1000 Geometrics

1000.1 General

The geometrics of a roadway consist of its horizontal alignment, vertical alignment, and cross section elements. The New Mexico Department of Transportation (NMDOT) has accepted the American Association of State Highway and Transportation Officials (AASHTO) A Policy on Geometric Design of Highways and Streets (Green Book) as its standard for geometric design. For projects on the interstate system, AASHTO's A Policy on Design Standards - Interstate System supplements the Green Book.

Designers are directed to the above-referenced documents for geometric design criteria. This chapter does not attempt to restate criteria contained in the Green Book; rather, it provides criteria specific to the NMDOT where it is different or more limiting than what AASHTO allows. In instances where these criteria cannot be met, Chapter 210 of the Design Manual describes NMDOT's documentation procedures for design exceptions and design variances.

1000.2 References

The following references are used in the design of roadway geometrics. Conformance with federal and state laws and codes is required.

1000.2.1 Federal/State Laws and Codes

- 23 Code of Federal Regulations (CFR) Part 625.4, Design Standards for Highways, Standards, Policies, and Standard Specifications.
- 18.31.6 New Mexico Administrative Code (NMAC), State Highway Access Management Requirements (State Access Management Manual [SAMM]).

1000.2.2 Design Guidance

- A Policy on the Geometric Design of Highways and Streets (Green Book), AASHTO, current edition.
- A Policy on Design Standards - Interstate System, AASHTO, 2005.
- Guidelines for Geometric Design of Very Low-Volume Local Roads (Average Daily Traffic [ADT] ≤ 400), AASHTO, current edition.
- Guide for the Planning, Design, and Operation of Pedestrian Facilities, AASHTO, current edition.
- Guide for the Development of Bicycle Facilities, AASHTO, current edition.
- Interstate System Access Informational Guide, Federal Highway Administration (FHWA), 2010.
- Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), United States Department of Transportation (USDOT), FHWA, current edition.
- NMDOT Functional Classification System Map, current version.
- NMDOT Standard Drawings.
- Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way, (PROWAG), SNPRM, 2013.
- Roadside Design Guide, AASHTO, current edition.

1000.3 Definitions

Refer to the Green Book, Chapter 2 of the SAMM, and the reference documents listed above for relevant definitions.

1000.4 Design Controls and Elements

In order to optimize or improve roadway design, the characteristics and criteria of vehicles, pedestrians, and traffic must be explicitly considered as discussed below.

1000.4.1 Functional Class

The functional classification of a roadway will guide the design criteria to be used for roadway design. The NMDOT's Functional Classification System Map provides roadway classifications for all interstates and state roads in New Mexico. For facilities within Metropolitan Planning Organizations (MPOs), current roadway classifications are provided on each MPOs functional classification maps.

1000.4.2 Design Vehicle

The design vehicle is generally the largest vehicle that is likely to use a facility with considerable frequency. It is typically determined from vehicle classification counts performed for existing facilities and its selection is important and directly related to such critical features as radii at intersections and radii of turning roadways. Per 18.31.6 NMAC, the design vehicle is subject to the approval of the District Traffic Engineer. There are four general classes of design vehicles: passenger cars, buses, trucks, and recreational vehicles. The passenger car class includes sport-utility vehicles (SUVs), minivans, and pick-up trucks. The bus class includes city transit, school buses, and articulated buses. The truck class includes single-unit and truck tractor-semitrailer combinations. The recreational vehicle class includes motor homes and cars with camper or boat trailers. More detailed discussion of the vehicles classes can be found in Chapter 2 of the Green Book.

1000.4.3 Traffic Characteristics

Traffic characteristics such as volume, typically expressed as average daily traffic (ADT), peak-hour traffic, directional distribution, and traffic composition should all be considered in the design of a roadway and its features. These characteristics are gleaned through data collection on existing facilities, and directly influence the selection of geometric design features such as the number of lanes, widths, alignments, and grades.

1000.4.4 Design Speed

Roadways should be designed to support vehicle operation at a speed that accommodates safe driving. Design speed is the control by which a facility is designed so that the facility fits the travel desires and habits of nearly all drivers expected to use it.

Design speed is a selected speed used to determine the various geometric design features of the roadway and to establish the limiting values of curve radius and minimum sight distance. It is often established based on current posted speeds. The selection of design speed for a roadway project should be done in coordination with the NMDOT.

1000.4.4.1 Low Speed vs. High Speed Design

The Green Book Chapter 2, Design Controls and Criteria, discusses speed and the differences between the design criteria applicable to low and high speed design. It defines the upper limit for low-speed design as 45 miles per hour (mph), and the lower limit for high-speed design as 50 mph.

1000.4.5 Capacity

Roadway capacity is discussed in the SAMM.

1000.4.6 Access Control and Access Management

A roadway's access control directly affects its service and safety, in terms of crash frequency and severity. Access control serves to manage the interference with through traffic from vehicles and pedestrians entering, leaving, and crossing the roadway. NMDOT's SAMM provides guidelines and criteria for the design of access points on state roads and non-National Highway System US routes.

Guidelines for interstates can be found in FHWA's Interstate System Access Informational Guide.

1000.4.7 Pedestrian and Bicycle Facilities

Interactions of pedestrians and bicyclists with traffic are a major consideration in roadway planning and design. AASHTO's Guide for the Planning, Design, and Operation of Pedestrian Facilities and Guide for the Development of Bicycle Facilities contain design guidelines and criteria.

1000.4.8 Safety

The safety of a roadway is related to a number of factors such as roadway design, roadside design, and traffic control devices. Improving safety by reducing the number and severity of crashes involves consideration of speed, traffic volumes, access control, and reducing the need for driver decisions, among many factors.

The Roadside Design Guide shall be referred to in optimizing roadside safety. The MUTCD shall be used for implementing standards for traffic control devices.

1000.4.9 Sight Distance

Sight distance is one of the principal elements of design that is common to all classes of highways and streets. It is the length of the roadway that is visible to the driver and is a function of design speed, brake reaction time, and deceleration rate. Values for and criteria to measure sight distance are provided in the Green Book. Additionally, the SAMM provides sight distance requirements for access points on state roads.

1000.4.10 Drainage, Utilities and the Environment

Drainage, utilities, and the environment are additional elements that influence geometric design and should be considered during the design of a roadway project.

1000.5 Horizontal and Vertical Alignment

Horizontal and vertical alignments (see Section 1000.5.5) are the primary controlling elements for highway design. It is important to coordinate these two elements with design speed, drainage, and intersection design in the early stages of design. Horizontal curve radii and curve length criteria are provided in the Green Book.

1000.5.1 Horizontal Curves

The NMDOT generally uses simple curves in horizontal alignment design. The NMDOT discourages the use of compound curves on the highway mainline and only allows their use to meet field conditions where a simple curve is not obtainable (e.g., to avoid obstructions that cannot be relocated). When compound curves are used on the highway mainline, it is preferable that the ratio of the flatter radius to the sharper radius not exceed 1.5 to 1.

1000.5.2 Maximum Deflection Angle without a Horizontal Curve

It may be appropriate to design a facility without a horizontal curve where small deflection angles are present. As a guide, the designer may retain deflection angles of approximately 30 minutes or less for mainline through-traffic conditions.

1000.5.3 Minimum Curve Length

Criteria for the minimum length of curve is found in the Green Book and reiterated here. The designer should refer to the Green Book for further information. The NMDOT minimum curve length, Lc_{min}, should be 500 feet long for a central angle of five degrees. The minimum lengths should be increased 100 feet for each one degree decrease in the central angle. The minimum length of curves on low speed urban streets will be determined on a case-by-case basis.

1000.5.3.1 All Major Highways

The minimum curve length, Lc_{min}, should be 15V, where V equals the design speed in mph.

1000.5.3.2 Freeways

For aesthetics, it is desirable that the minimum length of curve be 30V, where V equals the design speed in mph.

1000.5.4 Superelevation

The Green Book provides maximum superelevation (e_{max}) rates of up to 12 percent. However, the NMDOT limits the maximum superelevation rate to six percent.

1000.5.4.1 Superelevation Methods

The NMDOT uses two methods, Method 5 and Method 2 as described in the Green Book, to distribute superelevation and side friction factor. They are commonly referred to as the open roadway method and the low-speed urban street method.

The open roadway method uses Method 5 and applies to all rural facilities and all urban facilities where the design speed, V, exceeds 45 mph.

The low-speed urban street method uses Method 2. The practical effect of Method 2 is that superelevation is rarely warranted on low speed streets (design speed ≤ 45 mph).

1000.5.4.2 Superelevation Transitions

Superelevation transitions include a tangent runout and a superelevation runoff. Minimum lengths for these elements shall be determined from the Green Book.

1000.5.4.3 Location of Runoff with Respect to End of Curve

The NMDOT recommends the use of Green Book Table 3-18, "Runoff Locations that Minimize the Vehicle's Lateral Motion," to determine the proportion of runoff length on the tangent. The designer, if referring to NMDOT Standard Drawing 801-01-1/4, is advised to use the Green Book values.

1000.5.5 Vertical Alignment

The vertical alignment, or roadway profile, consists of a series of gradients connected by vertical curves. The designer should refer to the Green Book for criteria for minimum length (or K-value) of vertical curves, maximum/minimum grade, and other design criteria.

1000.6 Cross Section Elements

Cross section elements are determined by functional classification criteria, traffic volume, and whether the roadway is in a rural or urban area. General guidelines from the Green Book and the SAMM are summarized below.

1000.6.1 Lane Width

Twelve-foot lanes are predominant on high-speed, high-volume highways. In urban areas, 11-foot lane widths may be appropriate.

1000.6.2 Auxiliary Lanes

The SAMM requires 12-foot auxiliary lane widths. The Green Book recommends a width of 10 feet to 16 feet for continuous two-way left turn lanes.

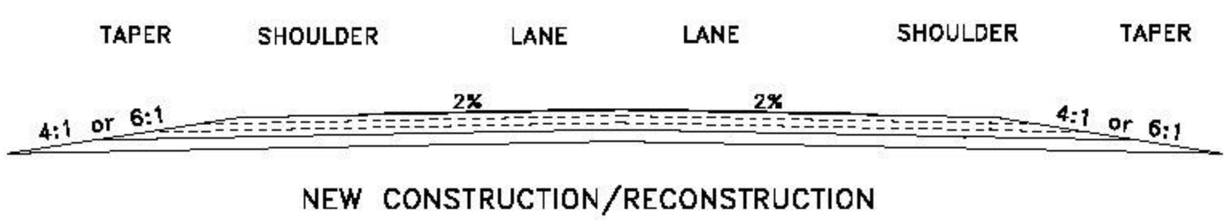
1000.6.3 Shoulder Width

- For higher speed, high volume roads, the NMDOT has adopted ten feet as the normal shoulder width.
- For low-volume roads, a minimum shoulder width of two feet is required, though six feet to eight feet is preferable.
- Where bicycles and/or pedestrians are to be accommodated on shoulders, the minimum usable width (i.e., clear of rumble strips and gutter pan width) is four feet.

1000.6.4 Minimum Cross Slope

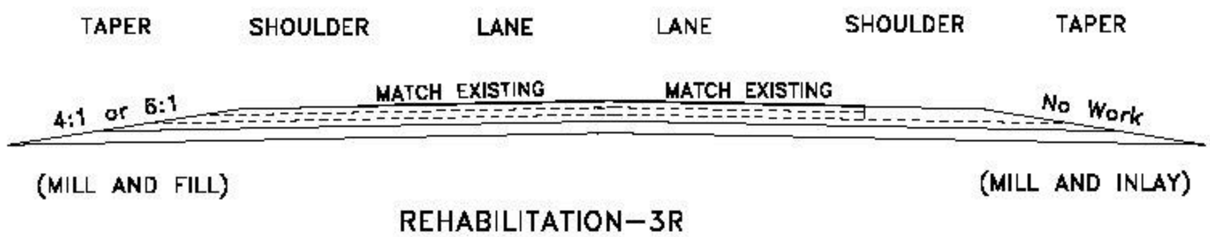
For new construction or reconstruction (4R) projects, the minimum roadway cross slope will be two percent. The shoulder cross slope will match the driving lane cross slope. See Exhibit 1000-1.

Exhibit 1000-1
Roadway Cross Slope for New Construction or Reconstruction (4R) Projects



For rehabilitation (3R) projects, the desirable roadway cross slope is two percent. However, where this is not possible, the existing roadway cross slope shall be matched, with a minimum roadway cross slope of 1.5 percent. The existing superelevation shall be maintained on 3R projects, as shown in Exhibit 1000-2.

Exhibit 1000-2
Roadway Cross Slope for Rehabilitation (3R) Projects



If the existing cross slope of a roadway is inverted, it should also be matched for rehabilitation projects.

1000.6.4.1 Rollover
The rollover is the algebraic difference in the rate of cross slope and occurs when the shoulder is sloped at a different rate than the traveled way. The maximum rollover shall not exceed eight percent.

1000.6.5 Edge Treatments

1000.6.5.1 Curb and Gutter
The use of curb and gutter serves any of the following purposes: drainage control, roadway edge delineation, right-of-way reduction, or delineation of pedestrian walkways. Curb and gutter is used commonly on all types of low-speed urban streets and highways.

For high-speed facilities, sloping (or mountable) curbs up to four inches may be considered for drainage purposes, restricted right-of-way, or access control considerations. When they are used, they should be placed at the outer edge of the shoulder. Vertical curbs should not be used along freeways or other high-speed roadways.

1000.6.5.2 Pavement Surfacing Taper
New Construction or Reconstruction (4R) Projects
Pavement edge treatments on all new construction, or reconstruction projects where curb and gutter is not used, will use a 6:1 surfacing taper when there are no constraints in regards to right-of-way, the environment, or funding. In other situations a 4:1 surfacing taper shall be used, as shown in Exhibit 1000-1, to minimize impacts.

Rehabilitation (3R) projects

Pavement surfacing tapers on mill and inlay projects are typically not affected as this process does not encroach into the taper area and therefore the existing surfacing taper will not be modified. Pavement surfacing tapers on 3R construction and mill and fill projects that do encroach into the surfacing taper will use a 6:1 surfacing taper when there are no constraints in regards to right-of-way, the environment, or funding. In other situations a 4:1 surfacing taper shall be used, as shown in Exhibit 1000-2, to minimize impacts.

1000.6.6 Side Slopes

Side slopes should be designed to enhance roadway stability and provide a reasonable opportunity for recovery for a vehicle departing the roadway. Side slopes will primarily be determined based on right-of-way availability, roadside drainage, and clear zone requirements. In general the NMDOT uses a slope of 6:1 for the foreslope immediately adjacent to the roadway shoulder. For moderate heights, steeper slopes up to 3:1 may be used. A maximum side slope of 2:1 is typically used for non-stabilized slopes. A non-stabilized side slope steeper than this must be evaluated with regard to soil stability and erosion potential.

Slopes steeper than 2:1 (in both cut and fill conditions) are permitted when stabilized with riprap or other material. It may not always be possible or economical to provide flatter side slopes. In these instances, the typical practice for NMDOT projects is to specify a depth-variable slope selection criteria in the plans. An example is provided below:

Depth	Maximum Allowable Slope
0 to 5 feet	6:1
5 to 10 feet	4:1
Over 10 feet	3:1

Barn roof sections can also be used in certain fill slope situations. Barn roof sections consist of a flatter foreslope to the required clear zone distance and a steeper fill slope to intersect with the existing ground.

1000.6.7 Roadside Elements

The guidelines above for surfacing tapers and side slopes do not preclude the need for the designer to assess clear zone and side slope treatments beyond the surfacing taper in accordance with the Roadside Design Guide. The designer should refer to the Roadside Design Guide for detailed information on clear zone and guidance on the use of roadside barriers.

1000.7 Intersection Geometrics

NMDOT's SAMM shall be used for geometric design criteria pertaining to access points (intersections and turnouts), on a state facility. The SAMM contains requirements and guidance for access spacing, suggested design vehicles, sight distance, speed change lanes, and median design for access points, among other criteria.

1000.8 Documentation

- Traffic count data
- Calculations
- Design exceptions and variances (if needed), per Design Manual Chapter 210