicle overturn	54	3.0	60	2.6	41	2.0

Source: (4)

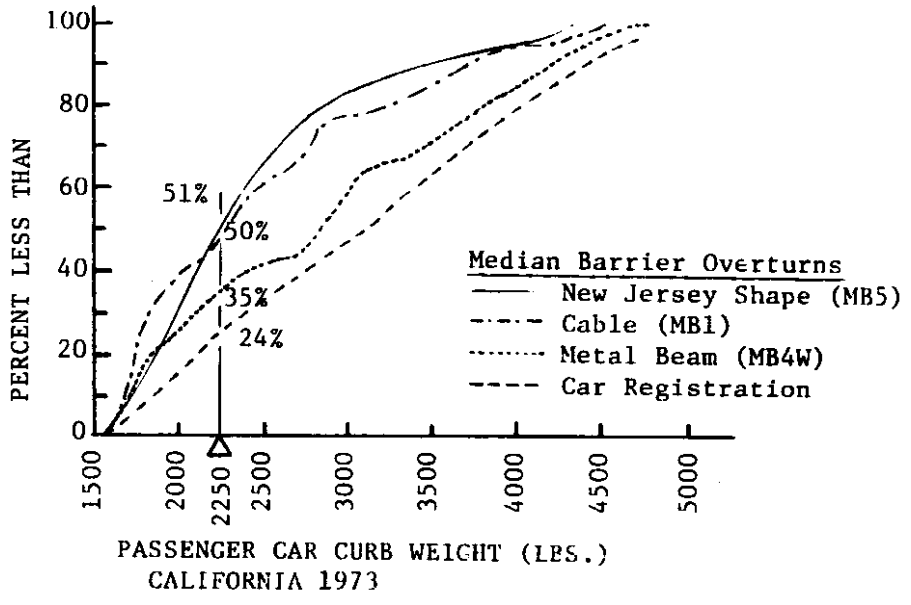

Figure 4-2. Curb Weight of Passenger Vehicles That Overturned After Impacting Median Barriers. California Freeways, 1979. Source (4)

less than 2,250 lbs. (1.02 Mg). The metal beam barrier distribution is much closer to the registration weight distribution (4).

The concrete median barrier (CMB), while a positive barrier, has increased the roll potential of small cars. Front wheel drive vehicles tend to climb the CMB (1).

The rollover problem is not unique to CMBs. There is a general trend for lighter vehicles to roll over after impacts with roadside obstacles, roadside slopes, or other vehicles. The trend is most graphically illustrated by a curve developed by the Texas Transportation Institute Accident Analysis Program (Figure 4-3) (4).

Full-scale tests have shown that the General Motors (GM) Concrete Safety shape profile can cause cars weighing 2,250 lbs or less to roll over (3). Therefore, the use of the GM shape has been recommended to be discontinued for new construction in favor of the New Jersey safety shape. The New Jersey shape has successfully redirected 1,800 lb cars at 50 mph in tests at 15 to 20 degrees (6). Another profile known as the F shape (see Fig 6.1) has also been shown by analysis and tests to reduce the tendency of small cars to roll over after impacting a concrete barrier (3). In view of extensive research and full-scale tests the following recommendations are suggested (3):

1. Both configuration F and the New Jersey shapes are recommended for installation. Agencies which already have the New Jersey shape as a standard should find it more economical to continue to use it in the future.

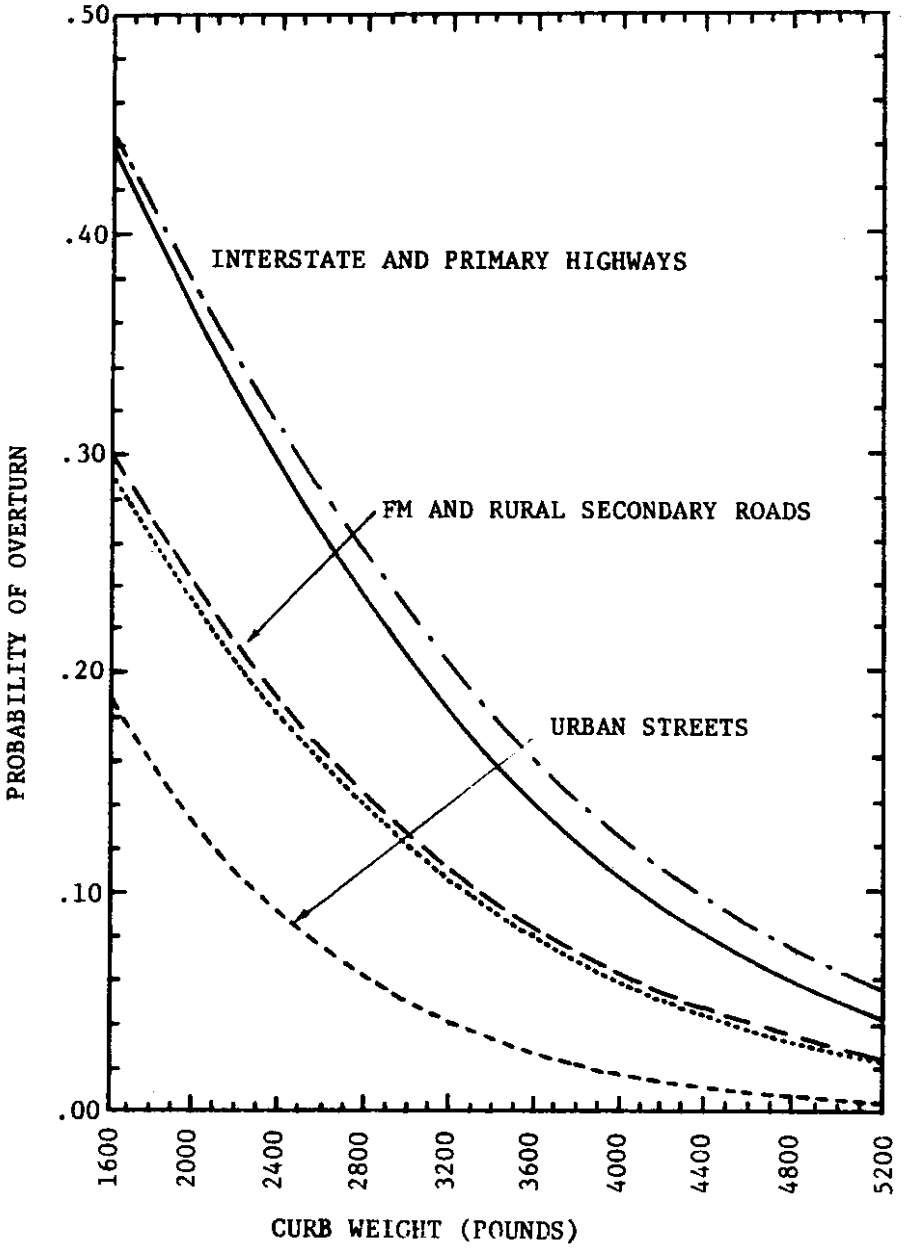

Figure 4-3. Vehicle Weights vs. Overturn Probability. Source (1)

2. Standardization of the shape is important, particularly for economic consideration of cast-in-place and precast barriers. Any modifications to the New Jersey shape or configuration F shape are considered both unnecessary and unjustified.
3. Open joints in CMB construction should be spaced at maximum intervals to take advantage of barrier mass and to minimize reinforcement required at joints to effect consistent strength.

Tests with 1,800 lb cars on a vertical-faced concrete wall have shown that a vertical barrier minimizes vehicle instability. Tests have also shown that a drainage depression 11 ft away from a concrete median barrier can cause an 1,800 lb car to roll over after impacting the barrier at 60 mph at 15 degrees (7,8). Roadside features such as drainage depressions and curbs, that impart a roll moment to the vehicle and compress its front suspension just prior to impact, are to be avoided if concrete barriers are to perform as intended.

4.4 - Summary and Conclusions (1)

Many important points have been made in this section and several conclusions can be drawn from them. They are:

1. The small car is not coming, it is already here.
2. Design may have to adapt to it in the future.
3. More severe accidents with highway hardware may be expected in the future, based on the limited experience reported to date.

4. The New Jersey type and configuration 'F' type of concrete median barriers have proven successful in full scale tests and in practice, and are therefore recommended for installation.
5. The bottom line, of course, is that without specifics regarding individual site configurations and corresponding accident date it is not possible to recommend what action should be taken on a state-wide basis.

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5 - THE PROBLEM OF HEAVY VERSUS SMALL VEHICLES

5.1 - The Problem

After many years of little change in the composition of highway traffic we are now experiencing a dramatic shift to smaller passenger cars and bigger, wider and heavier trucks. This combination is most unfortunate for the roadside barrier hardware designer. Since roadside hardware, such as guardrails and median barriers, was essentially designed to function with passenger vehicles (2000-4500 lb) in mind there is growing concern, supported by recent accident statistics and also by preliminary crash tests, that current roadside hardware will not function efficiently with vehicles that weigh over 4500 lbs. Moreover, as a result of the increase in bus and truck traffic, there is further concern that current roadside hardware will prove to be inadequate for heavy vehicles. This fact could easily lead to higher severity rates of roadside collisions.

Table 5-1 gives some characteristics of the static and dynamic properties of typical test vehicle (1). The heavy vehicle poses an entirely different set of problems to the road side hardware designer as compared to the small car. Some basic problems are described below:

1. On impact, the heavy vehicle may possess kinetic energy that is 40 times greater than that of a passenger car. Median barriers must therefore be substantially stronger in order to contain and redirect the heavy vehicle.

TABLE 5-1

Static and Dynamic Properties of Test Vehicles [a]

Designation	1800S	2250S	4500S	20,000P	32,000P	40,000P	80,000A	80,000F
Type	Minicompact Sedan	Subcompact Sedan	Large Sedan	Utility Bus	Small Inter-city Bus	Large Inter-city Bus	Tractor/ Van Trailer	Tractor/ Fluid Tanker
Mass—lb								
Test Inertial[b]	1800 ±50	2250 ±100	4500 ±200	13,800 ±500	20,000 ±750	29,400 ±1000	—	—
Dummy[c]	165	165 ±165	165 ±165	6,200 ±500	6,000 ±1,000	6,000 ±1,000	—	—
Ballast (loose)[d]	0	0	0	0	6,000 ±1,000	4,000 ±1,000	—	—
Gross Static[e]	1950 ±50	2500 ±100	4500±300	20,000 ± 500	32,000 ± 750	40,000 ± 1000	80,000 ±2000	80,000 ±2000
Typical Mass Moments of Inertia[f] lb-ft-s²								
I_{zz}—Yaw	667[h]		4167	48,000		125,000		
I_{yy}—Pitch	496[g]		4625	51,600		156,500		
I_{xx}—Roll	150[g]		—	5,660		23,000		
Typical Center of Mass-in.								
g—Height from grade	19.5	21.8	27.0	41		55.8		
h—From front axle	32.1	40.5	49.8	159		216		
c—Wheel base	87.0	97	121	254		260		
Reference DOT-FH	11-9287 11-9486	11-9462	11-8130	11-9462		11-9462		

Notes:

(a) Many of the vehicles and vehicle property requirements are new with this document; hence, typical data have not been measured or reported. Test agencies should measure and report vehicle properties in a format shown in Figures 1 and 2 in Chapter Four. Vehicle masses (test inertial, dummy, ballast and gross static) and center-of-mass location should be physically measured for each test vehicle; mass moments-of-inertia may be acquired from appropriate references for identical vehicle type and loading arrangement.

(b) Includes basic vehicle structure and all components, test equipment and ballast that are rigidly secured to the vehicle structure. This mass *excludes* the mass of anthropomorphic and anthropometric dummies, irrespective of restraint conditions, and ballast and test equipment that are not rigidly secured to the vehicle structure.

(c) For 1800S vehicle, one 50th percentile anthropometric or anthropomorphic dummy is specified; for other vehicle types, occupant mass may be simulated by 50th percentile anthropomotric, anthropomorphic, bags of sand or a combination thereof. See text for position and restraint conditions.

(d) Ballast that simulates cargo and test equipment that is loose or will break loose from tie-down during early stages of appurtenance collision.

(e) Sum of test inertial, dummy, and loose ballast mass; all component masses should be within specified limits.

(f) For vehicle in test inertial condition.

(g) Value for unloaded 1976 Honda Civic (dry fuel tank and mass of 1509 lb); value for 1800S vehicle will be slightly higher.

(h) Value for 1976 Honda Civic (curb mass of 1758 lb) with test instruments but without dummies at 1834 lb.

2. The median barrier must also be placed higher to properly interact with the larger vehicle, and its relatively higher center of mass.
3. Structural and foundation requirements of the barrier to sustain the intense dynamic force applied some distance higher above grade is technically feasible but more costly.
4. A special softening feature or staging may be required in the stiff structure described in (3) to safely accommodate the small car impacts, which are likely to be more numerous.

5.2 - Effects of Double-Trailer Trucks

As a result of the Surface Transportation Assistance Act of 1982, multi-trailer combinations are being increasingly used on the highway system. The most common configuration is two 28 ft. semi-trailers coupled by a dolly and pulled by a truck tractor. This Act directs that states cannot prohibit the operation of double trailer trucks on Interstate highways and on a system of other principal roads to be designated by the U.S. Secretary of Transportation. At the same time, Congress made a number of other changes in truck size and weight regulations that also provide new options to the trucking industry and influences its selection of equipment. These include provisions allowing 48-ft. single trailers, and vehicle widths of 102 inches on designated roads nationwide, and 80,000 lb trucks on all Interstates. After numerous revisions to the Act, negotiations with various states, and court challenges brought by several parties, including states, the U.S. Department of Transportation published its final

version on June 5, 1984, designating 181,000 roadmiles, including all Interstates and 55 percent of federal-aids primaries (3).

5.3 - Safety Consequences in General

Most objections to allowing increased use of doubles can be traced to concern that doubles will be less safe than conventional single-trailer trucks. Several studies, based either on statistical analysis or on actual accident data provide information on the relative safety of doubles, but accident study results are more directly applicable to predicting the changes in life and property losses that would result from a change in the mix of vehicles on the road.

Some of the more recent studies report that doubles have higher accident rates than singles,while others indicate either no appreciable difference, or that doubles are actually safer than singles in certain circumstances. Many of these findings have been questioned, because of methodological short-comings or doubtful data (4,5).

5.4 - Accident Studies Involving Median-Barriers and Heavy Vehicles

Although considerable effort has gone into the development of more forgiving roadside features with respect to the car, the development of barriers to contain heavy vehicles was, until the mid-1970s, thought to be infeasible, because cars represented the majority of vehicles on the road.

Research on the effects of heavy vehicles on median barriers has been meager and comparatively recent. It is not uncommon for large trucks, because of their weight and high center-of-gravity,

either to penetrate a traffic barrier or to overturn upon impact, rather than be redirected upright on a non-collision course. In a limited sample (68 cases) of truck accidents involving median barriers and guardrails, Vallette (6) found 35 percent of trucks striking guardrails mounted on wooden posts penetrated or vaulted the guardrail compared to 19 percent for guardrails with steel posts. Other evidence of the inadequacy of guardrails and medians for trucks was cited by Post (7). He reported that the number of trucks involved in traffic barrier fatal accidents in Texas increased from 16 to 21 percent over a 2-year period in the early 1970s. These cases prompted impact testing of large trucks into several types of barriers. Post did preliminary testing by running a loaded combination truck weighing 48,000 lb into a standard NJ CMB at a speed of 35 mph and an approach angle of 19 percent. The barrier proved adequate and only minor damage occurred to both truck and barrier (7).

Research by Dynamic Science, Inc. (8) established the upper performance limit of concrete median barriers. In a 40,000 lb cabin over engine combination truck, the tractor and the front of the trailer climbed the top of the barrier. Tests are still being done.

FHWA research is underway at the Texas Transportation Institute on barrier systems for heavy trucks, primarily concentrating on school and intercity buses. FHWA and the NJ Turnpike authority are developing a high performance median barrier capable of successfully redirecting an 80,000 lb combination truck without rollover.

5.5 - Summary and Conclusions

Given the confusing results of available single- versus double-trailer truck safety studies, and the effects of heavy trucks on median barriers, it is not surprising that this issue is unresolved. An ongoing 2-year research being done by the Transportation Research Board is assessing the safety implications of increased use of heavy trucks, including doubles (3). It would therefore be premature to recommend what ought to be done even in the short-term.

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6 - NEW TRAFFIC BARRIERS AND MEDIANS AND RECENT MODIFICATIONS TO EXISTING SYSTEMS

6.1 - Trends in New Design

The recent trends in vehicle size have had a significant impact on median barrier hardware design. Most new hardware is the results of simulations, theoretical design work and full-scale crash tests. The median barrier systems described in this section are ones that have a high probability of being adopted as operational barriers in the years ahead. It must be realized that the trends in passenger cars getting progressively smaller and commercial vehicles getting larger is a comparatively recent phenomenon; time and experience will therefore be needed to objectively assess the effectiveness of the new hardware.

6.2 - Self-Restoring Traffic Barrier (SERB) (1,2)

The self-restoring barrier (SERB) was designed to accommodate vehicles ranging in size from minicompact automobiles to inter-city buses. A secondary consideration was the development of a barrier which would require little or no maintenance after low angle impacts, and would remain serviceable even after severe hits. Four highway agencies installed a SERB at high-accident locations. Based on accident experience to date, the SERB is performing as designed and has required virtually no maintenance when hit.

The SERB median barrier was designed to deflect only 2 ft (610 mm) during a 60 mph (96.5 km/h) impact with a 40,000 lb (36,280 kg) intercity bus at 15 degrees so that it could be used

in narrow medians. This self-restoring barrier has a strong beam section that consists of two thrie beams bolted to a pair of open-web steel joists. The beam section is hung on steel posts that have a steel cap. This cap permits the beam section to translate 3.5-in (89 mm) laterally and to rise 6-in (153 mm) before bottoming out against the steel posts. After a collision, the beam section slides back down the cap to its original position.

Advantages of the SERB guardrail systems when compared with other metal barrier systems include the following:

1. Damage repair from typical shallow-angle impacts is projected to be minimal;
2. Forgiving redirection is provided for all cars as well as containment of heavy vehicles under severe impact conditions;
3. The 1.2-m maximum deflection during the intercity bus test (a design goal) makes application of the SERB guardrail to current roadside clearances reasonable even when heavy-vehicle containment is a serious consideration.

Advantages of the SERB system when compared with concrete barriers include the following:

1. Stable redirection of all classes of cars with minimal rollover potential;
2. Demonstrated performance with heavy vehicles such as the school bus and the intercity bus;
3. Demonstrated well-behaved performance without variables such as foundation support and rebar configurations, i.e.,

lightly reinforced to heavily reinforced concrete barriers and minimal to substantial foundation support; and

4. Definite advantage in performance for high angles of attack, i.e., those greater than 15 degrees.

6.3 - Ontario Ministry of Transportation--Highway Median Barrier (3)

A new highway median barrier system has been installed by Ontario's Ministry of Transportation and Communications on a 2.3 mile section of highway in North York, near Toronto. The system is a series of topless, bottomless boxes made from rollformed sheet steel. The boxes are joined end to end to form a continuous chain, after which they are filled with sand or gravel. A steel lid is then bolted on. The barrier is not anchored to the ground at any point. When filled, it weighs 1,100 pounds per foot.

The barrier combines life-saving energy absorption with virtual impenetrability. When deflection reaches a certain point, sufficient tension is built up along the barrier to begin to contribute to redirection. In tests involving vehicles of different sizes, as well as different speeds and angles of impact, it was discovered that, when a car weighing 1,670 lbs. traveling 69 mph at an angle of 20 degrees strikes the barrier, the sand inside provides the support required to allow the steel panel to deform only as much as is needed for safe redirection. Control of the vehicle appeared to be good throughout this test. A 2,000-lb car at 59 mph and at an angle of 15 degrees was lightly damaged and was drivable after impact. A 4,500-lb car at

62 mph at a 25-degree angle caused more damage to the barrier than the lighter cars but remained upright. The barrier moved 10 inches, while the side of the barrier in direct contact with the vehicle was deflected 20 1/2 inches.

Standard dimensions of the barrier are 42 inches high by 44 inches wide, with a base width of 28 inches. The side panels are 11 1/2 feet long. On the North York highway, the barrier is coated with polyvinyl-chloride and on the inside bin, a polyethylene film produced by Dow Chemical is bonded to the sheet by heat and pressure. Barrier sections are erected quickly and easily by hand on-site since all components are light enough for two workers to handle. The barrier can be assembled at the rate of 200 feet per hour. When repairs are required, damaged bins are emptied using a pneumatic drain cleaner.

The only other installation in actual use is in Florida, where it has been extremely successful. The system is also undergoing tests in the U.K.

6.4 - Continuous Concrete Median Barrier without Footing

The original California DOT (Caltran) barrier design included a 10-inch deep by 24-inch wide continuous footing that helped ensure barrier integrity. This time-consuming process of installingbarriers on existing highways not only caused traffic delays but also had the potential for causing construction-related accidents. Hundreds of miles of concrete median barriers were constructed in the 1970s and 1980s. In the early stages barrier slip form machines were used to cut construction time.

However, based on a recently conducted research started in 1976, Caltrans recommended that the footing be eliminated. Caltrans amended its standard plans for concrete median barriers to eliminate the footings. One continous #4 rebar was added to the upper stem to help prevent broken chunks of concrete from flying into opposing traffic lanes in severe impacts. Two continous #4 rebars were added at the bottom of the barrier to minimize lateral movement and to maintain reserve strength of the barrier in very severe impacts. The redesigned barrier can be slip-formed directly on top of pavements or on a compacted aggregate base in one operation. The barrier still remains connected to bridge decks by means of a dowel.

Caltrans estimates an average savings of $5 per linear foot for such barriers. In a 3-year period ending June 30, 1981, Caltrans built 292,000 linear feet of barriers for a savings of over $1,460,000. These barriers were installed more quickly and with less disruption to traffic than were the old barriers with footings. (4,5)

6.5 - Median Barrier Proposed and Tested by International Barrier Corporation (IBC)

The IBC median barrier system is the U.S. version of the median barrier described under 6-2. A series of topless, bottomless boxes or bins made from sheet metal are joined end-to-end to form a continous chain, and then filled with sand or gravel. In fact, it is the fill that does most of the work of safety redirecting wayward vehicles by absorbing impact energy. It is claimed that the IBC barrier combines the energy absorption

of a deformable barrier, and the virtual impenetrability of the non-deformable barrier, while requiring less maintenance than any other deformable system. The tests conducted on this barrier system demonstrate that it is efficient across a wide range of vehicle sizes and shapes (6).

This energy absorbing barrier has a multi-stage response to vehicle collisions. When the IBC barrier was impacted with a 1,670 lb (757 kg) car at 69 mph (111 km/h) and 20 degrees, the metal sidewall deflected just enough to safely redirect the vehicle. A 60 mph (96.5 km/h) impact with a 4,500 lb (2,040 kg) car at 25 degrees caused more distortion of the barrier and displaced more sand, which absorbed a greater amount of kinetic energy. This 42-in (1,067 mm) high median barrier deformed in the impact zone and slid laterally to redirect a 20,000 lb (9,070 kg) school bus at 53 mph (85 km/h) and 15 degrees (8).

6.6 - Concrete Median Barrier Research (Southwest Research Institute, San Antonio, CA) (8)

Based on the work done by Bronstad et al. at the Southwest Research Institute the following conclusions were arrived at:

1. Continued use of the General Motors shape would result in an increasing number of vehicle rollovers due to the increasing population of small vehicles.
2. Minimal reinforcement and foundation restraint are required to sustain heavy vehicle impacts and effect redirection based on a 53 mph (85.3 km/h), 16 degree angle impact with a 40,000 lb. (18,000 kg) bus.

3. The CMB has been an effective deterrent to crossover accidents while performing within acceptable vehicle deceleration ranges for angles up to 15 degrees. Impacts at 60 mph (95 km/h) and 25 degree angle are violent and somewhat independent of the shape.
4. The CMB has significant advantage over yielding barriers when considering damage repair/maintenance costs.
5. Based on observations of tests in this program and others, it is concluded that a 3-inch (75 mm) overlay placed at the base of the CMB would not have resulted in vehicle mounting the barrier top or otherwise going over. It is recognized that impacts not investigated in this and other programs might result in vehicles mounting the barrier or otherwise going over due to the resurfacing.
6. Both Configuration F and New Jersey shapes are recommended for installation. Agencies which already have the New Jersey shape as a standard should find it more economical to continue its use. States without significant CMB usage or users of GM shape are encouraged to evaluate the findings with regard to changing shapes. See Figure 6-1.
7. Standardization of the shape is important, particularly for economic consideration of cast-in-place and precast barriers. Any modifications to the New Jersey shape or Configuration F shape are considered both unnecessary and unjustified. For this reason nationwide standardization on the New Jersey shape is worthy of consideration. It must be

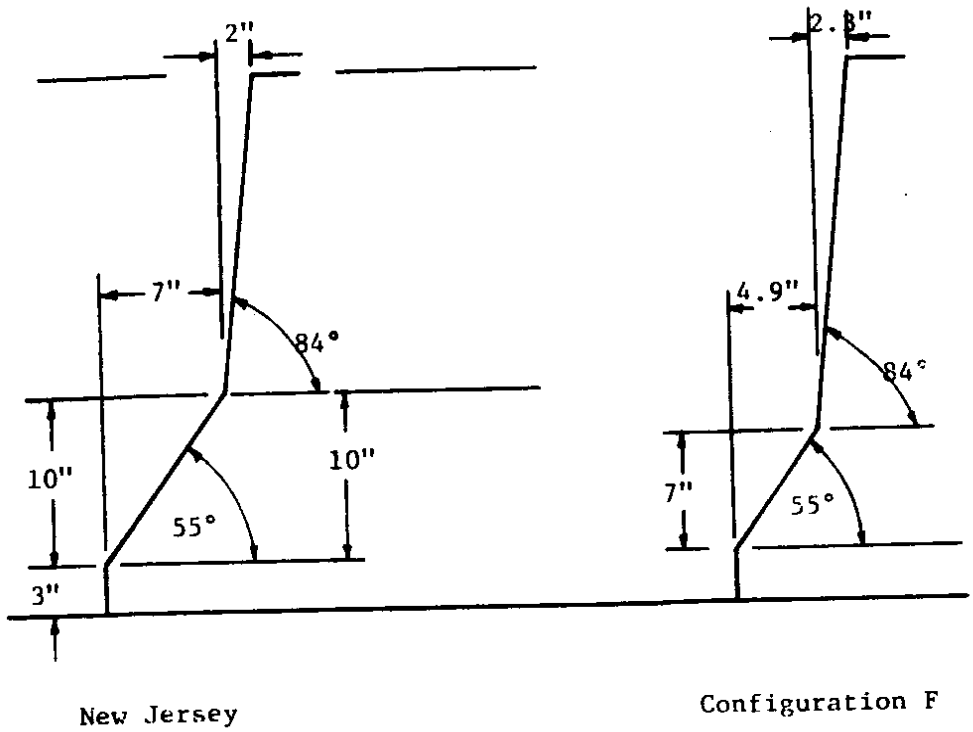

Figure 6-1. Configuration of Concrete Median Barriers.

noted that the fleet composition has changed since Bronstad's work was published.

6.7 - "Tall Wall" Median Barrier

A new 3½-ft-high (1.06 m) concrete safety-shape barrier, known as the "Tall Wall," has successfully redirected an 80,000 lb (36.3 Mg) tractor-trailer at 53 mph (86 km/h) and 15 degrees. This high performance barrier, developed in cooperation with the New Jersey Turnpike Authority, has also successfully redirected a 4,500-lb (2.0 Mg) sedan and a 1,800-lb (0.8 Mg) minicompact sedan at 60 mph (97 km/h) and 15 degrees. Tests with 1,800-lb (0.8 Mg) minicompact cars have shown that a drainage depression along a concrete median barrier can cause small cars to roll over.

The barrier is 12-in (305 mm) wide at the top. It contains a significant amount of longitudinal reinforcing steel and closed loop stirrups that transmit the flexural and torsional moments along the barrier. This distribution of impact forces along the length of the barrier is a key concept in designing traffic barriers that can contain heavy vehicles. The lower part of the concrete barrier profile is essentially a New Jersey profile with its 3-in (76 mm) reveal obliterated with a layer of asphalt. In other words, it has the same shape that the New Jersey profile will have after multiple pavement resurfacings. This new profile is very similar, but not identical to, the F shape. The new concrete median barrier has also successfully redirected 1,000 lb (815 kg) and 8,500 lb (2,040 kg) cars at 60 mph (96.5 km/h) and 15 degrees (9).

6.8 - Moveable Concrete Median Barrier

A moveable concrete median barrier is being developed that can be transferred from lane to lane at speeds of up to 10 mph (16 km/h). The barrier is made of hinged segments of New Jersey or F shape concrete barrier. Each precast barrier segment is 2.5 ft (1 m) long and has a concrete T cast in its top. When the barrier is moved, a trailer-mounted roller conveyor engages the T sections, lifts the barrier segments and transfers them through an S-shaped path to the other lane (10). This movable concrete median barrier is intended for contraflow lanes on bridges, but it may also have applictions in construction work zones.

6.9 - Summary

Over the years researchers have recommended modification to existing systems by systematic upgrading and they have also suggested new systems with higher performance to meet current demands. Some of the new systems tested are as follows:

1. The self-restoring barrier (SERB) is designed to accommodate vehicles ranging in size from minicompact cars to intercity buses.
2. The International Barrier Corporation (IBC) has come up with a unique median barrier system which is able to handle vehicles from mini-cars to 20,000 lbs. school buses.
3. Both configuration F and the New Jersey concrete median barriers are able to handle small cars as well as heavy vehicles (40,000 lb), and have significant advantage over semi-rigid barriers when considering damage repair and/or maintenance costs.

4. The "Tall Wall"-3½ ft concrete safety-shape barrier has successfully redirected 80,000 lb tractor trailers as well as 1800 lb minicompact sedans.

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