Roadway Design Standards

'Roadway Design Standards' pertains to multiple design elements, including: curbs, grades, medians, pavement, shoulder, signage, speed, and sight distance:

Curbs

Standards

AASHTO:

	Arterial	Collector	Local
Rural	No curb	6 In. vertical on right side	4 To 9 inch vertical
Urban	Vertical curb when needed	6 In. vertical on right side	4 To 9 inch vertical

PennDOT recommends use of AASHTO standards and PennDOT's Publication 408, Specifications.

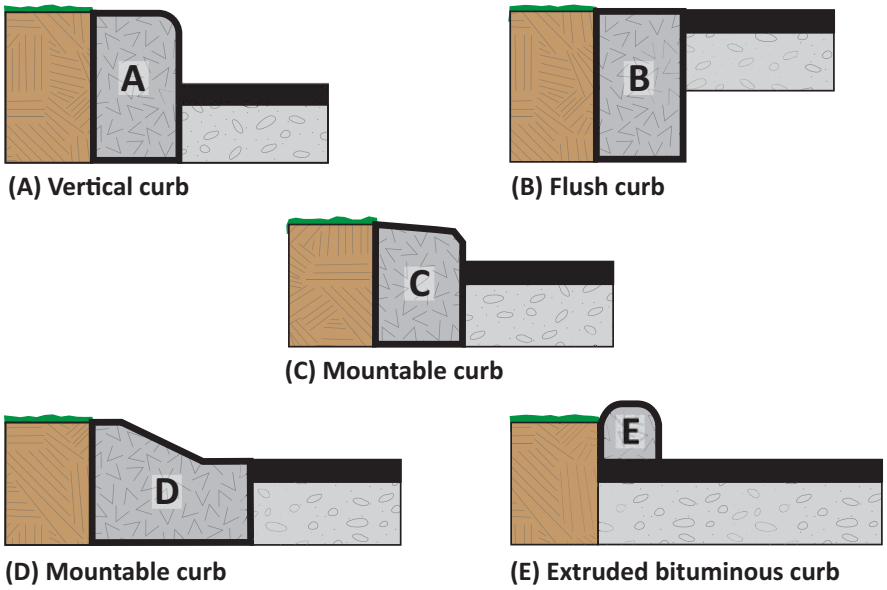
Comments

A curb serves one or more of the following purposes: drainage control; access control; pavement edge delineation and support; right-of-way reduction; aesthetics; delineation of pedestrian walkways; protection of pedestrians, signs, trees and grass; reduction of maintenance operations by preventing water seepage under the pavement; and assistance in orderly roadside development.

Mountable curb application to a center median.

CURBS
(aka barrier curb, vertical curb, mountable curb, extruded bituminous curb or combination curb with a gutter) - vertical or sloping structure generally along and defining the edge of a roadway.

Types of curbs



(A) Vertical curb

(B) Flush curb

(C) Mountable curb

(D) Mountable curb

(E) Extruded bituminous curb

Vertical curbs (A) are steep faced. They are designed to inhibit or at least discourage vehicles from leaving the roadway. They can provide support to the pavement and protect the cartway from rapid deterioration. Vertical curbs are used for drainage control and in snow areas curbs protect the grass from damage by snow plows. Initial construction cost is higher, but vertical curbs are more durable than any other type of curbing. During the construction of a subdivision, driveway locations must be determined prior to development because curb depressions need to be made. For aesthetic purposes, a more expensive vertical granite or Belgian block curb may be used. An added feature of granite or Belgian block curbing is that it is easy to replace short segments.

Flush curbs (B) provide support for the pavement and allow stormwater to run off into a drainage swale. Parked vehicles can also park on the curb. Economical driveway construction can be undertaken without curb depression. Driveway locations can be determined at a later date allowing flexibility in the timing and location of driveway construction. Flush curbs should be used in conjunction with an open drainage system using swales. Drainage patterns should be closely examined to determine the pattern of stormwater runoff.

Mountable curbs (C and D) are several inches lower than vertical curbs and are slanted since they are designed to be crossed when required. Economical driveway construction can be undertaken without curb depression. Driveway locations can be determined at a later date allowing flexibility in the timing and location of driveway construction. They are also quite durable, but must be properly installed to be effective. Mountable

curbs are used for drainage control. Over time, mountable curbs may face more expensive repaving costs because of the limited area available to be resurfaced.

Extruded bituminous curbs (E) are initially less expensive than both vertical and mountable curbs, but are less durable and require a significant amount of maintenance by comparison. In areas with snow, damage is caused by snow plows. This type of curbing is customarily found in areas with low traffic volumes. Bituminous curbs provide no support for the pavement, but are good for drainage control on short segments of roadway.

Recommendations

- Recommend use of vertical and mountable curbs whenever applicable using AASHTO's ***A Policy on Geometric Design of Highways and Streets***, and PennDOT standards. Specifically, PennDOT's Publication 408, ***Specifications***.
- Recommend the use of curbing in all new developments. Type of curbing depends on the intended function of the road. Use the following guidelines to determine which curb type to use:
- Vertical or mountable curbs should be used to control drainage.
- Flush curbing should be used to recharge the groundwater.
- Mountable curbing should be used where vehicles are expected to cross over the curb.
- Extruded bituminous curbing should be used to control drainage on short segments of roadway.
- Flush curbing should be used on narrow cartways in low density developments for pavement edge support.
- Use combinations of different curbing where warranted by different drainage patterns.
- The use of Belgian block curbing creates greater risk for tire damage and should be discouraged along transit routes unless adequate roadway width is provided to avoid its traverse.

Grades and Roadway Alignment

Standards

Rural

	Arterial			Collector						Local				
Design Speed mph	50	60	70	20	30	40	50	60	70	20	30	40	50	60
Level (%)	4	3	3	7	7	7	6	5	4	N/A	7	7	6	5
Rolling (%)	5	4	4	10	9	8	7	6	4	11	10	9	8	6
Mountainous (%)	6	6	5	12	10	10	9	8	6	16	14	12	10	--

Urban

	Arterial			Collector						Local
Design Speed mph	30	40	50	60	20	30	40	50	60	15% Max for Residential
Level (%)	8	7	6	5	9	9	9	7	6	8% Max, 5% Desirable for Industrial, Commercial
Rolling (%)	9	8	7	6	12	11	10	8	7	
Mountainous (%)	10	10	9	8	14	12	12	12	9	0.3% Min., 0.2% Acceptable for Drainage

PennDOT: AASHTO standards with these additions

	Arterial	Collector	Local
Rural	0.5% Min.	0.5% Min.	0.5% Min.
Urban	0.5% Min.	0.5% Min.	0.3% Min. – 15% Max.

Comments

Grades below the maximum values are always desirable, a minimum gradient on all curbed streets is necessary to prevent water from ponding. It is desirable to provide the flattest grades practicable that are consistent with the surrounding terrain.

Horizontal and vertical alignments should be designed together to complement one another to provide increased safety, uniformity of speeds and pleasing appearances. Avoid sudden changes in horizontal alignment by integrating the design speed and curvature of the roadway. Another way to reduce curvature is to super-elevate, or bank, the roadway. Super-elevation, side-friction and vehicle speed are the factors used to determine the horizontal alignment of a road. The topography, soil, geologic conditions, drainage patterns, potential runoff quantities, length and type of streets, and desired design characteristics should also be evaluated.

GRADES
(aka vertical alignment, gradient, or profile)
The rise and fall of the roadway.

FHWA research on arterial roads shows that as the radius decreases, the accident rate increases. Residential streets can be designed to discourage high speed traffic by providing minimum horizontal alignment.

According to AASHTO, vertical curves should be simple in application and should result in a design that is safe, comfortable in operation, pleasing in appearance, and adequate for drainage. The major control for safe operation on crest vertical curves is the provision of ample sight distances for the design speed. Minimum stopping sight distances should be provided in all cases. Wherever economically and physically feasible, more liberal stopping sight distances should be used. Additional sight distance should be provided at decision points.

Recommendations

- Review each situation to determine the impact on the environment of altering roadway grades to meet specific standards.
- For grades, follow the general recommendations of ***PennDOT Design Manual Part II: Highway Design: Chapter 2 –Design Elements***
- For roadway alignment, follow the recommendations of AASHTO's ***A Policy on Geometric Design of Highways and Streets***.
- Local roads within developments and streets within villages should be designed to discourage high-speed traffic by allowing the use of small horizontal radii.
- Preclude the use of maximum grade with the minimum curve radii.

Example of good roadway alignment.

Example of poor roadway alignment.

MEDIANS
The part of the divided highway separating opposing directions of travel.

Medians

Standards

AASHTO:

- **Rural Arterial** – Four to 6 feet wide under restricted conditions. Twelve to 30 feet at intersections to provide protection for left turning vehicles. Sixty feet or greater where feasible.
- **Urban Arterial** – A minimum width of 4 feet. A minimum of 12 feet, 18 feet desirable, at intersections to provide protection for left turning vehicles.
- Rural Collectors and all local roads do not require a median.
- **Urban Collector** – Two to 4 feet wide for a paint-stripe. Two to 6 feet wide for a narrow, raised median or curbed section. Ten to 16 feet wide for the above conditions with a left-turn lane.* Desirably 16 to 40 feet wide for left-turns and open space.

** An urban collector must have 4 lanes. For a list of suggested median opening widths for turning movements and U-Turns see AASHTO's, A Policy on the Geometric Design of Highways and Streets.*

PennDOT:

- Recommended use of AASHTO standards. Medians must be a minimum of six feet wide to allow for a pedestrian refuge area.

Comments

A median is a highly desirable element on roadways carrying four or more lanes since they provide:

- a storage area for left-turning and U-turning vehicles; a recovery area for out-of-control vehicles;
- a stopping area in case of emergencies;
- an area to provide safety treatment, such as a median divider or barrier;
- open space; and,
- extra right-of-way for future lanes.

Where intersections are signalized, wide medians may be disadvantageous by increasing the time required for vehicles to cross the median resulting in inefficient signal operations.

Recommendations

- Follow the recommendations of AASHTO Policy on the Geometric Design of Highways and Streets for median widths.
- Provide medians on four lane arterials.
- Preclude the opening of medians on arterial roadways for new development unless full channelization, and perhaps signalization, is provided.
- Provide some form of a barrier to preclude illegal left- and U-turn movements across grass medians.
- Provide landscaped medians, where practical, to reduce amount of impervious surfaces and to improve aesthetics.

Pavement

The selection of pavement type is determined by the volume and composition of traffic, soil characteristics, weather, performance of pavements in the area, availability of materials, energy conservation, the initial cost and the overall annual maintenance and service life cost. Pavement for residential streets should be designed to accommodate the volume and characteristics of traffic expected to use the streets.

Recommendations

- Follow the recommendations of PennDOT Publication 242 – ***Pavement Policy Manual*** and Publication 408 – ***Specifications***.
- Consider the use of porous pavement on low turnover parking areas.

Signage

Although safety and efficiency of operation depend to a considerable degree on the geometric design of the facility, the physical layout must also be supplemented by effective signing as a means of informing, warning and controlling drivers. Signing plans coordinated with horizontal and vertical alignment, sight distance obstructions, operation speeds and maneuvers and other applicable items should be worked out before design completion.

Recommendations

- Follow the recommendations of the: ***Manual on Uniform Traffic Control Devices*** (MUTCD); the Pennsylvania Code, Title 67, Chapter 211, ***Official Traffic Control Devices***; and PennDOT Publication 111 ***Pavement Markings and Signing Standards TC-8600 and TC-8700***.
- Prohibit signs within clear sight triangles, except for traffic signs.
- Provide a breakaway device where signs are not protected.
- Place street name signs on traffic signal mast arms where applicable.

PAVEMENT
The combination of sub-base, base course and surface course placed on a subgrade to support the traffic load or distribute it on the roadbed, or both. The term normally includes the traveled portion of the highway and extends to the face of the curb in a curbed section, not including shoulders.

SIGNAGE
(aka markings) - Any sign, marking or device placed or erected for the purpose of regulating, warning or guiding vehicular traffic or pedestrians, or both.

DESIGN SPEED
The maximum safe speed that can be maintained over a specific section of road when conditions are so favorable that the design features of the road govern vehicle operation.

SPEED LIMITS
A restriction placed upon a road which legally establishes the minimum or maximum speed which vehicles may travel.

Speed

The designed speed should be a logical one with respect to the topography, the adjacent land use and the functional classification of the road. The design speed selected should be consistent with the speed the driver is likely to expect and all the pertinent features of the highway should be related to this speed to obtain a balanced design. (ITE)

Establish the design speed to attain a desired degree of safety and efficiency while under the constraints of environmental quality, economics, aesthetics, and social and political impacts

Recommendations

- Follow the recommendations of PennDOT Publication 70M, ***Guidelines for the Design of Local Roads and Streets***.
- Design speeds for local roads should be calculated according to their intended function. Design speeds are not intended to replace legally posted speed limits.

Speed Limits

Proper use of speed regulation is based on the recognition that lower speeds reduce stopping distances and generally reduce the severity of accidents. Traffic moving at fairly uniform speeds flows more smoothly, with resultant improvements in both capacity and safety.

Transportation officials often receive requests to lower speed limits reflecting the opinion that the street is improperly posted or that vehicles are traveling at unsafe speeds. Such requests are based on the public misconception that lowering the speed limit will in fact reduce vehicle speeds and accidents.

The most effective means of controlling excessive speed is through enforcement.

Recommendation

- Follow the recommendations of the Pennsylvania Code, Chapter 33, ***Rules of the Road***, to establish speed limits on new roads or altering speed limits on existing roads.

Stopping Sight Distance

Standards

AASHTO: See, ***A Policy on Geometric Design of Highways and Streets*** for specific formulas related to stopping sight distance. The following tables provide general guidance.

Safe Stopping Sight Distances

Design Speed (mph)	70	60	50	40	30	20
Distance (feet)	625	525	400	275	200	125

Safe Stopping Sight Distances on Horizontal Curves

Design Speed (mph)	70	65	60	50	40	30	20
Distance (feet)	850	725	650	475	325	200	125

Minimum stopping distances and adjustments are based on wet pavement conditions.

Effect of Grade on Stopping Sight Distances

Increase for Downgrades				Decrease for Upgrades			
Design Speed (mph)	3%	6%	9%	Assumed Speed (mph)	3%	6%	9%
30	10	20	30	28	Nv	10	20
40	20	40	70	36	10	20	30
50	30	70	NV	44	20	30	NV
60	50	110	NV	52	30	50	NV
70	70	160	NV	58	40	70	NV

Comments

Values exceeding the minimum stopping sight distance should be used as the basis for design wherever conditions permit since the use of a higher value will only increase the margin of safety.

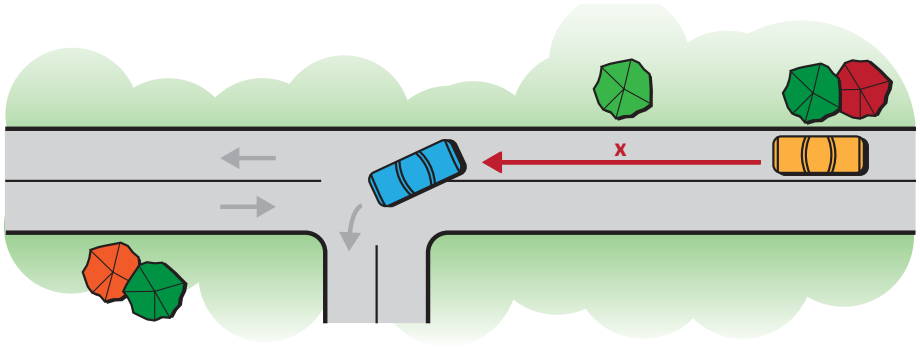
Recommendation

- Follow the recommendations of AASHTO and for further details see ***PennDOT's Design Manual Part II***, ***Chapter 2***.
- See also the PennDOT Driveway Sight Distance Measurements Form M-950S ***http://www.dot.state.pa.us/public/PubsForms/Forms/M-950S.pdf***

STOPPING SIGHT DISTANCE

(aka sight distance on horizontal curves) minimum distance required for a vehicle traveling at a given speed to stop before reaching a vehicle in its path. It is measured from a height of 3.5 feet above the pavement surface to an object 2.0 feet high.

Safe Stopping Sight Distance



Safe Stopping Sight Distance on Horizontal Curves