ROADSIDE HAZARDS

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The Need for Highway Safety Consciousness

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An Evaluation of Roadside Hazards on the Interstate System

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FOREWORD

For almost a decade since 1959, three years after the start of the greatest public works program ever conceived, the Special Subcommittee on the Federal-Aid Highway Program has served Congress as a monitor of the entire project. Under the leadership of Chairman John A. Blatnik of Minnesota, the Subcommittee has carried out its mandate to inquire into the policies, practices, and procedures involved in the administration of the Federal-Aid Highway Program.

The sustained investigative activity, public hearings, and Interim Reports of the Subcommittee have had a profound effect on administration of the highway program. They have produced significant organizational changes, not only in the Bureau of Public Roads but in the highway departments of the states. Far-reaching corrective measures on a national scale have been achieved.

As part of recent inquiries, the Subcommittee held hearings on the subject of roadside hazards affecting the safety and well-being of highway users. These hearings are reported fully in "Highway Safety, Design and Operations—Roadside Hazards" (90–21), House of Representatives, Ninetieth Congress, First Session.[1] Abstracted here, in articles by Chairman John A. Blatnik and by Charles W. Prisk, who was consultant to the Subcommittee in the inquiry into highway design and operational efficiency, are some of the significant findings developed through the hearings.

Signs of shortcomings in some present practices are demonstrated herein. They increase awareness of what constitute roadside hazards. But equal, if not greater, attention is given to recognizing examples of good design. Corrective procedures, accomplishable by operations and maintenance forces of highway agencies, are suggested to deal with the varied types of existing hazards. Recommended design practices are noted for the benefit of highway planning and design staffs in preparing future projects for construction.

1. U. S. Government Printing Office, Washington, D.C., 1968.

The Eno Foundation is pleased to make this information more widely available and to assist in the dissemination of Subcommittee findings. It is hoped that this publication will reach those who may derive the greatest technical benefit from the hearings' results. Translation of the recommendations into practices can help to assure all road users the benefits of safe and efficient highway travel.

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THE NEED FOR HIGHWAY SAFETY CONSCIOUSNESS

JOHN A. BLATNIK

Representative Blatnik is Chairman of the Special Subcommittee on the Federal-Aid Highway Program. The article which follows is based on the Subcommittee's highway safety hearings. Mr. Blatnik (D) was elected to the United States Congress in 1946 from the 8th Congressional District in Minnesota; he served in the Minnesota State Senate from 1941 to 1946. He has been a member of the House Committee on Public Works for twenty years. He is Chairman also of the Rivers and Harbors Subcommittee, and is ranking member of the Public Buildings Subcommittee. He is Chairman of the Executive and Legislative Reorganization Subcommittee of the House Committee on Government Operations. He is the author of many bills which are now public laws and takes special pride in having co-authored the 41,000-mile Federal-Aid Highway Act of 1956. His other special interests lie in the fields of community facilities and development; use and conservation of our natural resources; education, including vocational training; and regional economic development.

It would seem that today's automobile owner never had it so good. His car has air conditioning, stereophonic tapes, disc brakes, peek-a-boo lights, power steering, power windows, power seats, adjustable and telescoping steering post, and a host of other features meant to make his driving more safe and more pleasant. He is able to get into this luxurious palace and drive on superhighways from New York to Chicago without the interference of a single traffic light; soon he can so drive from one end of the country to another. Yet more and more a chill, almost a fear, is supplanting what used to be the sheer pleasure of driving, and a corresponding waning of confidence stealthily creeps in.

There is no paradox here. The motorist's common sense tells him that something is really wrong, that he cannot rely entirely on the glories of his car and of the road to keep him safe, because despite them 53,000 people are killed and 2,000,000 more are injured on our highways each year. One can hardly blame the motorist for feeling short-changed. After all, he spent thousands of dollars for the car and billions upon billions for the roads. Could not all this money have bought him better than the one chance in four that his car would become bloodied in a highway accident?

Recently, safety hearings before our Subcommittee on the Federal-Aid Highway Program proved conclusively that the quantity and quality of safety put into our nation's roads at the cost of those billions were substantially less than a more thoughtful approach to safety could have provided.

Our purpose is not to blame anyone for this. Overall, those whose responsibility it has been to design and construct roads have accomplished much. In contrast to his father, today's motorist enjoys such safety features in his road as multiple lanes, divided highways, limited access, separated grade crossings, shoulders and wider shoulders, better sight distances, and gentler curves. Our purpose is simply to do what we can to help recognize where we could have done better, to help correct what is wrong, and to do all we can to assure that past mistakes will not be repeated.

The emphasis placed on safety by the Federal-Aid Highway Act of 1956 was a major reason Congress so strongly supported it. To me safety is the most essential ingredient of the highway. In 1955 there were almost 37,000 highway fatalities. The figure appalled me. In 1956 I applauded the wisdom of Congress and the willingness of the people to spend so much on roads. Surely, if no other benefit were derived from that expenditure than a severe curtailment in that death rate, every dime will have been well spent. In 1956, however, the deaths climbed to more than 38,000. Surely, I thought, as we complete more and more of the program, the trend toward more highway deaths each year will be stemmed, hopefully reversed, and eventually reduced to a minimum.

What has in fact occurred is tragic history. There followed a relatively static period between 1956 and 1961 with an average annual death toll of about 38,000. Then the lid blew off: in 1962 there were 41,000 deaths; 1963, over 42,000; 1964, over 47,000; 1965, 49,000; 1966, 53,000. There are those who offer no comfort for the years to come; some estimate as many as 75,000 to 100,000 annual highway deaths within the next ten years.

How can we fully comprehend the magnitude of 100,000 deaths?

For years we have been trying to by saying that highway deaths in a year were more than those killed in this war or that war, or from this disease or that disease. This impresses me as it does you, I am sure. But I am much more impressed when I consider the 100,000 as a multiple of one: my son. If you consider your son as the one, together we are going to do all that can be done to keep him from becoming a statistic.

Perhaps we can begin by asking, "Why?" Why, with all the money that is being spent, have deaths increased 40 percent over the past six years? Increased vehicle registrations? Hardly, since that increase has been only 24 percent. Increased traffic mileage? The increase has been only 28 percent. To get the answer so far as it is obtainable, the Committee embarked on a study of design and operational safety on the nation's roads and streets, of which there are approximately 3¾ million miles.

We are concentrating a safety spotlight on the highway because it is an integral part of the trinity from which highway safety emerges. The other two integral parts, man and the machine, have received and will continue to receive great attention from other quarters. Whether this is a trinity in which all are equal, I do not think anybody knows. What I do know is that past efforts to give the dominant role to the man without due consideration to the other parts is to close one's eyes to the truth and to court continuing disaster. Man is just that—a being created by God in His likeness but with severe limitations which inhere all through a man's life. Sometimes, I fear, we expect a course of conduct from him which his Creator reserved to Himself. Man is flesh and blood desperately trying to use to best advantage for his survival imperfect eyes and ears, limited intelligence, and a complex of emotions bearing on his conduct that no one fully understands.

Consequently, those concerned with highway safety must be keenly aware of man's limitations and must not be taken in by those who would ascribe the majority of accidents to driver failure, or "to the nut behind the wheel." The word "failure" is too often misused in connection with the driver. To fail means to fall short of doing what one is able to do. When a driver falls victim to an accident despite his best efforts, it may not be the driver who has failed.

At present great attention is being given to the role of the machine in an accident. Certainly the machine is an integral part of the trinity but whether it is dominant, I do not know. I do know that the machine and the highway have something in common. Applying here the thought of a renowned jurist, both are of such a character that, when applied to the purposes for which they are designed, they are likely to become a source of great danger if not carefully and properly constructed.

Confining our attention to the road, let us scan what our hearings have suggested are potential sources of great danger. Joined together in a way reminiscent of Marley's chain are improper signing; poor skid-resistant qualities of the pavement; obstructed or poor sight distance; lack of lighting; unimaginative geometrics in regard to, for example, passing lanes, curves, curbs, slopes, and just about every other aspect of the road, including the right-of-way itself.

DANGERS IN ROADSIDE DESIGN AND CONSTRUCTION

Our Subcommittee has made an in-depth study of still another potentially dangerous component of the road, the roadside. This study proved beyond the shadow of a doubt that the roadside in too many cases has been designed in a manner so fraught with danger as to be comparable, without overtaxing the imagination, to tank traps. Testimony at our hearings, abundantly documented by hundreds of photographic slides, pointed out that some of the traps are openly laid. The unyielding light posts, the massive signposts, the sturdy trees, the exposed bridge abutments are all more than a match for any car or any truck, for that matter. Any vehicle colliding with them is torn apart and, barring a miracle, its occupants are, too. And does the collision have to be at a speed of at least 70 mph? No; 30 mph will do as well; 30, 40, 50, or 100 mph do not make much difference. Dead at 30 mph is no less dead than at 100.

Other traps, equally lethal, are laid more subtly. They have all the refinement of a booby trap. An attractive bridge railing, the motorist thinks, seems capable of keeping some car from hurtling off the structure. However, we learned that many attractive bridge railings have great lethal potentiality in their inability to retain a vehicle on the bridge even at low speeds.

Then there is the guardrail around a post—a light post, a signpost or perhaps just a post. It is placed there in many instances, we learned, because the post has been knocked down a few times and it's high time it was protected. This seems logical but it isn't. The logical thought is how can we protect the driver from that post. Too often we found that regardless of the motivation, the guardrail was placed in the shape of a V about the post. If a hapless driver should hit the apex of that rail, it could tear up his car (and him, too).

A guardrail along the edge of the road separating the road from some hazard, perhaps a ravine, also lends an aura of security to the motorist. But it is often a multipurpose snare. If the approach end is exposed, it can shear through a car and harpoon the occupants; if the rail is placed too high, it can cause a car to snag beneath the rail; if placed too low, it can cause a car to hurtle it; if a washer is not affixed to the bolt head, the rail can tear right over it; if there are spaces between the lengths of rail, the length struck can give and guide the vehicle headlong into an exposed end of rail that then becomes a harpoon; if the guardrail ends at an abutment, the vehicle striking the rail can be guided along it like a train on a track directly into the impenetrable abutment.

The frequency with which these traps are sprung and succeed in snaring victims is such as to alarm and astonish us all. Of the 53,000 highway deaths and the two million disabling injuries in 1966, many thousands involved a roadside hazard. What this means is that there exists a good probability that in 1966 a substantial number of those lives could have been saved if the roadside hazards had been previously removed or properly shielded.

It is the height of cynicism to contend that the drivers should never have left the road or that many of them must have been drunk, or that somehow the driver was at fault. Why or how he left the road is not the issue. Whether he left because he was drunk, or stealing a kiss, or because he suffered a bee sting, dozed, had a blowout, was sideswiped, or was forced off is irrelevant to road builders. What is relevant is that those who are responsible for road construction recognize that the roadside is as vital to the safe operation of a vehicle as the pavement itself, and that the duty to make that roadside safe is a very real one.

The great responsibility in regard to safer roadsides is obvious to anyone who drives with his eyes open. Drive down any stretch of road and it is readily recognizable that real danger lies in what happens to an errant car after it leaves the pavement. If only someone had not left that post there, if only someone had used common sense installing the guardrail, if only someone had used the wasted earth to make a gentler slope, if only someone had thought to lap the guardrail around the abutment, if only any one of a hundred roadside installations had been given just a second look, accident trends we so hungrily anticipated in 1956 would be closer to reality today.

EXAMPLES OF IMPROVEMENTS

A good example of what can be accomplished by a second look is the accident experience of General Motors on its Proving Ground, a 75-mile network of roads. General Motors found that its test drivers, despite optimum conditions and effort, would leave the test road out of control about once every 250,000 miles of operation. What thereafter happened to the driver and the car, they learned, largely depended on the condition of the roadside. The roadside condition determined whether the driver would recover control and simply continue on his way or have the misfortune to strike an obstacle or roll over.

Analyzing obstacles that were involved in accidents, GM found in many instances that the obstacle did not have to be. So they embarked on a program of removing the obstacles that did not have to be—like drainage ditches—and protected the driver from the others. The whole motivation behind this improvement was "to provide traversable roadsides, to give a driver time to recover, time to regain control of his car, time either to stop it or direct it back to the road." The result of GM's efforts was an accident record "25 times better than the public highway system. This is 2,500 percent better. It is hard to visualize, because today people are searching for 200 percent improvement, perhaps, in accidents represented on public highways." In the words of Louis C. Lundstrom, director of GM's Automotive Safety Engineering staff, "We are talking about 2,500 percent improvement. It is a fact, and it is proof that it can be done."

This safety record is all the more impressive when one considers that the severity of an accident is not to be measured by whether or not a death occurred. Often only a hair, figuratively speaking, separates accident injury from being or becoming accident fatality.

Is it only the expert like Lundstrom who can perceive what needs redoing on our highways? Our hearings showed that anyone willing to give some thought to the subject can come up with a host of areas requiring improvement. Our hearings opened with a series of slides depicting the types of roadside hazards we are discussing. They were most impressive in that many of them demonstrated the obverse of GM's experiencing the rewards of pinpointing a hazard and correcting it. These slides pinpointed the hazards and then demonstrated the broken and torn bodies, the disintegrated metal that resulted from not correcting them.

This opening presentation was not delivered by any safety expert but by Joe Linko, a Bronx television repairman, whose attention was attracted one day by two formidable posts right next to the pavement of the expressway he was traveling. Common sense told him immediately that if anyone ran off the road at that point and tangled with one of those posts, the post would be the winner hands down. It was inconceivable to this layman that the highway engineers could be aware of the threat posed by these posts. Accordingly, he called them to alert them to the danger. But nothing happened; the posts were not removed. At first Joe Linko was merely bewildered that people he considered incomparably better informed than he did not grasp the importance of the matter and take quick corrective action. Eventually his puzzlement became indignation. Determined to get action by documenting his findings, he began to photograph other roadside hazards he saw. The thousands of photos he made show the same roadside hazards in the New York City areas as the GM experts had discovered on their proving ground. They are in fact the same roadside hazards our staff found throughout the nation. Charles W. Prisk, Deputy Director of the Bureau of Public Roads' Office of Traffic Operations, served as a consultant to the committee, and with members of the staff inspected new highway segments in all nine regions of our nation. The inspection revealed that: (a) the same roadside hazards exist all over the country; (b) even the newest of our highways contain the same type of hazards.

Regarding this inspection, Mr. Prisk testified:

The newest Interstate highway projects in nine states were inspected during the period from April 3 to May 2, 1967, for the adequacy of their design for safety. These improvements appeared to represent impartially the freeway design just now being opened for public travel on the Interstate highway system. Each system was located in a different geographic region of the United States, corresponding with the regions of the Federal Highway Administration. In four states the projects were entirely rural, in two states entirely urban, and in three states a mixture of urban and rural. Roadside hazards were given special attention during the field review and a surprising number of these were observed on all nine projects. Because the projects visited are typical, it is not unreasonable to infer that many of the same weaknesses could and undoubtedly do exist throughout the 25,000 miles of the Interstate System that are now in use.

The most indigestible ingredient of our roadside hazard problem is that its existence cannot be predicated on ignorance. We have known for years the undesirability of placing nonyielding fixed objects along the roadside. The licking of this problem is not dependent on research coming up with any spectacular discovery; all it demands is that we open our eyes.

As Mr. Prisk so well put it years ago, in 1950,

I sincerely believe that the accident rate . . . in any state, can be cut 25 percent without our having to learn a single new fact about designing for safety. What we must accomplish now will not come by research. It will only come by conscientious determination to give safety a better chance. Streets and highways are expensive. So from the time the first design plans are drawn, we start sniping at the desirable standards to cut the cost estimates. Right-of-way is costly, so we buy less than we should have and try to get along, cramping the cross-section design. Out in the country, the location plans show an isolated sharp curve. What do we do? Well, we decide it is not feasible to do anything and the curve is built, a sure accident trap for the inattentive driver. Shoulders that ought to be 8 or 10 feet wide, we design for 6 feet and save a little dirt and money. This straying away from design standards is what we call being practical. And against this whittling of initial expenditures, we are deliberately gambling with the safety of the next generation, at least. We need to apply more of what we already know about safety in design. People will always be worth more than pavement.

A brief reference to current statistics adds weight to this reference as to how many lives can be saved. Certain studies show that on parts of the Interstate System as high as 60 percent of the deaths involve single vehicles running off the road, and that 75 percent of these then strike something placed or left in the roadside. The remaining 25 percent involve ditches, embankments, and slopes. Startling as these percentages are, the accident relationship of the vehicle and the roadside is even greater when one also considers the number of vehicles striking a roadside obstacle after being involved in a multiple vehicle accident on the paved roadway.

A good question is whether we can afford safety. Our hearings dwelt on this point. From the testimony it is apparent that the available safety dollar can be stretched. The testimony clearly indicated that the situations are multiple wherein the construction of an unsafe roadside actually cost more than safe construction would have cost.

We saw quantities of guardrail either placed where none was needed or placed where a minimum of grading would have eliminated the need for guardrail. In these cases, not only the cost of the guardrail could have been saved but also the costs of labor, maintenance, and replacement. Sign structures costing tens of thousands of dollars were shown to be entirely unnecessary. Many were placed in the vicinity of a bridge which could have supported necessary signing equally as well as the costly sign structures. Overdesigned supports, concrete bridge ends, twin bridge structures with duplicated and often dangerously exposed guardrail, barrier curb for which there was no need, bridge "safety walks" whose contribution to safety is very questionable since the walks act as an obstacle to automobiles and when struck can cause a vehicle to vault, more lighting standards than need be—all these were among the hazards paraded before the Committee that could have been eliminated at a savings in overall construction costs.

In many cases, safety could have been purchased at a nominal additional cost. For example, there was testimony that the cost to construct a light or sign pole with a breakaway base was but pennies more than that for the immovable kind. The conclusion is inescapable that much more can be done safety-wise than has been done with the resources available. There is no disputing that there are desirable safety features which would cost more money. As to these, it seems to me, the construction of no major road can be justified unless it includes the latest in reasonable safety features. If we cannot afford the safety, we cannot afford the road. Safety is as essential as the concrete or asphalt.

But since many of the safety shortcomings of our highway are not due either to a lack of knowledge or money, we must look elsewhere for the key to what has to be done in respect to these. The bits of this key need reinforcing. The first bit is that of communication. The communication gap between the men with knowledge and the men responsible for designing and making the installation must be bridged. It would be a criminal waste of brain power, time, energy, and money to keep prisoner life-saving safety concepts. There must be responsibility for seeing to it that the most up-to-date knowledge of safe highway design is utilized on the highway.

WHAT NEEDS TO BE DONE?

Better communication is also needed among those responsible for the various isolated components which together produce a finished road. Before design is executed, it should be carefully reviewed to assure the construction of maximum safety. Only then can safety features be intelligently installed to perform their function of protecting the driver. The nation can heave a sigh of relief because the first steps in this direction are being taken by the state highway departments and by the federal Department of Transportation.

Strengthening the second bit of the key requires a change in the concept of a highway department's function. From what we saw at these hearings that concept has been to build the road in the first instance and then to hand it over to the maintenance department. This is wrong. This is why mistakes are not corrected; this is why mistakes are repeated; this is why, at times, attempts to correct mistakes result in replacing what was already bad with what is worse.

Highway departments must not regard themselves as "construction agencies" but as the sustaining force of something that is alive. The highway is, in a sense, alive as an artery is alive. Through it flows the lifeblood of our nation. It is subject to embolisms, aneurisms, obstructions, calcifications, and sclerosis; we call them loosely highway hazards.

It is only when the highway department sees itself as serving an operations function that it will have the interest and drive to maintain a continuing concern and control over its creature. It must be ever vigilant to construct the best possible roads and then to keep them under constant observation, doing all that can be done to prevent deterioration and to be ready to correct immediately the first signs of trouble.

Everyone in the department should be thinking continuously in terms of highway safety in its broadest spectrum—thinking about eliminating hazards in future construction, thinking about correcting present hazards, thinking about the adequacy of highway patrols, communication with the driver, innovations like applying the wide field of modern electronics to the road. The "thinking" must be followed with seeing the thought into deed, and seeing to it with all the tenacity of a bulldog—or a Joe Linko.

In a word, what highway safety needs is a continuing sensitivity to the ordinary road needs of the motorist. Without this sensitivity, all of us—those of us who provide the money, those of us who pass the laws, those of us who build the roads—bear out the wise Italian saying that to do 99 things properly but not the hundredth is to dilute the achievement of the entire hundred. The importance of this dictum is greatly enhanced when the hundredth item is safety.

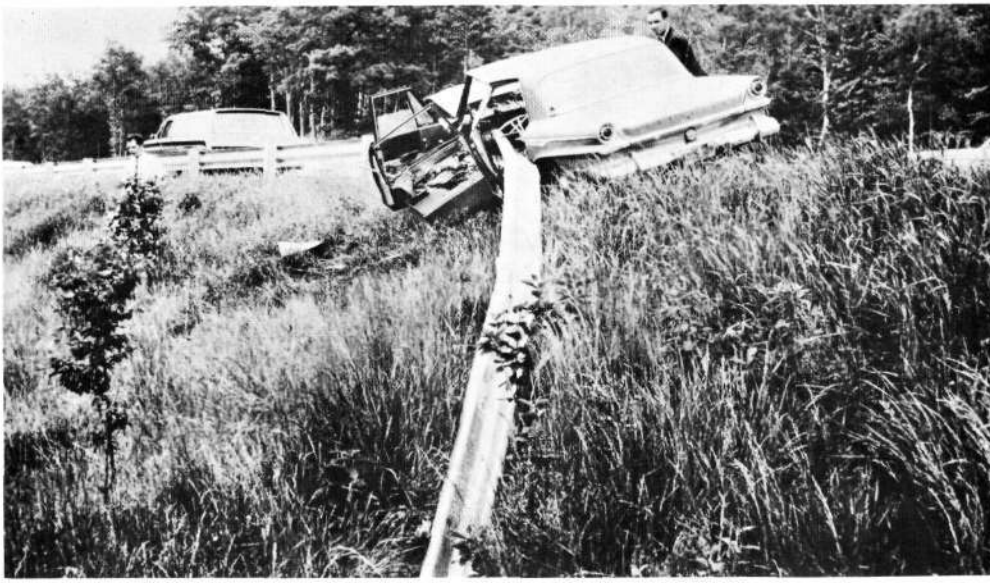

Figure 1. Type of accident that can and does occur when a vehicle strikes the front end of a guardrail. The guardrail penetrated the grill and exited out through the driver's seat. Careful consideration should have been given to burying and/or flaring of the ends of guardrails to minimize the hazards represented by the exposed ends such as in this case.

Figure 2. Here the exposed end of the guardrail penetrated the vehicle and passed through the passengers' side and out the rear window.

Figure 3. A massive and unprotected ground mounted sign placed at a minimum distance off the edge of the roadway. The supporting posts are 8-inch heavy duty steel I-beams bolted to concrete foundations; the concrete foundations rise approximately 18 inches above the ground level. In installations such as this, careful consideration should be given to placing such signs farther up the embankment, protecting such installations with adequate and sufficient guardrail, or the installation of breakaway type sign supports. Effective December 1, 1967 the Department of Transportation furnished instructions that on new federally aided construction, rigid standards (sign supports, light poles) will not be permitted.

Figure 4. A typical accident resulting from a car striking a fixed object. This illustrates the damage that can be caused by one 6-inch I-beam when struck at relatively low speeds.

Figure 5. Here is shown a car wedged between the steel sign support and a stone wall. At this particular location, a number of accidents have occurred over the years. The initial guardrail installation was demolished in one of the accidents and subsequently removed. The hazard was thereafter left unprotected and this accident then occurred. Consideration should be given to the placement of this steel sign support behind the relatively smooth stone wall or the proper installation of adequate and sufficient guardrail to protect against the steel sign support.

Figure 6. Placement of an overhead sign structure approximately 25 feet in front of an existing bridge structure. In situations such as this, careful consideration should be given to the placement of the signs on the structures themselves, thus eliminating the roadside hazards created by the sign supports at the ground level. Another factor would be that of economy; a sign truss of this dimension exclusive of the sign faces could cost as much as $10,000–12,000.

Figure 7. Installation of a median barrier rail. The rail was not carried around and through the median pier; as a result, an out-of-control vehicle could slide along this rail and be guided into the stone pier.

Figure 8. Placement of a massive ground mounted sign directly in the gore area. These sign supports are 8-inch steel I-beams embedded in concrete. Certain studies have revealed that there are four times as many accidents taking place in the gore area as on other segments of the highway systems. Guardrail has been installed for a distance of several hundred feet on the outside of the curve and the leading end of the rail has been brought between the two steel sign supports; the end of the rail creates an additional roadside hazard and the rail does not offer any protection from the sign supports. The installation of the guardrail on the outside of the curve is highly questionable because the area behind the gore is level and clear for many hundreds of feet and would provide a relatively easy escape area for an out-of-control vehicle, but the vehicle could not get to this escape area because the guardrail would prevent it.

AN EVALUATION OF ROADSIDE HAZARDS ON THE INTERSTATE SYSTEM

CHARLES W. PRISK

Mr. Prisk, Assistant Director for Safety, Office of Policy Planning in the Federal Highway Administration, acted as consultant to the Special Subcommittee during its inquiry into roadside hazards. He is a civil engineer, and joined the Bureau of Public Roads in 1935. He was Deputy Director of the Office of Highway Safety, which recently became the Office of Traffic Operations. From 1957 to 1959, he directed the Bureau's Highway Safety study and was principal author of the resulting report to the Congress entitled The Federal Role in Highway Safety. *He has been President of the Institute of Traffic Engineers, and Chairman of the Highway Research Board Committee on Highway Safety. Since 1961, he has been the United States representative to the Working Party on Road Safety Research in the Organization for Economic Cooperation and Development, an international organization with 25 member nations, and is at present Chairman of that organization's Crash Barrier Group.*

INTRODUCTION

A one-month inspection tour in the spring of 1967 of some of the newest Interstate Highway System sections opened to traffic produced evidence that the House Special Subcommittee on the Federal-Aid Highway Program had reason for its apprehension over safety deficiencies in the System.

In its role as "guardian" of the Federal-Aid Highway Program, the Subcommittee was fearful that almost unwittingly a unique type of safety hazard was being built into the country's most modern system of roads. Hearings were held to determine whether the construction of Interstate projects had included every reasonable safeguard. Opening the hearings on May 23, 1967, Representative John A. Blatnik, Chairman, declared that he was convinced that " . . . there is more that can be accomplished in the design of our highways from a safety standpoint." He pointed out that if this proved to be correct, " . . . steps must be taken to identify and eliminate built-in mistakes."

The inspections convinced me that there were many situations where improved engineering could have lessened the hazards on existing Interstate projects. Hazards to life and limb were not limited to older projects but involved some of the newest sections of the System. Unfortunately, this condition also proved to be relatively widespread and not confined to any state or geographical section of the country.

NEW INTERSTATE HIGHWAY PROJECTS VISITED

One state in each of the Federal Highway Administration's nine regions was visited and the Interstate projects most recently opened to travel were closely studied. In four states, the projects were entirely rural, in two states they were entirely urban, and in three a mixture of urban and rural.

The highway sections reviewed were on Interstate Routes 95 in Rhode Island, 80S in Ohio, 75 in Georgia, 69 in Indiana, 35 in Missouri, 40 in Oklahoma, 80 in Nevada, 90 in Montana, and 80 in Utah.

Special attention was given to hazards at the roadside and a surprising number were found on all nine projects. Because the project selection was basically random, I believe the projects are typical of recent Interstate construction. Consequently, it is not unreasonable to infer that many of the same weaknesses could and undoubtedly do exist at other points on the 25,000 miles of the Interstate System that had been constructed up to that time.

POTENTIAL ROADSIDE HAZARDS STUDIED

In the nine-state review, the following design elements were examined for their potential as roadside hazards:

Guardrails, median barriers, structures, shoulders, curbs, drainage facilities, signs and sign supports, lighting standards, entrance and exit points, and roadside slopes.

Information was assembled on each of the nine projects for these design elements, based on a field visit to each project, conferences with many of the concerned public officials, and an examination of the design policies and practices applicable in each case.

Any improvement of the identified deficiencies naturally rests first upon a thorough understanding of the nature of the hazards, and then upon a willingness and capability, both technical and financial, to undertake the practical corrective treatment. In my judgment, the conditions found arise not so much from any willful violation of official design standards for the Interstate System as from a widespread failure to recognize and treat a major accident problem that plagues our freeways.

The problem I refer to involves single vehicles that leave the roadway out of control. Accidents of this type account for about three-fourths of the traffic deaths among users of the Interstate System. A parallel and related difficulty stems from ignoring or failing to apply knowledge critical to safety. Much of this knowledge is readily available from reliable experience and research sources.

The nine projects upon which this account is based had been open to traffic for periods ranging from three to eight months. In most cases, additional work was still needed to obtain a facility as safe as originally planned. The missing items, sometimes important to safety, were typically classified as "clean up."

Included in this category were final alterations to guardrail, grading and paving of shoulders, grading and seeding of medians and slopes, closing of median crossovers used for construction purposes, installation of final signing, delineation, and mileposts, and numerous other features directly affecting the safety and quality of service available to users of the Interstate System.

Lethal roadside hazards are not rarities on the projects visited. Each state has its quota. What is particularly disturbing is that many of the hazards were observed not only on sections built in 1957 but also on very recently opened stretches of the Interstate System.

I believe that a brief reflection on the findings from this overview of nine new Interstate projects will establish beyond any reasonable doubt that there are two urgent needs. One is for the correction of the dangerous conditions found on Interstate sections such as those visited. The second and more far-reaching requirement is to create the awareness, the understanding, and the resolve to avoid the same errors on Interstate projects yet unbuilt.

Examples of the nature and extent of some of the deficiencies found on roadsides of the Interstate System are presented in the sections that follow.

GUARDRAIL (Figures 9–13)

Because guardrail is the roadway element most commonly struck as vehicles run off the roadway of the Interstate System, its design and use are of significant importance. Obviously the purpose of the usual guardrail installation is to protect the road user from a consequence more severe than that of striking the guardrail itself. It should be used only where necessary since it is itself a roadside hazard. Practices among the nine states visited vary substantially in this respect.

Heights of W-beam guardrail varied from 22 inches to more than 30 inches, sometimes as much as this within a given state. Full-scale tests have established that the effective height above ground level should be in the range of 24 to 27 inches. A growing appreciation of the value of 6′ 3″ post spacing is spreading in all states visited, and in their newest work at least, the closer spacing is being used to strengthen the W-beam guardrail sections. In only three states were guardrail installations regularly found to have washers on the bolt heads to prevent their pulling through the rail in the event of collision. These simple, inexpensive washers, along with the stiffening sections used at intermediate posts, will greatly strengthen beam guardrail installations.

Blocking-out of W-beam guardrail will prevent wheels from snagging on the guardrail posts, and the consequent violent stopping that injures vehicle occupants. However, the standard practice in nearly all states visited did not include blocking-out as a safety feature. On projects in two states, it was found that guardrail was blocked-out only at the sign installations. Other sections had no blocks. In one state, the median barrier post had actually been notched so as to obtain the minimum standard lateral clearance between the face of the rail and the edge of the pavement.

Guardrail ends can be extremely hazardous to cars running off the road and should be buried in the ground at their approach end. They were treated this way in three of the nine states visited. In other cases, rail was either flared back or installed parallel with the roadway alignment and not buried.

SIGNS AND SUPPORTS (Figures 14–27)

Wherever permanent signs were installed in the gore areas of the nine Interstate projects, they were, almost without exception, unreasonably heavy or massive. Mounting supports for the standard 5′×6′ EXIT sign varied all the way from double U-channel and three-inch steel posts for temporary installations to two steel I-beams six inches in depth for permanent mounting.

Supports for larger signs ranged up to multiple twelve-inch I-beams. The desirable breakaway feature, which the Bureau of Public Roads is urging state highway departments to use for sign installations, was found on only one of the nine projects, and in this case only on relatively minor type signs.

Routinely, the standard two-foot minimum clearance governed the lateral placement of signs, both large and small. Overuse of the regulatory type signs on unyielding supports and exposed footings close to the driver's path is another objectionable hazard that deserves early correction.

CURBS (Figures 28–31)

Barrier curb was used without any sufficient reason at many locations. For example, it was found well in front of a guardrail or median barrier, where it had little or no purpose but could adversely affect the proper performance of the rail structure. Curb was used often for delineation purposes to outline gore areas and other locations where there were no drainage, maintenance, or other functions to be served. A commendable design noted on one urban Interstate project was characterized by a curb located about two feet behind and parallel to the road edge guardrail. The entire shoulder was paved to and beyond the face of the guardrail and into the depressed gutter in front of the curb. Paving of the clearance area between the edge of the usable shoulder and the face of the guardrail would be a very desirable contribution to safety.

DRAINAGE ELEMENTS (Figures 32–35)

Facilities provided to accommodate roadway drainage were occasionally identified among other roadside hazards. Most familiar perhaps is the common culvert headwall which presents an unyielding target when exposed on the side slopes or in the median. Exposed walls at right angles to the direction of traffic were in a few cases uncomfortably close to lines of fast-moving vehicles.

During inspection of the nine Interstate projects, median inlets of about the same number of different designs were seen. Some of these had substantial structures projecting above the surrounding ground level. Others were flush and could be traversed safely by vehicles out of control. Without making any judgment as to the hydraulic adequacy of the several designs, there can be no doubt that many such inlets are in the class of a roadside hazard, while others apparently function well and could never contribute directly to an accident.

BRIDGES (Figures 36–47)

On Interstate System bridges, safety walks 12 inches and often 18 inches in width were relatively common. The need for more than a very narrow brush curb on bridges of the Interstate System is very questionable, in my opinion, and probably no curb would be a further improvement in many situations. From a performance standpoint, the traditional 12-to-18-inch safety walk presents a hazardous vertical face that tends to block traffic from the bridge entrance. At this point or on the bridge, the safety walk and curb combination can cause a vehicle to go out of control and to be lofted into the bridge railing system at a higher elevation than would otherwise be the case. A nearly vertical parapet wall with a small fillet section at its base, or a well-designed metal railing system is much to be preferred over the typical safety walk cross-section and obstructing curb found on many recent projects.

Even though standards of the American Association of State Highway Officials have been followed rather closely, the shoulder systems on these newest Interstate bridges on the nine state projects are not considered overly adequate for the needs of traffic. Only a few bridges of any length carried the full shoulder width. In one state there was a highly undesirable variation in the width of a rather closely spaced series of similar bridges. The explanation for this was that a design change took effect for some of the bridges which were designed within the Department, whereas the same criteria were not applied to other bridges on the project under design by a consulting engineering firm. This situation underlines the importance of timing to achievement of a consistent cross-section.

Median and side piers have a wide variety of protective shielding to avoid contact by motorists. In too many cases there was no protection whatever, or only one or two sections of guardrail placed in advance of side and median piers on structures. Elimination of the side pier hazard through the construction of two-span bridges deserves wider application.

In contrast to the generally inadequate shielding of center and side piers at undercrossings, a fairly elaborate treatment was common at twin bridges where an Interstate driver wandering off the roadway on the median side might otherwise drop through the median opening to a roadway below. On most projects studied, long sections of approach guardrail were flared as far as the median center line, sometimes beyond, to divert vehicles from the opening between bridges. The solution of decking the median area was seldom used. This solution has the advantage of eliminating the hazard just referred to and also removes the additional dangers posed by the left edge curbs, parapet walls, and railings.

Some states have concluded that 20 feet is about the widest median that can be economically paved between twin bridges. Others believe, after extensive analysis of typical conditions, that median widths up to 30 feet can be economically justified for paving. On the nine new Interstate sections inspected, many twin bridges had medians less than ten feet wide that were not paved. The separate structures were often less than 25 feet apart. Eliminating the two parapet walls on the left sides and the extensive length of approach guardrail would compensate in part or entirely for the additional cost of paving the median area. More importantly, the latter arrangement would be inherently safer because of the greater uniformity in the cross-section.

TRANSITION FROM ROADWAY TO BRIDGE SECTIONS
(Figures 48–53)

Noteworthy among the design problems that still await solution is the development of a satisfactory transition structure between approach guardrail and bridge railing or other elements of a grade separation structure. In two states, some attempt had been made to obtain an anchorage but the design was not altogether successful. In the other seven states, there was no physical connection or real evidence of any attempt to make the approach guardrail integral with the bridge railing, a pier, or any other structural component.

The need for an answer to this transition problem probably ranks as high as any on the list of immediate safety priorities in the area of roadside hazards. Studies show that a vehicle out of control is most likely to strike a guardrail. When a second object is struck, the same data show that a structure is the most frequent target. Information obtained during the survey indicated that most states plan some remedy of this deficiency, but it was startling to notice the variable timing. For example, in one state there was almost no guardrail on the approach to structures, whereas in another, the approach guardrail had been built to a bridge location even before the bridge deck had been completed.

BRIDGE RAILING (Figures 54–55)

The effectiveness of bridge railing is related to its height as well as to its design configuration and strength. Measurements were taken on many structures in the nine states. Bridge rail height, adjoining the roadway surface and measured from that elevation, was as low as 27 inches in some cases and as high as 44 inches in other cases. The most common height of bridge rail was 40 inches above the roadway surface. Only a few of the states had bridge railings lower or higher than 40 inches. This dimension, as well as the functional design requirements of bridge railing, may need to be studied and specified more exactly for application to bridges of the Interstate System.

Aluminum was a common alternate for steel in bridge railing. Many different configurations were noted. Combinations of single and multiple rail designs combined with various heights of concrete bridge parapets make this feature difficult to evaluate.

Bridge designers obviously exercise considerable individual expression in developing the design pattern of bridge rails. Aesthetics and the desire to have a bridge rail you can "see through" should not overshadow the need for a railing to withstand, within reasonable limits, a colliding vehicle without hazard to its occupants.

SHOULDERS AND SLOPES (Figures 56–58)

Some attention was given during the study to the use of shoulders on the main roadway and on ramps. In two of the nine states, the normal width of the shoulder was frequently obstructed by curbs placed around the entrance ramp terminal.

In addition to obstructions of the main roadway shoulders, which should in all cases be available for disabled vehicles, much inconsistency was detected in the design of shoulders for ramp roadways. In a few cases it was difficult to tell whether the ramp shoulder was paved. On one project the ramp had a paved shoulder six feet wide on the right and no shoulder paving on the left. In another state, the shoulder of the ramp was paved three feet wide both right and left. Elsewhere, ramps were bordered with curbs. The practice of paving shoulders on connecting ramps at interchanges obviously has not been very widely agreed upon. There is evidence from this review that the need for adequate shoulders at all locations has not yet been fully appreciated.

Flattening side slopes and rounding ditch bottoms to increase the safety of the roadside was not characteristic of most of the nine projects visited. Numerous situations were noted where, at least in localized areas, readily available embankment material could have been used to flatten slopes to 6:1, a slope that can be safely traversed by a conventional vehicle. Because grading costs are not a large part of the total project cost, much more attention should be devoted to examining slope adjustments as new projects are constructed. Savings in guardrail installations, maintenance, and possibly drainage features that otherwise might be required can be credited against earth-moving costs associated with flatter slopes.

LIGHTING (Figures 59–63)

It was previously observed that only four states installed roadway lighting on the Interstate projects visited. Of these four states, two used steel poles on transformer or flange bases mounted on concrete footings no more than 1½ to 2 feet off the outside edge of the paved shoulder. In two other states, the same lateral location was used but the lighting installation was less hazardous because frangible bases were employed on the exposed poles. The aluminum poles used were of a type shown by experience to break away at the flanged base without causing serious damage to the vehicle or its occupants.

Where roadway lighting is employed, concrete footings should be kept to the ground level and the lateral clearance from the edge of the shoulder or face of curb increased above currently used minimums. The enthusiasm for maximum lighting efficiency and aesthetics has sometimes resulted in having the poles in target positions undesirably close to the roadway. Longer mast arms are possible and, with more powerful luminaries at higher mounting heights, fewer light standards are needed.

FUTURE IMPROVEMENTS CONTEMPLATED

It was mentioned earlier in this record that two general courses of action were open for improving the safety of the Interstate System. One involves the treatment of existing roadside hazards such as have been described, and the other calls for tightening the standards to achieve a more perfect design and construction of Interstate sections still to be built. It is reasonable to expect that the state highway departments will follow both of these approaches, if the experience with the nine-state survey is representative. In each state visited, one or more specific programs were identified that dealt with Interstate System safety improvements, either on a project or statewide basis.

Examples of the changes that were reported during the inspection to have been recently accomplished or on the schedule for early attention on the projects visited are listed below. It is probable that these are typical of corrective work being undertaken as needed on other Interstate sections throughout the state.

Rhode Island Interstate 95

1. Signs originally placed two feet off the edge of shoulder will be moved back wherever viewing and other conditions permit.
2. Heavy sign bridge supports located in the gore will be eliminated by moving sign bridges to advance locations.

3. Curb and guardrail will be eliminated from gores and these areas will be graded with flatter slopes.

Ohio Interstate 80S

1. The present temporary signing on this project will be replaced with permanent signs of modern design as the next stage of improvement.
2. Guardrail adjustments are being made to provide additional shielding for structures and hazardous slope conditions.

Georgia Interstate 75

1. Guardrail will be revised to incorporate the safety refinements identified by recent research. Posts will be spaced closer to increase stability. The ends of the guardrail exposed to traffic will be anchored at ground level.
2. Frangible bases will be employed for light standards, replacing the existing bases wherever these are in exposed positions.
3. Traffic signs will be moved back at least 30 feet from the traveled way wherever possible.
4. Median inlets will be improved so as not to be an obstacle to traffic.

Indiana Interstate 69

1. Guardrail revisions will be made to include the anchorage of approach ends at ground level and shorter post spacing at points where maximum protection is required.
2. Drainage facilities will be made less of an obstacle by elimination of headwalls and by extension of present culverts.
3. Consideration is being given lighting requirements at interchanges and other points of need.

Missouri Interstate 35

1. Improvements will be made to median drains and ditch blocks.
2. Breakaway signs and light supports will be installed.
3. The installation of additional guardrail at points of special hazard will be undertaken and guardrail design will be improved to accord with latest safety standards.

Oklahoma Interstate 40

1. Improvements are being made in the anchorage of guardrail to bridge structures.
2. Improved guardrail designs are to be installed.

Nevada Interstate 80

1. Traffic signs will be relocated at a greater distance away from the roadway. They are presently two feet beyond the edge of the shoulder.
2. Additional guardrail installations will be made to protect motorists against the hazard of running off high embankments and some embankment slopes will be flattened.

Montana Interstate 90

1. The guardrail on this project will be blocked out throughout its length and shorter post spacing will be used to guard against penetration at locations of special hazard.
2. Improvements in the signing will include installation of breakaway design supports.

Utah Interstate 80

1. Some signs will be relocated to a position on overhead bridges so as to eliminate the hazard of ground structures.
2. Breakaway type signs will be installed throughout the project.
3. Better design will be used for the protection of motorists who strike the approach ends of guardrail.
4. The design of exit and entrance ramp terminals will be improved to reduce the fixed object hazards at these locations.

CONCLUSIONS

The study of the nine Interstate projects selected essentially at random has served to highlight significant needs that should be met if the Interstate System is to become as safe as the public interest deserves. The following conclusions are drawn:

1. Decisions on engineering design frequently have been based on first-cost considerations rather than on true annual cost analyses. High importance should attach to the choice of initial designs that will serve traffic adequately over the full life of the improvement at a minimum cost and with a maximum of safety. Maintenance and operating requirements associated with the various alternate designs are examples of cost factors that should receive more attention in advance of the decisions on design.
2. When separate contracts or subcontracts are negotiated for installation of signs, lighting, guardrail, drainage facilities, and similar elements, maximum coordination is called for to insure that

these several items and the features of the principal construction contribute in a unified way to the safety of the completed highway.

3. Immediate steps should be taken to establish a closer working relationship between bridge and roadway design engineers to achieve safer design conditions for the total highway, and especially for the roadway entrances to bridge structures. Liberal evidence exists that the rail-to-railing transition between roadways and bridges is one of the weakest components of present roadside design.

4. Multidisciplinary review teams, operating before, during, and after highway construction, should be used to crystallize timely decisions on many items affecting the safety of Interstate projects. Teams should be composed of representatives from design, construction, traffic, maintenance, and any other divisions of the highway department where decisions affecting safety features are made. Supplementary assistance of personnel from the Bureau of Public Roads and other component units of the Federal Highway Administration, and from enforcement authorities has proved valuable. Team functions should start in the earliest planning stage on such items as sign locations, guardrail placement, and lighting installations. Teams should also be active during construction so that desirable adjustments then found can be made. Before projects are opened to traffic, the review team should satisfy itself that the highway is in fact ready for public use. In the administrative area also, premature opening of projects not operationally safe for traffic should be avoided.

5. A safety cross-section that provides an adequate clear recovery area from the edge of pavement is one of the more important steps toward greater safety and should be a feature of Interstate projects. This is important enough to warrant the revision of plans and standards for new work and the acceleration of corrective programs aimed at removing fixed object hazards. Also evident is the desirability of using 6:1 or flatter slopes at the roadside wherever practical, and the smoothing and removal of all substantial obstacles from the exit gore. The standard EXIT sign and lightweight delineator posts are exceptions but the former should be on breakaway or yielding supports in all cases.

6. Where nearby fixed objects are not feasible of complete

removal or relocation from the immediate roadside, installation of effective barriers to shield piers, sign supports, and other features that cannot reasonably be eliminated or relocated should be installed at a maximum distance from the roadway rather than just outside the outer edge of the usable shoulder. Special impact-attenuating devices now being evaluated may soon be available as practical ways for shielding median piers and similar massive objects that must remain in proximity to the roadway.

7. Hundreds of high accident locations exist in current designs and on projects now carrying traffic. These should be the focus of stepped-up spot improvement programs and other efforts by traffic engineering and maintenance forces. Such corrective work should include the removal of unnecessary signs, the relocation of signs now too close to the roadway, the installation of readily adaptable frangible or breakaway bases for exposed sign supports and heavy light standards, the lowering of exposed concrete footings to ground level, the removal of unneeded barrier curb, the burying and/or flaring of guardrail approach ends, and the elimination of safety walks and wide curbs on bridge structures.

8. It would appear from the study that the communication and use of available research findings and improved techniques need major emphasis. The breakdown in communications is noticeable at all levels and actually may be somewhat more serious in the administrative area than at the technical level. A change of attitude which will recognize that the highway is a major factor contributing to or detracting from traffic safety will be a basic factor in overcoming the current difficulties in communication.

9. Concerted efforts should be made to compress the time period between final design decisions and public use of the highway improvement. This will bring the benefits of the most recent advancement in operational practices, designs and controls to new and remedial work on the Interstate System at the earliest possible date.

10. No findings from the overview and inspection of nine Interstate projects can or should be regarded as fully conclusive and final. Through properly directed research and additional investigation over a period of time, much more specific information as to

highway design details and operating deficiencies and optimized solutions will surely be identified. In the interim, the findings from this close observation and study of nine new and representative Interstate projects and from other related investigations are believed to have a high indicative value for those concerned with safe freeway design and operation.

SUMMARY

With the Interstate System a little more than half completed, a field survey and inspection was made during early 1967 of the highway sections most recently opened in nine states, one section in each region of the Federal Highway Administration. Principal attention was given to the safety aspects of the roadside, i.e., features and hardware adjacent to the main traveled way which, by their design or configuration, could affect accident frequency and severity.

Findings from the study suggest that roadside hazards on the Interstate System are comparatively frequent and often unnecessarily severe in their effects. Whether for the lack of sufficient engineering attention or for related reasons, some of the lower-cost construction items, it should be noted, are most conspicuous among the hazards.

Guardrail, signing, lighting, shoulders, curbs, and drainage facilities are prime examples. These features are thus candidates for spot improvement projects and for further deliberations by standardization groups.

Uniformity along the cross-section, especially between roadways and bridges, is another facet of the roadside safety problem. On Interstate-type design, well over half the traffic fatalities involve a vehicle running off the road. Roadway-to-bridge transitions must be designed deliberately to function on the side of safety in these events. An alternate solution, of course, would be to control the vehicle and driver so that it would be either impossible or very difficult to leave the roadway. That day could come but the use of that solution for the entire 41,000-mile Interstate System or for any appreciable portion is not yet practical.

Cost effectiveness will play a growing role in shaping the ultimate techniques for treating roadside hazards, but for current design decisions highway officials must look chiefly to research and to lessons learned from little more than a decade of operating the Interstate System.

The aim of this report, and of the commentary and photographic record which follow, has been to consolidate a series of rough-hewn truths about hazards at the roadside, based on a direct examination of nine representative Interstate projects, and to present the findings for whatever interim guidance they may provide.

It is no gamble to forecast that continuing refinement in the roadside design of those Interstate improvements still to come, and the correction of weaknesses on sections already completed, will earn worthwhile safety dividends for future users of the System.

Commentary on Interstate System Roadside Features

CHARLES W. PRISK

Approximately 2,300 photographs were taken during the 1967 inspection of newly completed Interstate projects. From this collection, a number of views are presented with brief observations on roadside features and their relationship to highway operation.

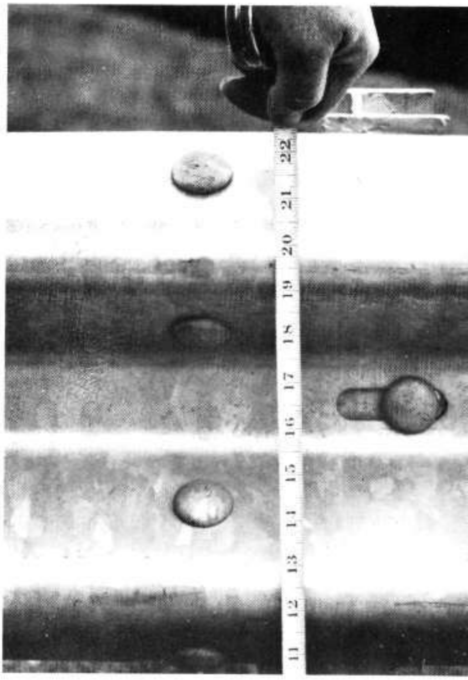

Figure 9 *left*. This view illustrates several principles of good guardrail installation. First, the rail is blocked out from the post, which prevents the wheel of the vehicle from snagging the post, which would result in a violent stop. Second, there is a good flat surface on the approach to the rail so that the barrier has an opportunity to perform as designed. Third, the washer placed over the head of the mounting bolt makes the guardrail and posts perform as a system, rather than independently.

Figure 10 *right*. Some W-beam guardrail is mounted with the top edge only 22 inches above the ground level, which is generally considered lower than desirable. Note the absence of washers and blocks.

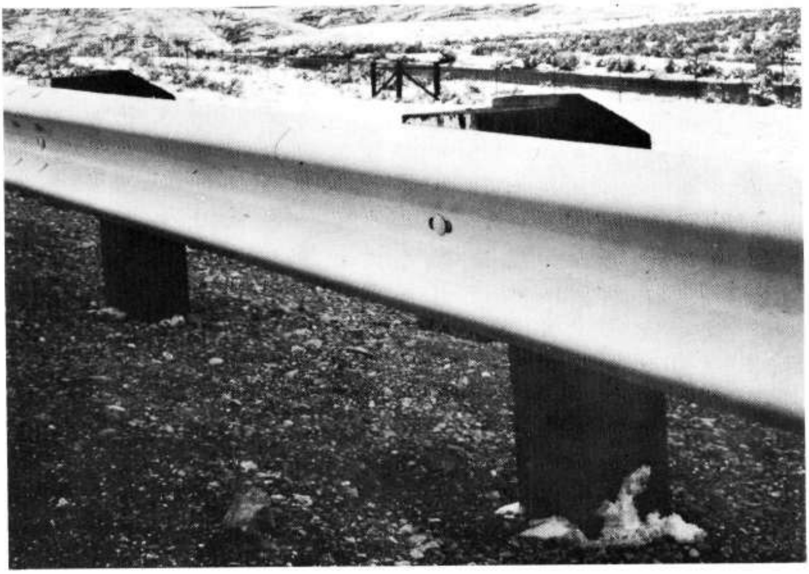

Figure 11. This is a properly blocked-out section of rail with 6′ 3″ post spacing, which has been painted white for increased visibility. However, the inexpensive washers which prevent bolt heads from pulling through the W-beam rail were not used on this project.

Figure 12. Here is a commendable corrective treatment where the rail on the approach to the structure is twisted, slightly flared, and buried in the cut slope.

Figure 13. Here is another guardrail turned and anchored at ground level on the approach to a bridge structure. Some designers prefer to have even less of the end of the rail exposed. Note the undesirable projection of the bridge curb in the background.

Figure 14. Freeway exits like this sometimes have excessive guardrail in the gore area. A vehicle running off the roadway could have multiple difficulties, striking both the exposed guardrail and the heavy sign supports. With a reasonably flat gore area, removal of the guardrail from the target position and the installation of a breakaway or yielding type sign support is the indicated solution.

Figure 15. This gore might be safely traversed by an out-of-control vehicle if it were not for the heavy sign installation.

Figure 16. This exit gore is the site of a butterfly mounting for the overhead signs shown. The central support is 24 inches in diameter and rests atop a steel base and a raised curb within the gore area. The guardrail completes the installation of a truly monumental obstacle. In most instances of this kind, the motorist is better served by an overhead sign bridge located a few hundred feet in advance of the gore, and the hazard is markedly less.

Figure 17. These are details of the heavy base supporting the butterfly sign installation just shown. The steel plate is 32 inches square and three inches thick — all bolted to a concrete base, which itself is virtually an immovable object.

Figure 18. Here is a unique treatment employed at an exit ramp in the neutral area in advance of a gore. A rough surface has been introduced to give an audible and tactual signal to the driver. An area so treated can be quite effective if it is placed in a longitudinal and lateral location which is correctly oriented to the pattern of traffic movement.

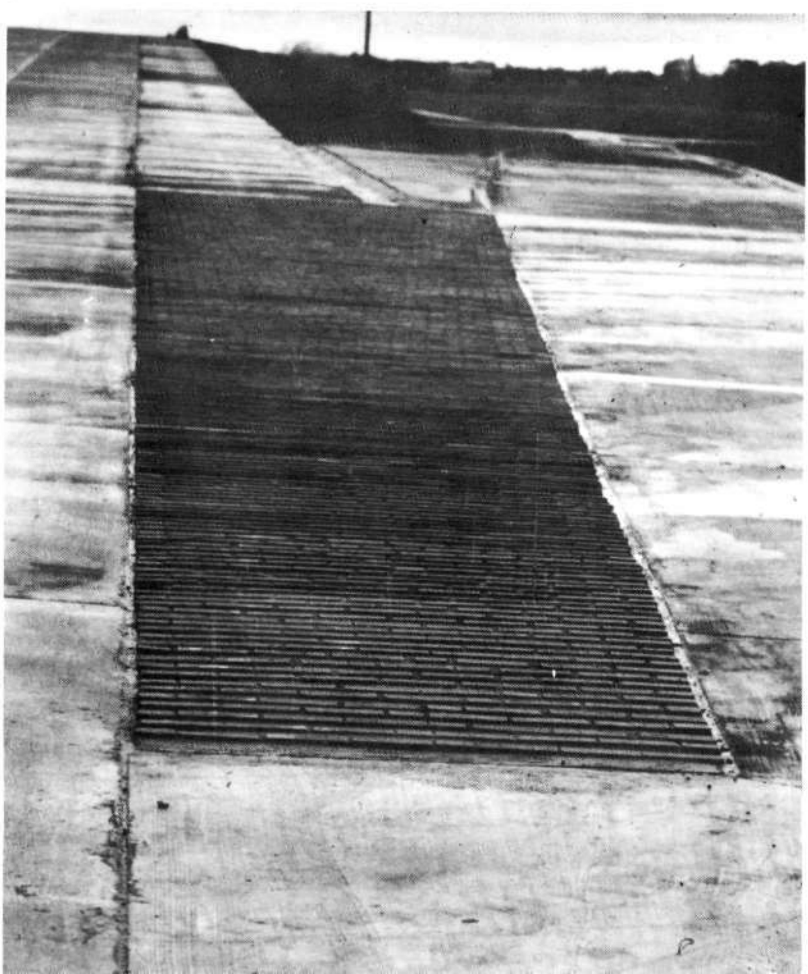

Figure 19. This gore location has several good features. There is a yielding type sign mounting, a nearly flat gore area, and a sloping paved section very slightly raised in the apex of the gore. A driver should be able to drive through this gore without suffering any violent effects.

Figure 20. The route marker here is shielded by only a short section of guardrail, the end of which flares abruptly away from the roadway. A sign located farther from the roadway on a breakaway or yielding type support would improve the safety of the roadside and make the guardrail unnecessary.

Figure 21 *left*. In some states the supports for the standard Interstate route markers are yielding posts of the U-section type, wood posts or other supports of breakaway design. Elsewhere, the same route markers are mounted on much heavier posts.

Figure 22 *right*. The support for this Interstate marker is a round steel pole which would not readily yield if hit by a vehicle. It could be made safer if located farther from the roadway or behind the guardrail installation in the background.

Figure 23. The performance of a breakaway sign frequently results in destruction of the installation instead of the vehicle or its occupants. The intended action occurred in the hinge joint just below the sign and at the base of the sign support, permitting the car to go on through without serious injury.

Figure 24. This overhead sign on a cantilevered support is just 25 feet in advance of the overhead structure. Although the support is behind the guardrail, it illustrates one situation where an overhead sign could be mounted on the face of the overcrossing structure without necessarily detracting from the aesthetic values.

Figure 25. Three factors make this sign installation hazardous. It is unnecessarily close to the traveled way, the supports are massive, and the concrete footings are far enough above ground level to cause damage.

Figure 26. Many of the small regulatory and warning signs serve insufficient purpose and their installation should be avoided wherever possible. When used, they should be a substantial distance from the roadway. Thirty to fifty feet from the edge of pavement is often practical.

Figure 27. The "emergency parking only" sign is one more sign that should be used on a selective basis according to need.

Figure 28. The combination of the guardrail and the roadside curb constitutes a noticeable deficiency because of the lack of harmony in their alignment. Early planning and coordination of all features of the roadside will avoid this problem.

Figure 29. Here the median barrier is being constructed on a raised median. The curb is not likely to improve the performance of the barrier.

Figure 30. Effective use of curbs on Interstate freeways is important to safety. This curb is located behind the guardrail out of the line of traffic and performs an essential drainage function.

Figure 31. On this project the curb is in front of the guardrail, in contrast with the preceding illustration. With such a condition, a vehicle may be airborne before it strikes the barrier. A clear level surface in front of any barrier helps to assure that it will perform in the manner for which it was designed.

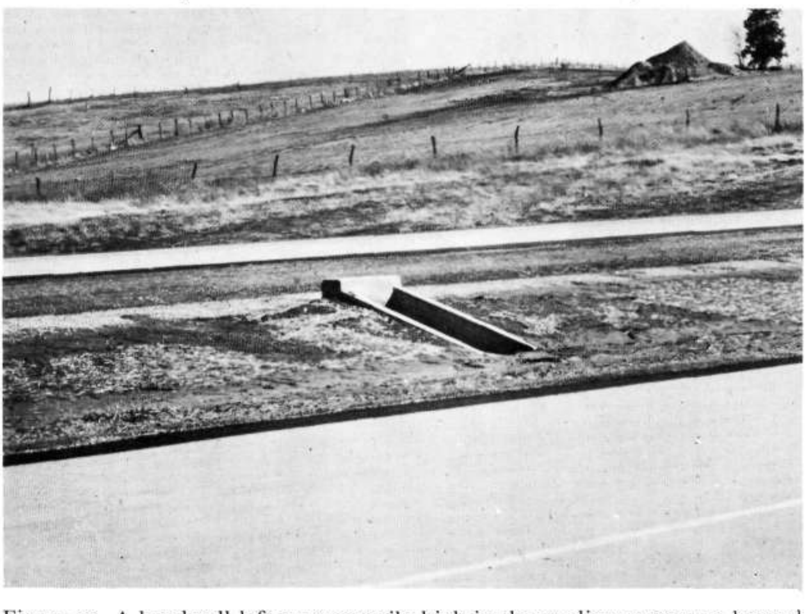

Figure 32. A headwall left unnecessarily high in the median presents a hazard when other roadside conditions are favorable.

Figure 33 *left*. A concrete box inlet that projects above normal ground level as this one does is an obvious obstruction for vehicles that happen to stray into the median at this point.

Figure 34 *right*. There are several designs of flush median inlets that function well and cause no problem for vehicles that inadvertently get into the median area.

Figure 35. This drainage system is entirely behind the guardrail on a project built within a relatively limited width of right-of-way. It appears to be performing satisfactorily and presents no roadside hazard.

Figure 36. Roadway shoulders should be extended with their full width across bridge structures. In this case, the bridge roadway shoulder was only partial width, which builds in a roadside hazard.

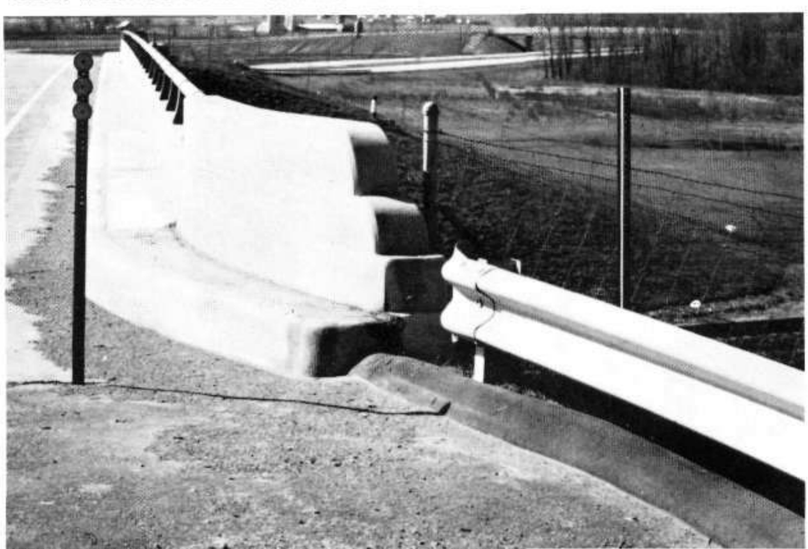

Figure 37. This is a scene of a double fatality. A vehicle struck a bridge parapet where the design was similar to that shown in the previous picture.

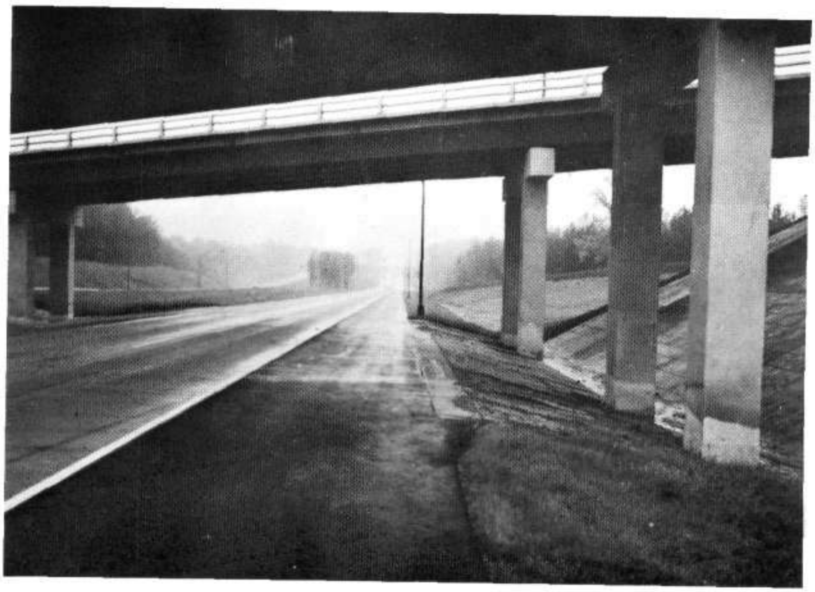

Figure 38. Where multiple piers carry twin bridges over this Interstate route, there are four destructive targets on each side.

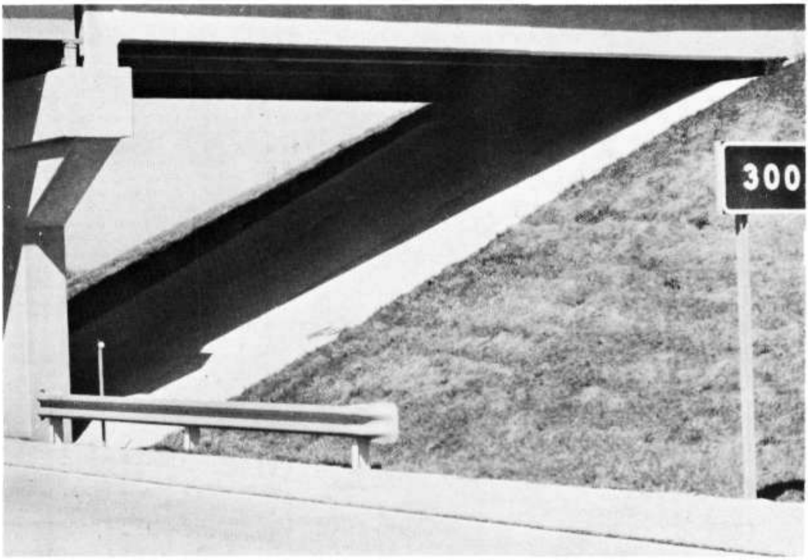

Figure 39. On this project, only one section of guardrail 25 feet long is used in advance of the side piers. This is too short to give any real protection to drivers who run off the roadway.

Figure 40. This guardrail installation has been placed close to the edge of the traveled surface. Most authorities agree that the guardrail would function effectively at a distance of three to five feet from the center pier, and in that location, give additional clear recovery room for vehicles that go out of control.

Figure 41. This guardrail at a bridge pier in the median has a good approach end treatment but would be a more effective shield if it were extended farther in advance and placed closer to the center pier.

Figure 42. The median pier at this undercrossing is located close to the outer edge of the shoulder without protection. But on the other end of the span, the right side abutment is placed well up the slope. One would logically conclude that the right side is considerably safer than the left side, at least for vehicles whose vertical height would not be a factor.

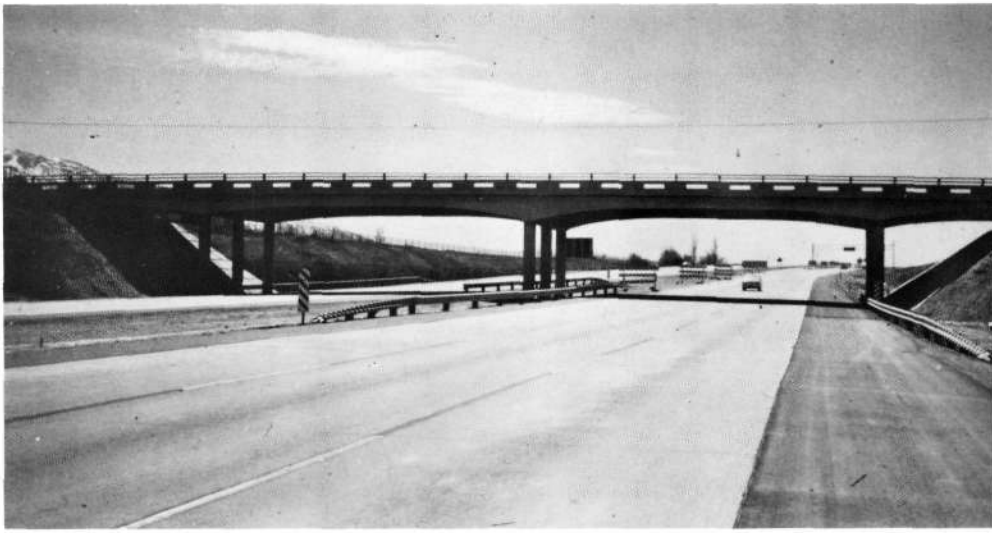

Figure 43. Guardrail ends are flared slightly away from the roadway and rail is carried through the undercrossing. This makes it much less likely that a motorist will come in contact with the concrete piers in the median or at the roadside.

Figure 44. The safety feature to be noted at this two-span undercrossing structure is the abutment face, which is part way up the slope. With this design, the driver has some recovery space which he should be able to use safely in any average emergency.

Figure 45. Here the two bridges are so close together that it is difficult to understand why a single structure would not be safer and more economical. With the single structure, the two parapet walls and the advance guardrail in the median would naturally be eliminated.

Figure 46. Here is evidence that drivers do leave the roadway. In this case, the vehicle straddled the guardrail on the approach to the bridge, and struck the bridge railing at the point where the damage is evident. The car and driver traveled 85 feet through the air between the two bridges and landed right side up on the roadway 26 feet below. In such a situation, a single bridge structure would have had a safety advantage over the twin bridges pictured. It would have eliminated both interior railings and made it possible to maintain a more consistent cross-section over the structure.

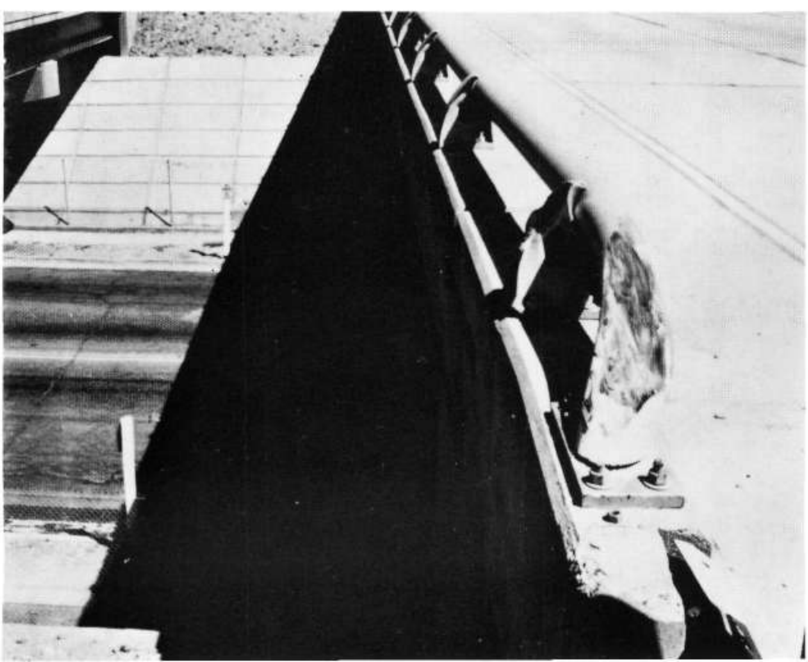

Figure 47. Here is a dual bridge where there is no protection on the median side to prevent drivers who stray into the median from dropping to the roadway below. The culvert headwall exposed near the center of the opening is an additional feature contributing to the hazard potential of this location.

Figure 48. There is no approach guardrail in advance of this structure. The exposed concrete parapet wall is marked only by a reflectorized bridge panel. The sign message adds an ironic touch.

Figure 49. Better lateral location of the guardrail and the light standard in relation to the bridge railing would have prevented this irregularity in the cross-section. Note the large concrete footing in the right background. Such footings should be kept at ground level wherever exposed.

Figure 50. Here, the open gap of eight or ten feet between the end of the guardrail and the beginning of the structure makes the bridge end a more vulnerable target.

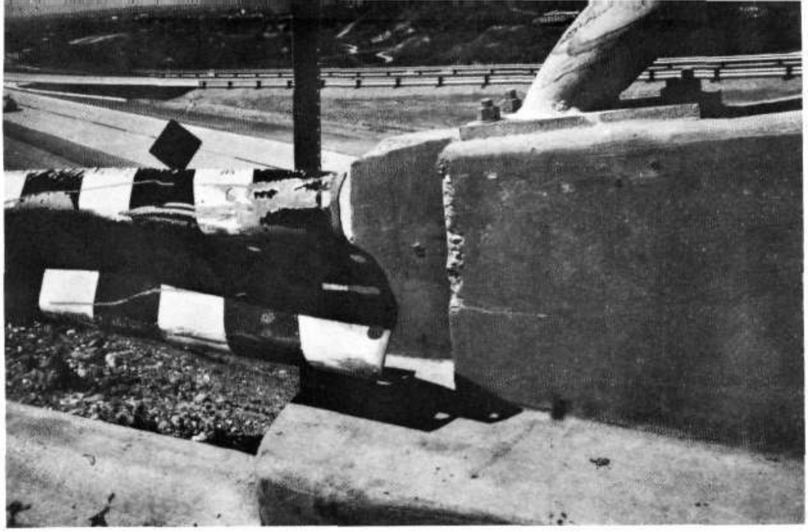

Figure 51. This is a view of a transition installation that was struck by a passing vehicle. The single bolt and relatively weak anchorage are not adequate for the violence of a traffic collision.

Figure 52. The highway department designed this physical connection between the guardrail and the bridge parapet. Additional design study is being given this feature to make it still more effective.

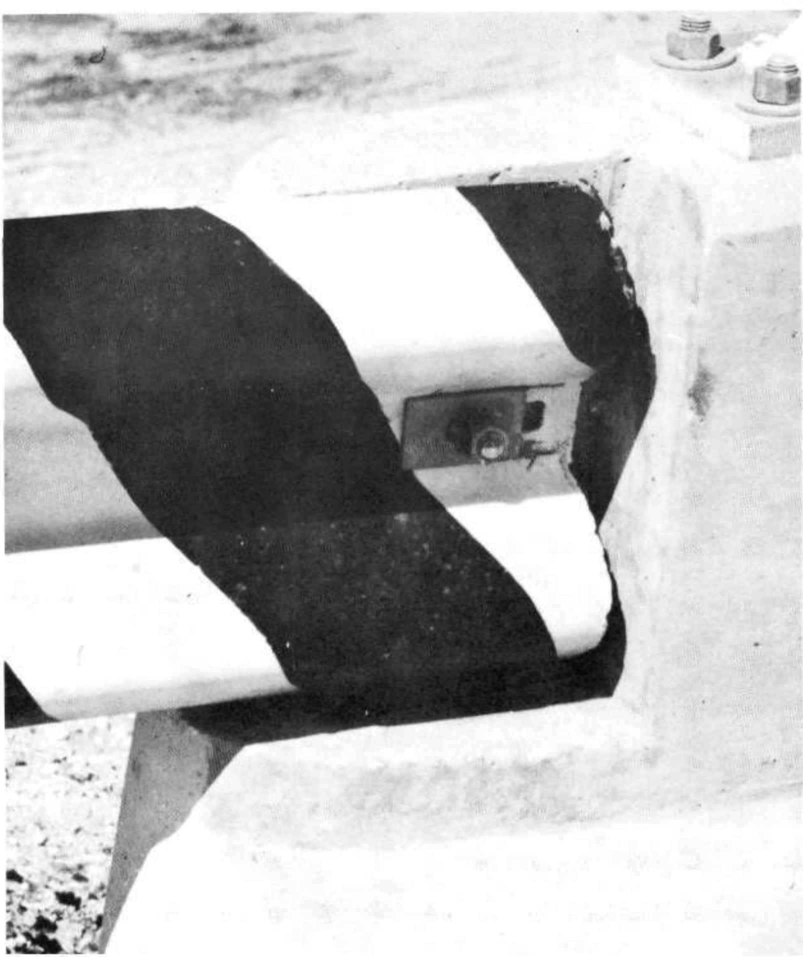

Figure 53 *left*. The favorable feature here is the overlapping of the approach guardrail on the bridge parapet. The lateral strength of this transition may be questionable but it does provide some smooth sliding surface for vehicles that stray off the roadway.

Figure 54 *right*. At this structure, no anchorage is provided between the guardrail and parapet wall, and the safety walk and curb limit the effectiveness of the bridge railing.

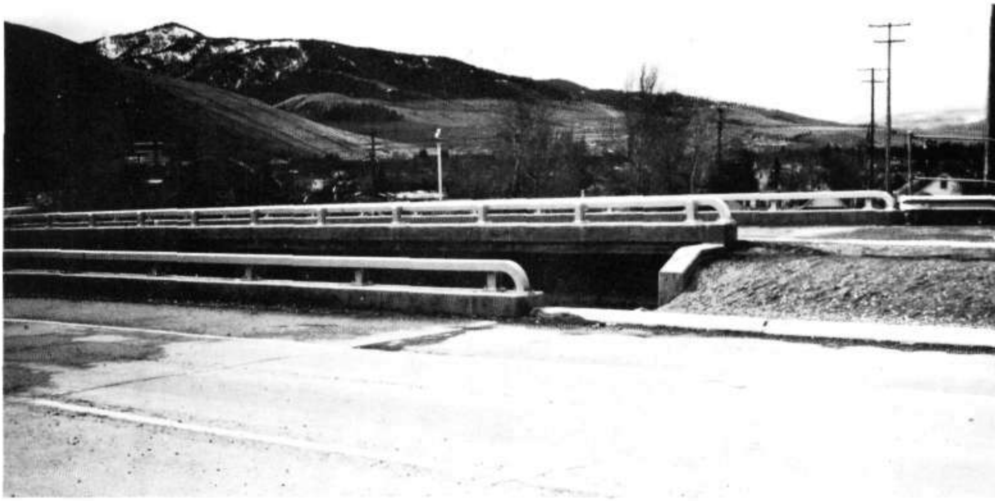

Figure 55. At this dual bridge, where the transition from guardrail to bridge railing has been largely ignored, the bridge rail is quite low, no more than 27 inches above the roadway.

Figure 56. In this case the shoulder ends where an entrance ramp joins the freeway and the light standard was placed directly in line with the shoulder. Safer design would have continued the shoulder and relocated the light standard.

Figure 57. The paved V-ditch at the bottom of the side slope is a substantial hazard and vehicles leaving the roadway at this point might readily overturn. A ditch with a rounded bottom would have superior safety characteristics.

Figure 58. Good attention was given to slopes and separate drainage for each roadway. The mounded median in the vicinity of the center piers on this project gives a degree of protection against this hazard for vehicles that leave the roadway.

Figure 59. Light standards located too close to the roadway edge make little contribution to safety. The guardrail here is behind the light standards. The gore area itself is quite flat and the need for guardrail in such a situation would seem to be open to question.

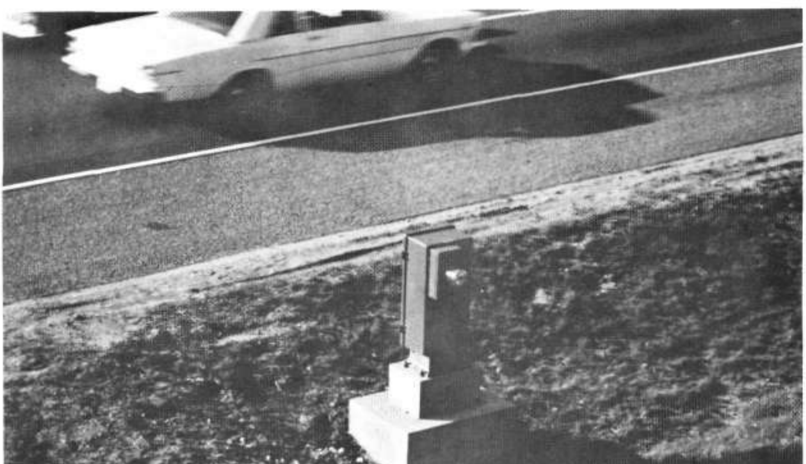

Figure 60. Units to control roadway lighting are sometimes placed close to the edge of the traveled way. If proper advance consideration has been given to safety, this hazard need not exist.

Figure 61 *left*. The slip-base unit shown can be used to adapt otherwise hazardous light poles to a safer design. When this installation is hit by a car, the lower section breaks readily and the pole is easily dislodged. The frangible insert can be rather cheaply added at many locations, sometimes for as little as $25 per pole.

Figure 62 *right*. When the pole is knocked away, automatic devices disconnect and seal off the high voltage electrical circuits to prevent fires and damage to persons and property.

Figure 63. In some states, light standards made of frangible metal are not shielded in any way with guardrail installations. Because guardrails are themselves a hazard, they should not be used except when the consequences of their installation are less severe than would be true if they were not installed.