

**Forest Service Handbook  
National Headquarters – Washington Office  
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**Forest Service Handbook 7709.56b – Transportation Structures Handbook  
Chapter 40 - Preliminary Design**

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**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

40.2 - Objectives .....	5
40.3 - Policy .....	5
40.6 - References .....	5
41 - Preliminary Design Process .....	6
42 - Selecting Alternative Structure Types .....	6
43 - Design Considerations.....	7
43.1 - Appearance.....	7
43.2 - Waterways.....	7
43.3 - Long Term vs. Short Term Structures .....	7
43.4 - Modular, Portable Bridges.....	8
43.5 - Use of Previously Used Material .....	8
44 - Economic Analysis of Alternatives .....	8
45 - Selecting the Alternative for Final Design .....	8
45.1 - Documentation .....	9

## 40.2 - Objectives

To develop preliminary structure designs for bridges, trail bridges, and major and minor culverts that include the following:

1. Development and evaluation of bridge and major culvert alternatives that meet the road management objectives (RMOs - FSM 7714).
2. Development and evaluation of trail bridge alternatives that meet the trail management objectives (TMOs).

## 40.3 - Policy

Develop preliminary designs for each bridge and major culvert and for trail bridges when the size and scope of the project are appropriate.

## 40.6 - References

1. American Association of State Highway and Transportation Officials (AASHTO). "The Manual for Bridge Evaluation. Current edition." The web address to order this publication is: [https://bookstore.transportation.org/browse\\_bookstore.aspx](https://bookstore.transportation.org/browse_bookstore.aspx)
2. U.S. Department of Agriculture, Forest Service (USDA-FS). The Least Total Expected Cost--An Economic Analysis Method for Selection of Culverts and Other Transportation Structures, EM-7700-9. The web address to order this publication is: <http://www.fs.fed.us/eng/techdev/sdt/dc.htm>
3. U.S. Department of Transportation. Federal Highway Administration (FHWA). Hydraulic Design of Bridges with Risk Analysis, FHWA-TS-80-226. March 1980. The web address to order this publication is: <http://flh.fhwa.dot.gov/resources/pse/specs/>
4. U.S. Department of Transportation. FHWA. Hydrology, Hydraulic Engineering Circular No. 19 (HEC-19), FHWA-IP-84-15. October 1984. The web address to order this publication is: <http://www.fhwa.dot.gov/bridge/elibrary.htm>
5. U.S. Department of Transportation. FHWA. The Design of Encroachments on Flood Plains Using Risk Analysis, Hydraulic Engineering Circular No. 17 (HEC-17), FHWA-EPD-86-112. 1981. The web address to order this publication is: <http://flh.fhwa.dot.gov/resources/pse/specs/>

## **41 - Preliminary Design Process**

Complete the following preliminary design steps:

1. Select structure types for analysis and comparison.
2. Analyze the alternatives.
  - a. Develop information needed for conducting the analysis.
  - b. Conduct an economic analysis (sec. 44).
3. Select an alternative for the final design.

## **42 - Selecting Alternative Structure Types**

Select tentative alternative structure types for analysis.

1. Each alternative should meet criteria and limitations specified in the following:
  - a. The Project Engineering Report (sec. 14).
  - b. The RMOs or TMOs (sec. 11.3).
  - c. The road design criteria (sec. 14.1).
  - d. The foundation investigation (sec. 31).
2. Also consider the following factors:
  - a. Stream channel alignment, cross-section, stability, need for protective measures, and channel modifications.
  - b. The availability of structural components.
  - c. Resource protection needs, including fisheries.
  - d. Lowering approach embankments, where possible, so that they are overtopped before the structure itself is overtopped or breached. This may save on construction costs and will reduce the possibility of damage to the structure. Allowing for more damage to the approaches may permit the structure to be made smaller and will normally result in less total cost to repair.

## **43 - Design Considerations**

### **43.1 - Appearance**

Design structures to be compatible with the natural surroundings and to meet visual quality objectives in form, color, and texture.

Locate surface drainage features to avoid causing discoloration of structure components. Use materials compatible with the surrounding environment. Miter large culverts consistent with structural adequacy and safety and bevel inlets to increase flow efficiency. Utilize the input of architects and landscape architects in planning and design activity when appropriate.

### **43.2 - Waterways**

Maintain natural stream conditions at waterway crossings. Ensure that desirable streambed conditions and fish habitat is protected when selecting structure type. When fish use the streams for habitat, spawning, or migration, consider using arches or bridges rather than culverts.

### **43.3 - Long Term vs. Short Term Structures**

Match structure design life with the structure service life identified in the RMOs or TMOs. When service life is relatively short, consider using modular portable bridge superstructures or other appropriate short-term facilities.

Avoid the following:

1. Replacing a component of a structure with materials that would have a design life less than, or significantly longer than, the remaining service life of the structure of which it will become a part.
2. Repeated disturbance of the streambed and stream banks when a structure is replaced.
3. Inadequate hydraulic capability for the structure design life.

Do not use short-term structures for long-term facilities without the Responsible Official making a travel management decision to do so. Any such travel management decision should be advised by an economic analysis that considers future replacement costs, costs of environmental consequences due to repeated construction activities, management requirements, and long-term maintenance/repair needs.

Use long-term structures for short-term facilities only if structures are designed for relocation and reuse at other sites.

#### **43.4 - Modular, Portable Bridges**

Design modular, portable, or reusable bridge superstructures to meet the same criteria used for short-term and long-term structures. Consider site safety requirements, abutment construction and hydraulic design needs, and total life-cycle costs before using a modular portable bridge.

Do not use modular bridges for long-term facilities except where permitted by Regional guidance and when cost analyses indicate lower life cycle costs.

#### **43.5 - Use of Previously Used Material**

Do not incorporate structural elements made from previously used materials into structures unless a registered professional engineer certifies in writing that the capacity and remaining life of the material is adequate for the intended use. Consider previously used materials only when a thorough inspection and structural analysis indicates an economic advantage for their use and a level of risk is acceptable.

Obtain approval from the Regional Director of Engineering before using any previously used materials in any road or trail bridge (FSM 7722.04c).

Do not use railroad car body units for permanent or temporary road or trail bridges on National Forest System roads, trails, or lands.

#### **44 - Economic Analysis of Alternatives**

Make an economic analysis of alternatives as part of the preliminary design activity. Economic analysis may be performed in accordance with professionally acceptable procedures such as analyses that consider costs incurred during the entire life of the structure.

#### **45 - Selecting the Alternative for Final Design**

In addition to economics, consider:

1. The appropriateness of the structure for the site (sec. 23).
2. RMOs and TMOs, including but not limited to:
  - a. Aquatic organism passage and resource protection.
  - b. Aesthetics.
  - c. Public safety.
  - d. Needs for maintenance of traffic when reconstructing bridges.



3. Ease and speed of construction. This will affect cost, traffic flow and usage, and total environmental effects,

4. Available construction skills and equipment.

#### **45.1 - Documentation**

Document the results of the preliminary design in a report. Include sketches or drawings, as appropriate. Recommend the preferred alternative. Place a copy of the report, sketches, and drawings in the project file.