STATES ARE DESIGNING FOR SAFETY

In this presentation we plan to concentrate on the design aspects of the Yellow Book Safety Review. Design means many things to many people. We in some way design almost every aspect of the highway, we design roadbeds, hardware, roadsides, geometrics, traffic control devices, drainage and many other things. I'll try to cover as many aspects of designs as I can, but I'm sure it won't be all inclusive.

I think one of the conclusions drawn as a result of this review was that generally, state design standards, specifications and policies are current and reflect safety considerations. During the office reviews we found very little to criticize in present design policies, and we thought that the states were in pretty good shape. Now that isn't to say that we didn't find obsolete standards related to safe design policies, we did, but this is a fast changing technology, and generally the states were already aware of the latest developments and were in the process of at least studying possible changes.

STATES' SAFETY DESIGNS DIFFER

I might point out that a very consistent comment made in all but one of the 22 states visited by the headquarters office task force was that "our state is unique." This statement was usually made during the first five minutes of the meeting and much of the rest of the meeting was devoted to supporting the uniqueness of the state. There was plenty of evidence that the differences exist; as an example, in 22 states:

(1) Fifteen used a turndown guardrail terminal and there were 12 different designs.

(2) We have pictures of about 50 different types of bridge rails and as many different transitions to guardrails as there are bridge rails.
(3) There were over seven different designs for breakaway sign supports.

(4) There were no two states with the same design for median pier protection.

SAFETY DESIGNERS NEED FEEDBACK—ACCIDENT ANALYSES

The review task force did not question the fact that different States have different designs for the same type of protection, but we are concerned over the lack of knowledge on the part of the designers on how well these various designs perform. It was a rare case when a designer had heard the results of an impact with one of his design features, either good or bad. The designer needs feedback on how well his designs are performing—usually he is not getting it. Another point along the same line, of the 22 states visited, only two had ever performed any crash tests on unique designs used in their states. I know crash testing is expensive and not necessary in every case, but if we are developing unique designs that have not been crash tested and we do not monitor their performance, how do we know if they work?

But most problems identified during the review were not caused by the design standards on policies themselves, but by how they were often interpreted and applied in the field. In some cases the original design concept was modified or changed during construction. In other cases they were "handbooked" into place with adverse results. Sometimes different policies were in conflict.

Again, I would like to point out the importance of using accident data in analyzing the safety performance of design policies. It's often stated that accident data was not available to analyze this performance. In some cases this was true, in all cases it takes some effort to acquire, but it's worth the effort.

Let me give you an example of the use of accident data. In one of the states reviewed, there was a design practice to berm the median on approaches to elephant traps, and to protect an errant vehicle from running into the steep side slope of the berm; guardrails were placed on either side of the bermed area parallel to the road. The review team concluded that this design would have a tendency to redirect a vehicle traversing the berm area into the rear of the guardrail. Those familiar with the area indicated that they had never heard of such an instance occurring. As a result, one evening we reviewed the raw accident reports occurring within a two-year period for a five-mile section of the freeway. Four injury accidents and one fatal accident had occurred at
the bermed areas during this period, all had run up on the berms and been deflected into the back of the guardrail. It became obvious that this policy needed to be changed, and it only took about 20 minutes to analyze the raw reports. Yet up to this point the designers were confident that the berm-guardrail design was acceptable; because no knowledge of accidents was considered positive information, there was no problem.

There is at least one other area where monitoring accident data to determine design performance may have saved us a lot of design controversy. This is the Texas twist problem. There are literally hundreds of thousands of these terminal designs on our highways today. There has been one crash test series that shows that if this design is hit in a critical location it can flip a vehicle onto its back. Admittedly, this is a relatively rare occurrence, or is it? What do the accident records show for this design? No one knows. If this design had been monitored through accident reports in the past, it certainly would have been helpful, and we would have a much easier time of deciding what to do about it today.

In summary, the task force felt strongly that accident reports can and must be used to verify designs and that designers should be responsible for this.

DESIGNERS AND CONSTRUCTORS NEED TO COMMUNICATE

Aside from the accident report use problem for safe highway design, there are a number of instances when somehow communications between design and construction personnel failed. Following are some photographs that show this communications failure. [Editors note—the text of this report continues in the figure captions of Figures 1 through 11.]

Figure 1. Note that while this guardrail is properly designed, it doesn't extend to the point of need.
Figure 2. It is difficult or almost impossible to determine all hazardous fixed objects along the roadway that will be shielded by a barrier system. Often the design deflection of the system seems to be forgotten in its placement. In modifying guardrail terminals to the BCT system this appeared to be a constant problem.

Figure 3. Another problem often encountered was the placement of barriers for no discernible reason. Barrier design is almost impossible to do on a plan sheet. It requires field inspection, and an unneeded barrier is also a hazard.

Figure 4. Some barrier designs such as the cable guardrail have desirable safety performance characteristics but are real maintenance problems. An inadequately maintained barrier is often more hazardous than no protection at all.
Figure 5. Obstructions such as curbs in front of guardrails negate the entire concept of the safe barrier system.

Figure 6. Some bridge rails are obviously strong enough to withstand a major impact, but are not designed to safety redirect the vehicle properly or prevent snagging.

Figure 7. One of the major gaps between design and construction were observed in problems relating to signing. The most reoccurring problem observed in 19 or 22 states was the low sign panel; even when sign panels were not low, hingepoints sometimes were.
Figure 8. Design policies which required signs to be placed close to the edge of the roadway in otherwise clear recovery areas were also a problem.

Figure 9. Single direction breakaway sign supports are fine for the main line of most freeways but should be modified where multidirectional hits can occur.
Figure 10. An area of major concern to the review team was the lack of a design policy for sidewalks in urban areas. Many states have no design policy for sidewalks in urban areas. Many states have no design criteria whatsoever for warranting sidewalks. This results in poor pedestrian accommodation. Designers appeared to have often forgotten about the pedestrian. This results in noncontinuous sidewalks and sidewalks obstructed by highway hardware.

Figure 11. Impact attenuator design was usually adequate. However, in many cases it was designed to either shield a specific fixed object without regard to other hazards at the same location, or the design did not take into account conditions on the approach that would minimize the safety effectiveness of the cushions.
Those are specific examples of the design problems we encountered during the review. There were a number of other general design policies which at least inhibited the safety of the highway environment. I would like to take a brief moment to discuss these.

The first area I would like to discuss is strict conformance to the 30-foot clear zone. See Figure 12. If designers were to consider their design from the standpoint of safety performance, I doubt that anybody in good conscience would follow the absolute 30-foot rule. A number of States have a policy of requiring breakaway designs within 30 feet of the travelled way but allow nonbreakaway devices beyond the 30-foot zone. This policy often results in pulling hazardous fixed objects
to the very edge of the clear zone when there is no necessity for the placement there at all.

Second, it was obvious to the members of the review teams that many of the major repaving projects reviewed were designed in a vacuum or at least without considering the impact of the repaving on the other safety features of the highway. See Figures 13, 14, 15. This resulted in low barrier heights and hazardous dropoffs. We realize that designers are sometimes not involved in safety upgrading projects for repaving only. But designers are certainly involved in safety upgrading projects requiring modification to existing highway hardware design. In a number of cases the review teams observed such things as modified transitions that attached to substandard bridge rails. If the barrier is worth installing, it's worth designing right. There are many instances where general design specifications were used as a substitute for specific
designs. This led to some very strange-looking highway hardware in the field, such as guardrails placed behind utility poles.

Probably the most disturbing design deficiency noted by the review teams was the use of barrier curbs on new projects. See Figure 16. It is inconceivable to me that any designer concerned with the safety of the driving public would purposely install a barrier curb between the edge of the roadway and the clear recovery area. The curb defeats the entire concept of the clear recovery zone. The purpose of the recovery zone

![Figure 16](image)

is to allow an errant driver to gain control of his vehicle while traversing the clear area and return safely to the highway. Placing a curb in front of the clear recovery area often causes the driver to completely lose control of his vehicle or in some cases damage his steering so that the driver can never regain control. The curb also negates the safety performance of crash cushions, barrier rails, and in some cases breakaway supports. Let's get rid of those curbs, or if it's absolutely necessary that a curb be present, let's at least make it mountable.

**HOW TO IMPROVE SAFETY DESIGNS**

So what will be the impact of the FHWA safety review on design? At this point I don't really know. FHWA has established an implementation task force to develop specific corrective action for the problems noted in the review. They are still in the process of developing these actions. However, I personally think there are a number of things that designers can do that would easily overcome many of the problems discussed today.

*Designers Must Be Aware of Desired Performance*

First the designer must be aware of the desired safety performance of his design. Most design specifications do not really address this issue and somewhere in the design process it appears that we lose sight of the basic intent of the design on some occasions. I think the best method to overcome this problem is to establish more performance standards
rather than specifications. Let's check the performance of the designed end product rather than the spec's and use proven designs to accomplish this.

**Train Constructors and Maintenance Personnel**

The second and probably more serious cause of most of the design problem is the inappropriate modification or adoption of the design during construction. Unfortunately, the designer can't afford to take the time to oversee the detailed construction of his design. The construction personnel must have knowledge of what the design is to accomplish and how it is supposed to perform. This will take training, and FHWA is in the process of working on a series of training programs to give construction and maintenance personnel just this type of knowledge. This is a start, but I think the designer must still periodically check on the final product to insure that its constructed as designed.

**Designers Should Evaluate Performance of Design**

Finally and most importantly, the designer must become involved in evaluating the safety performance of his designs. The designer will have to initiate this action—no one is going to supply him with accident data unless he asks for it, and unless he requests specific types of information, the information gatherers won't know what information to collect. I would recommend that designers should conduct performance reviews of their own to detect possible safety problem areas. Monitor and analyze the accidents in these specific areas and modify standards accordingly. Whatever happened to the design review team? No one seems to use them anymore. Here is a good place to start.

**SUMMARY**

In summary, we are not doing a bad job in safety design, but there are still some nagging problems. With a little more attention and concern in safety performance, we can do even a better job—and we should. It's human lives that may be in the balance.