



II. DESIGN CRITERIA

The design characteristics of a grade-separated structure must take into account numerous factors such as the type of obstacle that is being crossed, the surrounding land topography, the location of nearby drainage features, the length of the structure, visual impact, and maintenance and constructability to name a few. The following information serves as a guide to providing not only a safe and attractive facility, but also to strive for a level of structure consistency throughout the City.

II.1. Structure Height

It is critical to assure that the height of a grade-separated structure adequately meets specified dimensions for clearance so that pedestrians, cyclists, equestrians, and maintenance or emergency vehicles can safely use the facility. Dimensions are measured from the walking surface to the overhead obstruction.

Overpass or underpass used by pedestrians and cyclists—10 feet desirable, 8 feet minimum.

Overpass or underpass also used by equestrians—12 feet desirable, 10 feet minimum.

Overpass or underpass also used by emergency vehicles—13'-6". This dimension is required for structures where vehicle access cannot be provided to both sides of the structure from a cross street, trail or other access facility due to physical or topographical constraints. Project-specific design must be coordinated with the Poudre Fire Authority.

II.2. Structure Clearance

For overpasses that cross over a roadway or railway, the following clearance distances shall be provided along the entire length of the structure between the bottom of the structure and the roadway or railway surface:

Clearance between bottom or low chord of pedestrian structure and roadway—17'-6" minimum on state highways. On other city roadways, consult the *Larimer County Urban Area Street Standards*.

Clearance between bottom or low chord of pedestrian structure and railway tracks—23'-6" minimum.

For bridges over water routes, adequate clearance should be provided between the bottom of the structure and the normal water level to minimize the impact of minor flood occurrences. Bridges must be constructed out of the 100-year floodplain, or breakaway bridges and railings must be constructed in accordance with the City's Stormwater Utility regulations.

For a box culvert-type underpass, the minimum cover from the roadway pavement surface to the top of the box culvert shall be structurally verified to assure that vehicle loadings on the top of the underpass do not diminish the structural integrity of the underpass.



II.3. Structure Width

The width of a structure is as important as the structure height. A structure that is too narrow can be perceived as unsafe or simply not an inviting or pleasing facility that residents would want to use. The minimum dimensions identified below must be provided between any obstructions such as handrails, lighting, barriers, drainage facilities or artwork.

1. Entering path/trail/sidewalk width (minimum of 10 feet) plus 2 feet clear obstruction and drainage distance on each side; total of 14 feet.
2. For underpasses greater than 80 feet in length, refer to Table 1 for the minimum structure width.
3. For structures that include drainage facilities, (other than drainage pans as shown in Section II.14), the width of the drainage facility shall be in addition to the width dimensions noted in Table 1.
4. For structures that will accommodate equestrian usage, the width of the equestrian path, typically 6 feet, shall be in addition to the width dimensions noted in Table 1.
5. For structures over roadways or railways, the desirable structure width shall be 12 feet with a minimum width of 10 feet.
6. For structures that will accommodate emergency vehicles, the minimum width will typically be 20 feet. The Poudre Fire Authority shall be consulted on a project by project basis to determine structure width and surface material requirements when emergency access is necessary.
7. For structures that will accommodate wildlife movements, the width for wildlife movements shall be in addition to the width dimensions noted in Table 1. A biologist shall be consulted to identify expected wildlife types and determine additional structure width.

*Table 1
Minimum Underpass Structure Width*

Structure Length	Minimum Structure Width	Comments
<80 feet	14 feet	Includes 2 feet on each side of the structure for drainage pans and/or amenity (such as handrails, rubrails) clearance. For structures of 80 feet or greater in length, skylights shall be provided in the roadway median if a median is available.
80 feet to <110 feet	16 feet	
110 feet to <150 feet	18 feet	
150 feet to <200 feet	20 feet	For structures >150 feet in length, and where there is a median of sufficient width, two separate structures should be used to provide an opening of natural light. If two separate structures cannot be provided, skylights placed in a median, if available, shall be required.
>200 feet	22 feet	

II.4. Box Culvert-Type Underpass Entrance Design

The design of the entrance to a box culvert-type underpass is critical to the user comfort level of the facility. How the wing-walls are constructed to visually minimize the “tunnel” effect can be the difference between a well-used and avoided facility. Following are a few guidelines for entrance treatments.

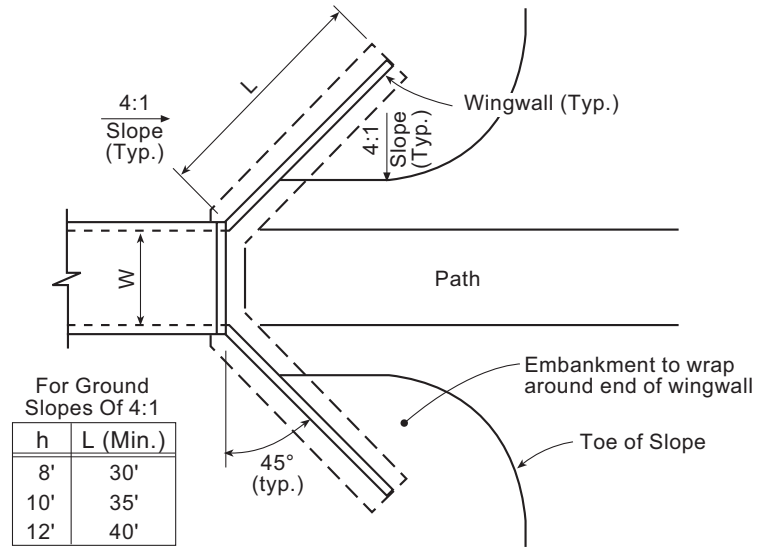
Wing-Walls

The intent of wing-walls is to retain the adjacent fill or natural ground. The typical design approach may not be the only acceptable design, however. The designer should consult with City staff regarding the proposed design at the initial stage of design preparation.

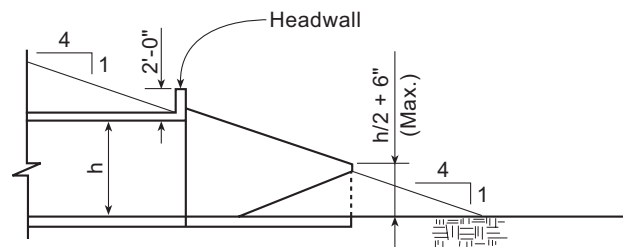
1. Wing-walls shall typically be constructed at a 45 degree angle measured from the face of the structure.
2. Wing-walls shall extend six inches above the adjacent ground slope.
3. The length of the wing-wall is dependent upon the height of the structure and the adjacent ground slope.
4. The roadway fill slope behind the wing-wall typically shall be 4:1.
5. Construct wing-wall faces to be inviting to users.

Entrance Flare

For structures of 80 feet or greater in length, the first ten feet at both ends of the structure shall be flared an additional 2 feet on each side of the structure to reduce the effect of “tunneling” by inducing deeper daylight penetration.

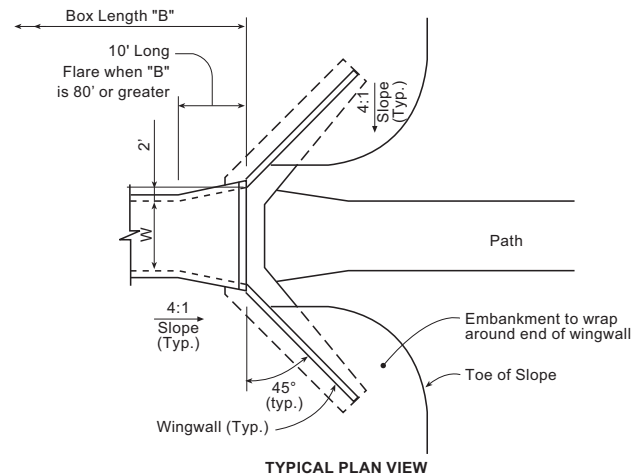


TYPICAL PLAN VIEW



TYPICAL LONGITUDINAL SECTION

Typical Wing-Wall Design



Entrance Flare Treatment

II.5 Roadway/Railway Overpass Covering

Overpasses that cross roadways, railways, or major drainage-ways should be covered to limit snow, ice, or water buildup on the walking surface. The covering shall be of a solid material and be integral to the structural components of the overpass design. In addition to protection from weather elements, a covering can also provide a location for the attachment of lighting facilities to create a more attractive environment and enhance safety.

II.6. Grade

The longitudinal grade of any structure, or any ramp or path accessing a structure, shall be 5% (20:1 ratio) or less. If physical constraints restrict achieving a 5% grade, a maximum of 8.33% (12:1 ratio) is permitted; however, grades greater than 5% require landings in the structure as follows:

- ▶ >5.00% (20:1 ratio) to 6.25% (16:1 ratio) = landing every 40 feet
- ▶ >6.25% (16:1 ratio) to 8.33% (12:1 ratio) = landing every 30 feet

The size of a landing shall be 5 feet long for the entire width of the ramp/path. If there is a change of direction in the ramp/path at a landing location, the minimum landing dimension shall be 5 feet by 5 feet¹.

II.7. Cross-Slope

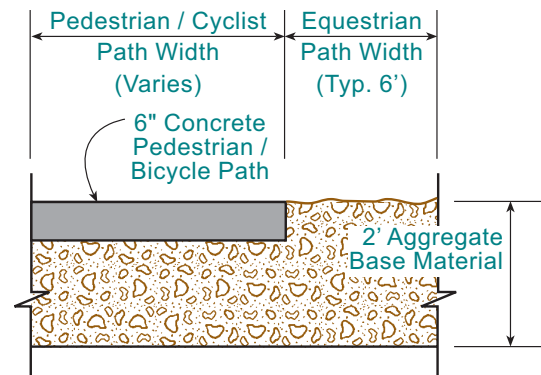
The design of cross-slopes for any structure shall be the responsibility of the structure engineer with the objective being to reduce flat areas where water or debris could accumulate. The typical cross-slope for entrance/exit paths shall be 2%. The minimum cross-slope in a box culvert-type underpass shall be 1%.

II.8. Surface Treatment

These guidelines do not strictly specify the type of material to be used for the construction of grade-separated crossings; however, since a design life of 50 years for overpasses and bridges, and 100 years for underpasses² must be provided, it is likely that a concrete surface will be the most common choice. A

wooden walking surface is discouraged given its relatively shorter life span and greater ease of destruction and/or vandalism. It is imperative that the pavement surface be smooth and devoid of irregularities that could affect the comfort and safety of pedestrians and cyclists. In underpasses where there is a likelihood of flooding, the surface shall be concrete and provided with a texture to resist slipping.

For facilities that accommodate pedestrians, cyclists and equestrians, a separate riding/walking surface for equestrians is necessary. For these structures, aggregate base material shall be used for the equestrian surface. The structure shall be designed so that this material remains within the structure boundaries and does not wash away or extend along the walking and riding surface for pedestrians and cyclists. If possible, a rider dismount area should be provided near structure entrances.



Surface Treatment for Equestrian Usage



II.9. Entrance/Exit Radii

At structure locations where the entrance/exit to a facility will require a curved path or ramp, the radius information of Table 2 shall apply.

When curve radii smaller than those shown in Table 2 must be used due to limited right-of-way, topographical features or other considerations, standard curve warning signs and supplemental pavement markings shall be installed in accordance with the *Manual On Uniform Traffic Control Devices (MUTCD)*.³ Other accommodations shall be made to facilitate safe movements. One method would be to widen the trail at sharp curves.

II.10 Approach Alignment

Approaches to each structure type shall have a minimum of 20 feet of straight trail alignment before accessing the structure.

II.11. Sight Distance Requirements

Stopping Sight Distance

The minimum stopping sight distance necessary to provide adequate reaction time to avoid unforeseen circumstances shall be per AASHTO⁴ requirements. These data provide the minimum stopping sight distance for a cyclist to come to a full controlled stop for varying design speeds and grades.

Landscape/Obstruction Restrictions

Landscaping and/or other obstructions that could restrict user visibility will not be permitted. Low-type ground covers are encouraged within user sight lines.

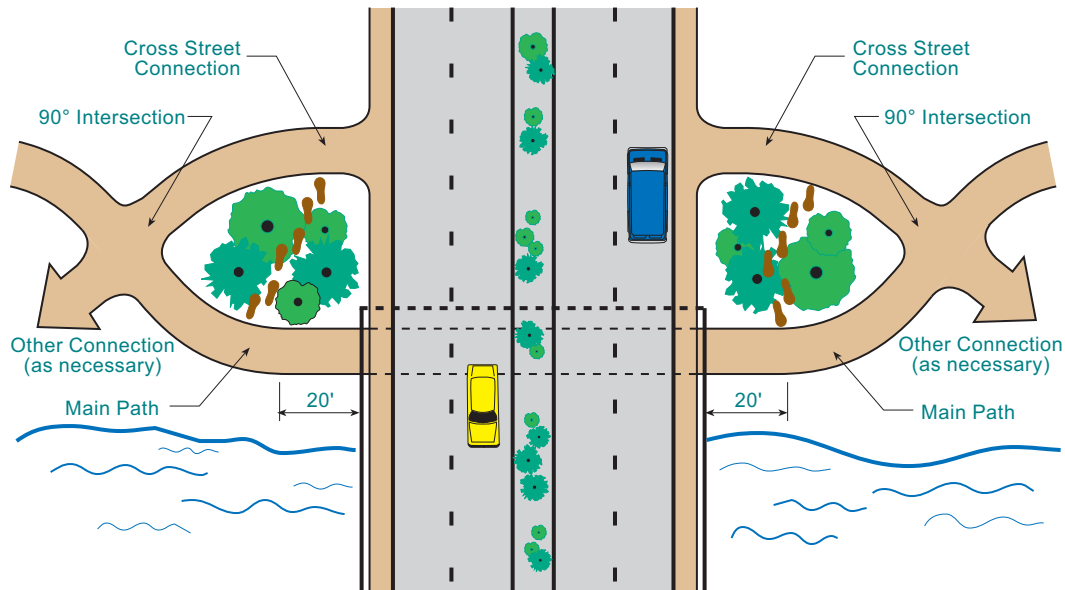
Table 2
Minimum Centerline Entrance/Exit Radii

15° Cyclist Lean Angle		2% Superelevation Rate and 20° Cyclist Lean Angle		
Design Speed (mph)	Minimum Radius (feet)	Design Speed (mph)	Friction Factor	Minimum Radius (feet)
12	36	12	0.31	30
20	100	20	0.28	90
25	150	20	0.25	155
30	225	30	0.21	260

Source: *guide for the development of bicycle facilities*, AASHTO, 1999.

II.12. Cross Street Accessibility

At all structure locations, a path must be provided on each side of the intersection of the roadway and the structure for accessibility between the roadway and the structure. These paths must meet the grade criteria established in Section II.6. The intent of these connections is to provide direct and convenient access to/from the cross street. Informal walking paths/steps should be provided to serve cut-through pedestrian traffic in landscape or grass areas.



Typical Cross Street Accessibility Design

II.13. Lighting

Lighting provides a welcome dusk and nighttime atmosphere where structure entrances/exits, destination points and features are highlighted. Traveled pathways can also be lighted to provide guidance. The basic objectives of lighting include:

- ▶ Safety and security
- ▶ Aesthetic image
- ▶ Nighttime visibility and function
- ▶ Environmental sensitivity

Safety and Security

Safety involves providing light on hazards so that they can be detected with sufficient reaction time. The lighting system, along with other site design elements, must provide visual information to assist users in avoiding collisions or a loss of bearings.

Security is often referred to as the perception of safety. Providing for security involves lighting potentially hazardous locations and situations. Lighting can also act as a crime deterrent by increasing the visibility in an area of concern.



Nighttime Visibility and Function (Lighting Quality not Quantity)

Too often, lighting quantity or lighting levels are used for design instead of lighting quality. Lighting quality involves contrast, brightness adaptation, glare and light source color. Increasing contrast will increase visibility. An example of poor contrast would be a person in dark clothing against a dark wall. If the wall is lighted, objects are easier to see.

Eyes adjust to the brightest object in the field of view. This adjustment is referred to as brightness adaptation. If an object is very bright, like uncontrolled light from a floodlight, everything else in the immediate surrounding area appears relatively dark, making it harder to detect object details.

Glare is usually caused by uncontrolled light emitted from unshielded luminaires. An example of this is unshielded wall pack fixtures or floodlights located on a wall. These situations can be easily avoided with proper equipment selection, location, aiming and shielding. Light sources and luminaires on overpasses shall not be so bright that the brightness causes a hazard to motorists driving below.

Light Sources

Light source color is another key to low light level visibility. Night vision is very sensitive to short wavelength light (blue and green light), resulting in crisp and clear vision, especially in peripheral vision. Reaction time and color recognition under low light levels is far superior with white light sources like metal halide, fluorescent, and induction lamps.

Environmental Sensitivity

Environmental sensitivity includes minimizing light trespass and lighting pollution, and using minimal energy through lighting equipment selection and operation. Recommended practice “Lighting for Exterior Environments”⁵ shall be used as criteria to limit light pollution and light trespass.

Light trespass is sometimes referred to as the “light shining in my window” syndrome. Usual culprits are

unshielded floodlights, high wattage pedestrian lights, wall packs and other unshielded luminaires that are improperly located and poorly aimed. Light trespass can be minimized with careful equipment selection, proper location, and proper aiming and shielding. Light trespass shall be minimized to the extent possible.

Light pollution is uncontrolled light that travels into the atmosphere. This light is wasted energy and creates a “sky glow”. Unshielded luminaires and excessively high lighting levels cause light pollution. High wattage luminaires with poor visual shielding will not be permitted. Excessive light levels with high amounts of reflected light will not be permitted. Use low wattage, shielded luminaires that are properly located and aimed.

Luminaire Selections

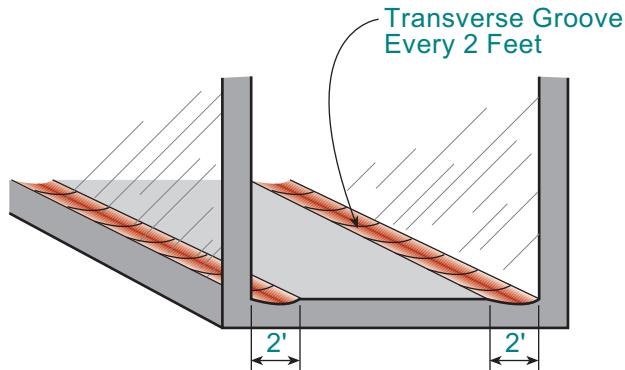
Underpass and overpass lighting should enhance the design theme of the structures. Luminaire selections should not only be based on photometric performance, but also on the aesthetic character appropriate for the design. All luminaires shall be vandal resistant, UL listed for wet locations, and meet Americans with Disabilities Act (ADA)¹ requirements. The type, style, color and location of luminaires shall be consulted with the City of Fort Collins for approval.

II.14. Drainage

Drainage facilities should be placed along the edges of the trail/path and out of the way of the main pedestrian/cyclist usable surface. Any drainage facility that must be in or along the usable surface must have a smooth, flat surface (in the case of a manhole) or inlet grates that are transverse to the trail/path direction. Careful consideration should be given to intercept groundwater at underpass entrances to prevent trail surface water from entering the structure and freezing during cold weather.

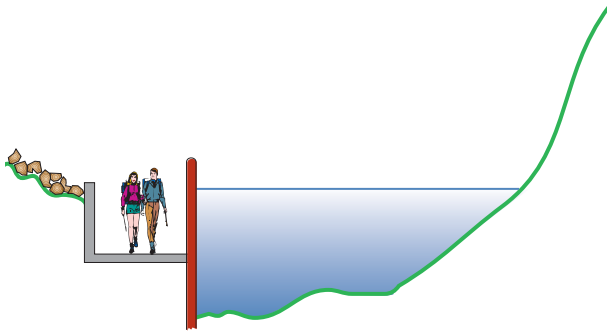
Each box culvert-type underpass shall be provided with drainage pans longitudinally along the entire length of the structure. The drainage pans shall be constructed of colored concrete to differentiate between the

drainage facility and the main travel path. The drainage pans shall also be provided with a transverse groove every 2 feet along the structure length to provide warning to errant cyclists similar to the design of a rumble-strip along a highway.



Drainage Pan Design

In some cases, the trail system may need to be lower than an adjacent creek, river or drainageway. The design of such facilities must be able to restrict normal water flow from encroaching onto the trail system.



Path Below Water Elevation

II.15. Structure Design Loadings

Typically, overpass structures shall be designed to accommodate a live load of 85 pounds per square foot. The design for each structure should be checked, however, to assure that an 85 pound per square foot live load is adequate for emergency or maintenance vehicle loadings.

For other design loadings for overpass and underpass structures, the engineer should refer to the following:

- ▶ “Guide Specifications for Design of Pedestrian Bridges”⁶
- ▶ “Larimer County Urban Area Street Standards”²
- ▶ “AASHTO Specifications for Highway Bridges”⁷
- ▶ “Colorado Department of Transportation Bridge Design Manual”⁸

II.16. Protective Barriers

Location

Railing, walls or other types of barriers shall be placed at locations where pedestrians, cyclists or equestrians require protection from obstacles; locations such as:

- ▶ Along the wing-walls and top of a box culvert type underpass,
- ▶ On underpasses between the walking surface and adjacent drainage facilities or other water features, and/or
- ▶ On overpasses to reduce the potential for objects falling from the overpass onto vehicles, trains or other users on the roadway, sidewalk or railway surface below the structure.

These barriers must be designed with care to ensure aesthetic compatibility with the surrounding area and to minimize visual impact.

Barrier Height

A 54 inch barrier height shall be provided along the entire length of the obstacle with a bicycle rub rail attached at a height of 42 inches.

II.17. Handrails

Handrails to assist in public access along structures shall be provided when the structure, entering trail facility or cross-street accessibility path, has a longitudinal grade greater than 5 percent. Handrails are required only along one side of the structure, entering trail facility or cross-street accessibility path.

Height

The height of handrails shall be 34-38 inches above the structure, trail or path walking surface.

Design

The design of handrails and their installation shall meet ADA requirements as documented in Figure 39, *Size and Spacing of Handrails and Grab Bars, Section 4.26 of the Code of Federal Regulations, 28 CFR Part 36, Nondiscrimination on the Basis of Disability by Public Accommodations and in Commercial Facilities* by the Department of Justice.

II.18. Stairs

Stairs for structure accessibility are discouraged. It is recognized, however, that certain locations with physical or topographical constraints may limit the construction of accessible routes to a grade-separated structure with appropriate grades as documented in Section II.6. Stairs may be provided only if an adequate and reasonable access per ADA requirements to both sides of the overpass or underpass structure can be provided.

II.19. Elevators

The need for an elevator at a grade-separated structure shall be decided on a project-by-project basis. Typically, elevators should not be designed for a facility if adequate grades can be provided for ramp construction. If the physical constraints of a structure location necessitates that the grade criteria of Section II.6 cannot be met, an elevator shall be provided.

II.20. Signing/Striping

Signing Guidelines

The installation of any warning, regulatory or other types of signs at structure locations or on structure approaches shall be per the MUTCD.

Striping Guidelines

Each approach to each structure shall have a painted yellow centerline for approximately 100 feet in advance of the structure entrance. All curves with restricted sight distances are required to be painted

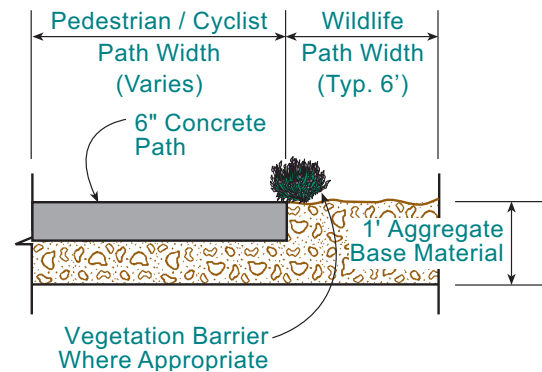
with a yellow centerline to separate traffic. The centerline shall be 4 inches in width.

Way-Finding Signing

At junctions of main trails and cross-street access routes, signing shall be placed to direct users to the appropriate side of the cross-street for the direction in which they wish to proceed.

II.21. Wildlife Movement

If an underpass is constructed where there is a likelihood that the underpass could also serve as a wildlife movement corridor, the designer should consult with a biologist to understand what species may use the underpass, in addition to humans, that could influence the structure design. Such factors as the openness of the structure, the presence of a natural or dirt floor, vegetation within the structure, wall color, and the absence of artificial lighting must be evaluated as part of the structure design. An artificial vegetation barrier could be used where natural light is not sufficient to grow living vegetation.



Surface Treatment for Typical Wildlife Movement

II.22. Bird Nesting Treatments

Structures shall be designed so that birds do not nest in these facilities. A typical treatment for an underpass would be to have angled top corners at 45 degrees.