20. Bridges in Remote Sites

20.1. Design Objectives

20.1.1. General

Chapter 20 presents practices that provide safe and cost-effective bridges in remote sites with low traffic volumes. Common characteristics of remote bridge locations to which this chapter applies are:

- They are off the main road system; barge service or air freight is frequently the primary means of transporting goods.
- Not on the NHS.
- No mining or other heavy industry is present.
- ADT ≤ 50 and ADTT ≤ 10.
- DOT&PF does not anticipate future traffic load or volume changes.

The DOT&PF typically provides the construction funding, selects the bridge type, and selects the appropriate standards for structural design. Designing and constructing bridges in remote sites presents special issues to consider, including:

- The bridge is often the only life-line between the village and the airport.
- The “heaviest vehicle in town” will provide useful information about the actual loading in these locations and should be identified as part of the design.
- The responsible local agency at remote sites does not typically have an engineer on staff or local design standards.
- There may be limited overweight vehicle enforcement in remote locations.
- The need to transport construction materials, equipment, and labor to remote sites can introduce design challenges.
- A bridge could have multiple users, such as pedestrians, all-terrain vehicles (ATVs), snow machines, etc.
- Balance between economy and durability as part of the life-cycle analysis offers long-term benefits. Due to access issues for remote sites, the goal is to provide a bridge that requires little or no maintenance. Life-cycle cost considerations justify higher initial costs, such as metallizing steel bridges to reduce maintenance costs.

20.1.2. Bridge Type Selection

DOT&PF typically uses steel girders or modular steel trusses in remote sites.

Treated timber bridges have historically demonstrated mixed results at some sites.

20.1.3. Safety

Reference: LRFD Articles C1.3.2.1 and C3.6.1.2.1.

In all cases, Chapter 20 intends to maintain the inherent safety of the *LRFD Specifications*. The HL-93 notional design load is based upon grandfathered load exemptions, which yields a realistic live-load model despite the lack of truck-traffic data for remote sites.

The statistics of load (mean and coefficient of variation) taken from freeway-type highways used for the calibration of the *LRFD Specifications* are not always appropriate for remote sites, allowing a slight modification of this approach.

The bridge engineer will apply the live-load load factors of LRFD Table 3.4.1-1, as modified herein, to the design of bridges in remote sites. The modifications to the load factors in Section 20.2.1.2 address lower ADTT, not the database of the original calibration.

20.1.4. Constructability/Maintainability/ Durability

Mobilization costs can dominate decision-making when constructing a bridge at a remote site. Neither roadway nor water access may be available. In addition, consider which materials to transport to the site; the objective is to specify materials that are extremely durable to maximize the probability of achieving a 75-year design life with little or no maintenance or rehabilitation. Follow these guidelines for remote bridge designs:

1. Consider what construction labor, materials, and equipment are not readily available at the site.

   Usually, the Contractor must transport all construction materials and equipment to these sites, typically over great distances. In addition, the Contractor may have to transport housing, vehicles, and other facilities for workers.

2. Avoid cast-in-place concrete components at remote sites where concrete batching is impractical. Use prefabricated/precast elements where possible (e.g., deck, caps, girders). Also consider using prefabricated abutments.

3. Design and detail prefabricated components considering the means of transportation to the site, possibly including cargo aircraft.

20.1.5. One-Lane vs. Two-Lane Bridge

For bridges at remote sites with an ADT less than 100 vehicles per day, one-lane bridges on two-lane, two-way roads can be considered during the Bridge Type Selection process. The roadway designer and regional traffic engineer must determine that a one-lane bridge can operate safely.

One-lane bridges should have pull-offs at each end where drivers can wait for oncoming traffic to clear. The minimum width of a one-lane bridge is 15 feet. Avoid using one-lane bridges wider than 16 feet because drivers may attempt to use them as two-lane structures.

Design one-lane bridges to accommodate future widening. For example, widenings that require cofferdams below the superstructure may be impractical, whereas pipe pile extension bents can be widened with greater ease and less cost.

Bridge Length

The longer the bridge, the more likely that an “undesirable” result would occur (i.e., two vehicles moving in the opposite direction meeting on the bridge). However, the longer the bridge, the higher the potential cost savings to constructing a single-lane bridge. This savings is not proportionate to the reduction in deck area. For example, a 50 percent reduction in the square footage of the deck may yield a 25 percent reduction in the total cost.

Sight Distance

If two vehicles on either end of the bridge cannot see one another, this is a disadvantage to installing a one-lane bridge on a two-way roadway.

Truck Traffic

With lower truck traffic on the roadway, a one-lane bridge is more feasible.

20.2. Limit States

20.2.1. Strength

Load Modifiers

Reference: LRFD Articles 1.3.2.1, 1.3.3, 1.3.4, and 1.3.5.

For all Strength limit states for bridges in remote sites, use:

$$\eta_D = \eta_R = 1.0$$

and

$$\eta_I = 0.95$$

yielding a load modifier for application in LRFD Equation 1.3.2.1-1 of:

$$\eta_i = 0.95$$

This load modifier represents the use of less stringent Strength limit-state criteria for bridges in remote sites. For all other limit states of bridges in remote sites, use a load modifier of:

$$\eta_i = 1.0$$

Live-Load Load-Factor Reduction

References: LRFD Articles 3.4.1 and C3.6.1.1.2.

The following applies:

1. For $50 \leq \text{ADTT} \leq 500$, reduce the live-load load factors in LRFD Table 3.4.1-1 to 95 percent of those specified.
2. For ADTT < 50, reduce the live-load load factors in LRFD Table 3.4.1-1 to 90 percent of those specified.

These reductions reflect the reduced probability of the design event occurring during a 75-year design life with reduced truck-traffic volume.

20.2.2. Service Live-Load Deflection Check

References: LRFD Articles 2.5.2.6.2, 2.5.2.6.3 and 3.6.1.3.2.

Do not apply the criteria for live-load deflection in LRFD Articles 2.5.2.6.2 and 3.6.1.3.2 or the criteria for span-to-depth ratios of LRFD Article 2.5.2.6.3 for the design of bridges in remote locations.

20.2.3. Load-Induced Finite-Life Fatigue II Limit State

References: LRFD Articles 3.4.1 and 6.6.1.2.

Design steel details on bridges in remote sites to provide the finite fatigue resistance associated with the ADTT, as specified in LRFD Equation 6.6.1.2.5-2, using the Fatigue II load combination of LRFD Table 3.4.1-1.

The ADTTs in remote sites are sufficiently low that the finite-life fatigue resistance is more appropriate as suggested in LRFD Table 6.6.1.2.3-2, where all of the governing ADTT thresholds for infinite-life are greater than 500 trucks per day.

20.3. Live-Load Analysis

Reference: LRFD Article 3.6.1.3, 4.6.2.2 and 4.6.3.

The following applies:

1. Apply the single-lane live-load distribution factors of LRFD Article 4.6.2.2 for the design of bridges in remote sites when using approximate methods of analysis. Do not apply the distribution factors for multiple lanes.
2. Where refined methods of analysis are used for the design of bridges in remote sites, load the model with only a single lane. The single-lane multiple presence factor of 1.2 from LRFD Table 3.6.1.1.2-1 still applies.
3. For determining negative moment in continuous spans, and the reaction at interior piers on bridges in remote sites, load all spans with a single design vehicle superimposed upon the design lane load.

   Do *not* apply 90 percent of the effect of two design trucks spaced a minimum of 50 feet between the lead axle of one truck and the rear axle of the other truck, combined with 90 percent of the effect of the design lane load as specified in LRFD Article 3.6.1.3.

Although heavy vehicles as represented by the HL-93 notional live-load model may cross bridges in remote sites, it is highly unlikely that multiple heavy vehicles, transversely or longitudinally, will be on the bridge simultaneously.

As specified in Section 20.1.5, design one-lane bridges to accommodate future widening without difficulty. Therefore, the live-load analysis should consider this possibility in proportioning superstructure and substructure components for one-lane bridges.

20.4. Design Details

20.4.1. Metalizing or Galvanizing of Steel Bridges

Metalize or galvanize all steel bridges to be erected in remote sites to provide a relatively maintenance-free coating. Metalize field sections greater than 50 feet in length. Use hot-dip, galvanized field sections less than 50 feet in length. The 50-foot demarcation represents the length of commonly available galvanizing tanks.

20.4.2. Approach Slabs

Reference: LRFD Article 3.11.6.4.

Do not use approach slabs on bridges with an ADT less than 100 and an ADTT less than 50. In such cases, apply the full live-load surcharge (LS) of LRFD Table 3.11.6.4-1 to the abutments.

20.4.3. Bridge Rail Systems

Comply with the requirements in Section 16.5.

20.4.4. Future Wearing Surface

Design all bridges for a future wearing or gravel surface assuming an additional dead load of 50 psf over the deck area.

20.4.5. Foundations

Although equipment for pile driving adds to the cost, the crane may be used for other purposes anyway. The bridge engineer may consider the use of shallow foundations for one-span bridges; however, the relatively high cost of riprap and the difficulty to maintain the riprap may offset the potential cost savings. If piers are used, then deep foundations will likely be required at the abutments also.

20.4.6. Temporary (Detour) Bridges

Consider reduced design standards for temporary bridges. Reductions might include one-lane traffic, design live loads, non-crash tested bridge rails, hydraulic capacity consistent with the anticipated life of the temporary structure, etc. Document the decision(s) to reduce design standards in the project files.

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