A major event occurred in the field of street and highway design in the past year—in late 2001, the American Association of State Highway and Transportation Officials (AASHTO) published a long-awaited update to A Policy on Geometric Design of Highways and Streets (1), commonly known as “the Green Book.” Green Book policies guide engineers in designing the physical layout and dimensions for safe and efficient highways.

The 2001 version—900-plus pages in an 8.5- x 11-in. softcover format (Figure 1)—is a comprehensive, substantive update of the 1994 edition. The AASHTO Subcommittee on Design and its Task Force on Geometric Design oversaw the updates to the Green Book, made with the assistance of National Cooperative Highway Research Program (NCHRP) contractor, Midwest Research Institute.1 The revisions incorporate results of extensive research on geometric design, conducted under the auspices of NCHRP and the Federal Highway Administration (FHWA) since 1994.

**Dual Units of Measure**

A major change is the adoption of two measurement systems throughout the text and exhibits. The 1990 Green Book and previous editions used U.S. customary units exclusively, and the 1994 edition used only metric units. The 2001 edition employs both, with the metric units presented first in the text, followed by U.S. customary units in square brackets. When necessary for clarity, exhibits are presented separately in metric and U.S. customary units.

The relationship between the units of measure is neither an exact (or soft) conversion nor a completely rationalized (hard) conversion. Users are advised therefore to work entirely in one system of units and not to convert between the two measurement systems.

**Key Revisions**

1 NCHRP Project 20-7(126), Production of the Year 2000 AASHTO Policy on Geometric Design of Highways and Streets.
As in previous editions, the Green Book is organized into ten chapters covering key aspects of geometric design for the facility types in the functional classes of highways (Table 1). The first chapter, defining the basic functional classifications of highways and streets, required no significant changes. The key revisions for the other chapters of the Green Book are summarized below.

**Design Controls and Criteria**
Chapter 2 defines the fundamental design controls and criteria that constitute the framework for the geometric design of highways. The Green Book addresses four classes of design vehicles: passenger cars, buses, trucks, and recreational vehicles. The 2001 edition updates the dimensions of many of the design vehicles and revises the format for the turning templates, which assist in plotting the actual paths of turning vehicles (Figure 2).

Several new bus design vehicles are introduced, and new guidance is provided for selecting an appropriate design vehicle and for accommodating the needs of bicyclists. The chapter adds emphasis to design considerations for the needs of older drivers and presents countermeasures that may alleviate potential problems for older drivers.

Revised definitions of operating and design speeds focus on practical applications. Operating speed is the speed at which drivers operate vehicles in free-flow conditions. Design speed is the speed selected to determine a roadway’s geometric design features. The new Green Book provides geometric design criteria for design speeds of 20 to 130 km/h (15 to 80 mph). Table 2 shows the correspondence of design speeds in metric and U.S. customary measures.

Traffic flow relationships are now consistent with those in the *Highway Capacity Manual 2000* (HCM) (2). The new Green Book has eliminated detailed material that duplicated HCM tables and procedures.

A rewritten and expanded section on access control and management incorporates material from NCHRP Report 420, *Impacts of Access Management Techniques* (3). The text presents basic principles, classifications, methods, and benefits of access management. Three new exhibits illustrate how access management measures may help reduce crash rates.

The consideration of pedestrian needs in geometric design receives new emphasis, with particular attention to accommodating persons with disabilities. The text offers seven specific measures to reduce pedestrian–vehicle conflicts.

Revised sections on safety in geometric design point out the need for adequate shoulders in narrow medians. The list of design considerations for rural intersections has been expanded.

**Elements of Design**

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* Based on Green Book Exhibit 2-29.
Chapter 3 defines the design criteria for specific elements of geometric design, including sight distance (the driver's ability to see ahead), horizontal alignment (the design of roadway curves), and vertical alignment (the design of roadway grades, crests, and sags).

The new Green Book incorporates updated criteria for stopping sight distance from research findings in NCHRP Report 400, Determination of Stopping Sight Distances (4). Changes include a revised braking distance equation based on driver deceleration instead of locked-wheel braking friction. Each design speed now has a single value—instead of a range of values—for stopping sight distance.

The design value for driver eye height has increased from 1070 to 1080 mm (3.51 to 3.54 ft) to match the latest field data. Because crash studies have found almost no collisions with objects shorter than 600 mm (2.0 ft), the design value for object height has increased from 150 mm (0.5 ft) to 600 mm. An object height of 600 mm corresponds closely with the taillight height of a passenger car. All horizontal and vertical alignment criteria in the Green Book incorporate the new values for driver eye height and object height.

The treatment of superelevation for horizontal curves is unchanged; superelevation is the introduction of an increased cross slope or banking on a horizontal curve to help vehicles traverse the curve safely. However, some recommendations from NCHRP Report 439, Superelevation Distribution Methods and Transition Designs (5), may lead to changes in the next edition of the Green Book. Other recommendations already have been incorporated into the updates of design controls for transitions from roadway sections with superelevation to sections without superelevation.

The upper limit for low-speed design is now 70 km/h (43 mph) instead of 60 km/h (40 mph). The section on curbs now stresses visibility for drivers. In addition, a change in terminology replaces the term “barrier curb” with “vertical curb” and the term “mountable curb” with “sloping curb.”

The discussion of surface types refers only to high- and low-type pavement surfaces, eliminating the intermediate pavement surface type. Also updated are the discussion of medians and the guidance on grades for parking areas in park-and-ride facilities.

A single section on pedestrian facilities incorporates material on sidewalks and is compatible with proposed criteria in the Americans with Disabilities Act Accessibility Guidelines (6). The updated section on sidewalk curb ramps (Figure 3) also corrects inconsistencies in the previous edition’s terminology.

Designing to accommodate bicycles receives added emphasis throughout the Green Book, following guidance and information presented in the AASHTO Guide for the Development of Bicycle Facilities (7).

Local Roads and Streets

Chapter 5 presents the design criteria for local roads and streets. The chapter exhibits reflect the changes to fundamental design criteria in Chapters 3 and 9. The maximum superelevation for rural roads has increased from 10 to 12 percent. Clear zone widths—the areas that should be clear of roadside obstacles and steep roadside slopes—are now 2 to 3 m (7 to 10 ft) for local roads and streets.

In 2001, AASHTO also published Guidelines for Geometric Design of Very Low Volume Local Roads (8), which applies to local roads and to some collector roads with average daily traffic volumes of fewer than 400

\[ \text{FIGURE 3 Sidewalk curb ramp.} \]
vehicles. The next edition of the Green Book will incorporate these design guidelines.

**Collector Roads and Streets**

Presenting the design criteria for collector roads and streets—which provide links from local to arterial roads—Chapter 6 and its exhibits also reflect the changes to fundamental design criteria in Chapters 3 and 9. A minimum clear-zone width of 3 m (10 ft) is recommended for rural collectors. The discussion of median width on urban collectors has received minor modifications, and the widths of parking lanes on collectors in residential, commercial, and industrial areas have been revised.

**Rural and Urban Arterials**

The recommended width of the traveled way—the portion of roadway in which vehicles are permitted to operate—has increased from 6.6 to 7.2 m (22 to 24 ft) for rural arterials with a design speed of 80 km/h (50 mph) and an average daily traffic volume of 1,500 to 5,000 vehicles. A minimum paved shoulder width of 0.6 m (2 ft) is recommended for pavement support, wide vehicles, collision avoidance, and bicycles.

A new section on bridges defines the minimum widths needed for the retention of bridges already in service. The text also updates the design criteria for highway medians in rural and in urban settings.

**Freeways**

The changes to the design criteria for rural and urban freeways in Chapter 8 are relatively minor. Exhibits are now consistent with information in Chapters 3 and 9.

The widespread use of cold milling technology has eliminated the need for vertical clearances to allow for changes that may result from resurfacing. The minimum vertical clearance above railroads has increased from 6.6 to 7.0 m (21.5 to 23 ft). Figure 4 illustrates a typical rural freeway.

**Intersections**

The revised Chapter 9 defines the functional—as distinguished from the physical—area of an intersection. Roundabouts (Figure 5) are a new topic in the Green Book, drawing on the recent FHWA report, *Roundabouts: An Informational Guide* (9), but without offering quantitative design criteria. The treatment of turning lanes and islands has been reorganized, and related exhibits have been updated to reflect changes in the design vehicles presented in Chapter 2.

Revised design criteria for intersection sight distance are presented, using research from NCHRP Report 383, *Intersection Sight Distance* (10). Several intersection sight distance cases now follow models for gap-acceptance—the process by which a driver entering traffic accepts an available gap for maneuvering into the flow of vehicles.
The discussion of median widths at divided highway intersections incorporates findings from NCHRP Report 375, Median Intersection Design (11). The chapter presents the advantages of offset left turns in reducing sight distance hindrances from opposing left-turn vehicles.

**Grade Separations and Interchanges**

Chapter 10 recommends the separation of bicycle and pedestrian movements from vehicle movements through interchange areas. Single-point urban interchanges—which control all left-turning traffic with a single traffic signal (Figure 6)—are now presented as a separate type of interchange.

The focus is on controlling access at interchanges, for example by minimizing traffic spillback on ramps and crossroads, providing sufficient length for merging maneuvers and for crossroad weaving maneuvers (i.e., when traffic flows cross one another), and providing storage (i.e., a temporary waiting area) for turning vehicles. Acceleration lengths for speed-change lanes have been recalculated and vary slightly from previous values. Designers are cautioned against using the minimum design requirements for tapered entrances, and against exceeding lane capacity on two-lane ramps.

**Future Research**

The AASHTO Task Force on Geometric Design has identified several topics for research to be incorporated into future editions of the Green Book. These include improved design criteria for freeway speed-change lanes, design criteria and warrants for right-turn deceleration, auxiliary through-lanes, and lane drops, and passing sight distance.

**References**


**FIGURE 6** Diagram of single-point urban interchange shows complexity of movements and access points.