Forest Service Handbook
National Headquarters – Washington Office
Washington, DC

Forest Service Handbook 7709.56b – Transportation Structures Handbook
Chapter 80 - Trail Bridge Design

Amendment: 7709.56b-2014-1

Effective date: November 24, 2014

Duration: This amendment is effective until superseded or removed.

Superseded Directive: 7709.56b,contents, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b, 0 Code Contents, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b, 0 Code, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b, 1 Contents, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b,1 Amendment, 7709.56b-94-1, July 27, 1994; 7709.56b, 2 Contents, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b,2, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b, 3 Contents, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b,3, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b, 4 Contents, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b,4, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b, 5 Contents, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b,5, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b, 6 Contents, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b,6, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b_7, Amendment 7709.56b-2005-1, August 26, 2005; 7709.56b_8, Amendment 7709.56b-2005-2, August 26, 2005; 7709.56b, 9 Contents, Amendment 7709.56b-94-1, July 27, 1994; 7709.56b,9, Amendment 7709.56b-94-1, July 27, 1994

Approved by: Gregory Smith, Acting Associate Deputy Chief, NFS

Date approved: November 18, 2014

Responsible Staff:

Explanation of changes: Following is an explanation of the changes throughout the directive by section.

7709.56b: The entire Handbook has been revised; refer to the digest for a summary of the revisions.

Zero Code: Makes minor technical and editorial changes, removes obsolete direction and terminology, and updates the coding system by changing from the one-digit to the two-digit coding system.

10: Recodes, reorganizes, and updates direction throughout the chapter. Makes minor technical and editorial changes, removes obsolete directions, and updates the coding system by changing from the one-digit to the two-digit coding system.

11: Recodes, reorganizes, and updates this section in its entirety. Replaces discussion of forest plans, ecosystem management, and least total cost method decisions with subsections on travel analysis and travel management decisions. Updates direction on road management to include direction on Trail Management Objectives and recodes the direction to section 11.3. Reduces scope of direction on alternatives to stay within limits of travel management decisions and the Road and Trail Management Objectives and recodes the direction to section 11.4. Recodes the remainder of the section to new section 11.5 entitled, "Project Development Process."

13: Sets forth new direction on inspection reports for existing structures and evaluation of load-carrying capacity of existing structures to listing of required design information.

20: Makes minor technical and editorial changes, removes obsolete direction, adds direction to meet Road and Trail Management Objectives, and updates the coding system by changing from the one-digit to the two-digit coding system throughout the chapter.

23: Adds direction to consider roadway widening needed to accommodate off-tracking of large trucks when curves are constructed close to bridges, to consider construction access to both sides of a stream, and to consider measures needed to maintain existing road traffic when replacing existing bridges.

30: Makes minor technical and editorial changes, removes obsolete direction, and updates the coding system by changing from the one-digit to the two-digit coding throughout the chapter.

34: Revises direction to conform to stream simulation requirements and to reference chapter 60.

35.4: Adds direction for identification of construction staging areas.

40: Makes minor technical and editorial changes and updates the coding system by changing from the one-digit to the two-digit coding throughout the chapter. Removes obsolete direction referencing economic analysis methods and flood insurance.

43.5: Updates direction to allow previously used materials only when they have been inspected, determined to be structurally adequate, economical and approved by the Regional Director of Engineering.

50: Changes chapter caption from "Hydrology" to "Hydrology and Geomorphology" and adds direction to require stream simulation and aquatic organism passage. Makes minor technical and editorial changes and updates the coding system by changing from the one-digit to the two-digit coding system.

60: Changes chapter caption from "Hydraulics" to "Hydraulics and Watershed Protection" and adds direction to require stream simulation and aquatic organism passage. Makes minor technical and editorial changes and updates the coding system by changing from the one-digit to the two-digit coding system throughout the chapter. Removes obsolete direction.

70: Changes chapter caption from "Structural Design" to "Road Bridge Design" and updates the coding system by changing from the one-digit to the two-digit coding system throughout the chapter. Adds new direction and revises, reorganizes, and recodes direction throughout the entire chapter. Changes various section captions to be applicable for road bridge designs and sets forth new direction throughout the chapter. Removes obsolete direction.

80: Changes chapter caption from "Operations" to "Trail Bridge Design" and updates the coding system by changing from the one-digit to the two-digit coding system throughout the chapter. Sets forth direction for planning, design, and construction of trail bridges and other engineered trail structures.

90: Changes chapter caption from "Construction" to "Road Bridge Operation" and updates the coding system by changing from the one-digit to the two-digit coding system throughout the chapter. Revises, reorganizes, and recodes entire chapter. Major changes are: 1) removes the distinction and inspection requirements between bridges formerly known as NBIS and non-NBIS (National Bridge Inspection Standards), 2) removes all trail bridge references and guidance and 3) incorporates culvert guidance.

100: Establishes code, chapter "Trail Bridge Operation", and sets forth direction for maintenance, inventorying, and operation of trail bridges and other engineered trail structures.

Table of Contents

80.6 - References

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17. U.S. Department of Transportation, FHWA. Hydraulic Engineering Circular (HEC) 26, Culvert Design for Aquatic Organism Passage. The web site to order this publication is: http://www.fhwa.dot.gov/bridge/elibrary.htm.

18. Western Wood Preserver's Institute (WWPI). "Best Management Practices for the Use of Treated Wood in Aquatic and Wetland Environments". Current Edition. The web site address to order this publication is: http://www.wwpinstitute.org/

81 - Design Standards for Trail Bridges and Other Engineered Trail Structures

Design trail bridges and other engineered trail structures in accordance with AASHTO's LRFD Bridge Design Specifications and AASHTO's LRFD Guide Specifications for the Design of Pedestrian Bridges. These specifications, along with the additional references listed in section 80.6, are the nationally accepted guidance for trail bridge design.

Any exceptions to the AASHTO specifications must be approved by the Regional Director of Engineering (FSM 7723.04c) and must be documented and cited in the structural design calculations and maintained in the permanent bridge file. Design exceptions, use limitations or special requirements must be shown clearly on the project plans.

81.1 - Trail Management Objectives, Trail Fundamentals, and Design Parameters

Trail bridges and other engineered trail structures must be designed to reflect the Trail Management Objectives (TMOs) that have been identified for the trail (FSM 2353.12). The TMOs indicate the appropriate Trail Fundamentals (FSM 2323.13), Recreational Opportunity

Spectrum (FSM 2353.14), and National Quality Standards (FSM 2353.15) for trails and applicable accessibility requirements (FSM 2353.17).

81.2 - Use of National and Regional Standard Plans and Construction Specifications

A series of nationally approved superstructure standard plans, substructure design aids, and standard construction specifications have been prepared. These plans, aids, and specifications are revised when necessary.

As appropriate, use National and Regional standard designs and plans for trail bridges and other engineered trail structures. National standard designs and plans must be approved by the Washington Office, Director of Engineering. Regional standard designs and plans must be authorized and approved by the Regional Director of Engineering.

Establish Regional guidance regarding the use of standard designs and plans, including any delegation of design or approval authority.

Preliminary engineering analysis (FSH 7709.56b, ch. 10 & ch. 60) and site specific engineering design are still required when standard designs and plans are used. Site-specific engineering designs should be prepared by or under the direct supervision of a Certified Bridge Design Engineer. See FSM 7723.04 for direction on authority to review, approve, and sign site-specific engineering designs.

82 - Design Requirements

82.1 - Bridge Widths

Bridge widths must be consistent with the Trail Fundamentals (FSH 2309.18, sec. 14), including the Design Parameters (FSH 2309.18, sec. 23), identified in the TMOs for the trail.

82.2 - Design Loads

Design loads must reflect the Trail Fundamentals, including the Design Parameters (FSH 2309.18) identified in the TMOs for the trail.

Design trail bridges and other engineered trail structures for the maximum loading or load combinations, taking into account such factors as pedestrian live load, snow, wind, snow groomers, seismic events, and light vehicle loads. At a minimum, the following nine provisions from AASHTO's LRFD Guide Specifications for the Design of Pedestrian Bridges apply.

1. Pedestrian Live Load. Design live loads for hikers, all-terrain vehicles, motorcycles, bicycles, over-snow vehicles, and pack stock are grouped together under pedestrian live loads. Use live loads specified in AASHTO's LRFD Guide Specifications for Design of Pedestrian Bridges. AASHTO specifications require a minimum live load of 90 pounds per square foot (psf).

AASHTO's LRFD Guide Specifications for Design of Pedestrian Bridges was prepared for urban settings with large numbers of potential users. Many Forest Service trail bridge sites are remote and only accessed by small groups of hikers. When the TMOs indicate such limited use, the pedestrian load can be reduced to 65 psf. The justification for a reduced design live load should be documented and included in the permanent bridge file.

Elevated viewing platforms must be designed for a minimum pedestrian live load of 100 psf.

2. Snow Loads. In determining snow loads, use the maximum ground snow load conditions, accumulation, and water content for the 50-year recurrence interval without reduction, or use load values developed by local building or public road authorities. Consider snow loads as live loads, and combine snow loads with other loads as described in section 82.3.

When trail bridges are designed for seismic events, any snow load is considered a dead load and should be added to the structure dead load. A reasonable design approach is to assume that 20 percent of the total snow load should be added to the regular dead load of the structure to calculate the total seismic weight of the trail bridge.

3. Wind Loads. Trail bridges and other engineered trail structures can be designed as specified in AASHTO's Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals; per Articles 3.8 and 3.9 in AASHTO's LRFD Guide Specifications for Design of Pedestrian Bridges; or as specified in AASHTO's LRFD Bridge Design Specifications. A design using AASHTO's Standard

Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals more accurately reflects the flexible nature of trail bridges. A design using AASHTO's LRFD Bridge Design Specifications is somewhat more conservative. See references in section 80.6.

4. Equestrian Loads. Design decks on equestrian trail bridges for a patch load of 1000 pounds over a square area measured 4 inches on each side. Design the entire trail bridge, including the deck, for the required uniform pedestrian load in combination with other loads as described in section 82.3.

5. Fatigue Load. Fatigue load applies only to steel members. In designing trail bridges, consider wind loads in determining fatigue load. Consider fatigue load as specified in AASHTO's LRFD Guide Specifications for the Design of Pedestrian Bridges. Pedestrian use on most Forest Service trail bridges will not significantly contribute to fatigue load.

6. Snow Groomer Loads. Snow groomer loads should reflect machinery currently in use or planned for use as described in the TMOs for the trail. Consider snow groomer loads as live loads, and combine snow groomer loads with other loads as described in section 82.3.

7. Seismic Loads. The primary design consideration in seismic design is user safety. Design for seismic loads per AASHTO's LRFD Bridge Design Specifications, when warranted.

8. Light Vehicle Loads. Where vehicle access is not eliminated by artificial or natural physical barriers, trail bridges wider than 7 feet must be designed for light vehicle loads. Design trail bridges having widths of 7 to 10 feet for a single H5 truck (AASHTO). Design trail bridges having widths greater than 10 feet for a single H10 truck (AASHTO). Post bridges 7 feet and wider with an R12-1weight limit signs in conformance with the MUTCD.

82.3 - Load Combinations

Consider all potential load combinations that may occur on a trail bridge.

Design Forest Service trail bridges for the anticipated users and snow load. When anticipated uses occur in winter, the live loads should be added to the snow load.

Design bridges exposed to high winds for lateral wind loads, overturning and sliding.

Bridges of sufficient width must be designed for occasional light vehicle loads in conformance with section 82.2.
Design trail bridges planned to undergo more varied live loading conditions using AASHTO's LRFD Guide Specifications for the Design of Pedestrian Bridges, with the following three modifications:

1. In general, maximum design snow loads are not to be combined with other live loads, except as indicated in section 82.3, paragraph 2. Use a load factor of 1.25 for the dead load and 1.75 for the snow load for a snow-only load combination.

2. Snow loads combined with other live loads must be considered in the following situations:

a. The primary users of the bridge include snow trail users. In these situations, determine the appropriate live load (for example, skier or over-snow vehicle) in combination with the appropriate design snow load. Use a load factor of 1.25 for the dead load, 1.75 for the live load, and 0.5 for the snow load, or use 1.25 for the dead load, 1.75 for the snow load, and 1.0 for the live load, whichever combination for the snow and live load combination is most critical.

b. Snow groomers will groom across the bridge. Determine the appropriate design snow depth, the corresponding snow load, and the snow groomer load. Show this loading on the plans, and incorporate it in the operating plan for the bridge. Use a load factor of 1.25 for the dead load, 1.75 for the snow load, and 1.75 for the snow groomer load for the snow and groomer load combination.

c. A trail bridge is roofed. The roof must be designed to carry the snow load, and the underlying deck must be designed to carry pedestrian live loads. Use the more critical of the following two combinations:

(1) A load factor of 1.25 for the dead load, 1.75 for the live load, and 0.5 for the snow load; or

(2) A load factor of 1.25 for the dead load, 1.00 for the live load, and 1.75 for the snow load.

3. In general, wind loads will not be critical to most trail bridges. However, for longer trail bridges with high exposure that are subject to high winds, the following applies:

a. Wind on live loads should not be considered;

b. Wind pressures on vertical snow loaded areas should be considered; and

c. The bridge should be checked for overturning and sliding.

Additional guidance on load combinations is provided in AASHTO's LRFD Guide Specifications for the Design for Pedestrian Bridges.

82.4 - Trail Bridge User Barriers

Trail bridge user barrier design should be site-specific. Design user barriers for all trail bridges except bridges, such as foot logs and other minor trail bridges, where user barriers are determined to be impractical or unnecessary. The Bridge Design Engineer and local Recreation staff should evaluate the resource and user safety needs at each site using the applicable TMOs as a guide and the physical characteristics of the site. Trail bridge user barriers can be curbs, railing systems, or a combination of the two.

Timber is often used for trail bridge railings. Designers may use a load duration factor of 1.25 for railing loads in the design of railing elements. (Refer to NDS, Appendix N.3.3

If a trail bridge on a trail intended for non-motorized use is determined to need a railing system, consider the following in the design with appropriate AASHTO and accessibility codes.

1. Heavily used trails, particularly near urban areas, may require a railing system meeting the following geometric requirements:

a. The top rail must be at least 42 inches high, measured from the deck surface.

b. A 4-inch-diameter sphere must not pass through the bottom 36 inches of the rail, and an 4-3/8-inch-diameter sphere must not pass through the rail above 36 inches.

2. Moderately used trails, typically in rural areas, may require a railing system meeting the following geometric requirements:

a. The top rail must be at least 42 inches high, measured from the deck surface.

b. A 6-inch-diameter sphere must not pass through the bottom 27 inches of the rail, and an 8-inch-diameter sphere must not pass through the rail above 27 inches.

3. Low-use trails may require a railing system meeting the following geometric requirements:

a. The top rail must be at least 42 inches high, measured from the deck surface.

b. The railing system must include a top rail and an intermediate rail. When this type of railing system is used on equestrian trails, a curb or kick rail should also be installed.

When a curb is determined to be adequate, the curb should consist of a top longitudinal rail, blocked off the deck surface to allow drainage and may vary in height and size depending on the Managed Use of the trail.

Railing systems for bicycle trail bridges shall be a minimum of 42 inches high but 54 inches high is recommended. Pedestrian and bicycle railing systems are usually adequate for other trail users, such as equestrians, motorcyclists, over-snow vehicle users, all-terrain vehicle users, snow-shoes, and cross-country skiers.

Design all trail bridge user barriers for the design loads specified in AASHTO’s LRFD Bridge Design Specifications.

1. Design each rail, including curbs, for a uniform load of 50 pounds per linear foot simultaneously applied horizontally and vertically and a 200-pound load simultaneously applied at the most critical location and most critical direction.

2. Design each post and curb connection for the uniform horizontal load acting on the top rail simultaneously with a 200-pound horizontal load at the top rail.

A trail intended for motorized use may require road bridge traffic barriers (FSM 7722.12 and FSH 7709.56b, sec. 72.3). All rails and curbs must meet the static strength requirements for the intended user in AASHTO’s LRFD Bridge Design Specifications.

82.5 - Deflection and Vibration

Generally, pedestrian live load deflection should not be greater than L/360. For trail bridges in which snow loads control the design, the snow load deflection may not exceed L/240. Refer to AASHTO’s LRFD Guide Specifications for Design of Pedestrian Bridges for more detailed descriptions of deflection considerations.

Vibration investigation is optional for most Forest Service trail bridges. When designing high-use, long, slender trail bridges, particularly for equestrian use, investigate vibrations as specified in AASHTO’s LRFD Guide Specifications for the Design of Pedestrian Bridges.

82.6 - Grades and Accessibility

Design grades on trail bridges and other engineered trail structures consistent with the TMOs for the trail. Consider skid-resistant surfaces when grades exceed 4 percent on high use trail bridges or equestrian trail bridges.

Consider surface drainage and erosion control when designing vertical alignment of trail bridges.

Accessibility requirements for trails are identified in the TMOs (FSM 2353.12 and 2353.17).

83 - Design Calculations and Plans

When National or Regional standard designs and plans are not used, prepare designs and plans as follows:

1. Complete structural and foundation design calculations and prepare construction plans for each trail bridge and other engineered trail structure in accordance with FSM 7723.03. All designs must be performed by a certified Bridge Design Engineer or by an Engineer who is under the direct supervision of a Certified Bridge Design Engineer (FSM 7723.04b and 7723.2).

2. When trail bridge and other engineered trail structure designs and plans are prepared by a Forest Service Engineer, ensure they are reviewed and checked by another Certified Bridge Design Engineer (FSM 7723.2).

3. When trail bridge and other engineered trail structure designs and plans are prepared by a Consulting Engineer, ensure that designs and plans are reviewed by a Certified Bridge Design Engineer and bear the seal and signature of the responsible professional engineer, registered in the State in which the bridge will be installed.

4. A Certified Bridge Design Engineer shall review all supplier or manufacturer product designs and plans in accordance with applicable Regional guidance and contract requirements (FSM 7723.1). Ensure that supplier or manufacturer product designs and plans bear the seal of the responsible professional Engineer registered in the State in which the bridge or products are manufactured.

5. Show foundation investigation, hydrological, and hydraulic data (FSH 7709.56b, ch. 30 & ch. 60), design users, snow and wind loads, and bearing pressures on the plans.

6. Design "half through trusses" (also referred to as side trusses or pony trusses) for lateral loadings and compression chord stability as specified in AASHTO's LRFD Guide Specifications for the Design of Pedestrian Bridges.

7. Include as-built plans, design information, design calculations, inspection reports, and load ratings for each trail bridge in the permanent bridge file.

84 - Structure Life

When sizing a trail bridge or other engineered trail structure and selecting the type of material to be used, consult the TMOs for the trail and consider the following:

1. Generally use long-term materials such as steel, concrete, aluminum, or appropriate preservative-treated wood. Untreated logs may be used in some situations, such as short-term uses or for temporary bridges. However, treated wood or naturally decay-resistant wood will last significantly longer.

    a. When practical, use air entrained concrete in regions subject to freeze and thaw cycles.

    b. Galvanize, paint, or use weathering (corrosion-resistant) steel to reduce damage from oxidation.

    c. When practical, use wood species that are either naturally resistant to deterioration (refer to AASHTO M168) or treatable using appropriate pressure treatments. Treat, clean, and handle wood in conformance with the requirements of AWPA's Book of Standards and WWPI's Best Management Practices for the Use of Treated Wood in Aquatic and Other Sensitive Environments (sec. 80.6).

2. Design permanent structures to last at least 50 years. Design short-term structures for a lifespan appropriate for their intended use and in conformance with the TMOs for the trail.

3. All structures should, at a minimum, be designed to withstand a 100-year flood. Provide for additional vertical clearance for the passage of woody debris and ice as necessary. The amount of additional vertical clearance should be based on applicable Regional guidance, channel configuration at the bridge site, and the requirements in section 62.2.

Consider designing critical or high-value trail bridges with 1 foot more vertical clearance than required for a road bridge due to a trail bridge's higher susceptibility to impact damage from debris. See AASHTO's LRFD Guide Specifications for the Design of Pedestrian Bridges for additional guidance on vertical clearance.

85 - Previously Used Materials

The use of previously used materials, particularly for structural elements, is discouraged in new trail bridges (sec. 43.5). The Regional Director of Engineering must approve the use of any previously used materials.

Do not use railroad cars as trail bridges on NFS trails.

86 - Privately Owned Trail Bridges

Special-use authorizations for privately owned trail bridges and other engineered trail structures on NFS lands authorized by permit, term permit, lease, or easement (special-use authorizations) should include clauses for design and construction requirements to adequately protect the public and National Forest System Lands and resources. The design and construction requirements within FSM 7723 and the guidance in this section are recommended for all trail structures designed and installed on NFS lands, regardless of ownership or jurisdiction.

Permit holders are responsible for compliance with the requirements, engineering, and construction costs for trail structures authorized by their permit.

The following provides technical advice recommended for trail bridges and other engineered trail structures authorized by a special use permit on NFS lands.

86.1 - Design

Ensure that all designs and calculations for trail bridges and other engineered trail structures are:

1. Completed, signed, and sealed by a professional engineer registered in the State in which the bridge is to be built.

2. Completed in accordance with the latest edition of AASHTO's LRFD Bridge Design Specifications and LRFD Guide Specifications for the Design of Pedestrian Bridges. The bridge design should be based on appropriate trail and site drainage information, topographical site surveys, hydraulic analysis, and geotechnical evaluations.

3. Designed to meet applicable AASHTO design loads per regional guidance.

4. Designed to accommodate a 100-year flood with appropriate freeboard for debris and to allow for passage of aquatic species. Abutments must be located outside the bankfull stream channel and installed so as to minimize resource damage.

5. Designed, as appropriate, to provide drainage away from the bridge and the stream; to incorporate appropriate additional drainage features such as sediment traps and cross drains; and to provide at least a 50-foot filtration or buffer from the stream channel for trail drainage to reduce sediment flow into the stream.

6. Designed with an appropriate user barrier in compliance with FSM 7723.12 and FSH 7709.56b, section 82.4.

7. Reviewed by the Forest Service Regional Bridge Engineer

86.2 - Construction

Ensure that the registered professional engineer who completed, signed, and sealed the design calculations, plans, and specifications establishes construction quality assurance measures, oversees these measures, and documents implementation of these measures. Upon completion of construction, ensure that the Engineer inspects the bridge or other engineered trail structure and certifies in writing that the structure was constructed in accordance with the approved plans and specifications. Ensure that the permit holder submits a copy of the inspection documentation and certification to the Forest Service.