

basic design controls (horizontal alignment, vertical alignment, stopping sight distance) mean that many existing freeways no longer meet current standards. Careful consideration of substandard geometry must accompany major rehabilitation or reconstruction of such freeways.

In addition, the policy clearly charts the course for a systematic approach to freeway and interchange design. Again, many older freeways require substantial planning and redesign to accommodate the operational objectives of the principles discussed in the new policy.

Finally, the policy maintains a proper stance toward the basic characteristics of freeways. The continued use of 60- and 70-mph design speeds and full-width cross-sectional elements is recommended. This should ensure the continuation of freeways as the safest, most efficient elements of the highway system.

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Impact of the AASHTO Green Book on Highway Tort Liability

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The new AASHTO design policy for highways and streets (Green Book) includes new and revised concepts on geometric design that reflect changes in design philosophy, design vehicles, roadside safety features, and driver behavior. Those concepts and how they affect highway tort liability are addressed. The consequences of design flexibility and functional roadway classification are presented; the implications of design consistency and driver expectancy are also discussed.

Many city, county, and state governments in the United States have been forced to devote extensive time and energy to defending themselves against highway tort litigation. (A tort is defined as a civil wrong, as opposed to criminal activity, and is

normally classified as negligence.) Highway tort actions normally are based on plaintiff accusations that the governmental agency (or its employees) responsible for design, maintenance, and operation of a roadway was negligent in performing its duties, and that this negligence caused the plaintiff to have a traffic accident that resulted in serious injury (or death). The plaintiff sues the agency in hopes of collecting an award (money) for his damages (injuries).

Proof of negligence must be clearly demonstrated by the plaintiff. One of the most effective methods to establish this proof is to show how the agency failed to design, maintain, or operate the roadway according to recognized standards, operational procedures, or policies.

Clearly identified as design criteria policies or guidelines, the AASHTO publications entitled *A Policy on Geometric Design of Rural Highways* (Blue Book) (1) and *A*

Policy on Design of Urban Highways and Arterial Streets (Red Book) (2) have been consistently accepted by the courts as the nationally recognized standards for highway and street design. The 1984 AASHTO publication, *A Policy on Geometric Design of Highways and Streets* (Green Book) (3), essentially replaces the Blue and Red books. Hence, it is sure to be touted as the latest edition of the nationally recognized design standards for highway and street design.

Because the Green Book contains some new and revised design concepts, there may be new areas of exposure to highway tort liability. An attempt to identify those new areas and explain methods for reducing the risk of lawsuit involvement in those areas is made in this paper.

STATE-OF-THE-ART DESIGN CRITERIA

The Green Book is a collection of design criteria pertinent at the time of its writing (1984); hence, the publication is considered representative of the state-of-the-art design criteria. It must be emphasized that the Green Book is not a publication of design standards. In the foreword of the book, it is clearly stated that "the intent of this *policy* is to provide *guidance* to the designer by referencing a recommended *range of values* for critical dimensions" (3) (italics added by the authors of this paper for emphasis). The Green Book, therefore, does not present a series of precise roadway design standards. Instead, it may be defined as a policy of design guidelines that recommends various ranges of dimensional values for consideration in design.

A common argument by the plaintiff in a tort case is that the roadway in question did not meet current design standards. This statement is often true. Most older roadways do not have the wide travel lanes, wide stabilized shoulders, or the bridge widths currently identified in the ranges of design values in the Green Book. In the foreword of the Green Book, this argument is clearly addressed (3):

The fact that new design values are presented does not imply that existing streets and highways are unsafe . . . This publication is intended to provide guidance in the design of new and major reconstruction projects. It is not intended as a policy for resurfacing, restoration, or rehabilitation (R.R.R.) Projects.

As design standards change, there is no requirement to reconstruct all roadways to meet the new standards. Such a requirement would be impossible to satisfy. Roads would never be completed because all roadways would have to be constantly upgraded. Furthermore, the funding requirements would be unbelievable.

All roadways cannot be continually upgraded to satisfy changing design criteria. The following is a good illustration of this principle. Suppose that a city government decides all residences must henceforth have a 30-ft setback from the property line instead of the 25-ft setback established by city ordinance. Does it make sense to require all residences having a 25-ft setback to be relocated an additional 5 ft away from the front property line?

The same principle could be applied in the automotive industry. Even though new safety design features are constantly being developed, automobile manufacturers do not recall all

their vehicles back to the plants for reconstruction every time a new design standard is introduced. Of course, on occasion, the manufacturer has to recall some automobiles to correct some deficiency. Similarly, to protect drivers who lose control of their vehicles, many state highway departments have upgraded roads by installing breakaway signs to replace fixed roadside signs and crash cushions (attenuation devices) in freeway gore areas.

The plaintiff's argument that the roadway in question did not meet current standards is best countered with the statements in the foreword of the Green Book. In support of the governmental agency's defense position, the Green Book may be used to illustrate that the roadway involved in the litigation actually met current design criteria and guidelines specified in the 1984 publication. The fact that a roadway designed in the 1950s still satisfies the state-of-the-art design criteria in the manual (Green Book) is strong supportive evidence that the agency is building and maintaining modern roadways.

DESIGN FLEXIBILITY

The Green Book attempts to avoid specifying exact geometric design dimensions for highways and streets. Instead, design guidelines and ranges of values are provided to allow some flexibility in the design of highways and streets. The roadway designer does not have to resort to prescribed designs and is allowed freedom for innovation. However, freedom may be viewed as a two-edged sword.

Most design engineers enjoy freedom of discretion when preparing a design for a new roadway. Available design criteria (including those in the Green Book) are most helpful in providing general (and sometimes specific) guidelines for dimensional design. It is helpful to recognize that when restrictions are placed on design options (e.g., narrow rights-of-way), minimal dimensions are still considered satisfactory and safe according to the Green Book guidelines.

However, discretionary freedom may also work against the original designer. Various opinions may be developed by other design engineers, and each of these opinions may be viewed as satisfactory according to the range of the design guidelines. Specific design criteria are easy to defend in a courtroom: the roadway design was either right or wrong. Ranges of design values present a more difficult defense position. Many design decisions could be viewed as satisfactory according to design standards, but the interpretation of choice falls into a gray area.

Some engineers believe that discretionary decisions are immune from tort liability. This belief is incorrect. Anyone (or any public agency) may be sued by anybody for anything at any time. (Of course, winning the suit is not always easy, but filing a claim is extremely easy and inexpensive.)

Generally, discretionary acts are design oriented and enjoy the protection of immunity from tort liability. However, there are exceptions. The courts may find that design immunity is not valid in cases where the design was not prepared with appropriate care, the plan was so obviously dangerous that a person acting prudently would not have approved it, or the design was dangerous or unsafe after its implementation (e.g., the design was simply not done correctly) and the responsible agency had received notice of that fact (4).

In presenting his claim, the plaintiff may hire an expert witness to testify that the roadway should have been designed differently and that if it had been designed differently, the accident in question would not have happened. Of course, the expert has the benefit of hindsight. However, the jury will be presented with the alternative design by the expert and will have to compare it with the actual design selected by the public agency. If both designs satisfy the design guidelines and criteria of the Green Book, the jury may have difficulty understanding why the alternative design was not selected.

In selecting a proper roadway design it is important to ensure that the design features satisfy the guidelines contained in the Green Book and that the design selected is satisfactory for the conditions and restrictions presented. Moreover, the basis for the design selection should be well documented to provide justification for the selected design and evidence for legal defense, if necessary. This documented evidence is the strongest argument that can be presented to counter the claims of the plaintiff's expert witness. Although not able to benefit from hindsight, the decision-making agency should document the reasoning for the design selection on the basis of projected traffic conditions. This decision-making process could be explained in the courtroom by a witness for the defense. However, the testimony is much stronger if a document is presented that describes the decision-making process and gives a preparation date several months (or years) before the relevant accident.

NEW AND REVISED CONCEPTS

General

The basis for the design modifications and new concepts in the Green Book may be found in the changes in philosophy or attitudes of the highway engineering profession, advancements in technology, and proven experiments and successful operations of new roadway geometric concepts.

Since the publication of the Blue and Red books, changes in philosophy and attitudes of highway design engineers have altered the concepts of design criteria. Probably the most significant design modification in the Green Book is based on a change in philosophy. Average daily traffic (ADT) volumes were used as the fundamental basis for design in the Blue and Red books. Roadways were designed for the design ADT volume. In the Green Book it is argued that roadways should be classified according to their function or use and then be designed to fulfill that function. Hence, the functional classification of roadways has become the initial requirement for design.

Additional design vehicles have been added to the Green Book, and new design topics have also been added. These additions reflect a desire to be more thorough with design standards.

A concentrated effort was made in the Green Book to develop design criteria that emphasize consistency. Significant attention has been devoted recently to the human factors element of highway design. Humans are creatures of habit and perform more efficiently when they work (or operate) in a familiar environment. In performing the driving task, humans

have a tendency to expect certain operational conditions and roadside features. Hence the need to acknowledge driver expectancy is encouraged in highway designs. Design consistency to satisfy driver expectancy is addressed throughout the text of the Green Book.

The new guidelines are very safety oriented and deal extensively with the "forgiving roadside" concept. At the same time, the Green Book includes geometric design and operational concepts that were developed during the past 10 to 20 years. An example is the two-way left-turn lane, which was not emphasized in either the Blue or Red book.

Technological changes have also had an impact on the Green Book. Since the oil embargo of 1973, American cars have been getting smaller, and trucks have been getting larger. Cars are no longer so powerful as they were 12 years ago, but trucks have become more efficient and more powerful. Trucks can now compete very well in acceleration and speed with the passenger car on high-speed, relatively flat roadways. Design modifications in the Green Book reflect these developments.

A major roadway design change related to the smaller car involves the lowering of driver eye height. For design purposes, the Blue and Red books used a driver eye height of 3.75 ft. The Green Book uses a driver eye height of 3.50 ft. Although this change may appear to be insignificant, it does affect sight distance calculations.

This overview of the new and revised concepts of the Green Book has identified four major areas of concern relative to potential tort litigation:

1. Functional classification,
2. Design vehicles,
3. Driver expectancy, and
4. Safety design.

Functional Classification

Functional classification groups rural highways and urban streets into categories according to their character of service. Initially, roadways are classified as either rural or urban, depending on their location. According to the Green Book, urban areas are "places within boundaries set by responsible State and local officials having a population of 5,000 or more" (3). Urban areas are further categorized as either "urbanized areas" (having a population greater than 50,000) or "small urban areas" (having a population between 5,000 and 50,000). Rural areas are those locations that do not qualify as urban areas.

Roadways are classified within urban and rural areas as follows:

<i>Urban</i>	<i>Rural</i>
Principal arterial	Principal arterial
Secondary arterial	Minor arterial
Collector street	Major collector
Local street	Minor collector
	Local road

Roadways fall into one of three general categories: arterials, collectors, or local streets and roads. The hierarchy of classification indicates that arterials are the major highways and

thoroughfares, and the local streets and roads are the least important roadways.

Some roadways can be easily classified into one of the categories. Obviously, Interstate highways and freeways are primary arterials. Other roadways may satisfy the descriptions of one of the other classifications without difficulty. However, some roadways are difficult to classify, and engineer discretion is required.

Population growth may cause some rural roadways to become urban roadways, but the classification guidelines are based on population figures and are very specific. Courts would have no problem discerning which classification applies. However, determining the appropriate category for those roadways that are difficult to classify causes some concern. For the higher functional classifications, design guidelines suggest wider roadways, more rights-of-way, stabilized shoulders, shorter curve radii, and generally a better or more sophisticated roadway. In litigation, a plaintiff will argue that the roadway in question should have been given a higher classification, and his expert witness will provide evidence as to why the higher classification was warranted and why different design criteria should have been used. The public agency will defend the design criteria used in constructing the roadway. Once again, the court is presented with arguments that are matters of opinion, and it must determine which argument is most valid.

The best defense for the public agency is to provide documentation addressing the basis for its classification system and the reasoning for selecting the functional classification category and the pertinent design criteria. Because the functional classification approach may be new to some design engineers, additional development of evaluation factors will be forthcoming. Until a more precise process is developed, design engineers must select the most reasonable classification categories for their existing and future roadways and be careful to document their decisions for purposes of justification and legal defense.

Design Vehicles

Design vehicles listed in the Blue and Red books included the following:

1. Passenger car,
2. Single-unit truck,
3. Single-unit bus,
4. Semitrailer intermediate,
5. Semitrailer combination, and
6. Semitrailer–full trailer combination.

Four additional design vehicles have been included in the Green Book:

7. Articulated bus,
8. Motor home,
9. Passenger car with travel trailer, and
10. Passenger car with boat and trailer.

The last three reflect AASHTO's recognition of the need to design unique roadways for unique vehicles.

The 1982 Surface Transportation Assistance Act allowed for larger vehicles than those just listed. They were not included in the Green Book because AASHTO decided that the time required to reflect the changes to the Green Book necessitated by the larger vehicles would excessively delay its publication date. A supplement to the Green Book that will address the additional design requirements for the larger vehicles is currently being developed.

What is important from a tort liability viewpoint is the need to recognize that the larger vehicles and the vehicle combinations (e.g., passenger car with trailer) require larger turning radii, and design engineers should consider these vehicles when selecting the geometric design criteria for roadways. This does not mean that all roadways must be designed to accommodate the larger vehicles. Such overdesigning is unnecessary and economically wasteful. But it does suggest that attention should be given to designing intersections, ramps, driveway entrances, and all roadway grades to minimize adverse operational effects on the larger vehicles. This need is especially important for roadways serving a significant traffic demand.

Some roadways require special design considerations for larger vehicles, recreational vehicles, or both. Roadways and intersections within or near industrial parks should be designed to accommodate the larger trucks that are expected to travel to and from the park. Roadways and intersections built to provide transport to recreational sites (campgrounds, lakes, state and national parks, etc.) should accommodate motor homes and the passenger car and trailer combinations.

Suppose that an accident involving a motor home on a roadway serving a popular state campground and park facility results in a tort claim. The plaintiff may contend that the geometric design of the roadway did not accommodate the required wide turn of a motor home and that this design deficiency caused the accident. It would be hard to defend the suit if no special consideration had been given to designing for that particular vehicle and if the state (or responsible governmental agency) knew that the roadway was built primarily to serve recreational vehicles.

Driver Expectancy

Expectancy "relates to the process in which an individual with an established set of ideas and concepts is presented with a stimulus of some type . . . and responds in some fashion to this stimulus" (5). Driver expectancy causes a driver to respond in a set manner to a traffic-related situation on the basis of previous experience. For example, because of consistent use of standardized signs, motorists expect to see STOP signs that are red and octagonal shaped, not circular and blue or rectangular and black.

The Blue and Red books did not emphasize design based on driver expectancy; however, the Green Book devotes significant attention to it. Some examples of driver-expectancy design criteria are the following:

1. Lane balance: Generally, lane balance is achieved in merging areas by maintaining the same number of through lanes approaching and leaving the merging areas and by gradually transitioning lane drops downstream of the merging areas. Such design is strongly encouraged in the Green Book.

2. Major route emphasis: When two roadways reach a point of bifurcation, the most direct connection should be the continuation of the most important route. Recommended freeway design criteria in the Green Book suggests this treatment.

3. Consistent freeway ramp design: Ramp design consistency (e.g., the same type of ramp along a section of freeway) and providing all freeway exits on the right are major driver expectancy design criteria included in the Green Book.

4. Design by functional classification: One of the purposes of establishing roadway design by functional classification is to develop consistency in roadway design features so that drivers will learn to recognize the function of a facility according to its geometrical configuration. Hence, the consistency in design will help to develop driver expectancies.

Another design feature addressed in the Green Book is the concept of decision sight distance, or "the distance required for a driver to detect an unexpected or otherwise difficult-to-perceive information source or hazard in a roadway environment that may be visually cluttered, recognize the hazard or its threat potential, select an appropriate speed and path, and initiate and complete the required safety maneuver" (3).

Decision sight distance is required in locations where driver expectancy is violated or where there is potential driver error in receiving information, making a decision, or controlling the vehicle. These locations include interchanges, intersections, lane drop locations, and areas having significant "visual noise." The values for decision sight distance contained in the Green Book reflect driver decision and reaction times in the range of 10 to 14 sec.

The concept of driver expectancy creates additional and unique exposure to tort liability. Because the Green Book emphasizes driver expectancy design, any roadway designed according to the guidelines should accommodate driver expectancy considerations. Plaintiff claims that indicate driver confusion or violations of driver expectancy may be dealt with in one of two ways.

First, an argument may be presented by the defense that driver expectancy was not violated, and factual proof supporting this contention may be provided. Second, the defense may recognize that the roadway condition may be contrary to driver expectancy (e.g., a left-side freeway exit), but that sufficient information was provided to establish adequate decision sight distance. In either situation, the driver expectancy concept may be difficult to defend because the human factors element plays such an important role. Furthermore, the human element is more clearly understood by a jury than engineering principles and technical computations.

Safety Design

The Green Book is very safety oriented. New design concepts and modified design criteria are all based on safety-related research, technological changes, or traffic operational findings. Design criteria and guidelines contained in the Green Book reflect wider, straighter, and flatter roadways, more recovery area for out-of-control vehicles, and greater built-in factors of safety than those in either the Blue or Red book.

Some specific safety design features included in the Green Book are the following:

1. Increased stopping sight distances: Driver eye height for design purposes was lowered from 3.75 to 3.50 ft to reflect the trend toward smaller American cars. Also, the design friction factors (or drag factors) used to determine braking distances were lowered to increase the design factor of safety. Because of these modifications, design stopping sight distances were increased for all types of roadways.

2. Increased vertical curve lengths: The reduction in driver eye height and the increase in stopping sight distances have resulted in longer vertical curves or, in essence, "flatter" curves.

3. More gentle horizontal curves: The increase in design stopping sight distance has necessitated longer radii for horizontal curves. In other words, minimum curve radii have been increased for various speeds.

4. Design criteria for emergency escape ramps: Among the new design concepts introduced in the Green Book are design criteria for emergency escape ramps. These ramps are designed primarily to stop out-of-control trucks on roadways in mountainous terrain.

All design criteria and guidelines in the Green Book reflect the most recent roadway safety design innovations available to the roadway designer. Consequently, roadways designed and constructed in accordance with the Green Book will be considered safe as well as efficient. Because tort claims result from traffic accidents, it stands to reason that fewer accident occurrences because of safer roads will result in fewer tort claims. Safe roadways do not eliminate accidents, but they help to minimize the number of occurrences and to reduce severity levels.

Governmental agencies can minimize their risk to tort litigation by ensuring that their new and reconstructed roadways are designed in accordance with the Green Book. In fact, one of the strongest defense positions that can be taken in a tort lawsuit is to demonstrate proof of conformance with recognized design standards, criteria, and guidelines that were in effect at the time of the design and construction of the roadway in question.

If severe design or operational restrictions prohibit a governmental agency from designing or constructing a new or reconstructed roadway in accordance with the Green Book, the agency should ensure that the decision-making process followed in deciding not to comply with the Green Book is documented and that the reasons why compliance was not possible are explained. Such documentation, usually in the form of standard policies and procedures, is necessary for possible legal defense. Without such evidence, the governmental agency may find itself in an extremely vulnerable position.

SUMMARY

New design concepts and modified design criteria in the Green Book are all based on safety-related research or operational findings. Applications of the design criteria and guidelines contained in the Green Book will provide safer, more efficient, and more comfortable roadways. Hence, the safer roadways will help to reduce traffic accidents, which in turn will help to minimize tort-related lawsuits resulting from accidents. Compliance with the Green Book is an effective method of reducing highway tort liability.

At the same time, there is a tendency to avoid establishing precise design criteria in the Green Book. Instead, ranges of design values are provided, which affords the design engineer greater flexibility in selecting the design features of a roadway. This design flexibility may be viewed as a two-edged sword. It allows the design engineer to be innovative and provides freedom to exercise discretion. However, the plaintiff in a tort lawsuit can present alternative designs that are claimed to prevent the tort-related accident. Both designs could satisfy the design criteria and guidelines of the Green Book. The jury faces a dilemma in trying to determine whether the original design was inadequate and therefore hazardous.

The best defense for a public agency is to document the decision-making process when selecting the design for new or reconstructed roadways. If the design does not comply with the Green Book, it is imperative that the reasons for non-compliance be explained and documented for use as potential evidence. Because a multitude of potential designs can be developed in accordance with the Green Book, it is important that the discretionary decisions made by the design engineer

also be documented. This documentation could provide the primary evidence necessary to successfully defend a future tort lawsuit.

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New Approach to Geometric Design of Highways

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A basic deficiency in the current practice of geometric highway design is a lack of sensitivity to traffic volume, traffic composition, and construction and user cost factors. Current practice is based on a deterministic approach, whereas the factors involved in the geometric design process (e.g., speed, friction, reaction time) are stochastic in nature and vary among road users. The current approach employs only a single value to represent each factor. Criteria that are used to generate these representative values are not made explicit. An alternative approach to geometric design of highways is presented in which sensitivity to the stochastic nature of the various factors involved in the design process and utilization of their distribution are used in calculating design values. The proposed

approach also attempts to achieve a cost-effective design by taking into account all the cost elements associated with the highway. An empirical example of a horizontal curve demonstrates the advantages of the probabilistic approach.

This paper is concerned with the concepts used in the geometric design of highways. A modified approach is proposed that would achieve more meaningful and cost-effective designs.

Current geometric design practice is based heavily on design standards and the following basic design process is used. First the highway section to be designed is classified into one of the several functional classes (e.g., freeway, arterial, local). Then a design speed is selected for the highway on the basis of its classification and local conditions. After highway classification and design speed have been specified, design values for the various highway elements are selected from a set of predefined design standards (1-3).

This design practice has two major advantages. First, the

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