



COMPARATIVE ANALYSIS OF DESIGN PARAMETERS FOR EQUESTRIAN BRIDGES

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Abstract

There is a growing demand for outdoor activities worldwide. Among these is horse riding, which has positive effects on both mental and physical health, thereby enhancing social well-being. Due to the increasing interest in horse riding globally, it is necessary to construct new trails and repurpose existing ones to ensure access for horse riders. As bridges are the most expensive individual elements of these trails, special attention should be given to their design. Pedestrian bridges intended to accommodate equestrian traffic must meet different requirements from those used solely by pedestrians or cyclists. As there is no pedestrian bridge manual providing comprehensive, standardized guidelines for the design of equestrian bridges, this paper presents, compares, and summarizes design principles and parameters gathered from various bridge and trail design manuals that should be considered when designing pedestrian bridges for equestrian use.

Keywords: bridge, equestrian, design, universal accessibility

1 Introduction

Horse riding is an outdoor physical activity that can improve social well-being, as well as mental and physical health [1]. Although the benefits of horse riding are well recognized, access to public routes for riders remains limited, even in countries with a large proportion of riders in the general population, such as the UK, USA, India, Canada and Australia [2, 3]. Ensuring better access for riders on trails in urban, rural, or remote areas and expanding the existing trail network is highly anticipated by the fast-growing equestrian industry. While it is advisable to plan equestrian trails so that they do not intersect waterways, roads, or railways, this is not always possible [2]. Bridges (in addition to fords) are the most common solution for waterway crossings [2]. Bridges minimize the number of potential conflicts between vehicles or trains and trail users, and provide maximum safety at road or rail crossings [4], but they are also the most expensive single element on the trail [2, 5]. All basic rules for bridge design defined in codes or other regulations in a particular country should also be applied to equestrian bridges, bearing in mind that bridges on bridleways and shared-use trails used by equestrians must accommodate spatial and load requirements that differ from those for bridges used only by pedestrians or cyclists, as well as account for animal behavior [2, 4, 6]. To the authors' knowledge, only a few bridge design manuals acknowledge the specifics of equestrian use within their scope [6, 7], and they provide only a limited number of parameters related to equestrians. Therefore, the authors seek equestrian trail design manuals that also address bridge design. The aim of this article is to provide an overview of manuals that address the peculiarities of equestrian bridge design, including both bridge design manuals and equestrian trail design manuals. The design principles and parameters are identified in each manual analyzed. The design principles are summarized, while the design parameters are compared and evaluated.

2 Manuals on equestrian bridge design – principles and parameters description

The following text presents the design principles and parameters for equestrian bridge design as outlined in selected manuals. CD 353 Design criteria for footbridges [6], published by Highways England in 2020, specifies the geometric and user requirements for designing footbridges for pedestrians, cyclists, and equestrians in England, Scotland, Wales, and Northern Ireland. For equestrian parameters, only the headroom (the vertical distance from the footway to the underside of an overhead obstacle) and the minimum clear width (the distance between parapets or railings) are defined. For parapets, CD 353 refers to CD 377 (table 1) [8].

Table 1 Design principles and parameters in CD 353 [6] and CD 377 [8]

Design principle / parameter	Description
Headroom [6]	Min. 3.7 m for mounted equestrians Min. 2.7 m for dismounted equestrians *
Clear width [6]	Min. 3.5 m for combined pedestrian/equestrian
Parapet height [8]	Min. 1.8 m all for all bridges used by equestrians
Parapet solid infill height [8]	Min. 1.8 m for railway crossings Min. 0.6 m at the bottom of the parapet for bridges not over railways

*NOTE: Mounting blocks should be provided on each side of the bridge if dismounting is required
Mounting blocks or other equipment should not reduce the bridge's clear width

The LRFD Guide Specification for Design of Pedestrian Bridges [7], published in 2009 by the American Association of State Highway and Transportation Officials (AASHTO) and applicable in the United States, covers the design and construction of typical pedestrian bridges intended primarily for pedestrians, cyclists, equestrian riders, and light maintenance vehicles, but not for standard highway traffic. This guide specifies that loads on bridges from equestrian traffic should be considered as a uniform load of 1.00 kip (4.3 kN/m²), arranged to produce the maximum load effect for global verification, and a patch load of 90 psf (453.6 kg) applied to an area of 4 in (10 cm) square for checking local effects. The Equestrian Design Guidebook for Trails, Trailheads and Campgrounds [4], prepared in 2007 in cooperation with the Recreational Trails Program of the Federal Highway Administration, U.S. Department of Transportation, provides guidelines and instructions for designing equestrian trails, including bridges. The design parameters for equestrian bridges are shown in table 2, and the design principles are as follows:

- **General:** The design should accommodate animal behavior, as animals may be frightened by unfamiliar materials, structures that create or amplify noise, or by narrow, swaying or vibrating bridges. Do not include steps on bridge approaches or on the bridge itself.
- **Structural materials:** Common bridge materials include timber, steel, concrete, and fibreglass. Concrete is not preferred in areas with low development, and fibreglass is not preferred in areas with high development.
- **Decking surfaces:** Common bridge decking materials include wood (slippery when wet), concrete (acceptable if surfaced with natural soils, sand, or a rough finish), steel (noisy, slippery when wet), fibreglass (requires a wearing surface), and composites made from plastic and wood (treated to prevent wear and slipping).

Table 2 Design parameters in Equestrian Design Guidebook for Trails, Trailheads and Campgrounds [4]

Design parameter	Description
Slope	Up to 5% to ensure drainage; not too steep for users
Clear width	Min. 1.5 in areas with low levels of development 1.5 to 2.4 m in areas with moderate levels of development Min. 3.6 in areas with high levels of development
Headroom	Preferred 3.6 m; min. 3.0 m
Parapets and infills	Min. height of parapet is 1.372 m If high-speed vehicles pass beneath the bridge, a solid barrier or panel (solid infill) should be installed
Loads	The load of horse and rider is between 454 and 771 kg; for design live loads, refer to the LRFD Guide Specification for Design of Pedestrian Bridges

In the absence of a national standard for equestrian trail design in Australia, Horse SA published two editions of the Horse Trail Infrastructure Guidelines for peri-urban precincts in Australia in 2010 and 2019 [5, 9]. Additionally, the Western Australian Horse Trail Management Guidelines [2] was published in 2025 by the Government of Western Australia. These guidelines provide advice on developing and managing sustainable horse trails, including concise design principles (described in the text below) and specific considerations for bridges on horse trails (shown in table 3).

Design principles:

- **General:** Bridges must match the trail experience and classification; their color, traction, and texture should ideally resemble the trail [2, 5, 9]. They must be placed to minimize disturbance to natural and cultural values, not alter water flow beneath the bridge, and be cost-effective and easy to maintain [2]. Bridges should not sway, vibrate, or be noisy in use [2, 5, 9].
- **Decking surfaces:** There must be no openings through which an animal can see or where a horseshoe could become stuck [2, 5]. Non-skid surfaces must be applied; grooves, grit-based surfaces, or matting provide additional traction [2, 5, 9].
- **Equipment and approaches:** Mounting blocks are mandatory on each side of the bridge if dismounting is required [2]. Flared approaches with railings help guide the horse onto the bridge [2, 5].

Table 3 Design parameters in trail guidelines published in Australia [2, 5, 9]

Design parameter	Description
Slope	Up to 5% to avoid horse slipping [2]
Clear width	Min. 1.5 on a low-use and remote trails [2] 1.8 to 2.5 m on moderate-use trails [2] 3.6 to 4 m in areas with high levels of development and on long or high bridges [2] Min. 3.5 m; may be narrower for individual sites subject to approval by horse owners [5]
Kerbs / kickboards	Prevents the hoof from slipping off the bridge; should be uplifted above the decking surface to ensure water drainage [2, 5] Min. height ranges from 0.2 m [2] to 0.25 m [5], with an uplift of 25 mm [5]
	Parapets and infills The parapet height should be greater than that for pedestrians (no specific height values defined) [2] A parapet height of 1.8 m [2010] is required over major highways [5] No parapet is required for wide bridges with good visibility where the deck is less than 0.6 m above the obstacle [2] A solid infill at the bottom of the parapet may prevent a hoof from slipping off the bridge [9]

The most comprehensive freely accessible online literature on equestrian trail design is published by the British Horse Society (BHS). Numerous manuals, fact sheets, and related documents address equestrian topics. Literature sources [1, 10-12], published by BHS, BHS Scotland, and BHS Ireland, contain information on equestrian bridge design. The design parameters for equestrian bridges are shown in table 4, while the most important information on design principles are as follows:

- **General:** Bridges must be robust, stable, and preferably free from extensive noise or echo [10].
- **Decking surfaces:** A non-slip wooden surface is achieved by treating with epoxy resin and bauxite grit [1, 10-12]. Stone mastic asphalt should be avoided [1, 11, 12]. Rubber compounds may be used as deck coatings for slip prevention and noise attenuation [1, 11, 12]. Gaps between decking planks should be less than 10 mm [10].
- **Approaches:** Fenced “wing” approaches may be used to reduce the risk of horses shying away from abutments [10].

Table 4 Design parameters according to BHS [1, 10-12]

Design parameter	Description
Clear width	Min. 1.5 m for spans up to 3 m; preferably min. 2 m for spans up to 8 m and min. 4 m for wide river and road crossings [10] Min. 2 m for $L < 3$ m and $h < 1$ m on watercourses (*) [1, 11, 12] Min. 3 m for $L > 3$ m and $h < 1$ m, and for $L < 8$ m and $h > 1$ m on watercourses (*) and over any road or railway [1, 11, 12] Min. 4 m and for $L > 8$ m and $h > 1$ m on watercourses (*) [1, 11, 12]
Headroom	Min. 3.4 m (ideally 3.7 m) [1, 11, 12]
Kerbs / kickboards	Min. height from 0.25 m and uplift of 50 mm [10] Min. height from 0.25 m and uplift of 25 mm [1, 11, 12]
Parapets and infills	Min parapet height 1.8 m (1.5 m acceptable depending on drop below bridge) [10] Min. parapet height of 1.2 m for bridges with $h < 1$ m (*); otherwise, 1.8 m [1, 11, 12] Bridges over watercourses may have no parapet if $h < 1$ m and clear width is min. 4 m (*) [1, 10-12] Solid infill height: 0.6 m (over watercourses), 1 m (over roads), and 1.8 m (over railways) [1, 11, 12]
Loads	The average weight of a horse and rider is 500–600 kg [9]. The peak force during horse’s foreleg and rear leg during different activities [1, 11, 12] Live load of 5 kN/m ² and a point force of 8.12 kN are reported [11]

Note: * L – span length; h – deck height over obstacle

3 Discussion on design parameters

Hereafter, the parameters presented in tables 1 to 4 are compared and evaluated. Design loads are given in only two manuals [7, 11]. Manual [4] refers to [7], while manuals [3, 9, 10, 12] provide the average horse weight and the force exerted by the horse’s hooves during different activities. The design values for continuous live load, used for verification of global effects in [7] and [11], are equal to the design values for pedestrian and cyclist bridges in the relevant manuals and codes [7, 15]. The point force of 8.12 kN [11] corresponds to the peak force during trotting on the horse’s foreleg and rear leg (8, 333 N) [1], while the patch load of 453.6 kg [7], intended to check local effects, corresponds to the mass distribution on the horse’s foreleg due to trotting (500 kg) [1]. The given values are not factored.

The headroom and clear width define the spatial parameters on the bridge (figure 1, right). The minimum headroom for mounted equestrians is specified as 3.0 m [4], 3.4 m [1, 11, 12], and 3.7 m [6], while manual [4] defines preferred (3.6 m) and ideal (3.7 m) headroom.

As the average height of a horse and rider is 2.5 m, and a minimum buffer zone of 0.5 m should be added [4], it is clear that for tall riders on large horses, the minimum value of 3.0 m prescribed in [4] is insufficient for comfortable use. Where riders lead horses over the bridge, the minimum headroom of 2.7 m defined in [6] is sufficient, as the average horse height is 2 m. In this case, mounting blocks must be installed on each side of the bridge. The greatest differences between manuals are found in the case of clear bridge width. Manuals [6] and [5] specify a single minimum clear width for shared-use trails of 3.5 m, while other manuals define clear width values based on infrastructure development [2, 4], span length [1, 10–12], deck height, or type of obstacle [10–12]. An absolute minimum of 1.5 m, which ensures an individual rider has sufficient maneuvering space to cross the bridge, may be applied according to [2, 4] on low-use trails, and according to [10] on bridleways with a span of up to 3 m. A width of 2 m is acceptable for short, low bridges over watercourses [1, 10–12]. For a moderate level of development, widths between 1.5–2.4 m [4] and 1.8–2.5 m [2] are acceptable. Widths up to 3 m allow only single-file riding; it is not possible to ride in pairs, overtake, or turn a horse on the bridge. A minimum clear width of over 3 m is prescribed by most manuals for a high level of development [2, 4], for long and high bridges over watercourses [1, 11, 12], for bridges over railways, roads [1, 11, 12] and wide rivers [10].

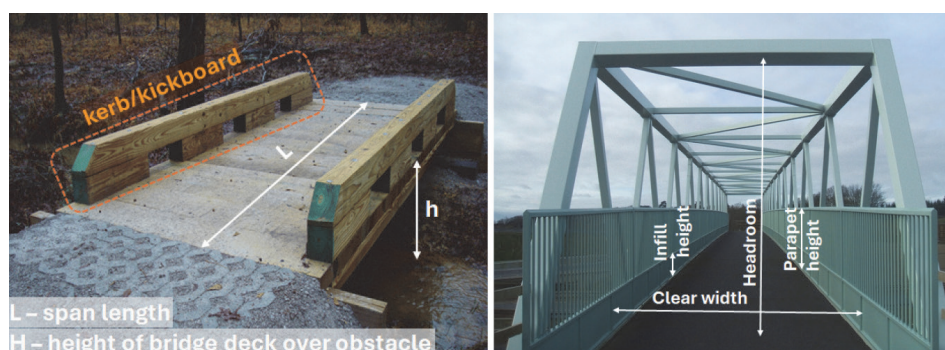


Figure 1 Bridge design parameters indicated on bridge photographs [13, 14]

The maximum slopes on bridges are defined in [4] and [2] as 5%. This slope is not too steep for users, ensures drainage, and prevents horses from slipping.

Parapets or fences prevent horses and riders from falling off bridges. An equestrian parapet height of 1800 mm is sufficient to deter horses from jumping over. A minimum parapet height of 1800 mm is specified for all bridges used by equestrians [8, 10], for bridges over major highways [5] and for all bridges with drop greater than 1 m in [1, 11, 12]. In some cases, bridges over watercourses with drops up to 1 m may have a reduced parapet height of up to 1.2 m [1, 11, 12]. The minimum height of 1, 372 mm, defined in [4] is insufficient for all types of equestrian bridges. Solid infill placed from the bottom of the railed fence prevents horses from being frightened by views of turbulent water, high-speed trains, or cars under the bridge, and may prevent a hoof from slipping off the bridge [4, 9]. Solid infills of at least 0.6 m (over watercourses), 1 m (over roads), and 1.8 m (over railways) are required in [1, 11, 12]. This aligns with the minimum infill height of 1.8 m for railway crossings and a minimum of 0.6 m for bridges not over railways in [7]. No parapet is required for short, low, and wide bridges over watercourses ($L < 3$ m, $h < 1$ m, clear width > 4 m) [1, 11, 12], or for wide bridges with good visibility and a drop below the bridge deck of less than 0.6 m [2]. Bridges without solid infills or parapets should be equipped with kerbs or kickboards at both bridge edges (figure 1, left) with a minimum height between 200 mm [2, 5] and 250 mm [1, 10–12], and an uplift from 25 mm [2, 1, 11, 12] to 50 mm [10].

4 Conclusion

In general, equestrian bridges, like other bridge structures, should be designed to be robust, resistant, and durable, regardless of the structural material used. The most common structural materials for equestrian bridges are timber and steel, while concrete and newly developed materials such as fibreglass are used less frequently. It is also desirable that bridges do not disturb natural or cultural values, do not alter the water flow beneath the bridge, and are cost-effective and easy to maintain. In addition, equestrian bridges must accommodate animal behaviour, as animals may be frightened by unfamiliar materials, structures that create or amplify noise, or by narrow, swaying, or vibrating bridges. However, no manual provides specific information on acceptable noise levels or vibration limits. Common bridge decking materials – wood, concrete, steel, fibreglass, and composites made from plastic and wood – should be surfaced with natural soils, roughened, treated with epoxy resin or bauxite grit, or fitted with rubber matting to make them more familiar to horses, prevent slipping when wet, and reduce noise. To ensure easier access to the bridge, it is desirable to build wider areas and to avoid steps on the bridge approaches. For safe and comfortable use, the following design parameters must be considered:

- the bridge slope should not exceed 5%
- the recommended minimum headroom for ridden use is 3.4 to 3.7 m
- the clear width should be greater than 3 m to allow horses to turn and overtake (a narrower clear width is acceptable on bridges on lightly used trails in remote areas; where there are greater numbers of equestrians, or on bridges on shared-use trails, the clear width should be greater than 3.5 m)
- equestrian bridges should generally have parapets at least 1800 mm high, with solid kickboards or infills if the parapet has railings
- on some low, short bridges over watercourses, the parapet height may be reduced or omitted (kickboards are mandatory for bridges without parapets).

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